The Locomotive

OF

THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

VOL. XXX.

PUBLISHED BY
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

HARTFORD, CONN.
1914-1915.

INDEX TO VOL. XXX—1914-1915

REFERENCES MARKED WITH A STAR (*) ARE TO ILLUSTRATED ARTICLES.

The Locomotive
of
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXX. HARTFORD, CONN., JANUARY, 1914. No. 1.

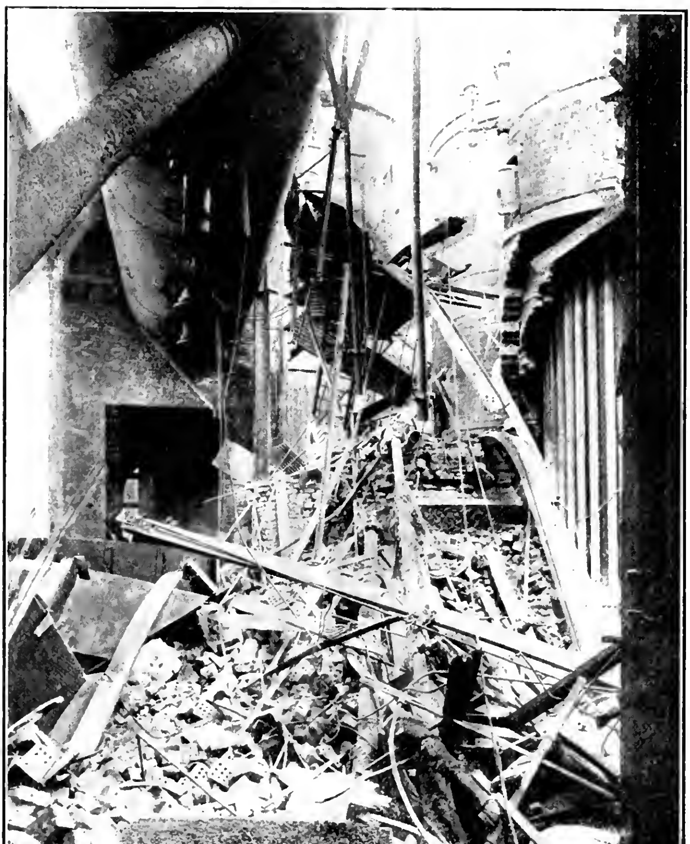


Fig. 1. Boiler Explosion, Staten Island.

Boiler Explosion on Staten Island.

On October 21, at about 5.12 in the afternoon, a large water tube boiler exploded in the power station of the Richmond Light and Power Co., Staten Island, N. Y. The explosion, which was of unusual violence, resulted in the instant death of six men, and the injury of five others, one of whom has since died.

The failure occurred at the turn of the flange of the lower head. The boiler, blown clear of its bottom head, went upward under the reaction of the powerful downward stream of steam and water, and in sky-rocket fashion passed out through the roof of the boiler house, falling practically intact into the Kill von Kull, some 400 ft. off shore. It was later raised and we are able to show an excellent photograph of it in Fig. 2. The character of the failure is so well shown by the photograph that further comment seems unnecessary, especially as we were unable to obtain any first hand details of the events preceding the accident, our representative not being given access to the plant. The property damage was heavy and the discomfort and suffering caused by the tieing up of all light, power and trolley service for several days was severe. Our front cover will give some idea of the havoc wrought in the boiler house itself.

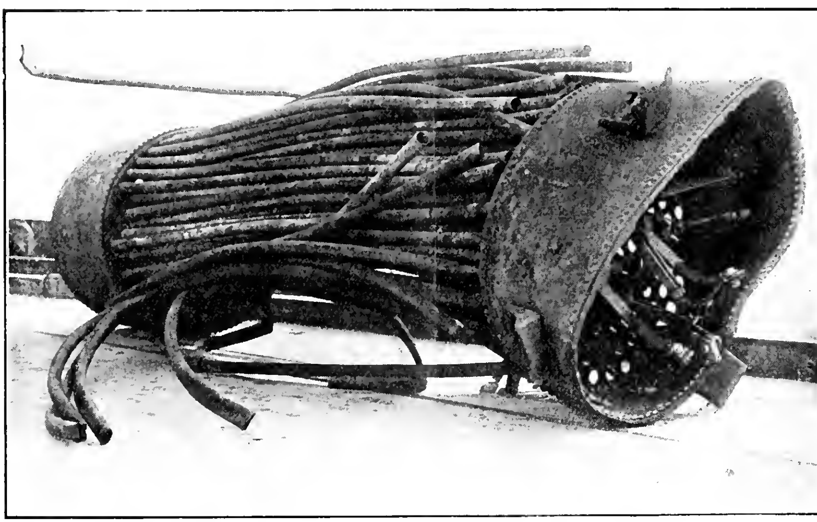


FIG. 2. VIEW OF RAISED BOILER

Stay-Bolt Heads.

If one examines a score of boilers with stay-bolted surfaces from different makers he cannot fail to be impressed with the variation exhibited in the workmanship and finish of the stay-bolt heads. Some will appear 'sound but rough, some trim and well formed', while some will undoubtedly be frayed and cracked until they resemble the head of a battered and abused cold chisel.

If the purpose of a stay-bolt head were merely a matter of finish we might dismiss it as such, but it is because the manner in which the heads are formed has a bearing on the soundness of the job as a whole that we have chosen to discuss this subject in The Locomotive.

It was discovered at an early stage of the development of stayed surfaces for boilers that a stay-bolt which was screwed into the sheet only, without head or nut did not give a satisfactory support. In the first place, it was not easy to make the job tight and in addition, the support was not well distributed over the sheet, but localized right at the termination of the bolt. The question of holding power was found not to be of so much importance as might at first appear, not because headed bolts are no stronger than those without heads, for it is easy to show that they are, but because the shearing strength of the threads is as great or greater than the tensile strength of the bolts, if the diameter of the bolt and the pitch of the thread are well chosen with respect to the thickness of the supported sheet. This fact is of course well known, for all of us have probably broken bolts or studs at some time by setting up too severely on their nuts. Stay-bolts, however, seldom break under direct tension. Boiler plate is a ductile material, and will bulge between the bolts when subjected to excessive pressure with the result that the holes in the sheet are stretched on the inside as is shown in Fig. 1. In this way, the bolts will usually pull out of the sheet or "unbutton" before a strain approaching their ultimate strength is applied.

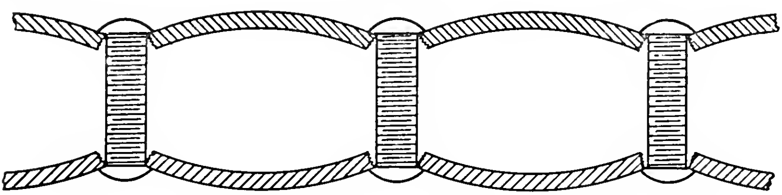


FIG. 1. SHOWING TENDENCY OF STAY-BOLTS TO "UNBUTTON."

The tendency of the plate to bulge between bolts can easily be lessened by spacing the bolts nearer together, so that many small bolts closely spaced afford a better support than the same amount of metal in larger bolts farther apart, even admitting that the stress in the bolts may be the same in each case. The supporting power of the bolt can also be spread over the sheet so as to limit bulging to a certain extent if each bolt is long enough to extend through the sheet and receive a nut and washer. For through braces, crown bar bolts and stay-bolts whose heads are not exposed to the fire, this is a very satisfactory arrangement. On the other hand, if the bolts are located in the side of fire sheets of a vertical or locomotive type boiler, such large masses of metal as would be presented by the nuts, situated so far from the cooling effect of the water are apt to suffer both from overheating and from contact with the fire tools in working the fire. It is customary, therefore, to permit these stay-bolts to extend through the sheet from two to three threads, and then to rivet them over cold, so as to form small rounded heads. The heads must be small because they must be formed cold, and cannot spread out so as to give the holding power obtained in ordinary hot rivets. If too great spread is attempted, the excessive cold hammering will harden and crystallize the metal causing it

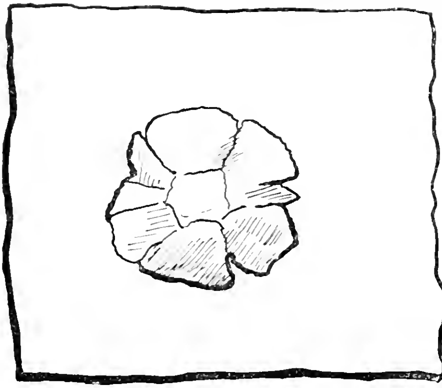


FIG. 2. FRAYED HEAD DUE TO EXCESSIVE HAMMERING

to be brittle and worthless, and appearance of the finished head will be frayed and cracked as is shown in Fig. 2. A moderate head can be formed, however, without excessive hammering, and will result in upsetting the metal so as to crowd the threads tightly into the tapped hole in the sheet, making a steam tight job, and will spread the fiber of the metal so as to increase its support of the sheet, as well as the grip of the bolt when the holding power of the threads are lessened by excessive bulging. Stay-bolt heads should be formed with many light blows rather than with a few heavy ones. Experience shows that such a procedure will confine the hardening and crystallizing effect of the cold hammering largely to the surface layer or skin of the head. If the work is to be done by hand, it is best to strike two or three "upsetting" blows with a rather heavy hammer squarely on the end of the bolt, and then to proceed to form the head with lighter blows from a light hammer. If air tools are available, however the forming operation can best be performed with a button set tool of the general shape shown in Fig. 3. This should produce a trim well rounded head as is indicated in Fig. 4. The central depression is formed first by the central projecting point of the button set. As this center is forced into the bolt by the blows of the air hammer the metal is spread outward and upset in such a way as to wedge the threads of the bolt tightly into the threaded hole in the sheet. Then as the deeper cup shaped portion of the tool comes into action, the metal in this outer ring is spread and turned back against the sheet to form a neat head of considerable strength. This secures both tightness and holding power without undue distress to the material.

FIG. 3. TOOL FOR FORMING STAY-BOLT HEADS.

The service which a stay-bolt is called upon to perform is a trying one. As is well known the most prolific cause for stay-bolt failures is to be found in the repeated bending stresses set up by the unequal expansion of the sheets which they support. A tough ductile material has been found to be best suited to this service, even if toughness is secured at the expense of tensile strength. Wrought iron, made from blooms so piled that there is a pronounced fiber lengthwise of the bolt at its center, surrounded by a layer in which the fiber is circumferential, so that strong threads are secured, is considered to be the best material available at present. Such a material is admirably adapted to cold heading, and will permit the fashioning of a good workmanlike head without distress. Harder and less ductile material however, does not lend itself so readily to this treatment, and it will generally show its properties by the checked and frayed appearance of the finished head. This furnishes

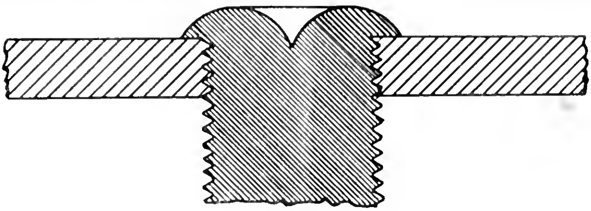


FIG. 4. SECTION OF A WELL FORMED STAY-BOLT HEAD.

one more reason why sound finished heads should be required on stay-bolts in high grade boilers, for if the heads are well formed and show no sign of distress we may be reasonably sure that the work is tight, that th bolts give a reliable support to the sheet, and that the material of which the bolts are made is adapted for the purpose. In addition of course is the important consideration that attention to one detail of workmanship is likely to indicate an equally careful attention to the other and less obvious details, while poorly executed stay-bolt heads, might easily lead to the suspicion that an otherwise well built boiler was carelessly made.

Explosion of a Turbo-Generator.

Translated from the September number of the *Zeitschrift der Dampfkessel-untersuchungs - und Versicherungs - Gesellschaft a.G.* (Vienna), by H. J. VANDER EB.

A 2500 K. V. A., three phase generator connected to a steam turbine exploded January 25, 1913, at 7.30 P. M., in a lighting and power station at Triest, Austria. The frame of the generator broke into three pieces. One piece, 600 kg. (1323 lbs.) broke through the roof of the engine house, and remained on top of the roof as shown in Fig. 3. The lower portions of the frame, torn from the bed-plate, were found near their original position. The shaft of the rotor was bent and thrown from its bearings. The segments of the flexible coupling were sheared off, and one of the field coils slid some 60 mm. (2.4 in.) from its pole piece. The turbine shaft was also sprung, and the governor pendulum damaged.

Eyewitnesses describe the events preceding the explosion as follows: The lamps appeared first to grow dim and then increased again in brightness. The turbine, which at first ran irregularly, finally speeded up. Seeing that the voltage continued to increase in spite of diminishing the field strength, the switchboard operator threw off the load. He then ran to the turbine, with the turbine operator. One of them opened the vacuum breaker, while the other

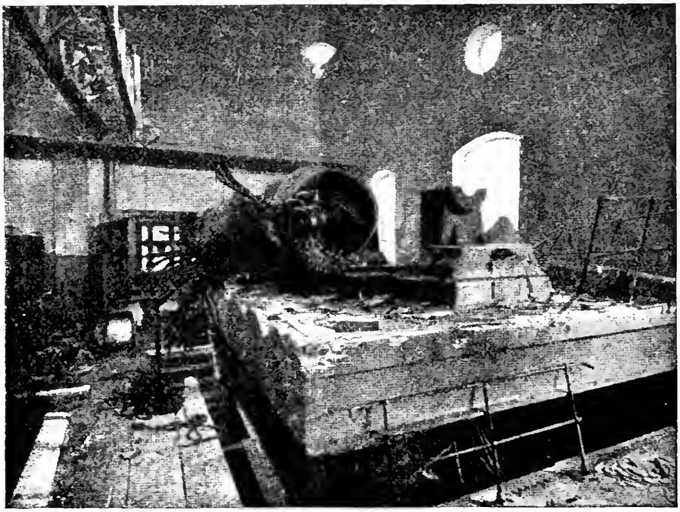


FIG. 1. THE EXPLODED TURBO-GENERATOR.

attempted to close the main stop valve, after which they both left the raised turbine foundation as fast as they could. Just as they reached the floor level, the generator exploded, fortunately without injuring anyone, although two mechanics and an oiler were near the unit at the time. At the instant when the explosion took place, the chief engineer of the plant stepped across the threshold of the engine room door, in front of which was hurled the exciter field ring.

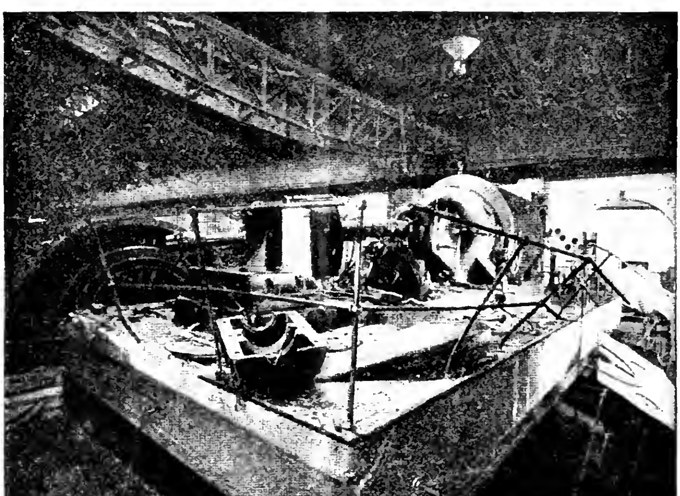


FIG. 2. ANOTHER VIEW OF THE WRECKED UNIT.

The immediate cause of the accident was the racing of the turbine. An expert investigation determined the cause of the racing, and also the probable amount of the increase in speed. The turbine was of the reaction type. The control is indirect depending on a governor driven from the main shaft, which operates the pilot valves of the throttle, giving them a constantly oscillating motion which causes the throttle to periodically open and close. On the shaft of the main governor is a releasing governor in unstable equilibrium, and counterbalanced by a weight which can be shifted on the sleeve. When the velocity has reached the allowed 15% increase, the main stop valve is automatically released, as follows: The pendulum of the releasing governor flies out, coming in contact with a disc, which it causes to rotate. By means of a thread cut on its hub, the disc actuates a worm wheel, which in turn through a cam and roll lever releases the pawl holding up the main stop valve. The main stop valve is arranged to serve both as the regular operating stop valve or throttle, and in emergencies, as a quick closing or releasing valve. It closes under the action of a spring when the pawl is tripped. The spindle of the stop valve is made in two parts as is shown in Fig. 4. The lower part is attached to the valve proper and has at its upper end a fixed turnbuckle, into which the upper spindle screws. By turning the hand wheel on the upper

Fig. 3. The Damaged Roof, Showing Fragment of Generator Frame.

spindle the valve is manipulated, while the hand wheel itself remains at a fixed height. The engineer in charge thought it inconvenient not to be able to know how far the valve was open. He therefore constructed an indicating device and installed it just above the valve yoke, but under the hand wheel. This contrivance consisted of a metal block provided with an index pointer, which could slide up and down in a slotted frame. The block was driven by means of a portion of a thread cut in its back, meshing with a threaded collar secured by set screws to the spindle. A glance at Fig. 4, together with the previous description, will make it clear that with this device, the quick closing valve would fail to act on the release of the pawl, because the stem would be prevented from dropping the intended distance by the threaded collar.

The initial cause for the racing is attributed to the sticking of the main or working governor. When the turbine had speeded up to 1500 r.p.m., the limit stop began to act, a fact which was observed by an oiler. The quick closing valve probably stuck however, as it was not until the hand wheel had been given three turns that it was heard to drop by the machinist, who, believing that the flow of steam had been cut off, hurried from the unit as fast as he could. Because of the sleeve of the indicating device, the valve remained open some 27.5mm. (1.08in.) This opening was sufficient, as was shown from a simple calculation, to permit full load steam to flow.

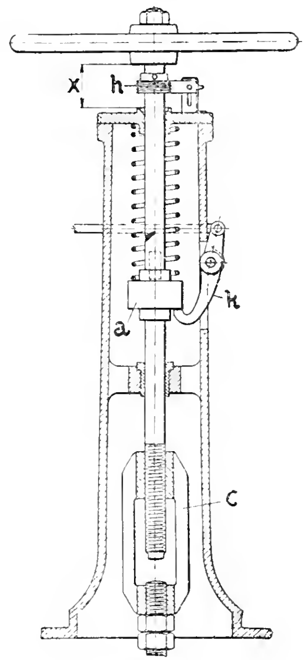


Fig. 4.

DETAILS OF STOP VALVE.

Data from which the probable increase in speed was estimated was obtained from three separate sources. In the first place, the men who were present at the time of the explosion were made to reproduce all the operations just as they had performed them at that time, and the time necessary for this was carefully determined. From this it was estimated that from the time of the first irregularity in the running to the instant of explosion, a time of 14 seconds must have elapsed. The cutting out of the load consumed 11 seconds, and the operations at the machine three seconds more. This time, if taken as the time of acceleration, could be used along with a knowledge of the inertia of the rotating parts and the power of the turbine, to estimate the speed which might be attained. The probable speed estimated from this source proved to be 2175 r.p.m.

The second method for estimating the speed was from the properties of the material from which the bolts holding the pole pieces of the revolving field were made. Taking the diameter and tensile strength of these bolts, together with the weight of the pole pieces and their distance from the center of the shaft, it was possible to estimate the centrifugal force with which they left the rotor, and therefore to determine the speed at which this centrifugal force could have been developed. This method of calculation, yielded a value of 3000 as the probable bursting speed.

The third method was through a consideration of the change in form of some of the pole pieces which remained in place upon the rotor. When the elastic constants of the metal forming the pole pieces was determined, by tests, and the change in shape of these pieces under the action of the centrifugal stresses was measured, a second value for the probable centrifugal force exerted, and hence for the speed attained was calculated. This third calculation pointed to a speed between 2500 and 2600 r.p.m. These three values must be considered as agreeing rather well with each other, when one considers the approximate character of the methods employed.

It should be mentioned that after the accident, seven minutes were required for the operators to start spare units and resume the entire load. This fact, proved by the recording instruments, is an excellent record for the operating force.

Concerning Steam Gages.

Henry H. Carter, Inspector.

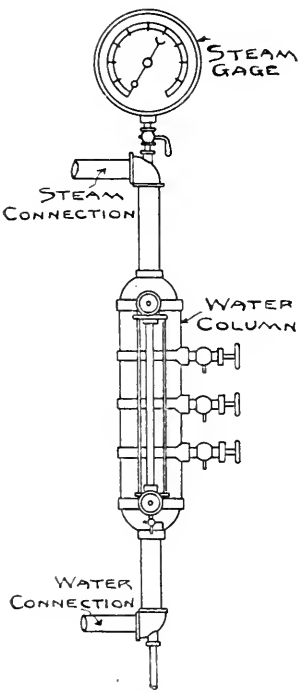


Fig. 1.
Faulty Gage Connection.

It seems strange that one of the most important attachments to a steam boiler, the steam gage, is so often neglected. That such is the case however, is proved by the large number of defective gages found by the inspector in the course of his work. Most of these defective gages can be accounted for by improper methods of attachment to the boiler. The tube of a steam gage should be filled with water at all times. Should steam enter, it would take the temper out of the metal causing it to stretch and indicate a higher pressure than that in the boiler.

A short time ago while inspecting a boiler, the engineer in charge of the plant called my attention to the trouble he was having with one of the steam gages and asked if I could explain the difficulty. After testing the gage several times I found that it registered different pressures at each test. On removing the hand and face I found that the tube was badly burned and the small coil spring ruined. This state of affairs was due to an improper connection as is shown in Fig. 1. After changing the connections as is indicated in Fig. 2, no further trouble occurred. Three gages were damaged in less than a year by this improper arrangment of the piping.

Gages may be connected properly, either as in Fig. 2, or as in Fig. 3, but the arrangement in Fig. 2 is recommended. Either of these connections gives condensing surface so that steam will condense and be trapped in the gage tube, filling it with water. This will prevent contact of the tube with steam, and will therefore protect it from deterioration.

Any considerable amount of vibration will cause a steam gage to fail because of the wear resulting to the rack and pinion. It is necessary therefore to support a gage so that it shall be as free from vibration as possible.

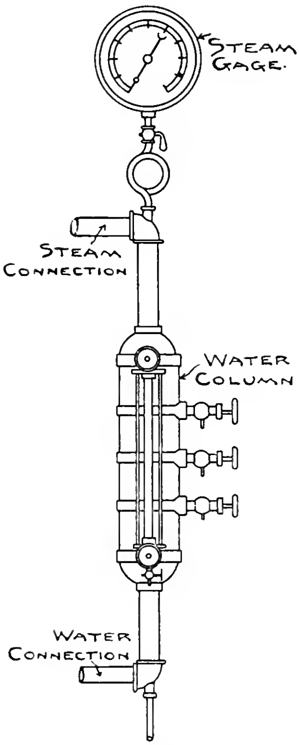


FIG. 2.

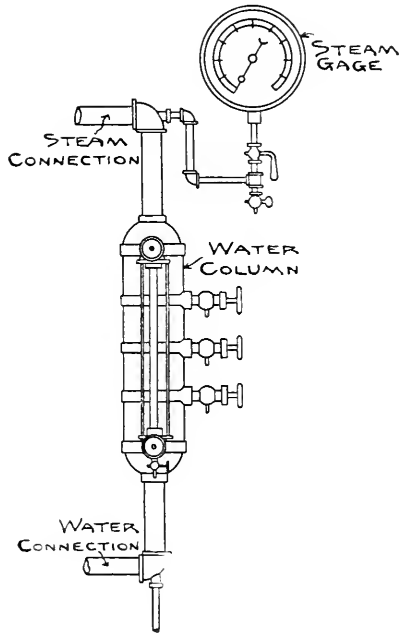


FIG. 3.

PERMISSIBLE STEAM GAGE CONNECTIONS.

The siphon connection and stop cock below the gage should be taken down and cleaned frequently. This is necessary because of the tendency of these connections to choke with rust and corrosion. The practice of opening the drain cock below the gage to blow out the siphon and gage connection when the boiler is under steam should not, however, be permitted except when there is actual danger that the connections are plugged. In case it is done, the stop cock at the gage should be closed, to prevent steam entering and injuring the tube, and should not be reopened until steam has had an opportunity to condense and fill the siphon.

The following condition was found in a plant not long ago. The steam gage on the boiler was graduated to 100 lbs., while the safety valve was set at 120 lbs. When the safety valve popped, the gage had to register 20 lbs. more than it was intended for. This will overthrow the spring tube in the gage and render it defective. A gage should be used which is graduated to at least 25 lbs. more than the pressure at which the safety valve is set. (It is better to use a gage graduated to one and one half times the working pressure, as this will greatly prolong its life and accuracy. Editor.)

It is probable that there have been many cases in which safety valves have been set by defective gages. One should never tamper with a safety valve until he is sure that the gage is correct. Furthermore if gage and safety valve do not agree, it is better to suspect the gage and have it tested before attempting to reset the safety valve, than to set the valve to a defective gage.

Two Old Cartoons.

A Boiler Inspection.

While rummaging an old desk, which has long been a piece of the home office equipment, we discovered in its recesses, some interesting old drawings, two of which we have reproduced here. This old desk has served in turn nearly all of the officers of the Company, past and present, and when or by

whom these drawings were stowed away in it we do not know. Several of the older men at the home office recall seeing them at some time in the past, but no one has succeeded in giving a definite clue as to their authorship, or the events which led up to their production.

We reproduce them however, in the hope that they may furnish our readers with as much enjoyment as we experienced when they were shown us. We can only suggest that the quality of city inspections, which are apparently the subject uppermost in the mind of the unknown humorist must have improved immensely since that day.

Scraps from the Editor's File.

All sorts of unexpected and unusual things filter through the correspondence files of the Company, and finally gravitate to the editor's desk. Many scraps of letters and reports furnish incidents, amusing, instructive or interesting because of some unusual condition disclosed, which are perhaps of enough general readibility to warrant their infliction on our long suffering readers. We may as well confess that we have been cleaning house, and offer the following disjointed scraps, just as we find them, for what they may be worth.

One letter refers to the qualifications for an inspector, and is indeed an application for a position. We will quote the letter entire, omitting of course, names and dates.

...., 19...

The Hartford Steam Boiler
Inspection & Insurance Co.,
Hartford, Conn.

Gentleman, Sirs:

Do you employ assts' to your inspectors? I have no Technical Education only a knowledge of facts from experience of repairing them.

The mere fact of asking a fireman or engineer how a boiler is, testing a blow-off valve and looking wise in a white shirt is some inspection, I dont think. The duty of an inspector is to get busy and see it all, the brace supports blow-off valve and fire wall are of some importance.

This means dirt, and not many, yes few, will do it, but it means business. I beg leave to call your attention to one of the common, yes to common defect of the present day. This is the placing of the stack weight directly on the shell of the return tublar boilers right here is the most expansion owing to being over the fire box and should be supported by steel superstructure, instead of the shell itself with the ignorance displayed installing them, they do wonderfully good, I am told that I would last a week with an Insurance Company because I note every defect and believe me there are enough and in plain sight. Trusting to hear from you, I remain Truly.

—— ———.

N. B.
Age 38 yrs.
Hght. 6 ft.
Wght. 120#.

Who shall say that this applicant was not in earnest? "The duty of an inspector is to get busy and see it all," not a bad statement of an inspector's duty if we add the further requirements of tact and judgment. Then, too, think of the advantage a six foot, 120 pound man would have when entering man-holes below the tubes? But who ever heard of a real live boiler inspector looking wise in a white shirt?

We next find a sheaf of letters from an inspector in the field to his chief. Which district, or what chief, we must of course refrain from mentioning. We will content ourselves with isolated quotations from these letters. For instance: "I recall an article in the Locomotive in which a certain engineer placed a fusible plug in the head of a boiler, 2" above something, he had forgotten what. I encountered almost a parallel case at .... Co., ..., ... Although my report was specific as to the location of the fusible plug, the engineer had 'translated' it to be; Plug to be placed in bottom of first course, two inches from front head. Steam gage connection, for the attachment of test gage, to be 2" above top row of tubes in rear head * * * * * * * * * * * * * * He also inquires why didn't they send weights for the safety valve on No. 2 boiler like they did for the valve on No. 1 boiler. (Valve on the No. 2 boiler is a pop valve.)" Again, the same inspector, referring to a different plant writes: "The assured however was encountering some trouble in setting the safety valve from 120 pounds to 100 pounds, the latter being the stipulated pressure in the policy. His engineer was not conversant with the spring pop, and being acquainted with the ball and lever type he informed me 'this valve (pop) works backwards from the old valve' and he had reduced the pressure from 120 pounds to 115 pounds by attaching a wire to the lever of the valve, and to the end of the wire he had made fast an iron weight. By request of the assured I set the valve to blow freely at 100 pounds.

This plant is a saw mill and the reason for the lack of power at 100 pounds, for which the pressure was raised, I discovered was due to the relief valves on the cylinder releasing when the governor was about half open. I set the safety valve at 100 pounds, adjusted the relief valves to conform, and I anticipate a less consumption of fuel and oil.

Farm hands would be more numerous here if this state had an engineer's license law, it occurs to me."

Not a bad commentary on what a conscientious inspector must contend with, is it? Ignorant but willing engineers to educate, owners equally ignorant but also willing, and withal a very doubtful safety factor as to operating intelligence. This is however, but an added argument for boiler inspection, and for the value of the service rendered in connection with boiler insurance.

In another case, we find a sketch of a return tubular boiler, turned in by an inspector in the course of his work. He found that this boiler had formerly been fitted with an internal feed pipe entering the shell on top, in the first course. It then dropped down to an elbow just below the water line, and ran back parallel to the tubes toward the back head, where it was turned across and down, in the usual fashion. So long as this was used for feeding no particular criticism could well be directed to it, but unfortunately some steam fitter, seeing the connection passing through the shell at the top, when connections were being changed or the boiler reset, thought this a good place to attach the top connection to the water column which he proceeded to do, without however, stopping to see if there was any interior attachment to the connection. Just what the indications of that water column were we can only imagine.

All misconceptions are not confined to the backwoods plant. Sometimes an engineer working for a large corporation will make blunders of an equally amusing character. In support of this, let us quote from an inspection report of the conditions at a plant of one of our large assured. "The fusible plug had been substituted for the safety valve. This mistake however, has been remedied by replacing the safety valve and fitting the fusible plug at the point provided." We were nonplussed by this announcement for some time. How could any one possibly mistake a fusible plug for a safety valve? We certainly could not conceive of such a thing. Further correspondence however, disclosed the fact that the fusible plug was one of the well known low water whistle alarms actuated by the melting of a fusible button, and this had been mistaken for the small pop safety valve provided for the boiler.

One more safety valve incident concludes our list. One of our inspectors after paying a first visit to a plant, reported conditions of safety valve arrangement, which were entirely novel to us. This was a carriage and wagon works. The boilers were located below the floor on which the wagons were stored. On one of the boilers a pop safety valve had been originally fitted, the top of which came to within something like a foot of the floor above. At some time previous to the inspector's visit the lifting gear had been removed from the valve, and a home made loading device installed. A square nut was screwed on to the end of the adjusting stem of the valve, and screwed down far enough so that the stem projected through it for several threads. Then a short piece of gas pipe was fitted over the end of the stem, resting upon the nut, and extending to within a short distance of the floor above, so that by this device, the adjusting stem of the valve was in effect extended to the end of the piece of pipe. Now a wooden wedge was inserted between the gas pipe and the floor, the square nut screwed up tight so as to clamp all securely, and in this position, if I have made myself clear, it will be seen that the valve was blocked securely against the ceiling of the boiler room, which was the floor of the storage room above. In order for the valve to open it must lift this floor by the amount of the valve lift. There is a beautifully automatic feature about this arrangement which should not escape our attention, namely, that the more customers and wagons there are waiting for attention on the floor above, the higher the pressure that will be carried on the boiler, the faster will the engine operate, and so the load will be proportioned to the production! It is scarcely necessary to add that this arrangement did not appeal strongly enough to the imagination of the inspector for him to permit its continuance in operation.

Preventing Steam Boiler Accidents.

Accidents in connection with steam boiler operation are among the most distressing which can occur in any industrial establishment. Not only is there the risk of death or broken bones, crushed or maimed limbs when a boiler or steam line suffers accident, but there is almost invariably the accompaniment of severe and often fatal burns from the escaping steam or hot water. In this connection, therefore, the following rules for boiler operation and repair, taken from the book of rules issued by the Inland Steel Co., should prove of interest to all boiler owners and operators. It is recommended that they be posted in a conspicuous place in every boiler room:

1. Two men should always work together when cleaning out boilers, it being the duty of one man to remain outside of the boiler all of the time in a position to see the man working in the boiler and give assistance in case it is needed.

2. Never go into a boiler until you have locked the steam valve and closed all other valves.

3. Before entering a boiler put a torch or candle inside to determine the presence of gas or bad air.

4. In cutting a boiler in and out, use the non-return valves exclusively, in order to insure their proper working. Should the non-return valve fail to work in any instance, notify the foreman immediately.

5. The automatic valves should be examined sufficiently often to insure their prompt action in emergencies, such as the bursting of tubes.

6. When boilers are taken off for cleaning, the main stop valve in the steam connections should be shut off and dependence not put on the automatic quick-closing valves alone.

7. A sign, "Danger, do not move," should be hung on the steam valve of any boiler when it is shut down.

8. Never open a slide or valve when a danger sign is attached and until you have seen that no one is in the boiler.

9. Safety valves should be tested every shift.

10. When opening up any steam line take the following precautions: (a) Open all available drips; (b) warm the line by opening the by-pass when possible, or by opening the stop valve sufficiently to warm it slowly; (c) never allow an inexperienced man to turn steam into a cold line, unless accompanied by the foreman; (d) never open the main valve until certain that the line is thoroughly heated.

11. When starting up a boiler that has been dead, raise steam slowly, drop the pressure a few pounds on remaining boilers in the battery, and do not open the stop valve until the gage on the dead boiler shows the same pressure as the other boilers. Then open the stop valve slowly.

12. All steam traps taking care of large lines shall be kept clean and in working order as this is the only safe way to remove water from the line. Should a trap get out of order and it is impossible to repair it at once, the by pass should be opened sufficiently to eliminate all water that might collect. Blow off boilers every shift.

13. Leaks in pipes, flanges and gaskets should be repaired at the earliest possible moment, as they may be caused by defective material.

14. Keep the water glasses clean and the tops and bottoms open by frequent blowing out every shift.

15. In carrying water, try cocks should be frequently used, and dependence not wholly placed on gage-glasses.

16. Never tighten any bolts or nipples or do any caulking while steam pressure is on the boiler.

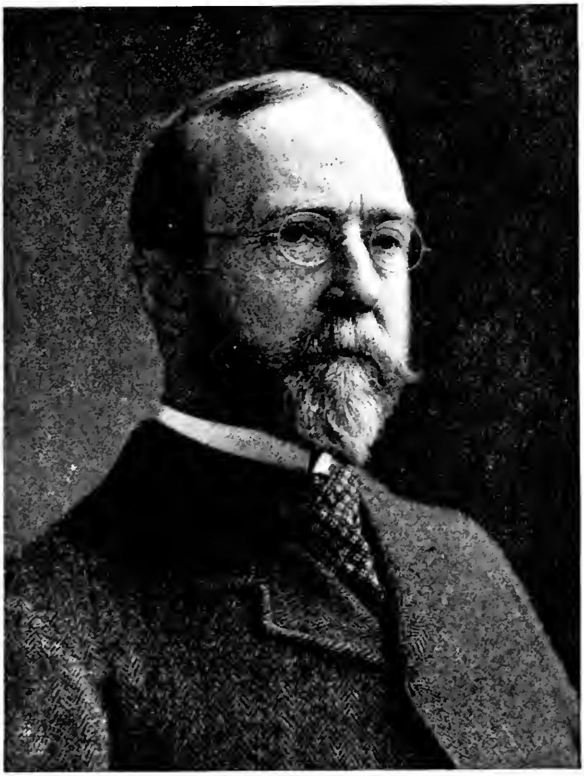
17. Take great care in cooling and handling flue dust, as it is liable to fly, slide and explode, causing bad burns. Never step on it. From *Industrial Engineering and Engineering Digest.*

The suggestions which we reprint above from *Industrial Engineering and The Engineering Digest* were developed by the engineers of the Inland Steel Co., for the safety of their employees. We commend them most heartily to our readers. Let us add also that the precautions given are all of them so important that it is worth while enforcing them rigorously in any plant. We have ourselves called attention to many of them before through the columns of The Locomotive.

There is another side to the question of safety in and around boilers which this list of rules brings to our mind, namely the safety of the inspector. Considering the hazardous nature of the work, accidents to boiler inspectors are fortunately rare. This may be due in large part to the fact that their whole training makes them careful and observant, and leads them to seek just this sort of precautions in a spirit of self preservation. Nevertheless, there are mighty few inspectors who do not sooner or later meet with some sort of accident which might be prevented were regulations of the sort quoted in force. We can recall specific instances of scalding from the careless opening of stop valves and especially of blow-off valves, and injuries from hot brick work covered with soot and ashes to bear out our statement.

Upon the value of a man on watch outside a boiler when anybody, inspector or employee is working within, we can readily attest. One of our inspectors was engaged in making an internal examination of a very hot boiler using, as is common practice, a candle for his source of illumination. He became suddenly aware of a commotion outside and made his exit through the man-hole as rapidly as was possible, only to find the chief engineer standing over the form of a fireman whom he had just knocked into the coal pile. It developed that the chief had entered the boiler room just in time to see this fireman start up on top of the boiler with a bucket of crude oil intending to throw it inside. Realizing that the oil would vaporize almost instantly in the hot boiler, and that an explosion from the flame of the inspector's candle would probably follow, he knocked the man down as the only sudden way to arrest his progress, as the man did not speak English. A man on watch outside would have prevented this possibility.

Obituary.



Jasper M. Lawford.

Jasper M. Lawford, senior member of the firm of Lawford and McKim, General Agents of The Hartford Steam Boiler Inspection and Insurance Company at Baltimore, Md., died December 15, 1913, at his home, 718 Howard St., in that city. His death followed a three days' illness, and was due to pneumonia.

Mr. Lawford was born in Wales, January 19th, 1843. He came to this country with his parents when a youth, locating first in Canada, and later in West Virginia, where he was engaged in the operation of iron furnaces. He afterward became Secretary of the Baltimore Car Wheel Company, which position he held until about 1883.

On January 1, 1886, he entered the firm of Lawford and McKim, succeeding his father, Thomas W .Lawford, then 85 years old, who retired to his farm at Lawford, Virginia, where a son and several daughters were living. The firm of Lawford and McKim was founded in 1870 by Mr. Lawford's father and the late John McKim. They represented The Hartford Steam Boiler Inspection and Insurance Company, and were also General Agents for the Massachusetts Mutual Life Insurance Company, until some time after the younger Mr. Lawford entered the firm. In 1890, the firm accepted the General Agency of the Employer's Liability Assurance Corporation, and they have represented this company, together with The Hartford Steam Boiler Inspection and Insurance Company, ever since.

From the time of Mr. Lawford's entry into the firm, the business increased rapidly, due to his energy and ability, and he was largely instrumental in developing the business to its present proportions. When he entered the firm, there was but one inspector in the district, while at the present time there are seven.

At the time of his death, Mr. Lawford had been engaged in the casualty business in Baltimore, longer than any other General Agent, and was generally considered one of the best posted men in this line in the city. He was president of the Casualty Underwriters' Association of Maryland, and was active in promoting its interests at the time of his death.

Beside his activities in business he was always very much interested in public questions and a strong advocate of reforms which he believed would be of public benefit. He was the treasurer of the Maryland Branch of the Civil Service Reform Association.

Mr. Lawford never married. He is survived by two sisters and two brothers, living in British Columbia and in Virginia. At one time he was very much interested in entomology, and his collection of insects, paraphernalia, books on natural history and kindred subjects, was bequeathed to the Entomological Society of Washington. The remainder of his library, he left to the Westmoreland Club of Richmond, Va. His interest in the firm of Lawford and McKim he left to Arthur Koppelman and Walter A. McGlannan, his partners at the time of his death.

W. A. Craig.

It is with deep sorrow that we record the death of William A. Craig, Assistant Chief Inspector of our Pittsburgh Department, on December 30, 1913.

Mr. Craig was born in McKeesport, Pa., July 29, 1850. He was educated in the schools of that city. After an experience, alternating between boiler making and mechanical engineering, he entered the boiler inspection field in 1883. He joined the Pittsburgh Department as inspector in 1893. About two years ago, he was appointed Assistant Chief Inspector in that Department, the position he held at his death.

Mr. Craig was a thorough inspector and was highly respected for his knowledge of the business. He was a kindly, genial gentleman, pleasant in his dealings with his associates, and his death is greatly deplored by all who had his acquaintance.

The Locomotive
of
THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

C. C. PERRY, EDITOR.

HARTFORD, JANUARY, 1914.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

On another page we print an account of a very interesting accident to a turbo-generator. This one of the first, if not the very first case of which we have knowledge in which a rotating field has been disrupted under the action of centrifugal force in service. The general characteristics of this installation do not differ in any essential from many of the installations with which our readers are familiar. It offers therefore a timely hint of the devastation which may be expected to follow attempts to redesign or improve safety mechanisms which, especially in the case of steam turbines, have reached a very high state of mechanical development. In this instance the added "improvement" was undoubtedly a convenience and it is quite likely that it could have been so devised as to be safe as well. But the failure of the chief engineer to fully comprehend the emergency action of his over speed stop permitted the installation of a device which completely nullified its safety features. Another interesting characteristic of this failure, is the manner in which the flying pole piece lost its energy by exchange so to speak. That is it gave its energy in disrupting the encircling generator frame, and in propelling one heavy portion, weighing more than half a ton, upward through the roof of the building. This action is not unlike the exchange which may occur between two billiard balls, when upon collision, the struck ball proceeds, leaving the striking one "dead" in its tracks. Finally we cannot escape a word of commendation for the ingenuity displayed in arriving at an estimate of the probable bursting speed, by three independent methods, each of which yielded a value in substantial agreement with the others, and all obtained from very slender evidence.

Accidents such as this to costly turbine machinery are likely to become more frequent with the increasing use of this class of apparatus. That this is realized by those who own and operate such installations is shown by the already well-evidenced demand for its insurance protection.

Our Company has for several years past been issuing an insurance contract covering steam turbines against both the fly-wheel hazard and also that due to pressure of steam. This contract has become quite popular, both because of the well-recognized advantages of the inspection service which accompanies the contract and the indemnity which it would provide for replacing very expensive apparatus damaged by just such accidents as we have described.

We again have the pleasure of reprinting a news item from the Hartford Times, announcing the reinsurance of still another company's steam boiler and fly-wheel line with the Hartford. As is stated in the article mentioned, this is the fourth time within a year that we have been called upon to extend a welcome to the Hartford to a group of policy holders from another company.

ACQUIRES MORE BUSINESS.

Hartford Steam Boiler Takes Over Missouri Fidelity and Casualty--Twelfth so Acquired.

FROM THE HARTFORD (CONN.) *Times*, Monday, Nov. 24, 1913.

President Brainerd of The Hartford Steam Boiler Inspection and Insurance Company, has returned from a western trip, visiting several of the larger branch departments of the company. While in Springfield, Mo., he paid his respects to President Taylor of the Missouri Fidelity and Casualty Company of that city, and finally arranged with the Missouri Company to take over all of their steam boiler and fly-wheel business.

The Missouri company was organized and commenced business in 1911, with a paid up capital of $250,000, as a multiple line company, writing the numerous casualty lines, including the steam boiler and fly-wheel lines. It made a special effort to control and secure the business of its home and adjoining states, and gradually worked up and perfected a very efficient and effective organization as is evidenced by the fact that its estimated premium income for this present year will amount to about $750,000.

Its principal or larger lines are the liability and workmen's compensation and it found from experience that in writing, the steam boiler and fly-wheel line it in many cases doubled up its liability, as it is hardly possible to sustain a bad boiler explosion and not at the same time sustain a loss under liability and workmen's compensation policies, and as these two lines are the most profitable and possess greater possibilities for development it naturally desired to sacrifice the steam boiler and fly-wheel lines.

The number of boilers and fly-wheels thus taken over amount to about 700, and the insurance liability amounts to a little more than $3,600,000. The business is located chiefly in the states of Kansas and Missouri. This is the twelfth company that has transferred its steam boiler business to the Hartford, and the fourth company that has done so during this present year.

Personal.

On December 1, 1913, Mr. H. E. Dart joined the engineering forces of The Hartford Steam Boiler Inspection and Insurance Company as Superintendent, Engineering Department. He brings a broad experience in general consulting work. Graduated from the Massachusetts Institute of Technology in 1901, in the Department of Electrical Engineering, he returned to the institute as assistant to Prof. F. A. Laws, in the standardization laboratory remaining until 1903. Since then he has been employed in varied engineering work; with Mr. W. R. C. Corson from 1903 to 1907, with the Board of Water Commissioners of the City of Hartford, 1907, 1910, and with Buck and Sheldon, Inc., now Ford, Buck and Sheldon, Inc., in charge of their mechanical and electrical engineering departments, from 1910 till 1913.

His work during this period ranged from the construction of street railway and lighting plants, the design and construction of power, heating and ventilating plants for manufacturers, to the design of municipal sewage pumping plants and wiring plants for large buildings. He has designed and supervised the construction of power plants aggregating many thousands of horsepower.

Mr. Dart is an associate member of the American Institute of Electrical Engineers.

A complete index and a title page for Vol. XXIX of The Locomotive have been prepared and are now in stock. They will be sent to such of our readers as care to bind their copies, upon application to the home office of the Company.

We regret to say that an unfortunate printer's error caused a break in the sequence of the page numbers, so that the pages of the October, 1913, issue bear numbers too large by 32. In view of the difficulty which would be experienced in indexing and binding we have had a limited number of the October, 1913, Locomotives reprinted with correct paging. These we will be glad to send out to those desiring title pages and indices while they last so that their bound volumes may be correct.

We also announce that we are prepared to furnish Vol. XXIX fully bound at the regular price, $1.00, and can ship promptly from stock.

Fly-Wheel Explosions, 1913.

(32.) — A fly-wheel exploded September 27, at the plant of the Marcellus Paper Co., Marcellus Falls, N. Y. The damage was confined to the engine.

(33.) — A fly-wheel exploded October 10 at the sugar plant of the Idaho-Utah Sugar Co., near Elsinore, Utah. No one was injured.

(34.) — A large fly-wheel exploded October 25, at the plant of the American Rolling Mill Co., Zanesville, O. The engineer was fatally injured while attempting to close the throttle. The property damage was considerable.

(35.) — A pulley exploded October 27, at a saw mill of the Powell Lumber Co., Edna, La. No one was injured.

(36.) — On October 28, a pulley exploded at the Lake Charles, La., mill of the Powell Lumber Co. The flying fragments of the exploded wheel destroyed two adjacent wheels. No one was injured.

(37.) — A fly-wheel exploded November 4, at the mills of the New England Cotton Yarn Co., New Bedford, Mass. It appears from press accounts that the wheel left the shaft and was broken by impact after it left the engine.

(38.) — A fly-wheel exploded violently on November 8, at the twine mill of the International Harvester Company Auburn, N. Y. A woman, employed in the mill was injured by one of the fragments of the wheel.

(39.) — A large fly-wheel exploded with great violence at the power house of the Oskaloosa Traction and Lighting Co., Oskaloosa, Ia., on November 24. Fragments of the wheel wrecked the engine house, and flying for a considerable distance, severely wrecked a dwelling situated a block away. Very fortunately no one was injured, though the property loss was great.

(40.) A rope drive wheel attached to the engine driving a paper machine at the mill of the St Croix Paper Co., Woodland, Me., exploded December 16.

(41.) — A fly-wheel exploded December 26, at the plant of the Athens Brick Co., Athens, O. The wheel wrecked the engine, did considerable damage to the building, and one fragment wrecked a nearby dwelling. No one was injured.

Boiler Explosions.

August, 1913.

(291.) — A boiler exploded August 1, at the Briscoe logging camp near Rochester, Wash. Clyde Briscoe, one of the owners, was instantly killed.

(292.) — On August 1, a tube ruptured in a water tube boiler at the East St. Louis, Ill., plant of Swift and Co. Two men were injured.

(293.) — A tube ruptured August 2, in a water tube boiler at the plant of the Helena Gas and Electric Co Helena, Ark.

(294.) — A boiler exploded August 3 in a turkish bath establishment at Brockton Mass. The proprietor of the bath was burned to death and several persons were seriously burned while attempting to rescue him.

(295.) — On August 4, the main steam pipe failed at the Windsor Print Works, North Adams, Mass.

(296.) — A threshing machine boiler exploded August 5, at Iowa City, Ia. Two men were severely injured.

(297.) — On August 6, a tube ruptured in the boiler of C. M. Rogers, Sayville, N. Y.

(298.) — A cast iron tee ruptured in the main steam pipe line at the James McCreery and Co., department store, New York City, on August 6. One man was killed, and two others badly injured.

(299.) — A blow-off pipe failed August 6, at the plant of the C. H. Klein Brick Co., Chaska, Minn. One man was injured.

(300.) — A boiler exploded August 7, at the Hobi camp of the Willapa Logging Co., near Aberdeen, Wash. Two men were instantly killed and the machinery driven by the boiler, wrecked.

(301.) — A cast iron mud drum exploded August 7 in a water tube boiler at the Joliet, Ill., plant of the Public Service Co., of Northern Ill.

(302.) — A boiler exploded with considerable violence at the Majors' saw mill, near Clarksville, Tex., on August 9. Five men including the owner of the mill were instantly killed, while two more were very seriously injured, one fatally.

(303.) — Three firemen were scalded August 9, when the steam gage of a steam fire engine exploded at a fire in Pittsburgh, Pa.

(304.) — A tube burst in a boiler located in the sub-basement of the North American Building, Chicago, Ill., on August 10. One man was killed, one badly scalded, and three others narrowly escaped, owing to the fact that escape from the sub-basement was cut off by the steam which quickly filled all parts of this floor level. People on the upper floors were driven into a panic, and prevented from leaving the building owing to the stopping of the elevator service.

(305.))— A small return tank exploded August 11, at the Sanitary Laundry, Mason City, Ia.

(306.) — A boiler exploded August 12, at the plant of the Citizens Ice Co., Toledo, Ohio. One man was fatally scalded.

(307.) — On August 12, an automatic check valve ruptured on the connection between a boiler and the main steam line at the plant of the Kansas City Packing Box Co., Kansas City, Kan.

(308.) — A compressed air tank ruptured August 13, at the N. P. Pratt Laboratory, Atlanta, Ga. One man was slightly injured.

(309.) — On August 14, a tube ruptured in a water tube boiler at the plant of the Philadelphia Rapid Transit Co., Philadelphia, Pa.

(310.) — A stop valve ruptured August 14, on the main steam pipe at the Beaver Mills, Keene, N. H.

(311.) — A Milwaukee locomotive exploded August 14, at Roundup, Mont. The train was wrecked, two men were killed and two seriously injured as the result of the accident.

(312.) — A blow-off pipe failed August 15, at the Locustville Woolen Co., Hope Valley, R. I. One man was injured.

(313.) — On August 16, a tube ruptured in a water tube boiler at the Gottfried Brewing Co., Chicago, Ill. One man was killed.

(314.) — On August 16, a tube ruptured in a water tube boiler at the plant of the Louisiana Pulp and Paper Co., Braithwaite, La. One man was killed.

(315.) — A tube ruptured August 16, in a water tube boiler at the Manilla Anchor Brewing Co.. Dobbs Ferry, N. Y. One man was injured.

(316.) — On August 16, a tube ruptured in a water tube boiler at the American Boston Mining Co., plant of M. A. Hanna and Co., Clowry, Mich.

(317.) — A boiler ruptured August 16, at the plant of the Excelsior Springs Ice and Cold Storage Co., Excelsior Springs, Mo.

(318.) — A tube ruptured August 18, in a water tube boiler at the Grand Pacific Hotel, Chicago, Ill.

(319.) — On August 19, a tube ruptured in a water tube boiler at the Manilla Anchor Brewing Co., Dobbs Ferry, N. Y.

(320.) — A boiler exploded August 19, at the Buntyn Lumber Mill, Hooperville, Miss. Four men including the owner of the mill were killed and two others seriously injured.

(321.) — A cast iron mud drum ruptured August 20, at the Rankin Wire Works plant of the American Steel and Wire Co., Pittsburgh, Pa.

(322.) — On August 21, two tubes ruptured in a water tube boiler at the plant of the Ashland Iron and Mining Co., Ashland Ky. The damage to the boiler was considerable.

(323.) A blow-off pipe ruptured at the plant of the Robert Mitchell Furniture Co., Cincinnati, Ohio, on August 21. One man was scalded.

(324.) — A hot water boiler exploded August 24, at Liggetts Drug Store, Weybosset St., Providence, R. I. Five persons were injured by the accident.

(325.) — A carpet drying cylinder exploded with considerable violence August 25, at the mill of M. J. Whittall, carpet manufacturer, Worcester, Mass. No one was injured, but the property damage was estimated to be in excess of $10,000.

(326.) — The boiler of a traction engine exploded August 25, at Owasa, Ia. Two men were injured, four horses killed, and the engine and a threshing outfit wrecked as the result of the explosion.

(327.) — On August 28, a tube ruptured in a water tube boiler at the plant of the Carnegie Steel Co., New Castle, Pa.

(328.) — A boiler ruptured August 28 at the Hiawatha Mine of the Munro Iron Mining Co., near Stambaugh, Mich.

(329.) — A blow-off pipe failed August 28, at the Clyde Cotton Mills, Newton, N. C.

(330.) — A boiler ruptured August 29, at the No. 6 mine of the Nevins Coal Co., Pittsburg, Kans.

(331.) — The boilers of the tug Alice exploded August 30, on the Ohio river near Pittsburgh, Pa. The boat was wrecked, nine persons were killed, and six more injured as the result of the explosion.

(332.) — A tube ruptured in a water tube boiler at the plant of the Murphy Power Co., Detroit, Mich. The boiler was considerably damaged.

(333.) — A boiler exploded August 31, at the Itasca Cotton Oil Mills, Itasca, Tex. Three men were killed, a fourth was missing, probably buried under the ruins, and property was damaged to an extent estimated at $15,000 as the result of the explosion.

September, 1913.

(334.) — On September 1, a flue collapsed in a vertical boiler at the canning house of H. G. Elzey and Sons, Sharptown, Md. One man, who was not an employee of the establishment, was killed, three girls and a boy were injured.

(335.) — A tube failed September 2, in a water tube boiler at the plant of the John A. Moran Ice Co., Ft. Wayne, Ind. Wm. Morris, chief engineer, was scalded.

(336.) — On September 2, two tubes and a cast iron header failed in a water tube boiler at the plant of the Schwartzchild and Sulzberger Co., 45th St. and 1st Ave., New York City.

(337.) — A boiler exploded September 3, in a cannery at Millington, Md. Two men were very seriously scalded, and the engine house wrecked as a result of the accident.

(338.) — On September 4, a tube ruptured in a water tube boiler at the Brooks Works of the American Locomotive Co., Dunkirk, N. Y.

(339.) — A blow-off pipe failed September 5, at the cotton mill of the Pelham Mfg. Co., Pelham, Ga. Wm. Fields, fireman, was scalded.

(340.) — A tube ruptured September 6, in a water tube boiler at the plant of the Standard Steel Co., Alabama City, Ala.

(341.) — On September 7, a blow-off pipe failed at the Archer Ave. and Salt St. plant of the Peoples Gas Light and Coke Co., Chicago, Ill. Patrick Gordon, fireman, was injured and died later.

(342.) — A boiler exploded September 8, at the Linwood quarries near Davenport, Ia. One man was killed.

(343.) — On September 9, a boiler ruptured at the shops of the Southern Ry., Atlanta, Ga. Two men were seriously but not fatally scalded.

(344.) — A number of cast iron headers failed September 9, in a water tube boiler at the plant of the Semet-Solvay Co., East Steelton, Pa.

(345.) — A boiler ruptured September 9, at the plant of the Worcester Salt Co., Ecorse, Mich.

(346.) — On September 10, a boiler ruptured at the plant of the Chicago Heights Oil Mfg. Co., Chicago Heights, Ill. The damage was small.

(347.) — A blow-off pipe failed September 10, at the Reliable Laundry and Dry Cleaning Co.'s plant, Toledo, Ohio. Considerable property damage resulted from the failure.

(348.) — A tube failed September 10, at the plant of the Philadelphia Rapid Transit Co., Philadelphia, Pa.

(349.) — A boiler ruptured September 10, at the plant of the Trulock Ice Co., El Reno, Okla.

(350.) — Twenty-five tubes failed September 10, in a water tube boiler on board the torpedo boat destroyer U. S. S. Craven at sea, bound from Charleston to Savannah, Ga. Two men were killed and three injured.

(351.) — On September 11, a blow-off valve burst at the plant of the Munger Oil and Cotton Co, Mexia, Tex. Two men were injured.

(352.) — A tube failed September 11, in a water tube boiler at the Electric Light and Water Works, City of Fremont, Fremont, Neb.

(353.) — On September 13, a boiler ruptured at the plant of the Dallas Coffin Co., Dallas, Tex.

(354.) — A boiler exploded September 13, at the mill of the Bartlett Lumber Co., Shelldrake, Mich. No one was injured, but a fire started by the explosion did considerable damage to the buildings of the plant.

(355.) — A boiler exploded September 13, in the saw mill of Merton Garrison, East Schodack, N. Y. In addition to the destruction of the mill, the small railway station adjoining, known as Garrison's Station was partially demolished.

(360.) — Five cast iron headers ruptured September 14, in a water tube boiler at the plant of the North Shore Gas Co., Waukegan, Ill.

(361.) — A man was seriously if not fatally scalded September 15, by the explosion of a lard rendering tank at the pork packing plant of Herman Ernst, Philadelphia, Pa.

(362.) — A small boiler exploded September 15, at the lace curtain laundry of Mrs. L. C. Rogers, Louisville, Ky.

(363.) — A steam receiver exploded September 15, at the mill of the Waclark Wire Co., Rahway, N. J. Two men were killed and a third fatally injured as a result of the accident.

(364.) — A boiler exploded September 15, at the cannery of Williams Bros., Carleton, Mich. Two men were injured.

(365.) — A hot water heating boiler exploded September 15, at the home of Mrs. Samuel Dayton, Mt. Airy, N. J. The damage was estimated at $2000.

(366.) — On September 17, a tube ruptured in a boiler at the gas plant of the Winchester Repeating Arms Co., New Haven, Conn. Two men were injured.

(367.) — A boiler ruptured September 19, at the plant of the Clinton Knitting Co., Clinton, N. Y.

(368.) — A blow-off failed September 19, at the plant of the Ft. Worth Cotton Oil Co., Ft. Worth, Tex. One man was injured.

(369.) — On September 20, a tube ruptured in a water tube boiler at the ice factory of the William Ulmer Brewing Co., Greenport, L. I., N. Y. Two men were injured.

(370.) — On September 21 a furnace ruptured in a Scotch marine boiler at the plant of the Worcester Salt Co., Ecorse, Mich.

(371.) — A tube ruptured September 21, in a water tube boiler at the plant of the Ft. Wayne and Northern Ind. Tratcion Co., Ft. Wayne, Ind.

(372.) — A boiler exploded at a convict stockade at Kelly Butte, near Portland, Ore., on September 22. One man was seriously, and perhaps fatally injured, and the prisoners were formed into a bucket brigade to extinguish the fire resulting from the explosion.

(373.) — A boiler ruptured September 23, at the plant of the Dallas Fertilizing and Reduction Co., Dallas, Tex.

(374.) — On September 23, a boiler ruptured at the plant of the Banner Canning Co., Ogden, Utah.

(375.) — A boiler exploded September 24, at Jones' Mill, near Arkadelphia, Ark. One man was fatally burned and four others severely injured.

(376.) — A blow-off failed Setpember 25, at the plant of the La Garde Lime and Stone Co., Anniston, Ala. One man was injured.

(377.) — On September 26, the cast iron mud drum of a water tube boiler ruptured at the plant of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(378.) — The boiler of the tug William P. Dalton exploded September 26, on the barge canal operation near Troy, N. Y. The engineer of the tug was fatally injured, the boat itself was wrecked, and its pilot and a deckhand were thrown into the water, though not seriously injured as the result of the explosion.

(379.) — A boiler exploded September 26, at the piano factory of Kosegarten Bros., Nassua, N. Y.

(380.) — A boiler exploded September 26, at a coal mine near Albia, Ia. fatally injuring a boy and seriously injuring his father.

(381.) — On September 26, a furnace of a Scotch marine boiler collapsed at the plant of the Worcester Salt Co., Ecorse, Mich.

(382.) — On September 27, the inner shell of a fertilizer dryer ruptured at the East St. Louis plant of Swift and Co.

(383.) — A boiler exploded September 27, at Clark's sand washing plant, Bridgeton, N. J.

(384.) — The boiler of a threshing machine exploded September 28, at Hurdsfield, N. D. Five men were injured by the explosion.

(385.) — Three tubes ruptured September 30, in a water tube boiler at the mill of the Brier Hill Steel Co., Brier Hill, P.

(386.) — A section ruptured September 30, in a cast iron sectional heater at the Opera House, owned by Leopold Dryfus, La Fayette, Ind.

(387.) — On September 30, a boiler ruptured at the plant of the Toledo Brick and Tile Co., Toledo, Ia.

OCTOBER, 1913.

(388.) — On October 1, a tube ruptured in a water tube boiler at the Coal St. station of the Public Service Corp'n of New Jersey, Newark, N. J. Two men were injured.

(389.) — A tube ruptured October 3, in a water tube boiler at the Plankington plant of Swift and Co., Milwaukee, Wis.

(390.) — On October 3, a furnace collapsed in an internally fired boiler at the plant of the Guth Chocolate Co., Baltimore, Md.

(391.) — On October 3, a tube ruptured in a water tube boiler at the Abbeville Cotton Mills, Abbeville, S. C.

(392.) — A locomotive crashed into a steam shovel October 3, at a silver mine near Virginia, Minn. The shovel boiler was ruptured by the impact resulting in the death of two men by scalding, and the fatal burning of a third.

(393.) — A tube ruptured October 5, in a water tube boiler at the plant of the Merchants Ice and Cold Storage Co., Cincinnati, Ohio.

(394.) — On October 6, a tube ruptured in a water tube boiler at the plant of the Standard Steel Co., Alabama City, Ala.

(395.) — On October 7, a seam at the rear end of a locomotive boiler failed near Boothwyn Station, Pa. One man was injured.

(396.) — Two cast iron headers ruptured October 8, in a water tube boiler at Factory No. 2 of the Union Ice Co., Pittsburgh, Pa.

(397.) — On October 9, a blow-off failed at the cotton gin and grist mill of M. D. Flowers, Waelder, Tex. The fireman in charge of the boiler was killed.

(398.) — On October 10, a boiler exploded at the saw mill of Lightsey Bros., Miley, S. C. One man was killed and three injured.

(399.) — A threshing machine boiler exploded near Chaseley, N. D. on October 10. Seven members of the threshing crew were scalded.

(400.) — A boiler exploded October 10, at a saw mill owned by J. W. Light, Sewanee, Tenn. Mr. Light and one other were instantly killed. The cause of the explosion was attributed to an overloaded safety valve.

(401.) — A cast iron header ruptured October 10, in a water tube boiler at the plant of the Hooker Electro - Chemical Co., Niagara Falls, N. Y.

(402.) — On October 11, two tubes failed in a water tube boiler in the office building belonging to the estate of Jas. W. Arrott, Pittsburgh, Pa.

(403.) — A cast iron sectional heater ruptured October 12, at the apartment house of Minnie Banner, Broadway and 162nd, St., New York City.

(404.) — Two cast iron sections cracked October 14, in a cast iron sectional boiler at the apartment house, No. 6 Follen St., Boston, Mass.

(405.) — A blow-off pipe failed October 15. at the plant of the South Acton Woolen Co., South Acton, Mass.

(406.) — On October 15, a section cracked in a cast iron sectional heating boiler at the Christ Protestant Episcopal Church, New Brighton, Staten Island, N. Y.

(407.) — On October 16, a blow-off ruptured at the Colorado Packing and Provision Co., plant of Armour and Co., Denver, Col. One man was injured.

(408.) — Two sections failed October 18, in a cast iron sectional heating boiler at the plant of the Steel Wedeles Co., 151 S. Water St., Chicago, Ill.

(409.) — During a fire which destroyed the residence of Henry Bach, at Bath, N. Y., October 18, the hot water heating boiler in the cellar exploded with some considerable violence.

(410.) — The crown sheet of a locomotive type boiler ruptured October 20, at the log mill of Harris Danforth, Norridgewock, Me. Mr. Danforth was fatally scalded.

(411.) — A tube ruptured October 20, in a water tube boiler at the plant of the Philadelphia Rapid Transit Co., Philadelphia, Pa.

(412.) — On October 20, two sections cracked in a cast iron sectional boiler at the Washington School, Louisville, Ky.

(413.) — On October 20, a hot water heater exploded, setting fire to the residence of F. N. Richards, Ranier Beach, Wash. The building was entirely destroyed.

(414.) — The boiler at Manley Chew's saw mill exploded October 21, at Midland, Ont. Two men were killed, and two injured by the explosion.

(415.) — A mangle exploded October 21, at the Troy Laundry, Tremont St., Lynn, Mass. Two men were slightly injured, and property was damaged to the extent of about $3000.

(416.) — A steam receiver exploded October 21, at the plant of the Youngstown Consolidated Gas and Electric Co., Youngstown, Ohio. Two men were injured.

(417.) — A boiler exploded with unusual violence October 21, at the power house of the Richmond Light and Power Co., Staten Island, N. Y. Six men were killed, a very great property damage was done, and Staten Island was left without lighting, power, or trolley service for several days.

(418.) — Three sections ruptured October 23, in a cast iron sectional heating boiler in the apartment house 263 West 153d, St., owned by Matilda and Flora Meyer, New York City.

(419.) — A tube ruptured October 23, in a water tube boiler at the Electric Light and Water Works of the City of Fremont, Fremont, Neb.

(420.) — On October 23, six cast iron headers failed in a water tube boiler at the plant of the Semet-Solvay Co., Eusley, Ala.

(421.) — A boiler exploded October 23, at the Ridgewood Pumping Station, Brooklyn, N. Y. Three men were very seriously scalded.

(422.) — A boiler exploded October 24, at the Linde shoe repairing shop, Davenport, Ia.

(423.) — On October 25, a boiler ruptured at the stone quarry of J. B. Millard and Sons, Meyerstown, Pa.

(424.) — On October 27, a blow-off pipe failed at the plant of the Borden's Condensed Milk Co., Brooklyn, N. Y. Four men were injured.

(425.) — A small boiler exploded October 31, in the mushroom plant of William Gunger, Provisio, Ill. Mr. Gunger was instantly killed.

(426.) — The boiler at the plant of the Pure Ice Co., Bowling Green, Ohio, exploded October 31. One man was fatally scalded.

Another Domestic Explosion.

We have recorded Duck explosions and Omelet explosions, but we now discover in the recesses of *The Boston Almanac* for 1844, a copy of which strayed into our office recently the following Sausage explosion.

"An old lady at the North End left the frying pan with sausages in it over the fire while she stepped out. In her absence there was a violent explosion throwing the hot fat in all directions. Wholly attributable to not puncturing the sausages. Take warning ladies."

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1913.

Capital Stock, ... $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$186,187.28
Premiums in course of collection,		285,163.53
Real estate,		90,600.00
Loaned on bond and mortgage,		1,193,285.00
Stocks and bonds, market value,		3,506,178.40
Interest accrued,		75,600.51
Total Assets,		$5,337,014.72

LIABILITIES.

Premium Reserve,		$2,211,732.44
Losses unadjusted,		94,913.83
Commissions and brokerage,		57,032.71
Other liabilities (taxes accrued, etc.),		47,740.86
Capital Stock,	$1,000,000.00	
Surplus over all liabilities,	1,925,594.88	
Surplus as regards Policy-holders,	**$2,925,594.88**	2,925,594.88
Total Liabilities,		$5,337,014.72

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. E. JETER, Supervising Inspector.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

Incorporated 1866. Charter Perpetual.

The Hartford Steam Boiler Inspection and Insurance Company

ISSUES POLICIES OF INSURANCE COVERING

ALL LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.,	W. M. Francis, Manager and Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.,	Lawford & McKim, General Agents. R. E. Munro, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. Roberts, Manager. Joseph H. McNeill, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.	W. G. Lineburgh & Son, General Agents. F. S. Allen, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. Lemon, Manager. James L. Foord, Chief Inspector. J. T. Coleman, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. Gleason, Manager. Walter Gerner, Chief Inspector.
CLEVELAND, Ohio, Century Bldg.	H. A. Baumhart, Manager and Chief Inspector.
DENVER, Colo., Room 2, Jacobson Bldg.	Thos. E. Shears, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. Williams, Jr., General Agent. F. S. Allen, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	Peter F. Pescud, General Agent. R. T. Burwell, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. Gardiner, Manager. W. W. Manning, Chief Inspector.
PHILADELPHIA, Pa., Cor. Fourth and Walnut Sts.	Corbin, Goodrich & Wickham, General Agents. Wm. J. Farran, Chief Inspector. S. B. Adams, Assistant Chief Inspector.
PITTSBURG, Pa., 1801-1802 Arrott Bldg.,	J. J. Graham, Manager. Benjamin Ford, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.,	McCargar, Bates & Lively, General Agents. C. B. Paddock, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. Mann & Co., General Agents. J. B. Warner, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. Ashcroft, Manager. J. P. Morrison, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.,	H. N. Roberts, General Agent.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

Vol. XXX. HARTFORD, CONN., APRIL, 1914. No. 2.

Heating Boiler Explosion, 1757 Third Avenue, New York City.

An Investigation of the Explosion of a Sulphite Digester in the Paper Mills at Grand' Mère, Quebec.*

By H. O. KEAY.

The circumstances surrounding the disasterous explosion of one of the sulphite digesters in the paper mills of the Laurentide Company at Grand' Mère, Que., have presented a problem of no small interest, and it was with a view of determining so far as possible the causes leading up to this explosion that an investigation was made, at the request of the Company, with the results set forth in this paper.

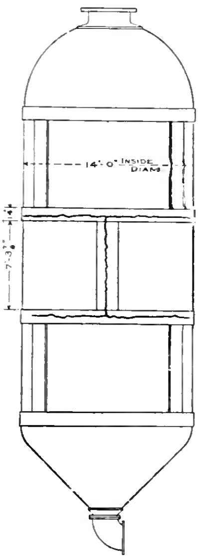


FIG. 1.

The rupture of the huge steel receptacle evidently started in one of the three vertical seams in the middle course, as indicated in Fig. 1. The sudden failure of the vertical seam was immediately followed by an opening out of the plates along the adjacent girth seams, until the upper and lower portions of the digester were completely separated.

The preliminary investigation immediately following the explosion failed to point conclusively to the cause of the trouble. Up to the time of the explosion, no signs of weakness in the digester were apparent. The superintendent of the Sulphite Department had visited the digester house within the hour and found everything proceeding as usual. Charts recovered later showed no evidence of abnormal conditions, such as excessive pressure, sudden opening of the relief valve, or other action recognized as provocative of explosions in boilers. In the operation of these digesters, there is no appreciable amount of water hammer due to the introduction of steam at the bottom. The digester shells are protected on the inside by a lead lining, and a thorough inspection of the ruptured seams after the explosion revealed no pitting from acid to account for a failure from this cause.

The usual calculations for direct stress on the seams of this digester (Fig. 2.) do not indicate stress likely to produce rupture.

Thus, where

P=internal pressure, taken as 100 lbs. per sq. inch, to cover the gage pressure, the hydrostatic pressure of the contents, and any slight fluctuation above normal.

r = inside radius of the digester shell = 84 inches.

t = thickness of the steel shell = 1 inch.

f = circumferential stress in the shell, in lbs. per sq. inch.

$$f = \frac{P\,r}{t}$$

$$= \frac{100 \times 84}{1} = 8400 \text{ lbs. per sq. inch.}$$

*Reprinted by permission of the author, and of *Paper* in which journal the article originally appeared. An account of the explosion which led to this investigation will be found in the April, 1913, Locomotive.

and the longitudinal stress $= \frac{P\ r}{2\ t} = 4200$ lbs. per sq. inch.

Taking a single pitch length of $4\frac{7}{8}$ inches on the vertical seam the sectional area of the plate is reduced by rivet holes as follows:

Shell plate, $\frac{3.311}{4.875} = 0.6792$ of full pitch section.

Cover plate, $\frac{3.5625}{4.875} = 0.7308$ of full pitch section.

Hence the direct stress in tension in the vertical seam becomes for the shell plates $\frac{8400}{0.6792} = 12{,}370$ lbs. per sq. inch, and for the cover plates ($1\frac{1}{8}$ inches thick), $\frac{8400}{1.125 \times 0.7308} = 10{,}220$ lbs. per sq. inch.

For the girth seam by a similar process, the stress in tension is for the shell plate, 6750 lbs. per sq. inch, and for the cover plate, 5480 lbs. per sq. inch; hence the circumferential tension on the shell plate is the greatest, and assuming an ultimate tensile strength of plate 55,000 lbs. per sq. inch, the factor of safety in tension is $\frac{55{,}000}{12{,}370} = 4.5$.

Attention is now naturally directed toward the material of which the digester was constructed. For the purpose of forming an estimate of the suitability of this material, specimens were taken for chemical and physical tests, with the following results:

Chemical analysis of shell plates, Digester No. 3.

Sample	Carbon Per cent.	Sulphur Per cent.	Phosphorous Per cent.	Manganese Per cent.
1	0.18	0.016	0.013	0.37
2	0.22	0.016	0.015	0.41
3	0.19	0.016	0.013	0.41
4	0.22	0.016	0.015	0.40
5	0.23	0.020	0.015	0.41
6	0.22	0.017	0.021	0.37
7	0.23	0.018	0.012	0.35
8	0.20	0.016	0.021	0.37
9	0.21	0.016	0.013	0.38

Chemical Analysis of Cover Plate, No. 2 Digester.

	Per cent.
Total carbon	0.313
Phosphorus	0.037
Manganese	0.420
Sulphur	0.020

Comparisons with the specifications of the American Society for Testing Materials shows that the shell sheet falls within their recommendations, while the cover plate fulfills the specifications except in the matter of carbon, which is somewhat in excess — tending to give a harder and less ductile steel than is ordinarily used in boiler work.

Physical tests were made at the McGill University Laboratory, with the following results:

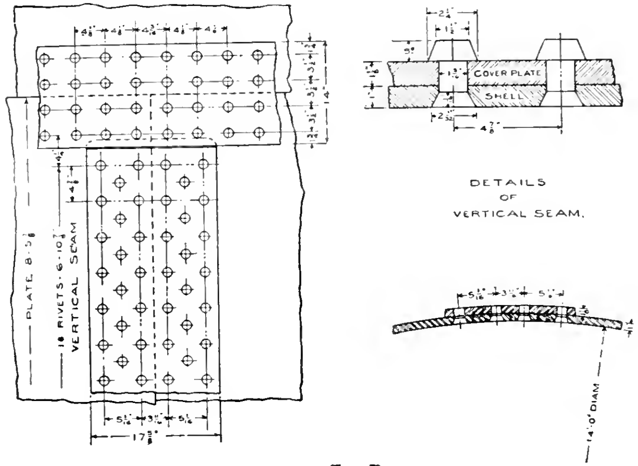


Fig. 2.

Physical Tests of Material from Shell of Exploded Digester.

Physical properties	Specimen 1	Specimen 2	Specimen 3
Ultimate strength. Lbs. per sq. inch..	55.700	55.600	56,300
Elastic limit. Lbs. per sq. inch.......	10,700	16,200	16,900
Yield point. Lbs. per sq. inch.......	26,900	27,000	27,000
Elongation in 8 inches..............	.....	31.1%	31.0%
Reduction in area	57.9%	57.9%	58.4%
Modulus of elasticity	32,800,000	30,000,000	26,000,000

For comparison with the foregoing, the following tests were also made upon 1⅛ inch steel recently furnished for similar purposes:

Physical properties	Specimen A	Specimen B
Ultimate strength. Lbs. per sq. inch...............	64,000	62,000
Elastic limit. Lbs. per sq. inch......................	15,000	13.700
Yield point. Lbs. per sq. inch.....................	(a)	(a)
Elongation in 8 inches.............................	31.1%	31.0%
Reduction in area..................................	50.6%	53.0%
Modulus of elasticity.............................	29,000,000	29,000,000

(a) No pronounced yield point, but a gradually increasing yield after the elastic limit was passed.

In both the foregoing tests the American Society for Testing Materials specifications are satisfied except for the yield point which is low. The *elastic limit,* or the limit of proportionality of stress to strain, however, is very low in both the old and the new material, ranging from 10,700 to 16,900 lbs. per sq. inch in the former, and from 13,700 to 15,700 in the latter. This characteristic of low elastic limit will be brought up later in the calculation of total stresses.

Subsequent investigation of the other vertical cover plates and of those removed from digesters of similar design and service revealed cracks starting between the rivet holes along the inner vertical row — precisely where failure occurred in the ruptured seam. The nature of the cracking is indicated in Fig. 3, which represents a piece of cover plate broken apart by blows from a

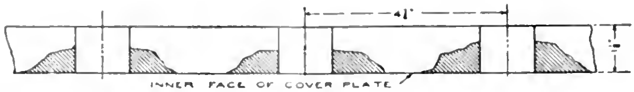


FIG 3.

sledge hammer. The shaded portion shows the location of cracks which had started near the rivet holes, largely on the inner side of the plate.

The general nature and location of these cracks pointed strongly to a failure by repeated bending under stress. While measurements on the inside of a similar digester showed a slight flattening of the curve near the seam, due probably to difficulty in the bending rolls, this peculiarity would prove rather of a benefit than an injury, since the tendency of the cover plate is to take this formation under stress. The line of resistance in cylindrical shells under internal pressure tends to conform to the circle and since the single outside cover plate construction throws this line of resistance outside of the true circle, the tendency under stress is to restore it by bending the cover plate inward as illustrated in Fig. 4.

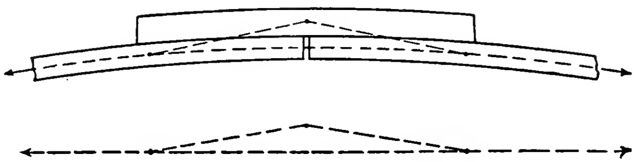
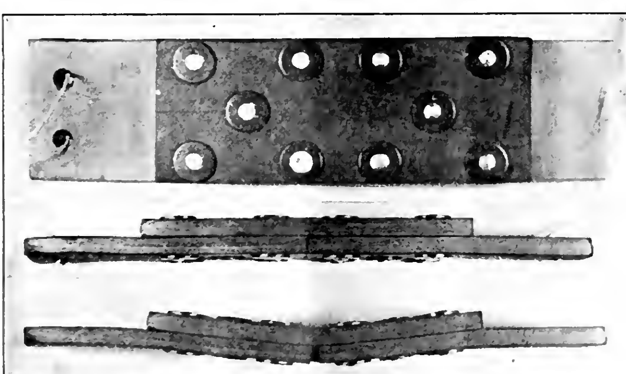


FIG. 4.

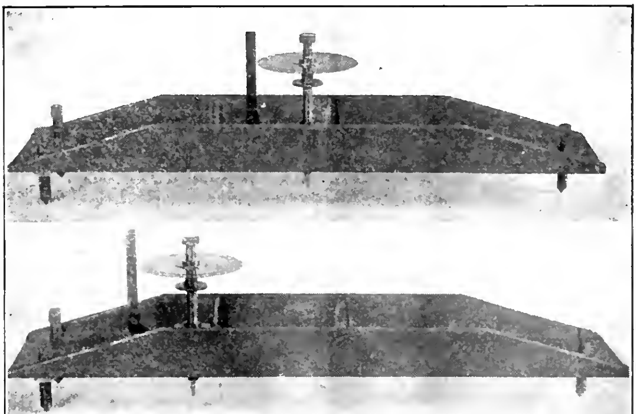
To exhibit this action more clearly, a one-fourth size rubber model of a section of this seam was made, as seen in Fig. 5. Fig. 6 shows a profile of the model before tension was applied, and Fig. 7 indicates clearly the effect of tension on the seam. Particular attention is invited to the concentration of bending between the inner rows of rivets corresponding in the full size seam to a span of about 3 inches.



FIGS. 5, 6 and 7

This evidence naturally led to a desire to determine if possible, the nature and extent of the inward deflection of the vertical cover plate under working conditions, and for this purpose a deflection gage was devised as in Fig. 8.

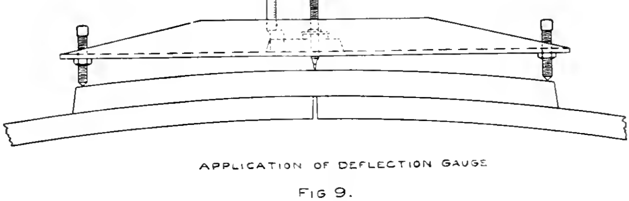
The frame of the instrument was made from a piece of 4" channel bar. The set screws constituting the legs are of hardened tool steel. The two at the left are pointed, while the single one, at a distance of 17 inches from the first two is slightly rounded. The outer legs are forced into the cover plate near its outer edge by light blows when the instrument is first set in place, so that in subsequent readings it is necessary only to set the pointed legs back into these little depressions to insure an exact reproduction of the original setting.



Figs. 8 and 10.

The cover plate is polished where the single rounded screw-leg rests as are also the spots where the micrometer measurements are made.

Fig. 9 indicates the method of application of the instrument for the measurements of the deflections at the center of the 17 inch span. The micrometer is firmly fixed at the center of the instrument frame for this setting, and in making observations, the micrometer screw is advanced until the sense of touch lightly indicates that its point rests upon the polished plate.

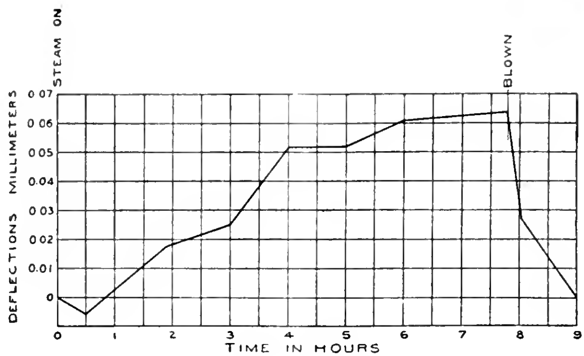


Application of Deflection Gauge

Fig 9.

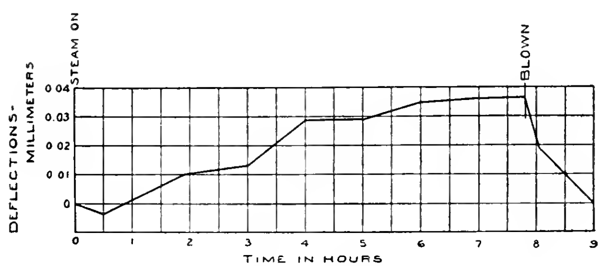
In exploring the curve formed by the deflections in the cover plate the micrometer was relocated at a point 4 inches off center, as shown in Fig. 10.

Measurements were taken at intervals ranging from thirty minutes to an hour, starting before the steam was turned on, and continuing for at least half an hour after the digester was blown. The diagram, Fig. 11, which is typical, presents a graphical record on a time base, of the deflections observed at the center of the 17-inch span, while that of Fig. 12, is for a point 4 inches off center.



INWARD DEFLECTION OF VERTICAL COVER PLATE—CENTER OF 17 INCH SPAN

FIG. 11.

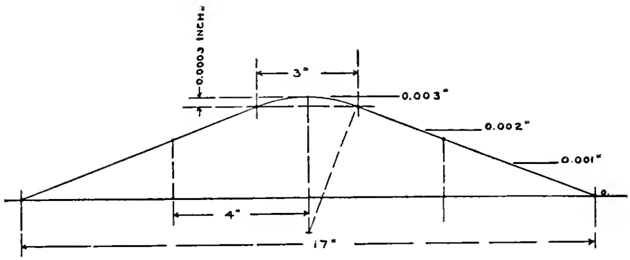


INWARD DEFLECTION OF VERTICAL COVER PLATE—AT POINT 4 INCHES OFF CENTER

FIG. 12.

The maximum deflections obtained in the tests represented by Figs. 11 and 12 are replotted on the diagram in Fig. 13, on a base line representing the 17-inch span. The ordinates at the center, and at points 4 inches off center are plotted to a magnified scale and the smooth curve drawn through these points shows the nature of the deflection. As forecast roughly in the behavior of the rubber model, the concentration of bending is almost exactly over a span of three inches in the middle portion. The deflection at the center of the three inch span is found to be 0.0003 inch.

Just why the cover plate should persist in bulging out slightly immediately after the steam was turned on the digester, following the recharge, as is shown by the negative deflection in both diagrams, was at first a troublesome question, and called for further investigation.



MAXIMUM INWARD DEFLECTION OF COVER PLATE.

Fig 13.

Since these deflections were assumed to be the result of circumferential stress in the shell, it seemed reasonable to suppose that if some sort of extension gage were applied to the shell sheet in this region, the corresponding stress could be readily calculated. For this reason a Howard strain gage was applied at the same height in the digester as the deflection gage, and midway between the vertical seams of the adjacent sheet. This strain gage is in reality a special micrometer capable of indicating within 0.0001 inch error any change in the length between two small carefully prepared holes, drilled 10 inches apart. Where the modulus of elasticity of steel is 30,000,000, an extension of 0.0001 inch represents a tensile stress of 300 lbs. per sq. inch. This test length was taken along the circumference, and the readings were made simultaneously with those of the deflection gage, together with the shell temperatures obtained from a thermometer sealed to the shell sheet. The results of these readings are shown in full lines on the diagram, Fig. 14, while the dotted lines indicate how this test length would have varied under the influence of temperature alone. It was of course prevented from so varying by the internal pressure, therefore the distance measured up from the dotted line to the full line gives the extensions due to internal pressure.

To exhibit more clearly what is going on during a single cook in the digester, a combination diagram Fig. 15, has been plotted with diagrams A, B, C, and D on the same time base.

Diagram A gives a graphical record of the temperatures inside the digester, the shell temperatures, and the temperatures at a point in the middle of the brick lining. The latter were obtained by drilling a small hole through the shell and half-way through the lining. Into this hole a thermometer was inserted and carefully packed with fiber to isolate the bulb from outside conditions. An important feature of this diagram is the fall in temperature of the middle of the lining and of the shell after the steam was turned on, continuing for two or three hours and finally rising again. This is due to the chill of the recharge and the slow transference of heat in the brick and cement lining.

Diagram B is plotted from the pressure chart, and the figures at the left show the pressures in pounds per square inch during the cook, while the figures at the right show the corresponding calculated stress in the shell, and the maximum stress — between the rivet holes — in the cover plate, respectively.

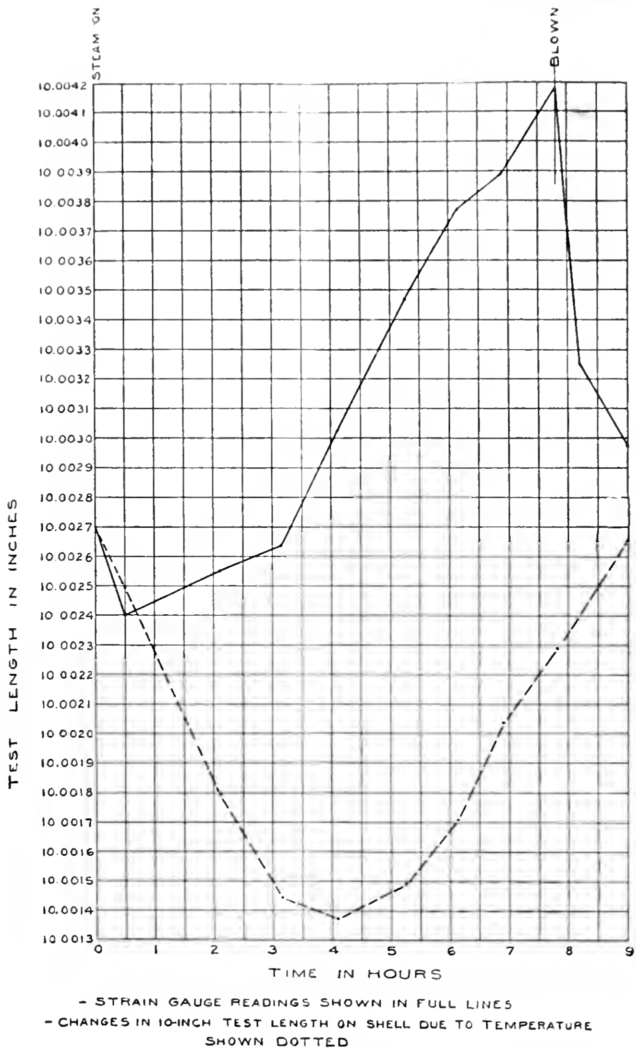


FIG. 14.

On diagram C the full line indicates the stress in the 10-inch test length calculated from the pressures in diagram B, while the dotted line shows the stretch in this test length obtained from the strain gage readings, corrected. for shell temperatures as explained in connection with Fig. 14. The maxima of the two curves are placed as nearly coincident as possible in order to show how nearly back to zero the dotted line will come; in other words, how nearly back to rest the shell plate will come, at the beginning of a cook. It will be noted that there appears to be 1180 lbs. per sq. inch residual stress in the shell sheet at the time when the steam was turned on, falling to 850 lbs. per sq. inch half an hour later and then rising slowly to the maximum.

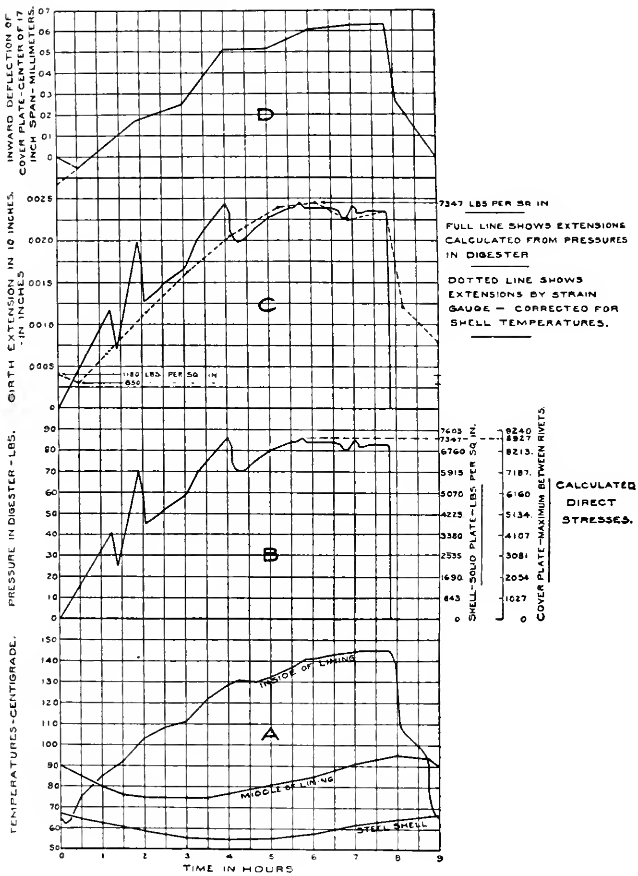
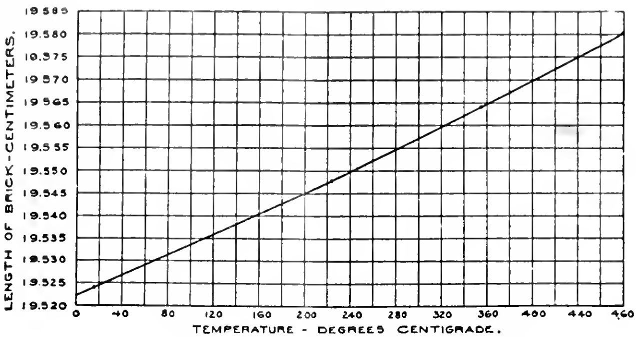


FIG. 15.

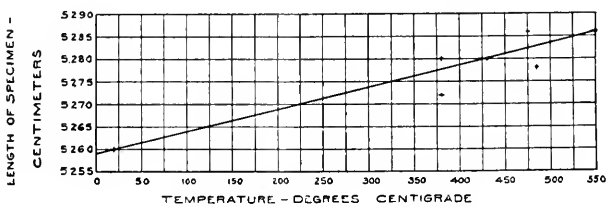
For convenience of comparison, diagram D, showing the corresponding deflections at the center of the cover plate, is plotted immediately above C. It is at once noticed that the cover plate began its inward deflection exactly half an hour after the steam was turned on *and simultaneously with the beginning of the stretch in the shell,* shown dotted in diagram C.

Thus far we have established the relation in action between the girth tension in the shell and the inward deflection of the cover plates, but the reason why the stress relaxed for a short time, or for any time at all, after the steam had been turned on the digester, had not been explained. It was felt that in some way the expansion of the brick lining had something to do with the case, and it had even been suggested that this expansion may have been able to produce an excessive stress upon the seam. That the latter assumption is incorrect, is shown first by the fact that the strain gage did not indicate a greater stretch in the shell than would be expected from the internal pressure; and again, from the following separate investigations of the characteristics of the brick and cement of the lining:



THERMAL EXPANSION OF DIGESTER BRICK

FIG. 16.



THERMAL EXPANSION OF DIGESTER LINING CEMENT.

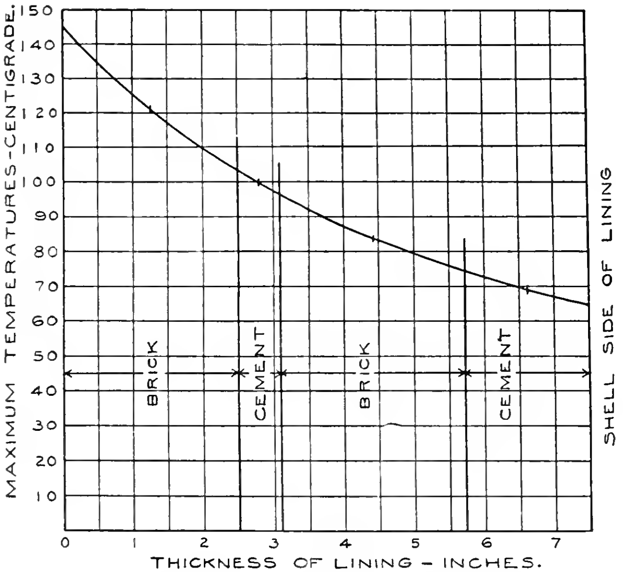
FIG. 17.

A sample of the brick similar to that used in the lining of this digester was selected for determining its thermal expansion. This brick was polished at points on its ends, and slowly heated in a gas furnace in contact with the thermo-junction of a LeChatelier pyrometer, and its length measured every few hours with a delicate micrometer. The result of this experiment is shown graphically in Fig. 16. Similar tests were applied to a cube of lining cement, with results as shown in Fig. 17. From these, the coefficient of thermal expansion of the brick was found to be 0.00000608, and of the cement, 0.00000927 per degree Centigrade.

From the diagram A of Fig. 15, the maximum temperatures attained by the inside and middle of the lining and of the steel shell were replotted in Fig. 18 on a base to represent the thickness of the digester wall, and a smooth curve drawn to show the fall in temperature from the inside to the outside of the digester.

The mean temperature of each layer of the lining, taken from Fig. 18, was now utilized to determine the amount of expansion in each case for the entire circumference — assuming the layers free. The results of this calculation are given in the last column of Fig. 19 under the heading "Free Extension."

It will be noticed that the circumference of the shell will extend 0.25 inch during the cook, while the average extension of the inner two layers of the lining would be 0.34 inch if allowed to expand freely. At the most, this would give a difference of 0.09 inch to be accomodated between the shell and lining



APPROXIMATE MAXIMUM- TEMPERATURES IN DIGESTER LINING.

FIG. 18.

in the entire circumference of the digester. It can be readily shown that this has no effect since if the shell extends 0.0024 inch in ten inches due to internal pressure (see diagram D, Fig. 15), then in the circumference of the digester there would be a total extension due to pressure alone $=(531 \times 0.0024) \div 10 = 0.127$ inch, which lifts the shell clear of any possible crowding by the lining while the pressure is on.

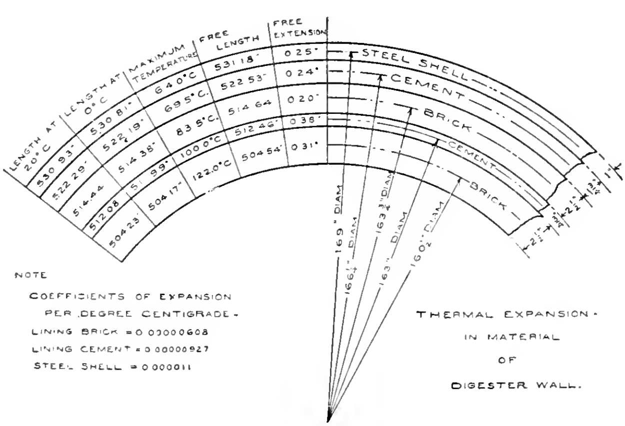


FIG. 19.

When the digester is blown, however, the removal of the internal pressure causes the shell to contract, and it therefore settles back upon the lining, which at this time is expanded to its maximum by heat. Diagram A Fig. 15, shows the temperature of the middle of the lining to be *decreasing* after steam has been turned on, with consequent contraction so the shell now follows the lining back until internal pressure again lifts the plate away from the lining. This accounts for the curious action of the shell and cover plate for the brief period at the beginning of the cook.

Where the shell is shrinking back upon the lining, the latter would be expected to compress more than the former to stretch for a given force, and it was with a view of determining the exact relation that the moduli of elasticity of both the brick and the cement were obtained from compression tests at the McGill University Laboratory. Results of these tests are shown in the following table:

Physical properties.	Brick.	Cement.
Ultimate compressive strength. Lbs. per sq. in....	8,770	4,800
Modulus of elasticity	3,080,000	1,150,000
Length taken for extensometer	4 inches	1.4 inches

Thus the modulus of elasticity of the steel is about ten times that of the brick lining; in other words, a given section of brick would compress ten times as much as an equal section of the shell would stretch, within the elastic limit of the weaker material.

Total Stress.

Proceeding now to the calculation of maximum stress in the cover plate, it will be recalled from the diagram, Fig. 13, that the maximum deflection at the center of the three inch span was found to be 0.0003 inch. Making use of the general formula for the deflection of beams of uniform section, within the limits of proportionality of stress to strain

$$d = \frac{A\bar{x}}{EI}$$

where

d = distance from a point on beam to any tangent.

L = length of tangent thus included.

A = area of bending moment diagram.

$\bar{X}$ = distance from chosen point to center of gravity of bending moment diagram.

E = modulus of elasticity of material.

I = moment of inertia about neutral axis.

M = bending moment (uniform in this case).

f = extreme fiber stress.

y = distance from neutral axis to extreme fiber.

$$A = ML, \text{ and } \bar{x} = \frac{L}{2}$$

$$d = \frac{A\bar{x}}{EI} = ML \times \frac{L}{2} \times \frac{1}{EI} = \frac{ML^2}{2EI}$$

$$M = \frac{2EId}{L^2}$$

$$\text{but } f = \frac{M\,y}{I} = \frac{2\,E\,I\,d\,y}{L^2\,I} = \frac{2\,E\,d\,y}{L^2}$$

Substituting, $d = 0.0003$

$L = 1.5$

$E = 30{,}000{,}000$

$y = 0.5625$

$$f = \frac{2 \times 30{,}000{,}000 \times 0.0003 \times 0.5625}{1.5 \times 1.5}$$

$= 4500$ lbs. per sq. inch due to bending.

Adding to this the maximum direct stress in the cover plate, 4500+10,220=14,720 lbs. per sq. inch, the maximum repeated stress on the inner side of the cover plate.

Reverting to the results of the tensile stress on material from the shell of this digester, and from new material used for similar purposes it will be recalled that the true elastic limits were shown to range from 10,700 to 16,900 lbs. per sq. inch. Since the true elastic limit, rather than the ultimate strength, is a vital consideration in repeated stresses such as we are dealing with here, the fact that the maximum fiber stress of 14,720 lbs. per sq. inch falls within the range of elastic limit of the material is significant. No steel will endure for an unlimited period a repeated stress even slightly above its elastic limit. In this case it took fourteen years of repetition of the stress to cause rupture, but the same action is present in all digesters of similar design — the stress varying in magnitude with the thickness of the cover plate and the pressures carried. Where this stress is shown to exceed the elastic limit of the material of the cover plate to any extent whatever, ultimate failure from repeated bending must be expected.

— McGill University, Montreal, Canada.

Some German Experiences With Autogenous Welding.

H. J. VANDER EB.

In Germany, the year 1912 brought many interesting object lessons concerning the practical use of the autogenous welding process in boiler manufacture, unfortunately however, at the expense of many lives and considerable property damage. A brief review may be of interest to American mechanics.

In this country, autogenous welding of steel plates along with electric welding is steadily gaining in popularity among boiler and tank makers, especially in railroad shops where these processes have been practiced with considerable success for welding plates that are not directly subject to tensile strain and for the welding of the tubes to the tube sheets.

The uncertainty of the strength of the welded plates has thus far proved the main obstacle for the universal application of welding to all plates, which would eliminate riveting, and it would appear doubtful if ever a method can be devised for determining the efficiency of the weld without testing same to destruction.

But even from the welding of such parts as are not subject to tension in the same sense as a boiler shell, trouble may be expected, as is evident from the following, which is an abstract of a translation from the "Zeitschrift für Dampfkessel und Machinenbetrieb" concerning three cases of failure of welded water legs of water tube boilers, two of which were properly staybolted, while in the third one a faulty layout of staybolts was held partly responsible for subjecting the weld to more strain than it could resist.

I. On June 13, 1912: A water tube boiler exploded at the power house of the "Phönix A. G. Für Bergbau und Hüttenbetrieb's" plate and tube works, Düsseldorf, Germany. Three men were killed and seven injured. The boiler was made in 1910 and was of the inclined tube type with wrought steel waterlegs and two horizontal drums over the tubes similar to Heine construction. The waterlegs were made up by the autogenous welding process, and the rupture took place in the front leg.

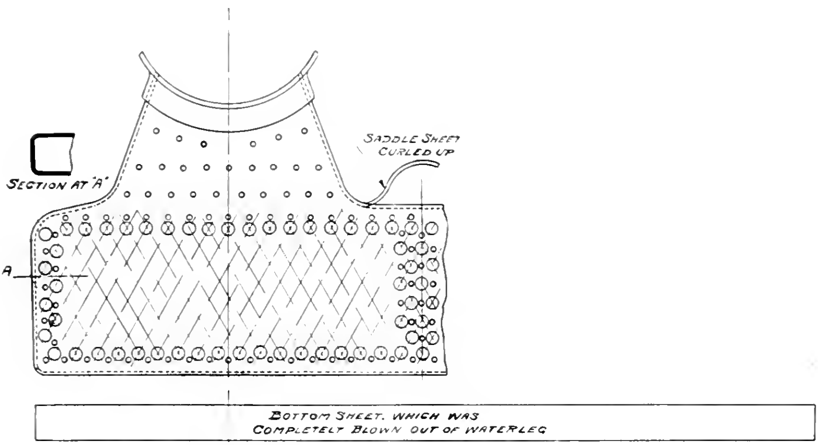


Fig. 1.

THE DÜSSELDORF BOILER.

At the time of the explosion the boiler was being run lightly at about 190 lbs. pressure. No leakage had previously been observed.

The entire bottom of the waterleg tore itself completely from the front and tube plates and was later found in the wreckage. Also the strip of plate that formed the top of the header, between the two throats connecting the leg to the drums, had loosened itself for a length of about 6 feet and was bent upward.

The bottom strip had been let in between the front, back and side sheets and then welded in this position. Not in a single place on any of the four sides had the weld completely filled in between the abutment of the sheets. The failure of the upper sheet was also along the weld line.

The violence of the explosion is illustrated by the fact that the boiler somersaulted through the air and landed right side up some 130 feet away.

Test strips, cut from the various sheets of which the header was made, showed up very well in ductility and strength, even in the welded portions. The material was a soft Siemens-Martin steel having a tensile strength of 44,000 to 58,000 lbs. per square inch and was well adapted for welding.

II. On November 23, 1912, another water tube boiler with welded waterlegs exploded at the rolling mill of the "Eisenindustrie Zu Menden & Schwerte A. G." Schwerte, Germany. Three persons were killed and two injured.

This boiler was of practically the same make as the one mentioned above, but was the product of a different manufacturer and made in 1911. The failure of the waterleg was so similar to the one in Düsseldorf, that detailed description seems hardly necessary. In this case too, the bottom sheet let go from the front and tube sheets, but did not detach itself from the sides, inasmuch as it was made in one piece with the sides; the top of the waterleg also parted in the welds, but this latter rupture was attributed to the many shocks the boiler received in landing, the boiler being hurled bodily in a horizontal direction some 190 feet away from its proper location, during which journey it came several times in contact with the ground.

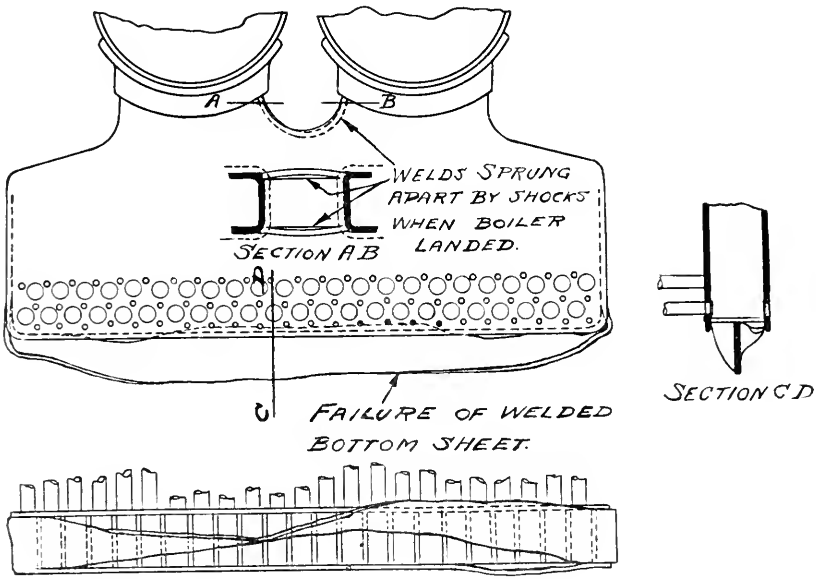


FIG. 2.
The Schwerte Boiler.

As a probable cause of the explosion the following is offered: The failure of the welded seam was apparently the consequence of local overheating, caused by heavy accumulation of oily scale in the front waterleg, aggravated by insufficient protection by brick work, which probably had fallen down. The bottom sheet was found discolored to a bright blue from overheating.

It was noted that the surfaces of the ruptures at the top sheet were smooth and straight; only here and there were little rough places to be seen.

III. On November 24th, 1912, another water tube boiler with welded waterlegs, at the Band Iron Mill of the "Gewerkschaft Deutcher Kaiser" Dinslaken, Germany, exploded, the failure again being in the welded waterleg. One man was killed.

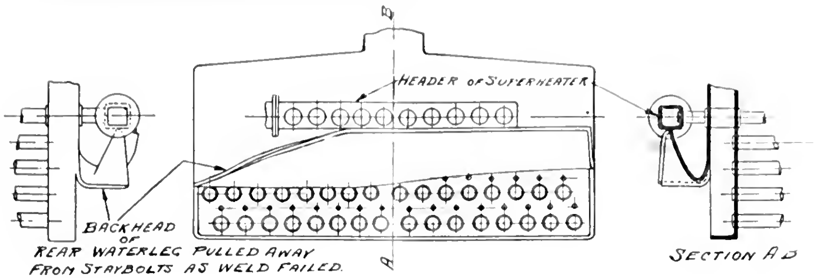


FIG. 3

THE DINSLAKEN BOILER.

This boiler was of the same general design as the two previously described, but had only one horizontal drum, and was made by still another manufacturer in 1897. It had been found necessary after one of the periodical inspections in 1904, to repair the front waterleg at a bad place in the welded seam. According to a report of four years later, in 1908, this same seam had been rewelded.

The rupture took place, however, not in the rewelded front leg but in the rear waterleg. The fireman had shortly before the explosion heard an outrush of steam and thinking that the safety valve was blowing, called the water-tender's attention to this fact, who told him that this was impossible since the pressure was too low for this, there being then 100 lbs. pressure.

The watertender then went behind the boiler where the bottom seam of the waterleg had commenced to leak. At about this moment the explosion occurred, killing the man.

The outside plate of the rear waterleg tore off from the bottom plate in the welded seam and rolled up to about the second row of staybolts from the bottom. All staybolts in the two lower rows had failed. The boiler was pushed from its foundation about 20 feet.

The cause of the explosion is to be attributed to the loosening of the weld at the bottom of the outside sheet in connection with the circumstance that the lower row of staybolts was somewhat too far from the bottom seam and the staybolts consequently were overstrained. The overstrain was aggravated by the fact that six staybolts of the lower row had snapped off before the explosion, as could be seen from the appearance of the broken surfaces of these bolts.

The broken bolts would no doubt have been detected, had they been provided with telltale holes.

That the material of the waterleg was good weldable steel, was shown by a test, in which after two pieces were welded together and subjected to tension, the fracture took place outside the weld.

Tests made with the steel of the outer sheet of the waterleg showed poor results as regards ductility, since, as could be observed from the appearance of the fracture, this material had in places been burned.

These three failures, coming so close one after another, and representing as they do the most conspicuous failures of autogenous welding did much to dampen the enthusiasm of the advocates of welding instead of riveting, and naturally provoked considerable discussion and writing on the subject, the echoes of which appeared in technical journals all over the civilized world, and many suggestions were offered for producing a more reliable weld conspicuous among which was one, advising the annealing of the welded vessels in order to eliminate strains that may have been brought on during the fusing together of the plates and the filler. The official investigators of the foregoing explosions were, however, unanimously of the opinion that annealing would not have done any good in the case of these waterlegs.

In July of last year (1913) another failure of a welded waterleg was added to this series of disasters. This accident took place at a paper mill in Mahrens, Germany.

Here too the bottom of the front waterleg blew out, very much after the fashion of the Düsseldorf explosion, described above. Two men were killed, and enormous damage was done to surrounding property.

Two Explosions from Cast Iron Heating Boilers.

We present in this issue illustrations showing something of the damage wrought by the violent explosion of two heating boilers. The illustration on the front cover shows the interior of a five story apartment house located at 1757 Third Ave., New York City, after the explosion of a hot water boiler on February 26th, 1914. This boiler was operated by a janitor, and the accident is said to have been caused by the attempt of the janitor to thaw out some of the service piping which had frozen, by building as hot a fire as he could. The boiler does not appear to have possessed a safety valve, and the violent explosion which followed is exactly what should have been expected under the circumstances. The force of the explosion demolished the boiler, blew out almost the entire first floor, shattered the second floor, and damaged floors, walls and ceilings throughout the house. The janitor was blown a distance of about fifteen feet, and severely bruised and burned. No insurance was carried, and the boiler and piping does not appear to have been inspected.

The second explosion was from a steam heating plant. It occurred at about 11 P. M. March 2d., 1914, in the St. John's Lutheran Church, Des Moines, Ia. This explosion was very violent, wrecking the church badly, the damage being estimated at $10,000. Fig. 2 shows the interior of the boiler room as seen from what had been the floor above, after the accident. In this instance, the boiler is said to have been fitted with a ball and lever safety valve. The weight was arranged to slide, and while it was supposed to be set for about 10 lbs., the janitor was in the habit of running the weight out on the lever to "stop the noise." He said after the accident that he had seen as high as twenty pounds registered on the gage. On the evening in question, he had banked the fire and gone home before the explosion. It is said that there were but two radiators turned on that evening, all the rest being cut off. Taking account of the limited radiating surface connected, the uncertain setting of the safety valve, and the fact that the boiler was

Fig. 2. Wrecked Boiler Room at St. John's Church.

not under inspection, the cause of the accident does not seem very hard to find. We learn that, as is usual in such cases, an attempt was made to prove that the trouble was due to low water, but we feel sure that in the light of the probable condition of the safety valve, and the great violence of the explosion, no one familiar with such accidents would be apt to consider that the cause. Far too much energy was displayed for an empty boiler, while all the resulting conditions point toward over pressure as the cause. Not only was the church itself wrecked, but derbis was blown out on the adjoining street to such an extent as to impede trolley traffic for some time.

Both these accidents took place in cast iron heating boilers, the kind which so many people feel are too trifling and unimportant to warrant protecting with insurance and its attendant inspection, and indeed neither of these boilers was insured. Our readers, however, may draw their own conclusions from the accompanying photographs as to the soundness of this view.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. Perry, Editor.

HARTFORD, APRIL, 1914.

Single copies *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
The Locomotive of The Hartford Steam Boiler I. & I. Co.

At times we are flooded with inquiries about accidents listed in The Locomotive as boiler explosions. Sometimes data as to the type or make of boiler is wanted, sometimes we are taken to task for publishing as a boiler explosion an accident which was really of a different nature (a matter which we are always glad to correct when it is brought to our attention), and frequently our correspondents think that we have magnified a trifling occurrence into a sizable affair. In nearly every case our friends assume that we are possessed with full and complete data regarding all particulars of each explosion.

As a matter of fact if the inquirer would consult a file of The Locomotive he would find us on record in many places as disclaiming all responsibility for the accuracy of the lists. It necessarily follows from the impossibility of one company being involved in all accidents to insured boilers as well as from the improbability of all exploded boilers being insured, that we cannot make a list from our loss files alone with any pretence at completeness. Moreover, a moment's consideration will show that only in exceptional cases can we obtain full and accurate data of accidents where we have no insurance interest, except as this data becomes public through the press.

We compile our lists from just these sources, getting from the press nearly all our information regarding accidents not found in our loss files, and while we make every effort to be accurate, scrutinizing press clippings carefully in an endeavor to abstract the real facts from the "story" within which newspaper men are prone to bury them, still we cannot make the list more accurate than its sources. As regards the violence of an accident, we do try to distinguish between explosions which are violent, and fractures and ruptures which are less so. We always make an effort to reserve the term explosion for cases where we are led to believe that an actual explosion has taken place. In view of this, we feel that we have given all the information in the lists which is justified in most cases. Where an accident is of enough interest to merit more detailed study, and where our facts are sufficiently well proven to warrant it, we devote space to its discussion in the body of The Locomotive and give our readers all the information possible, which may lead to a proper understanding of the cause of the trouble.

Personal.

Mr. E. H. Holmes returned to the Hartford on February 1, 1914, as Resident Agent at Minneapolis, Minn. Mr. Holmes first became connected with the Hartford in September 1907, when he was appointed a Special Agent, and attached to the Detroit office. He served the Company faithfully in the Michigan territory until August 1912, when he left to become Manager of the Liability branch of the Grinnell-Row-Althouse agency at Grand Rapids, which position he now leaves to again take up the work of the Hartford. Mr. Holmes is a lawyer by training and has practiced law previous to his insurance connection. He succeeds Mr. Ralph A. Abear at Minneapolis who so well represented the interests of the Hartford until failing health required his transfer some months ago to the Atlanta office and a less rigorous climate.

Correction.

On page 23 of the January Locomotive, appears in our explosion list (No. 294,) an account of an accident in a turkish bath establishment in Brockton, Mass., on August 3, 1913. We have learned since the Janauary issue went to press, that this accident was a gas explosion, and not due to steam pressure. We are very glad to correct the error at this time.

Obituary.

Mr. William J. Pierce.

Mr. William J. Pierce, for many years cashier of The Hartford Steam Boiler Inspection and Insurance Co., and a brother of the late Joseph B. Pierce, Secretary of the Company, died January 21, 1914, at his home 213 Garden St., Hartford. Mr. Pierce was born in Thomaston, Ct., September 30, 1830. He entered the employ of the Hartford in 1889, and continued in active service until 1905. Mr. Pierce is survived by his wife, a brother and two sisters.

Charles F. Bennett.

Mr. Charles F. Bennett, an inspector in the service of the Hartford, dropped dead on the street February 7, 1914, at Bridgport, Ct. Mr. Bennett was attached to the Bridgeport office as an inspector from 1895 until his death. He had appeared in good health, and had worked actively at his inspection duties until his sudden death, and none of his associates suspected the existence of the heart trouble which was given as its cause. Mr. Bennett was born in Wilkes Barre, Pa., October 8, 1859. He learned the boiler maker's trade, and followed boiler making until he entered the service of the Hartford as inspector.

Annual Statistics of Boiler Explosions and of the Work of Our Inspection Department, for the Year 1913.

We present as is usual at this time, the statistics of boiler explosions, and also the statistics of the work of our inspection department, for the past year. The number of deaths compared to the number of explosions seems to be lower than for some years past, although there is considerable difficulty in determining from press reports in all cases the exact number fatally injured, as fatal cases are many times reported as serious or dangerous. From the fact as we have them, it would appear that there were about 2.75 accidents per death, while there were 1.4 men either killed or injured per accident.

Concerning the inspection statistics, we can say little more than to repeat what we have said in the past, that these statistics representing as they do, so large a number of boilers, and so widely distributed over the entire country, give an exceedingly valuable guide as to the average condition of American boilers, and the frequency with which any particular class of defect may be anticipated. As heretofore, the greatest single cause for trouble in boiler operation is poor feed water, as is evidenced by the number of cases of scale and sediment, together with defects due to corrosion. After the feed water defects, the largest single item is that of defective tubes. Tube defects, especially if they are not attended to in time to prevent tube ruptures, are becoming a frequent form of trouble with water tube boilers, and they are very fruitful of personal injuries, often of a serious nature.

Summary of Boiler Explosions for 1913.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January	61	30	81	111
February	50	10	34	44
March	42	11	22	33
April	32	12	22	34
May	30	8	14	22
June	34	10	24	39
July	41	14	19	33
August	43	29	34	63
September	54	13	37	50
October	39	18	27	45
November	29	12	22	34
December	44	13	33	46
Totals	499	180	369	549

Summary of Inspector's Work for 1913.

Number of visits of inspection made	192,569
Total number of boilers examined	357,767
Number inspected internally	144,601
Number tested by hydrostatic pressure	8,777
Number of boilers found to be uninsurable	832
Number of shop boilers inspected	10,808
Number of fly wheels inspected	13,394
Number of premises where pipe lines were inspected	5,010

Summary of Defects Discovered.

Nature of Defects.	Whole Number.	Dangerous.
Cases of sediment or loose scale	27,402	1,623
Cases of adhering scale	45,654	1,645
Cases of grooving	2,754	278
Cases of internal corrosion	16,180	821
Cases of external corrosion	10,018	936
Cases of defective bracing	1,085	330
Cases of defective staybolting	1,821	441
Settings defective	8,655	877
Fractured plates and heads	3,650	524
Burned plates	5,134	535
Laminated plates	515	47
Cases of defective riveting	1,749	248
Cases of leakage around tubes	11,866	1,343
Cases of defective tubes or flues	14,695	6,748
Cases of leakage at seams	5,587	416
Water gages defective	3,369	788
Blow-offs defective	4,863	1,451
Cases of low water	546	166
Safety-valves overloaded	1,363	392
Safety-valves defective	1,583	434
Pressure gages defective	7,678	660
Boilers without pressure gages	531	69
Miscellaneous defects	3,049	567
Total	179,747	21,339

Grand Total of the Inspectors' Work from the Time the Company Began Business, to January 1, 1913.

Visits of inspection made	3,505,491
Whole number of inspections (both internal and external)	7,108,532
Complete interval inspections	2,796,507
Boilers tested by hydrostatic pressure	316,653
Total number of boilers condemned	23,429
Total number of defects discovered	4,332,651
Total number of dangerous defects discovered	450,310

Summary of Inspectors' Work since 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1876	16,409	34,275	10,669	2,150	16,273	4,275	89
1877	16,204	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29 324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595
1895	98,349	199,096	76,744	8,373	144,857	14,556	799
1896	102,911	205,957	78,118	8,187	143,217	12,988	663
1897	105,062	206,657	76,770	7,870	131,192	11,775	588
1898	106,128	208,990	78,349	8,713	130,743	11,727	603
1899	112,464	221,706	85,804	9,371	157,804	12,800	779
1900	122,811	234,805	92,526	10,191	177,113	12,862	782
1901	134,027	254,927	99,885	11,507	187,847	12,614	950
1902	142,006	264,708	105,675	11,726	145,489	13,032	1,004
1903	153,951	293,122	116,643	12,232	147,707	12,304	933
1904	159,553	299,436	117,366	12,971	154,282	13,390	883
1905	159,561	291,041	116,762	13,266	155,024	14,209	753
1906	159,133	292,977	120,416	13,250	157,462	15,116	690
1907	163,648	308,571	124,610	13,799	159,283	17,345	700
1908	167,951	317,537	124,990	10,449	151,359	15,878	572
1909	174,872	342,136	136,682	12,563	169,356	16,385	642
1910	177,946	347,255	138,900	12,779	169,202	16,746	625
1911	180,842	352,674	140,896	12,724	164,713	17,410	653
1912	183,519	337,178	132,984	8,024	164,924	18,932	977
1913	192,569	357,767	144,601	8,777	179,747	21,339	832

Boiler Explosions.

NOVEMBER, 1913.

(427.) — On November 1, a boiler ruptured at the plant of the Pittsburgh and Eastern Coal Co., operated by M. A. Hanna and Co., Cherry Valley, Pa. Considerable damage was done to the boiler.

(428.) — A cast iron sectional heating boiler ruptured November 1, in the business block of the Everett Associates, Everett, Mass.

(429.) — A boiler used to operate a corn shredder on the farm of Peter Schram near Frazee, Minn., exploded November 3. One man was killed and two others seriously injured as the result of this accident.

(430.) — The boiler of a Great Northern freight engine exploded November 6, at Gold Bar, Wash. The engineer and fireman were both fatally scalded.

(431.) — On November 7, a tube cap blew off from a water tube boiler at the Mt. Washington House, Bretton Woods, N. H. Robt. E. Chapman, chief engineer, and John H. Rousseau, fireman, were injured.

(432.) — A tube ruptured November 7, in a water tube boiler at the plant of the Bryant Paper Co., Kalamazoo, Mich.

(433.) — On November 7, a tube ruptured in a water tube boiler at the plant of the Mt. Vernon Woodbury Cotton Duck Co., Baltimore, Md. Joseph Hine, boiler maker, was slightly injured.

(434.) — A boiler ruptured November 8, at the American Locomotive Co.'s plant, Manchester, N. H.

(435.) — On November 8, a cast iron header ruptured in a water tube boiler at the light and power plant of the City of Starksville, Starksville, Miss.

(436.) — A boiler exploded November 10 at the plant of the American Writing Paper Co., Franklin, O. A locomotive on an adjacent railway track was badly damaged. One man was injured, and property was damaged to an extent estimated at $30,000.

(437.) — A boiler ruptured November 10, at the Perry County Infirmary, New Lexington, O. One man was injured, and the boiler considerably damaged.

(438.) — A saw mill boiler exploded November 11, near Searcy, Ark. Three men were killed and one fatally injured as the result of the accident.

(439.) — An instantaneous hot water heater exploded November 10, at the plant of the Western Electric Co., Pittsburgh, Pa. One man was killed and a boy injured as the result of the explosion, while property was damaged to the extent of several hundred dollars.

(440.) — On November 14 the crown sheet of a locomotive collapsed at the plant of the Cotton States Lumber Co., Meehan Junction, Miss.

(441.) — A boiler ruptured at the plant of the Picksville Distilling Co., Picksville, Md., on November 14.

(442.) — A blow off failed November 14 at the plant of the Atlantic Ice and Coal Co., Atlanta, Ga. Cliff Booth, fireman, was injured.

(443.) — On November 14, a tube ruptured in a water tube boiler at the plant of the Duquesne Light Co., Pittsburgh, Pa. Two men were quite severely injured by the accident.

(444.) — On November 17, a blow-off pipe failed at the Lawrence Hotel, Erie, Pa.

(445.) — A tube ruptured November 17, in a water tube boiler at the plant of the Manhattan Slate Co., Slatesdale, Pa. One man was injured.

(446.) — On November 18, a section and a manifold cracked in a cast iron sectional boiler at the Holyoke Club, Holyoke, Mass.

(447.) — A tube ruptured November 22 in a water tube boiler at the plant of the Bryant Paper Co., Kalamazoo, Mich. Jacob Sootsman, coal passer, was injured.

(448.) — On November 23, eleven cast iron headers ruptured in a water tube boiler at the creosote works of Sylvester W. Labrot, New Orleans, La.

(449.) — The boiler of the locomotive pulling freight No. 93, of the Big Four railroad exploded November 24 near Shiloh, O. Three men were badly scalded as a result of the accident.

(450.) — Five sections ruptured in a cast iron sectional boiler belonging to the Shulte Realty Co., New York City.

(451.) — A boiler exploded November 27 at the plant of the Bergdoll Brewing Co., Philadelphia, Pa. One man was injured.

(452.) — A boiler exploded November 27 at the Price saw mill near Rue, Alabama. Three men were killed, and two others injured, one of whom was not expected to survive.

(453.) — A boiler ruptured November 28, at the Ninety-Six Cotton Mill, Ninety Six, S. C.

(454.) — An accident occurring in the fire box of locomotive No. 9373 of the Pittsburgh and Lake Erie R. R. on November 29 near McKeesport, Pa., resulted in the injury of four men, one of them seriously.

(455.) — On November 30 a tube ruptured in a water tube boiler at the plant of the Central Ice and Cold Storage Co., New Orleans, La.

December, 1913.

(456.) — On December 1, a boiler ruptured at the retail store of the Tobey Furniture Co., No. Wabash Ave. and Washington Sts., Chicago, Ill.

(457.) — A tube ruptured Dec. 3, in a water tube boiler at the plant of the Semet-Solvay Co., Eusley, Ala.

(458.) — On December 4, a tube ruptured in a water tube boiler at the plant of Brown and Co., Pittsburgh, Pa. One man was injured and considerable damage was done to the boiler.

(459.) — The boiler of a Southern Pacific locomotive exploded December 4, at Shreveport, La. One man was fatally injured, and property including other locomotives on adjoining tracks was badly damaged as a result of the explosion.

(460.) — Two boys, Rex and Louis Vining, of Dalton, Ga., were seriously injured December 4 by the explosion of a toy boiler which they had made, and with which they were playing.

(461.) — Seven cast iron headers ruptured December 5 in a water tube boiler belonging to the Continental Trust Co., Baltimore, Md.

(462.) — On December 5, a cast iron sectional heating boiler ruptured at the Bassett School, Iola, Kans.

(463.) — A tube ruptured December 9, in a water tube boiler at the plant of the C. W. Hunt Co., West New Brighton, N. Y. One man was injured.

(464.) — On December 9, two sections ruptured in a water tube boiler in a dwelling belonging to C. N. Hull, Kansas City, Mo.

(465.) — A boiler exploded December 9 at the plant of the Illinois Steel Co., Lockport, Ill. One man, a valve inspector, was killed.

(466.) — On December 10, four sections ruptured in a cast iron heater at the Annawam Mills, Fall River, Mass.

(467.) — A rupture occurred December 10 in a water tube boiler at the plant of the American Steel and Wire Co., Waukegan, Ill. The damage was confined to the boiler.

(468.) — A tube failed December 11 in a water tube boiler at the plant of the Empire Gas and Electric Co., Auburn, N. Y. One man was injured.

(469.) — On December 11, a tube ruptured in a water tube boiler at the plant of the Lackawana Steel Co., Wehrum, Pa.

(470.) — On December 12, the furnace of a vertical boiler ruptured at the plant of the Waterbury Steam Carpet Beating Co., Waterbury, Conn.

(471.) — A boiler exploded December 12 in the Lane milling plant, Ellisburg, Ky. The entire mill plant was destroyed, and two men, bystanders, were fatally injured.

(472.) — A tube ruptured December 13, in a water tube boiler at the Brooks Works, of the American Locomotive Co., Dunkirk, N. Y.

(473.) — On December 13, a tube ruptured in a water tube boiler at the plant of the James Lappan Mfg. Co., Pittsburgh, Pa. One man was injured.

(474.) — A boiler exploded December 14 in a steam laundry at 78 Fulton St., Brooklyn, N. Y. The explosion set fire to the building and several persons were overcome by smoke before they could make their escape, although all were rescued. The property loss was considerable, but was almost entirely due to the fire.

(475.) — A hot water boiler exploded December 14 wrecking the building of Arlington Gas Light Co., Arlington, Mass.

(476.) — A violent explosion of a hot water boiler in an apartment house at 6 Claflin Road, Brookline, Mass, wrecked the building, injured fourteen persons, one fatally, and did property damage to an amount estimated at $30,000.

(477.) — On December 15 a cast iron header ruptured in a boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(478.) — A boiler exploded December 16 in the Harcourt apartment building, 1357 East Fifty-Seventh St., Chicago, Ill. Miss Sarah E. Wiley, who occupied the apartment on the first floor was fatally injured.

(479.) — A boiler exploded December 17 at the plant of the Jackson Lumber Co., Lockhart, La. One man was killed, and two fatally injured.

(480.) — A tube ruptured December 19, in a water tube boiler at the power house of the San Joaquin Light and Power Co., Bakersfield, Cal. Considerable damage was done to the boiler.

(481.) — A boiler exploded December 19 at Smith Bros. saw mill, Highway, Ky. One man was killed, while three others and a small boy were frightfully scalded.

(482.) — A cast iron header ruptured December 20, at the plant of the Milwaukee Gas and Coke Co., Milwaukee, Wis.

(483.) — On December 20, a tube ruptured in a water tube boiler at the plant of the Mercer County Light, Heat and Power Co., Greensville, Pa. One man was injured.

(484.) — On December 20, a cast iron header ruptured at the plant of the Utah-Idaho Sugar Co., Sugar City, Idaho.

(485.) — A boiler exploded December 21 at the foundry of the Benle Iron Co., Bismarck, Mo. One man was killed, two injured, and the mill property almost entirely destroyed by the accident.

(486.) — A tube ruptured December 22, in a water tube boiler at the plant of the American Bridge Co., Toledo, O.

(487.) — On December 23 the furnace of a vertical tubular boiler failed at the plant of the Hanover Street Laundry Co., Manchester, N. H.

(488.) — A cast iron header ruptured December 24, in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka. Ind.

(489.) — A blow-off pipe failed December 24, at the plant of the West Side Laundry Co., Racine, Wis.

(490.) — The boiler of a Wabash locomotive exploded December 25 at Buffalo, N. Y. Two men were killed and six injured by the explosion.

(491.) — A heating boiler exploded in the basement of the Holy Name of Mary Church, Ellicottville, N. Y., on December 25. High mass was being celebrated at the time of the explosion. Fortunately no one was injured, but the building was damaged to the extent of about $2,000.

(492.) — On December 26, four sections of a cast iron sectional heater failed at the building of Vogel and Company, Hanover St., Boston, Mass.

(493.) — On December 26, a vertical boiler failed at the plant of the Bodwell Granite Co., Vinal Haven, Me.

(494.) — A steam heater exploded December 27, in the car Rebecca of the La Feria Land syndicate, at Sioux City, Ia. No one was seriously injured, but passengers waiting in the nearby station were badly frightened.

(495.) — On December 28, a blow-off pipe failed at the plant of the Ulster Knitting Mills Co., Kingston, N. Y. One man was injured.

(496.) — A cast iron sectional heating boiler ruptured December 29 at the apartment house owned by Louville V. Niles, 362 Mass. Ave. Boston, Mass.

(497.) — On December 29, a cast iron header ruptured in a water tube boiler at the power house of the Pittsburg and Butler St. Ry. Co., Renfrew. Pa.

(498.) — A water boiler exploded December 29 in the home of Joseph I. Scott, 4006 Westminster St., Northside, Pittsburgh, Pa.

(499.) — A section of a cast iron sectional heating boiler ruptured December 31, in the business building owned by W. A. Maurer and W. S. Keeline, Council Bluffs, Ia.

January, 1914.

(1.) — Two cast iron heating boilers ruptured Jan. 1st, at the St. Anthony Church and School, Toledo, O.

(2.) — A steam pipe burst January 2, at the plant of the Martin-Halloran-Klaus Laundry Company, St. Louis, Mo. Two men were scalded, one perhaps fatally.

(3.) — On January 2, a cast iron header ruptured in a water tube boiler at the power house of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(4.) — A boiler exploded January 2 beneath the stage and musicians pit of the Arcadia Dancing Academy, Indianapolis, Ind. No one was injured, although the people in the hall at the time were thrown into a panic. The property loss was estimated at about $500.

(5.) — On January 3, a boiler ruptured at the oil refining plant of The Sun Company, Toledo, O.

(6.) — A boiler ruptured January 4, at the New Century Hotel, Dawson Springs, Ky.

(7.) — A cast iron header ruptured January 4, in a water tube boiler at the plant of the Ohio Electric Light Co., Lima, O.

(8.) — A steam pipe burst January 4 at the plant of the Norwood Electric Light and Power Co., Yaleville, N. Y. No one was injured, but some damage was done to the electrical equipment of the plant by the escaping steam.

(9.) — On January 5, a tube ruptured in a water tube boiler at the plant of the Appalachian Paper Co., Switchback, W. Va. One man was injured.

(10.) — Four sections of a cast iron heater ruptured January 5 at the State Normal School, Denton, Tex.

(11.) — A boiler exploded January 5 at the plant of the Hammonds Lumber Co., Countiss, Ark. One man was killed, and five others injured.

(12.) — A heating boiler ruptured in the apartment house "Elmwood," Portchester, N. Y., on January 6.

(13.) — On January 7, a boiler ruptured at the plant of the Pelham Oil and Fertilizer Co., Pelham, Ga.

(14.) — On January 7, three sections of a cast iron heating boiler ruptured at the Carl Leon Hotel, Independence, Kans.

(15.) — Four sections ruptured January 7, in a cast iron sectional heater at the Willowcraft Shop, North Cambridge, Mass.

(16.) — A boiler exploded January 8 in the gasoline plant of the Ohio Oil Co., Bridgeport, Ill. Three men were killed and four injured, two of whom were not expected to live.

(17.) — A boiler exploded January 8 on the farm of Earl Campbell, Fisher, Ill. The boiler was attached to a corn shelling outfit, and two men were seriously injured as a result of the explosion.

(18.) — A blow-off pipe failed January 9 at the department store of J. N. Adams, Lowell, Mass. No one was injured.

(19.) — On January 10, a tube ruptured in a water tube boiler at the plant of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(20.) — Two slashers were injured in an explosion at the Prescott Mills, Lowell Mass,. on January 9. No one was injured.

(21.) — A contractor's boiler exploded on the elevated road construction at 2nd. Ave. and Washington St., Astoria, New York City, on January 10. Fourteen persons were injured by the explosion.

(22.) — A boiler ruptured January 12 at the plant of the Lebanon Valley Iron Works, Lebanon, Pa. Five men were slightly injured.

(23.) — On January 12, a section cracked in a cast iron sectional heater at the Moore Hotel, owned by the John Moore Realty Co., Kansas City, Mo.

(24.) — On January 12, the crown sheet of a locomotive boiler collapsed at the brickyard of G. A. Guignard, Columbia, S. C. One man was injured.

(25.) — Two cast iron headers ruptured January 12, in a water tube boiler at the plant of the American Steel and Wire Co., Waukegan, Ill.

(26.) — A valve burst January 13, in the boiler room of the Hotel Ansonia, New York City. One man was badly injured.

(27.) — A boiler exploded January 12, at the saw mill of Drake and Thompson, near Albany, Ga. Three men were injured, one fatally.

(28.) — A boiler exploded January 13, at Smiles' saw mill, near Shirley, Ark. Two men were killed.

(29.) — On January 13, a cast iron heater failed at the apartment house owned by the estate of Harriet Fellner, 6 Humbolt Ave., Roxbury, Mass.

(30.) — A cast iron mud drum failed January 13 in a water tube boiler at the plant of the American Steel and Wire Co., Braddock, Pa.

(31.) — Four cast iron headers ruptured January 13, in a water tube boiler at the plant of the Ohio Electric Railway Co., Lima, O.

(32.) — A tube ruptured January 14, in a water tube boiler at the plant of the Coshocton Light and Heat Co., Coshocton, O. R. C. Moore, fireman, was injured.

(33.) — A hot water boiler exploded January 14, in the home of Fred Etnier, Huntington, Pa. No one was injured, but the property damage was estimated at $3,500.

(34.) — A kitchen boiler exploded January 14 in the home of James Gottholf, Jersey City, N. J. Three persons were injured, and damage by fire to the extent of about $1,000 resulted.

(35.) — A house heating boiler burst January 14, in the home of S. Hirsch, Plainfield, N. J. The damage was confined largely to the boiler.

(36.) — The hot water front in a stove burst January 14, in the home of Joseph Alpert, North Adams, Mass. Simon Alpert, the two and a half year son of Mr. Alpert was fatally burned. The accident was caused by the freezing of the connections to the water front.

(37.) — A boiler exploded January 14 in Santangelo's bottling works, Red Bank, N. J.

(38.) — Several sections ruptured in a cast iron heating boiler January 15, in the apartment house at 98-102 Gainsboro St., Boston, Mass.

(39.) — A boiler exploded January 15 at the saw mill of Jim Roe Black, near Guin, Ala. Two men were killed, and a third fatally injured.

(40.) — A small boiler exploded January 15, in the garage of E. H. Friedrich, Holyoke, Mass. The garage was damaged, fifty chickens killed, and Roger O'Meara, chauffeur, was painfully injured.

(41.) — A tube failed in a boiler used for hoisting purposes at the Pittsmont mine, Butte, Mont., on January 15. No one was injured, and the damage was confined to the boiler and its setting.

(42.) — On January 16, a boiler ruptured at the plant of the Saranac Glove Co., Littleton, N. Y.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1914

Capital Stock, ... $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$241,350.34
Premiums in course of collection,		287,689.64
Real estate,		90,300.00
Loaned on bond and mortgage,		1,199,345.00
Stocks and bonds, market value,		3,516,405.80
Interest accrued,		77,404.77
Total Assets,		$5,412,495.55

LIABILITIES.

Premium Reserve,		$2,293,028.64
Losses unadjusted,		41,990.28
Commissions and brokerage,		57,537.92
Other liabilities (taxes accrued, etc.),		47,429.31
Capital Stock,	$1,000,000.00	
Surplus over all liabilities,	1,972,509.40	
Surplus as regards Policy-holders,	**$2,972,509.40**	2,972,509.40
Total Liabilities,		$5,412,495.55

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Supervising Inspector.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank Hartford, Conn.

LYMAN B. BRAINERD, Director, Swift & Company.

MORGAN B. BRAINARD Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

GEORGE C. KIMBALL, President, The Smyth Mfg. Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., and Director N. Y., N. H. and H. R. R. Co.

DR. GEORGE C. F. WILLIAMS, Treas. and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

Incorporated 1866. Charter Perpetual.

The Hartford Steam Boiler Inspection and Insurance Company

ISSUES POLICIES OF INSURANCE COVERING

ALL LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.,	W. M. FRANCIS, Manager and Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.,	LAWFORD & MCKIM, General Agents. R. E. MUNRO, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. ROBERTS, Manager. JOSEPH H. MCNEILL, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.,	W. G. LINEBURGH & SON, General Agents. F. S. ALLEN, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.,	H. M. LEMON, Manager. JAMES L. FOORD, Chief Inspector. J. T. COLEMAN, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.,	W. E. GLEASON, Manager. WALTER GERNER, Chief Inspector.
CLEVELAND, Ohio, Century Bldg.,	H. A. BAUMHART, Manager and Chief Inspector.
DENVER, Colo., Room 2, Jacobson Bldg.,	THOS. E. SHEARS, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. WILLIAMS, JR., General Agent. F. S. ALLEN, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	PETER F. PESCUD, General Agent. R. T. BURWELL, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. GARDINER, Manager. W. W. MANNING, Chief Inspector.
PHILADELPHIA, Pa., Cor. Fourth and Walnut Sts.	CORBIN, GOODRICH & WICKHAM, General Agents. WM. J. FARRAN, Chief Inspector. S. B. ADAMS, Assistant Chief Inspector.
PITTSBURG, Pa., 1801-1802 Arrott Bldg.,	J. J. GRAHAM, Manager. BENJAMIN FORD, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.,	MCCARGAR, BATES & LIVELY, General Agents. C. B. PADDOCK, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. MANN & CO., General Agents. J. B. WARNER, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. ASHCROFT, Manager. J. P. MORRISON, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.,	H. N. ROBERTS, General Agent.

The Locomotive
of
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXX. HARTFORD, CONN., JULY, 1914. No. 3.

Water Tube Boiler Explosion, Meridian, Miss.

A Violent Explosion From a Water Tube Boiler.

Notwithstanding the fact that water tube boilers are frequently exploited as safer than those of the fire tube type, we occasionally are confronted with an exceedingly violent explosion caused by the failure of a water tube boiler. Such an explosion occurred June 8, 1914, at the plant of the Meridian Light and Railway Co., Meridian, Miss., when at 6.45 a. m., boiler No. 2, in a battery of five water tube boilers, exploded. The boiler, which was of the horizontal type, in which the water tubes are placed beneath a drum, connecting two water legs attached to and below the ends of the drum, failed by the tearing out of the rear head at the turn of the flange, where we are told the structure had weakened by the formation of a circumferential crack. Our information is such that we are led to believe that aside from the failure of the head, the boiler was but slightly damaged, and showed no other defects, although it turned a complete somersault in its journey from its setting to its final resting place in the street, some fifty feet distant.

FIG. 2. THE REAR HEAD, AFTER THE EXPLOSION.

The boiler room adjoined the engine and turbine room of the power house, and the boilers were set so that they backed up to the division wall. When the head tore away from the drum it was propelled backward through the division wall, portions of which it carried with it, and doing an as yet undetermined amount of damage to the turbines and electrical equipment in its path. At the same time the boiler proper was driven forward by the reaction of the issuing steam and water, and tearing its way through the boiler house, went end over end into the street. One man, a negro, John Ruffin, was killed, and two others were seriously injured by the accident. The property damage was estimated at from $30,000 to $50,000, although at the time our information was

Fig. 3. Wrecked Engine and Turbine Room.

obtained no close estimate of the damage to turbines and equipment was possible. All lighting, power and street car service was interrupted, and cannot be resumed until sufficient repairs have been made to permit the running of the remaining equipment. It is a matter of interest that the local newspaper, which depended entirely on the Lighting and Railway Company for its motive power, appeared on time through the enterprise of its management, who rigged a temporary countershaft, and backed an automobile up to a side door, jacked up the rear axle, belted the rear wheels to their countershaft, and ran enough of their machinery to get out the paper. We understand that acting on the suggestion obtained from the success of the newspaper, numerous other automobiles and even motorcycles were impressed for temporary service as isolated plants. Our photographs show the wreckage excellently. On the front cover is shown the boiler in the street, and in the background the wrecked boiler house. The drum, minus its rear head, faces the camera, and as this is the exact reverse of its initial position, it will be seen that our statement of somersaulting is proved. Fig. 2 shows the head which wrecked the turbine room, and Fig. 3, an interior view in the engine room, shows this destruction in the background.

Boiler Inspections *

S. F. Jeter.

Most of those present no doubt attended the recent banquet of the Insurance Institute and those who did I feel sure were impressed by what Professor

* A paper read before the Insurance Institute of Hartford.

Fisher said in regard to the chief function of insurance being the prevention of, rather than the indemnification for loss, and also what was told of the work of the life extension institute along these lines. What the life extension institute is now attempting to do for life insurance by periodic examination of the risk was a fundamental principle with boiler insurance from its inception in this country in 1866 and the boiler insuring company has been a life extension institute for boilers from the start.

In naming The Hartford Steam Boiler Inspection and Insurance Company it was decided to place Inspection before Insurance because it represented the more important of the two functions as expressed in the name. You have already been told by previous speakers that upwards of fifty per cent. of the gross premium receipts are expended in making inspections, so that you can see that boiler inspections are a very important part of the business of boiler insurance. The value of boiler inspections both to the assured and the insuring company can never be fully measured. The mistakes of the inspector always stand out in bold relief after an accident, as also the soundness of his advice when compliance with his recommendations and demands could be assumed to have prevented the accident, but how many explosions are prevented by timely warning and advice that is heeded can never be known. All comparisons regarding the relative number of accidents between boilers that are insured and those not insured seem to indicate that the uninsured boilers, which in nearly all cases mean the uninspected boilers, are very much more liable to explode than the insured boilers.

The present day "safety first" movement has apparently taken all by storm, but if full credit is to be given where credit is due, it must be remembered that boiler inspection was the first "safety first" movement placed on a business basis. Before telling you how inspections are made, it will be in order to briefly describe the qualifications required of boiler inspectors.

It is the first duty of the boiler inspector to prevent accidents to the boilers under his care, and after that to give such advice as will prolong the life of the boilers, reduce the operating costs to the owner and become a general instructor and walking encyclopedia for the plant operatives, particularly in mechanical matters, but often required to give advice in connection with family troubles. A good boiler inspector to a casual observer is an ordinary mortal, but in reality he is a wonderfully constructed being. He must possess a large assortment of apparently contradictory virtues. The layman naturally assumes that if a man knows boilers and can tell when repairs should be made and how to determine safe pressure, he is fully equipped as an inspector. If this were true, the insurance companies would have to hire a corps of bouncers to get rid of the applicants for inspectorship.

An inspector must of course know boilers thoroughly; in fact, he must know them so well that he feels confident that his recommendations or demands are absolutely right. On the other hand, he must be anything but bull-headed, and always open to argument, and be broad-minded enough to at once admit error if he finds he has taken an incorrect view owing to a lack of knowledge of all the facts or from any other cause. The inspector must be a close student of human nature, and know just how to approach an assured in order to get desired repairs made. Some people can be handed an idea, metaphorically speaking, on a silver waiter and assimilate it at once, while others require the use of an axe in order to make an impression. The inspector must be fully capable of deciding at once whether the silver waiter or axe is to be used, and if the wrong vehicle is employed no end of trouble results, and often a good risk is lost for the want of a little tact.

The inspector must have a backbone without joints when it comes to arguing a case with an assured who demurs regarding changes that are necessary for safety. The inspector is often given honeyed words and false praise in an endeavor to cause him to recede from demands for changes or recommended condemnation of unsafe apparatus, but if he knows he is right he must turn a deaf ear to all such blandishments.

The inspector must be physically robust, for boiler inspecting is no child's play, but is one of the most fatiguing of occupations. The inspector is often required to undergo severe temperature changes; notwithstanding, the inspection of boilers is a very healthful occupation owing to the exercise and outdoor nature of the work. The boiler inspector should be gastronomically built like a camel and learn to eat and drink when he reaches a point where food may be obtained. These gastronomic requirements do not particularly apply to New England inspectors, but in the West and South it is a real and necessary qualification. The inspector must be capable of expressing himself well, both orally and in writing, for it is only by properly presenting the findings of his inspection that he can hope to impress the assured with the value of his work.

The inspector must be cosmopolitan in every sense of the word, for while he necessarily comes in contact with and must treat in a manner to retain the friendship of lower grade employees in a plant, he must also be capable of meeting the higher officials on an equal footing.

Boiler inspections are divided into two general classes, usually termed external and internal inspections, but the names would better designate the nature of the inspections if they were called operating and general inspections. The external inspection is usually made without any previous notice to the assured and the inspector's duties in connection with this inspection are such that the operation of the plant is in no way interfered with, providing, of course, everything is found in order.

To make an internal inspection of a boiler it is necessary that it be idle and empty and the manhole and handhole plates removed, as well as otherwise prepared for examination. I will first describe the internal or general inspection, because the first of such inspections is the one required for the approval of the risk for insurance.

It will be assumed that an application for insurance on a plant consisting of boilers of the horizontal return tubular type has been secured and the inspector is assigned to make the inspection and report fully, giving the highest pressure for which these boilers are insurable. We will leave out the details of how he reaches the plant, assuming that he has been given definite directions in regard to its location, but I can assure you that finding the boilers is sometimes no mean part of the inspector's task.

On arriving at the plant the inspector should endeavor to see the owner or the one highest in authority. It is best to do this even if nothing more is done than to shake hands and let the owner know that the inspector is on the ground. First impressions are the most lasting and it is very essential that the boiler inspector make a good first impression on the management of a plant before offering criticisms which the inspection may disclose as necessary.

From the office the inspector is directed to the boiler room, where he usually meets the chief engineer and other plant attendants. At this meeting the inspector's ability to size up his man is most important, because the plant employee can make his task difficult or otherwise as he may see fit, and he also can be of inestimable value in imparting information regarding operating conditions which the inspector could not hope to obtain in any other way.

After disrobing, the inspector puts on his special suit of overalls and usually a hood and work shoes. Boiler inspecting is very dirty work unless the inspector is properly equipped, but with such equipment and reasonable washing facilities, the inspector can keep his personal appearance, when not actually engaged in work, beyond reproach.

In making the inspection it is important that a fixed scheme be followed — that is, each inspection of a return tubular boiler should be made in the same way. The particular routine observed is not of great importance, but sticking to the same routine for each inspection is very necessary; otherwise some points are very liable to be overlooked. On reaching the boiler room containing the boilers to be inspected, the logical procedure is to first make a general survey of the surroundings to ascertain how they affect the risk. Often an accident of a minor nature has resulted in the injury or death of an employee— causing mental anguish as well as physical pain, and besides an expense to the assured or insuring company which could have been prevented by providing reasonable means of exit. The blow-off connection is a fruitful source of such accidents. The blow-off valve is often located so that the man operating it is in a closely confined space with the piping so arranged that a break at any point during the act of blowing off is likely to cut off all means of escape. It is the inspector's duty to recommend the necessary changes required to prevent such an occurrence. The inspector should examine the location of the boilers with a view of determining the probable damage to surroundings should an explosion occur. This is particularly important in case of a very large coverage or of use and occupancy insurance. While the foretelling of the damage likely to result from an explosion is practically impossible, the general exposure of machinery and employees can be more or less well determined.

The steam and water piping as a whole has to be carefully considered to see that there are no connections that may lead to accidents or dangerous conditions of operation. The feed appliances such as pumps, injectors, etc., and the piping between them and the boilers must be inspected for safety as well as general plan and capacity, so that the boilers may at all times be supplied with an abundance of water to meet the maximum capacity they are capable of delivering.

The blow-off piping outside of the boiler setting must be thoroughly inspected, for notwithstanding the fact that the coverage of a boiler insurance policy usually ceases at the blow-off valve, the arrangement of piping beyond this point is often such as to produce conditions which may react on the parts included within the coverage. With separately set boilers the connecting pipes to the water space of the boilers must be examined to see that each is separate and distinct with check valves properly arranged to prevent the transfer of water from one boiler to another. In some cases with heating plants working on very low pressures and gravity returns, it is found best to do away with check valves between the boilers. The steam pipes must be so arranged that no pockets will be formed to trap condensation and it must also be connected so that the movement due to the expansion and contraction of the pipes can take place without undue strain on any of the parts. Many lives have been sacrificed owing to a lack of precaution and forethought in suitably arranging steam piping.

An examination of the connections and attachments for determining the water level must be made, for it matters not how strongly a boiler is built if the water line is continually carried below the fire line, even a small amount; disaster is almost certain to follow sooner or later. Water columns are frequently found set so low that the safety of the boiler is endangered. The blow-off or drain connection from the water column is examined to see that its size is ample. The connection from the steam space of the boiler to the top of the water column must be inspected to see that there are no connections on this pipe that are required to furnish a supply of steam for any other apparatus or that water can be trapped in the pipe. Either of these conditions will render the indications of the water level inaccurate. Whether the location of the steam gauge is correct or not must be determined; frequently a gauge is so connected to a boiler that the steam comes in direct contact with the spring or the gauge is fastened so that it is exposed to heat from some part of the boiler or smoke flue, either of which conditions render its indications inaccurate. The safety valve is a very important attachment and deserves the closest scrutiny to determine its condition. The escape pipe from a safety valve is often a source of danger and the inspector must see that it is properly drained and well supported to prevent undue strain on the valve.

If the boilers are of the suspended type, the ability of the supports to safely carry the load must be determined. This usually requires complete data of columns and supporting members as well as sizes of hangers, etc. The determination as to whether each support is carrying its proper proportion of the load is necessarily made, for the proper support of a boiler is just as important as regards its safety as is its strength in any other respect.

The inspector, after writing the answers asked on his data slip regarding the various parts examined so far, enters the top manhole of the boiler, with light, rule, calipers, hammer and usually a depth gauge. He first carefully examines the condition of the parts. The shell may show evidences of pitting, especially along and just below the water line. The tubes may be pitted, or thin from general corrosion. The braces may be weakened by corrosion or they may be loose, due to strain or improper fitting. The soundness of the braces is usually determined by striking them with the hammer as well as by visual inspection. The shell is carefully sounded to determine if there are indications of cracks or laminations in the shell material. Many of the rivets are sounded for tightness. The condition of the upper portion of the boiler as regards scale or oil deposits is ascertained and it is not uncommon to find the spaces between the tubes against the rear heads completely stopped with scale for a distance of a foot or more. Such conditions are very likely to lead to serious trouble, if not explosion. Any indication of oil in a boiler is a serious matter, for there is no substance likely to reach the interior of such a vessel that can produce an effect at such wide variance with the apparently harmless nature of the cause.

All openings to outside attachments or connections are examined to see if they are free; many boiler explosions have been caused by a stoppage of the water column connection. Where connections are supplied with a pipe screwed into a part of the boiler or into a flange riveted to the shell, the inspector must note whether the screwed joint has been fully made. Since this inspection is assumed to be the first one made of the boilers under question, the inspector must obtain the necessary data for calculating the strength. He must know the distance between the shell and tops of tubes to correctly estimate the amount of bracing required. He must know the number and size of braces at their least section on each head. The number and size of rivets attaching the braces to both the head and shell must be known so that the weakest element in the construction can be taken into account in calculating the strength. The thickness of the heads must be ascertained in order to estimate the strength of any unstayed surfaces and to judge whether a suitable bearing surface has been supplied against which the tubes were expanded. The pitch and size of the rivets must be obtained as well as the design of the joint, so that its strength relative to that of the solid plate may be determined.

The size of the rivets is usually judged from the dimensions of their heads. The thickness of the shell is necessary; this can usually be measured by means of a depth gauge applied along the edges of the plate at the girth seams, and it can often be calipered at an opening in the shell. If there is a dome on the boiler, the details regarding the bracing of the head as well as those of the connection to the shell must be secured, also the dimensions of the reinforcement around the opening from the boiler to the dome should this opening be of large size.

Upon coming out of the boiler, the inspector can place the data obtained on the data slip, but he usually waits until after completing his inspection to do so. The layman might think it a difficult feat to commit all of these measurements to memory, but the average inspector can generally repeat offhand the principal data of a boiler several weeks after taking it.

The next point to be examined is the interior below the tubes if the boiler is supplied with a manhole communicating with this part of the structure. The usual points to be given attention here are the soundness of the bracing, condition of the shell as regards corrosion or other defects; also heads and tubes, and note the quality and quantity of the scale attached to the surfaces. Quality of scale is just as important as quantity as regards its ability to injure a boiler or detract from its economical operation. The tube cleaner salesman and the boiler compound man frequently quote tables giving the different efficiencies of operation due to fixed thicknesses of scale in boilers. While there is more or less regular change in the efficiency of a boiler with increasing thicknesses of scale of the same quality, it is pure buncombe to state that a given thickness of any kind of scale will reduce the efficiency a fixed amount.

Proper make-up of the blow-off pipe is determined while the inspector is in the lower part of the boiler. If there is no manhole below the tubes, the information specified above is determined as well as possible while in the upper part of the boiler and also through the hand holes which are usually supplied in the front and rear heads of such boilers.

After completing the internal inspection, the inspector should examine the front heads externally. Here corrosion of the head and tube ends is very likely to occur, especially if the boiler is fitted with a stack connected directly to the extension sheet, for under these conditions rain may come down the stack during idle periods, and the sulphur deposit in the stack and on the head from the furnace gases combined with the moisture causes extremely rapid corrosion. The inspector must next examine the front especially to determine that no weight of the boiler is carried on it, unless it should happen to be one of the type, now rapidly disappearing, which is especially designed to carry the weight of the front end of the boiler.

The inspector now enters the furnace and notes the condition of the fire sheets and seams, and should make a careful examination of the surfaces to locate any brands or stamps which are placed on the sheets by the manufacturers of the material, and from which the tensile strength of the plate can usually be obtained. If rivets leak, it is the outside of the boiler that usually reveals this fact, and when leakage is discovered its cause has to be ascertained, so that necessary recommendations can be made. Leakage of the girth seams can be caused in many ways; if from scale or oil deposit the inspection of the interior already made will generally reveal the cause. Poor workmanship in making the boiler will usually be evident to the experienced inspector.

The location, shape and size of the bridge wall which forms the rear limit of the grate surface is often the cause or contributes to leakage at the girth seams. In many types of boilers the improper support is a contributing cause to such trouble. Feeding in the bottom of the boiler through the blow-off connection is a very fruitful source of such trouble. The inspector must examine into all of these phases of the case and recommend the necessary changes to relieve the trouble.

The inspector must keep a sharp eye for evidences of leaks coming from the vicinity of longitudinal seams. Any leak from such a location must be regarded with the gravest suspicion, for the cause is likely to prove a hidden crack. This defect has caused some of the worst explosions in the history of steam boiler insurance and no leak at a longitudinal seam should be considered harmless until it has been proven to be so.

The condition of the setting walls must be noted by the inspector, particularly with respect to their ability to properly support the boiler. The blow-off pipe should be examined to see that it is sound and free at the bottom — that is, that no weight is resting on it, as this is a very common source of accident. The freedom of the blow-off pipe where it passes through the setting wall is also essential to safety, as is the proper protection of the pipe from the direct impingement of the flame and highly heated gases from the furnace.

The rear tube ends must be examined for leakage and corrosion, and if such defects are disclosed, the cause must be determined and proper recommendations made. The condition and position of the covering over the rear combustion chamber must be examined into; the arches generally used at this point are frequently located so high as to cause the overheating of the head above the water line. The fusible plug which is located in the rear head must be inspected to see that the fusible metal is in proper condition to respond to an increase in temperature should low water occur. After examining the blow-off valve and outer portion of the pipe, the inspector is ready to test and if necessary to correct the steam gauge, and the inspection is completed.

The inspector after completing the inspection usually discusses the various points revealed by his examination with the chief engineer, and directs him in regard to the making of repairs or the betterment of operating conditions. Inquiry should be made as to the maximum steam pressure required to properly operate the machinery used in connection with the plant as this should be given due consideration in fixing the maximum pressure to be allowed. The inspector before leaving the plant should endeavor to see the highest one in authority that can be reached, and discuss with him fully all the facts developed by his inspection. In the average case the inspector is able to state at once whether or not a suitable pressure can be allowed on the boilers inspected.

The report of the examination is usually prepared after the inspector returns to his hotel or office, and it is reviewed by his chief inspector or someone under his direct supervision, who edits the report and makes any changes that may seem necessary. If changes to be made are of any importance, the report is held up until the subject can be discussed with the inspector or taken up by letter. The report, after receiving the approval of the chief inspector, is typewritten and mailed to the assured. The written report, being the official statement of the insuring company with regard to the condition of the boilers inspected, must always contain all the facts discussed between the inspector and plant management.

The external or operating inspection as previously indicated is generally made without any advance notice to the assured. The inspector arrives at the plant and usually visits the office before proceeding to the boiler room. The exact manner used to obtain admission depends on the plant rules in regard to such matters. While the external inspection is not nearly so complete as the internal, it is notwithstanding a very important inspection. Operating conditions can be observed at such an inspection and dangerous practices stopped before it is too late to check their effect on the boilers. The inspector has a card or list indicating the allowed pressure on the boilers to be inspected and on entering the boiler room he should note the gauge pressure carried, also the fact as to whether all the gauges register alike or not.

The water column must be blown down to determine the freedom of the connections leading to the column, this being made readily evident by the speed with which the water returns to its original level as well as the behavior of the water in the gauge glass if the boiler is steaming. The gauge cocks should be tried to see if they are free and in operating condition. An examination is next made of the fire surfaces of the boiler and the conditions of the furnace walls as far as can be ascertained from the furnace doors. Also notice is taken of any tendency towards leakage or bagging or blistering of the plates. The front flue doors are opened in order to view the tube ends, which can be examined for leakage and general condition.

The rear of the boilers is now to be visited and the condition of the blow-off valve and connection is determined as far as their operating condition is concerned. There is frequently a cleaning door located in the rear setting wall in such position that the fire surfaces and possibly the rear tube ends may be examined from this point.

The inspector next visits the top of the boilers and, ascertaining the steam pressure at the time, he tries the safety valves or has the engineer try them. With a safety valve of either the spring loaded type or of the ball and lever design and with the steam pressure not over 20 per cent. less than the pressure for which the valve is set, a very accurate idea of the pressure at which a safety valve will operate can be obtained by testing the freedom of the valve by hand. If the safety valve does not appear to be properly adjusted, the inspector requires that steam be raised until the valve operates in the regular manner or until the increase in pressure positively demonstrates that it is set for a pressure in excess of the limit allowed by the policy.

One of the most important features regarding the external inspection is the discussion of plant conditions with the employees, for information of the greatest value both to the assured and insuring company is often obtained in this way.

In conclusion I may say that the subject allotted to me has been so broad that I have been able to touch only on the regular inspection of one of the simplest types of boilers, while there are a large number of different types practically all of which are far more complicated than the one discussed, and each of these has its own peculiarities to be considered, so you can see that the subject of boiler inspections is almost unlimited in scope.

Boiler Feed Piping.

Boiler feed piping for the purpose of the present discussion may be considered to include everything from the feed heater to the discharge end inside the boiler. Because the feed line naturally divides itself into two parts, that inside and that without the boiler, with the point of division where the pipe enters the boiler shell, and also because these two portions of the feed piping perform somewhat different functions, and have somewhat different requirements, we will divide the discussion of them in the same manner.

Internal Feed Arrangements.

The purpose of an internal feed pipe, or an internal feed device of any sort, is to raise the temperature of the entering feed water as nearly as possible to that of the contents of the boiler before discharging it, and secondly to direct the flow of the discharged water so that it will assist and not retard the natural circulation due to convection currents in the boiler. In addition to discharging the feed in the direction of the natural circulation, it is also necessary to prevent the entering water from striking directly on heated shell plates or tubes, and particularly must this be avoided in the neighborhood of joints. Careful choice of layout for an internal feeding device may even do more than this, for it is quite possible to so direct the flow of the entering water, and to so control its temperature at the moment of discharge as to very greatly modify the deposition of scale and sediment, and in this way assist in the maintenance of a clean internal heating surface.

Years ago it was a common practice to feed boilers at the bottom. Sometimes this was accomplished through the agency of a mud drum into which the feed was introduced, while in other cases the feed connection was through the blow-off. Trouble was experienced because the water so introduced was of necessity colder than the water already in the boiler, even when a heater was used. The temperature difference, running anywhere from 50 or 60° to 100° F., depends on the pressures carried and the efficiency of the feed heater. Of course much greater differences could be obtained if high pressure boilers were fed with cold water, a condition frequently found even today.

The feed introduced in this way at the bottom of the boiler, colder than the water already inside, is of course always *denser* than the boiler water. Hence it cannot rise with the natural circulation, until it becomes heated to such a temperature that its diminished density makes it rise. It follows then that the feed must spread out on the lowest part of the boiler surface, displacing the hotter and lighter water, until it has taken up enough heat from the metal of the boiler to rise naturally and take its place in the circulation. The metal of the boiler is certain to become appreciably cooled by this enforced heating of cold water, and it will cool rapidly, because the *rate* of heat transfer from the hot metal to the cold water, depends on the temperature difference, and will be greater the colder the water. The cooling is also assisted by the fact that it takes much more heat to raise the temperature of a pound of water 1° than is given up by the cooling of a pound of steel through a like temperature range. Moreover, since the heating is so rapid, by far the greater portion of the heat given to the cold feed must come from the store of heat *already in* the metal. and not from the heat being transferred *through* the metal from without. Therefore, a cooling of the boiler metal through a considerable range at each entrance of fresh cool feed water is to be anticipated.

It is perhaps well to consider the magnitude of the mechanical stresses which may be involved when a structure like a boiler shell is locally cooled. Some years ago this subject was considered in The Locomotive (March, 1893) and calculations were made for the case of a steel boiler, working at 100 lbs., into which feed water at 100° F. was introduced. It was shown that under such conditions the plate would experience a drop in temperature of some 200° F. and also that if the plate could be conceived of as held rigidly at the edges by the unchilled portions of the boiler, stresses of 37,700 lbs. per square inch might be developed in the chilled portions of the boiler plate. This stress is great enough to seriously damage the plate, or indeed to rupture girth seams, but it is unlikely that so great a stress is produced, because the cooled portion of the plate is not held at its edges by an absolutely rigid structure, but is part of a shell which is elastic and yields under the pull of the cooled portion. Calculations which took account of this sort of action in the chilled boiler plate led to the conclusion that stresses of the order of 8,000 to 10,000 lbs. per square inch might be expected to occur in the particular boiler considered. This of course would be in addition to the pressure stress which a working boiler is always called upon to carry. It is therefore easy to see that a boiler plate, when stressed by the admission of cold feed water, must bear stresses quite too close to the elastic limit of the material for safety, and indeed cracks, ruptures, leaking joints, any or all of these defects are absolutely certain to follow the continued discharge of cold water directly on the shell of a high pressure boiler, and they frequently occur in a surprisingly short space of time.

The most familiar means for avoiding trouble of this nature is some form of internal feeding device which shall provide a means for raising the temperature of the entering water to boiler temperature before it is discharged and allowed to mingle with the boiler contents. In general, two methods are available for accomplishing this, the internal feed pipe, and the method of spray or steam space feeding.

The internal feed pipe consists of a length of piping disposed near the water line of a boiler, and of such length that the feed may be heated in traversing it very nearly to the boiler temperature. The discharge end is then so located, depending on the type of boiler, as to direct the water flow away from joints and the shell, and so far as possible, along the path of the natural circulation.

The various forms of steam space feed depend on breaking up the incoming water into a spray or thin sheet so as to expose as large a surface as may be to contact with the steam. The effect is to condense enough of the steam to raise the water to boiler temperature while falling to the surface of the water already in the boiler. One form of this device used largely abroad, where boiler forms are such as to render it practicable, consists of a series of trays so disposed in the steam space that the entering water flows over them in thin sheets and is heated by contact with the steam, at the same time depositing much if not all of its scale forming solids on the trays. The objection to such an arrangement in the boilers in common use in this country is that so much of the available room above the water line would be taken up by the device that the boiler would be almost inaccessible for inspection, and indeed this is a serious objection to many forms of steam space feed. Another objection is that under some conditions of loading, and especially in a boiler of restricted steam room, the introduction of a spray feed has a tendency to increase the moisture content of the steam. This objection has been much overrated, and many times a top feed would work well in boilers where the operator fears to introduce it because he expects a large increase in the moisture carried by the steam.

The exact design of an internal feed pipe must vary with the type of boiler. In the familiar horizontal return tubular type the best practice is to carry the pipe through the front head at the side and just above the top row of tubes. The pipe then extends back toward the rear head for about ⅔ or perhaps ¾ of the tube length, running parallel to the tubes. At this point its direction is changed through 90° by an elbow, and the pipe is carried across the boiler to a point near the opposite side where it terminates in an open elbow, which is arranged to look down. The pipe should be rigidly supported by straps from the braces so that there can be no chance of its rubbing on the tubes or plate when it pulsates under the intermittent action of the pump. If rubbing should occur, a very rapid corrosive action is to be expected at the point of contact. The cause, often wrongly attributed to friction alone, is to be found in the displacement of rust or scale at each pulsation of the feed pipe so that fresh metal is constantly exposed to the corrosive action of the boiler water, so that a rapid attack is to be expected even from waters not otherwise especially corrosive.

In a vertical tubular boiler the internal feed pipe, when present, is usually fitted to discharge just below the water line, near the center of the tube nest. This arrangement, while in most cases quite satisfactory, has been the cause of trouble in at least one case, from the repeated contraction and expansion of the tubes directly exposed to the impingement of the entering water. This may perhaps be due to the fact that in this type of vessel it is not very easy to arrange an internal pipe long enough to serve as efficiently as does its counterpart in the horizontal tubular boiler. However, with the feed heated to a reasonable degree by some of the many forms of feed water heaters, no trouble need ordinarily be anticipated. In very small vertical boilers, it is usual to introduce the feed water at a point near the bottom of the water leg, although this practice is not to be commended.

In locomotive type boilers, wherever the construction makes it possible, an internal feed pipe of the type described for horizontal tubular boilers should be used. When this is not possible, the feed should be introduced in the barrel as far from the fire box as is feasible.

Where feed pipes pass through boiler shells or heads, we have found the best construction to consist of a boiler bushing of either brass or steel, threaded tightly into the head or shell plate, and with an internal thread into which the outside portion of the feed pipe may be screwed on the outer end while the internal pipe is screwed into the inner end. The bushing should be long enough to permit both these connections to be made to the full depth of thread required by standard pipe fittings of the diameter used, without the ends of the two portions of the feed pipe binding on each other inside the bushing before the joints are tight.

Two general considerations should always receive attention before a layout for an internal feeding device is approved. First, it is imperative that the internal piping be arranged so as to remain full of water, for should it become in part steam bound, a water hammer is to be expected when the water flow is again established. Secondly, the piping should be so placed as to be readily accessible for cleaning and repair, as the internal portion of a feed line is subject to incrustation or choking from scale, and when partially filled with such a deposit, it may not be able to supply feed fast enough to meet the conditions of maximum steam demand without permitting the water level in the boiler to become dangerously low. A choked feed pipe is especially dangerous in a plant where it is the practice to feed up the boilers as much as they will stand without priming, and then let the level gradually lower to the lowest safe limit on peak loads, so that the fireman need not contend with the added effort of heating incoming feed water when called upon for the greatest flow of steam. Under these conditions, and they are quite too common, if the feed pipe is not free, and the pumps in good order, trouble is very apt to be experienced in getting the water line back to a safe point if for any reason the excessive draught of steam should last a little longer than is usual, or if the fireman should be a little careless and let his water go too long before starting to feed up again.

The best material for internal feed pipes must be left for individual conditions to determine to some extent. On the other hand, it is true that with few exceptions, brass is to be preferred. Brass pipe will outlast iron in boilers fed with very pure soft water, carrying some organic matter, and will have a life at least as long as iron in the great majority of boilers. More important perhaps even than the question of durability is the great freedom of brass pipe from choking. This is due both to the fact that no rust scale forms, and to the great difficulty which ordinary scale matter seems to experience in attaching itself to this material. This greater freedom from scale deposits has at times been questioned, but the record of long experience seems to justify the statement. The gain in safety from a clean feed pipe is greater than might be expected, for in addition to the greater area of an unchoked pipe, there is the very greatly lessened friction of the smooth internal surface. The choking of feed pipes is particularly troublesome in some parts of the country where boilers must be operated on waters carrying large amounts of scale matter, and we have frequently observed cases where the pipe was so nearly closed off by deposits of hard scale as to make it a matter of wonder how the boiler could possibly have been operated so long without replacing or cleaning the pipe.

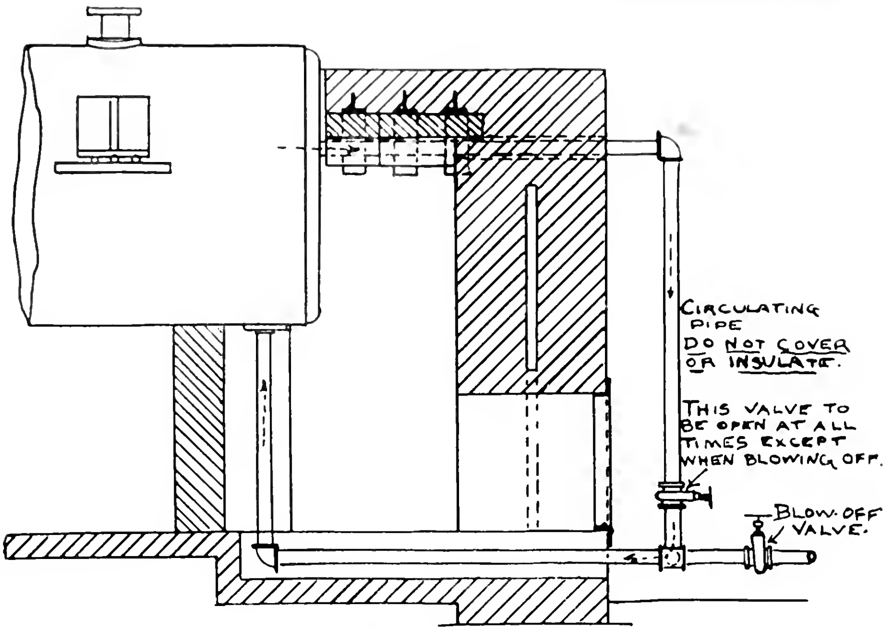


FIG. 1. SKETCH OF CIRCULATING PIPE.

One reason why the practice of feeding through the blow-off has persisted so long in some regions, in spite of all recommendations to the contrary, is that this practice protects the blow-off pipe. Where a very large amount of scale matter is deposited by the feed water there is a tendency for sediment and scale to form in the blow-off pipe, and when this sediment becomes hardened and attached to the metal, overheating follows, since the blow-off passes through about the hottest part of the boiler setting, where it receives the direct impact of the hot blast from over the bridge-wall. When there is a constant flow of feed water through this pipe, the sediment is kept well stirred up and has much less chance to settle and bake on with disastrous results. We cannot see, however, why this fact, true though it undoubtedly is, should be made an excuse for preserving the blow-off at the expense of the boiler itself. It is a very simple matter to arrange a circulating pipe as shown in Fig. 1, which will accomplish all that the feed water can do in the way of keeping the blow-off free, and at the same time will permit feeding the boiler in the safer manner through a proper internal feed pipe. The action of the circulating pipe is so simple that it is hardly necessary to comment on it; a glance will show that the vertical part of the connection, since it is outside of the setting and not covered, will radiate heat to the atmosphere fast enough to cool the column of water contained in it. This cooled water, as it is denser than the boiler water in the proportion of their difference in temperature, will flow down into the blow-off pipe, there to be again heated by the impact of the hot gases, and thus as it rises again to the boiler a flow will be established which will be rapid and will be maintained automatically as long as the boiler is under steam. Experience shows that such an arrangement will effectively overcome the scaling and overheating of the blow-off at least as well if not better than the flow of the entering feed. It will be seen from the sketch that a valve is fitted in this vertical pipe, near the tee where it joins the blow-off line. This valve should be open at all times except when the boiler is being blown down, and it should be manipulated in a regular routine with the blow-off valves, so that the operatives will acquire the habit of first closing the circulating valve, then blowing down in the usual way, and finally when the blow-off is again secured, open the circulating valve. The importance of such a routine in preventing lapses of memory in the performance of duties of this sort may best be appreciated if one will attempt to tie one's shoes in the opposite order from that to which he is unconsciously accustomed, and see what a degree of mental effort is required to accomplish it.

In water tube boilers, the same principles should be applied as in fire tube boilers. The feed should not be introduced through mud drums or directly on the heating surface, but some form of internal feed pipe, adapted to the design of the boiler, and which will be accessible, heat the feed water properly, direct its flow away from the heating surface and in line with the natural circulation current should be provided. This will usually be most easily accomplished by feeding in an upper or steam drum. Many excellent devices to do this have been designed by the various builders of water tube boilers, and many attempts have been made to combine with the feed heating device some arrangement which will arrest and hold the sediment deposited by the entering feed when heated. There is only one objection to these devices and that is that in the smaller drums usually associated with this type of boiler construction, it is rather difficult to so design an effective water heating device which can at the same time act as a scale catcher, without seriously obstructing the spaces which must be visited by the inspector, and therefore rendering difficult the detection of incipient defects.

A single case exists where it is permissible and indeed advisable to feed boilers through the blow-off connection. Where boilers are operated at low pressure for steam heating, and are fed with the condensed water returned from the radiating surface, then since the temperature differences are not great, both the circulation in the system, and the return of the condensate will be facilitated by feeding through the blow-off. This subject was discussed in The Locomotive for January, 1913, and suitable arrangements and precautions for such an installation were described at that time.

External Feed Piping.

External feed piping should be laid out so as to secure the most reliable supply of feed water for each boiler which is possible. It should also secure for each boiler a feed supply which is as nearly as may be independent of conditions in every other boiler.

To this end it is best to employ extra heavy brass pipe for the entire feed system from the heater to the boilers because of the greater freedom of brass pipes from choking and so stopping the water flow, as well as because of its longer life under the corrosive action of hot water.

The layout of the external feed line should be such as to secure a direct short connection to each boiler, with all portions of the piping accessible and in plain sight, to facilitate inspection and repair. With the exception of a stop valve and in some cases a relief valve near the pump, all valves should be located in the separate branches, keeping the main line free. All feed lines are best fitted with tees or crosses instead of elbows, where a change in direction is necessary, the unused openings of which should be plugged so that the runs may be cleaned with the least possible loss of time. To further facilitate the quick repair of either the main line or its branches, either flanged or screwed unions should be used with reasonable freedom, so that a portion of the piping may be removed without any very general dismantling of the system. Provision should be made for the necessary expansion, and care should be also taken to see that the piping is anchored securely against the pulsating effect of a reciprocating feed pump.

Each branch to a boiler should be fitted with a swing check to prevent the flow of water back into the line from the boiler, and also with at least one stop valve, gate preferred, for regulating the water flow to that boiler, located between the check and the boiler. When two or more boilers are fed from the same feed line, it is best to provide two stop valves, one on either side of the check valve, so that the branch pipe or the check for any boiler may be overhauled without interfering with the operation of the unit.

The location of the stop valve used for the regulation of the feed to a boiler is a matter for some consideration. In the first place its location will be determined by the level from which the water tender or the fireman is to work. In plants where the water glasses are high up on vertical or other high boilers, so that a gallery is provided for the supervision of the gage glasses and gage cocks, then it is probably best to locate the feed valves so that they may also be operated from the same gallery, and the water tender may then get at all of his valves and gages with the least loss of time and effort. When, however, the water is under the control of the fireman, or a water tender most of whose duties require his presence on the firing floor, then the valves should be located at some convenient point, preferably on the boiler fronts where they are easily accessible without the necessity of leaving the fires to adjust the feed.

Some Results From the Working of Steel Plate.

We have two very unusual illustrations, from widely different sources, showing interesting results which followed the working of the plate in the boiler shop.

Fig. 1 is a photograph of a portion of a large plate of open hearth steel from a well known maker. The plate was 80½" wide, 105" long, and 1" thick. It was punched with four groups of 10 holes each, arranged so that there was a group of holes near either end of each long edge, one group showing in the photograph. These holes were 1" in diameter, and were pitched 3" apart. After the completion of the punching operation, a 2¼" flange was turned along each of the short edges, and a portion of one of these flanges is also shown in the illustration. A close study of the picture will disclose the line of heating back of the turn of the flange, and will show that it did not extend very far back into the plate. The flanging was completed at just about six o'clock in the evening, and so the plate was set aside over night. In the morning, when the

FIG. 1. CRACKED 1" PLATE.

workmen started to resume operations on this particular job it was discovered that during the interval a crack had developed as is shown in our view. This crack extended from the third rivet hole, which was 12" back from the turn of the flange, 34" into the plate, terminating at a point 22" back from the flange. The crack stood open at the plate edge about 1/4 inch, and the portions of the plate were sprung so that the two edges of the crack were separated about 1/4 inch in a direction perpendicular to the surface of the plate. The plate appeared and worked like good soft material. The buttons punched from the holes stood up well when they were hammered down flat, both endwise and sidewise, and under this flattening showed no undue tendency to crack or crumble.

Several possible causes for such a behavior suggest themselves, but in the absence of information which could only be arrived at by a careful microscopic

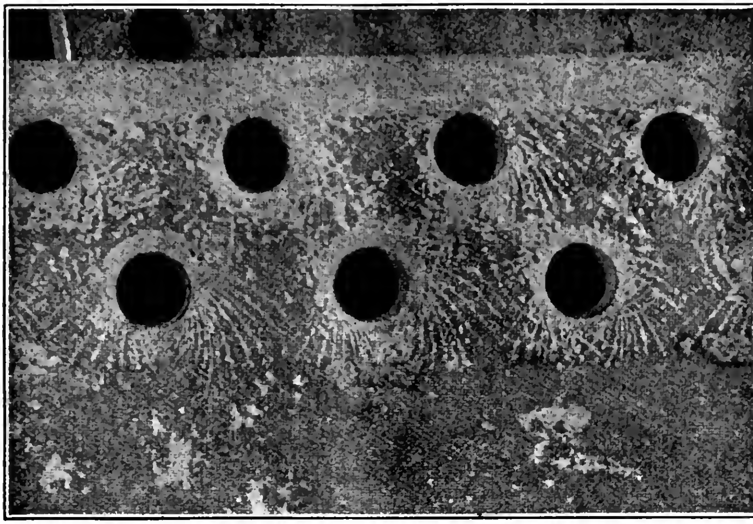


Fig. 2. Surface of Plate Disturbed by Stresses from Punching Holes.

and chemical study of the material in the neighborhood of the failure, we hesitate to pronounce an opinion, preferring to leave the matter open to the discussion of those interested.

Fig. 2, reproduced from the Zeitschrift für Dampfkessel und Maschinenbetrieb shows a difficulty of another sort. It illustrates the disturbance of the mill scale on a piece of boiler plate due to punching holes for a double riveted seam. This is a particularly good illustration of the disturbance of the metal caused by punching, and merits careful study, especially as to the direction and grouping of the radiating lines. The plate was 0.47 in. thick, the holes 0.87 in. in diameter, pitch 2.8 in., distance between rivet rows 1.77 in., and the distance from the edge of the plate to the first row of rivets was 1.34 in. The length of the longest radiating line was about 1.2 in.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. Perry, Editor.

HARTFORD, JULY, 1914.

Single copies *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
The Locomotive of The Hartford Steam Boiler I. & I. Co.

We wish to call attention to the article in this issue on feed piping. It came about as the result of repeated requests for information on the different phases of the feed pipe question; and the discovery when we consulted our files that this important feature of boiler installations had been neglected in our columns for many years. We felt that while it might be charged that there was little new to be brought forward at this time, still a review of the whole subject which would gather together the best in our previous articles and bring the matter down to date might be of value and interest to many of our readers. We present it therefore, not as new or particularly original, but as a careful reiteration of our position in the matter.

One of our departments has recently pointed out to us a curious inconsistency which has been met in the field; the case of the manufacturer who is very willing, even eager to secure insurance protection for the boilers at his place of business but who cannot or will not see the necessity of covering with insurance the vessels used to heat his residence. Can it be that boiler users are unwilling to extend the same degree of protection to their personal property and the life and limb of their family that they willingly provide for their factories and employees, or is it merely that people have not yet awakened to the potential danger of heating boilers? If it be the latter (and pleasanter) reason, a moment's perusal of The Locomotive explosion lists covering the months from October to April of any year should be sufficient to dispel it.

We do not believe that in the ultimate analysis, either of these reasons would prove correct. We hesitate to think that the average power boiler owner is either careless of the safety of his family and the value of his household goods, or entirely unaware of the hazard connected with the operation of all boilers, whether worked at high or low pressure. We feel inclined to think that his neglect is really due to oversight, a failure to stop and consider the possibilities of the situation in the press of other business. This belief of ours is strengthened by the fact, many times brought to our notice, that when one of these boiler owners is brought face to face with an accident to one of his power boilers, he immediately seeks ample protection for all the other vessels in his possession, or under his charge.

Obituary.

CHARLES A. BURWELL.

Charles A. Burwell, who was connected with the Hartford Steam Boiler Inspection and Insurance Company at its Cleveland office for many years, serving as Inspector, Chief Inspector, and later as Manager, died at his home in Cleveland Monday, June 1st. He is survived by a widow and two sons.

Mr. Burwell was born at Talmadge, O., in 1838. Moving to Cleveland later he attended the schools there, leaving the high school in 1858. He became an apprentice to the first plumber who settled in Cleveland, and continued at that business until he joined the Hartford's forces as an inspector in 1882. He retained his connection with the Hartford until his death although he retired from active service in 1908.

JAMES F. QUIGG.

Mr. James F. Quigg, for many years an employee of our New York department, died April 27, 1914. Mr. Quigg was born January 23, 1862, and entered our New York office at the age of 14 or 15, where he remained until his death. Mr. Quigg never married. He served the Company long and faithfully, and to the best of his ability.

A New Hazard from the Pressure of Steam, Affecting the Agricultural Districts.

When one attempts to keep track of the vagaries of steam container explosions he must expect to be lead by various and devious paths. We have discussed explosions of omelets, explosions of peas, and even ducks and sausages have burst with such dire results as to eventually find a place in our record of explosions. Now indeed a calamity has come to light. All our special agents in the northern agricultural districts must conceal their whereabouts unless they wish to explain why we do not desire to write Pumpkin endorsements. We are even wondering if we shall not be called upon eventually to start a course of instruction for Pumpkin Inspectors. The cause of all this underwriting commotion is to be found among our newspaper clippings, and runs as follows:

Pumpkin Explosion, Demolishing Stove.

STEAM FORMS IN FROZEN GOURD WHEN PLACED IN OVEN BY POUGHKEEPSIE WOMAN.

(Special to The Free Press.)

Poughkeepsie, N. Y., March 20.— Mrs. James Crasher of Freedom Plains, Dutchess County, is minus a kitchen range and wonders why she escaped without serious injury in a peculiar accident today.

A pumpkin which she was thawing out in the oven blew up and wrecked the stove, besides shattering every window pane in the kitchen.

Steam which formed inside the pumpkin caused the explosion. Mr. Crasher had left the pumpkin in a wood shed where it froze.— (*Detroit Free Press.*)

Fly-Wheel Explosions.

1914.

(1.) — A fly-wheel exploded January 17, at the plant of the Parsons Pulp and Paper Co., Parsons, W. Va. Three employees were seriously injured and the plant was shut down for some two weeks pending repairs.

(2.) — On March 17, a fly-wheel exploded at the handle factory of E. A. Burnett, Harbor Springs Mich. Portions of the wheel destroyed the roof of the building and one fragment struck the engineer, rendering him unconscious. He was seriously but not fatally injured.

(3.) — On March 21, a fly-wheel exploded at the plant of the Seymour Manufacturing Co., Seymour, Ind. The fragments of the wheel did some considerable damage to roofs and buildings, but missed injuring any workmen although there were many of them directly exposed to the danger.

(4.) — A 12-foot fly-wheel exploded March 31 at the tissue paper mill of the Sweet Bros. Manufaçturing Co., Phoenix, N. Y. Fragments of the wheel were thrown for great distances, one piece landing across the Oswego River, 1000 feet from its starting point. No one was injured, though we are told that one person was covered with mud from the impact of a fragment landing beside the road on which he was walking.

(5.) — An extractor exploded May 1, in the laundry of Charles Lehman, Jersey City, N. J. Three men were killed by the explosion.

(6.) — A fly-wheel burst May 5, at Bon Ami, La. One man was killed.

(7.) — A fly-wheel exploded May 13, at the plant of the Carbo Steel Post Co., Chicago Heights, Ill. One man was killed, and one other slightly injured by the flying fragments.

Boiler Explosions.

January, 1914.

(Concluded from the April, 1914, Locomotive.)

(43.) — A heating boiler ruptured January 17 at the store of Long Brothers and Co., Federalsburg, Del.

(44.) — A small boiler burst January 17, in the kitchen of the National Preparatory School, Philadelphia, Pa.

(45.) — A boiler exploded January 17 at the saw mill of Bartlett Bros., Shavertown, N. Y. George Bartlett, one of the owners of the mill, and George Hubbard, fireman, were fatally injured. The mill was completely demolished.

(46.) — On January 18, a tube ruptured in a water tube boiler at the State Hospital for the Insane, Mt. Pleasant, Ia.

(47.) — Seven sections ruptured January 20, in a cast iron sectional heater at the grocery house of J. B. Blood and Co., Lynn, Mass.

(48.) — A boiler ruptured January 21, at the St. Mary's School for boys, Feehansville, Ill.

(49.) — A vulcanizer exploded January 21 in the garage of H. C. Lintott, Nashua, N. H. There was a considerable property damage.

(50.) — A boiler exploded January 21 at Howick pavilion, Ottawa, Can. This building was used as an exhibition building in connection wth Ottawa's winter fair. Three men are known to have been killed, many were injured, and a very large number of prize horses and live stock, of very great value were killed and injured. The property loss has been estimated as in excess of $450,000, largely on account of the value of some of the stock killed.

(51.) — A heating boiler exploded January 21, in the high school building at Warren, Ill. The damage was confined to the boiler.

(52.) — On January 22, an accident occurred to a boiler in the office building of B. F. Kauffman et al., Des Moines, Ia.

(53.) — A boiler exploded January 22, at the plant of the Shelby Iron Co., Shelby, Ala. Two men were killed and one injured. The property damage amounted to about $2,000.

(54.) — On January 23 a tube ruptured in a water tube boiler at the plant of The Chapin-Sacks Mfg. Co., Washington, D. C. One man was injured.

(55.) — A cast iron header ruptured January 26, in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(56.) — On January 27, a tube ruptured in a water tube boiler at the plant of the National Tube Co., Pittsburgh, Pa. Four men were injured.

(57.) — On January 28, a boiler ruptured at the Young Men's Christian Association, Omaha, Neb.

(58.) — A tube ruptured January 30, in a water tube boiler at the plant of The Union Specialty Machine Co., Chicago, Ill. One man was killed.

(59.) — On January 30, the furnace of a vertical boiler collapsed at the lumber mill of E. P. Benton and Co., Charleston, S. C.

FEBRUARY, 1914.

(60.) — An accident occurred to a boiler at the plant of the Union Special Machine Co., Newburgh, N. Y., on February 1. The engineer was scalded to death as a result of the accident.

(61.) — On February 1, a 40 gallon hot water tank exploded at the home of F. Irving Sears, Webster, Mass. The property damage was estimated at $5,000.

(62.) — The crown sheet collapsed in a boiler on the dredge Panama, owned by Johnson & Co., Miami, Fla., on February 2.

(63.) — Two sections ruptured February 3, in a cast iron sectional heater at the Owl Amusement Co.'s theater, Central St., Lowell, Mass.

(64.) — A boiler burst February 3, at the Hotel Utica Garage, Utica, N. Y. The fireman, who was standing near the boiler at the time of the accident, was severely scalded.

(65.) — A section ruptured February 4 in a cast iron sectional heater at the New Dublin Hotel, Dublin, Ga.

(66.) — A boiler exploded February 5 at the saw mill of Thomas Hayer near Urban, Ky. Six men were instantly killed and many more were injured, some perhaps fatally.

(67.) — A traction engine used on road work near Howenstine, O., was wrecked February 5 by the explosion of its boiler. Three men were injured, one of them fatally, while there was some doubt expressed as to whether one of the others could recover.

(68.) — On February 6, a tube ruptured in a water tube boiler at the plant of the Indianapolis Light and Heat Co., Indianapolis, Ind.

(69.) — A tube ruptured February 6, in a water tube boiler at the plant of the American Steel and Wire Co., Waukegan, Ill.

(70.) — A cast iron sectional heater ruptured February 6, in the building of the Brier Shadel Mercantile Co., Hiawatha, Kan.

(71.) — A Wabash switch engine dropped its crown sheet February 7 at St. Louis, Mo. The force of the explosion was sufficient to drive pieces of metal through a near-by house, and the escape of persons occupying the damaged rooms at the time of the accident seems almost unbelievable. A railroad watchman, 76 years old, seated in his shanty near the scene of the accident, was severely scalded and bruised.

(72.) — On February 8, a tube ruptured in a water tube boiler at the Skelp and Sheet Tin Mill of The Reeves Mfg. Co., Canal Dover, O.

(73.) — A tube ruptured in a water tube boiler at the hotel of the Coronado Beach Co., Coronado, Cal., on February 9th. The property damage was small, but R. M. Johnson, assistant engineer, and Fred. Strum, fireman, were injured.

(74.) — A blow-off pipe ruptured February 11, at the plant of the Wm. Lawther Co., Dubuque, Ia.

(75.) — Two sections ruptured February 11, in a cast iron sectional heater at the stable of The Henry Siegle Co., Albany St., Boston, Mass.

(76.) — A boiler used for pumping oil exploded February 11, at the lease of the Bankline Oil Co., near Bakersfield, Cal. No one was injured.

(77.) — A public school was destroyed by fire February 12, at Hoboken, N. J. The fire originated from the explosion of the heating boiler.

(78.) — A steam heating boiler exploded February 12, in a street car on the Camden and Trenton Line at Burlington, N. J. Four persons were injured, one of them seriously.

(79.) — A heating boiler burst February 12, in the basement of the North Asbury fire company's house, Asbury Park, N. J.

(80.) — On February 12 a section failed in a cast iron sectional heater at the Arlington Five Cent Savings Bank, Arlington, Mass.

(81.) — One section and one manifold ruptured February 12, in a cast iron sectional heater in the gymnasium of the Dana Hall School, Wellesley, Mass.

(82.) — A cast iron header ruptured February 12, in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(83.) — On February 12, a six inch elbow in a return pipe ruptured under a boiler at the greenhouse of Geo. Bayer & Sons, Toledo, O.

(84.) — A boiler ruptured February 12, at the greenhouse of the J. M. Gasser Co., Cleveland, O.

(85.) — A section ruptured in a cast iron heating boiler February 15 at the Young Men's Christian Association Building, Billings, Mont.

(86.) — A water heating boiler exploded violently February 15 in McCarthy Bros. restaurant, Elkhart, Ind. One man was seriously and perhaps fatally injured.

(87.) — A cast iron header ruptured February 16, in a water tube boiler at the plant of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(88.) — On February 16 a section fractured in a cast iron sectional heater at the plant of the Northern Stores and Dock Corporation, D St., South Boston, Mass.

(89.) — A blow-off pipe failed February 16 at the plant of Frederick Stearns & Co., manufacturing pharmacists, Detroit, Mich. Daniel Bell, a boiler maker, was slightly injured.

(90.) — On February 16 a blow-off pipe failed at the plant of the Cincinnati Coffin Co., Cincinnati, O. John Shockley, night fireman, was injured.

(91.) — A section ruptured in a cast iron heating boiler February 18 at the Carl Leon Hotel, operated by A. C. Stitch and G. M. Carpenter, Independence, Kan.

(92.) — A boiler ruptured February 16 in the J. A. Moeller Creamery, Cedar Rapids, Ia. One man was scalded.

(93.) — A boiler exploded February 16 at the Acme Mills, Knob Noster, Mo. No one was injured, but the property damage was estimated at $2,000.

(94.) — A hot water boiler exploded in a demonstration car belonging to the Pittsburgh and Southern R. R., February 16, at Chicago, Ill. One man was knocked insensible, and much damage was done to surrounding property.

(95.) — A small boiler exploded February 18, at the Hi Mount Bakery, Lake Charles, La. No one was injured, but there was some damage to property.

(96.) — The crown sheet of a locomotive type boiler collapsed February 18 at the plant of the Storb Trappe Rock Co., Pottstown, Pa.

(97.) — A boiler ruptured February 19 at the saw mill of the Smith Cooperage Co., Livermore, Ky.

(98.) — A tube ruptured February 19, in a water tube boiler at the plant of the King Paper Co., Kalamazoo, Mich.

(99.) — On February 19 two cast iron headers ruptured in a water tube boiler belonging to the Continental Trust Co., Baltimore, Md.

(100.) — Three cast iron headers ruptured February 21, in a water tube boiler at the plant of the Milwaukee Coke and Gas Co., Milwaukee, Wis.

(101.) — On February 22, a tube ruptured in a water tube boiler at the North Boiler House, Building No. 70, of Swift & Co., Chicago, Ill. Considerable damage was done to the boiler.

(102.) — A boiler exploded February 22 at the power house of the Bellevue Illuminating and Power Co. Bellevue, O. Two men were fatally injured and the interior of the building was badly wrecked.

(103.) — A tube ruptured February 23, in a water tube boiler at the plant of the Miller Lock Co., Philadelphia, Pa.

(104.) — Four tubes collapsed February 24, in a boiler at the tannery of the National Calfskin Co., Peabody, Mass.

(105.) — Two cast iron sections ruptured in a sectional heater February 24, at the apartment house, The Sheffield, Boston, Mass.

(106.) — A tube ruptured February 24, in a water tube boiler at the plant of Peet Bros. Mfg. Co., Kansas City, Kan. A fireman was injured.

(107.) — A cast iron header ruptured February 24, in a water tube boiler at the Pumping Station, City of Troy, Troy, O.

(108.) — A boiler exploded February 24, at the residence of W. Irving Wolfe, Far Rockaway, N. J. The damage was estimated at $4,000.

(109.) — The boiler of an Erie locomotive exploded February 24 at Creston, O. Two men, the fireman and a brakeman, were fatally injured.

(110.) — A boiler exploded February 24, at a portable saw mill near Howard City, Mich. Two men were seriously injured, and the boiler was demolished.

(111.) — A cast iron hot water heater ruptured February 25 at the residence of the Sisters of the Holy Ghost Corporation, Hartford, Conn.

(112.) — On February 25, a tube ruptured in a water tube boiler at the plant of the Barney & Smith Car Co., Dayton, O. The engineer was slightly injured.

(113.) — A cast iron section ruptured February 25 in a heating boiler in the apartment house of Hugh Greenberger, 111-113 Easts 113th St., New York City.

(114.) — A blow-off pipe failed February 26 at the high school of the School District of St. Joseph, St. Joseph, Mo. The engineer was injured.

(115.) — A tube ruptured, February 26, in a water tube boiler at the plant of Crane Co., Chicago, Ill.

(116.) — A hot water heater exploded February 26 in the apartment house at 1757 3d Ave., New York City. Three persons were injured, and the property damage was large.

(117.) — A locomotive boiler exploded at the plant of the American Hominy Co., Indianapolis, Ind. The engineer was injured.

(118.) — The boiler of a dredge belonging to Wills & Lasswell, Kenentt, Mo., exploded February 26. The dredge was wrecked and the engineer badly injured.

(119.) — A boiler ruptured February 27, at the plant of the Chapman Steel Co., Indianapolis, Ind.

(120.) — On February 27, a cast iron header ruptured in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(121.) — An accident occurred to the boiler of the Grace M. E. Church, Newburgh, N. Y., on February 27.

(122.) — A tube ruptured February 28, in a water tube boiler at the plant of the Oliver Chilled Plow Co. South Bend, Ind. One man was injured.

(123.) — A blow-off pipe failed February 28, at the plant of the Sigourney Electric Co., Sigourney, Ia. One man was slightly injured.

March, 1914.

(124.) — On March 2, a corrugated furnace collapsed in a Scotch marine boiler located at the plant of the Rockford Electric Light Co., Rockford, O. The boiler was injured to such an extent as to necessitate extensive repairs, while Lewis Henson, a visitor to the plant at the time of the accident, was injured.

(125.) — A hot water heater exploded March 2, in a restaurant at Canton, O. One man was injured. The accident was attributed to frozen connections.

(126.) — A hot water heater exploded March 2 in the book bindery of Wm. A. Leonard, Baltimore, Md. Mr. Leonard and an employe were seriously bruised and scalded as a result of the accident.

(127.) — A cast iron sectional heater exploded violently March 3, in the basement of the St. John's Lutheran Church, Des Moines, Ia. The building was badly wrecked by the force of the explosion. (See the April, 1914, Locomotive for a more detailed account of this accident.)

(128.) — An old boiler used to furnish power for wood sawing exploded March 3 on the farm of Fred. LeBarr, Howard City, Mich. Although six or seven persons were grouped around the outfit at the time of the explosion, only one of them was injured.

(129.) — A marine type boiler ruptured March 3, at the plant of the Ætna Laundry Co., Indianapolis, Ind.

(130.) — A cast iron header ruptured March 3, in a water tube boiler at the plant of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(131.) — A boiler ruptured March 3 at the Electric Light and Water Works Plant of the Village of Stephan, Stephan, Minn.

(132.) — A tube ruptured March 4, in a water tube boiler at the plant of the Carnegie Steel Co., So. Sharon, Pa. One man was injured.

(133.) — A heating boiler exploded March 5 at the home of R. H. Cook, Detroit, Mich. The heater was projected upwards through two floors, doing considerable property damage.

(134.) — A tube burst March 6 in a water tube boiler at the steel plant of Sanderson Brothers, Syracuse, N. Y.. One man was fatally injured.

(135.) — On March 7 the blow-off pipe failed on a boiler at the plant of the Carrol Box and Lumber Co., East 18th St., New York City. Five firemen were injured as a result of the failure.

(136.) — A heating boiler exploded March 7 at the plant of the Beuter-Hawkins Specialty Co., St. Louis, Mo. One man was injured.

(137.) — A cast iron header ruptured March 7, in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(138.) — A tube ruptured March 8, in a water tube boiler at the plant of the Michigan Alkali Co., Wyandotte, Mich. The boiler was considerably damaged.

(139.) — Six sections ruptured March 8 in a cast iron sectional heater at the Training School of the Commonwealth of Pennsylvania, Morganza, Pa.

(140.) — On March 9, an accident occurred to a boiler at the plant of the Landis Machine Co., Waynesboro, Pa.

(141.) — A cast iron header failed March 10, in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(142.) — While attempting to repair a leaking boiler under pressure, a tube burst, frightfully scalding two men at the box manufacturing plant of Albert Darr, Burlington, N. J., on March 10.

(143.) — A boiler burst March 11, at a pumping station on the Southern Ry., near Grassland, Ill. One man was fatally injured.

(144.) — A small boiler exploded March 12, on the Griswold Bros. lease, Fulmer Valley, near Wellsville, N. Y. One man was slightly injured.

(145.) — Four sections ruptured March 14, in a cast iron sectional heating boiler at the plant of the Central Casket Mfg. Co., Buffalo, N. Y.

(146.) — A cast iron header ruptured March 16, in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(147.) — Two cast iron headers ruptured March 17, at the Pumping Station, City of Troy, Troy, O.

(148.) — On March 17, a blow-off pipe failed at the plant of the Ruby Lumber Co., Madisonville, Ky. Three men were injured, one of them fatally.

(149.) — Two sections cracked March 18 in a cast iron heating boiler at the Central Hotel, Charlotte, N. C.

(150.) — On March 18, a cast iron heating boiler ruptured at the office of the Southern New England Telephone Co., New Canaan, Conn.

(151.) — A boiler exploded March 18, at the quarry of the Penn-Bangor Slate Co., Wind Gap, Pa. One man was seriously and perhaps fatally injured.

(152.) — A contractor's boiler exploded March 19, near Tiltonville, O., resulting in the injuring of six men, three fatally. The men were engaged in the construction of a smelter.

(153.) — A furnace ruptured in a Scotch marine type boiler at the plant of the Peerless Oyster Co., Bay St. Louis, Miss., on March 20.

(154.) — A cast iron section ruptured in a cast iron sectional heater on March 21, at the apartment house of V. Steuben & Co., East 41st St., New York City.

(155.) — A blow-off pipe failed March 21 on a boiler at the box and lumber plant of Lange & Crist, Clarksburg, W. Va. The engineer was scalded, the fireman probably fatally injured, while the little son and daughter of the engineer were both injured, the daughter fatally.

(156.) — A locomotive boiler exploded March 21, on the C. and A. near Tolluca, Ill. No one was injured, but a near-by house was considerably damaged by the force of the blast.

(157.) — A boiler exploded March 25 at the saw mill of W. T. Smith, near Three Forks, Ky. One man was injured and the mill was badly wrecked.

(158.) — A steam pipe used in connection with the steam heating system burst March 25, on the Jersey Central ferry boat, Elizabeth, New York City. A woman and two men, who were sitting directly over the pipe, were scalded.

(159.) — On March 26 the boiler of Southern Pacific locomotive No. 483 exploded in the yards at Crowley, La. The engineer and fireman were seriously and perhaps fatally injured.

(160.) — A tube ruptured March 27 in a water tube boiler at the plant of the Superior Steel Co., Carnegie, Pa. One man was slightly injured.

(161.) — On March 28 the crown sheet collapsed in a locomotive type boiler operated by the Maryland Dredging and Contracting Co., on the barge canal contract at Medina, N. Y. The boiler was seriously damaged.

(162.) — A cast iron header ruptured March 28 in a water tube boiler at the plant of the Dodge Mfg. Co., Mishawaka, Ind.

(163.) — Seven cast iron headers ruptured March 31 in a water tube boiler at the plant of the Memphis Steam Laundry Co., Memphis, Tenn.

April, 1914.

(164.) — A blow-off pipe failed at the plant of the American Silica Co., Rockwood, Mich., on April 2. One man was slightly injured by stepping into hot water on the boiler room floor.

(165.) — On April 2 four sections ruptured in a cast iron sectional heater at "The Sheffield," an apartment house owned by Louville N. Niles, Boston, Mass.

(166.) — On April 2, two sections ruptured in another boiler at "The Sheffield" apartment house, Boston, Mass. (This was a separate and distinct accident.)

(167.) — A blow-off pipe failed April 2 at Monmouth College, Monmouth, Ill.

(168.) — A boiler ruptured April 2, at the plant of The Wm. H. Gallison Co., steam fitters, Olive St., Boston, Mass.

(169.) — A boiler exploded violently April 2, at the Drummond Collieries, Westville, Nova Scotia. Two men were instantly killed, three fatally injured, and several others seriously injured by the explosion. The accident was especially fruitful of personal injuries owing to the fact that many of the men were seated about the boiler eating their lunch at the time of the explosion.

(170.) — A boiler explosion on April 3, at the summer home of Mrs. Jessica Taylor, Cedarhurst, L. I., resulted in a fire which destroyed the building. The property loss was estimated at $250,000.

(171.) — A tube ruptured April 3, in a water tube boiler at the Schwarger-Nettleton Mills, Seattle, Wash. The boiler was seriously damaged.

(172.) — On April 4, a boiler ruptured at the brick yard of Wm. J. Parrish, Richmond, Va.

(173.) — On April 7, a boiler ruptured at the brick yard of Wm. J. Parrish, Richmond, Va. (This second accident occurred to a different boiler from the one recorded above.)

(174.) — Three cast iron headers ruptured April 8, in a water tube boiler at the plant of the Oliver Chilled Plow Co., South Bend, Ind.

(175.) — Two sections ruptured April 9, in a cast iron heating boiler at the building owned by the Thistle Investment Co., 501 Highland Ave., Kansas City, Kan.

(176.) — A cast iron header ruptured April 9, in a water tube boiler at the plant of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(177.) — A tube ruptured April 10, in a water tube boiler at the LaCrosse Gas and Electric Co. plant of the American Public Utilities Co., of Grand Rapids, Mich.

(178.) — A boiler explosion at a saw mill near Tallahassee, Fla., on April 10, resulted in the death of William Manning. Mr. Manning was filing the saw at the time of the explosion, and was forced over onto the teeth of the saw by the force of the blast so that the teeth penetrated his body, causing his almost instant death.

(179.) — On April 13, a tube ruptured in a water tube boiler at the Electric Light and Water Works of the City of Starkville, Miss.

(180.) — While trying to thaw a frozen saw mill boiler on April 13, Wm. Plumbley was severely scalded by the blowing out of a pipe connection, near Parrishville Center, N. Y.

(181.) — The crown sheet of a locomotive collapsed on April 15 at the plant of the Glengarry Lumber Co., Glengarry, W. Va. Two men were injured.

(182.) — A tube ruptured in a water tube boiler April 15 at the department store of the Burgess-Nash Co., Omaha, Neb. One man was injured.

(183.) — A tube ruptured April 15, at the Omaha, Neb., plant of Swift & Co. One man was injured.

(184.) — A boiler exploded April 16, at the plant of the Lebanon Manufacturing Co., Lebanon, Ind. Two men were instantly killed.

(185.) — The boilers of the tug Aries exploded April 16, while the vessel was bound from New London, Conn., for Perth Amboy, N. J. The vessel was sunk, resulting in the death by drowning of two of the crew.

(186.) — On April 17, a tube ruptured in a water tube boiler at the plant of the American Axe and Tool Co., Glassport, Pa.

(187.) — A blow-off pipe failed April 19, at the plant of Israel Rokeach, Brooklyn, N. Y. Three men, the engineer, a fireman and a helper, were injured.

(188.) — On April 21, a tube ruptured in a water tube boiler at the plant of the Orono Pulp and Paper Co., Bangor, Me.

(189.) — A tube ruptured April 22, in a water tube boiler at the Massachusetts Mills in Georgia, Lindale, Ga.

(190.) — A tube ruptured April 22, in a water tube boiler at the Hamilton Club, Brooklyn, N. Y. One man, the night engineer, was injured.

(191.) — Two sections ruptured April 23, in a cast iron heating boiler at Clarence G. Bostwick's Sheet Metal Mfg. plant, Hartford, Conn.

(192.) — Two tubes ruptured in a water tube boiler April 23, at the glycerin works of Armour & Co., Chicago, Ill.

(193.) — A tube ruptured April 25, in a water tube boiler at the plant of the Peoples Ice and Cold Storage Co., Omaha, Neb. One man was slightly scalded.

(194.) — On April 26, a tube ruptured in a water tube boiler at the plant of Swift & Co., So. Omaha, Neb.

The Hartford Steam Boiler Inspection and Insurance Co.

ABSTRACT OF STATEMENT, JANUARY 1, 1914

Capital Stock, . . . $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$241,350.34
Premiums in course of collection,		287,689.64
Real estate,		90,300.00
Loaned on bond and mortgage,		1,199,345.00
Stocks and bonds, market value,		3,516,405.80
Interest accrued,		77,404.77
Total Assets,		$5,412,495.55

LIABILITIES.

Premium Reserve,		$2,293,028.64
Losses unadjusted,		41,990.28
Commissions and brokerage,		57,537.92
Other liabilities (taxes accrued, etc.),		47,429.31
Capital Stock,	$1,000,000.00	
Surplus over all liabilities	1,972,509.40	
Surplus as regards Policy-holders,	**$2,972,509.40**	2,972,509.40
Total Liabilities,		$5,412,495.55

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Supervising Inspector.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, Director, Swift & Company.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

GEORGE C. KIMBALL, President, The Smyth Mfg. Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., and Director N. Y., N. H. and H. R. R. Co.

DR. GEORGE C. F. WILLIAMS, Treas. and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

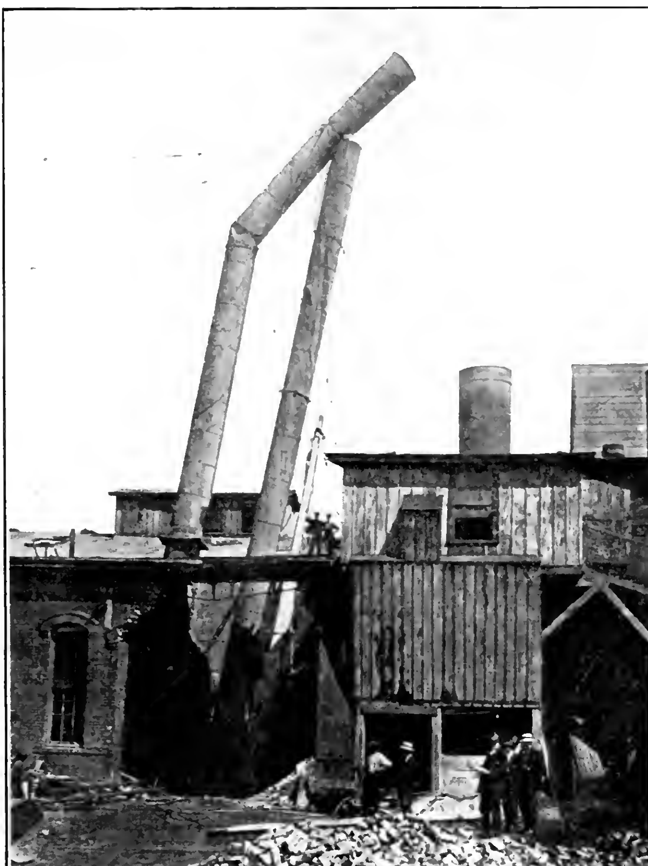
JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co. Simsbury, Conn.

The Locomotive

of

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXX. HARTFORD, CONN., OCTOBER, 1914. No. 4.



Boiler Explosion at Londonderry, N. S.

FIG. 2. PORTIONS OF EXPLODED STEAM DRUM, LONDONDERRY EXPLOSION.

A Lap Seam Boiler Explosion in Canada.

A boiler exploded July 25, at the foundry of the Canada Iron Corp., Ltd., Londonderry, Nova Scotia. The boiler, which was of the internally fired fire-tube type, with an upper steam drum in four courses, was of lap seam construction. The failure occurred at the longitudinal seam of the third course of the upper drum. This course unwrapped, and the remaining portions of the drum were propelled to the front and rear respectively, wrecking the boiler house and stacks. The wreckage of the building and stacks is shown in the photograph on our front cover, while the two portions of the upper drum are shown in Fig. 1. The lower drum of the boiler, containing the furnace and tubes, was left behind in the wreck of its setting. Aside from some damage to its setting, the adjoining boiler was not injured, and was put back into service as soon as the masonry was repaired. The lower drum of the exploded boiler is shown in Fig. 2. There were no personal injuries, but a mule and its cart, which happened to be passing at the instant of the explosion, were struck, killing the mule and demolishing the cart. The property loss was in excess of $3,000.

A New Inspection Method.

The whole art of boiler inspection rests upon the possibility of detecting nearly every sort of dangerous boiler defect while it is still in an incipient stage or at least before it has progressed far enough to produce an accident. How well this ideal has been accomplished is too well known to need further corrobo-

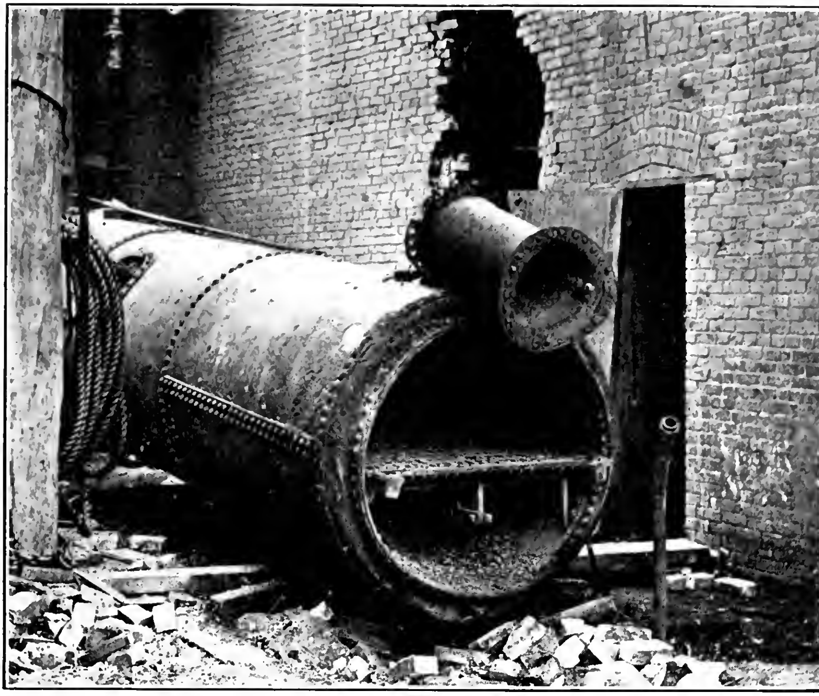


FIG. 2. LOWER SHELL OF EXPLODED BOILER, LONDONDERRY, NOVA SCOTIA.

ration, and yet in spite of the enormous decrease in boiler casualties which has followed the general adoption of some sort of inspection, a few types of defects, like some diseases of humans, have always been difficult of diagnosis.

Probably the hidden crack which forms under the overlap of a joint has been more fruitful of destruction and less open to detection by preventive inspection than any other boiler ill. As is but too well known such cracks form with alarming frequency in the seams of lap seam boilers when they have passed through a sufficient length of service. The reason for this has been so often discussed that it scarcely needs more than a passing mention, namely the breathing of a shell slightly "out of round" owing to the overlapped seam which endeavors to assume a truly circular form upon each application of internal pressure.

The extreme difficulty which has attended the detection of this trouble has been due to the fact that the crack forms under the overlap of the joint as is shown in Fig. 1, where it cannot be seen until it has progressed far enough to render an explosion extremely probable. Add to this the further fact that as most boilers are set, one side of the longitudinal joint is very apt to be hidden by the insulating material or the brickwork of the setting so that only the inside is available for the intimate examination of the inspector, and one sees why the majority of lap seam accidents have escaped prevention.

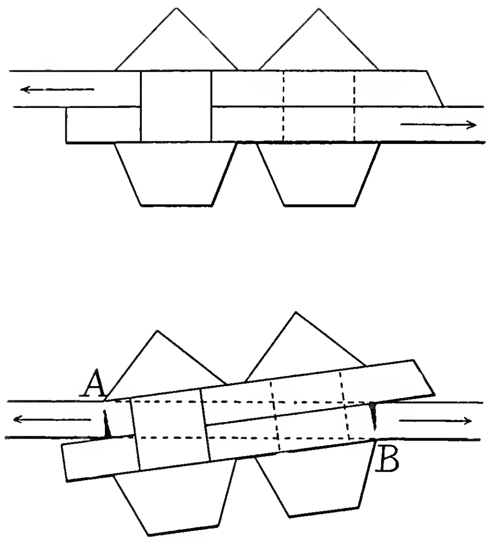


Fig. 1. Formation of Lap Cracks.

It must not of course be concluded from what we have just said that inspectors have never been able to detect lap cracks, for of course this is far from true. Sometimes a persistent leak at a longitudinal seam has lead to an investigation by the inspector. He generally applies a hydrostatic test pressure to the suspected boiler and proceeds to hammer the doubtful joint while the pressure is on. In many cases this treatment has caused a small crack to open sufficiently to indicate a serious defect and the removal of the plate has revealed the crack.

Mr. S. F. Jeter, Supervising Inspector of The Hartford Steam Boiler Inspection and Insurance Company, has recently patented a method for rendering the detection of seam cracks more certain. It bids fair to remove most of the uncertainty, and hence much of the danger of ultimate violent failure from this sort of defect. His process (U. S. Patent No. 1,091,847) consists in cutting narrow grooves or slots nearly through the plate, and at right angles to the probable course of the crack, at points where cracks are liable to form so that a crack will reach the bottom of one of these slots and either show up to the eye of the inspector or develop a leak which will give warning, while the plate still has a large part of its original thickness, and before the structure has weakened to the explosion stage. This is shown in Figs. 2 to 4. V-shaped notches may be cut in the calking edge of the overlapping plate to uncover the region in the underlying plate subject to crack formation, dependence being placed on the slots to give warning if the crack develops in the overlap. Such notches or slots will not weaken a joint appreciably or reduce the safe working pressure if they are cut at intervals of a foot or so along the longitudinal seams.

The method is strictly analogous to that adopted long ago for the discovery of fractured stay bolts. Here also we have a type of defect which could often

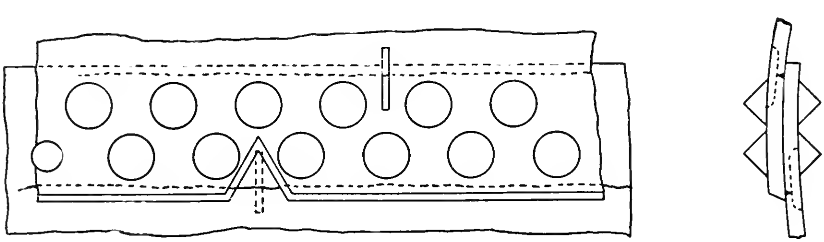


Fig. 2. Mr. Jeter's Slots Applied to a Lap Seam.

be discovered through the agency of the inspector's hammer, owing to the vibrations which light hammer blows set up in a fractured bolt. So much uncertainty attached to this method, and so much skill and experience was necessary before an inspector could trust himself to order partly fractured bolts replaced, with the attendant expense and the discredit which he would receive regarding his ability if it should prove that he had marked sound bolts for renewal, that nearly as many stay bolt troubles occurred in inspected as in uninspected boilers. All this has been changed in a large measure through the practice of drilling tell-tale holes in the ends of the bolts. The holes need not extend more than a short way through that part of the bolt in the supported sheet, as nearly all the fractures occur just inside the stayed sheet, and at the end of the bolt holding the thickest sheet, where the destructive bending is largely concentrated. Here also, the weakening of the bolt by the hole is trivial, while a leak gives early warning of the formation of a crack.

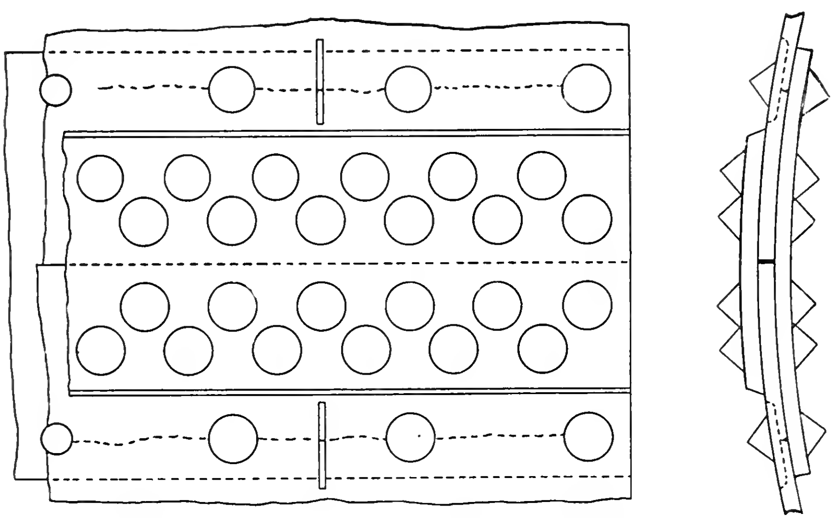


Fig. 3. The Method Applied to a Butt Joint of the Wide Inner Strap Type.

Lap seam boilers have been referred to for the most part as subject to the hidden crack. While it is true that they are more affected than these of butt and double strap construction, owing to the more nearly circular form of the latter, still cases have come to our attention, where a butt strapped boiler has developed hidden cracks of the same nature, probably because of poor forming of the ends of the plates when they were rolled up into a cylindrical form in the boiler shop. The plate ends are especially hard to get truly round and if they are flattened, then the butt joint will suffer a breathing action from the internal pressure as well as the lap joint, and the formation of cracks may be expected to follow the breathing after a sufficient time. Anticipating the probability of an increasing number of these cracks coming to light in the future as the average age of the butt joint boilers in use increases, Mr. Jeter has adapted his system of slots and V notches to this construction as is shown in Figs. 3 and 4, where the

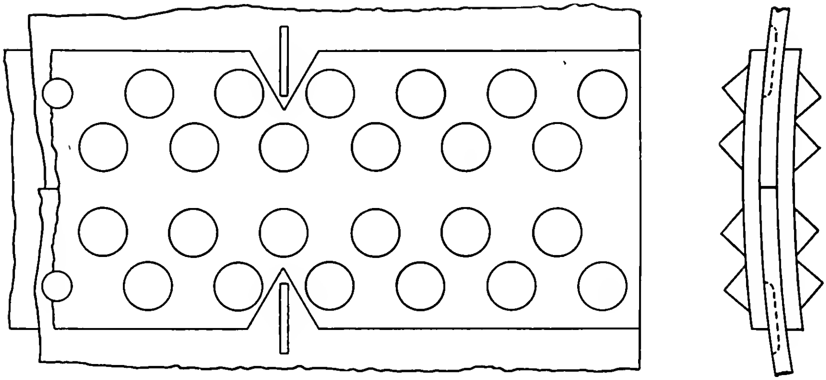


FIG. 4. APPLICATION OF THE METHOD TO BUTT JOINT WITH STRAPS OF EQUAL WIDTH.

method is applied to the case where the inner strap is wider than the outer one, the common construction in this country, and also to the case of straps of equal width, the more common practice abroad.

Test of the Radial Stays Between the Combustion Chamber and the Shell of a Marine Type Boiler.

Reprinted from *Vulcan*, and there appearing as a translation from the forty-fifth annual report of the Swiss Society of Steam Boiler Owners.

[Any destructive test of a boiler, carried on in a skillful manner so that reliable information is derived as to the behavior of the different parts of the structure under test is of interest and value to boiler designers, boiler makers, and boiler owners. It is for this reason that we reprint from the pages of *Vulcan*, our English contemporary, the following report. In so reprinting it we neither criticise nor endorse the conclusions of the testing engineers, preferring to let them tell their own story in their own way, and draw their own conclusions. We would, however, particularly emphasize their statement as to the effect of the weight of the internal parts being carried as a bending stress on the staybolts between the back combustion chamber sheet and the rear head.—Editor.]

The Lake Geneva General Navigation Company (M. Cornaz, Director) has found that in most of the boilers of their steamers the radial stays between the combustion chamber and the shell had a tendency to break, and that afterwards, owing to lack of space, these could not be replaced. M. Cornaz proposed to omit these stays in the future, and he placed at our disposal two marine boilers belonging to the steamer William Tell (which was laid up) to be subjected to the tests. In addition to the Swiss Society of Steam Boiler Owners, Messrs. Sulzer Bros., Winterthur; Messrs Escher Wyss and Company, Zurich, and afterwards the Technical Section of the Federal Department of Posts and Railways, Berne, interested themselves in the tests.

These two boilers, each having a heating surface of 613 square feet, and a working pressure of 7.5 atmospheres, (about 110 lbs. per square inch) were made in 1888 by Messrs. Escher Wyss and Company, Zurich, who furnished the following data on the material used during construction: —

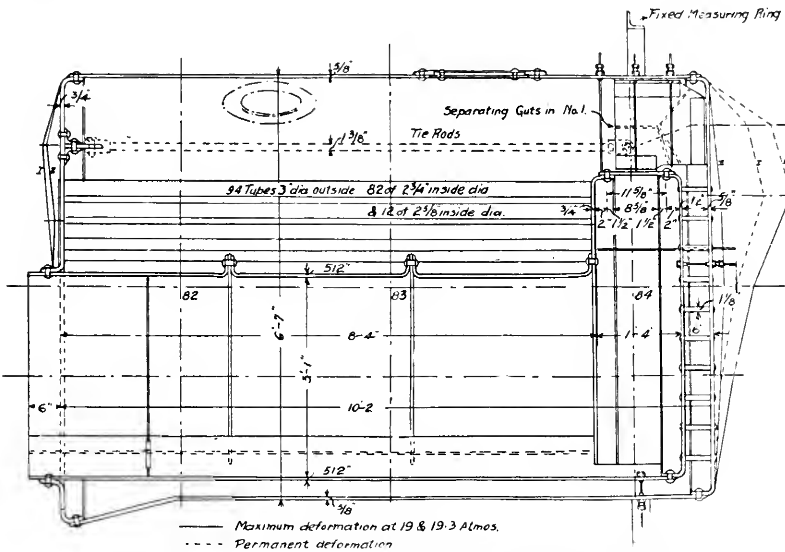


FIG. 1. MARINE BOILER FROM STEAMER "WILLIAM TELL."

Back part of the flue tube, Low Moor iron of the best quality, other parts of homogeneous Krupp iron; these plates all having a high tensile strength and an elongation of at least 20%. The tests took place from the 18th to the 22d of February, 1913, at the Dockyard at Ouchy.

As regards boiler No. 1 the radial stays between the combustion chamber and the shell were bored out, and the holes fitted with water tight screws in order to be able to observe the behavior of the combustion chamber in the absence of these stays. Then the tie rods between the two end plates were removed, and the stiffening piece at the back end was cut through longitudinally as shown in Fig. 1. This was done in order to be able to observe the effect produced on the back end plate by the elimination of the stiffening piece, which itself is thoroughly efficient.

No. 2 boiler, with the stays and tie rods was left in the condition in which it stopped work. It was desired to submit the boilers to a gradual hydraulic test to as high a pressure as possible. The boilers were placed on a solid wood floor, and the boiler to be tested was placed upon a strong test bed of iron and wood. The boiler under test was enclosed in a solid angle ring nearly over the center of the combustion chamber as is shown in Figs. 1 and 4.

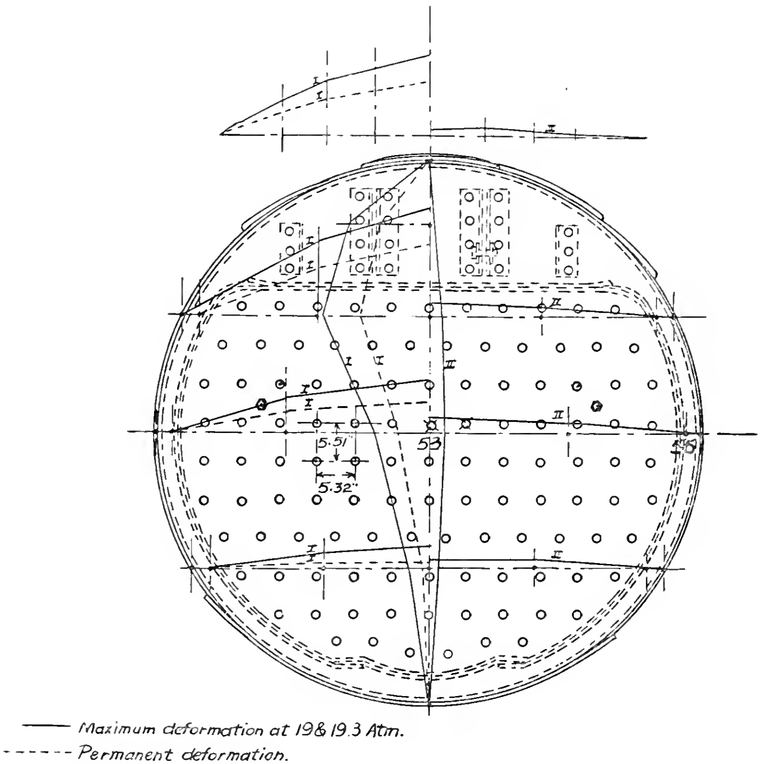


FIG. 2.

In addition to the effect on the combustion chambers, it was also desired to observe how the boiler shells sustained the test, and for this reason more than 80 observation points were arranged for each boiler, and these were continually watched. At 15 points gage needles were inserted, which led to the outside through stuffing boxes. The increase of and diminution of the water pressure were as follows: — 0–4–8–12–16–8–0–16–19 (possibly 19.3) atmospheres and back to zero. The variations at each point were noted and graphic tables were prepared. An example of this in Fig. 6, indicates the variations at point 53 on the back end plate of boiler No. 1, which is upon the main center line of the boiler. Fig. 6 shows that the deflections increase more rapidly than the pressures, and is typical of the majority of the points. Fourteen photographs were also taken.

In order to check the quality of the metal after the principal trials of the boiler No. 1, four careful tests of the tensile strength were made, also four bending tests when hot and four cold. All the tests were made without regard to the direction of rolling of the plates. The principal results are given in tables.*

Boiler No. 1 sustained the pressure up to 14 atmospheres or 206 lbs., without leakage of any importance, then loud cracking sounds were repeatedly heard in the longitudinal seams — a proof that the force of friction of the seams between the plates of the boiler was exhausted — and at and after 16 atmospheres serious leakages occurred at the longitudinal seams, which became so severe that it was not possible to exceed a pressure of 19 atmospheres, or 280 lbs. per square inch, although the water used for the test was taken from a pipe where the pressure was 22 to 24 atmospheres, *i. e.*, from 323 to 352 lbs. per square inch. The longitudinal seams exhibited a recognizable slip of 1.5 mm., or 59/1000 in., and the shell of the boiler assumed a shape somewhat like that of a cask. The manhole frame of welded iron remained intact, and the water tubes continued tight, the end plates and the combustion chamber showed deformations, some temporary, and others permanent, as we shall see further on, the crown sheet of the combustion chamber collapsed.

The results from boiler No. 2 were on the whole very similar to those obtained from the tests on the No. 1 boiler. It was possible to raise the pressure to 19.3 atmospheres. The crown of the combustion chamber collapsed much less than did that of the No. 1 boiler. When the boiler was being dismounted it was found that of the 24 radial stays between the combustion chamber and the shell of the boiler, 19 had been broken while the boiler was at work, and this is the reason why the trials of the two boilers were on this point practically alike.

An account is given of the deformations in Figs. 1 to 6. It would be superfluous to mention here all the notes taken, and we limit ourselves to giving the graphic results for the pressures of 19 and 19.3 atmospheres for the boilers Nos. 1 and 2, as also those for the permanent deformations of boiler No. 1 after the pressure of 19 or 19.3 atmospheres.

Fig. 1 represents a longitudinal section of the boiler. The measuring ring is shown about the middle section of the combustion chamber. As we have already said the tie rods between the end plates of boiler No. 1 were removed, and the stiffening pieces of the crown of the combustion chamber were cut in the manner indicated. The consequence of this was the more extensive deformations of boiler No. 1, to which point we will return. In order to render the deformations more easily visible, they have been magnified 30 times in the drawing.

It might naturally be expected that the combustion chamber of the No. 1 boiler, having had the stays cut, collapsed more easily than that of the other boiler. The deformation, on the same scale as the drawing, is shown in Fig. 5. The cause was not confined to the hydraulic pressure, the flange of the end plate of the combustion chamber also exerted a stiffening effect on the crown.

In Fig. 2, which represents the back end, the movements of boiler No. 1 are shown to the left and those of No. 2 on the right, exaggerated 30 times. As the variations were almost exactly symmetrical to the middle line, this method of representation is admissible.

The same method has been adopted in Fig. 3 for the representation of the front end. As regards boiler No. 1, the permanent deformations after the maximum pressure were so great that they are also indicated on the drawing in

*Not published in the *Vulcan* translation. — Editor.

dotted lines. The increase of the deformations of the end owing to the longitudinal stays being absent is evident. The most serious deflections ought to be found at the mean center of the stresses which are exerted on the end plate and are not neutralized by the stay bolts of the combustion chamber. This remark also applies to the stiffening pieces of the back end plate at the approximate height of the water level, which are generally now made in the form of T-iron. When the longitudinal stays exist, as in the case of boiler No. 2, or when the staying of the end plates is fixed to the shell of the boiler the case is different, for then the mean center of the stresses lies more towards the longitudinal axis of the boiler.

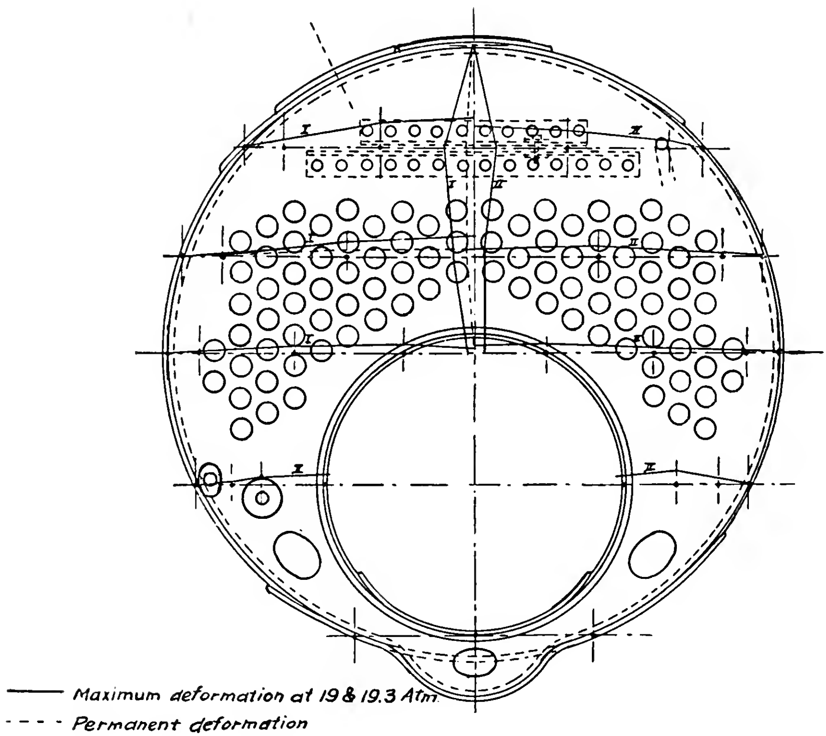
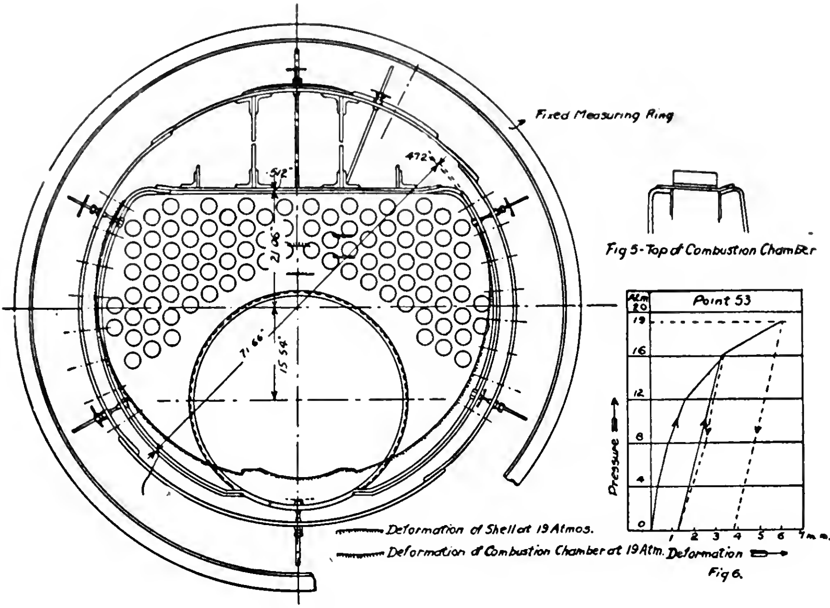


FIG. 3.

Fig. 4 is given in order to show the deformations which occurred in the combustion chamber of boiler No. 1. It was decided not to give those of the No. 2 boiler as they were practically identical; the lines of total deformations are also here exaggerated 30 times, in order that they can be easily noticed. The permanent deformations were very slight (less than 1 mm.).

RESULTS.

The practical result of the trials has proved that the stays of the periphery of the combustion chamber may be dispensed with without danger to the boiler,



FIGS. 4, 5, AND 6.

provided that the plate of the round part of the combustion chamber has the necessary thickness. This conclusion is confirmed by Bach, who writes on the subject of the tests made at Danzig: —

"The staying of fire tubes by means of rings of angle iron connected to the tube in the usual way by a certain number of stays (rivets) is of little value."

(Researches concerning the Powers of Resistance of Boiler Shell Plates, by C. Bach, No. 2.) These data may be applied to the case with which we are now occupied.

The effect of internal pressure and of heat causes the shell of a boiler to enlarge while the combustion chamber tends to be enlarged by heat and compressed by the external pressure. The expansion of the boiler shell and combustion chamber are not equal, and this sets up a tensile stress in the stays. To this has to be added the bending stresses caused by the unequal expansion of the shell of the boiler and of the combustion chamber in the direction of the axis of the boiler. The extent of these stresses cannot be absolutely determined by calculation, but the frequent breaking of the stays which are fixed at the rigid extremity of the shell of the boiler which is at the same time the colder, cannot be accounted for otherwise.

Our view as to these stays may be summed up briefly: —

The static state of the combustion chamber provided with stays is indeterminate because it can already by itself be constructed so that it satisfies the static conditions.

The thickness of the plate of the combustion chamber can first be determined from formula N. 7 of the Hamburg standards (made by Bach):

$$(1) \quad S = \frac{pd}{2400}\left(1 + \sqrt{1 + \frac{a}{p} \times \frac{L}{L + d}}\right) + C$$

of which the first number is the internal pressure, the root is on account of the danger of deflection of the tubes, and the C is added for corrosion; p in atmospheres and d in centimeters.

The Hamburg Standards assign a figure of 100 to 50 as the value of a, according to the nature of the seams and the position of the tubes; we ourselves give a value of 2 mm. to C for land boilers.

The factor of safety that this formula ensures works out to an average of 5.7 by the tests at Danzig on the flue tubes (see the book already mentioned by C. Bach and "The principles of German Material and Construction Regulations for Steam Boilers," by Professors Bach and Bauman.)

If a = O and C is ignored the formula becomes:

$$(2) \quad S = \frac{pd}{1200} = \frac{pd}{2 \times 600}$$

and this gives the thickness of the plate by only admitting the forces of compression (600 kilog./cm.^{2}).

As combustion chambers of marine type boilers are generally very short and as the two outer plates — the tube plate and the back end plate — also act as a very powerful preventive against deflections the question may be raised whether we are obliged to adhere to Formula No. 1, which applies specially to tubes or if we can make use of Formula No. 2 which gives lower values.

Let us again mention that in the tests at Danzig the proportion of $\frac{L}{a}$ has been in all cases much greater than in the tests at Ouchy, where that proportion was: —

$$\frac{300}{1820} = \frac{1}{6.07}$$

The writer is of the opinion that formula No. 2 may be adopted without hesitation provided that this proportion be small, and knowing that the combustion chamber is short.

By using the following values (furnished by the tests of the boilers at Ouchy): $p = 7.5$ atmos., $d = 1820$ mm., L = 300 mm. (from one riveted seam to the other riveted seam), the formulæ 1 and 2 would give the following results:—

(1) $a = 50$, C = 2, S = 15.6, about 16 mm. or 0.63 in.

(2) a = O, C = O, S = 11.4, about 12 mm. or 0.47 ins.

The thickness of the ends of the combustion chamber tested was 12 mm., according to the second calculation, and it was possible during the test to raise the pressure to 19 and 19.3 atmospheres.

It is evident that adequate means should be provided for carrying the weight of the combustion chamber and the flue tube when not supported by the floating power of the water in the boiler; and also for resisting any upward force due to excess of floating power when the boiler is filled with water. Assuming the radial stays to be omitted, the whole of this duty would be imposed on the back plate. By calculations that were made it was found that as regards the boilers under test the weight of the flue tube, the combustion chamber, and the small tubes, *i. e.*, the internal parts, was 3.4 tons, which was imposed upon the bottom of the boiler when empty. With the boiler full there was an upward pressure of one-half ton. The center of gravity of the weight and of the compression would be rather near the center between the two end plates, slightly nearer the back end plate.

By adopting for the internal parts a flexible support, each of the 113 stays of the back end plate (121 mm. long and 29 mm. in diameter,) has a bending stress of one quarter ton per inch with the boiler empty.

The calculations relative to several new marine type boilers have given analogous results, *i. e.*, the weight and the water almost exactly balance one another so that only the weight of the internal parts enters into the case. Therefore the connection of these parts to the back end will only be really safe *if the stays are short;* but as soon as owing to their excessive length the bending stress becomes too severe, a special staying of the combustion chamber to the back end plate becomes necessary.

We continue our statement as follows: —

For marine type boilers of the sizes generally used in Switzerland, the radial stays can be dispensed with without scruple, provided that the shell of the combustion chamber is sufficiently strong, and that the staying of the internal parts to the back end plate is adequate. It will then be necessary in each case to consider whether the thickness of the plate to withstand the lateral flexure must be calculated by compression or in accordance with the pressure only. This proceeding has the advantage that the construction makes steady progress from the first, and does not become liable to alteration as is the case when stays break.

We can again give briefly the results of some observations which may be interesting:—

The stress exerted on the longitudinal seam was at the pressure of 19 atmospheres = 10.4 tons per square inch, (calculated) which is still far from the limit of stretching.

The rivets of the longitudinal seam withstood a shearing stress of 13.8 tons per square inch and those of the circular seams one of 13.6 tons per square inch (calculated).

As the first cracking sounds in the longitudinal seam occurred at a pressure of about 14 atmospheres or 206 lbs. per square inch it may be calculated that the pressure by deflection of the rivets (90 mm.) was 12,400 kg., and that the sliding resistance was therefore, 8 tons per square inch. The slipping resistance is defined by Bach viz., Pressure ÷ size of the whole of the transversal section of the rivets as: —

$$P : n \, . \, \frac{\pi d^2}{4}$$

The tubes which, however, had only been measured crosswise and in one place only, showed at the pressure of 19 atmospheres a deviation of 0.8 mm., from their previous shape.

It is evident that the longitudinal stays in the No. 2 boiler were under a considerable amount of tension, as shown by the fact that they increased in length by 3 mm., or about ⅛ inch under pressure equivalent to a tensile stress of about 24 tons per square inch.

At the high pressure the boiler took the shape of a cask. At the measuring points Nos. 82, 83, 84, fine steel wires encompassed the boiler, point No. 83 being at the center, and the others at the ends.

The circumference of the shell sustained the following elongations: —

Pressures; Atmospheres		12	16	19 (18.3)
		inches	inches	inches
	82 in front	.082	.126	.256
	83 at center	.082	.134	.382
Boiler No. 1	84 at the back	.094	.138	.236
	82 in front	.059	.094	.291
Boiler No. 2	83 at center	.047	.098	.334
	84 at the back	.031	.071	.161

It follows that as regards boiler No. 1, at a pressure of 19 atmospheres the circumference was on an average .136 in. longer in the middle than at the ends, and as regards boiler No. 2, at 19.3 atmospheres it was .108 in. longer on the average. On the other hand at the pressures of 12 to 16 atmospheres the differences were hardly perceptible.

The increase of circumference greater at the middle than at the ends naturally arises from the staying effects of the ends. Another factor might also contribute to it: as the internal parts (tubes, flue tubes, combustion chamber) act as tie rods, a large part of the pressure on the end plates is neutralized, and in consequence in the shell of the boiler, a part of the longitudinal stress.

In conclusion we have again to express our thanks to those who by their sacrifices or by their interest have lent their support for the success of these tests. — Höhn.

Core Sand in the Heating System.

At the beginning of the heating season, when many people are starting up their heaters after the summer period of disuse, we believe it well to reiterate the caution, often expressed; to flush out the system thoroughly for the first week at least, to prevent the excessive accumulation of sediment from new cast iron parts which may have been installed.

All new radiators, steam fittings, cast iron boiler sections, headers or drums are apt to contain core material from the foundry. Hollow castings are made by suspending in the molds cores formed by ramming a mixture known as core sand into suitable boxes, and then baking the resulting mass in an oven to give it additional hardness and coherence. The core sand mixture contains sand and flour mixed to a stiff paste with water and perhaps molasses, clay or rosin. Even straw or chopped rope may be added for additional strength. When baked this produces a hard and fairly homogenous mixture, though very brittle and porous. The finished core is placed in the mold so that the iron runs into the space between the core and the mold walls, leaving the core material enclosed in the finished casting. The extreme heat from the molten metal crumbles and disintegrates the core more or less perfectly, permitting most of it to be readily shaken out of the finished section or fitting through the openings left for connections. Since the complete removal of the core is not easy especially in castings of the form of boiler or radiator sections, it is to be expected that much will remain even after they are installed. In consequence of this when steam is first turned on new radiators or formed in a new cast iron boiler, the flow of steam and condensate loosens the remaining sand and gradually sweeps it back to the boiler in the form of mud or sediment.

The first evidence which the boiler attendant perceives to warn him that something is wrong comes when he attempts to open a damper and brighten his fire. He will find that on the slightest increase in the rate of steaming, the water becomes strongly agitated in the water glass, and begins rapidly to disappear. Careful listening will disclose the fact that water is flowing along with the steam in the connection to the risers, or in other words the boiler is foaming or priming. The explanation of this is simple. Large amounts of sludge or sediment change the character of the ebullition in the boiler. Instead of boiling quietly, the water froths and foams, surges up and down, and considerable masses of water in the form of spray are thrown up in to the steam space, there to be picked up by the current of steam and carried along into the piping.

If the radiators are cold, so that steam flows out from the boiler rapidly to be condensed as soon as it reaches the radiators, then since a pound of water occupies so much less space than a pound of steam, the pressure at the cold end will remain for some time less than that in the boiler, and the steam will leave the boiler much faster than the condensate returns. So much of the process as we have just described is of course quite normal and occurs every time steam is turned upon a cold system of piping. The difficulty comes about from the fact that if the boiler water is full of mud and sludge, then the rapid production of steam means foaming, and hence in addition to the ordinary flow of steam, the water itself is picked up as we have suggested and carried along, resulting in a very rapid though temporary emptying of the boiler.

If the boiler attendant is unfamiliar with this sort of behavior, it will almost invariably puzzle him greatly. He will of course cover his fires and endeavor to regain the lost water level as soon as the water drops to a dangerous stage, but when he has brought the condition back to normal, he can find nothing wrong, and can not account for the trouble. He will find. however, that every attempt to open his damper sufficiently to force the fire will bring the same result, perhaps even with increased vigor, since the sand and mud will be brought back to the boiler in increased amounts at each passage of steam through the piping. If soda ash has been added to the boiler water as a preventive of pitting, then the foaming is apt to be increased even over what might be anticipated from the presence of the sand and sludge.

The remedy is so simple that it should be applied on the first intimation of trouble, and indeed it is well to apply it in any case whether trouble has been experienced or not. It is merely to keep the boiler and piping clean, either by allowing the condensate to run to the sewer for several days after starting up, which is the surest way, though somewhat expensive from the standpoint of coal consumption, as the hot returns would keep a certain amount of heat in the system, or else if it is not practical to turn away all the returns, the boiler should be blown off freely and often, so that no appreciable amount of sludge is permitted to accumulate. Where the boiler has filled up with sediment before an attempt is made to free it, it may be necessary to open up the boiler and wash it out with a hose, as it is not always possible in cases where a large amount of material is to be removed, to secure the desired end by blowing alone. In this case it is only necessary to remember that the boiler (and setting if it has one) should be cooled off before the water is drawn down, otherwise the sediment will tend to bake on as a hard scale from the heat stored in the boiler or its setting.

Notes on Economizer Operation.

We frequently come upon conditions in the installation or operation of vessels of all sorts, which though apparently unimportant, prove ultimately to contain the elements of great danger. A recent accident to a large economizer which fortunately did not prove serious except to the vessel itself has brought this fact home so forcibly that we believe the lesson taught will be of interest to our readers.

The plant in question contains two groups of boilers, an equal number in each group. Half the boilers discharge their products of combustion into one stack, while the remainder are served by an adjoining one. The whole arrangement is symmetrical, so that the boiler house contains practically two duplicate plants. Had this duplication been absolutely complete, with no interconnection, it is possible that the circumstances to be described might have been avoided.

The boilers were fed through large economizers. There were two of these, one located in the flue between each group of boilers and its stack. Each large economizer was made up of two smaller ones placed end to end in the same setting and arranged so that they operated as a single unit. Feed pumps were provided for both of the large economizers, and feed water was pumped through them into a single feed main, running the length of the boiler house. All the boilers of both groups were fed from this line. Provision had been made through valves to divide the feed line in half, letting one economizer feed into each half, and so serve to heat the feed for the group of boilers which furnished the hot gases for its operation but this sectionalization had not been thought necessary prior to the accident.

The events which led up to the accident were somewhat as follows: Early one morning a rumbling was heard at the hot end of one of the economizers, which the attendant interpreted as meaning that the vessel was overheated. A connection had been placed on the pipe between the two sub-groups of this vessel so that the feed might be by-passed around the colder section and pass through the hotter one only. The attendant attempted to open the valve so as to by-pass the feed as described above, when there occurred a violent and sudden rupture of this valve, together with the rupture of several tubes and headers in the economizer itself. (These ruptures were confined, however, to the "hot" half of the vessel.) Fortunately the man himself was not injured.

An investigation showed that the initial cause of the trouble came from the corrosion of an iron gate valve in the line connecting the economizer with the feed main. The nut which fastened the gate wedge of the valve to the spindle had so far wasted away from the attack of the hot feed water that it failed, permitting the wedge to fall into the closed position and interrupt the flow of water through the vessel. As the failure probably happened at night when the boilers were but lightly loaded, the fact was not noticed at once. Enough feed water easily passed into the feed main through the other economizer to supply the demand, at the low rate of steaming, of both groups of boilers. The isolated economizer, however, heated up when the circulation through it was destroyed, and in all probability steam was formed, which would account for the rumbling that disturbed the attendant. Then when the first of the relatively cold feed was by-passed into the hot and perhaps partially steam bound vessel, the inevitable water hammer occurred, rupturing the valve and tubes as we have mentioned. That such was the case is further evidenced by the condition of the pressure gage attached to the vessel after the accident. The gage had been subjected to so violent an over pressure that the pointer had been overthrown with force enough to bend it against the stop pin. Only an impulsive force of the nature of a water hammer could well have been the cause of the bending, for the safety valves on the vessel were in working order and set to relieve at a pressure far below the upper limit of the gage, but of course could not instantly relieve the very great pressure of a water hammer in the very short time necessary for its development and subsidence.

In a sense the stage was set for this accident when the two boiler groups, each with its own stack, economizer feed pump, etc., were tied together through the common feed main. Had the feed line been sectionalized, then when the outlet valve on one of the vessels failed from corrosion, the fact would have soon been noted by a lowering of the water level in the boilers in spite of efforts to maintain it. The speeding up of the feed pump would have caused the economizer relief valve to operate, and so have given warning that the stoppage was between the economizer and the boilers. It seems probable that under such circumstances steps could have been taken to obviate the trouble before the trouble had advanced far enough to be dangerous. With the feed line not sectionalized, however, the danger stage was really reached before any warning was received. We have pointed out previously in The Locomotive that the formation of steam in an economizer is of itself a very dangerous condition, since the tubes are attached to the headers by pressed fits, and a very little expansion of the top headers relative to the tubes would suffice to permit the blowing off of the top boxes at or below the pressure at which the safety valves are set. Such a condition has been suspected with considerable certainty as the cause of one very violent economizer explosion.

The practice of attempting to cool off a cast iron vessel suspected of being overheated by passing relatively cold water through the *hottest* part of the structure must of course be condemned at once. The proper procedure in such a case would be to close the dampers shutting out the hot gases, and passing them to the stack by way of the by-pass flue at the first suspicion that overheating had occurred. That is what the by-pass flue is provided for. All men about a power house with authority to open valves should understand this. Then, when the *supply of heat* has been cut off, the flow of water should be stopped, and the vessel allowed to cool off completely before making any further attempt to investigate the trouble or determine the extent, if any, of the damage.

The corrosion of the iron valve was not an unusual occurrence considering the service it had to perform. Brass has long been recognized as far more suitable than iron for service on feed lines or other portions of the pipe system where hot water has to be handled. It is doubtful if the saving in first cost of the iron fittings is justified where reliability in service is of importance.

The Effect of the War on Boiler Inspection Abroad.

Many interesting side lights on industrial conditions abroad during the early stages of the present war may be had from a perusal of the various foreign journals devoted to boiler inspection and power plant engineering.

Our English contemporary, "Vulcan," shows little change either in appearance or contents, while some of the other English papers show a conspicuous absence of the familiar advertisements of German and Austrian houses. The greatest hardship so far seems to have fallen to the lot of the German and Austrian inspection associations, where the large portion of the male population called to the colors, has sadly depleted the ranks of both the inspection forces and the power plant operatives.

The journal of the Berlin Steam Boiler Inspection Association ("Zeitschrift für Dampfkessel und Maschienenbetrieb") has reduced its issue from 26 to 12 pages, with an almost total absence of advertising matter. The issues of Sept. 4 and 11 contain an article on English power plants which is far from flattering either to English engineers or their work. They also devote considerable space to a discussion of the patent situation in Germany during the war.

The Bavarian inspection paper, published at Munich ("Zeitschrift des Bayerischen Revisions-Vereins") has dwindled to eight pages of reading matter with practically no advertising. The issue of August 31 contains a patriotic discussion of the value of technology and technically trained men to the Fatherland in time of war. The issue is headed with an appeal to subscribers to be patient with the management in their effort to continue the regular publication of the paper. They beg their friends to bear with them if they cannot maintain their standard of regularity and size, and suggest that conditions may necessitate the publication of double numbers in place of two regular issues. They state that of the 85 men who composed their force prior to the mobilization, 20 have been called to the front. Eleven of these were from their six boiler inspection offices, and two were electrical men. Although they have been forced to sacrifice various matters of scientific and engineering research, together with much of their testing work, still, unless a further call is made, they can maintain the necessary inspection service to protect the safety of the vessels under their care. They will endeavor to make the stipulated inspections on time and especially to protect the interests of their clients in view of the presence of nearly all the trained operatives with the colors.

The "Zeitschrift der Dampfkessel Untersuchungs und Versicherungs Gesellschaft, a.G.," the paper published by the Vienna boiler inspection and insurance company, indicates that conditions in Austria resemble those in Bavaria. The issue of August 8 commences with a copy of the order from the Imperial Minister of Commerce and Railroads, under the date of August 5, annuling the requirement that boilers and power machinery be operated by licensed operatives, during the period of mobilization and the duration of the war. The company, in commenting on this, announces that they will endeavor to protect the property of their assured by an increase in the rigor and number of inspections, as long as their lessened inspection force will permit, hoping thereby to offset in some measure the dangers which attend the placing of unskilled and unfamiliar men in charge of boiler and power plant equipment.

Had Learned His Lesson.

(Atchison Globe).

A fireman was up for examination for promotion to the position of engineer. He passed a fair test on the rules and machinery, but during all of it the examiner was constantly lecturing him as to the need of economy in the use of fuel and oil, so that by the time he finished his examination it was pretty well on his nerves.

Having finished the technical part the examiner thought he would put the man in a critical position to see what he might do in an emergency. So he put to him this question:

"Supposing you are the engineer of a freight train on a single track, and you are in a head-on collision with a passenger train and you knew that you could not stop your train, that a collision could not be averted, what would you do?"

The man, unstrung by the vigorous instruction he had received as to economy, replied in this way: "Why, I would grab the oil can in one hand and a lump of coal in the other and jump."

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. Perry, Editor.

HARTFORD, OCTOBER, 1914

Single copies *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
The Locomotive of The Hartford Steam Boiler I. & I. Co.

Through chance we are able to preface our account of Mr. Jeter's method for the detection of seam cracks by an account of a violent lap seam explosion. We are glad to be able to assure our readers that the method has stood the test of successful application, and has already been the means of giving a valuable and timely warning of the deterioration of several suspected boilers. Moreover it has served to assure the owners in some cases that their boilers were not yet in a dangerous condition, and were therefore capable of additional years of service. When it is remembered that this defect has probably been the cause of more destruction of life and property than any other cause for the explosion of inspected boilers, it is seen how powerful and valuable an addition to our inspection resources has been developed.

Winter is approaching. Most of us have already started our heaters for the season. If your heating system is operated by steam have you considered sufficiently the hazard of its operation and the satisfaction which you would feel if you knew that it had been subjected to a searching and rigorous examination by an expert? If it has not had such an examination, if you are satisfied with taking a chance, are you sure after all that you would care to dig down into your reserve funds to replace not only the heater but perhaps also your building and its contents in case of an accident? A great many owners of heating plants have satisfied themselves that a policy of insurance for their heating boiler offers the best solution for the problems these questions suggest. It is wiser to be safe than sorry.

An extremely interesting development of the marine boiler tests at Ouchy, Switzerland, an account of which appears in this issue of The Locomotive, is the conclusion reached as to the possibility of the internal parts of the boiler (furnaces, tubes, combustion chamber) floating when the boiler is filled with water. In these particular boilers the upward thrust (buoyancy) of the water was in excess of the weight of the internal parts by something like half a ton, so that the system would be about balanced with the grates and fire in place.

This fact presents the function of the radial combustion chamber stays in a somewhat different light from that to which we are accustomed. If we concede that these particular combustion chambers were strong enough to resist collapse without any radial stays, we must still consider whether the absence of such stays (as the writer points out) would throw an excessive bending moment on the stay bolts between the back combustion chamber and the rear head at each emptying and filling of the boiler. We doubt whether the question of the buoyancy of the internal parts of some types of internally fired boilers has been given the attention by designing engineers which it deserves.

Personal.

Mr. E. A. Corbin, for many years a member of the firm of Corbin, Goodrich & Wickham, General Agents for The Hartford Steam Boiler Inspection and Insurance Company at Philadelphia, has retired from the activities of the agency.

Mr. Corbin has been a very active representative of the Hartford, especially during the early efforts of the Company to advance the theory of boiler underwriting, and carries the best wishes of the organization with him in his retirement.

The firm will be known as Goodrich & Wickham, and we bespeak for them the continued patronage of our assured and agents in their territory.

On Habit.

Great indeed is the force of habit. So thoroughly imbued do we become with customary ways of doing things that if the form of a thing is not unusual, we are not always conscious of all the details of the thing itself.

One of our inspectors, blessed with a sense of humor, conceived the notion of announcing the state of disintegration to which his "grip" had advanced by writing a formal report of its condition. This he did, observing in every detail the conventions which usually govern the form and style of an inspection report. The manuscript account of the grip's condition was turned in with a batch of boiler reports in the course of his regular routine. It was so regular in its phraseology and form that the stenographer, accustomed to transcribing quantities of such material, paid no attention to its subject matter and typed it along with the rest, carbon copies for filing and all. Indeed its real character was not discovered until, when being made ready for signing and mailing, inquiry was made as to the address of the owner of the "vessel." Then the thing finally "took" and the humor of the situation became apparent. We append the report itself, except of course for names.

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY MAKES THE FOLLOWING REPORT OF THE CONDITION OF YOUR STEAM BOILER INSPECTED ON THE 25TH DAY OF JANUARY, 1914.

By Inspector ——— ———

1 Inspector's Grip — No. 2 Inspector's Grip W100W.

INTERNALLY: —

Riveted seams, shell plates and heads show evidence of considerable weakness and distress. There was serious corrosion and grooving detected on shell plates and heads. This grip is getting old and very weak.

EXTERNALLY: —

No bulges or blisters or fire cracks noted on outer surfaces of shell plates, but we note the outer surfaces heavily corroded and considerably deteriorated. The riveted seams to shell show evidence of leakage. The outer appliances were in place but appear to be in bad working order, and it is our opinion that in the near future this grip will have to be condemned owing to the weak condition of shell plates and a new one put in place of same.

Respectfully,

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

——————— Department.

Table of Boiler Heating Surface and Horse-Power.

We are rapidly drawing away from the horse-power method of rating boilers. This has come about through the working of two different tendencies, both of which diminish the value of such a statement of boiler capacity. In the first place there no longer exists any particular equality between the horse-power of a boiler and the amount of engine power which it may be expected to serve, although at the time of the adoption of the present unit, in 1876, it was given a value about equal to the average steam consumption per horse-power of the engines exhibited at the Centennial Exposition, on the assumption that this would approximate average conditions at that time. Modern engines have so far improved in economy that it is now possible for one boiler horse-power to serve from two to three engine horse-power of connected load under favorable circumstances. There is, moreover, another influence at work to lessen the value of the horse-power rating, namely the growing demand for greater and greater boiler output per unit of heating surface, so that it is no longer a matter of special novelty to read test returns of boilers in regular operation at upwards of 200 per cent. of what a few years ago would have been considered a proper performance.

The result of these two changes in power plant economics is to make it more and more necessary to plan boiler plants on a heating surface and not a horse-power basis. The designing engineer first determines the rate at which he expects to be able to work his heating surface with the character of coal, draft setting, etc., which he expects to utilize. That is, he sets a figure for the amount of water which he may expect to evaporate on each square foot of heating surface in the particular plant he has in mind. It is then only necessary to add the combined water rates of the different steam consuming devices, and divide by the evaporative rate, to arrive at the total heating surface, which he can divide among the proper number of boilers.

When an essentially non-technical buyer of boilers is obtaining competitive bids from boiler makers he is apt to think and talk in terms of dollars per 100 or 150 (or some other number) horse-power. He naturally assumes that this is a proper basis upon which comparisons may be made. He will, of course, be disappointed if, having purchased the boiler from the lowest bidder, he finds to his surprise that this builder has bid on a boiler rated at 10 square feet to the horse-power, while perhaps his engineer, in deciding on the necessary size, has calculated on a 12 square foot to the horse-power rating. This is very confusing to the owner who is not an engineer, or who is not familiar with the diversity which exists among boiler makers as to the proper rate of evaporation to use as the foundation for a catalog rating. It is not at all uncommon for the condition outlined above to come about, resulting in the purchase of a boiler 20 per cent. smaller than either the buyer or his engineer desired.

Those of our readers who may have experienced this trouble, or who may encounter it in the future, will find the accompanying table of service in that it enables them to compare directly both the heating surface and the horse-power rating of a given boiler with any other boiler. It is only necessary to know the diameter of the boilers, and the diameter, length and number of tubes, to arrive at the data required, with the assurance that it is calculated upon the same basis and gives a fair comparison of the size of the units. The table should also prove of value in deciding how many boilers of a given size would be required to equal any desired fraction of the capacity of a plant, if the new boilers are to be run at the same rate of evaporation as the existing ones. For such purposes, the comparison should be based upon heating surface and not horse-power.

TABLE OF HEATING SURFACE AND HORSE-POWER

FOR

STANDARD SIZES OF HORIZONTAL TUBULAR BOILERS WITH MANHOLES BELOW TUBES.

Diameter of Boiler.	Tubes. Length.	Diam.	No.	Heating Surface. Tubes.	Shell.	Rear Head.	Total.	Horse-Power.
54″	14′	3″	54	552	99	8	659	66
54″	16′	3″	54	631	113	8	752	75
54″	14′	3½″	44	526	99	8	633	63
54″	16′	3½″	44	601	113	8	722	72
54″	14′	4″	34	467	99	8	574	57
54″	16′	4″	34	534	113	8	655	65
60″	16′	3″	72	841	125	10	976	98
60″	18′	3″	72	946	141	10	1097	110
60″	16′	3½″	50	684	125	10	819	82
60″	18′	3½″	50	770	141	10	921	92
60″	16′	4″	46	722	125	9	856	86

Diameter of Boiler.	Tubes. Length.	Diam.	No.	Heating Surface. Tubes.	Shell.	Rear Head.	Total.	Horse-Power.
60"	18'	4"	46	812	141	9	962	96
66"	16'	3"	94	1098	138	11	1247	125
66"	18'	3"	94	1235	156	11	1402	140
66"	16'	3½"	70	957	138	11	1106	110
66"	18'	3½"	70	1077	156	11	1244	124
66"	16'	4"	56	878	138	11	1027	103
66"	18'	4"	56	988	156	11	1155	115
72"	16'	3"	118	1378	151	13	1542	154
72"	18'	3"	118	1550	170	13	1733	173
72"	20'	3"	118	1722	189	13	1924	192
72"	16'	3½"	94	1285	151	13	1449	145
72"	18'	3½"	94	1446	170	13	1629	163
72"	20'	3½"	94	1606	189	13	1808	181
72"	16'	4"	70	1098	151	13	1262	126
72"	18'	4"	70	1235	170	13	1418	142
72"	20'	4"	70	1372	189	13	1574	157
78"	16'	3"	140	1635	163	15	1813	181
78"	18'	3"	140	1839	184	15	2038	204
78"	20'	3"	140	2043	204	15	2262	226
78"	16'	3½"	108	1477	163	15	1655	165
78"	18'	3½"	108	1662	184	15	1861	186
78"	20'	3½"	108	1846	204	15	2065	206
78"	16'	4"	88	1380	163	14	1557	156
78"	18'	4"	88	1553	184	14	1751	175
78"	20'	4"	88	1725	204	14	1943	194
84"	18'	3"	172	2260	198	17	2475	247
84"	20'	3"	172	2511	220	17	2748	275
84"	18'	3½"	136	2092	198	17	2307	231
84"	20'	3½"	136	2324	220	17	2561	256
84"	18'	4"	106	1871	198	16	2085	208
84"	20'	4"	106	2078	220	16	2314	231

The above table is figured on the basis of ten (10) square feet of heating surface per boiler horse-power; the heating surface as calculated includes all of the *inside* tube area, one-half the area of the cylindrical portion of the shell, and two-thirds of the area of the rear head minus the combined cross-sectional area of the tubes.

Boiler Explosions in Great Britain.

We have received the annual report of the British Board of Trade, giving the summary of the results of the inquiries held concerning the causes and responsibility for the boiler explosions which occurred in Great Britain during the year ending June 30th, 1913. As we have pointed out before, these British reports deal with accidents on land and with all accidents on ships of British registry as well. Moreover all accidents, no matter how trivial, receive attention, and if there is any blame or negligence found, it is fixed if possible upon the guilty party without fear or favor.

During the year from July 1, 1912, to June 30th, 1913, there were held 66 preliminary inquiries, and 14 formal investigations. Formal investigations are held in those cases where there has been a loss of life, and it is necessary if possible to place the responsibility for it so that criminal proceedings may follow if it is shown that they are warranted. Of the 80 explosions, 40 resulted in either loss of life or personal injury. Thirty-one persons were killed and 42 injured. The 31 deaths were caused by 20 explosions, of which 11 occurred on land, and 9 on ships. The report states that the number of persons killed is above the yearly average, while the number of injured is considerably below it. It is also worthy of note that in one instance the Commissioners of the Board of Trade found that the owner should have had his boiler inspected, and recommended that he have it insured, so as to get the benefit of expert advice from the inspectors of the insurance company.

We print some of the tabulated summaries in which the accidents are classified as to type of boiler, cause of accident, etc.

Classification of Causes of Explosions, and Types of Boilers which Exploded, 1912-1913.

Causes of Explosions.	No. of Cases.
Deterioration or corrosion	24
Defective design, or undue working pressure	13
Water-hammer action	11
Defective workmanship, material, or construction	16
Ignorance or neglect of attendants	8
Miscellaneous	9
Total	81

Types of Boilers.	No. of Cases.
Horizontal multitubular	13
Vertical	5
Lancashire, Cornish	3
Locomotive	3
Water-tube	8
Tubes in steam ovens	9
Heating apparatus	4
Steam pipes, stop valve chests, etc.	18
Hot-plates	3
Calenders, drying cylinders, etc.	6
Economizers	3
Steam jacketed pans	1
Miscellaneous	4
Total	80

STATISTICS FOR 31 YEARS.

Year.	No. of Explosions.	Personal injuries. No. lives lost.	No. injured.	Total.
1882-83	45	35	33	68
1883-84	41	18	62	80
1884-85	43	40	62	102
1885-86	57	33	79	112
1886-87	37	24	44	68
1887-89	61	31	52	83
1889-90	67	33	79	112

Year.	No. of Explosions.	No. lives lost.	Personal injuries. No. injured.	Total.
1890-91	77	21	76	97
1891-92	88	23	82	105
1892-93	72	20	37	57
1893-94	104	24	54	78
1894-95	114	43	85	128
1895-96	79	25	48	73
1896-97	80	27	75	102
1897-98	84	37	46	83
1898-99	68	36	67	103
1899-00	59	24	65	89
1900-01	72	33	60	93
1901-02	68	30	55	85
1902-03	69	22	67	89
1903-04	60	19	45	64
1904-05	57	14	40	54
1905-06	54	25	21	46
1906-07	77	28	65	93
1907-08	73	23	50	73
1908-09	93	12	53	65
1909-10	103	14	62	76
1910-11	100	13	61	74
1911-12	106	30	75	105
1912-13	80	31	42	73
Totals	2260	820	1803	2623
Average of 31 years	72.9	26.5	58.2	84.6

Boiler Explosions

MAY, 1914.

(195.) — A boiler exploded May 1, at the plant of the Pickwick Lumber Co., Pickwick, La. Two men were killed as the result of the explosion.

(196.) — On May 1, a blow-off failed at the power house of the Minneapolis, St. Paul and Sault Ste. Marie Ry. Co., Duluth, Minn.

(197.) — A boiler ruptured May 2, at the plant of the E. P. Benton Lumber Co., Charleston, S. C.

(198.) — A tube ruptured May 2, in a water tube boiler at the plant of the Oklahoma Portland Cement Co., Ada, Okla.

(199.) — A traction engine boiler exploded May 6, on the farm of John Murray, near Buffalo Center, Ia. No one was injured though the engine was wrecked.

(200.) — A sulphite digester exploded May 8, at the mill of the York Haven Paper Co., York, Pa. Beside a considerable property damage, two men were fatally injured.

(201.) — A mud drum failed on a water tube boiler May 9, at the power house of the Detroit United Railways Co., Mt. Clemens, Mich. Two men were fatally injured as a result of the accident.

(202.) — A boiler ruptured May 9, at the plant of the Joplin and Pittsburg Ry. Co., Pittsburg, Kansas.

(203.) — On May 10, a boiler ruptured at the plant of the Excelsior Ice Co., Bradentown, Fla.

(204.) — A steam pipe burst May 10, at the plant of the Standard Ice Co., Altoona, Pa. One was seriously injured.

(205.) — On May 11, an explosion occurred in the combustion chamber of one of the boilers of the Old Dominion Line steamer Jefferson, as she was leaving Norfolk, Va., for New York. Seven men were killed and several injured as a result of the accident.

(206.) — On May 12, a tube ruptured in a water tube boiler at the plant of the Scoville Manufacturing Co., Waterbury, Ct.

(207.) — The cast iron cylinder of a dryer ruptured May 14, at the East St. Louis, Ill. plant of Morris and Co.

(208.) — A tube ruptured May 13, in a water tube boiler at the plant of the Semet-Solvay Co., Lebanon, Pa.

(209.) — A tube ruptured May 13, in a water tube boiler at the power house of the Pittsburg and Butler Street Railway Co., Renfrew, Pa.

(210.) — On May 14, a tube ruptured in a water tube boiler at the plant of the Scoville Manufacturing Co., Waterbury, Ct.

(211.) — A boiler expoded May 14, at the Stowe saw mill, Parishville Center, N. Y. No one was injured as there was no one in the immediate vicinity of the boiler at the time.

(212.) — On May 14, an accident occurred to a boiler at the Hoboken Paper Mill, Hoboken, N. J. One man was severely scalded by escaping steam.

(213.) — A tube ruptured May 15, in a water tube boiler at the plant of the Hagerstown and Frederick Railway Co., Security, Md.

(214.) — On May 18, a tube ruptured in a water tube boiler at the plant of the Hausman Brewing Co., Madison, Wis.

(215.) — A boiler ruptured May 19, at the plant of the Excelsior Ice Co., Bradentown, Fla.

(216.) — A boiler ruptured May 20, at the plant of the Worcester Salt Co., Ecorse, Mich.

(217.) — On May 25, a hot water boiler exploded in the laundry of R. C. Yow, Greensboro, N. C. The boiler was fitted up with a homemade coil furnace, composed of standard pipe and fittings. The owner of the laundry, Mr. Yow, was killed, while a colored woman employed by him was fatally injured. The building was completely destroyed by the force of the explosion and the fire which followed.

(218.) — On May 21, the furnace of a boiler failed at the plant of the Bodwell Granite Co., Vinal Haven, Me.

(219.) — On May 24, a tube failed in a water tube boiler at the plant of the Scoville Manufacturing Co., Waterbury, Ct.

(220.) — Tubes failed in the boiler of the Dredge Iroquois in the Passaic river near Harrison, N. J., on May 27. One man was killed, three were badly scalded, and severe damage done to the vessel as the result of the accident.

(221.) — A boiler exploded May 27, at the plant of the Doud Bros' Sand Mill Co., Sault Ste. Marie, Mich. The engineer of the plant discovered that the boiler showed signs of distress in time to warn the employees, so that no one was injured.

(222.) — Two tubes ruptured May 29, in a water tube boiler at the Easley Cotton Mills, Easley, S. C.

(223.) — Two explosions occurred May 29, at the plant of the Frederick Cowan Co., Joliet, Ill. The first accident consisted of a cylinder failure on a rolling mill engine, while the second and more serious one was a tube explosion. Two men were seriously injured by the tube failure, one of them fatally.

(224.) — On May 30, the crown sheet of a locomotive boiler collapsed at the plant of the Loutre Shingle Co., Cargile, Ark.

(225.) — A boiler used for agricultural purposes on the farm of H. E. Cushing, Seekonk, R. I., exploded May 29. Three men were injured, one seriously.

(226.) — A boiler ruptured May 30, at the Foster Pumping Works, Brooklyn, N. Y. One man was injured.

(227.) — The boiler of a locomotive used on the tram road of the Bowman-Hicks Lumber Co., exploded May 30, near Oakdale, La. Four men were killed and two others injured by the explosion.

(228.) — A boiler exploded at the Metzel saw mill near Lakeside, Ore., on May 29. Two men were killed and one other terribly injured as a result of the accident.

(229.) — A soda water tank exploded May 30, at Hamburg, Ark. A 13 year old girl was killed and two others were injured by the expdosion.

June, 1914.

(230.) — A boiler tube burst June 2, on the U. S. S. Salem at Puerto, Mex. Three men were seriously injured.

(231.) — A log hauling locomotive boiler exploded June 2, at French Mills, near Salamanac, N. Y. The engineer was killed.

(232.) — A hot water boiler exploded June 2, in an apartment house at 137 East Thirty-third St., New York City. Two children were thrown down and slightly injured by the force of the explosion.

(233.) — The boiler of a Norfolk and Western freight locomotive exploded June 3, near Duval, O. The engineer and fireman were killed, eight cars were wrecked, and a mile of track is reported to have been torn up as a result of the accident.

(234.) — A hot water boiler exploded June 6, in the garage of A. J. Horlick, Racine, Wis. No one was injured, but there was a considerable property damage.

(235.) — A steam pipe burst in a N. Y., N. H. & H. locomotive cab June 7, near Stamford, Ct. The engineer was hurled from the cab and severely injured.

(236.) — A tube ruptured in a water tube boiler June 8, at the Christian Heirich Brewery, Washington, D. C. One man was injured.

(237.) — A water tube boiler exploded June 8, at the power house of the Meridian Light and Railway Co., Meridian, Miss. One man was killed, two others injured and property damage done to an extent estimated at $20,000 by the explosion.

(238.) — On June 9, a boiler ruptured at the plant of the Leonard Ice and Light Co., Leonard, Tex.

(239.) — A threshing machine boiler exploded June 12, near Franklin, Ga. J. P. Pyles, the owner of the outfit, his son, and two grandsons were killed, while five others were injured by the explosion.

(240.) — On June 13, a tube ruptured in a water tube boiler at the plant of the Michigan Carton Co., Battle Creek, Mich. Considerable damage was done to the boiler.

(241.) — A boiler ruptured June 13, at the plant of the Millhiser Bag Co., Richmond, Va.

(242.) — A hot water heater exploded June 13, at the plant of the Deere Harvester Co., Moline, Ill. One man was injured.

(243.) — A hot water tank exploded June 15, in an apartment house at 54 Vernon St., Brookline, Mass. No one was injured, but the property loss was considerable.

(244.) — A hot water boiler exploded June 15, at the Ideal Hotel, Franklin, N. H. No one was injured.

(245.) — A cast iron header ruptured June 16, in a watertube boiler at the plant of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(246.) — A boiler exploded June 10, on a pumping boat belonging to the Diamond Run Coal Co., at Monongahela, Pa. The boiler was blown completely out of the boat onto an adjoining railway track. One man, the night watchman on the boat was seriously and perhaps fatally injured. The explosion was unknown until the boiler was discovered by railroad men.

(247.) — On June 20, a boiler ruptured at the plant of the Milledgeville Ice Co., Milledgeville. Ga.

(248.) — On June 21, a tube ruptured in a water tube boiler at the plant of the Charleston Consolidated Railway and Lighting Co., Charleston, S. C. One man was injured.

(249.) — A blow-off failed June 22, at the plant of the C. W. Smith Electric and Ice Co., Laird, Kans.

(250.) — A portable saw mill boiler exploded June 22, at Bosler, Mich. One man was killed.

(251.) — On June 22, a cast iron section ruptured in a sectional heating boiler at St. Michael's Church, Toledo, O.

(252.) — A boiler used for driving the Volger feed mill exploded June 23, near Littleton, Ill. Two men were killed and the mill was badly wrecked.

(253.) — On June 26, a blow-off pipe failed at the machine shop of Ida L. Prew, Fall River, Mass.

(254.) — A tube ruptured June 26, in a water tube boiler at the plant of the Desplaines Safety Deposit Co., Chicago, Ill.

(255.) — A blow-off pipe failed June 27, at the plant of the A. J. Johnson and Sons Furniture Co., Chicago, Ill. One man was injured.

(256.) — A tube failed June 27, in a boiler at the plant of the London Packing Co., Mattoon, Ill. One man was fatally injured.

(257.) — A boiler exploded June 30, at the plant of the Standard Roller Bearing Co., Philadelphia, Pa. One man was probably fatally injured.

July, 1914.

(258.) — On July 1, a blow-off failed at the plant of the Hartman Provision Co., Cleveland, O.

(259.) — A cast iron boiler and hot water tank burst July 1, at the Hotel Francis, Kokomo, Ind. The accident was said to have been due to the closing of valves by a workman in such a way as to isolate the system allowing an excessive pressure to accumulate. The property damage was considerable.

(260.) — A boiler exploded July 3, near the J. A. M. Scott mine office, Galena, Ill. One man was killed.

(261.) — Three cast iron headers ruptured July 3, in a water tube boiler at the Phoenix Hotel, Lexington, Ky.

(262.) — On July 7, a tube ruptured in a water tube boiler at the plant of the Omaha Electric Light and Power Co., Omaha, Neb.

(263.) — A boiler exploded July 9, at the Chapman carriage factory, Jacksonville, Fla. No one was injured, but the boiler was propelled through the walls of two buildings.

(264.) — Seven cast iron headers ruptured July 10, in a water tube boiler at the hotel of the White Sulphur Springs Hotel Co., White Sulphur Springs, W. Va. The boiler was considerably damaged by the accident.

(265.) — On July 12, a cast iron header ruptured in a water tube boiler at the pumping station of the city of Troy, Troy, O.

(266.) — The boiler of a threshing machine engine exploded July 13, on the farm of M. L. George, near Bronaugh, Mo. Three men were injured, one fatally.

(267.) — On July 14, a blow-off pipe failed at the plant of the Wynne Stave Co., Wynne, Ark. One man was injured.

(268.) — The boiler of an Atlantic Coast Line freight locomotive exploded July 14, near Holder, Fla. The engineer, fireman, conductor, and one trainman were killed, while the boiler, blown completely clear of the running gear, landed some 100 yards ahead of the train on the track.

(269.) — A tube ruptured July 14, in a water tube boiler at the Coal St. station of the Public Service Corporation of New Jersey, Newark, N. J.

(270.) — An exploding hot water heater wrecked the kitchen of the parish house of the Church of the Sacred Heart, Philadelphia, Pa., on July 17.

(271.) — The boiler of a threshing machine engine exploded July 17, near Aledo, Ill. Two men were injured seriously, and the boiler itself was propelled something over 300 feet by the force of the explosion.

(272.) — A boiler ruptured July 18, at the plant of the Madeira Hill Coal Mining Co., near Barnsboro, Pa.

(273.) — A hot water boiler exploded July 27, in the basement of the Strong Building, Springfield, Mass. The explosion spread the fire in such a manner that the building was seriously damaged, the property loss being estimated at $50,000.

(274.) — On July 29, an accident occurred to a boiler at the plant of the Huron Portland Cement Co., Alpena, Mich., which resulted in considerable damage to the boiler.

(275.) — The boiler of an Erie freight locomotive exploded July 31, at Hunts' N. Y. Both engineer and fireman were killed.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1914.

Capital Stock, . . . $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$241,350.34
Premiums in course of collection,		287,689.64
Real estate,		90,300.00
Loaned on bond and mortgage,		1,199,345.00
Stocks and bonds, market value,		3,516,405.80
Interest accrued,		77,404.77
Total Assets,		$5,412,495.55

LIABILITIES.

Premium Reserve,		$2,293,028.64
Losses unadjusted,		41,990.28
Commissions and brokerage,		57,537.92
Other liabilities (taxes accrued, etc.),		47,429.31
Capital Stock,	$1,000,000.00	
Surplus over all liabilities	1,972,509.40	
Surplus as regards Policy-holders,	**$2,972,509.40**	2,972,509.40
Total Liabilities,		$5,412,495.55

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Supervising Inspector.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, Director, Swift & Company.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

GEORGE C. KIMBALL, Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., and Director N. Y., N. H. and H. R. R. Co.

DR. GEORGE C. F. WILLIAMS, Treas. and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co. Simsbury, Conn.

Incorporated 1866. Charter Perpetual.

The Hartford Steam Boiler Inspection and Insurance Company.

ISSUES POLICIES OF INSURANCE COVERING

ALL LOSS OF PROPERTY

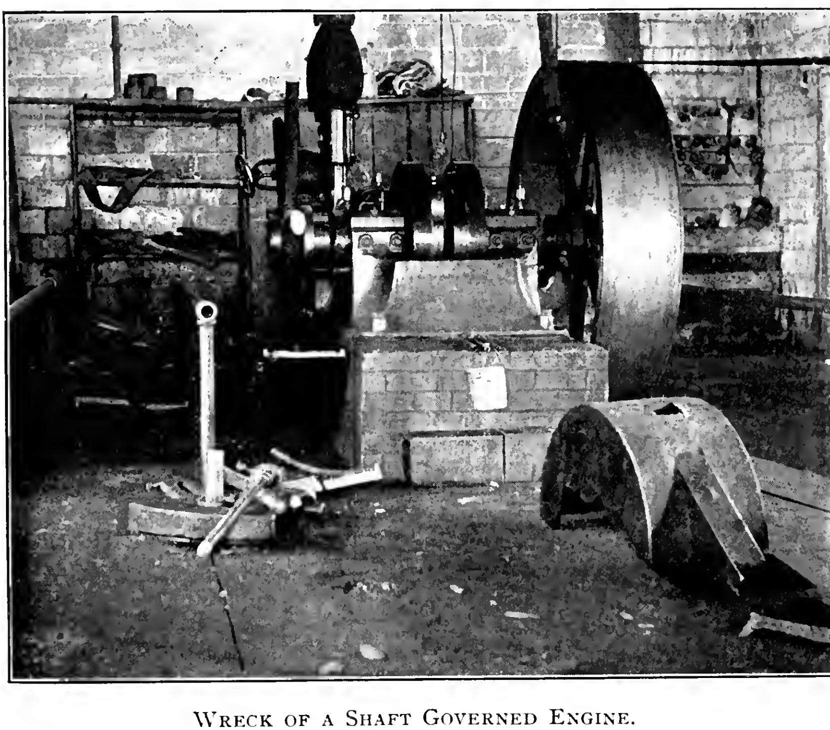
AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.	W. M. Francis, Manager and Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	Lawford & McKim, General Agents. R. E. Munro, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. Roberts, Manager. Joseph H. McNeill, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.	W. G. Lineburgh & Son, General Agents. F. S. Allen, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. Lemon, Manager. James L. Foord, Chief Inspector. J. T. Coleman, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. Gleason, Manager. Walter Gerner, Chief Inspector.
CLEVELAND, Ohio, Century Bldg.	H. A. Baumhart, Manager and Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg., Cor. 15th & Champa Sts.	Thos. E. Shears, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. Williams, Jr., General Agent. F. S. Allen, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	Peter F. Pescud, General Agent. R. T. Burwell, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. Gardiner, Manager. W. W. Manning, Chief Inspector.
PHILADELPHIA, Pa., Cor. Fourth & Walnut Sts.	Goodrich & Wickham, General Agents. Wm. J. Farran, Chief Inspector. S. B. Adams, Assistant Chief Inspector.
PITTSBURG, Pa., 1801-1802 Arrott Bldg.	J. J. Graham, Manager. Benjamin Ford, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	McCargar, Bates & Lively, General Agents. C. B. Paddock, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. Mann & Co., General Agents. J. B. Warner, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. Ashcroft, Manager. J. P. Morrison, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. Roberts, General Agent.

The Locomotive
of
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXX. HARTFORD, CONN., JANUARY, 1915. No. 5.



Wreck of a Shaft Governed Engine.

Wrecked Governor Wheel on an Automatic Engine

Our cover illustration this month shows the condition of a high speed automatic cut off engine at Mine No. 30 of the New York Coal Co., Orbiston, O., after the wreck of its governor wheel on November 27, 1914. This engine was controlled by an inertia governor of the Rites type. The accident seems to have followed the failure of the stud securing the pivot pin about which the inertia bar turned. When the stud failed the heavy inertia bar was thrown against the wheel rim and probably fractured it without any special rise in the engine speed. Marks, as of the impact of a heavy piece, such as would be produced in the action we have outlined, were found so located as to point very strongly to this mode of failure. Those of our readers who are interested in failures of this character will find in the LOCOMOTIVE for April, 1911, a description of a similar accident. Here again the wheel appeared to have been fractured by the impact of a portion of the inertia bar, though the heavy piece which caused the wreck detached itself from the bar, instead of the whole bar coming adrift.

The Endurance of Metals Under Repeated Stresses Some New Facts, and a New Method of Testing

If we take a brief resumé of our knowledge of the strength of materials, we find that we can divide it roughly into two parts, first the strength of materials under steady loads and second, their strength when subjected to varying and repeated loads, or to vibrations of various sorts.

The first part of the subject has been pretty well worked over. We know with a fair degree of certainty what to expect of a given kind of stuff of known size, subjected to a stated steady load, and have test methods to determine those properties of ultimate strength, elastic limit, ductility, elastic modulus, etc., from which we may arrive at a satisfactory quantitative result by calculation for the safe loading of a structure or machine. We have had this knowledge for many years. It has become the foundation of all our engineering economics, enabling us to design structures properly proportioned without undue waste of material or effort.

Varying or repeated stresses have not been so well understood. Many conjectures were advanced to explain the cases, continually brought to the attention of engineers, in which repetitions of apparently harmless loads brought about the ultimate failure of the material. About the middle of the last century a great controversy developed as to whether or not wrought iron undergoes a change from a fibrous to a crystalline condition, under vibratory or repeated stresses, which would account for its failure. Some thought even, that magnetism was the offender, and that some sort of magnetic action either upon or betwen the molecules of the metal caused its nature to change to such an extent that it could no longer sustain its full load.

Kirkaldy* showed that it was the rate of breaking and not fatigue which determined the character of the fracture of wrought iron. A sudden break gave rise to a coarse, crystalline fracture, whereas a slow, steady break produced a silky, fibrous appearance at the ruptured surface. He remarked that the difficulty which had arisen over the matter came about through confusing the nature of the fracture and the state of the material. If a piece of wrought iron which had been subjected to fatigue stresses failed so as to show a crystalline structure, it was evidence that the material had been so weakened as to break suddenly, but did not prove a change in structure, for he could produce either type of fracture at will from a new piece of sound metal by merely varying the speed of breaking.

The first important experiments on the behavior of metals under repeated stresses were published by Wöhler in 1871. He devised machines to apply either repeated bending, repeated tension, repeated compression, alternate tension and compression, or repeated torsion to specimens. In his tests he set up specimens and gave them regular repetitions of a known load, keeping up the process until failure occurred. This procedure might involve a very long time for the testing of a single specimen, as some materials required as many as 40 million applications of the test stress before failure, taking up some two years time in the process. As a result of his tests on different materials, and at widely different stress intensities, Wöhler deduced the following conclusions:

First — Materials subjected to stresses, each of which is less than the elastic limit of the material, will fail after a definite number of repetitions.

Second — The smaller the stress, the greater the number of applications necessary to produce rupture. A very great number indeed may be required (over 40,000,000 in one instance) so that it would appear probable that some limiting value of stress might be found such that it should just be able to rupture the specimen after an indefinite number of applications. Any stress greater than this limiting value, would then certainly break the piece after some finite number of applications, while a smaller stress could be repeated forever without causing failure. His experiments also showed that it was not the total stress on a body which affected its fatigue failure, but the amount of variation in stress. That is if a repeated stress was added to a steady load the number of repetitions necessary to produce failure would be determined by the stress variation, and not by the total load. This matter was later discussed by Sir Benjamin Baker† in connection with bridge design. He argued from this basis that bridge members having a large, steady load, but a smaller proportionate live or variable load might easily be safe at a much smaller factor of safety than other members where the proportions were reversed. As an illustration he pointed to certain members in the Conway tubular bridge which had carried the traffic of the London and Northwestern Railway for 36 years on a safety factor of from 2 to 2.5, but in which the stresses due to live load were a very small part of the total, while he commended fully the requirement which had been made for a safety factor of more than double this in the case of the structure supporting the elevated railway in New York City, since in the latter case nearly all the stress would be from live load.

---

* Experiments on Wrought Iron and Steel, 1864.

† Notes on the working stresses in Iron and Steel, Sir B. Baker, Trans. A. S. M. E. Vol. VIII, 1887, p. 157.

Many other investigators have worked at this intensely interesting problem. and their work has confirmed the observations of Wöhler and Baker, without, however, increasing our knowledge very much beyond the point at which they left it.

In one respect, however, a distinct advance has been made. It has been shown from our fundamental laws of thermodynamics that at low stresses where bodies are essentially perfectly elastic, that is, where a stress produces a change in form which is proportional to the load, so that half the load makes half the deformation, a substance should have its temperature raised by compression and lowered by tension, but in either case the temperature should return to normal with the removal of the stress, there being no permanent loss or gain of heat. It has been further shown that when stressses are applied to a solid body greater than a certain amount, but still perhaps within the elastic limit as ordinarily understood, a permanent development of heat takes place, giving rise to an increase of temperature, regardless of whether the stress is one of tension or compression. Turner* in 1902 measured some of these changes in temperature but failed apparently to realize their importance as a possible method of testing.

The explanation advanced for the evolution of heat, which seems consistent, is that small stresses produce changes in the size of a body by straining the structure but do not cause the small grains or crystals — in the case of a metal — to slip over each other and generate heat by internal friction. Stresses, however, which are greater than some limiting value do cause internal slipping and consequent friction, and are attended with the permanent evolution of heat. It is also easy to conceive that a substance which has experienced such slipping may have been slightly weakened so that after a sufficient number of repetitions of the weakening process, it might fail in the manner which we are accustomed to attribute to fatigue. Ewing and Rosenhain† found that when bodies are strained so as to take a slight permanent set, slip marks may be seen under the microscope on a polished and etched section, and subsequent experiment has confirmed the fact that the slip marks they described are due to a real slip of the character we have just discussed.

The evolution of heat which we have been considering is of course but the beginning of the phenomenon familiar to all of us, that when a wire is ruptured by repeated bending it may become uncomfortably warm, or that heat is always evolved when a test specimen is about to fail under tension in a testing machine.

The facts which we have so far discussed are of the greatest service in explaining the *mechanism* of the failure of metals under repeated stresses, but they fall short of complete usefulness because they do not assist us in *calculating* the performance which we can expect from a given piece of material under some set of conditions to which we wish to subject it. Neither does it appear from any of these experiments how we may co-ordinate the results and make test data apply to conditions slightly different from those under which the test was conducted. To illustrate this we may be able from such tests as those of Wöhler to predict that a certain kind of material will stand a very large number of repetitions of stress A, and a certain smaller number of repetitions of stress

* Trans. Am. Soc. Civil Eng. 1902, Vol. 48.

† Ewing and Rosenhain, The Crystalline Structure of Metals, Phil. Trans. Roy. Soc. vol. cxciii A, 1899.

B, but we cannot say how many applications of a third stress C, not used in the experiments, will be necessary to cause rupture, except that if C is less than A, we may be reasonably sure that the number would be very great indeed, and the piece correspondingly safe. This is merely another way of saying that while we have accumulated a mass of facts, they have not been fitted into a law showing their inter-relation, so that we may use them for engineering calculations. They of course indicate the wisdom and indeed the absolute necessity of adopting a larger factor of safety for live or repeated loading than is required for a steady load, but give us no inkling of how much the factor should be for any particular case. One further difficulty which has greatly hindered the application of this knowledge to engineering is the time and expense necessary to get at any notion of the stress which will serve to rupture a specimen after a very great number of applications. Tests which may require from eighteen months to two years are obviously a long way from what the average engineer would consider practical. Indeed, it has been suggested by Dr. Martens of the German National Physical Laboratory (Physikalische-Technische Reichsanstalt), to adopt as a standard of comparison the number of times that a specimen can sustain the application of a stress of 3000 atmospheres, that is about 19 tons to the square inch.

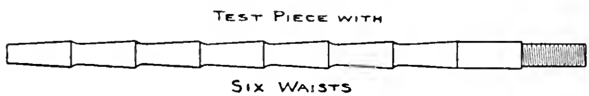


Fig. 1.

Fortunately it would seem that we are about to be provided with a quantitative statement of the facts, and with a test method for determining the properties of resistance of material to fatigue which is simple and quick enough to come within the realm of commercial testing, and so furnish a basis for the engineer to use in design. Mr. C. E. Stromeyer, Chief Engineer of the Manchester Steam Users Association, of Manchester, England, in a memorandum to the Executive Committee of the Association, dated June, 1914, has described the results of a long series of experiments conducted by him, and by the National Physical Laboratory under his guidance, which not only provides us with a large amount of new test data, but from which he has been enabled to derive a law correllating the tests, and giving the relation between the behavior of a specimen at one stress intensity, with its behavior at any other. In other words, to use our illustration of a few paragraphs since, he is able, given the number of times which stresses A and B respectively must be applied to rupture a specimen, to predict accurately the number of applications which will be required of stress C to do the same, and this for any value of C.

Furthermore, he has developed a test method which will give the number of applications required to cause rupture with a given stress, and also that limiting value of the stress just capable of breaking a body after an indefinitely great number of applications, which he calls the Fatigue Limit, all within the space of about an hour, and in a relatively simple manner. We will endeavor to describe his methods and results in the remainder of this article.

Mr. Stromeyer designed a test piece of such form that he could secure several tests at points near each other on a relatively short bar. (Fig. 1.) His object was to overcome if possible irregularities in his results which might be due to real variations in the fatigue resisting power of his samples, as it is well known that no material is perfectly homogeneous, but exhibits variations in strength at different points to an extent which depends somewhat upon the nature of the substance and somewhat upon the method of its manufacture. He believed that much of the lack of harmony between previous test results could be laid to this cause and determined if possible to eliminate it at the start of his own work.

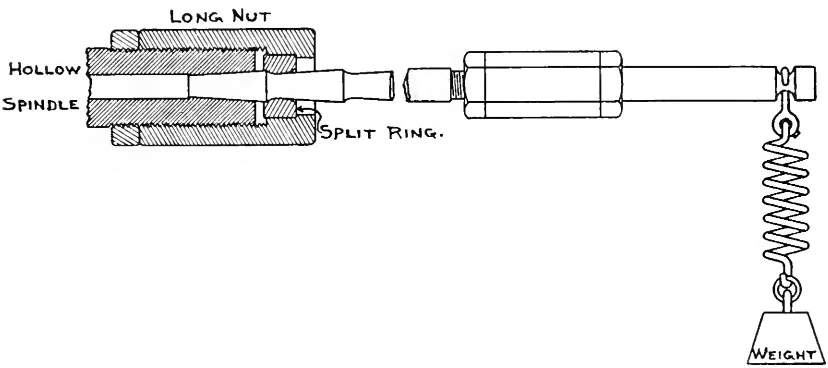


FIG. 2. ARRANGEMENT FOR BENDING TESTS.

The peculiar form of his test piece is due to two requirements. The constrictions or waists present regions of weakness owing to the lessened cross section, so that successive breaks will come at definite points. The conical shape of the specimen between waists permits it to be gripped in the end of a hollow spindle (see Fig 2.) and as each taper is turned to standard dimensions, the specimen can be gripped readily after each successive break. The greatest distance between waists employed in the tests was 1½ inches, while the least was 1 inch. The specimens were usually provided with six waists, so that six separate tests could be made on a given sample.

The result of using this type of specimen was a much greater uniformity of data than had previously been possible. The fatigue behavior was separated from the mere chance variations in the strength of the material, and it was therefore possible to co-ordinate these test results and express them in terms of a law. It was found that if N = the number of repetitions of stress required to break the specimen; $\pm S_n$ = the stress applied (the sign $\pm$ indicates that a stress of S_n tons per square inch might be applied alternately as a tension or as a compression, or as a bending or twisting stress, first in one direction and then in the other); also if C represents a constant of the sample tested and Fl the fatigue limit which we have already defined; then

$$N = \frac{10^6 \quad C^4}{(S_n - Fl)^4}$$

(Where 10^6 is a convenient way of writing the very large number 10,000,000) or

$$+ S_n = Fl + C\sqrt[4]{\frac{10^6}{N}}$$

so that if Fl and C are known for any material, we can tell in case it fails at a known number of repetitions of a stress, exactly how large that stress was, or conversely, we can predict exactly how many repetitions of a given stress the material should stand before rupture. This then is the law which furnishes the starting point for much of Mr. Stromeyer's work.

The mathematical form of the law* will indicate to those familiar with the plotting of curves that if we make a diagram such as Fig. 3, where the values of N are plotted horizontally to a peculiar scale ($x = \sqrt[4]{\frac{1}{N}}$) so that an infinite number of repetitions is indicated by the zero of the diagram (at the left) and decreasing numbers, plotted to the peculiar scale, are read off to the right, while the stress is plotted vertically on a uniform scale, then if the test results really fit the law, the points which represent corresponding stresses and repetition numbers for any one sample should lie along a straight line. When the proper values of Fl and C are used, the law applies to either bending or torsional fatigue. Tests of both sorts will be found recorded on diagrams such as we have described in Figs. 3 and 4. It will be seen that the departure of the tests from a straight line is not marked, or what is the same thing, the law fits very well.

A straight line is completely determined by two points, therefore it was possible to lay down the line from which all the fatigue properties of a sample may be determined by making two accurate tests, one at such a stress as to require a large number of repetitions, say one million, and the other at a much higher stress so that failure would take place at two or three thousand repetitions. If the line determined by the tests is extended to cut the axis of stress, that is to pass through the point corresponding to N = an infinite number of repetitions, then the stress indicated by this intersection is the fatigue limit, Fl. The constant C may be found from the slope or inclination of the test line. From this it will be clear that two tests will not only yield the diagram of a sample, but that from the diagram both Fl and C may be readily obtained. This would seem to give us a very satisfactory increase in our knowledge of fatigue, but as Mr. Stromeyer points out, we are still left a long way from a practical application of the method to design because of the time and expense required to make the two tests necessary.

We will describe the method by which Mr. Stromeyer made his original tests before we take up the short cut method which he subsequently developed. He arranged for two sorts of tests. In one case the specimens were broken by repeated bending, while in the other the stresses used were repeated torsions. The bending test was carried out in the manner indicated in Fig. 2. A hollow spindle was mounted so that it might be given a continuous motion of rotation. The

* It will be seen that the equation for S_n is linear if we consider S_n and $\sqrt[4]{\frac{1}{N}}$ as the variables. This of course is the basis of the Stromeyer diagrams, and results as we have indicated above in a somewhat unusual scale of N. It makes possible, however, the determination of Fl by direct extrapolation, whereas if the curves had been plotted with N and S_n as coordinates, Fl would have been given by the intersection of the graph with the line $N = \infty$, which would have been indeterminate as far as graphical values are concerned.

end of the spindle was reamed out to the same taper as the conical portion of the test piece. The test piece could then be inserted in the tapered hole of the spindle, where it was secured by means of a split ring bearing on the shoulder behind the first waist, and held by a long nut as is shown in the sketch. The outer end of the specimen was threaded to receive a coupling, by means of which an extension piece was attached, carrying a weight at its extreme end. A study of Fig 2 will show that the weight sets up a bending stress in the specimen which is largely localized at the waists. The waist nearest the spindle is stressed most, because farthest away from the weight (or if you like, because the weight acts on this waist with the longest lever arm). The next waist is stressed less, and so on, the last waist being the most lightly stressed of all. If the spindle is rotated, each fibre in the test bar will be bent first one way and then the other, so that the result of a continuous rotation of the spindle is the alternate bending of the bar first one way and then the other.

When the specimen has been secured in the machine, it is started with such a value of weight as will secure the breaking of the first waist with a moderate number of revolutions. The specimen after the first fracture is again clamped into the spindle, the weight remaining the same, and the rotation continued till the next waist breaks, and so on until the last waist has been broken, or until one of the waists requires about a million revolutions before fracturing. The weight remains the same throughout all the tests on a given bar, because the distance between any particular waist and the weight does not change with the breaking of waists farther back, and so the stress on each waist is the same from the starting of the test until it breaks. For this reason the value of N for each waist goes back to the start of the test, and is the *total* number of turns from the start until that waist breaks. This makes it possible to get six tests, at six different stress values on a bar within a length of from six to nine inches.

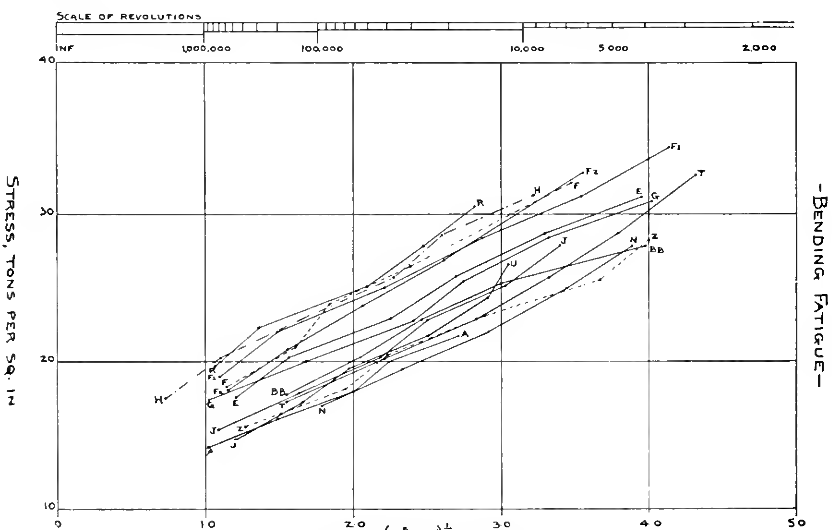


FIG. 3. DIAGRAM OF BENDING TESTS.

The arrangement for torsion testing was as follows: "A test piece was fixed axially between the ends of two shafts, of which one was oscillated about 600 times a minute by means of a small revolving crank and connecting rod. The other shaft carried circular discs and was oscillated in unison with the first shaft by means of the intervening test piece." The test piece was of course subjected to a twisting or torsional stress determined by the number of oscillations a minute and the amount of resistance offered to a change in motion by the inertia of the discs. A typical set of torsion curves are shown in Fig. 4.

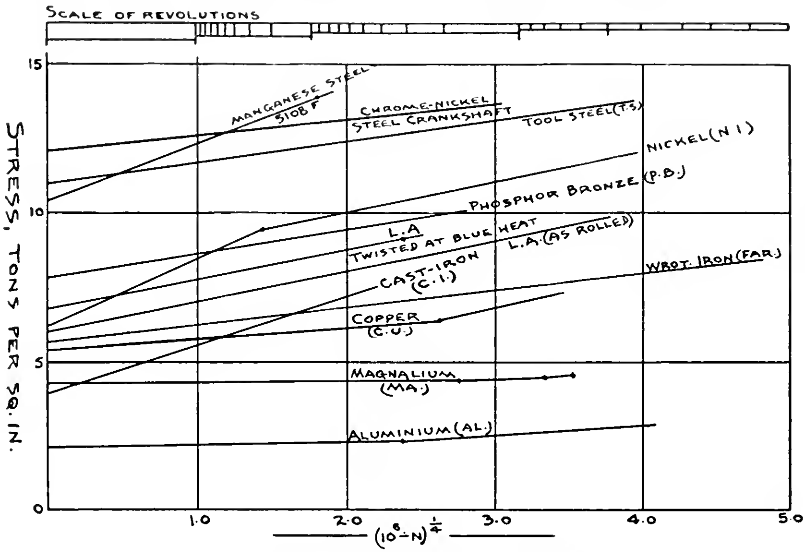


FIG. 4. TORSION TEST DIAGRAM.

Not only was it desirable to get a shorter and more practical testing method, but it was also important if possible to get at some direct method for measuring the fatigue limit. The only means so far available was, as we have noted, by prolonging the line of test points on the diagram. This is uncertain for two reasons, first it contains all the errors of the original tests, and second it depends for its reliability on the assumption that the law which was obtained by fitting the test data to an equation or formula, holds good not only for stresses which require say one million repetitions to fracture the specimen, but also for smaller stresses up to and including the fatigue limit. It is clear, however, that if direct measurements of the fatigue limit could be made which would agree with the values obtained from the diagrams for similar material, then we could trust the formula, the new method, and the original tests with a considerable degree of certainty, for each determination would act as a cross check on the others.

Mr. Stromeyer's short cut seems to have fulfilled all these conditions. He has shown how the fatigue limit may be determined quickly, and how in conjunction with one fatigue test at a large stress value so that the specimen is quickly fractured, all the other information may be obtained. He took advantage of the fact already noted, that a material becomes heated when it is stressed beyond a certain definite point; which he believed to be the fatigue limit. He tested this by surrounding his specimens with a thick walled rubber tube of such size as to leave a narrow annular space between it and the test piece. Water could flow through the passage while the specimen was undergoing the test, and if heat was developed, it would be noted by a rise in temperature of the water. If the heat quantities were small, then a slow flow would permit a very little water to receive the heat and so get a measurable rise in temperature, while if more heat developed, a larger flow would keep the water temperature within the desired range. Moreover, the quantity of water passing in a known time, together with its rise in temperature, would give an accurate measure of the heat developed. Trial showed that the test was very sensitive, a rise of 0.1° Cent. being measured with certainty. The stress values at which heat first appeared were consistent, and checked well among themselves, as they also checked with the fatigue limits determined from the diagram. It should be clear that if a direct measure of the fatigue limit is made then but one other point is needed to complete the diagram. The method of procedure finally adopted was as follows: A specimen was set up in the machine with the water jacket in place and started running. The load was then slowly increased until a very small rise in temperature was found. A check test was made to accurately determine the point at which the temperature rise began, and then the stress was quickly increased up to a point where the heat given off was considerable, indicating that the material would be quickly broken. The stress would then be kept constant at the higher value until failure occurred. Thus both the fatigue limit and the stress to produce failure in a measured small number of repetitions was determined in what was practically a single test of short duration.

The determinations of the fatigue limit proved more consistent than the elastic limit as ordinarily determined for a group of specimens of the same material, and agreed well for consistency with determinations of ultimate strength. To illustrate this, Mr. Stromeyer cites the case of tensile tests on eight coupons cut from a large plate of boiler steel weighing about 2 tons. Sample No. 1 was cut from the edge of the plate after 1-16 inch of metal had been planed from the sheared edge to remove all traces of distress from the shearing. Samples Nos. 2, 3, 4, etc., were then cut adjacent to the first, and separated from each other only by the width of the saw cut. In spite of the fact that these samples represent only about eight inches of a very large plate, considerable variations occurred between the values derived for the different specimens as is shown in Table 1.

To quote Mr. Stromeyer's paper, "it appears that the difference between the highest and lowest values for the tenacities is 0.9 ton or 3.2 per cent. of the mean value, and the elongation variations exceed 20 per cent. of the mean. The elastic limit variations are much worse, for the difference between the highest and the lowest value is 3.5 tons or 29.4 per cent. of the mean, and the yield point differences are 23.5 per cent. of the mean." This set of values is confirmed by tests made by Martens.* He tested 41 steel bars, taking samples from either end and two from the middle of each bar. From the variations in tensile strength, elastic limit, elongation, etc., for the series of tests, Mr. Stromeyer shows that "the probability is that amongst about 40 pairs of samples

* Mitteilungen, Physikalische Technische Reichsanstalt, 1914, vol. xxxii, p. 57.

TABLE I.

Tensile Tests of Eight Samples Sawn from the Corner of a large Boiler Plate.

Sample Number	Test Results. Elastic Limit.	Yield Point.	Tenacity.	Elongation.	Differences from Mean. Elastic Limit.	Yield Point.	Tenacity.	Elongation.
	Tons per square inch.			Per cent.	Per cent.			
1	....	22.0	28.2	22.5	....	—.5	+.7	—8.1
2	14.1	24.6	28.0	24.0	+18.5	+11.3	.0	—2.0
3	12.5	21.7	27.4	26.5	+5.0	—1.8	—2.1	+8.1
4	10.7	22.0	28.0	24.0	—10.0	—.5	.0	—2.0
5	11.4	22.6	28.2	24.5	—4.2	+2.2	+2.2	0
6	10.6	22.1	28.0	23.0	—10.9	0	0	—6.1
7	12.2	22.5	27.9	24.5	+2.5	+1.8	—.4	0
8	11.9	19.4	28.3	25.7	0	+12.2	+1.1	+12.2
Mean.	11.9	22.1	28.0	24.7	—	—	—	—

differences of tenacities of over 10 per cent. will occur in one or two cases, and that for the same number of pairs of tests, differences of from 10 to 50 per cent. as regards elastic limit, will number about 18, or nearly half the number of tests. Differences of over 50 per cent. amongst one pair of 40 are not at all improbable."

When the fatigue limits are considered, taking every case where several determinations are available, and comparing them on the same basis as the 41 tensile tests of Dr. Martens, the following table results:

14 pairs had differences of 3% or more.
22 pairs had differences of 2% or more.
30 pairs had differences of 1% or more.
10 pairs had smaller differences than 1%.

This puts the fatigue limit tests on practically the same footing of reliability as Dr. Martens' results for tensile strength. A further check on the reliability possible in fatigue limit measurements was had from a consideration of the result of testing 19 samples from a chrome nickel steel crank shaft. If these results are stated in terms of the Martens results, we should expect that "amongst 40 pairs there would be only seven for which the fatigue limit differed by 1.3 per cent., and probably about 30, or 75 per cent. of the pairs of tests would agree within 1 per cent. as against 9 and 14 cases amongst Prof. Martens' tests."

It is extremely fortunate, as Mr. Stromeyer points out, that the fatigue limit determined either by the calorimetric method or measured from the diagram checks up so closely. We have realized that it was not safe to load material beyond the elastic limit, but since the ultimate strength can be so much more accurately determined than the elastic limit, we have based our calculations on it, dividing by a factor of 5 or 4 or whatever in our judgment was enough to secure safety. Now, however, if we can establish through the careful analytical study of failures of machines or structures, that the fatigue limit furnishes a trustworthy indication of the probable behavior of materials of construction in service, we are in a position to replace the uncertainty involved in placing the safe load at ⅕ or ¼ the ultimate strength, by the certainty of a working load based on the measured fatigue limit. Verifications of this relation must be made in many cases before we are justified in accepting the new order of things in place of the old. One such investigation has already been made by Mr. Stromeyer, and will be described later.

To show how the fatigue limit should be used in choosing the proper material for a particular service, mention is made of two different steels. In the first, Fl = 12.6, and C = .504, while for the other Fl = 11.1 and C = 2.42. The material with the higher value of Fl would be the choice for service where it would be called upon to sustain a large number of stresses within the fatigue limit, because, having a high Fl, a smaller section of the material could be used with safety. On the other hand if we required a material to withstand a large number of severe shocks, in excess of the elastic limit perhaps, knowing that the material would eventually fail, but desiring to use that material which would last the longer, we should then use a material like the second one, in which the constant C is as large as possible, even at the sacrifice of Fl. To show this, if we were to require that a material should sustain repeated loadings of say 16 tons per square inch, we would find the second material much the more reliable, for while it would sustain 60,000 of the 16 ton shocks, the other steel would fracture at 480 repetitions.

We reprint one table of fatigue limits in order to show the magnitude of the fatigue limit and the constant C for several common materials. With it we print a portion of another table, showing the chemical properties of some of the samples listed in the fatigue table. In the original paper, those interested will find a large amount of this test data, carefully arranged, and in addition to the limits measured by Mr. Stromeyer, a table is given showing the values for Fl and C obtained by plotting the principal results of previous investigators, so that their work becomes available on a comparative basis. It is interesting to note that in nearly every case these earlier tests could be plotted to yield a fairly straight line on the Stromeyer diagram.

Mr. Stromeyer has made an interesting investigation of the data concerning the failure of 100 copper steam pipes in vessels, which were reported by the British Board of Trade. The failures were due to the vibration set up by the engines, causing the ends of the pipes to be displaced a small amount at each revolution until they finally failed from fatigue. As of course no fatigue limits had been measured for the actual material of which the pipes were made, it was necessary to assume that all of them had values of Fl and C equal to those determined from representative samples of copper. An estimate was made of the probable number of revolutions the engines had made during the life of the pipe in each case. From this estimated value of N, and the assumed values of Fl and C, it was possible to calculate a probable value for the repeated stress imposed on the pipe at each revolution of the engine. In every case the values so calculated indicate a stress in excess of the fatigue limit of copper, and so lead to the conclusion that if a knowledge of this property had been at the

Table II.

Summary of Torsion and Bending Fatigue Tests.

Materials.	Torsion Fatigue. Fl.	Torsion Fatigue. C.	Bending Fatigue. Fl.	Bending Fatigue. C.
	Tons per sq. inch.		Tons per sq. inch.	
Chrome Nickel Steel, F 5117	12.60[1]	0.50	....	....
Nineteen samples of Chrome Nickel Steel	11.37[1]	0.70	....	....
Manganese Steel, F 5109	11.10[1]	2.42	....	....
Cast Steel	10.70[1]	0.68	....	....
“ “	7.03[1]	1.91	....	....
Mild Steel Plates, high results, Q	9.69	1.26	14.08	4.70
“ “ “ “ “ H	9.71	1.55	13.86	5.46
“ “ “ “ “ R	11.04	1.11	13.82	5.71
“ “ “ “ “ L	8.16	1.55	14.39	4.36
Mean for above Mild Steels	9.65	1.37	14.04	5.06
Mild Steels, exceptional qualities, Y	7.56	2.40	13.30	5.40
“ “ “ “ F	8.64	1.26	doubt	ful
Mild Steel Plates, low results, J	7.01	1.36	9.36	5.31
“ “ “ “ “ A	7.09	1.26	8.94	4.76
“ “ “ “ “ T	6.33	2.03	8.95	5.13
“ “ “ “ “ U	6.94	1.69	8.15	5.61
“ “ “ “ “ Z	5.54	1.43	9.69	4.53
“ “ “ “ “ N	5.90	1.58	7.42	5.17
Mean	6.47	1.56	8.75	5.09
Mild Steel Rods, LF	6.83[1]	1.60	....	....
“ “ “ LA	5.97[1]	0.97	....	....
Pure Nickel Rods, NI	6.22[1]	1.83	....	....
Farnley Iron Rods, FAB	6.00[1]	0.61	....	....
Copper Rods as rolled, CU	5.50[1]	0.41	....	....
“ “ annealed, CU	2.69[1]	0.97	....	....
Aluminum Rods as rolled, AL	2.16[1]	0.13	....	....
Cast Iron, (one sample), CI	3.98[1]	1.61	....	....
Phosphor Bronze Rods, as rolled, PB	7.82[1]	0.77	....	....
Magnalium Rods, as rolled, MA	4.21[1]	0.78	....	....
Duralium Rods, as rolled, DA	5.80[1]	negative.	....	....

[1] These fatigue limits were determined calorimetrically.

disposal of the designers of these pipes, the failures might have been avoided. It is noteworthy that although the stresses were greater than the fatigue limit of copper, they were less than that of steel, so that steel pipes would not have

TABLE III.

Chemical Analysis of Steels Mentioned in Table II.

Marks and Quality.	Chemical Analysis.					
	C.	Si.	S.	Mn.	P.	N.
F German O. H. basic (plate)	0.10	0.026	0.048	0.54	0.220	0.0051
H " Acid Bessemer (plate)	0.21	0.135	0.062	0.31	0.079	0.0141
J " O. H. basic (plate)	0.19	0.013	0.043	0.44	0.050	0.0046
R British O. H. acid (plate)	0.16	0.015	0.014	0.59	0.177	0.0030
Y " " " "	0.27	0.650	0.030	0.82	0.037	0.0024
Z " " " "	0.19	0.100	0.036	0.64	0.038	0.0033
LA German basic O. H. (bar)	0.14	0.010	0.042	0.33	0.017	0.0087
LF " " Bessemer (bar)	0.15	0.010	0.043	0.36	0.066	0.0167

failed from this cause. A further comparison of copper and steel can be had when we consider the magnitude of the displacement of the pipe ends necessary to produce the calculated stresses. It was shown that displacements of .38 inch should be allowed for. Steel pipe might have been safely displaced .43 inch per revolution without failure, although the copper would have averaged but 42 days of service if the engine displacements were as severe as that. On the other hand, if the displacements had been as small as .27 inch, the copper would have lasted indefinitely. This study of pipe failures is not in itself a proof of the trustworthiness of the fatigue limit as a measure of safe loads, and yet, such close agreement between the new theory and the actual failures, considering the very reasonable nature of the assumption made, goes a long way toward a confirmation of it. If more extended tests and investigations do not develop some unexpected point of controversy, it would seem that we were upon the threshold of a new epoch in material testing, and that we need no longer hear safety factors referred to so commonly as "factors of ignorance."

The Hazard of the Domestic Hot Water Boiler

The percentage of domestic hot water boiler explosions, compared with the total number in use is undoubtedly small, probably much smaller than the percentage of accidents among steam boilers, used either for power or heating. The violence of the explosion, however, which may come from a common kitchen boiler is so great that some of the conditions which make for greater safety to this almost universally used adjunct to modern comfort and convenience should be of interest.

The violent accidents to hot water boilers are usually due to over pressure. No relief valves are fitted as a rule because it is thought that a vessel strong enough to withstand the ordinary service pressure, and piped so as to be always in open communication with the mains through the medium of the inlet pipe regardless of whether the outlet is open or closed, cannot accumulate a pressure in excess of that in the mains. The difficulty arises because this open communication with the mains is not always an actual fact.

If for any reason a large amount of heat is given to the water in the boiler at a time when no appreciable amount of hot water is withdrawn, the temperature will rise until the boiling point of water at the service pressure is reached. Then if the supply of heat is continued, steam will form. The temperature rise of the water is accompanied by expansion, and if steam is formed a still greater expansion takes place. This results in some of the hot water being forced out of the boiler and back through the inlet pipe. Most of the meters in use on water supply pipes are actuated by hard rubber moving parts, which frequently take the form of tilting or oscillating discs. So long as the meter is called upon to handle cold water only, hard rubber is an almost ideal substance for this service. If hot water works back, however, in the manner suggested above, the hard rubber parts are apt to soften and warp. This of course affects the accuracy of the readings if nothing more.

A practice has grown to some extent among the employees of municipal water works of putting a check valve on the house side of new meters which they are called upon to install in place of those which have been injured by overheating. Whether or not this practice is sanctioned by those in authority and who should know better is of no consequence in view of the fact that every now and then an instance of it comes to light. Of course the meter is protected by the check valve, but there is no longer any open communication between the hot water boiler and the supply pipe if the pressure within the boiler exceeds the service pressure. Moreover, the pressure within the boiler will *always* exceed the service pressure when water is being heated but not used, or used only in small amounts. The tendency of the water to expand will cause a rise in pressure for only a slight change in temperature, and so subject the boiler to a continual but unknown over pressure which the combination of a bright fire and no open faucets may bring to the danger point at any time.

It has been suggested by a trained boiler inspector after investigating a very violent domestic water boiler explosion, that in his estimation the accident was due to the hard rubber disc in the water meter being so softened with heat as to squeeze out over the inlet opening and so become in itself a very effective check valve. We are not in a position to positively affirm the truth of the suggestion, but we felt at the time that it offered the most plausible explanation which we had seen for that particular case.

The proper means for preventing accidents of this character requires careful consideration. A relief valve will prevent a dangerous over pressure, but it must be so constructed that its reliability will be of a high order under the condition of very infrequent operation. It must be installed also in such a manner that when it does operate, no serious damage to walls, floors or furnishings will result, and still we feel that the discharge should be arranged so that the working of the valve would be noticed. Perhaps an arrangement such that an escape pipe from the valve could lead to a nearby sink would answer as well as any we can suggest. The design of the valve which will fulfill the requirements outlined is as we realize, not an altogether simple matter, though we do not think it involves any insuperable difficulties. The lifting pressure to which a kitchen boiler relief valve should be set is a matter which would require different treatment in different places. Nearly all cities have a greater service pressure at night and on Sundays than at other times. If check valves are fitted for meter protection the relief valve must be set for a high enough pressure to insure sufficient hot water in the boiler at times when the demand is small, so that rise in temperature is accompanied by a considerable pressure rise. A few pressure gage readings at times of maximum pressure should settle the matter for any particular place, having due regard of course for the strength of the boiler.

FIG. 1. WRECKED HOME AT ILLION, N. Y.

In view of the apparent increase in the frequency of destructive and even fatal explosions from domestic water boilers, the subject of their proper installation and protection is one which should engage the attention of manufacturers of valves and fittings, hot water fitters, and engineers. Most of the accidents seem to be clearly of a preventable sort, and if so they should certainly be avoided.

As an example of the disastrous character which a kitchen boiler explosion may assume, we print the accompanying photograph showing the wreck of the residence of Mr. Harry Eckler, Ilion, N. Y., after the explosion of his hot water boiler on October 20, 1914. We are not possessed of sufficient information to state the exact cause of the accident, though the facts which we have are suggestive. It is said that the family left the house with the gas burning in the coil gas heater with which the boiler was fitted. On their return, they not only found their own home in the condition shown, but that of their neighbor had also been damaged by flying debris, and one piece of material had injured a sleeping two year old child in the adjoining house. Not the least unfortunate feature of the accident was the fact that the house was new, being finished, we are told, during the past summer.

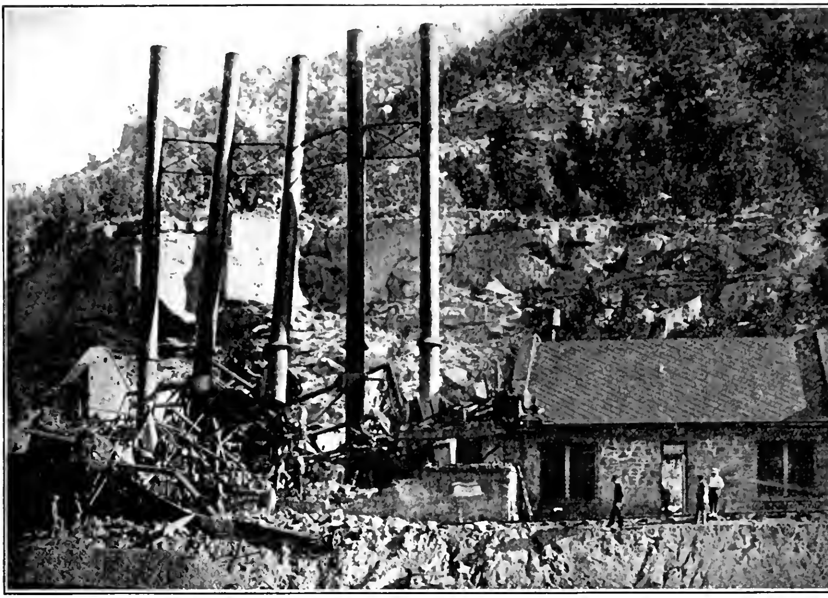


FIG. 1. WRECKED BOILER HOUSE AT STORRS.

Boiler Explosion at a Utah Coal Mine

On September 28, 1914, a dry back Scotch marine type boiler exploded with considerable violence at the coal mine power plant of the Spring Cañon Coal Co., Storrs, Utah. The boiler failed at the junction of the front head with the corrugated furnace, and was shot backward from the boiler house for a considerable distance. In its travel it undermined a roadway which ran along the top of an embankment, parallel to, and near the rear wall of the boiler house. A passing wagon was overturned and torn loose from its team, while the driver and horses were but slightly injured. The boiler house walls, of heavy stone construction, were blown down, both in front of and behind the boiler, while the roof was also damaged. Two men were killed, one of them, a fireman, was blown some 400 or 500 feet out through the front wall of the building, landing on the opposite slope of the valley. In addition to those killed, five were injured.

Fig. 1 gives a front view of the wrecked boiler house, while Fig. 2 shows the rear of the building with the boiler where it landed. A close inspection will show the scooped out road and the partly demolished wagon.

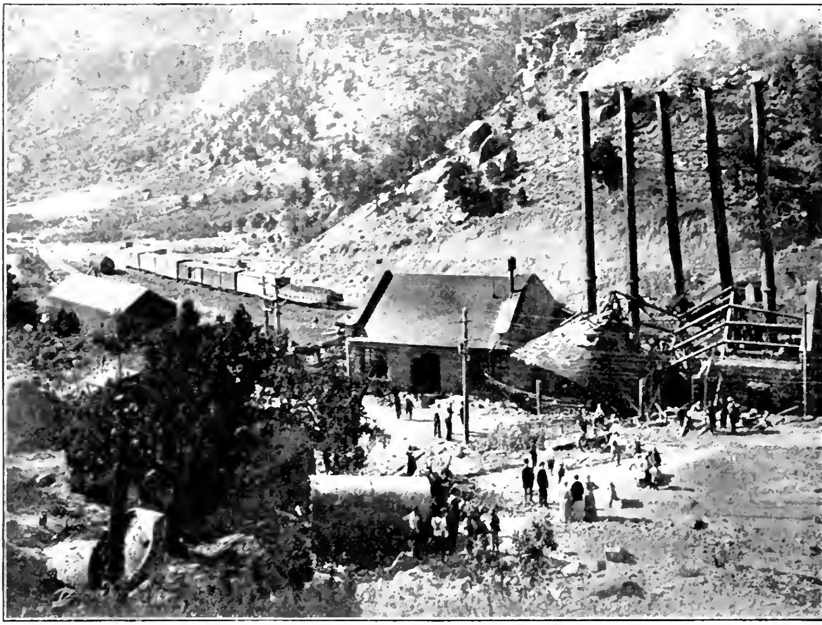


FIG. 2. REAR VIEW, STORRS EXPLOSION. SHOWING FINAL RESTING PLACE OF EXPLODED BOILER.

Water in the Engine Cylinder

We recently had an urgent telephone call from an assured in a neighboring city, who desired the immediate inspection of his boilers. As an inspection had been arranged for by correspondence, to be made the following week, we were somewhat surprised at the request. The assured however insisted that he was in trouble, and finally asked our representative if he could not hear an unusual noise over the 'phone. After careful listening he discovered that he could hear a rhythmic pounding or knocking which the assured declared came from his engine cylinder, and was due to water. The immediate stopping of the engine was advised, and an inspection arranged for as soon as train schedules would permit.

The result of the investigation was so unusual and so interesting that we have decided to present it to our readers. The inspector found, on visiting the plant, that water had been carried over copiously to the engine cylinder ever since a certain boiler had been placed back in service, following repairs. The walls and floor of the engine room gave abundant evidence of the faithful service which the relief valves had been called on to perform. Indeed it was difficult to believe that they could have handled so severe a flood without damage to the cylinder or piston. Finding that no previous trouble had been experienced from foaming or priming, he proceeded to examine the boiler which had just been put back in service. The trouble was not hard to explain when he entered the steam space. The boiler was of the horizontal return tubular type, and he found that recent changes had been made in the internal feed pipe, following a request at a previous inspection that the pipe be more securely fastened to the braces. A steam fitter had been assigned to this job who, it seems, thought he could more firmly attach the pipe by dispensing with that portion which extended across the boiler near the back end. He disconnected this cross pipe, but decided to leave the elbow attached to the longer portion which ran back parallel with the tubes from the front head. In his efforts to make as secure and strong a job as possible, he raised the rear end of the pipe up among the braces, where he lashed it fast in such a position that the upturned elbow on its end reposed near and almost in line with the nozzle from which steam was drawn. It is easy to see that the feed water must have been discharged into the steam space in such a way that it was practically forced as a jet, to pass out along with the steam, and this of course accounts for the floods at the engine.

It is perhaps needless to point out that a somewhat more detailed supervision of the repairs by someone from the engineering staff of the plant would have prevented the whole occurrence.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. PERRY, EDITOR.

HARTFORD, JANUARY, 1915.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

Caveat emptor; let the buyer beware. Modern business is tending rapidly away from the principle involved in this expression. Our periodical literature is filled with demonstrations from every standpoint that this policy in selling goods does not pay. Yet it prevails in the sale of second hand boilers to almost as great an extent as in the proverbial "hoss trade." Given an old and infirm boiler, it is only necessary to add a fine coat of tar paint or asphaltum varnish and it is ready to sell. The buyer may take it or leave it and judge for himself if it is not a bargain. Of course old boilers are not always sold with the intent to deceive, for many times their real worthlessness is unknown to the seller. Moreover, some second hand boilers are worth buying, and such a purchase may be made to the mutual advantage of both parties to the transaction. But if one places the slightest value on his property or the safety of either himself or those whom he may employ, he will not purchase a second hand boiler from his best friend without having it examined by a trained boiler inspector, to whose eyesight, a coat of paint will scarcely cover serious structural weakness. There is much in common between the diagnosis of human ills by a physician and the inspection of a boiler by one who knows how. A clue here, a suggestion there, the examination for certain symptoms and their correlation, and finally a thoughtful estimate of the condition which could give rise to all the various points in evidence. If further comment is necessary, let us refer the reader to the account printed on another page, of the spectacular end of a small second hand boiler.

Our attention is once more drawn to the hazard of the shaft governed engine. There can be no doubt that fly-wheels may be wrecked quite as readily on this type of prime mover as upon those whose speed is controlled by a governor of the belt, chain or gear driven type. The striking thing about the accident illustrated in this issue is that there does not appear to have been a material rise in speed. On a similar engine with which we are familiar, the governor wheel was also broken by a blow from the heavy parts of the inertia bar, but in this other case the bar broke in two, one of the heavy ends acting as the battering ram which produced the initial fracture. This time, however, the engine did speed up as was indicated by the violence of the final disruption. Both cases, however, exhibit the same initial cause, namely a heavy part of the inertia governor mechanism came adrift.

Obituary

Wallace W. Manning.

Just as this issue of the Locomotive goes to press we are shocked to learn of the sudden death in the very prime of life, of Wallace W. Manning, Chief Inspector in the New York Department.

Mr. Manning was in the office as usual on Saturday, December 19, though suffering from a slight cold. Pneumonia developed, however, from which he died Sunday evening, December 27, 1914.

Mr. Manning was born April 8, 1880, in Cincinnati, Ohio. A graduate of Pratt Institute, Brooklyn, he first entered the service of The Hartford, as draftsman and general assistant to the late R. K. McMurray, in August, 1899. On Mr. McMurray's death in March, 1910, he was made acting Chief Inspector, and received his appointment as Chief Inspector on January 1, 1911. A wife and two small sons, John aged 9, and Ward one year old, survive him.

Mr. Manning was a most faithful and loyal worker for the Company's interest and held the highest esteem and respect of the inspectors of his department, as well as of all those with whom he came in contact.

Colonel E. D. Meier.

We, in common with all who have had to do with the development and use of steam power in the United States, are saddened by the news of the death of Col. E. D. Meier. As engineer and boiler manufacturer he has held a prominent place in the growth of much that goes to make up a modern power plant.

Believing that we can find no better tribute, we reprint the following paragraphs from *Power* of December 22, 1914.

Col. Edward Daniel Meier, eminent engineer and manufacturer, died at the home of his daughter in New York City, Dec. 15, in his 74th year. The immediate cause of death was heart failure and hardening of the arteries. Ill health had kept him from active participation in business for over a year. The funeral services were held from his home in St. Louis, Dec. 17.

Colonel Meier was born May 30, 1841, in St. Louis, Mo., the son of Adolphus Meier, a prominent industrialist.

After a scientific course in Washington University, St. Louis, young Meier studied for four years at the Royal Polytechnic School, Hanover, Germany. In 1862 he started as an apprentice at the William Mason Machine Works, Taunton, Mass., but soon entered the army. Here he served in an engineering capacity and had the honor to receive the surrender of Lieutenant-General Hood. His colonelcy was acquired in the Missouri National Guard, following his activity in the railroad riots of 1877. He declined a commission as brigadier-general.

After the war Colonel Meier was for a year connected with the Rogers Locomotive Works, Paterson, N. J., and in 1867 was made assistant division superintendent on the Kansas Pacific R. R., later becoming superintendent of machinery. After his resignation in 1871, due to ill-health, he took an active part in various industrial enterprises, such as the coking of Big Muddy coals and the smelting of Iron Mountain ores. He was chief engineer of the Illinois Patent Coke Co. In 1872 he was manager of the Meier Iron Co. and built its blast furnaces. From 1873 to 1875 he directed the machinery department of the St. Louis Interstate Fair. During this time he was actively interested in the St. Louis cotton industry and designed machinery for baling cotton, first with the St. Louis Cotton Factory and then with the Peper Hydraulic Cotton Press.

About 1884 Colonel Meier organized the Heine Safety Boiler Co. for the development in the United States of the water-tube boiler of that name, and was its president and chief engineer until his death. He was also responsible for the introduction of the Diesel motor into the United States. He visited Germany in 1897 to investigate it, and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Co.

Colonel Meier was active in a number of professional organizations. From 1881 to 1884 he was treasurer of the St. Louis Engineers' Club and president from 1889 to 1890. During the latter period he was also secretary of the American Boiler Manufacturers' Association. As chairman of the committee on materials, he is largely to be credited with both the first and second sets of standard specifications. In 1908 to 1909 he was president of the association and also of the Machinery and Metal Trades Association.

In the American Society of Mechanical Engineers, Colonel Meier was active on many committees, and was twice its vice-president, serving his first term from 1898 to 1900, and beginning the second in 1910. He was elected president of the society for the year 1911.

As the seventieth birthday of Colonel Meier, retiring president of the society, occurred on Memorial Day, 1911, during the Pittsburg meeting, a large number of the members united in a subscription and presented him an illuminated address of congratulation, and also asked his consent to give sittings for a portrait. The artist was Daniel J. Strain, vice-president of the Boston Art Club.

William MacDonald.

William MacDonald, resident inspector for The Hartford Steam Boiler Inspection and Insurance Company, at Rochester, N. Y., died December 21, 1914 at his home in that city, following an illness of several months.

Mr. MacDonald was born in Scotland in 1852. Experienced as an engineer and mechanic he entered the service of The Hartford as an inspector in the New York Department in 1897. Several years ago he was stationed as resident inspector at Rochester, which post he held at the time of his death.

William Lang.

William Lang, an inspector for The Hartford Steam Boiler Inspection and Insurance Company, died October 28, 1914, at his home in Joplin, Mo., following a ten weeks' illness with typhoid fever.

Mr. Lang was born in Chicago, Ill., October 18, 1880. Educated in the public schools of that city, he early entered the field of steam and electric power plant work. He served in various capacities with the Illinois Central Ry. Co., The South Side Electric Ry. Co., and The Commonwealth Edison Co., gaining a wide experience with the operation of steam and electric equipment, and especially steam turbines.

In 1910 Mr. Lang entered the service of the Hartford as an inspector in the St. Louis Department, which position he held till the time of his death.

A wife and three children survive him.

A Small Second Hand Boiler Explodes

We illustrate the condition of a small boiler house and an adjoining barn after the explosion of a small vertical tubular boiler, which occurred recently. The boiler, used to operate a milk pasteurizing outfit, had been purchased at second hand and used but a few months. Some days before the accident the attention of the firm from whom the boiler had been purchased was called to a leak in the fire box. Some slight repairs were made and the owner was advised that nothing more serious than the putting out of the fire could happen.

Fig. 1. Wrecked Boiler House.

The explosion occurred at about 6.30 A. M., while the owner was at breakfast. It consisted of a rupture of the fire sheet at about the first row of stay bolts. The downward flow of steam and hot water caused the boiler to shoot up rocket fashion through the roof of the boiler house, falling at a point some 110 feet away, and grazing the corner of a neighboring barn as it fell (Fig. 2.). The damage was estimated at from $1,000 to $1,200, not covered by insurance.

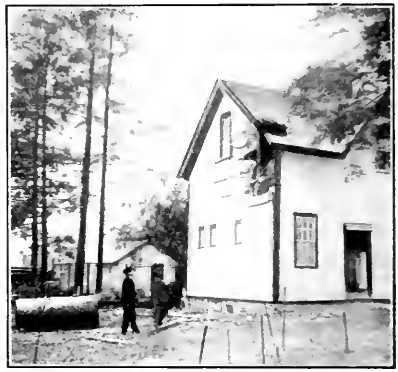


FIG. 2. BOILER'S LANDING PLACE.

One curious freak of the explosion is the fact that the tin roof of the boiler house, which must have been lifted clear to permit the escape of the boiler, fell back again into place, and showed only a crease to indicate its trap door action.

The boiler gave evidence of serious weakening by corrosion, especially on the fire sheets, but as it had not had the benefit of a boiler inspector's examination, this was not discovered, not even when the initial leakage took place. It is pleasant to note, however, that its successor will get a much better start in life, as it is to be cared for under a policy in The Hartford.

Fly-Wheel Explosions, 1914

(8.) — A pulley exploded June 19 at the plant of the Boston Woven Hose and Rubber Co., Plymouth, Mass. The accident was attributed to a blow received by the wheel from the cylinder head of the engine, which was broken by the follower nut on the piston rod working loose.

(9.) — A sixteen foot fly-wheel exploded June 19 at the plant of the Suffolk Peanut Co., Suffolk, Va. Fragments of the wheel plowed their way through five stories of the building, but fortunately no one was injured.

(10.) — An eight foot fly-wheel exploded June 29, at the brewery of the Union Brewing Co., St. Louis, Mo. The fragments of the exploded wheel wrecked the ammonia refrigerating system of the plant, the property damage exceeding $13,000.

(11.) — A fly-wheel exploded July 6, at Anton Hoffman's cooperage factory, 317 E. 91st St., New York City. Two men were injured, and considerable property damage was sustained.

(12.) — A pulley exploded July 21 at the mill of the Powell Lumber Co., Eden, Ia. The damage was practically confined to the wheel.

(13.) — A fly-wheel burst at the furrier's establishment of John D. Williams, Brooklyn, N. Y., on July 23. One man was injured.

(14.) — A 44 inch wheel on a blowing engine burst July 27, at the plant of the Scott Brick Co., near Knoxville, Tenn. The damage was slight.

(15.) — A 14 foot fly-wheel exploded July 30 at the power house of the Waverly Sayre and Athens Traction Co., Sayre, N. Y. No one was injured, but there was a considerable property damage.

(16.) — A fly-wheel burst September 14, at the No. 2 mill of the Richard Borden Mfg. Co., Fall River, Mass.

(17.) — A fly-wheel exploded September 22, at the St. Matthew's, S. C., mill of the Southern Cotton Oil Co. One man was injured slightly.

(18.) — An automobile fly-wheel exploded October 10, breaking the leg of George Kuester, at Griswold, Ia. The car was badly wrecked.

(19.) — A fly-wheel exploded October 14, at the Dwight Cotton Mill, Alabama City, Ala.

(20.) — A fly-wheel exploded October 22, at a straw board mill at Noblesville, Ind.

(21.) — A large fly-wheel exploded October 27, at the plant of the Iola Portland Cement Co., Iola, Kans. The property damage was large.

(22.) — A fly-wheel exploded November 27, at mine No. 30, New York Coal Co., Orbiston, O. (See account elsewhere in this issue.)

Boiler Explosions

August, 1914.

(276.) — On August 1, the furnace of a Scotch marine type boiler collapsed at the plant of the Altamaha Wood Working Co., Darien, Ga.

(277.) — An accident occurred August 2, to a boiler at the plant of the Tulare County Power Co., Lindsay, Cal. Considerable damage resulted to the boiler.

(278.) — A tube ruptured August 2, in a water tube boiler at the ice plant of C. N. Avery and M. L. White, Austin, Tex.

(279.) — Three sections ruptured August 3, in a cast iron sectional heating boiler in the building of William P. Boutelle, 63 Cornhill, Boston, Mass.

(280.) — On August 3, a tube ruptured in a water tube boiler at the plant of Proctor and Gamble, Ivorydale, O. Wm. St. John, fireman, was injured.

(281.) — A hot water boiler exploded August 3, in the bakery of Alphonse Gaboury, Webster, Mass. Two girls were instantly killed, and a third person injured by the explosion.

(282.) — A blow-off pipe failed August 4, at the plant of the Hiawatha Electric Light Co., Hamilton, Kans. The engineer was injured.

(283.) — A boiler exploded August 6, at Unicorn, Lancaster Co., Pa. The boiler, which was used to drive a saw mill, wrecked the mill and did property damage estimated at $3,000. It was carried 400 feet from its setting.

(284.) — On August 7, the dome cap was blown from a locomotive owned by the Bowman Hicks Lumber Co., Oakdale, La.

(285.) — A plug which had been used as a temporary repair, replacing a tube in a vertical tubular boiler at the plant of the Diamond Milling Co., Livermore, Cal., blew out August 8. A man who was engaged in adjusting the oil burner at the time of the accident was severely scalded.

(286.) — A tube ruptured August 10, in a water tube boiler at the plant of the Duquesne Light Co., Pittsburg, Pa. One man was scalded.

(287.) — The crown sheet of a traction engine boiler collapsed August 11, near Ithaca, N. Y. John Molloy, who was running the engine, was fatally scalded when the contents of the boiler were discharged through the fire box.

(288.) — A tube ruptured August 13, in a water tube boiler at the plant of the Wm. Tod Co., Engine Manufacturers, Youngstown, O.

(289.) — Two men were injured August 13, in a boiler accident at Leipsic, O.

(290.) — On August 16, a boiler ruptured at the plant of the Crystal Ice Co., Ashtabula, O.

(291.) — A boiler ruptured August 16, at the packing house of I. Belsky and Co., Dubuque, Ia.

(292.) — A boiler ruptured August 17, at the plant of the Narragansett Milling Co., East Providence, R. I.

(293.) — On August 17, a tube ruptured in a water tube boiler at the Electric Light and Power House of the City of Monroe, Monroe, La. A trespasser in the boiler room at the time of the accident was fatally injured.

(294.) — A boiler exploded August 17 at a saw mill near Pembroke, Ga. Four men were killed and several injured. Newspaper accounts credit the cause of the explosion to lightning!

(295.) — The boiler of a traction engine, used for threshing, exploded August 22, on the farm of W. E. Sheriff, near Salina, Kans. Several were injured, one of them very seriously.

(296.) — Three young men, Harry, Leonard and Louis Hanchett, were severely injured August 25, by the explosion of the boiler attached to a small engine with which they were working at their home in Elgin, Ill.

(297.) — An air tank exploded August 26, at the plant of the Central Iron Works, San Francisco, Cal. No one was injured, but the property loss was estimated at $1,000.

(298.) — On August 26, a boiler ruptured at the ice and bottling works of Malloy Bros., Weston, W. Va.

(299.) — A tube ruptured in a water tube boiler August 26, at the plant of the Omega Portland Cement Co., Jonesville, Mich. Two men were injured.

(300.) — On August 28, the boiler of a locomotive exploded, by the failure of its crown sheet from low water. The locomotive was the property of Proctor and Gamble, located at Port Ivory, Staten Island, N. Y. Two men were scalded and property was damaged to the extent of about $4,000.

(301.) — A boiler exploded August 28, in a cider mill near Churchtown, Pa. Amos Burkhart, 13 years old, was killed, his father was injured, a man carrying a bag of apples to the mill was blown into the road, and a boy was hurled through a board partition.

(302.) — A boiler exploded August 29, at the plant of the American Sewer Pipe Co., East Liverpool, O.

(303.) — A tube ruptured August 30, in a water tube boiler at the plant of Swift and Co., Union Stock Yards, Chicago, Ill.

(304.) — On August 30, a tube ruptured in a water tube boiler at the plant of the Proximity Mfg. Co., Greensboro, N. C.

September, 1914.

(305.) — An oxygen tank used in connection with a welding outfit exploded September 3, at Rice and Montjoy's Garage, Atlanta, Ga. One man was slightly injured.

(306.) — A boiler exploded September 5, at the cotton gin of Hughes Bros., near Cameron, Tex. One man was killed and two others seriously injured, while the building was badly wrecked.

(307.) — On September 7 a tube ruptured in a water tube boiler at the Charleston Consolidated Railway and Lighting Co. plant of the United Gas Improvement Co., Charleston, S. C. One man was injured.

(308.) — Another tube failed at the same plant as the above, on the same day, but in a different boiler. (A separate and distinct accident.) One man was killed by this second accident.

(309.) — A tube ruptured September 7, in a water tube boiler at the plant of the Birmingham Railway Light and Power Co., Birmingham, Ala. Two men were injured.

(310.) — On September 8, a tube ruptured in a water tube boiler at the plant of the Cape May Light and Power Co., Cape May, N. J.

(311.) — Seven sections fractured September 9 in a cast iron sectional heating boiler at the plant of the Central Casket Co., Buffalo, N. Y.

(312.) — A boiler exploded September 8, in a turkish bath establishment at Portchester, N. Y. Three men were injured.

(313.) — A section cracked September 10, in a cast iron sectional heating boiler at the Warren Hotel, Worcester, Mass.

(314.) — On September 10, a blow-off pipe ruptured at the cotton mills of the Pelham Mfg. Co., Pelham, Ga. One man was fatally scalded.

(315.) — On September 7, a stop valve ruptured in the main steam line at the plant of the Thomas Iron Co., Wharton, N. J.

(316.) — A threshing machine boiler exploded September 11, near Welch, Okla. George Davis, the owner of the outfit, was killed.

(317.) — A tube ruptured September 12, in a water tube boiler at the plant of the American Steel and Wire Co., Waukegan, Ill.

(318.) — A boiler exploded September 14, at the power house of the Southern Railway, Pinners Point, Va. One man was fatally injured and another so seriously injured that his recovery was considered doubtful.

(319.) — A boiler in use on bridge construction exploded September 15, at Piper City, Ill. One man was scalded.

(320.) — On September 16, a boiler ruptured at the plant of the Flower City Tissue Mills Co., Greece, N. Y.

(321.) — A boiler ruptured September 16, at the plant of the American Yarn Mfg. Co., Pawtucket, R. I. The boiler was damaged to such an extent as to render it unfit for further use.

(322.) — On September 22, a boiler tube failed at the East Chicago, Ill., plant of the Republic Iron and Steel Co. One man was seriously and perhaps fatally injured.

(323.) — A boiler exploded September 21, at the Widows' Home, Reading, Pa.

(324.) — A boiler exploded September 22, at the A. Wilson Saw Mill, near Covington, Ga. One man was killed and two others were seriously injured.

(325.) — A boiler used to run a threshing machine exploded September 22, at Vernon, Mich. The operator of the machine was severely scalded, and considerable damage was done by fire, resulting from the fire under the boiler being scattered about over inflammable straw, etc.

(326.) — On September 24, a blow-off failed at the saw mill of J. M. Goodwin, Freemont, Ind.

(327.) — Two tubes ruptured September 24, in a water tube boiler at the Eureka No. 35 Mine of the Berwind-White Mining Co., Windber, Pa.

(328.) —A blow-off pipe failed September 25, at Highland Park College, Des Moines, Ia. One man was injured.

(329.) — A boiler ruptured September 25, at the Troy Steam Laundry, Bowling Green, Ky.

(330.) — A tube ruptured September 26, in a water tube boiler at the plant of the Texas Southern Electric Co., Victoria, Tex.

(331.) — A tube ruptured September 27, in a water tube boiler at the power house of the Richmond Light and Power Co., West Brighton, Staten Island, N. Y. Two men were badly scalded. (An account of a violent boiler explosion at this same plant was published in the January, 1914, LOCOMOTIVE.)

332.) — A boiler exploded September 27 at the canning factory of Joseph W. Archer and Sons, Belair, Md.

(333.) — On September 28, a boiler of the Scotch marine type exploded at the mine of the Spring Cañon Coal Co., Storrs, Utah. Two men were killed, five injured, and property damage resulted estimated at $4,000.

(334.) — A boiler exploded September 29, at Freihofer's bakery, Atlantic City, N. J. One man was scalded.

OCTOBER, 1914.

(335.) — A tube ruptured October 2, in a water tube boiler at the plant of the Bimkie Compress and Warehouse Co., Bimkie, La. One man was severely injured.

(336.) — On October 3, a blow-off pipe failed at the plant of the Sacuger Ginning Co., Elmendorf, Tex. One man was injured.

(337.) — A large portable boiler exploded October 3, near New Salem, N. Y., while being moved. One man was severely burned.

(338.) — A heating boiler exploded October 4 in the basement of the home of G. A. Fletcher, Kansas City, Mo. Mr. Fletcher and a negro employee were seriously burned.

(339.) — A heating boiler exploded October 5, in the residence of E. H. Wikoff, New Brunswick, N. J. Property damage was estimated at $2,000.

(340.) — On October 7, a tube ruptured in a water tube boiler at the plant of the Hooker Electrochemical Co., Niagara Falls, N. Y. The boiler was considerably damaged as a result of the accident.

(341.) — A steam heated kettle exploded October 7, at the plant of the Pratt-Low Preserving Co., Santa Clara, Cal. One man was seriously scalded.

(342.) — A boiler exploded October 8, at the mine of the Rock Hill Coal and Iron Co., Robertsdale, Pa. One man was killed, three were injured, and the mine buildings seriously wrecked as a result of the accident. It is also stated that the mine would be forced to shut down for about three weeks, throwing 500 men out of employment.

(343.) — A blow-off pipe failed October 9, at the plant of the Canton Oil Mill Co., Canton, Miss. One man was injured.

(344.) — A tube ruptured October 10, at the Kansas City Electric Light Co. plant of the Metropolitan Street Railway Co., Kansas City, Mo. Three men were injured.

(345.) — An accident occurred October 10, to a boiler at the apartment house of Henry Warschauer, Milwaukee, Wis.

(346.) — A boiler exploded October 12, at the asphalt mixing plant of the Ford Asphalt Co., Beatrice, Neb. One man was killed and three injured.

(347.) — A heating boiler exploded October 13, in the freight office building of the Grand Trunk Railroad, Battle Creek, Mich. Property was damaged both by the direct effect of the explosion and by a fire which followed. Two men were seriously injured and about a dozen others received minor injuries.

(348.) — A boiler exploded October 14 at the lumber mill of M. T. Dillon, Rodman, Ky. The mill was wrecked, one man was killed and four others seriously injured.

(349.) — A cast iron heater failed October 14, in a water tube boiler at the plant of the Lordsburg Water, Ice and Electric Co., Lordsburg, New Mex.

(350.) — A tube ruptured October 14, in another water tube boiler at the plant of the Lordsburg Water, Ice and Electric Co., Lordsburg, New Mex. This is a separate accident from the above, occurring to a different boiler, two hours later.

(351.) — On October 14, a tube failed in a water tube boiler at the plant of the Loose-Wiles Biscuit Co., Kansas City, Mo. One man was killed.

(352.) — A boiler exploded October 15, at a cotton gin and grist mill at Sylvania, Ala. Two men were killed and several others seriously injured by the explosion.

(353.) — A locomotive boiler undergoing repairs at the roundhouse of the Western Maryland Railroad, York, Pa., exploded October 15. No one was injured.

(354.) — A boiler ruptured October 16, at the sanatorium of the New York and Astoria Land and Improvement Co., Long Island City, N. Y.

(355.) — A section cracked October 19, in a cast iron sectional boiler at the District No. 4 School House, Kanopolis, Kans.

(356.) — On October 20, a cast iron heater ruptured in a water tube boiler at the power house of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(357.) — A hot water boiler exploded October 20, in the residence of Harry Eckler, Ilion, N. Y. Both Mr. Eckler's house and an adjoining one was wrecked. A two year old child was injured in the adjoining house.

(358.) — The boiler of an engine used for threshing exploded October 20, on the August Holtman farm, Osage, Ia. No one was injured, but a straw pile and some farm equipment were burned.

(359.) — On October 22, a cast iron section ruptured in a cast iron sectional heating boiler at the apartment house of Louville V. Niles, 60 Water St., Boston, Mass.

(360.) — On October 23, an accident occurred to a boiler at the plant of the Kellog Toasted Corn Flakes Co., Battle Creek, Mich.

(361.) — Three sections ruptured October 23, in a cast iron sectional heating boiler at the restaurant of the Horn and Hardart Co., 106 W. 43rd St., New York City.

(362.) — On October 24, several headers ruptured in a water tube boiler at the Light and Water Works, City of Starkville, Starkville, Miss.

(363.) — On October 24, a tube ruptured in a water tube boiler at the above plant. This is a separate accident, and to a different boiler.

(364.) — A tube ruptured October 26, in a water tube boiler at the sugar house of L. Wagnespack Bros., Oubre P. O., La.

(365.) — A boiler exploded October 26, at a saw mill near Watts, Okla. One man was killed and three others fatally injured.

(366.) — A cast iron sectional heating boiler exploded October 26, in the basement of Costello Brothers' Undertaking Rooms, Chicago, Ill. One man, a member of the firm, was killed, and three others injured by the explosion, which was of a violent character.

(367.) — On October 26, the head of a Scotch marine type boiler pulled off the tubes at the Cafe Boulevard, 41st St. and Broadway, New York City. Two men were killed, two injured, and a considerable amount of property damage done as a result of the accident.

(368.) — A steam pipe ruptured October 27, at the plant of the B. T. Babbitt Co., North Bergen, N. J. One man was killed and two others fatally injured.

(369.) — A hot water boiler exploded October 29, in the residence of Alexander Konta, 42 W. 47th St., New York City.

(370.) — On October 29, a tube ruptured in a water tube boiler at the plant of the Pittsburg, Harmony, Butler and New Castle Railway Co., Harmony Junction, Pa. One man was injured.

(371.) — A tube ruptured in a water tube boiler at the plant of the Scoville Mfg. Co. Waterbury Ct.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1914.

Capital Stock, . . . $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$241,350.34
Premiums in course of collection,		287,689.64
Real estate,		90,300.00
Loaned on bond and mortgage,		1,199,345.00
Stocks and bonds, market value,		3,516,405.80
Interest accrued,		77,404.77
Total Assets,		$5,412,495.55

LIABILITIES.

Premium Reserve,		$2,293,028.64
Losses unadjusted,		41,990.28
Commissions and brokerage,		57,537.92
Other liabilities (taxes accrued, etc.),		47,429.31
Capital Stock,	$1,000,000.00	
Surplus over all liabilities,	1,972,509.40	
Surplus as regards Policy-holders,	**$2,972,509.40**	2,972,509.40
Total Liabilities,		$5,412,495.55

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Supervising Inspector.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, Director, Swift & Company.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

GEORGE C. KIMBALL, Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., and Director N. Y., N. H. and H. R. R. Co.

DR. GEORGE C. F. WILLIAMS, Treas. and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

Incorporated 1866. Charter Perpetual.

The Hartford Steam Boiler Inspection and Insurance Company

ISSUES POLICIES OF INSURANCE COVERING

ALL LOSS OF PROPERTY

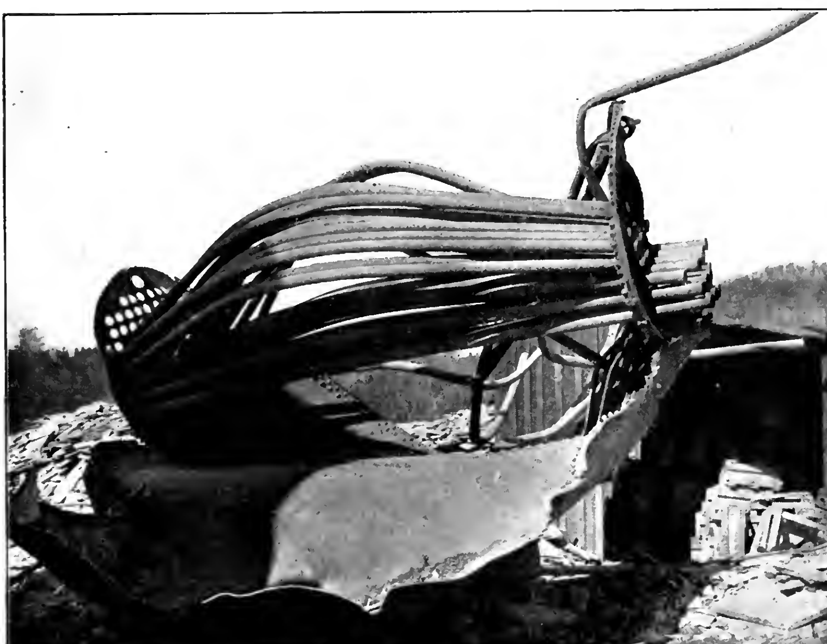
AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.	W. M. Francis, Manager and Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	Lawford & McKim, General Agents. R. E. Munro, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. Roberts, Manager. Joseph H. McNeill, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.	W. G. Lineburgh & Son, General Agents. F. S. Allen, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. Lemon, Manager. James L. Foord, Chief Inspector. J. T. Coleman, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. Gleason, Manager. Walter Gerner, Chief Inspector.
CLEVELAND, Ohio, Century Bldg.	H. A. Baumhart, Manager and Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg., Cor. 15th & Champa Sts.	Thos. E. Shears, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. Williams, Jr., General Agent. F. S. Allen, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	Peter F. Pescud, General Agent. R. T. Burwell, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. Gardiner, Manager. W. W. Manning, Chief Inspector.
PHILADELPHIA, Pa., Cor. Fourth & Walnut Sts.	Goodrich & Wickham, General Agents. Wm. J. Farran, Chief Inspector. S. B. Adams, Assistant Chief Inspector.
PITTSBURG, Pa., 1801-1802 Arrott Bldg.	J. J. Graham, Manager. Benjamin Ford, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	McCargar, Bates & Lively, General Agents. C. B. Paddock, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. Mann & Co., General Agents. J. B. Warner, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. Ashcroft, Manager. J. P. Morrison, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. Roberts, General Agent.

The Locomotive
of
THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

Vol. XXX HARTFORD, CONN., APRIL, 1915. No. 6.



Exploded Boiler at Arrington, Va.

An Unusual Confirmation of the Colburn-Clark Theory of Boiler Explosions.

The first really satisfactory hypothesis of the mechanism of a boiler explosion was published by Zerah Colburn in 1860, though it is supposed that the idea originated with Mr. D. K. Clark. This view supposes that the average explosion,* "although seemingly instantaneous, may actually be a succession of operations, three or four at least, as the following:

"(1) The initial rupture under a pressure which may be, and probably often is the regular working pressure; or it may be an accidentally produced higher pressure; the break taking place in or so near the steam space that an immediate and extremely rapid discharge of steam and water may occur.

"(2) A consequent reduction of pressure in the boiler, and so rapid that it may become considerable before the inertia of the mass of water will permit its movement.

"(3) The sudden formation of steam in great quantity within the water and the precipitation of heavy masses of water, with this steam, toward the opening, impinging upon adjacent parts of the boiler and breaking it open, causing large openings or extended rents, and, often shattering the whole structure into numerous pieces.

"(4) The completion of the vaporization of the now liberated mass of water to such an extent as the reduction of the temperature may permit, and the expansion of the steam so formed, projecting the detached parts to distances depending on the extent and velocity of this action.

"This series of phenomena may evidently be the accompaniment of any explosion to whatever cause the initial rupture may be due . . . . . A local defect well below the water line would simply act as a safety valve, discharging the contents of the boiler without explosion."

While it is of course true that any such picture of what happens in an explosion is artificial and speculative, still the experience of more than half a century has so largely confirmed it that it remains today by far the most probable of all the theories.

Every now and then the circumstances attending an explosion are of such a nature that they permit us to reconstruct by inductive reasoning some portion of the rapid succession of events. Such a case occurred recently in the explosion of a boiler at a soapstone quarry at Arrington, Va. In accordance with the Colburn-Clark theory, a rupture below the water line *need* not be attended with violent results, while if the rupture is *below* but *near* it should be possible for both sorts of action to take place, first an outflow of water without violent disruption of the boiler until the water line is lowered to the immediate neighborhood of the break, followed by a violent explosion when that point is reached. This possibility is in no way at variance with that type of explosion where a large rupture takes place well below the water line in say, a vertical boiler, and the reaction of the issuing jet of steam and water is so great that it lifts the boiler bodily, projecting it to a considerable distance, exactly as the issuing stream of water or steam propels a turbine wheel, or the issuing gases propel a sky-rocket, for in this latter case the explosion is not violent in the sense that the boiler is torn and disrupted as if by a blow, but is only the natural consequence of the powerful jet action following a very rapid outflow below the water line.

*Quoted from Steam Boiler Explosions, Thurston; pp 51, 52.

FIG. 2. SHOWING THE DESTRUCTION OF THE BOILER HOUSE AT ARRINGTON, VA.

It so happened that the boiler which exploded at Arrington was of the horizontal return tubular type made of two sheets, a single top and bottom sheet. This necessitated two continuous longitudinal seams the length of the boiler located at approximately the horizontal diameter of the heads. These seams were of lap riveted construction. So it will be seen that the longitudinal seams were located below the water line, and indeed below the upper rows of tubes. The appearance of the boiler after the explosion, indicated that the initial rupture took place at a seam crack in one of the longitudinal seams, of the type familiarly associated with the lap riveted construction.

At the time of the explosion one of the employees of the plant was in front of the boiler which failed. Fortunately, though seriously injured, he was not killed. His story furnishes the clue to what must have taken place. He says that prior to the actual explosion came a dull roar, and streams of water poured out of the furnace and ash pit. He seems to have started for safety when a second and much more violent disturbance took place, after which he was overtaken by falling debris, under a wagon where he had plunged for safety.

Assuming the substantial accuracy of his statement, this accident furnishes an almost absolute substantiation of the details of the theory which we have just set forth, the lap crack, which had no doubt been a long time forming, finally reached such a length and depth that the seam could no longer sustain the ordinary stresses due to the working pressure. A rupture followed through which water flowed with comparative quietness until the level came down to that of the crack, then followed the rapid outflow of steam and the sudden destructive "water hammer" action, described in the paragraphs quoted above, with the violent disruption of the boiler. The violence of this particular explosion, coming as it did from a rupture below the normal water line, was undoubtedly due to the large volume of hot water, and hence available heat energy still remaining in the boiler when the second stage of the explosion arrived.

Otherwise, the accident, while destructive, presented no unusual features. One man who was between the exploded boiler and an adjoining one was killed, and the plant was seriously damaged, as indicated in Fig. 2.

Rectangular Pressure Vessels.

H. J. Vander Eb.

One of the problems that usually give the machine designer trouble, speaking with particular regard to those who have to do with the design of pressure vessels, is the calculation of the proper plate thickness of vessels that are rectangular or square, instead of cylindrical in shape, and vice versa, of the pressure that can safely be allowed on such a square vessel of a given thickness of material.

In many types of water tube boilers the square form is used for several details, such as headers, water boxes and mud drums, and not much trouble is generally encountered in the way of structural weakness, due to the presence of flat surfaces, because their cross sectional dimensions are usually not large in connection with their comparatively heavy wall thickness and the pressures commonly employed.

With pressures higher than the usual, which are sometimes used for certain processes of manufacture, such as 300, 500 and more lbs. per square inch, it becomes desirable to investigate the probable resultant stresses in the square headers and boxes due to internal pressure, so that some idea can be gained as to their safety; especially so when they are subject to the temperature of superheated steam. In the case for instance of a superheater header the temperature is a factor to be considered as will be evident from the following.

Take the temperature of steam of 300 lbs. gauge pressure with a superheat of 100 deg. Fahrenheit, this amounts to $413 + 100 = 513$ deg. Fahrenheit. At this temperature, steel is blue hot, a condition in which to bend it, steel requires only about two-thirds* of the effort that it takes to bend it when at normal temperature. It is also a widely known fact that a piece of steel which is strained by changing its form at a blue heat, acquires an excessive brittleness.

From these facts it appears highly desirable that no deformations of the walls of a vessel take place, while at a blue heat, or at least, that whatever change of form takes place due to working pressures be limited to a minimum and consequently that the thickness of the walls be such as to afford a liberal factor of safety against elastic deflections.

* Stromeyer's "Marine Boiler Management and Construction."

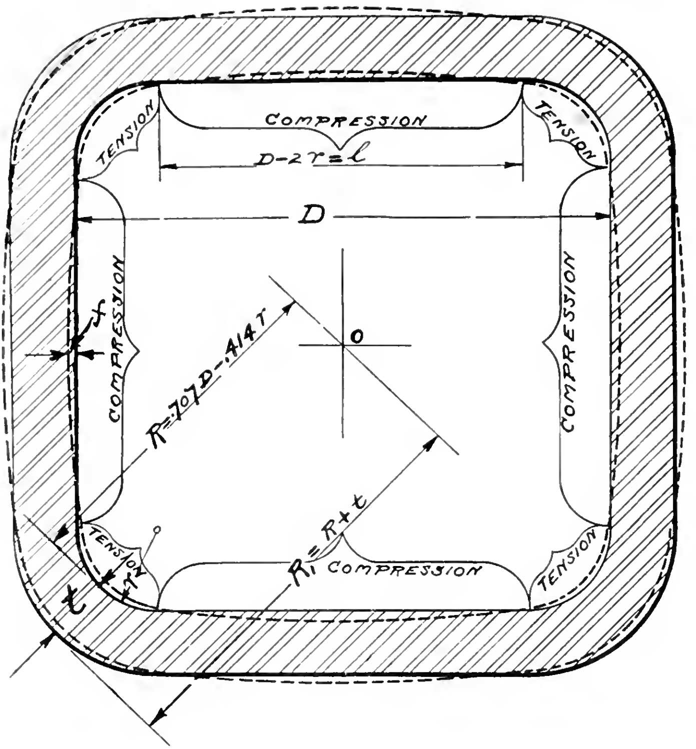


FIG. 1.

The tendency of a square vessel, a cross section of which is shown in Fig. 1, is to become round when subjected to internal pressure or in other words, such parts of the circumference as are flat tend to become curved, and the corners to straighten out, as shown in dotted lines.

Referring to Figs. 1 and 2, two different sources of stress are readily recognizable, namely: the direct stress due to the tendency to separate as shown in Fig. 2, and the indirect stress, which may be produced by the tendency of the vessel to assume a cylindrical form.

The direct stress is easily calculated by means of the usual formulæ for cylinders. In the case of the small dimensioned vessels with the comparatively thick walls under discussion it is well to use Lamé's formula for thick walled cylinders in preference to the formula usually employed for boiler shells. The total tangential stress in the material of any cylinder is not evenly distributed throughout the thickness "t" of the material, but gradually diminishes from the inner skin of the plate toward the outer skin, so that the maximum stress occurs in the inner skin of the metal.

Accordingly letting S represent direct stress in the inner skin of the material, P the internal pressure and further referring to the notations in Fig. 1,

$$\text{Then} \qquad S = P\,\frac{(R_1^2 + R^2)}{(R_1^2 - R^2)} \qquad 1)$$

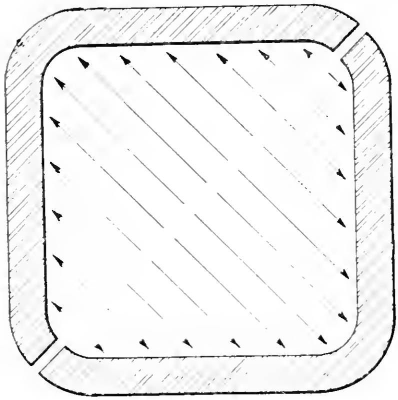


FIG. 2.

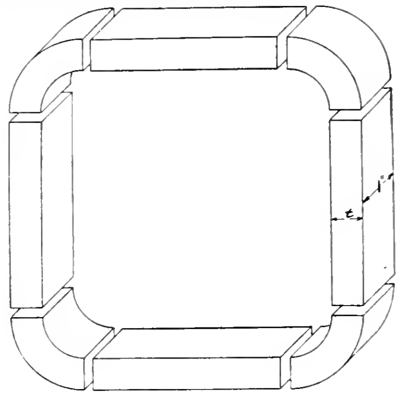


FIG. 3.

For the sake of simplicity we might use the usual boiler shell formula, namely: $S = \frac{P \cdot R}{t}$, but this would be at the sacrifice of accuracy, since it produces a result that is considerably less for thick walled structures of small diameter than Lamé's formula, which is theoretically correct, and therefore we would err in the wrong direction.

The stresses due to the tendency of the square vessel to become cylindrical are not so easily calculated. Considering what takes place when the internal pressure "P" is exerted on the walls of the vessel, we observe as is shown in dotted lines in Fig. 1 that the flat portions bend outward, acquiring a deflection "f," while the curved corners tend to straighten, or in other words, acquire a deflection which is in an opposite direction to the deflection "f" with regard to the center "o" of the cross section.

If we regard the curved corners as short curved beams, and consider a length of vessel of one inch, we can distinguish two groups of four beams, namely, four straight ones and four curved ones, the straight beams being the sides of the structure. In Fig. 3, these beams are shown separated for the sake of clearness. When a simple beam is subjected to a uniformly distributed load, the fibers on the load side of the neutral axis are compressed or shortened and on the other side stretched.

Because of the fact that the four side beams, and corner beams form one continuous structure, but bend in opposite directions from each other, it follows that for elastic deflections the shortening of the inner fibers of one set of beams is equalized by a corresponding elongation in the inner fibers of the other set of beams, or expressed differently: speaking with regard to the total inner surface of a square vessel, it is an obvious law that the sum of all elongation equals the sum of all contraction in that surface, so long as the elastic limit of the material of the vessel is not exceeded by the attendant fiber stresses. So that if we can calculate the shortening of the inner fibers of one straight beam of the given length $D\text{-}2r$, due to a given pressure load, we may take this result as being equal to the elongation of the inner fibers of one curved beam of the length $\frac{1}{2}\pi r$. It is not the purpose of this article to attempt a complete mathematical analysis of the true stresses as they exist in the different parts of the square structure under discussion, which is extremely complicated, but rather to suggest a way to make a safe approximation of the probable maximum stresses in the absence of anything better, and in order to have some reasonable rule to go by for the purpose of computing allowable pressures.

The amount of the tension stress then in the fibers lying on the inside of the neutral axis of the curved beam may be approximated in the following manner:

It is first necessary to calculate the deflection f of the straight beam D-$2r$, due to a given pressure load.

This straight beam is neither a so called simple beam, nor is it a beam of which the ends are rigidly fixed, since, although its ends are integral with the ends of the adjacent curved beams, yet this does not have the effect of making these ends immovably fixed, owing to a certain amount of yield that the end connections allow.

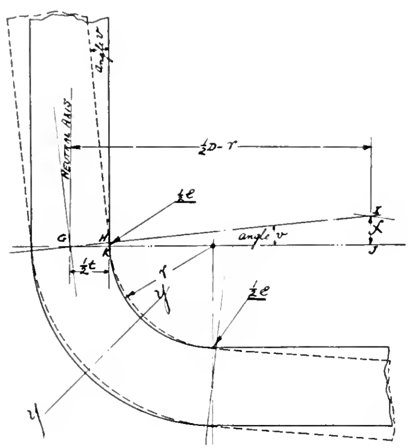


FIG. 4.

Therefore by assuming a deflection for the straight beam D-$2r$, the same as if it were a simple beam, the deflection of which is considerably more than for a beam with fixed ends, we commit a certain error, but the error is on the side of safety and is an unknown addition to the factor of safety that is to be allowed on the material, which goes to offset certain other unknown factors, as for instance, the influence of high temperature in headers of superheaters. Then deflection $f = \frac{5}{32} \frac{w\, l^3}{E\, t^3}$ in which l=length D-$2r$

W = pressure load Pl
E = Modulus of Elasticity

so that we may write this equation $f = \frac{5}{32} \frac{P\, l^4}{E\, t^3}$ 2)

The width of the beam being equal to one, this element need not appear in the deflection formula. An initial tension in the beam of the length l equal to ½ D P, producing a small bending moment which opposes deflection in an outward direction is herein neglected.

In order to find the shortening of the fibers on the compression side of the straight beam, which is equal to the elongation of the fibers of the tension side of the curved beam, we may consider the elastic curve of the straight beam as being the two equal sides of an isosceles triangle, which has for a base the length l and an altitude equal to the deflection f. The two equal angles of the isosceles triangle are then each represented by angle v, Fig. 4, which for clearness' sake is here shown enormously exaggerated. Applying one half of the triangle at the rectangular end of the straight beam as shown, we find from the similar triangles $G\,H\,K$ & $G\,I\,J$ that one-half the elongation e of the curved beam is: $\frac{1}{2}\, e = \frac{\frac{1}{2}\, t\, f}{\frac{1}{2}\, l}$ or elongation $e = 2\, \frac{t\, f}{l}$ 3)

In reality the base of the isosceles triangle just referred to does not have the length l, but has a length l minus an amount e, so that a slight error is committed. This error is, however, small owing to the fact that e is such a very small proportion of l that it is negligible.

The stress that is proportional to this elongation of the outermost fibers of the curved beam for elastic conditions of the material can be calculated from: $S_1 = \frac{Ee}{\frac{1}{2}\pi r}$ 4)

which is the formula of proportionality of stress to elastic deformation.

From formula 3 and 4 we would then find the unit stress in the metal of the inner skin of the curved beam through line Y-Y due to the bending of the straight beam to be: $S_1 = \frac{2tf}{l} \times \frac{E}{\frac{1}{2}\pi r}$

substituting for f, $S_1 = \frac{2t}{l} \times \frac{5}{32} \times \frac{Pl^4}{Et^3} \times \frac{E}{\frac{1}{2}\pi r} = \frac{Pl^3}{5.02\, t^2 r}$ 5)

Then combining formulæ 1 and 5, that is, adding the direct and indirect stresses, we find the total unit fiber stress of the metal of the inner skin of the curved beam. Naming this stress S_2, we get:

$$S_2 = S + S_1 = \frac{P(R_1^2 + R^2)}{(R_1^2 - R^2)} + \frac{Pl^3}{5.02\, t^2 r} = P\left(\frac{R_1^2 + R^2}{R_1^2 - R^2} + \frac{l^3}{5.02\, t^2 r}\right) \quad 6)$$

As has been said above, the theory of this discussion like all theories where the flexure of beams is involved, becomes void as soon as the stresses resulting from the pressure load exceed the elastic limit of the material. It is therefore necessary in all cases to figure the probable maximum stresses in the straight beam first, in order to see whether this is still within the elastic limit, and also for later comparing this stress with the stress found for the curved beam from formula 6). The maximum unit stress in the straight beam is: $S_4 = \frac{Pl^2}{8} \times \frac{6}{t^2} + \frac{1}{2}\frac{DP}{t} = P\left(\frac{3l^2}{4t^2} + \frac{D}{2t}\right)$ 7)

The allowable pressure on the vessel should then be based on the weakest part, whichever of the beams is found stressed the highest.

With this method of calculation, the all important radius of the corner fillet is duly taken into account. From the theory of curved beams this is very essential since in this form of beam, when of rectangular cross section the location of the neutral surface does not coincide with the center of gravity of the section as it does in straight beams, but its distance from the concave side of the beam is proportional to $\frac{t}{r}$. For $\frac{t}{r} = 0$, which is radius = infinity, or a straight beam, the distance of the neutral surface from the outer fibers is $\frac{1}{2}t$. For a curved beam of a microscopically small radius, which is a sharp corner, the neutral surface and the concave outer surface coincide, which makes the stresses in the concave side infinitely large in the case of a sharp corner.

Between these limits the following values for the distance of neutral surface to concave side of curved beams obtain:

$\frac{t}{r}$ = Sharp corner	10	5	1	$\frac{1}{2}$	$\frac{1}{16}$	Straight beams
Distance = 0	.317 t	.358 t	.443 t	.466 t	.492 t	$\frac{1}{2}t$

The fiber stresses in the metal of the concave side of the beams vary inversely to these distances. This shows clearly the importance of having an ample fillet radius at the corners of rectangular vessels.

A numerical example is now in order for additional elucidation:

A square header has a side dimension of 7¼", an internal fillet radius of 1" and a thickness of ⅝". What is the maximum fiber stress at 300 lbs. gauge pressure? Referring to Fig. 1, the following values appear:

$$D = 6''; \ r = 1''; \ l = 4''; \ t = .625''$$
$$R = .707 \times 6 - .414 \times 1 = 3.828''$$
$$R_1 = 3.828 + .625 = 4.453''$$

Then from formula 7), maximum fiber stress in straight beam:

$$S_4 = 300 \left(\frac{3 \times 4^2}{4 \times .625^2} + \frac{6}{2 \times .625} \right)$$
$$= 300\ (30.7 + 4.8) = 10{,}650 \ \textit{lbs. per sq. inch.}$$

This is well within the elastic limit of the material.

And from formula 6), maximum fiber stress is curved beam:

$$S_2 = S + S_1 = 300 \left(\frac{4.453^2 + 3.828^2}{4.453^2 - 3.828^2} + \frac{64}{5.02 \times .39 \times 1} \right)$$
$$= 300\ (6.65 + 32.67) = 11{,}800 \ \textit{lbs. per sq. inch nearly.}$$

With material of an ultimate tensile strength of 60,000 lbs. per sq. inch, this header would have a factor of safety of 5+.

It is with regard to the deflection *f*, that this method of calculation is open for verification and probably revision. That is, micrometer measurements for deflection of the sides of a square vessel when subjected to a test pressure, will probably produce a smaller value for *f* than the figured value at that pressure.

Such a test if made would then be of benefit in revising the deflection formula and thus rectify the figured factor of safety, so that a more correct formula could be established than the one here suggested. At any rate, the formula as suggested would appear to be a safe approximation and yet sufficiently accurate for practical purposes.

Convenient Form of Plate Caliper.

Measuring up a boiler is one of the duties of an inspector when visiting a new risk that calls for the display at times of considerable ingenuity. Boiler data, to be of service in setting safe working pressures, must be exact. How to obtain it from the finished boiler is the question. Much might be written concerning ways and means for measuring rivet pitches, determining approximate rivet diameters, getting the areas of surfaces to be braced or stayed, etc. Each of these measurements presents an individual difficulty, different with the varying types and sizes of boilers. At this time we are concerned with the measurement of plate thickness. How shall we get at it in a finished boiler? The edges of seams are apt to be upset or bent from shearing, or on the outside they will be distorted by caulking. (Fig. 1.) Moreover plate edges are

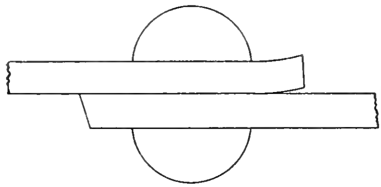


Fig. 1.

practically always beveled, so that a direct measurement of the plate edge is apt to be misleading. The plate may be calipered at openings to domes, or any other opening where the edge of the plate is exposed in such a way as to permit the application of a caliper, but such measurements are far from satisfactory, because plates used for boiler construction vary somewhat in thickness from the edges toward the middle of the sheet, due to the spring of the rolls between which the sheet was formed. It is of course necessary to base calculations of safe working pressure on the weakest portion of a boiler, and so minimum and not maximum plate thickness are what we desire, or in other words we must measure our plates near the edges.

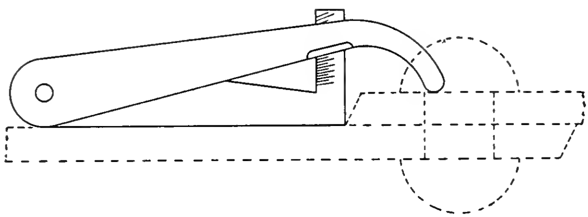


Fig. 2.

Mr. C. R. Summers, assistant Chief Inspector in our Atlanta Department, has contrived the form of caliper sketched in Fig. 2. This tool, graduated to read in terms of plate thickness at the point of contact of the curved arm, is intended to be applied to the girth seams of a boiler, from the inside. The caliper arm projects far enough to reach the overlapping plate at a point between the rivets, where both plates are most likely to be in contact as the grip of the rivets will there be greatest. It is clear that no distortion of the plate edge can effect such a measurement, and results of ample precision are assured if care is taken to clean a place quite free from scale or sediment on which to rest the straight part of the tool. It will probably prove desirable to harden the tool to a spring temper, so that wear may be reduced as far as possible, for it is clear that wear of the contact point will gradually throw the readings on the scale out of truth. Any machinist should be able to make and calibrate such a plate caliper at small expense.

The Explosion of a Small Hot Water Heater in a Garage.

During a period of extremely cold weather, below zero, a small cast-iron heater used to furnish hot water for a single radiator in a private garage exploded with great violence, considering the small size of the installation. The boiler was reduced literally to fragments as is shown in Fig. 1, and was blown through the side of the building. Two automobiles, standing in the

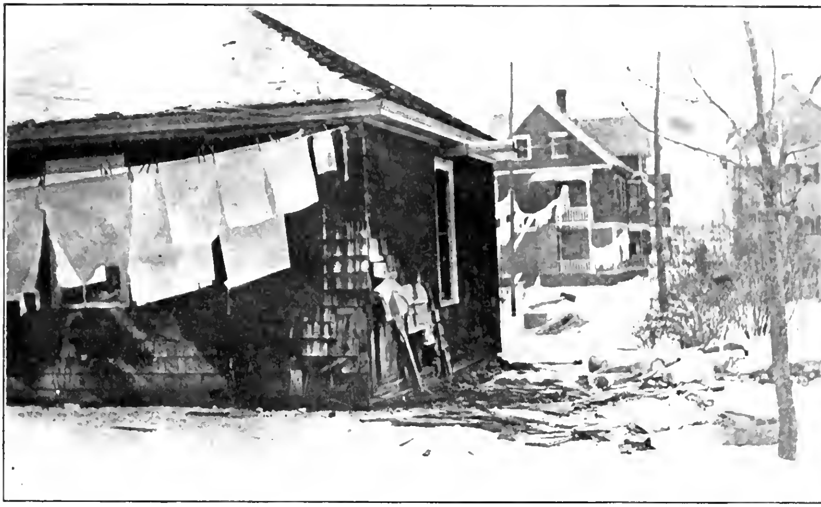


Fig. 1.

garage at the time, were struck by a piece of metal which passed through a front wheel of one and a rear wheel of the other, damaging the spokes to some extent.

That the damage was small was largely due to the isolation of the building, its small size, and the fact that no one was near at the time.

The cause of the explosion seems to have been the freezing of the expansion tank or its connecting pipe, and was no doubt due to the manner in which the outfit was installed. Figure 2 is a diagrammatic sketch of the connections. *A* is the small jacketed stove or heater, *B* the expansion tank, *C* the ½ in. riser to the tank, tapped into the supply pipe, and *D* is the single radiator, located about a dozen feet from the heater. The tank *B* was situated some five or six feet above the supply pipe near the eaves of the small unsheathed building, where it was exposed to a considerable draught of cold air. It was fitted with an ample vent to the atmosphere, and with a water gage glass as shown, so that a proper water level might be easily maintained. The fault lay in the use of the single riser. No circulation was provided for through the tank, and so the water could not be kept as warm as that in the rest of the system, with the result that in extreme weather the tank could easily freeze, notwithstanding the fact that a bright fire was maintained. Once frozen, the failure of the system at its weakest point, in this case the heater, was bound to follow.

This is not by any means the first heater explosion in a small garage which has been brought to our attention, and in view of the necessity of heating these buildings to prevent the freezing of radiators and cylinder jackets on the cars stored in them, we feel that we may be doing our readers a service by calling their attention to the faults of this particular arrangement. A better way would have been to lead the flow pipe from the heater straight up to the tank then from the tank to the radiator, and back to the heater. If this had been done, the hot water from the heater would have passed continually

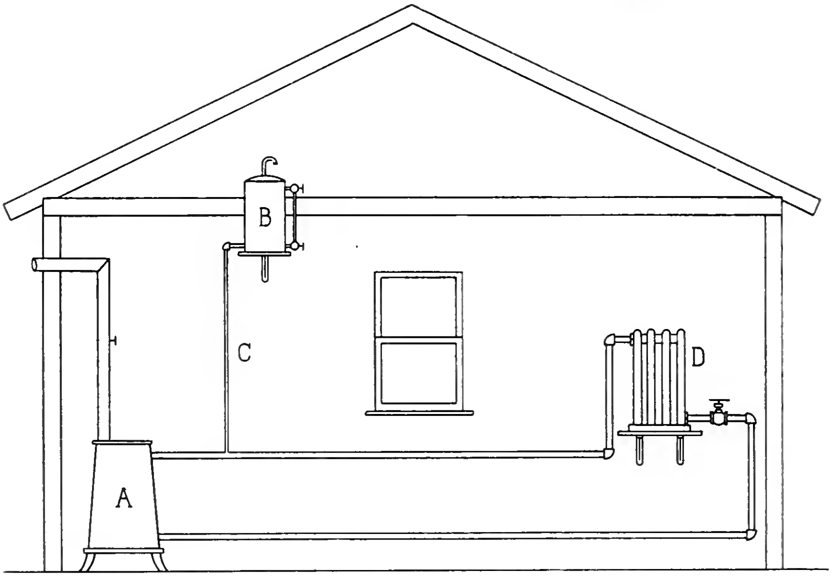


Fig. 2.

through the tank, so that the surface of the tank as well as that of the connecting pipes would have been useful as additional radiating surface, and would have in no way detracted from the serviceableness of the installation, while at the same time it would have been practically impossible for water to freeze in any part of the system so long as a fire was maintained in the heater. Indeed, far from detracting from the serviceability, this arrangement with its added radiating surface would probably have been more economical, and would certainly have provided a more uniform distribution of heat in the building.

An Unusual Fly-Wheel Explosion.

We illustrate in Fig. 1, the wreck of an engine at the Municipal Electric Light Station, at Nelsonville, O., after the explosion of its fly-wheel on December 8, 1914.

The engine was of the high speed shaft governed type, and was fitted with a riding cut off valve gear, in which the riding valve, whose only function was to determine the point at which cut off occurred, was under the direct control of the governor. Admission was controlled by a main slide valve, upon which the riding valve traveled, while exhaust and compression were provided for through the expedient of a pair of oscillating plug valves. All except the riding valve driven by fixed eccentrics, cut-off alone being influenced by the action of the governor.

The unusual feature of this accident is found in the apparent failure of the engine at an excessive speed, in such a manner that the governor was in no way responsible, and indeed was powerless either to cause or prevent the trouble.

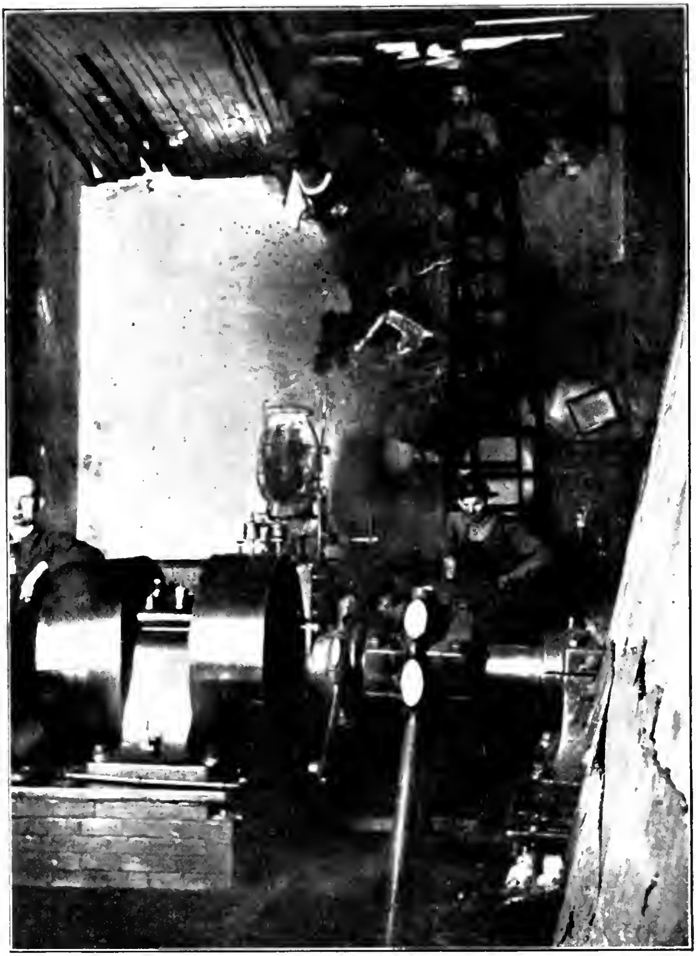


Fig. 1. Wrecked Fly Wheel at Nelsonville.

That the speed was excessive is attested by the violence of the explosion, the distance to which large pieces of the wheel were projected, and also by the fact that lamps were burned out by an excessive voltage, which would accompany an increase of speed, just prior to the disruption of the wheel. The governor was wrecked but there is good reason to believe, as we shall endeavor to show, that its wreck occurred *after* the engine had been released from its control and from the effect of the high speed to which it was subjected.

There are certain peculiarities of the valve gear which should be made clear before attempting to explain the probable cause of the accident. A riding cut-off valve consists of a small valve arranged to travel on the back of a main slide valve. Ports are provided through the main valve, and the riding valve serves to close these periodically. It may be thought of as a device to secure a variable steam lap on a simple slide valve. This variation in lap, and its attendant variation in the point in the stroke at which cut off will occur, may be either controlled by a hand adjustment, as in the case of an adjustable speed engine designed to run at different speeds at the will of the operator, when some form of throttle governor is ordinarily used, or it may be utilized as in the present case, as a device to place the point of cut off under the control of a shaft governor, while the other events in the cycle of steam expansion are controlled by valve action from a set of fixed eccentrics. This secures a result not unlike that obtained with the well known corliss gear, but capable of running at high speed.

The principal benefits in engine economy obtained by such a design, are constant lead and compression, with a quick opening of the main valve at admission. To make sure of this result it is customary to design the main valve with a long travel, so that it shall pass the edge of the cylinder ports at high speed, and also to give it little or no steam lap in itself, that is, if the engine were run without the riding valve, the cut-off would be either very late, or would not take place at all. Steam would "follow the piston full stroke" as in the case of steam pumps, and some hoisting apparatus. This effect is well known to develop the maximum power of which a given size of cylinder is capable, though of course at a sacrifice of economy. Moreover it is quite possible for a result approximating that due to the removal of the riding valve, to be brought about by the breaking of the rod by which the riding valve is driven. At least one end of the engine would act non-expansively, and the action of the other end would depend on the position at which the riding valve lodged. If such action should take place at any engine load short of the greatest overload which could be carried, an increase in speed would follow, the rate of increase depending on the load, as it would be possible to accelerate a lightly loaded engine much more rapidly than one more heavily loaded.

At Nelsonville, something of this sort appears to have happened. The chief engineer is said to have heard a noise as if something had snapped or broken. He went to the engine, and, as he approached the throttle, something flew past his head, while the engine began to speed up. He feared that he could do nothing before an explosion would occur, so ran to the boiler room, and began to close the stop valves at the boilers. He succeeded in closing two out of the three valves when the wheel exploded. The valve rod to the riding valve was found to have broken short off near the valve, and the valve was driven against the back (head) end of the valve chest. This seems to fit in to the case as the snapping noise the engineer first heard. The piece which passed his head may have been a part of the governor, as a portion of it was found on the engine room roof, in such a position as to make this explanation quite possible. The engine, freed from governor control, and acting now, at least at the crank end, under the late cut-off provided by the main valve alone, speeded up, but not instantaneously by any means, for in the interval the engineer was able to shut two out of three boiler stop valves, as well as to go from the engine to the tops of the boilers. It will be seen that all the known facts in the case fit very well with the theory we have advanced to explain the accident.

As will be seen from the photograph, the engine was considerably damaged. Some damage was also done to walls, roofs, windows and stack, while the generator which was belt connected to this engine, as well as the driving belt, suffered more or less from the accident. Fortunately no lives were lost and no one was injured.

American Society of Mechanical Engineers—Boiler Code.

It has long been recognized that uniformity in boiler construction was a condition to be desired, both from the standpoint of safety and economy. The Hartford Steam Boiler Inspection and Insurance Company has probably been more influential toward this end than any other one factor in this country. The Company in 1879, advertised, and has, ever since advocated and issued standard specifications to its assured and had given advice towards this end even before that early date. The boiler manufacturers, individually and collectively, have also for many years advocated the adoption of uniform boiler specifications through their organizations.

While The Hartford Steam Boiler Inspection and Insurance Company's standards were adopted and recognized by the leading engineers and boiler manufacturers of the country, as well as being used as a basis for the most advanced laws on the subject of boiler construction; it was found that as the different state and city laws were enacted, conflicting rules in regard to minor details were made. This conflict of rules acted to prevent the construction of a boiler to comply with the rules of all states and municipalities having boiler laws. This condition was, of course, entirely illogical, and as the number of boiler laws increased, it was seen that conditions would soon become unbearable to the boiler manufacturer and there would also be placed a very considerable and unnecessary burden on the purchaser, by increasing the cost of boiler equipment.

Recognizing the chaotic conditions that were fast being approached in the business of manufacturing steam boilers, the American Society of Mechanical Engineers through the late Col. E. D. Meier, then President of the Society, appointed in 1911 a committee of five from that Society to formulate standard specifications for boiler construction. It was hoped that the adoption of a standard specification by the A. S. M. E. would result in uniformity of legislation on the subject of boiler construction. This move, as was anticipated, resulted in all interested parties taking a hand in either the criticism or compilation of these specifications, this result being demonstrated by the numerous and lengthy discussions which took place at the various meetings of the Society at which the tentative specifications were submitted.

The final outcome of the discussions on this subject was the appointment of an advisory committee of seventeen members, representing practically all the interests concerned to aid the original committee in making a final draft of the Code and to combine as far as possible all of the desirable features brought before the committee at the various meetings at which discussions of the proposed Code took place. This final draft was presented to the Council of the Society and approved by them on February the 13th, last, and it probably represents the best collection of data on the subject of boiler construction that has been produced up to the present time.

The Code is divided into two main divisions, Part I and Part II. Part I deals with new installations exclusively and comprises about 95% of the

Code, this part is sub-divided into two main divisions, Section I and Section II, relating to power boilers and heating boilers respectively; these divisions being made to simplify the wording of the rules which would have been more cumbersome and difficult to handle without such division. An appendix of twenty pages is added containing such tables, cuts and other matter of an explanatory nature that could not be considered strictly a part of the Code proper.

The Code starts with a general description of the requirements for materials that enter the construction of boilers, there then follows detailed specifications for practically all of the materials used for this purpose. The term, "maximum allowable working pressure," is clearly defined so there can be no mistake as the pressure to which the allowable stresses and factors of safety specified for use apply. A treatment of the subject of boiler joints and tube ligaments follows, defining the efficiency of such sections of a cylinder and specifying the minimum allowable distance between rows of rivets in joints, or back pitch, as well as specifying the allowance to be made for the effect of angularity to the direction of length of a cylinder with respect to the strength of tube ligaments.

The subject of braced and stayed surfaces which occupies about twelve pages of the Code is very complete. The formula adopted for determining the spacing of stays over a flat surface being a true beam formula can be extended to cover the distribution of practically all forms of boiler bracing over such surface. While the treatment of the spacing of stays over flat surfaces is very similar to that used in the Lloyds register rules, it will be found on close examination that the constants are more logically arranged to cover the various conditions to be met in practice.

The allowable working stress on braces and stays, other than screwed staybolts, has been materially increased over former general practice in this country and that such increase is justified, seems to be amply demonstrated by practical experience in connection with this detail of boiler construction. The limit of pressure on cast iron headers has been fixed at 160 pounds and a demonstrated factor of safety of 7.5 is required on specimen parts for such construction. Standard tube thicknesses are required to be increased at 165, 235 and 285 pounds working pressure for water tube boilers, one gage heavier tube thickness being required at each point. In fire tube boilers pressures above 175 pounds require an added gage to the standard tube thicknesses for the sizes used.

The subject of circular furnaces and flues is treated in a very complete manner and the limitations imposed as to the uses of the several formulas given probably result in more logical allowable working pressures than have been permitted by any similar collection of rules on this subject. New formulas have been introduced for long flues from 5 to 18 inches in diameter. These were formulas proposed by Prof. Reid T. Stewart and based on the numerous experiments made by him in connection with the collapsing strength of tubes published in 1912.

The subject of safety-valves has been treated in an entirely different manner from that in previous rules, and instead of a rule of thumb method as adopted in the past, a logical means of arriving at the number and size of valves required based on their performance, is substituted. This change in safety-valve rules was made possible by the manufacturers of such valves, who came to an understanding as to the maximum and minimum lifts to be used and the relieving capacity of their valves at such lifts. The manufacturers agreed to stamp all valves with the lift, pressure for which design and relieving capacity in pounds of steam per hour. The minimum safety-valve capacity required by the Code is determined from the amount of heating surface present in a boiler, and this minimum capacity, with high-lift valves, is about equivalent in size and number of valves required to the best present practice. The minimum safety-valve capacity, under the Code requirements, provides for boilers that are capable of being operated up to about 200% or more of rating. The Code safety-valve rules must be looked on by all engineers as a distinct advance in apportioning safety-valve capacity to boilers.

The rules for heating boilers, covered in Section II of Part I, require a distinct advance in the present practice for the manufacture of such equipment. Cast iron boilers of this class, used for hot water heating and operated at pressures in excess of 30 pounds, must withstand a test pressure of 2½ times the working pressure. All boilers used exclusively for low pressure steam heating are limited to 15 pounds working pressure. Proper rules for the equipment of heating boilers with safety-valves have been made, this is a point that has long needed attention.

Part II, dealing with present equipment, is very limited in scope, as was made necessary by conditions to be met when a code of this character is incorporated into law. Minimum factors of safety have been prescribed of a character that will produce interference with the operation of existing installation, only when reasonable requirements for safety demand interference. Rules with respect to boilers already installed that are so drastic as to interfere in an unwarranted manner with the property rights of the citizen have no doubt been the cause of the most severe criticism against proper legislation on the subject of boiler operation.

At another place in this issue is stated The Hartford Steam Boiler Inspection and Insurance Company's position with respect to the application of the A. S. M. E. Code to its new designs and the Code provisions seem worthy of the support of every steam-user, boiler manufacturer insurance company and others interested in the safe design and operation of steam boilers, to the end that it may be adopted by all states and municipalities having laws on the subject.

Hartford Inspection Service During 1914.

On the pages following we print our annual tabulation of the work of our Inspection Department for the year just past as well as the customary comparative table of Inspectors' work since 1870. As we have so often pointed out in the past, it will be seen that by far the greater portion of the defects discovered were due to impure feed water. The large number of cases of scale, sediment and corrosion, bear out this statement. The next item in importance, and a growing one, is the item of tube failures and defects. The importance of this type of defect will perhaps be more apparent, if note is taken of the large percentage of defective tubes which were dangerous, it will be found that the ratio is relatively very high.

Summary of Inspectors' Work for 1914.

Number of visits of inspection made	198,431
Total number of boilers examined	368,788
Number inspected internally	145,871
Number tested by hydrostatic pressure	8,239
Number of boilers found to be uninsurable	756
Number of shop boilers inspected	8,429
Number of fly wheels inspected	15,786
Number of premises where pipe lines were inspected	4,999

Summary of Defects Discovered.

Nature of Defects.	Whole Number.	Dangerous.
Cases of sediment or loose scale	29,008	1,920
Cases of adhering scale	44,554	1,739
Cases of grooving	2,806	382
Cases of internal corrosion	18,320	855
Cases of external corrosion	11,597	949
Cases of defective bracing	935	245
Cases of defective staybolting	2,336	453
Settings defective	9,241	949
Fractured plates and heads	3,340	523
Burned plates	5,793	511
Laminated plates	431	31
Cases of defective riveting	1,616	264
Cases of leakage around tubes	12,222	1,549
Cases of defective tubes or flues	16,592	6,860
Cases of leakage at seams	5,742	578
Water gages defective	4,067	927
Blow-offs defective	6,523	1,983
Cases of low water	440	116
Safety-valves overloaded	1,488	426
Safety-valves defective	1,883	426
Pressure gages defective	8,030	866
Boilers without pressure gages	71	71
Miscellaneous defects	3,847	549
Total	190,882	23,012

Grand Total of the Inspectors' Work from the Time the Company Began Business, to January 1, 1914.

Visits of inspection made	3,703,922
Whole number of inspections (both internal and external)	7,477,320
Complete internal inspections	2,942,378
Boilers tested by hydrostatic pressure	324,892
Total number of boilers condemned	24,185
Total number of defects discovered	4,523,533
Total number of dangerous defects discovered	473,322

SUMMARY OF INSPECTORS' WORK SINCE 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1876	16,409	34,275	10,669	2,150	16,273	4,275	89
1877	16,204	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29 324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39.777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51.483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595
1895	98,349	199,096	76,744	8,373	144,857	14,556	799
1896	102,911	205,957	78,118	8,187	143,217	12,988	663
1897	105,062	206,657	76,770	7,870	131,192	11,775	588
1898	106,128	208,990	78,349	8,713	130,743	11,727	603
1899	112,464	221,706	85,804	9,371	157,804	12,800	779
1900	122,811	234,805	92,526	10,191	177,113	12,862	782
1901	134,027	254,927	99,885	11,507	187,847	12,614	950
1902	142,006	264,708	105,675	11,726	145,489	13,032	1,004
1903	153,951	293,122	116,643	12,232	147,707	12,304	933
1904	159,553	299,436	117,366	12,971	154,282	13,390	883
1905	159,561	291,041	116,762	13,266	155,024	14,209	753
1906	159,133	292,977	120,416	13,250	157,462	15,116	690
1907	163,648	308,571	124,610	13,799	159,283	17,345	700
1908	167,951	317,537	124,990	10,449	151,359	15,878	572
1909	174,872	342,136	136,682	12,563	169,356	16,385	642
1910	177,946	347,255	138,900	12,779	169,202	16,746	625
1911	180,842	352,674	140,896	12,724	164,713	17,410	653
1912	183,519	337,178	132,984	8,024	164,924	18,932	977
1913	192,569	357,767	144,601	8,777	179,747	21,339	832
1914	198,431	368,788	145,871	8,239	190,882	23,012	756

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. PERRY, EDITOR.

HARTFORD, APRIL, 1915.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

The calculation of the factor of safety of a boiler is not an altogether satisfactory operation. Boilers are complex structures and subjected to exceedingly complicated distributions of stress. In general we may take it as almost axiomatic that whenever we depart from forms which may be either considered as simple cylinders or spheres we find types for which *exact* stress calculations are difficult if not impossible. Many such forms are in use and are accepted without question because they have been shown by test or long usage to be safe. When, however, it becomes necessary or desirable to subject such a form to conditions of unusually severe loading or excessive pressure, so that our experience can no longer be trusted as a guide, we are often at a loss to tell what constitutes a safe limit. Such a state of affairs exists with respect to the square headers so desirable for many kinds of construction. While the exact stress distribution is complex, Mr. Vander Eb, in the article printed in another column, has contrived a very ingenious form of approximation by which he hopes to set limiting values for the maximum fiber stress, at the most stressed portion, namely the inner corners.

Only carefully conducted hydrostatic tests, so controlled as to yield a set of trustworthy deflection measurements on the flat sides of actual headers can establish the formula beyond question, but we feel that the method carries so much of promise, and is so ingenious that it is worth while presenting to our readers for their consideration. We expect it to be received in the light in which we have presented it, and sincerely hope that any test data, tending either to substantiate or disprove the result given may be forthcoming.

The idea that a shaft governed engine is automatically freed from the hazard of a fly-wheel wreck, receives another jolt through the accident reported on another page. Here the governor apparently was powerless either to assist or prevent the accident. Most types of shaft governed valve gears would fail to drive the engine at all if their connection with the governor should break, but this arrangement — which is used in several different modifications by engine builders, involving a complicated system of valves, part of which is driven directly by fixed eccentrics, while only one portion is under governor control — seems to have a peculiar weakness of its own. This class of engines, if they are to be adequately protected, appears to need one of the many forms of independent automatic over speed stop, which could shut the engine down by means removed as completely as possible from the governor and valve gear. Certainly in the case described, there was an abundance of time in which such a device could have operated, removing one of the strongest arguments against their adoption, that they are slow in some cases.

The Hartford Steam Boiler Inspection and Insurance Company adopts the A. S. M. E. Code.

In another article in this issue will be found the facts relating to the compilation and adoption of the American Society of Mechanical Engineers' Boiler Code, but we desire to make a special note of the fact that having been in close touch with the preparation of the Code, we were acquainted with its provisions and, as they were consistent with our own experience of nearly fifty years, we instructed our designing department to make changes in our standards wherever any difference was found just as soon as the American Society council accepted it. As the council approved the Boiler Code as presented by the special committee on February 13th, 1915, the Code was on that day accepted as a standard by this Company.

There may be some difference between the existing rules of certain states and municipalities and the standard Code, making it necessary for designers to take into consideration those differences when designing boilers for those localities, but hereafter designs by this Company will conform to the standards of the American Society of Mechanical Engineers' Code unless local laws require a departure therefrom.

In this connection we are pleased to note that the Board of Boiler Rules of the state of Ohio has very promptly adopted, on March 25, 1915, the following resolution, and we predict that other states as well as cities will sooner or later take similar action.

"Until further notice, an Inspector holding a Certificate of Competency and a Commission authorizing him to inspect steam or hot water boilers which are to be installed within the State of Ohio, is hereby authorized to inspect during construction and on completion to stamp OHIO STD with Serial Number any boiler constructed in accordance with the Rules formulated by the Boiler Code Committee as submitted to the Council of the American Society of Mechanical Engineers on February 13, 1915."

Personal.

We take pleasure in announcing the appointment of Mr. Norman F. Shailer, as Chemist in charge of the laboratory of the Company.

Mr. Shailer is a graduate of the Sheffield Scientific School, Yale University, class of 1908, where he specialized in Chemistry and Metallurgy. Since leaving college he has been engaged in chemical and metallurgical work.

Mr. Shailer is well equipped to maintain the high order of service to our assured through the analysis of feed waters, and the prescription of methods for their treatment in practice which has been obtained from our laboratory in the past. We take pleasure in introducing Mr. Shailer to our own force, and to our assured.

Obituary.

George H. Seyms.

It is with a deep feeling of personal loss that we record the sudden death on January 6, 1915, of George H. Seyms, Chemist of The Hartford Steam Boiler Inspection and Insurance Company. Though not in the best of health for some time prior to his death, he nevertheless continued at his work until Saturday, January 2.

Mr. Seyms was born in Hartford, Conn., August 3, 1849. He was a graduate of Trinity College, preparing for Civil Engineering. After leaving Trinity, he took up graduate work in Chemistry and Mineralogy at the Sheffield Scientific School, Yale University, and Chemistry rather than engineering became his life work.

Mr. Seyms' first work for the Hartford Company, dates from October 18, 1876, but he did not become regularly attached to the Company's staff as Chemist until May, 1881. His work in analysing boiler waters for practically the whole of the United States and much of Canada, was of the highest order, and he acquired a knowledge of boiler water conditions in this country which placed him in a position of recognized authority. Always careful and painstaking to a fault, he was a scholar in the truest sense whose best efforts were none too good for the solution of any problem, no matter how trivial. The systematic record of analytical results for 38 years further testified to his painstaking skill.

Mr. Seyms had an attractive personality. Open and generous with a gentle humour, he was a fine type of gentleman.

While of a most retiring disposition, he still found an interest in public affairs, and served the city of Hartford for many years as Water Commissioner.

Mr. Seyms is survived by his wife, two sons, George B., and Robert, and a daughter, Miss Katherine Seyms.

Patrick Henry O'Brien.

P. H. O'Brien, an inspector in the Philadelphia Department of The Hartford Steam Boiler Inspection and Insurance Company, died March 31, at his home in Philadelphia, Pa., after a long illness.

Mr. O'Brien was born in Ireland, May 12, 1839, and came to Philadelphia with his parents at the age of seven years. He served in the United States Navy from 1858 to 1861. At the expiration of his term of service he returned to Philadelphia and learned the boiler making trade, which he followed until he entered the service of The Hartford in 1875. Forty years of continuous service as an inspector for the Company, was a record which placed Mr. O'Brien among the very oldest of the Company's employees. As an inspector of boilers, he has been a most faithful and loyal worker for the Company's interest, and was held in the highest esteem by the inspectors of the department, as well as by all with whom he came in contact.

He is survived by a wife and nine children, five daughters and four sons.

Summary of Boiler Explosions, 1914.

We append our usual annual compilation of boiler explosions, listed by months, with the number of explosions, number killed, injured, and the total of killed and injured. While we cannot claim absolute completeness for this list we have endeavored to make it as complete and accurate as possible, and trust it may be of interest to our readers.

SUMMARY OF BOILER EXPLOSIONS FOR 1914.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January	59	21	47	68
February	64	13	33	46
March	40	10	29	39
April	31	10	14	24
May	35	24	20	44
June	28	14	17	31
July	18	8	5	13
August	29	7	25	32
September	30	8	24	32
October	37	13	46	59
November	34	12	18	30
December	62	8	37	45
Totals	467	148	315	463

Boiler Explosions.

NOVEMBER, 1914.

(372.) — On November 1, three sections of a cast iron sectional heater ruptured at the plant of the Garwood M'f'g. Co., Garwood, N. J.

(373.) — A boiler ruptured November 1, at the plant of the Willand Dairy Co., Itasca, Ill.

(374.) — Two sections of a cast iron sectional heating boiler ruptured November 2, at the Charlesbank Homes, 333-334 Charles St., Boston, Mass.

(375.) — A steam radiator exploded November 2 at the offices of the Belknap Wagon Company, Grand Rapids, Mich. A young lady who was seated at a desk near the radiator was painfully but not dangerously burned. It is stated that a pressure of 50 lbs. was carried at the time of the accident.

(376.) — On November 3, a blow-off pipe failed on a boiler at the plant of the Houston Collieries Co., Olmstead, W. Va. One man was killed.

(377.) — A blow-off pipe failed November 3, at the mill of the Bond Lumber Co., Bond, Miss. One man was scalded.

(378.) — A boiler ruptured November 4, at the plant of the City Ice Co., Des Moines, Ia.

(379.) — The boiler of a steam engine outfit used for sawing wood exploded November 4, on the farm of Joseph Ramer, near Selingsgrove, Pa. Mr. Ramer and his son, Charles, were fatally injured, while four other children, three sons and a daughter were seriously injured. The accident was attributed to over pressure in an old and weak vessel.

(380.) — On November 3, an internally fired boiler ruptured at the turn of the flange between the furnace and the front head at the plant of the Spring Cañon Coal Co., Storrs, Utah.

(381.) — A boiler ruptured November 7, at the cotton gin of Cobb and Furguson, Munday, Texas.

(382.) — On November 8, the manifolds of two cast iron sectional boilers ruptured at the plant of the Woolson Spice Co., Toledo, O.

(383.) — On November 9, a boiler exploded at the American Beauty Mine, near Granby, Mo. One man was killed and one injured. The coroner's jury brought in a verdict of "defective boiler."

(384.) — A tube ruptured November 10, in a water tube boiler at the plant of the Interborough Rapid Transit Co., New York City. Two stokers were scalded.

(385.) — A cast-iron heater exploded November 11, in the home of Edward Harrison, Manayunk, Philadelphia, Pa. Mrs. Harrison was fatally injured.

(386.) — A tube ruptured November 16, in a water tube boiler at the plant of the Wilmington and Philadelphia Traction Co., Wilmington, Del. One man was injured.

(387.) — A boiler exploded November 16, in the pumpernickel bakery of Thomas Horst, Baltimore, Md. Mr. Horst was seriously scalded, and considerable damage was done to the building.

(388.) — A boiler exploded November 16, at the cotton gin and saw mill of J. W. Sloan, near Garner, Ark. Mr. Sloan and his foreman, Frank Wade, were instantly killed, while the buildings were completely wrecked. It is stated that a son of Mr. Sloan lost both arms in a similar explosion a year before.

(389.) — On November 16, the furnace flue of a boiler collapsed at the packing house of H. J. Lockington, Aberdeen, S. D.

(390.) — A boiler exploded violently November 18, at the shingle mill of the Munroe Shingle Co., Munroe, La. C. C. Stewart, owner of the plant, was instantly killed and two negro helpers were seriously injured. The mill was demolished.

(391.) — On November 18, the return pipe from the heating system broke at the flange where it joined the boiler, at the High School, Plymouth, Mich.

(392.) — The head of a mud drum fractured November 19, in a water tube boiler at the plant of the Bancroft and Martin Rolling Mills Co., South Portland, Me.

(393.) — A boiler attached to a donkey engine exploded November 21, at the Inman-Poulsen Lumber Camp, on Coal Creek, Wash. The engineer and a boy helper were killed.

(394.) — A hot water heating boiler exploded November 21, in the bakery of Joseph Deni, Frankford, Pa. The property damage was estimated at $1,000.

(395.) — A boiler ruptured November 21, at the tile factory of E. G. Blaser, Upper Sandusky, O.

(396.) — On November 23, four sections of a cast-iron heating boiler ruptured at the office building and factory of the George A. Hill Co., South Boston, Mass.

(397.) — A tube failed November 23, in a water tube boiler at the plant of the Sioux City Traction Co., Sioux City, Ia.

(398.) — A cylinder head blew off November 23, at the Union Mills, Fall River, Mass. Timothy D. Harrington, engineer, was fatally scalded. It is stated that Mr. Harrington might have made his escape, but stuck to his post in an attempt to shut off the escaping steam and save his engine.

(399.) — On November 23, a blow-off pipe failed on a boiler at the building of A. S. Taft, Cincinnati, O.

(400.) — A blow-off pipe failed November 26, at The Water Works, City of Liberty, South Liberty, Mo.

(401.) — A boiler exploded November 26, in a mushroom house owned by E. H. Jacobs at Green Hill, near West Chester, Pa.

(402.) — A rendering tank exploded November 27, at the plant of the St. Louis Hide and Tallow Co., St. Louis, Mo. Two men were injured.

(403.) — A tube ruptured November 27, in a water tube boiler at the plant of the Pittsburg, Butler, Harmony and New Castle St. Ry. Co., Harmony Junction, Pa. Four employees of the plant and an insurance solicitor were injured.

(404.) — On November 29, three sections ruptured in a cast-iron sectional heating boiler at The Brockton National Bank, Brockton, Mass.

(405.) — A heater exploded November 30, in the basement of a house at 719 South Ashland Boulevard, Chicago, Ill. The house was being remodeled, and the workmen were at lunch when the blast occurred, but a 7 year old girl was killed.

December, 1914.

(406.) — On December 1, a cast-iron sectional heating boiler ruptured at the State Police Barracks, West Butler, Pa.

(407.) — A vertical tubular boiler ruptured December 1, at the machine shop of Knowlson and Kelly, Troy, N. Y.

(408.) — The cast-iron header of an economizer ruptured December 1, at the plant of the Federal Sugar Refining Co., Yonkers, N. Y.

(409.) — A cast-iron hot water heater exploded December 2, at the premises owned by Mrs. Mary Bottigliero, 717 South Ashland Ave., Chicago, Ill. Margaret Bottigliero, four and one half years old was fatally burned.

(410.) — A boiler exploded December 2, at the saw mill of A. R. Rollings, Pinewood, S. C. One man was very severely, and perhaps fatally injured, while the plant was badly wrecked as a result of the accident.

(411.) — An air tank exploded December 3, at the McGregor Garage, Waltham, Mass.

(412.) — A steam pipe ruptured December 4, at the L St. plant of the Edison Electric Illuminating Co., South Boston, Mass. Three men were scalded, one dangerously.

(413.) — A boiler exploded December 4, at the Atlas mine, Carthage, Mo. Eight men were injured.

(414.) — A boiler ruptured December 5, at the Van Wert Light Co. plant of the Associated Gas and Electric Co., Van Wert, O.

(415.) — On December 5, a boiler ruptured at the plant of the Munger Oil and Cotton Co., Mexia, Tex.

(416.) — A boiler ruptured December 6, at the plant of the Gem Coal Co., Straitsville, O.

(417.) — A blow-off pipe failed December 7, at the plant of the Omaha Electric Light and Power Co., Ohama, Neb.

(418.) — A boiler exploded December 7, at the plant of Rich and Hochester, celluloid comb manufacturers, New York City.

(419.) — A boiler exploded December 10, at the milk pasteurizing plant of N. C. Downs, Vineland, N. J.

(420.) — On December 9, an accident occurred to a boiler at the Wellington Hotel, Des Moines, Ia.

(421.) — Three cast-iron headers ruptured December 10, in a water tube boiler at the Adlers Monument and Granite Works, Maspeth, New York City.

(422.) — Two boilers exploded December 10, at the plant of the Roane Iron Co., Rockwood, Tenn. One man was killed outright, one injured perhaps fatally, and the boiler house demolished by the accident.

(423.) — A cast-iron water heater exploded December 10, at the Y. W. C. A. building, Des Moines, Ia. The engineer, Jack Dublin, was killed. The explosion is said to have been caused by closed valves on both the inlet and discharge pipes of the heater, which was seldom used, but was fired up on the day of the accident.

(424.) — Two boilers exploded December 11, at the Blackburn school, Carlinville, Ill.

(425.) — A boiler exploded December 11, at the Lassiter saw mill, near Winfield, Ark. Two men were killed, and two other men and a woman painfully injured by the explosion, which completely destroyed the mill.

(426.) — A blow-off pipe ruptured December 12, at the Hotel Buckminster, Boston, Mass.

(427.) — A section ruptured December 14, in a cast-iron sectional heating boiler at the automobile show room of Oscar Rosenberger, Detroit, Mich.

(428.) — A number of sections cracked December 14, in two cast-iron sectional heating boilers at the District No. 2 school house, Oakland, Ill.

(429.) — On December 14, five sections ruptured in a cast-iron sectional heating boiler at the plant of the Eagle Glass M'f'g. Co., Wellsberg, W. Va.

(430.) — A blow-off pipe failed December 15, at the spoke factory of Edward G. Willington, Memphis, Tenn. One man was injured.

(431.) — On December 15, the main steam line failed at the Decatur Railway and Light plant of the Illinois Traction System, Decatur, Ill.

(432.) — On December 15, a cast-iron heating boiler failed at the Arthur Hotel, San Antonio, Tex.

(433.) — A water front in a kitchen range exploded December 15, in the home of I. A. Horney, Pratt, Kans. Mr. Horney was slightly injured by the explosion, which wrecked the kitchen badly.

(434.) — The boiler of the hot water heating system exploded violently in the home of Paul E. Wirt, Bloomsburg, Pa., on December 15. The house was damaged to an extent estimated at $3,000, but fortunately no one was injured as the family were away while repairs were being made.

(435.) — A boiler exploded December 15, at the Meuller Bros. bakery, Jefferson City, Mo.

(436.) — A hot water boiler exploded December 15, in a house at 645 Edgewood Ave., Akron, O. Eleven year old Jacob Fried was injured. The accident was attributed to frozen pipes, as the fire had been allowed to go out over night, the explosion following its relighting in the morning.

(437.) — A heating boiler exploded December 15, at the Scripps-Greer store, Canton, Ill.

(438.) — A heating boiler exploded December 16, in the building of the Fortnightly Musical Club, Coldwater, Mich. No one was injured, but the building was wrecked.

(439.) — A compressed air tank exploded beneath a street car at Park Row, New York City, on December 16.

(440.) — A heating boiler exploded December 16, in the basement of the First Methodist Church, Leavenworth, Kans. The explosion, which was of a violent nature was said to have been the result of frozen pipes, as fires had been out in the building for several days during extreme weather.

(441.) — A boiler exploded December 17, at the home of Mrs. Elizabeth Freiberg, Quincy, Ill. The pipes in the system had been frozen, and a fire was started, it is said, to thaw them out, resulting in a violent explosion.

(442.) — A heating boiler exploded December 17, at the home of Harry Hipple, Bellefontaine, O. Mrs. Hipple was badly injured.

(443.) — A steam pipe ruptured December 17, in a building owned by the Raniville Leather and Belting Co., Grand Rapids, Mich. W. H. Knox, night watchman, was killed.

(444.) — A cast-iron heating boiler failed December 17, at the Thompson Hotel, Montgomery, Ala.

(445.) — A blow-off pipe failed December 17, at the plant of the Acme Building Supply Co., Meridian, Miss. Two men were injured.

(446.) — The main stop valve on the steam line failed December 17, at the plant of the Independent Ice Co., Baltimore, Md.

(447.) — On December 18, a blow-off pipe failed at the woolen mill of Charles A. Stevens, Ware, Mass. One man was injured.

(448.) — A boiler exploded December 18, at the North Kearsage Mine, Shaft No. 6, of the Osceola Consolidated Mining Co., Calumet, Mich. One man was killed and property damage estimated at $25,000 resulted from the accident.

(449.) — A section ruptured in a cast-iron sectional heating boiler December 20, at the restaurant of Horn and Hardart, 106 West 43d St., New York City.

(450.) — On December 20, eleven sections cracked in a cast-iron sectional heating boiler at the First National Bank, Pittsburg, Pa.

(451.) — A tube ruptured December 21, in a water tube boiler at the Bay View Asylum, Highlandtown, Baltimore, Md. One man was injured.

(452.) — A heating boiler burst December 21, at the County Court House, Greenfield, Ia.

(453.) — A kitchen boiler exploded December 21, at the home of Mrs. R. O. Jefferson, Wollaston, Mass. Miss Ruth Tilton was very dangerously scalded.

(454.) — On December 22, a section ruptured in a cast-iron sectional heating boiler at the Masonic Temple, Braintree, Mass.

(455.) — On December 22, a tee exploded in a main steam pipe at the New York Mills, New York Mills, N. Y.

(456.) — Three sections ruptured in a cast-iron sectional heating boiler at the plant of the Eagle Glass M'f'g. Co., Wellsburg, W. Va.

(457.) — About December 25, a boiler which had been repaired by the local blacksmith, and which is said to have been fired up to test it following the completion of the repairs before its removal from the blacksmith's shop, exploded at Parkers Prairie, Minn. The blacksmith was injured, his shop badly wrecked, and the boiler in its flight is said to have passed completely over two teams without damage to either horses or drivers.

(458.) — Three sections ruptured December 26, in a cast-iron sectional heater at the Fourth Congregational Church, Hartford, Ct.

(459.) — A boiler ruptured December 26, at the Eagle Hotel, Gettysburg, Pa. Pending repairs, the hotel secured heat through the use of a traction engine boiler.

(460.) — A kitchen range boiler exploded December 26, at the home of Mrs. Rachel Howell, 1708 North Sydenham St., Phila., Pa. Mrs. Howell and her two small children were injured.

(461.) — A boiler exploded December 27, in the Cookman M. E. Church, Wilmington, Del. The explosion occurred just prior to the holding of Christmas exercises, which had to be postponed. No one was injured.

(462.) — A boiler exploded December 28, at the plant of the Matawan Tile Company, Matawan Station, N. J. One man was scalded.

(463.) — On December 28, the crown sheet of a locomotive fire box boiler collapsed at the shops of the L. S. and M. S. R. R. Co., Ft. Wayne, Ind. One man was killed.

(464.) — A boiler exploded December 28, in a warehouse occupied by the Henry B. Pancoast Co., Philadelphia, Pa. Three men were seriously injured, one of them receiving most of his injuries while trying to rescue the other two.

(465.) — A hot water heater exploded December 28, at the plant of the Boston Gear Works, Norfolk Downs, Mass. One man was injured.

(466.) — A tube ruptured December 29, in a water tube boiler at the plant of the Duquesne Light Co., Pittsburg, Pa. Two men were injured.

(467.) — On December 31, a cast-iron cross connection on a water tube boiler ruptured at the plant of the Clinton Sugar Refining Co., Clinton, Ia.

Boiler Explosions, 1915.

January.

(1.) — On January 1, the stop valve on a steam pipe ruptured at the box board factory of McEwen Brothers, Whippany, N. J. The rupture occurred as a boiler was being cut in on the line. One man was fatally injured.

(2.) — Two sections ruptured January 1, in a cast-iron sectional heating boiler at King's Block, belonging to the Peabody Academy of Science, Salem, Mass.

(3.) — On January 2, the inner flue of a drier collapsed at the packing house of Hammand Standish and Co., Detroit, Mich.

(4.) — A boiler exploded January 2, at the power house of the Wheeling Traction Co., Wheeling, W. Va.

(5.) — On January 3, a connection to a furnace failed at the plant of the Central Realty and Warehouse Co., St. Louis, Mo. One man was killed and two others injured.

(6.) — A boiler exploded January 4, at the shingle mill of J. W. Hall, Tifton, Ga. One man was instantly killed and two others seriously injured, while the mill was badly wrecked.

(7.) — On January 5, the crown sheet of a portable locomotive boiler used by the James McNeil and Bros. Co., on a construction job at Cleveland, O., collapsed.

(8.) — A boiler burst January 6, at the pumping plant of the city of Marion, Marion, Ind.

(9.) — A boiler ruptured January 8, at the plant of the Grand Rapids Lumber Co., Grand Rapids, Mich. One man was injured so seriously that it was thought he could not recover.

(10.) — A tube ruptured January 8, in a water tube boiler at the plant of the Allegheny Steel Co., Brackenridge, Pa.

(11.) — A blow-off pipe ruptured January 9, at the bakery of the Heissler and Junge Co., Chicago, Ill:

(12.) — A boiler exploded January 9, in an apartment house at 25-27 West Thirty-sixth St., New York City.

(13.) — On January 10, two sections of a cast-iron sectional heating boiler ruptured at the apartment house of E. Hugo Friedrich, Holyoke, Mass.

(14.) — On January 11, the shell of a water tube boiler ruptured at the coal pocket of the Philadelphia and Reading Coal and Iron Co., Salem, Mass.

(15.) — A blow-off pipe failed January 12, at the round house of the Chicago, Rock Island and Pacific Ry. Co., Philipsburg, Kans. One man was scalded.

(16.) — A boiler ruptured January 12, at the plant of the Pluto Powder Co., Ishpeming, Mich.

(17.) — A blow-off failed January 13, at the cotton gin on the estate of J. Darnbush, Vicksburg, Miss.

(18.) — On January 13, three sections failed in a cast-iron sectional heater at the confectionary store of St. Clair's, Inc., Boston, Mass.

(19.) — On January 14, a section cracked in a cast-iron sectional heating boiler in a building at 341-351 Trumbull St., Hartford, Ct., owned by the estate of Chas. F. Pond.

(20.) — A hot water heater exploded January 14, at the baker shop of S. J. Goldstine, Terre Haute, Ind.

(21.) — A boiler exploded January 13, at the home of Mrs. Thomas McDermott, Jessup, Pa.

(22.) — On January 16, the crown sheet of a locomotive boiler ruptured at the plant of the Richton Lumber Co., Richton, Miss.

(23.) — A heating boiler exploded January 19, at the Mosher House, Hillsdale, Mich.

(24.) — A boiler exploded January 20, at the saw mill of Joseph Trusty, Beverly, Mo. Mr. Trusty was fatally injured, while his two sons were killed.

(25.)— On January 21, a heating boiler burst at the Smith Hotel, Hillsdale, Mich.

(26.) — A tube failed January 21, on board the U. S. S. San Diego, at La Paz, Mex. Five men were killed and eight injured.

(27.) — A steam pipe burst January 21, at the breaker house of the Cambridge Coal Co., Shenandoah, Pa. Five men were working about the pipe at the time of the accident, all were injured, three fatally.

(28.) — A boiler ruptured January 22, at the Lindell Hotel, Lincoln, Neb.

(29.) — A cast-iron header failed January 22, in a water tube boiler at the plant of the Peoples Brewing Co., Trenton, N. J.

(30.) — On January 23, a blow-off pipe failed at the candy factory of Hardie Bros. Co., Pittsburg, Pa.

(31.) — A sterilizing tank exploded January 26, at the Philanthropic Hospital, New York City. No one was injured and the damage was slight.

(32.) — Four sections ruptured in a cast-iron sectional heating boiler at the plant of the F. Bissle Co., Toledo, O.

(33.) — A water back exploded in a cook stove at the home of Dick Bose, Smith Center, Kans., on January 28. The accident which wrecked the house, was attributed to frozen connections.

(34.) — A section ruptured January 29, in a cast-iron sectional heater at the Willard School, Ada, Okla.

(35.) — A tube ruptured January 29, in a water tube boiler at the plant of the Lonsdale Co., Lonsdale, R. I.

(36.) — On January 30, a section cracked in a cast-iron sectional heating boiler at the East End School, Indiana, Pa.

(37.) — A boiler exploded January 30, at the plant of the Grupe Drier and Boiler Co., Davenport, Ia. One man was injured.

(38.) — A tube ruptured January 31, in a water tube boiler at the Maywood, Ill., plant of the Public Service Co., of Northern Ill. One man was injured.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1915.

Capital Stock, . . . $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$229,528.21
Premiums in course of collection,		285,417.97
Real estate,		90,200.00
Loaned on bond and mortgage		1,266,145.00
Stocks and bonds, market value,		3,741,954.00
Interest accrued,		86,619.48
		$5,699,864.66
Less value of Special Deposits over Liability requirements		40,291.16
Total Assets,		$5,659,573.50

LIABILITIES.

Premium Reserve		$2,331,531.90
Losses unadjusted,		44,573.69
Commissions and brokerage,		57,083.59
Other liabilities (taxes accrued, etc.),		46,656.55
Capital Stock,	$1,000,000.00	
Surplus over all liabilities,	2,179,727.77	
Surplus as regards Policy-holders,	**$3,179,727.77**	3,179,727.77
Total Liabilities		$5,659,573.50

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Supervising Inspector.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, President, Director Swift & Co.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

GEORGE C. KIMBALL, Capitalist, Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and Treasurer, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, The Johns-Pratt Co., Hartford, Conn.

Incorporated 1866. Charter Perpetual.

The Hartford Steam Boiler Inspection and Insurance Company

ISSUES POLICIES OF INSURANCE COVERING

ALL LOSS OF PROPERTY

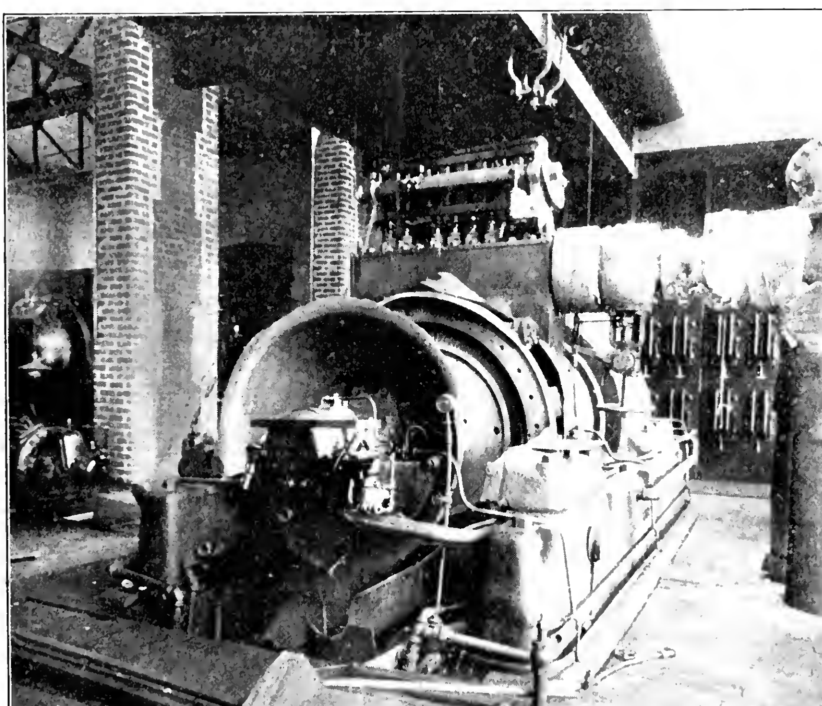
AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.	W. M. FRANCIS, Manager and Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	LAWFORD & MCKIM, General Agents. R. E. MUNRO, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. ROBERTS, Manager. JOSEPH H. MCNEILL, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.	W. G. LINEBURGH & SON, General Agents. F. S. ALLEN, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. LEMON, Manager. JAMES L. FOORD, Chief Inspector. J. T. COLEMAN, Assistant Chief Inspector.
CINCINNATI, Ohio, First Natonal Bank Bldg.	W. E. GLEASON, Manager. WALTER GERNER, Chief Inspector.
CLEVELAND, Ohio, Century Bldg.	H. A. BAUMHART, Manager and Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg., Cor. 15th & Champa Sts.	THOS E. SHEARS, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. WILLIAMS, JR., General Agent. F. S. ALLEN, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	PETER F. PESCUD, General Agent. R. T. BURWELL, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. GARDINER, Manager.
PHILADELPHIA, Pa., Cor. Fourth & Walnut Sts.	GOODRICH & WICKHAM, General Agents. WM. J. FARRAN, Consulting Engineer. S. B. ADAMS, Chief Inspector.
PITTSBURG, Pa., 1801-1802 Arrott Bldg.	J. J. GRAHAM, Manager. BENJAMIN FORD, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	MCCARGAR, BATES & LIVELY, General Agents. C. B. PADDOCK, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. MANN & Co., General Agents. J. B. WARNER, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. ASHCROFT, Manager. J. P. MORRISON, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. ROBERTS, General Agent.

The Locomotive
of
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXX. HARTFORD, CONN., JULY, 1915. No. 7.



Steam Turbine Explosion, Waltham, Mass.

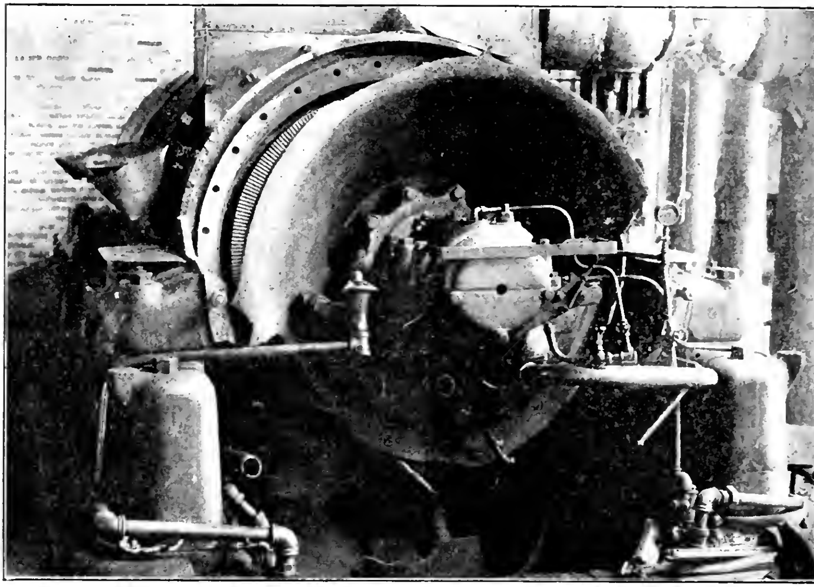


FIG. 2. A CLOSER VIEW OF THE DAMAGED CASING.

Explosion of Steam Turbine.

Photographs of steam turbine explosions are so seldom available that those shown here of a wrecked 750 k. w. machine, at the plant of the Boston Manufacturing Company, at Waltham, Mass., should prove of special interest as illustrating the possibilities of an accident to this class of apparatus.

In this case the exhaust end of the turbine casing exploded from internal pressure. There can be no doubt of the violence of the explosion, for pieces of the casing were hurled about the room, knocking the brick from a wall and otherwise damaging the power house structure. The engineer standing in front of the turbine was thrown through one of two large windows, both of which were blown outward. The glass in other windows on the side of the room was blown inward. These results are all characteristic of the sudden release of gas under pressure, and as steam is the only gas conceivably within the turbine case, it must be concluded that the internal pressure was of steam.

On an impulse turbine the casing under normal operating conditions is not subjected to any great pressure, for the steam after passing the expansion nozzles of each stage, is reduced in pressure at once practically to the pressure of the exhaust from that stage. Accordingly in a single-stage turbine, the pressure in the casing would not anywhere be materially greater than that in the exhaust pipe and the casing is designed with this fact in view.

The Boston Manufacturing Company's turbine was of the impulse type and of single-stage. It was operated non-condensing with its exhaust supplying the low-pressure side of a large engine and also the mill heating system. The accident occurred at the end of the day's work as the machine was being closed down. The evidence on which to base a theory of its cause is conflicting. It was stated that the throttle valve had been closed and that no valve had been manipulated which would have admitted high pressure steam to the exhaust system or which would have prevented the relief of that system through the automatic valves with which it was adequately provided. The automatic reliefs were found in operating condition after the accident and no defect of the machine itself or of its controlling mechanism was discovered which would have contributed to the result. From the character of the accident, it must be concluded that excessive steam pressure did build up in the casing, and in spite of the statements to the contrary, it is difficult to account for this, except on the theory that the throttle valve was at least partially open and that the exhaust system was practically closed against release to atmosphere at the time the accident occurred. The presence of a valve between the turbine and the atmospheric release suggests at least the possibility that the last condition was fulfilled.

The Prevention of Fly-Wheel Explosions.

1st Paper; The Throttle Governed Engine.

A series of articles, of which this is the first, is in preparation, in which we shall endeavor to cover the sources of fly-wheel accidents to be expected with different sorts of engines. It is planned to devote each paper to one particular type of engine, and to discuss both the peculiar hazards of that type and some of the means of lessening or eliminating these hazards available to the operating engineer.

All engines might be classed as either constant speed, adjustable speed, or variable speed machines, according as they are designed to run at one fixed and definite speed, or to maintain constant any one of several different speeds to which they may be set by the operator, or in the third case if they can be run at any speed at the will of the operator, changing either up or down as desired. To the first class belong most governed engines, although the second class is also made up of engines under governor control in which the governor is capable of being set at will to maintain any one of several possible speeds. To the third class belong the various sorts of ungoverned engines, such as many hoists, locomotives, marine engines and most steam pumps. Throttle governed engines may be of either the adjustable or the constant speed type, and both will be considered in this paper, taking first the constant speed variety.

The throttle governor has one characteristic which is inherent in the design and is common to a greater or less extent to all makes. The control is not prompt. Since with this sort of governor, the speed of the engine is dependent upon the degree of opening of the valve controlled by the governor, which is external to the engine, it follows that in the event of a decrease of load, followed by a closing of the throttle, the steam contained between the throttle and the engine valve, that is in the steam chest and piping, will continue to expand and so tend to increase the engine speed before the influence of the governor's action is felt. Likewise, if an increase of load requires a wider opening of the governor valve, a time lag will occur between the movement of the governor and the effect of that movement on the speed of the engine. In many cases this slowness is more of an inconvenience than a hazard, but it is not difficult to see that conditions may exist, as in the case of a heavily loaded engine, with a light wheel offering little resistance to acceleration and running but little below the bursting speed, where a sudden loss of the entire load, as say the breaking of the main belt, might be attended with serious results. Two courses are open to offset this hazard. In the first place the governor should be set as close to the steam chest as is possible, so that the volume of the space between the governor valve and the engine valve shall be a minimum. Then it is well to consider the speed and weight of the fly wheel, as will be shown further on, with a view to reducing the engine speed to a safer value if conditions seem to warrant it. Moreover the effect of friction should receive attention as we shall show. It should be reduced as far as possible in the governor mechanism.

Most governors designed to adjust a throttle valve are driven either by a belt, rope or some form of gearing. Obviously, since the governor is arranged to open the throttle at slow speed and close it as the speed increases, a failure of the driving mechanism, which would permit the governor to stop revolving, would tend to give the widest possible throttle opening and so cause the engine to over speed. Some provision is made in nearly all such governors to modify this hazard, by a form of trip gear usually supported by an idler on the governor belt, which will become operative upon the failure of the drive and close the throttle. The weight of the idler is expected to maintain a proper amount of tension in the driving belt, and automatically compensate for stretching, slipping, etc. Since this stop gear is very seldom called upon to act, it should receive regular attention from the operating engineer, and should be known to be in good working order at all times. To secure this condition, it is necessary that all working parts of the trip gear be kept clean, well lubricated, and protected from blocking by any chance material which may have gotten in the wake of the mechanism. It is also well to throw off the belt occasionally, when the engine is at rest and see that the idler trips promptly and efficiently.

While it is true that the idler stop is provided with the idea of preventing any accident that might arise from a failure of the governor drive, still it is much wiser to be sure that the drive is at all times in the best of condition, than to depend upon the working of any safety device as an excuse for careless maintenance. It is possible for example, in case the idler stop is seldom overhauled and lubricated, for a very oily belt, in conjunction with a somewhat sticky stop gear, to permit the belt to slip enough to make the governor action very sluggish, even if it does not cease revolving altogether. This condition spells accident, for any slowing down of the governor even if it does not stop, means an excessive engine speed as soon as a marked reduction in the load occurs. The precaution to avoid such an occurrence is obvious, the governor belt should receive careful inspection whenever the engine is looked over, and its length should always be kept such that it is neither loose nor unduly tight. It is quite proper to depend on the idler for slight adjustments in the belt tension, indeed a slight slackness in the governor belt gives rise to just enough motion on the part of the idler arm to keep it free and in working order, but any real stretch or any wear in the lacing should be noted and repaired at the earliest possible opportunity. If it is impossible to prevent the throwing of oil by moving parts of the engine, or its leakage from bearings, so that the governor belt becomes soaked with it, then some form of simple sheet metal oil guard will not only prevent injury to the most vital part of the engines' safety equipment, but will also effect, if well arranged, a considerable saving in oil. Many engines are provided with flanged pulleys on the governor drive whose object is to prevent the running off of the belt. These are excellent so long as they are well lined up, but care should be taken that the belt runs true, and does not rub against the flanges, as otherwise, the edge of the belt will be slowly but surely cut and worn, resulting in ultimate failure. One more caution is desirable while discussing the question of the governor drive, and that is the hazard from the chance of material falling upon, or being thrown against the governor belt. Some engines are particularly unfortunate in their surroundings. In saw mills flying material is often encountered, and in other cases where the conditions surrounding the transmission of power are severe, the main belt is subject to frequent breakage or may often be thrown off. Such cases may be greatly improved from the standpoint of safety if the drive to the governor, and indeed the governor itself are guarded in such a way that the chance of injury is eliminated as nearly as possible.

Before leaving the subject of governor drive, mention should be made of one or two matters which have received more detailed treatment in previous issues of THE LOCOMOTIVE. When the governor for any reason is driven from a countershaft, then the idler stop, in its usual form will operate only on the failure of one part of the drive. To secure full protection, an idler is required on each belt intervening between the engine shaft and the governor. A suggestion to that end will be found in THE LOCOMOTIVE for January, 1913, page 157. Reference should also be made to a suggestion appearing in the July LOCOMOTIVE for the same year, 1913, for an alarm arrangement to be used in the case of one type of governor stop, which is not actuated by an idler, but depends on the failure of the governor to revolve. This design is excellent except in one particular, that it is not self adjusting, and requires to be set to a starting position when the engine is at rest, but when the engine has been brought up to speed, the device must be set to its safety position by hand. This last manipulation is apt to be forgotten, or even purposely neglected as a nuisance, unless some means is adopted to make the engineer remember it, or else to make its action automatic and self setting.

The effect of friction in a governor, of whatever type, is frequently overlooked, although it is extremely important. A little thought will show that friction tends to hold back the governor whenever it changes its position, whether the change is due to an increase or a decrease of speed. Let us consider an extreme case of a badly stuck governor and a variable load. Suppose the load is heavy and that in spite of friction the governor has reached the proper position for the load carried. Now if the load is suddenly lessened, by throwing off a heavy machine perhaps, the governor will try to rise, but will be hindered for the time being by the necessity of overcoming the effect of friction. After the engine has attained a considerable increase in speed, the force exerted by the governor against the frictional restraint will have become so great that it will suddenly overcome it and jump out to a position corresponding to a much diminished throttle opening. The engine will at once slow down, and will continue to slow down until, overcoming again the frictional restraint the governor jumps back and opens the valve, when the action will go on as before. Of course this condition will be immediately apparent to the engineer as the speed of the engine will vary between wide limits. The hazard comes from the fact that with moderate changes of load, which come on slowly, the friction is overcome so gradually that the sticking is overlooked.

It is only when an unexpectedly great load change occurs, such as say the breaking of the main belt, that the effect may be great enough and sudden enough to permit the engine to attain the bursting speed of the wheel before the governor gets the upper hand and controls the situation. It will be seen then, that whatever the type of governor, it is of the first importance from the safety standpoint that the arrangements provided for governor lubrication are adequate, and that the oil used is of the right sort. This does not mean either excessive flow, or heavy oil, for the governor is not a mechanism which transmits any very large amount of power, what it does mean is that one should be sure that the oil flow to all parts of the governor is sufficient at all times, and that dust and dirt are kept away from the bearings and oil cups, to minimize the chance of gumming. In a like manner, it is desirable to restrain the man with the paint brush, and see that he confines his decorative efforts to those parts of the governor which have no relative motion, and that all moving and rubbing surfaces, pin connections, etc., are kept clean and bright.

Another hazard, common to all governors, is that of wear. A governor is so reliable, and so nearly fool-proof, doing its work day in and day out with little or no attention, that it requires an effort sometimes to realize that it should be looked over, to be sure that it is in a safe state of adjustment. It is not at all an uncommon occurrence to find pin connections, gears, and gear shafts so worn, that it is a matter of wonder how the mechanism has continued to render efficient service. Such conditions are to be *expected* after a period of considerable use with any engine, and should be detected by thorough periodic examinations by the engineer in charge of the plant, and remedied as soon as found. This is to be especially emphasized wherever the conditions of exposure make engine maintenance difficult. Where the atmosphere is charged with dust of an abrasive character, or where dirt and moisture are difficult to eliminate, the engineer would not dream of running without constant watchfulness and care of his main bearings, guides, connecting rod ends, etc., but he is apt to think that, when he has seen to these vital parts, his duty is done, forgetting that if the governor fail, all his watchfulness will have been for no purpose. It is also well to let the examination proceed to the "insides" of the governor, if it is of the throttle type. One is apt to find that valve discs need grinding, that seat rings are no longer tight, and that shoulders are worn on rods, or that rods are cut, corroded or out of round where they pass through stuffing boxes. All these matters should receive attention at the time when they are discovered, and should not be put over to a more convenient season.

All throttle governed engines, have a comparatively simple form of valve gear, usually driven by a single eccentric. It is important to make sure from time to time that the setting of the eccentric is correct, a slippage will change the cut off, depending upon its direction to an earlier or later point in the stroke. In any event such a movement will alter the speed at which the engine will run, for any given position of the governor, assuming normal load and steam pressure. The occasional use of the indicator, or careful inspection of marks placed for the purpose on both the eccentric, and the shaft will insure against an eccentric creepage going undetected. If a movement is found, it should be corrected at once.

While speaking of the necessity for constant attention to the condition of the engine, it may be well to emphasize the fact that the flywheel merits its share of care and inspection. The engineer should look over the wheel frequently with an eye to the formation of cracks, or the loosening of either rim or hub bolts. A light hammer will be found of assistance in making these examinations. See also that the keys and any set screws used at the hub of the wheel are tight. It is of service to keep a flywheel scrupulously clean, so that cracks, or movement at bolted joints may be readily detected; a thick coat of caked on dirt and grease, though it may protect from rust, is neither decorative nor transparent. In case cracks or other conditions not normal to the installation are found at such an examination, it is unwise to run the wheel again until its safety has been passed upon by some one qualified. If the wheel is insured (as it should be), the nearest inspector of the Insurance Company should be notified at once; if not insured, some other competent expert should be called, for a defective wheel is just as dangerous as a defective boiler. The questions of wheel strength determination will not be touched upon here, but are reserved for subsequent installments in the series. It is however thought best to call attention to one matter at this time, which will be referred to again in a later paragraph, and that is the matter of speed changes. Throttle governors, and indeed all governors driven by belts, permit of the engine speed being altered in a very simple fashion. All that is required is to change the ratio of pulley diameters on the governor drive. If the pulley on the governor is enlarged, the engine must travel at a higher speed to produce the same number of turns per minute in the governor, while if the governor pulley is diminished in size, the engine may run slower for a given governor speed. The object in calling attention to this matter of speed changing is to sound a warning to those who, having an engine loaded to about its capacity, desire to increase its power output. The obvious way to accomplish this is to speed up the engine, as the horse power output for a given cylinder, working at a given cut-off, is exactly proportional to the speed. It is true that in many cases the line shafting or machines will not stand an increase in speed and still perform their duties, but this can be easily arranged for by changing the pulley sizes in the main drive, so that although the engine revolves faster and delivers more energy per minute to the line shafting, the speed of the shafting is not altered. This result can be obtained as we have shown above, by either altering the ratio of the pulley diameters in the governor drive, or by an increase of steam pressure, leaving the governor unchanged. Two conditions require very careful investigation before such a change is authorized. First it should be determined beyond the shadow of a doubt that the flywheel will stand the increase in speed with no unsafe reduction in its safety factor. In this connection it is well for the engineer to remember that the stresses tending to burst a flywheel increase as the square of the speed; that is if we double the speed of a wheel, there is *four times* as much bursting stress, or if we should increase the speed to three times its original value, the bursting stress would be *nine times* as great. On this account, a small increase in speed will be attended with a much larger increase in stress than is at first apparent, and the safety of the wheel at the new speed should be determined with great care, having regard for the construction of the wheel, the size and distribution of the bolts with which it is held together, and perhaps most important of all, the effect of flanges in the rim. If these flanges are between spokes, they should receive the careful consideration of one competent to pass on the stresses involved. The second consideration is as to whether, in case it is desired to increase the steam pressure, the cylinders, valve chests, piping, etc., are strong enough for their new duty. Questions such as we have suggested should be submitted to some one fully competent to deal with them. In case a wheel is insured, or is to be insured, the engineers of The Hartford Steam Boiler Inspection and Insurance Company will be very glad to advise as to the safety of any contemplated changes in speed, and are in a position to render expert service. For uninsured wheels, an engineer should be consulted whose opinion will be certain to be sound, as the hazard may be very great indeed if the change should prove to be ill advised.

In considering engines of the adjustable speed type, such for instance as are to be found driving paper mills, to cite a familiar example, most of what has been said for the constant speed machines, may be applied directly. The special hazards of the adjustable speed feature, are connected for the most part with the determination of the safe upper limit of speed which may be allowed. Not only must the safe upper limit be calculated for the particular wheel involved, but it is also necessary to make sure that the governor mechanism, although permitting adjustment between the upper and lower limits, is so arranged that it is impossible for the engine to attain any excess over the upper limit, while under governor control. That is, the means of speed adjustment should be so designed and installed that nothing short of the complete failure of the governor mechanism will admit of speeding up above the limit set. There is another feature that requires particular care in this class of equipment. The upper speed limit is very apt, for reasons of cost, to be set at or very near the highest safe speed which the wheel may be permitted, so that a failure of the governor drive, at top speed, if it should happen to coincide with a loss of, or great reduction in the load, might result in an accident before the stop gear had time to act. For this reason, the adjustment, lubrication, and design of stop gears should be given much greater consideration with the average adjustable speed engine than in the case of the constant speed machine (although this statement must not be taken as a warrant for relaxing in watchfulness in the latter case.) In many instances, adjustable speed machines, are used in a service where the load at any speed is very constant indeed, and hence a heavy flywheel is not needed. With such an engine, it must be borne in mind that the light wheel makes it particularly easy for the speed to rise rapidly, in case the load is suddenly dropped, and hence emphasizes the hazard just described. A considerable margin of safety may be added to an installation of this sort if some means is provided to positively stop the engine, independently of the governor, or its safety stop, when the engine attains a predetermined limit of overspeed, usually from two to five per cent. above that at which the governor is supposed to act. However, the remarks which we have made above regarding a light wheel speeding up quickly, apply with double emphasis in this case, and extreme care should be exercised in the choice of the independent stop equipment, to make sure that it is fast enough for the particular case.

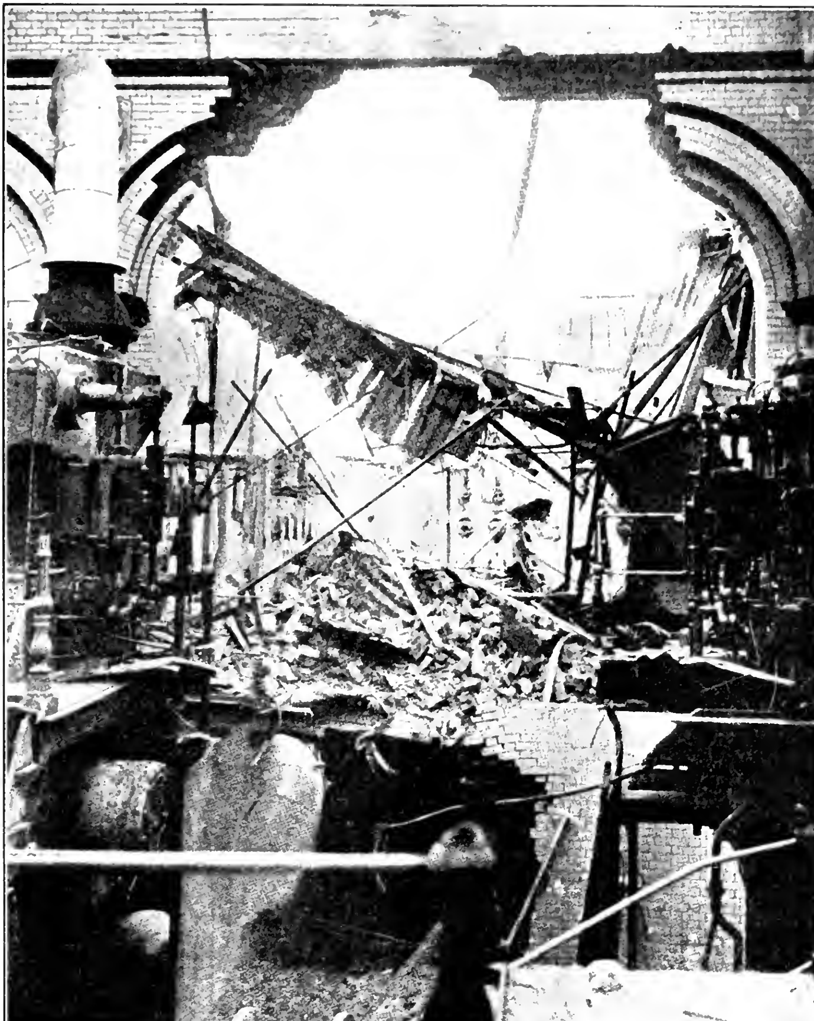


FIG. 3. WRECKED POWER STATION AT CARDIFF.

A Flywheel Explosion at Cardiff, Wales.

The accompanying photograph which we have reproduced from *Vulcan*, our well known English contemporary, shows the result of one of the most expensive flywheel wrecks of which we have any knowledge. The details of the accident we quote from the April number of *Vulcan*.

"On Sunday, the 21st ult., at 6.30 p. m., a very destructive flywheel burst took place at the Electric Power Station of the Cardiff Corporation. It appears that at the time stated one of the engines in the station began to race, and before the steam could be shut off a huge flywheel, weighing it was stated, over 70 tons was burst into fragments. Enormous damage was done both to the machinery in the station and to the building, and though it is impossible to estimate it exactly, it is affirmed that the cost of repairs will not be less than £20,000 ($100,000). Fortunately no personal injury was sustained, a fact which is remarkable, having regard to the sweeping character of the destruction. One large piece of the flywheel weighing about three-quarters of a ton was hurled through the roof of the building and then fell through the roof of the boiler shed, crashing into the only boiler in the place which was not under steam. Had it fallen upon one of the other boilers, of which there were several, the accident would in all probability have been accompanied by a disastrous boiler explosion. Other large fragments of the wheel penetrated surrounding premises while others were found in fields a considerable distance away. As a consequence of the burst the tramway power service was completely disorganized, and it was not until the following Tuesday that a restricted service could be inaugurated. A further result was that the city lighting arrangements were interfered with and several parts of the city were in almost total darkness. It is not known what was the precise cause or why the governor or other speed controlling devices of the engine failed to act, but this no doubt will be made the subject of inquiry at the hands of the technical staff. We understand that the engine was insured, but to what extent we are unable to say."

Some Recent Heating Boiler Explosions.

In spite of all the publicity which has been accorded the failure of heating boilers in the technical press, and especially in THE LOCOMOTIVE, we find most owners and even some heating contractors and heater manufacturers skeptical with regard to there being any real danger of violent explosions. During the season just passed several accidents have happened, some of which have been investigated for us by our friends in the locality, and we present here the stories as they were transmitted to us, as a witness to the reality of the heating boiler hazard. It may be well to say in passing, that each one of these cases has been verified through clippings from the daily press, in addition to the special reports which we have received. We only regret that we have not been fortunate enough to obtain photographs to adequately illustrate all the descriptions.

Case one is the explosion of a boiler used for heating a freight house at Battle Creek, Mich., used in connection with a hot water system. We are told that the boiler was an old track locomotive boiler, installed to take care of the heating load. Our information leads us to suspect that closed valves on the circulating pipes may have been to blame for the trouble, though we cannot affirm this definitely. The explosion was violent, and did considerable damage. A man and a woman were seriously injured, and in addition to the demolition of the boiler, the basement of the building was completely wrecked.

Case two relates to the bursting of a cast-iron sectional heating boiler, used to supply a steam heating system in the basement of an undertaker's establishment in Chicago, Ill. This explosion occurred when the boiler was first fired up after alterations, and before the steam fitters had left the premises. We learn from our informant that no safety valve was attached to the boiler, and this was probably a contributing cause to the accident, though we are unable to learn the exact events which preceded the explosion. One man was instantly killed, three others were so severely injured that they were not expected to live, and the extent of the property damage can be guessed at from the statement that trolley service in the adjacent street was interrupted for a considerable time.

Case three happened near Philadelphia, Pa. A small cast-iron heater, which consisted practically of only a cylindrical jacketed fire pot, was installed in a house originally for the purpose of heating water for domestic uses. Later some radiators and an expansion tank were added, arranged so that the heater could heat the house in winter, in addition to its summer service. We are told that valves were provided to permit of both ways of operating the system, and that although the housewife had been warned not to operate them, on the day of the accident, which was quite cold, she went into the cellar to try and turn the hot water through the radiators. In any event, the boiler exploded, injuring her fatally, and doing a considerable amount of damage to the building and its contents. It was difficult, if not impossible, to reconstruct the piping and valves after the accident to determine just what changes in their adjustment had been made, owing to the completeness of the demolition, so we are not able to set the exact cause of the trouble.

Case four is that of a cast-iron sectional heater, used to supply hot water heat in a mushroom plant. The boiler which exploded was one of two used for the purpose, and was cut off from the line by closing valves provided for the purpose in the supply and return pipes, in order that needed repairs might be made. When the repairs were completed, a man was sent to fire up the boiler and put it again in service. He neglected to reopen the closed valves, with the result that, as the boiler was not provided with a relief valve, a violent explosion followed. Several sections of the other boiler were wrecked, while the boiler house was completely destroyed. The property damage was estimated to be in the neighborhood of $2,000.00. It is of interest to learn that the new boilers are being fitted with safety valves.

Case five was a cast-iron sectional heater in a house in Chicago, Ill., used to supply a hot water heating system. This accident, as in so many of the other cases, came just after starting fires, and again the suggested cause was closed valves on the supply and return pipes, though this was not definitely proved, according to our information. A four year old girl, who was playing in the basement at the time, was so severely injured that she died in the ambulance on the way to the hospital. Fire broke out following the explosion, and added considerably to the property damage.

Case six was in Des Moines, Ia. A small sectional cast-iron heater was used in conjunction with a storage tank to supply hot water for the Y. M. C. A. building. Gate valves were installed in both the inlet and discharge pipes of the heater and were closed. The accident happened when the heater was fired up for the first time after an interval of several months. No relief valve was fitted. When the boiler burst, the fireman who was nearby was instantly killed, although the damage to property was small, probably not in excess of $150.00.

Case seven, which was very destructive, was almost identical with case four. It took place in a fine residence in Bloomsburg, Pa. Here two cast-iron sectional heaters were installed to heat the residence in connection with a hot water system. During the first part of the season but one boiler had been used, but as the weather had turned much colder on the day of the explosion, the other one was fired up, and its explosion followed shortly afterward. The expansion tank,

Fig. 1. Exploded Water Tank. Case Eight.

with its overflow and vent, were all found free and in good working order after the accident, while the owner of the house was quite positive that he had opened the flow and return valves to the exploded boiler before he left instructions for it to be fired up. However, both of the valves were found tightly closed. Owing to the expensive character of the building and its furnishings, it is probable that the damage amounted to between $8,000 and $9,000, though fortunately no one was injured.

Wreck of a Sleeping Room and of the Heater. Case Eight.

Figs 2 and 3.

Case eight happened on a country estate on Long Island. In this case alone were we able to secure photographs suitable for publication, illustrating the extent of the damage. The vessel which burst, was a copper hot water tank used as a storage tank to supply hot water for laundry and bath in the chauffeur's cottage. The water, supplied from an overhead tank at about 60 lbs. pressure, passed through a reducing valve to a cast iron heater, after which it flowed to the storage tank. No safety valve was installed. The explosion came at about 3 A. M., and we are informed that the fire in the heater was banked at 5 o'clock the preceding afternoon. As our photographs show, the tank burst violently, and it is a matter for wonder that the people sleeping in the cottage, directly over the tank escaped practically unhurt. Only one man was injured to any extent, and he received his bruises falling through an opening made in the floor, in his effort to ascertain what had happened. It seems quite likely that the cause of this accident is to be found in the fact that a reducing valve such as is used in a water pipe may act as a non-return valve, and so would have the same effect on such a hot water system as was installed in this case as does the familiar check valve so often introduced with disastrous effects in the case of kitchen boilers to protect the rubber disk meter from overheating. Of course this is but a supposition on our part, as we could not establish it beyond question.

Case nine the most recent one, was that of the explosion of a cast-iron water heater, used to heat the water for the baptistry of a Baptist Church in Sioux Falls, S. D. The heater was arranged to carry city pressure, and was not provided with a relief valve. The janitor is said to have closed the valve between the heater and the city mains, after lighting his fire on a Sunday morning. This resulted in a violent explosion, while morning services were in progress. Although the property damage amounted to some $1,500, no one was seriously injured.

All nine of these cases represent, so far as we are able to determine, uninsured boilers. It is a matter for interesting speculation, whether or not any of these accidents would have happened to vessels which had had the inspection of a qualified inspector, and had been provided with such safety appliances, and such rearrangements of valves and piping as he would in all probability have recommended. The almost incredible absence of relief valves is at least worthy of consideration.

In any event, the evidence is sufficient to prove that average heater installations in all sorts of buildings, and about in the condition in which we would find many others if we were enabled to observe them, are possessed of a very definite hazard, unless safeguarded by all the means available in the present state of the art.

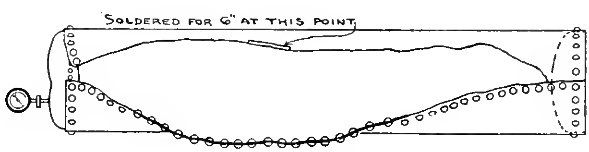


FIG. 1. EXPLODED AIR TANK.

Three Instructive Accidents.

We are in receipt of descriptions of three wholly unrelated accidents, all of which are instructive, in that they emphasize some particular hazard, and should serve as a warning for the prevention of similar mishaps.

The first on our list is the explosion of an old kitchen boiler, which had been installed in a garage as a storage tank in connection with a compressed air system, designed to furnish "free air" to the customers. The tank, which had been purchased at second hand, was supposed to be capable of withstanding 200 lbs. pressure, and was to be operated at 140 lbs. When the pressure was raised to about 45 lbs., the tank ruptured, as is shown in our sketch, Fig. 1. The rupture disclosed the fact that the seam had been soldered for a six inch length, as the sketch indicates. The dimensions of the tank were, length 70 inches, diameter 16 inches, shell of 3/32 in. plate, single riveted, 1/4 in. rivets, pitched 3/4 in.

The heads were but ⅛ in. thick. It seems almost impossible to understand why people will continue to use any old riveted tank, whose dimensions and construction, not to mention its internal condition, are entirely unknown, as a container for air or steam, or indeed any fluid under pressure, on the mere say so of a second-hand dealer. Pressure tanks, for whatever use they may be desired, cannot be too well made, and it should be definitely established that they possess a considerable safety factor, say five, based on a knowledge of their material and method of construction, before people risk their lives and property by subjecting them to pressure. In this case, there were in addition to the soldered portion, indications that a crack or fracture had been present for practically the entire length of the seam. One man was seriously injured.

The second accident was from a cause which we have frequently pointed out in the columns of THE LOCOMOTIVE. A man was sent to clean the combustion chamber of a water tube boiler. Although the boiler is said to have been out of service for five days preceding the accident, the four months' accumulation of ash with which the setting was filled had not been disturbed, and when the cleaner entered the combustion chamber, with a water service hose, the ash and the brickwork beneath it were still in a very hot state. It is thought that, choked by the steam and fumes given off when the stream of water came in contact with the heated ash and brick work, the man made an effort to escape through the clean-out door at the back end. He was found with his head and shoulders in the opening, lying in the hot ashes, but was so severely burned that he died three hours afterwards. It is always dangerous to enter the combustion space of a boiler setting before the accumulation of ash and soot has been swept out. Only those who have learned by bitter experience can appreciate the length of time that brick work will remain at practically a red heat when covered by such a non-conducting ash blanket, certainly a four months' accumulation, in a plant working at any thing like the capacity of many of our modern boiler plants, should never be permitted to remain five days after fires had been allowed to burn out, and certainly not after a man had been ordered to work in the setting.

The third accident was the explosion of a bleaching kier. A kier is a vessel provided with a cover or door which may be readily removed, in which cloth, thread, yarn, lace or some form of textile product may be boiled in the process of bleaching and finishing. These vessels are not ordinarily subjected to a very high pressure, and should be provided with both reducing and relief valves to limit the pressure which may accumulate in them. In the present instance, two kiers were installed in a plant for bleaching lace. They were not fitted with either reducing valves, or safety valves, but the pressure was controlled by throttling the steam supply, so that it was possible for full boiler pressure to be communicated to the kiers. The explosion consisted of the blowing off of the cover, failure taking place at the holding down bolts. The explosion was violent and expensive, for in addition to the damage done to the mill, a large and expensive charge of lace was ruined. The damage was estimated at $3,500.

FIG. 1. OLD TANK IN THE MIDST OF THE MOLASSES LAKE.

New Wine and Old Bottles.

Our illustration shows an old iron oil tank, some 66½ ft. in diameter by 25½ ft. high. Constructed of iron plates, which were of necessity small in size, the tank was built in six courses, the two lower ones are said to be 5/16 in. thick, while the rest are but ¼ in. thick. The history of the tank is of no interest, except that it is said to have been erected in its present position at second hand, some 15 years ago, and that its bottom, which is none too thick, is supported on a timber structure, carried on piles. Some time since an adjoining oil tank burned and the one under discussion, which was empty, was damaged to an unknown extent by overheating. The fire found its way under the empty tank, and did some damage to its bottom, though the extent of the injury is not known.

So much for the "old bottle." There is nothing surprising or unusual about a crippled and ancient tank, but who would care to entrust a product worth thousands of dollars in such a container? This, however, is just what was done in the present instance. The tank was hired by the owners of a cargo of molasses for storage purposes. Notwithstanding the fact that a simple calculation showed the ability of the old tank to withstand the expected hydro-static pressure was very doubtful indeed.

The tank steamer laden with the molasses cargo arrived, and after proper connections were established, started to discharge its freight. When the tank was about two-thirds filled leakage appeared at the point in the bottom where the fire damage was said to have been most pronounced. Upon the discovery of the defect all possible efforts were concentrated on saving the molasses. It was pumped back to the steamer, and into tank cars, but without success, for a large pool of the material formed on the ground. This was then surrounded with an earthen dam, or retaining wall, with such success that the tank as it appears in our illustration is at the center of a molasses lake, said to have been four feet deep! The loss was not expected to exceed 150,000 gallons. (We wonder if any of this "pond molasses" will ever reach the editorial kitchen!)

No further comment is necessary beyond the statement that the estimated value of the cargo was $30,000.

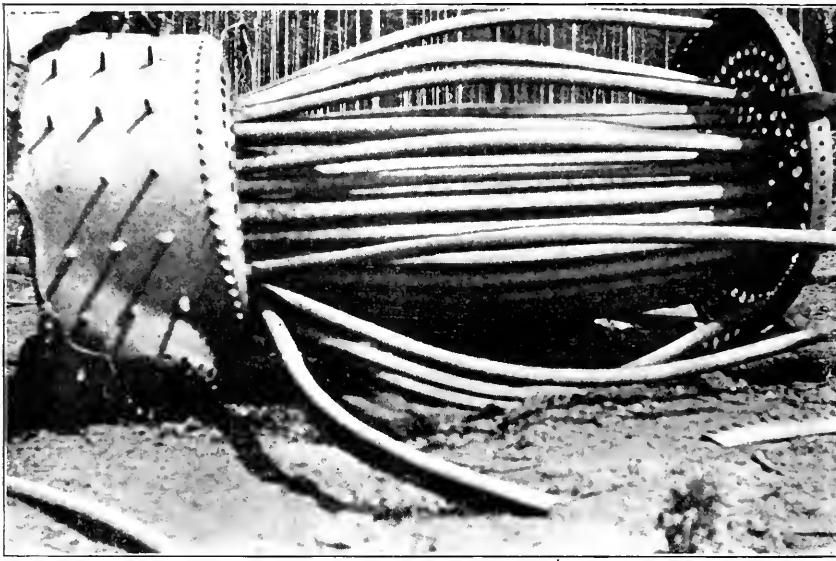


FIG. 2. REMAINS OF THE PATCHED LAP SEAM BOILER.

The Inevitable Result of Patching a Lap Crack.

The lap seam crack has been discussed in the columns of THE LOCOMOTIVE from nearly every conceivable standpoint. We have treated it from its causes through all the stages of its formation, and have even disclosed ways and means for its discovery while still in the incipient stage. We cannot but feel that we have contributed our share toward educating both boiler makers and boiler users to a full recognition of the danger of this style of boiler construction.

For a lap crack to disclose itself in a peaceful fashion is unusual enough, but when a boiler owner attempts to cover up this defect in a boiler which has been considerate enough to disclose the fact without a violent explosion, he is surely tempting Providence in his efforts to get further service from his equipment. It is indeed hard to realize that there are boiler makers and boiler operators who do not know the seriousness of cracking along the longitudinal seams of a lap riveted boiler, but no other explanation would seem to cover the conditions presented by the case before us. Surely no sane man, whether boiler maker, boiler owner or boiler operator would intentionally set a death trap, and the patching of a lap crack sets a death trap as surely as the setting of a spring gun.

The explosion which has suggested the warning which we have just enunciated was that of a vertical tubular boiler, used on a lumbering operation in Washington, on June 12. This boiler was used to furnish steam for pumps, which supplied feed water for several boilers, scattered through the woods, and used for logging. The boiler was some seventeen years old, 48 inches in diameter, and 8 ft. 8in. high. Built of iron shell plates, with steel heads, it presented no unusual features, either of construction or design. When new it had been attached to a double hoisting rig, and was said to have operated at a pressure of from 160 to 170 lbs. This may have contributed to the formation of the crack, for this pressure was higher than would ordinarily be allowed an insured boiler of similar size and material, and so the breathing action, to which the formation of lap cracks is usually attributed, would no doubt have been accentuated.

Some time ago a crack about five inches long developed parallel to the longitudinal seam, and near the inner row of rivets. The crack opened enough to permit leakage, and so it was repaired by stitching with plugs, and covered with a patch secured with patch bolts. The lumber company seem to have suspected that perhaps the boiler was not so vigorous as it had been, for they removed it from the hoist, after the repairs, and relegated it to the pumping service described above.

In its new position it was fitted with a safety valve, though we were unable to ascertain the load which the valve carried. Those familiar with the plant, agreed that not more than 90 or 100 lbs. were required to run the pumps. The boiler had not been in use for a week or so prior to the explosion, but on the morning of the accident, orders were given to fire up. Just before the explosion, the safety valve was heard to blow freely. The break come about one and one-half hours after the fire was started. The operator was instantly killed, and horribly mangled. When found he held the hand wheel of the feed valve tightly clutched in his hand, and this lent color to the immediate local verdict of cold feed introduced into an overheated and nearly dry boiler, as the cause of the trouble. It is surprising how tenaciously the non-technical public, and the average newspaper account refer to this as the absolutely certain cause of almost all boiler explosions, in the light of the many unsuccessful attempts that have been made to blow up an experimental boiler in this way.

Examination showed that the outer lap was cracked at the edge of the inner sheet for a distance of possibly five feet. The shell was hurled for about 200 ft., stopping finally because of an encounter with a stump. The remainder of the boiler, which is shown in our photograph, traveled about 20 feet from its foundation. The shell unwrapped itself completely from the top head, shearing all the rivets. The fracture then proceeded downward from the patch and passed around the boiler through the fire door, leaving part of the lower section of the shell attached to the fire box. All the stay bolts pulled through the shell sheet.

This boiler was not insured, and it is doubtful if it was ever inspected except by local boiler makers who made repairs. While it is true that the most rigid inspection sometimes fails of discovering a lap crack in time, still it is hard to believe that any boiler inspector would have sanctioned the patching and continuing in service in the manner described, of a boiler which had given evidence of such a crack to the extent of developing a leak. Thus one more reason appears for the inspection and insurance of all boilers, no matter where located, nor for what service they may be used.

Obituary.

HENRY G. GOODRICH.

Henry G. Goodrich, of the firm of Goodrich and Wickham, General Agents for The Hartford Steam Boiler Inspection and Insurance Company, at Philadelphia, Pa., died at Atlantic City, N. J., on April 28, after an illness of about a year.

Mr. Goodrich was born at Berlin, Conn., September 19, 1846. His parents were natives of Connecticut. His youth was spent on his father's farm, and his early education was obtained in the country schoolhouse nearby.

He removed to Philadelphia at the age of 21, and in the Spring of 1867, with Mr. E. A. Corbin, formed the firm of Corbin and Goodrich, to represent The Hartford Steam Boiler Inspection and Insurance Company. This firm, known as Corbin and Goodrich; Corbin, Goodrich and Wickham; and since the retirement of Mr. Corbin in 1914 as Goodrich and Wickham has represented the Company continuously in the Philadelphia territory for a length of time practically identical with the corporate existence of the Company itself.

When Mr. Goodrich left the office in May, 1914, he was apparently suffering from a stubborn cold, which did not appear to be serious. It was soon discovered, however, that his heart was seriously affected, and he was last in his office for a period of two days, in June, 1914. In October, 1914, he seemed somewhat improved, and went to Atlantic City, where he occupied a cottage until his death. From Christmas time on he was very ill, though his death came as a result of pneumonia which developed about the first of April.

Mr. Goodrich occupied a very prominent position in Philadelphia, and numbered among his intimate friends, many of her most influential citizens. A long time member of the Presbyterian Church, he held many important places in connection with its government. He was a director of the Presbyterian Ministers Fund, believed to be the oldest life insurance company in the country, and a very prosperous one, and was an Elder of the church for many years. His beautiful character endeared him to all who were fortunate enough to know him well.

GEORGE H. BROWN.

George H. Brown, Special Agent in the Boston Department of The Hartford Steam Boiler Inspection and Insurance Company, died June 21, 1915.

Mr. Brown was born in Boston in 1841. He attended the schools in that city and later served an apprenticeship at the machinists trade. When the Civil War broke out, Mr. Brown enlisted for a three months' term in the 1st Mass. Light Battery, and at the termination of this brief enlistment, entered the navy, where he served for about two years as Third Assistant Engineer on the ships Iron Age and Montgomery.

After the war, Mr. Brown was engaged as a marine engineer on boats sailing out of Boston, for a period of ten or twelve years. He was later employed by the American Steam Boiler Insurance Co., as a boiler inspector, and left this position to enter the service of The Hartford, in which service he remained continuously and faithfully until his death.

Mr. Brown was a member of Post 26, G. A. R., and for the past year was Commander of the Minute Men.

Double-Boiler Explosion.

If one were to attempt to arrange and classify all the various sorts of vessels which at one time or another explode from the pressure of steam, he would be astonished at the variety of accidents, and the varying fields of human activity to which his attention would have to turn before his task was complete. We have no idea how many different types of explosions have been treated in The Locomotive, but we must add, if we are to believe the press notices which come to our desk, the explosion of a domestic double boiler, a utensil to which we had never before attributed any special hazard.

Explosion Injures Miss Spicer.

The explosion of a double boiler in which she was cooking some chocolate painfully burned the face and arms of Miss Cecil Spicer, of 529 Sherman west, Sunday morning at 11 o'clock. The boiler had become filled with steam and when the lid blew off the boiling water was thrown into Miss Spicer's face. She was better last night and it is not thought any permanent scars will result.

(Hutchinson, Kan. Gazette.)

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. Perry, Editor.

HARTFORD, JULY, 1915.

Single copies *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
The Locomotive of The Hartford Steam Boiler I. & I. Co.

The paper on throttled governed engines, in another column begins a series of articles which are planned to run through the coming issues of The Locomotive covering the field of flywheel operation. It is hoped to make the series of great interest and value to the operating engineer, refreshing his memory on some points, and perhaps giving new information, or a new view point on others to the end that he may be able to handle the equipment placed under his care more safely. The Locomotive has filled its pages for over forty years with information designed to make for safer boiler operation, but with the exception of a lesson here and there which has been drawn from some accident described, it has not attempted any extended discussion of the care of flywheels. Of course it is to be understood that in these papers we shall hold ourselves free to interpret the word "flywheel" in a sense broad enough to cover all rotating objects which would be considered insurable under a flywheel policy, in the same way that we frequently extend the meaning of the word boiler to cover many other sorts of pressure vessels. We sincerely hope that the series will prove as readable and instructive as we intend it to be.

The value of a specialist's advice is frequently most in evidence after a mistake has been made. The opinion of one thoroughly familiar with all phases of a problem has value also even though it may appear very simple, and when the situation is explained almost self evident. We are led, perhaps not infrequently to measure the value of the advice given by its complexity and abstruseness and if we have consulted an expert, only to be told some exceedingly simple way out of our trouble, we sometimes feel that the effort has been wasted. As a case in point one need only mention the difficulty often met in getting boiler operators to follow directions for eliminating scale.

Many times a feed water, although troublesome, will yield readily to the simplest and most inexpensive treatment. If directions are given, prescribing the simple treatment, the owner or his engineer feels hurt because such a simple remedy is recommended for so trying a disease and assuming that no good can follow, discards the advice before it is even tried. On the other hand, if several unnecessary but harmless ingredients had been added to his water treatment, so that he felt possessed of a potent and mysterious "boiler compound" formula he would have turned night into day in his haste to comply with the minutest details of the cure.

So also in seeking and following advice about engineering matters, it is curious how little attention is paid to important and fundamental things if they appear simple and obvious. Not only is this the case, but many times when simple advice is of the utmost importance it will not be sought because of the feeling that it is after all unnecessary.

The material available for the preparation of this issue of THE LOCOMOTIVE was unusually full of instances of what we have in mind. For example, nine heater accidents are reported somewhat in detail. In practically every case we reach the conclusion from a review of the information presented, that simple changes, either in the layout or the method of handling the apparatus would have diminished the probability of an accident to next to nothing. In none of the cases does it not appear that complex or difficult changes were required, but advice by some one qualified to give it was not less necessary on that account.

Then we have the accidents to the air tank and the bleaching kier, and the fatal burning from hot brick work in a combustion chamber, all preventable if simple precautions had been taken. The same reasoning is applicable to the loss of the valuable cargo of molasses from the oil tank, and finally to the explosion of the lap seam boiler to which repairs had been attempted by stitching and patching.

The very complexity of modern life and the infinite ramifications of modern business and industry make it impossible for any of us to be familiar with all the details of all the equipment for which we are responsible. The time has passed in most cases, when, for instance, the head of a manufacturing concern can be intimately acquainted with the details of his power plant, his manufacturing plant and processes, and his business and financial interests as well. Nor is it wise or necessary that he should do so.

In his special field the boiler inspector makes it his business in life to know intimately and to the smallest detail the principles and practice of boiler building and operation. He becomes so familiar through experience and constant contact with all sorts of steam generating equipment that conditions which to the layman might appear quite proper are instantly recognized as containing the elements of hazard. Probably no thinking person will doubt the soundness of this statement, it is indeed almost axiomatic. Why, then, are there uninsured and uninspected boilers? Probably the same explanation, if it could be found, would answer the question of why there are able bodied men, earning a fair living who do not carry life insurance. Whether this is due to the innate gambler's instinct for taking chances, or to mere carelessness we cannot tell.

If no one could suffer but the owner of a boiler or pressure vessel through its explosion we could only appeal to him through his desire for indemnification. Unfortunately, however, boilers have a bad habit of injuring the persons and property of others than their owners, and so the public at large becomes interested in their safe construction and operation.

Such movements as that which is endeavoring to secure the enactment of legislation in the different states to compel boiler owners to install only such boilers as will fulfill the requirements of some recognized set of regulations like the A. S. M. E. Code will go a long way toward giving boilers a right start in life, but only continued supervision and inspection can keep them properly installed and operated, and even then accidents of the unpreventable or difficultly preventable sort are to be expected for which indemnification under an insurance policy offers the most logical remedy. As a general proposition it is good business as well as good engineering to offer boilers, pressure vessels, etc., for insurance. If they are accepted then it is equally good business to keep them insured. If they are rejected after careful examination for causes which cannot be economically removed or repaired, they may well be considered unfit for further operation.

Because much of the advice and many of the suggestions of the boiler inspector are simple obvious things, after they are pointed out to us, should not become an excuse for belittling either the advice or the skill of the inspector. He is concentrating his whole attention upon a very special field of work and training himself in the habit of seeing all the details of a boiler installation, and having seen, of analyzing the case and establishing at once the probable bearing of a multitude of little things easily overlooked. His advice therefore takes on a value which is seldom appreciated by most of us until we have actually experienced a case of the prevention of a serious accident.

If the layman could or would train himself as the inspector has been trained and could become familiar with the large number of boiler installations which the inspector is compelled to visit in the course of his work, he could doubtless inspect his own boilers. So could he perhaps acquire the necessary experience to plead his own cases in court or prescribe for his physical welfare. If he is wise, however, and busy, he will get the advice of an inspector for his boiler ills just as unhesitatingly as he will hire an attorney to look after his legal affairs or a physician to prescribe for the maintenance of his health.

Patchwork.

A boiler manufacturer, his agent and their customer recently participated in a curious three cornerd controversy growing out of the fact apparently that the customer was entirely unacquainted with the appearance of a butt-strapped boiler, but had the very evident desire to get his money's worth. The boiler was a small vertical tubular one with a double riveted double butt-strapped longitudinal joint, and the large number of rivets, together with the straps gave the impression to the customer that he had been the victim of a fraud on the part of the manufacturer and that he was expected cheerfully to accept a piece of patchwork. The letters which follow from the agent to the manufacturer, and the latter's reply are self-explanatory.

(From the Agent to the Boiler Maker.)

Home Office:

The three boilers on the above order have arrived, and our customer says they are the worst looking boilers they have ever seen, and say they look like crazy patch work. They are made of so many pieces with so many seams.

We have not seen the boilers, and are writing you to have you explain the matter fully, so that we will be in position to make defense. They tell us they think we must have had some scrap plates laying around, and used them up in these boilers, but we told them that we were under the impression that the plates were ordered especially from the mills, and that the boilers were made as they should be, but this does not satisfy them, and we must make some clear and full explanation so please post us thoroughly, and oblige

Yours truly,

(The Reply.)

Dear Jack:

I have your letter of the 18th, in reference to —————————— order, and note carefully what you say in your letter. Confidentially Jack these boilers were built from some old plates, which we had lying around the place since the flood, of various thicknesses, and it was necessary to cut them up in a great many pieces in order to cut out the bad parts. We, of course, had no trouble whatever in getting Ohio, Mass., Chicago and Detroit inspection on the patch work boiler, and are a little disappointed, if the customer discovered this so soon.

On the square, we are surprised that you would write a letter of this kind, knowing that these boilers are built in accordance to the code of Ohio, Mass., Chicago and Detroit. In the first place you know very well that it is absolutely necessary for us to order special material in order that it pass the inspection of these codes. Also that it would be absolutely impossible for us to do anything like you indicate in your letter and get them accepted and inspected.

These plates were ordered special from the mills, and the boilers are two ring boilers, standard construction for 42x108. It may be possible that your customer never saw a butt strap boiler before, and he thinks it was necessary for us to put the strap on the outside because the plate was not big enough to lap, in this way .make a patch out of it. In fact the whole statement is so ridiculous that it is impossible. Why he should take this stand we do not know unless he does not want to pay for the boilers. Why don't he get some inspector or take it up with someone who knows. That's all.

Yours respectfully.

Why Green's Boiler Exploded.

We clip the following from a Pittsburg paper:

Mr. Green lived on the outskirts of town and owned a mill. He had started in life a poor boy and by industry and practical economy had accumulated a competence. His close attention to business made his enterprise a success and his mill was in constant operation.

Of late years he devoted much of his time to the study of scientific problems, and one of his chief studies was steam, and particularly relating to boiler explosions. His opinions on that subject were decided, and he believed that gases were formed from decomposed organic matter and by some mysterious process accumulated in the boilers which caused their explosions.

Mr. Green owned a fine estate, on which was built a handsome residence. Mrs. Green was proud of it, the position that she held in society, and the success attending the enterprise of her lord and master. Every rose has its accompanying thorn, and every house its secreted skeleton.

There was a thorn in the rose-tinted life of Mrs. Green which saddened her brightest moments of happiness. Immediately adjoining the princely manor of Green, was a detestable hovel owned in fee-simple by Tompkins. The Tompkins estate was an eye-sore to Mrs. Green, and marred the beauty of the landscape. Many were the overtures made for its purchase. Tompkins was an erratic, independent Irishman, and detested aristocracy, and, although the price offered was many times the value of Tompkins' "bit of a lot," he, from pure spitefulness and love of power to inflict a member of the detested aristocracy, refused to sell.

Tompkins, like many Irishmen, owned a "lump of a pig." The hog made predatory incursions on the Green estate, and notwithstanding closed fences, watch dogs and cross gardeners, Tompkins' hog did much mischief to the gardens, and made picturesque the landscape set out in beautiful squares, diagonals, and diamonds of monthly blooming roses, geraniums, and dahlias. The hog was worried by Green's dog and imbibed feelings of hatred akin to those possessed by his master for the entire Green fraternity, their retainers and dependents.

Mr. Green made a visit to a distant city on business pertaining to his mill. Before leaving he cautioned his engineer to be careful with the boilers and guard against the accumulation of gases.

The gardener fed Tompkins' pig some poison. He became thirsty and going to the creek where the pipe entered to feed the boilers he drank largely to quench his thirst and fell over and died, covering the end of the pump pipe.

The day after Green's departure, the engineer went down town, leaving the engine in charge of the firemen. The boilers were fed by a double-acting rotary pump, with no dead centers. Soon after the engineer left, the pump, although in operation, stopped forcing water into the boilers. The fireman, lacking experience, did not know this, but supposed, as the pump was revolving, that all was right.

When the bell rang for six o'clock the machinery was stopped for the night, the fireman banked the fires and departed for home. The water was low in the boilers and the engineer had not returned from town.

Immediately over the fire-bed there was a defective sheet in one of the boilers. Mr. Green did not know of this sheet being bad, the boiler-maker did not know, and the firm that sold the iron did not know of it being defective. The iron was of the best brand of Sligo charcoal, and made from Knobling blooms. The roller that made the iron knew of the bad spot; he worked by the ton and a bad sheet knocked something off from the profits. The bad sheet was made in this way. When the bloom came from the heating furnace, and after going through two or three passes of the rolls, there appeared a large blister that would swell and expand after each pass. This blister was prodded by the roller with a sharp pointed iron, allowing the gas to escape. The iron at this place did not weld, but when it was finished no appearance of the defect could be observed, and the roller passed it as No. 1 iron. This sheet was put in Green's boiler and right over the hottest portion of the fire.

The next morning the fireman was late and hurried up the fires. As the boss was gone the engineer did not put in an early appearance. From the fires there soon rolled heavenward, dark volumes of unconsumed carbon. The fireman tried the water. The upper gauge showed no water. He hastily tried the second, when nothing but dry steam escaped. With a nervous hand he tried the third and last gauge, and to his horror there was a hissing of blue steam! He rushed to the pump to start it. Fatal step! It was a match to the magazine.

It was a December morn. Frost covered the face of nature, forming beautiful crystalline flakes and making crisp the atmosphere. The moon in its last quarter shone peacefully in the heavens. Aurora was seen approaching in the east, when a crash was heard, loud, long, and deafening. The boiler had exploded, carrying death and destruction in its wake. The fireman was killed outright, and some others who had arrived early were wounded. The engineer, who lived close to the mill, was the first on the scene. Some experts arrived and gathering fragments of the boiler began to investigate for the cause of the explosion.

The engineer was examined and gave as evidence that the boiler contained "plenty of water," and could not explode from that cause, the only one that could contradict his evidence was the fireman, and he was dead.

Mr. Green arrived and was energetic in observations; he examined the feed-pipe in the creek and found the defunct Tompkins hog. He at once mounted his hobby, and showed how decomposed vegetation and decayed organic matter with a devilish intent united their gases, with a hellish purpose they entered their boilers, and with a damning result caused disastrous explosions; and very many other persons agreed with Mr. Green, and could not be convinced that a lack of water had anything to do with it.

The Locomotive, Dec. 1881.

Personal.

The rapidly increasing requirements of states and municipalities under recent steam boiler inspection laws have made it advisable for THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY to create a new office for the general supervision of its engineering work, and so it has established the position of Chief Engineer, to which position it has appointed Mr. Sherwood F. Jeter, who has since 1911 been the Supervising Inspector of the Company.

Mr. Jeter needs no introduction to the Company's representatives, but to those who are unacquainted with him, we extend assurances that all problems submitted to Mr. Jeter will be most carefully and thoroughly treated. In addition to the previous synopsis of Mr. Jeter's experience, we desire to say that he is a member of the American Society of Mechanical Engineers and served on the advisory committee appointed to assist the boiler code committee in the preparation of the recent A. S. M. E. boiler code. The original and advisory committees have since been consolidated to supervise the working of the code.

The death of Mr. Wallace W. Manning, on December 19, 1914, created a vacancy in the position of Chief Inspector in the New York office. To fill the vacancy, Mr. Joseph H. McNeill, lately Chief Inspector in the Boston office of the Hartford has been transferred to New York.

Mr. McNeill was Chief Inspector and Chairman of the Board of Boiler Rules for the Commonwealth of Massachusetts prior to his connection with the Boston office of the Company. Experienced as a marine engineer and boiler inspector, and with his long service as Chief Inspector, both as a State official and for The Hartford, he should prove a worthy successor to Mr. Manning.

Mr. Charles D. Noyes has been appointed Chief Inspector in the Boston Department to fill the vacancy due to Mr. McNeill's transfer. Mr. Noyes has been connected with the inspection force at the Boston office for 20 years, joining the Company's service in 1895. He was born in Woodstock, Me., in 1853, and trained as a mechanic, his long connection with the Boston office, and his wide acquaintance with the district fit him especially for his new duties.

Mr. A. E. Bonnett, an inspector in the New York Department has been promoted to the position of Assistant Chief Inspector in that office. Mr. Bonnet was born in Brooklyn in 1874. He was educated at the Stevens Academy and entered the employ of the Hartford as an inspector in the New Orleans office in 1904. With the exception of a brief interval, he remained at New Orleans until he was transferred to the New York office in 1913. Mr. Bonnett's promotion comes as a merited recognition of faithful service.

Boiler Explosions.

FEBRUARY, 1915.

(39.) — A boiler ruptured February 1, at Horst's bakery, Galesburg, Ill. The damage seems to have been slight.

(40.) — A tube ruptured in a water tube boiler at the plant of the Milwaukee Electric Railway and Light Co., Racine, Wis., on February 1. Charles Perry, chief engineer of the plant was fatally scalded.

(41.) — A steam separator in a pipe line exploded February 1, at the Klinkert Brewery, Racine, Wis. One man was fataly burned.

(42.) — On February 1, a cast iron sectional heating boiler ruptured at the Fourth Ward School, Borough of Latrobe, Pa.

(43.) — The suction dredge Eastern turned turtle in a gale on February 2, off Port Jefferson, N. Y. Following the accident, a boiler exploded, which completely destroyed the vessel. Four men were lost.

(44.) — On February 3, twelve cast iron headers failed in a water tube boiler at the plant of the Pressed Steel Car Co., Allegheny Works, Pittsburg, Pa.

(45.) — A boiler ruptured February 4, at the plaster board plant of the Bestwall M'f'g Co., Clearing, Ill.

(46.) — A blow-off pipe failed February 4, at the Grendel Mills, Greenwood, S. C. One man was injured.

(47.) — A section ruptured February 4, in a cast iron sectional heater at the business building belonging to Amelia B. Tewksbury, Lawrence, Mass.

(48.) — A boiler exploded February 4, at Bell's Mill, Boggy Creek, near Kissimmee, Fla. Two men were instantly killed, and two more fatally injured as a result of the accident.

(49.) — On February 6, a boiler exploded at the plant of the Abilene Gas and Electric Co., Abilene, Tex. The property damage was in the neighborhood of $1,500.

(50.) — A tube ruptured February 6, in a water tube boiler at the Avondale Mills, Birmingham, Ala. The only damage was to the boiler itself.

(51.) — An explosion occurred February 5, in connection with the boiler plant of the Northwestern Tie Preserving plant, at Escanaba, Mich. The boilers and settings were considerably damaged.

(52.) — On February 7, four sections of a cast iron sectional heater ruptured at the Circle Theater, Broadway and 60th St., New York City.

(53.) — Fire resulting from a boiler explosion seriously damaged the plant of the Scanlan-Morris Co., Madison, Wis. One man was injured, and the property damage, most of which was done by fire was very large, said to have exceeded $60,000.

(54.) — A hot water tank exploded February 9, in The Chestnut Street Station of the Springfield Fire department, Springfield, Mass. The damage to the building was considerable, but fortunately no one was injured.

(55.) — A boiler ruptured February 9, at the Consumer's Gas Co. plant of the United Gas Improvement Co., Reading, Pa.

(56.) — A blow-off pipe failed February 9, at the mill of the White Pine Sash Co., Spokane, Wash.

(57.) — Three sections failed February 11, in a cast iron sectional heating boiler at the St. James Catholic Church, Jamestown, N. D.

(58.) — A sawmill boiler exploded February 12, at Reese, Texas. One man was killed and two others injured so severely that their recovery was not expected.

(59.) — On February 13, a boiler failed at the Blondel-Donovan Lumber Mills, Bellington, Wash.

(60.) — A boiler exploded February 14, at the electric light plant at Menlo, Ia. Three men were killed as a result of the explosion.

(61.) — On February 15, an accident occurred to a boiler at the plant of the Williamson-Kinny Mill and Lumber Co., Mound City, Ill.

(62.) — On February 15, a second blow-off failed at the plant of the White Pine Sash Co., Spokane, Wash.

(63.) — A section ruptured in a cast iron sectional boiler February 15, at the plant of the Thompson Milling Co., Lockport, N. Y.

(64.) — A boiler exploded in the oil fields near Sapulpa, Okla., about February 15. One man was seriously injured.

(65.) — On February 16, a cast iron mud drum failed in a water tube boiler at the plant of the Southwestern Milling Co., Kansas City, Kas.

(66.) — The boiler of a peanut and pop-corn machine exploded February 20, at Vincennes, Ind. Fragments of the boiler destroyed several expensive plate glass windows in nearby stores, and damaged the goods displayed. The damage was estimated at $1,500.

(67.) — On February 22, a section ruptured in a cast iron sectional heating boiler at the apartment house belonging to Harry Bierhoff and Bernard Greeff, 56 East 118th St., New York City.

(68.) — A tube ruptured February 22, in a water tube boiler at the plant of the American Steel and Wire Co., Waukegan, Ill.

(69.) — On February 23, a tube ruptured in a water tube boiler at the plant of the United States Glue Co., Carrolville, Wis.

(70.) — A boiler ruptured February 22, at the bleaching plant of V. L. Crawford, Meridian, Miss.

(71.) — A kitchen boiler burst February 23, in the home of Albert Schlager, Scranton, Pa.

(72.) — A tube ruptured February 25, in a water tube boiler at the plant of the American Sheet and Tin Plate Co., Chester, W. Va. One man was injured.

(73.)— A tube ruptured February 25, in a water tube boiler at the plant of the Middle West Utilities Co., Lebanon, Ind.

(74.) — A main steam pipe burst February 26, on board the Steam Schooner Lakme, at sea bound from San Francisco for Eureka. The vessel was forced to return to port under sail for repairs.

(75.) — A boiler used as an air tank exploded February 26, at the plant of the Cudahy Packing Co., Wichita, Kas.

(76.) — On February 27, two sections and a manifold ruptured in a cast iron sectional heating boiler at the apartment house of Peter Ratti, Saratoga Springs, N. Y.

(77.) — A boiler exploded February 27, at the quarry of the Phoenix Soapstone Co., Arrington, Va. One man was killed, one injured and property damage to the extent of about $7,000 done to the plant.

MARCH, 1915.

(78.) — Locomotive 968 of the Oregon Short Line, dropped a crown sheet from low water March 1, near Hammett, Idaho. The engineer and fireman were killed and the boiler of the locomotive was blown clear of the frame.

(79.) — On March 3, a tube failed in a water tube boiler at the starch works of the Douglas Co., Cedar Rapids, Ia.

(80.) — A hot water boiler exploded March 3, in one of the apartment houses Nos. 50-56 Vernon St., Brookline, Mass. This is the second time in nine months that one of these houses has been seriously wrecked by the explosion of a hot water boiler.

(81.) — A boiler used in connection with a steam heating system exploded at the Country Club, Oakland pasture, New Orleans. Four men were injured as a result of the accident, which is said to have occurred as steam was raised for the first time in order to test the working of the installation.

(82.) — A hot water boiler exploded March 4, at the Grand Central Hotel, Fresno, Cal.

(83.) — A boiler exploded March 4, at the Woodward ore mines, Red Mountain, near Birmingham, Ala. One man was killed and another was fatally injured.

(84.) — A steam boiler exploded March 5, in the basement of the "National" rooming house, 373 West St., New York City. Two men were injured.

(85.) — Nine sections failed March 7, in a cast iron sectional heating boiler at the plant of the San Telmo Cigar M'f'g. Co., Detroit, Mich.

(86.) — The crown sheet of a vertical tubular boiler cracked March 10, at the plant of Sulzberger and Sons, Dallas, Tex.

(87.) — A tube ruptured in a boiler at the power plant of the Cairo Electric and Traction Co., Cairo, Ill., on March 7. Two men were severely burned.

(88.) — A boiler exploded March 8, at the quarry of the Progressive Realty Co., Allentown, Pa. The building and plant were badly damaged and three men were injured.

(89.) — A tube ruptured March 10, in a water tube boiler at the plant of the B. F. Goodrich Co., Akron, O.

(90.) — On March 11, five sections ruptured in a cast iron sectional heating boiler at the apartment of L. V. Niles, Center St., Roxbury, Mass.

(91.) — Two sections cracked March 11, in a cast iron sectional heating boiler at the varnish factory of William Harlan and Son, Buffalo, N. Y.

(92.) — On March 12, a blow-off failed at the Milwaukee Downer College, Milwaukee, Wis.

(93.) — On March 12, seven sections failed in a cast iron sectional heating boiler at the bakery of James M. Hallinan, New Britain, Ct.

(94.) — A cast iron header failed March 13, in a water tube boiler at the Ohio Light and Power Co., plant of the American Gas and Electric Co., Tiffin, O. Two men were injured.

(95.) — A boiler exploded March 16 in the basement of an apartment house at 5353 Pine St., Philadelphia, Pa.

(96.) — A boiler exploded at the mill of C. T. White and Son, Waterside, N. B., Can., on March 17. The mill was badly wrecked, one man was killed and four others seriously injured, one perhaps fatally, as a result of the explosion.

(97.) — A boiler burst March 18, in the cleaning establishment of I. L. Sakowski, Kirkwood, near St. Louis, Mo.

(98.) — A boiler exploded about March 20, at a stone quarry near Hatfield, Pa. One man was injured.

(99.) — Ten boilers are said to have exploded March 20, at the Lawrence Mine, Mahanoy City, Pa. The boiler house was destroyed, and as floods were feared it was necessary to hoist the mules and close the mine, which employed about 800 men, until new boilers were installed.

(100.) — An accident occurred March 22, to a boiler at a creamery, Cherry Valley, Ill.

(101.) — A blow-off pipe failed March 22, at the plant of the Silk Finishing Co. of America, New York City.

(102.) — On March 24, a boiler failed at the Thompson Creamery, Thompson, O.

(103.) — A tube failed March 24, in a water tube boiler at the starch factory of The Douglass Co., Cedar Rapids, Ia.

(104.) — On March 24, a section ruptured in a cast iron sectional heating boiler at the plant of the Standard Oil Company of New York, Springfield, Mass.

(105.) — A hot water tank exploded March 25, at 303 East 105th St., New York City.

(106.) — A steam heater exploded in an interurban trolley car near Wichita, Kas., March 30. Two men were injured.

(107.) — On March 31, a tube ruptured in a water tube boiler at the Claypool Hotel operated by the Indiana Hotel Co., Indianapolis, Ind. One man was killed and extensive repairs were required to the boiler.

April, 1915.

(108.) — On April 1, a tube ruptured in a water tube boiler at the plant of the Ohio Electric Railway Co., Zanesville, O. Two men were injured.

(109.) — A blow-off pipe failed April 3, at the plant of the Western Cotton Oil and Gin Co., Haskell, Tex. One man was injured.

(110.) — On April 6, a blow-off pipe failed at the plant of the Chas. Taylor and Sons Co., Cincinnati, O.

(111.) — On April 7, a blow-off pipe failed at the St. Tammany Lumber M'f'g. Co., Ramsay, La. One man was injured.

(112.) — Two boilers exploded April 7, at the power plant of the Hammond Mill Co., Astoria, Ore. This plant furnished light and power for Astoria, and as a result of the accident the town was in darkness for some time. One man was injured seriously.

(113.) — A boiler exploded April 9, at a saw mill at Wahalak, Miss. One man was killed and a second severely injured.

(114.) — A boiler ruptured April 13, at the W. F. Priebe Co. plant, of Swift & Co., Atlantic, Ia.

(115.) — A blow-off pipe failed April 13, at the plant of the D. N. Thomas Sand and Gravel Co., Williamsport, Pa. One man, the night watchman, was fatally scalded.

(116.) — A boiler exploded April 17, at a saw mill belonging to Henry Fields and Sons, Sinclair, Ont., Can. Two men were killed.

(117.) — A tube ruptured April 19, in a water tube boiler at the plant of the Jackson Light and Traction Co., Jackson, Miss. One man was injured.

(118.) — A hot water storage tank exploded April 19, in the basement of the chauffeur's cottage on the estate of George F. Baker, Jr., Locust Valley, L. I. The building was badly damaged, but fortunately no one was seriously injured.

(119.) — On April 23, a boiler failed at the Poor Farm, County of Wyandotte, Horniff, Kas.

(120.) — Several sections ruptured April 23, in two cast iron sectional boilers at the apartment house owned by the St. Philip Protestant Episcopal Church, 127 West 135th St., New York City.

(121.) — On April 24, a section ruptured in a cast iron sectional heater at the Fourth Ward School, Borough of Latrobe, Pa.

(122.) — A hot water heater, used to heat the water for the Baptistry, exploded April 25, at the City Temple, Sioux Falls, S. D. The accident occurred during the course of the morning service, and did considerable damage to the building, but fortunately none of the worshipers were injured.

(123.) — Three cast iron headers ruptured April 25, in a water tube boiler at the plant of the New York and Pennsylvania Co., Willsboro, N. Y.

(124.) — On April 29, the main steam pipe failed at the plant of the Scranton Bolt and Nut Co., Scranton, Pa.

(125.) — A tube ruptured April 30, in a water tube boiler at the water works of E. M. Ellsworth, Vicksburg, Miss.

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY is now issuing to its policy-holders its "Vacation Schedule" for 1915. Like those of previous years, this schedule affords a most convenient form for arranging and recording the holiday period allotted to each of the clerks or other employees of an institution. From it at a glance may be determined how many and what members of the force will be absent on any given date and thus by a little foresight and care the assignment of the same days to those whose simultaneous absence would cause inconvenience may be avoided.

Copies may be obtained by our policy-holders on application to the nearest of the offices listed on the last page of this issue.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1915.

Capital Stock, ... $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$229,528.21
Premiums in course of collection,		285,417.97
Real estate,		90,200.00
Loaned on bond and mortgage,		1,266,145.00
Stocks and bonds, market value,		3,741,954.00
Interest accrued,		86,619.48
		$5,699,864.66
Less value of Special Deposits over Liability requirements		40,291.16
Total Assets,		$5,659,573.50

LIABILITIES.

Premium Reserve,		$2,331,531.90
Losses unadjusted,		44,573.69
Commissions and brokerage,		57,083.59
Other liabilities (taxes accrued, etc.),		46,656.55
Capital Stock,	$1,000,000.00	
Surplus over all liabilities,	2,179,727.77	
Surplus as regards Policy-holders,	**$3,179,727.77**	3,179,727.77
Total Liabilities,		$5,659,573.50

LYMAN B. BRAINERD, President and Treasurer.

FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.

L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.

S. F. JETER, Chief Engineer.

H. E. DART, Supt. Engineering Dept.

F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, President. Director Swift & Co.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

GEORGE C. KIMBALL, Capitalist, Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford, Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, Johns-Pratt Co., Hartford, Conn.

Incorporated 1866. Charter Perpetual.

The Hartford Steam Boiler Inspection and Insurance Company

ISSUES POLICIES OF INSURANCE COVERING

ALL LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.	W. M. FRANCIS, Manager and Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	LAWFORD & MCKIM, General Agents. R. E. MUNRO, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. ROBERTS, Manager. CHARLES D. NOYES, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.	W. G. LINEBURGH & SON, General Agents. F. S. ALLEN, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. LEMON, Manager. JAMES L. FOORD, Chief Inspector. J. T. COLEMAN, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. GLEASON, Manager. WALTER GERNER, Chief Inspector.
CLEVELAND, Ohio, Century Bldg.	H. A. BAUMHART, Manager and Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg. Cor. 15th & Champa Sts.	THOS. E. SHEARS, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. WILLIAMS, JR., General Agent. F. S. ALLEN, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	PETER F. PESCUD, General Agent. R. T. BURWELL, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. GARDINER, Manager. JOSEPH H. MCNIEL, Chief Inspector. A. E. BONNET, Assistant Chief Inspector.
PHILADELPHIA, Pa., Cor. Fourth & Walnut Sts.	GOODRICH & WICKHAM, General Agents. WM. J. FARRAN, Consulting Engineer. S. B. ADAMS, Chief Inspector.
PITTSBURG, Pa., 1801-1802 Arrott Bldg.	J. J. GRAHAM, Manager. BENJAMIN FORD, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	MCCARGAR, BATES & LIVELY, General Agents. C. B. PADDOCK, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. MANN & CO., General Agents. J. B. WARNER, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. ASHCROFT, Manager. J. P. MORRISON, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. ROBERTS, General Agent.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

Vol. XXX. HARTFORD, CONN., OCTOBER, 1915. No. 8.

Boiler Explosion at Pleasant Valley, Ct.

Fig. 2. Demolished Boiler House, Pleasant Valley.

Explosion of a Two Sheet Boiler From Grooving.

A boiler exploded June 10, 1915, at the plant operated by the Rogers Rake Co., Pleasant Valley, near New Hartford, Ct. The boiler as is indicated by the photographs was constructed of two sheets, and was 44 inches in diameter, with tubes 12 feet long. The longitudinal seams were of lap riveted construction and were located approximately opposite the ends of a horizontal diameter of the heads, coming below the level of the tubes. The top sheet was the inner sheet in that it was lapped under the bottom sheet at the joints. This as will be seen, taken in conjunction with the small size of the boiler and the location of the seam made the portion of the bottom sheet directly beneath the joint practically inaccessible for purposes of inspection. Examination of the exploded boiler disclosed the fact that grooving had been in progress, parallel to the edge of the underlap, in the bottom plate and on both sides of the boiler. This was probably brought about by the breathing of the shell along this line. Contrary to many cases of a similar nature the effect of the breathing appears to have localized at the edge of the lap instead of beneath it, resulting in grooving instead of the familiar lap crack, since the strained portion of the plate was exposed to the action of the water. This is an interesting case and merits attention as a further demonstration if one were needed of the unreliable performance of two sheet boilers. Breathing is inevitable with this type of construction. The lap crack is the common result but if the bending becomes localized at a point not covered by the lap, then grooving and not cracking is to be expected. Corrosion attacks regions of local strain more rapidly than other parts of a boiler. A coating of rust once formed is disturbed at the next succeeding motion of the plate. Fresh metal is exposed, deeper corrosion results only to be again disturbed and so the endless chain is repeated until either the groove is discovered at an inspection or as in the present instance it proceeds until the boiler is no longer

FIG. 3. THE EXPLODED BOILER, SHOWING RUPTURE.

able to sustain its working pressure and an accident results. As we have intimated, the grooving in the boiler we are describing was so inaccessible as to escape detection by inspection. A striking feature of the appearance of the boiler after the explosion is exhibited by the photograph on our front cover. It will be noticed that the boiler plate is marked by a distinct streak. This discoloration was confined to the line directly over the groove which did not fail. It consisted of a definite stripe which was no doubt produced by a minute network of fine surface cracks set up by the repeated bending at the groove, and was probably similar in its origin to the discoloration which is seen in the surface of a wire bent back and forth at one point until it is about to break. We were very fortunate in being able to secure a photograph of this marking, distinct enough for reproduction.

The boiler was operated at a pressure of 80 lbs, or less in connection with a small locomotive type boiler. High pressure (80 lbs.) steam was only required when power in excess of that developed by a water wheel was needed. At other times the pressure was allowed to fall to a point sufficient for steaming and to supply the dry kiln. The completeness of the demolition of the boiler house is indicated by Fig. 2, while Fig. 3 shows the opposite side of the boiler from our cover, giving an excellent idea of the manner in which the plate was torn through the groove parallel to the joint.

The accident took place at about 8.30 a. m., just after steam had been raised. Two men were painfully but not dangerously injured by falling debris. The boiler itself was thrown some 350 feet horizontally and appears to have surmounted a tree in its flight, which indicates plenty of water and at least the full working pressure at the time of the explosion.

The Prevention of Flywheel Explosions.

2D PAPER: ENGINES WITH RELEASING VALVE GEAR.

Engines with releasing valve gear represent a class of machines in which the details of the mechanical design vary within wide limits. They have one feature in common, however, which is of sufficient importance to set them off from other engines as a type or class by themselves. This feature is the fact that whereas the opening of the valves is determined by some sort of mechanism driven from an eccentric (or in some cases a cam), the closing of those valves which control the admission of steam is an entirely separate function, and is performed by a special closing device at a point in the engine's stroke which proportions the work done by the steam to the demands of the driven load. The timing of the release of the steam valves from the eccentric mechanism, so that the closing arrangement may act, is in all engines of this class performed by the governor. It will be seen that this classification is broad enough to include not only the familiar corliss valve gear, but also those other forms in which various sorts of rocking, sliding or even lifting (poppet) valves are driven positively up to the point of cut off, to be released by the governor and closed by some special closing mechanism.

All engines of this type represent attempts by engine designers to produce a steam distribution freed from the defects of the simple slide valve, improving the economy by eliminating such of these defects as were inherently wasteful. The first step came through attempts to secure the sharpest closure of the valve at cut off which could be obtained. This evolved the releasing gear itself and immediately made necessary the separation of the exhaust functions of release and compression from the steam events, admission and cut-off, resulting in two valves or sets of valves, one controlling live steam only, and the other confined to the control of exhaust steam. While but two valves are required to bring about this condition, four were used almost exclusively, since by so doing, a large amount of surface exposed to the steam in passages and clearance spaces could be eliminated, which improved the economy by lessening cylinder condensation.

The exhaust valves may be driven by some form of non-releasing gear, and as we are concerned with the safety rather than the economical working of the engine we need not refer to the exhaust mechanism further than to note that these valves may either be operated by the same eccentric used to drive the admission valves, or they may be operated from an entirely separate eccentric of their own.

In the corliss type use has been made of oscillating plug or rocking valves by all designers, though the details may be very different in different makes. In nearly every case, the valve is driven by a crank arm attached to an extension of the valve, and operated by a short connecting rod from an oscillating wrist plate, which in turn receives its motion from the eccentric. The exhaust valves are driven positively back and forth by their connecting rods and wrist plate, and hence it follows, that once adjusted, the timing of the exhaust events does not vary with changes either in speed or load. The connection between the connecting rods and crank arms of the steam valves however is of a quite different sort. The connecting rod is usually attached to a bell crank, free to rotate about the same axis as the valve, indeed it frequently rotates upon an extension of the valve itself. This bell crank, through the agency of a catch and latch block, picks up and rotates the crank on the valve until a cam intervenes to release the latch or trip, when as the valve has been opened against a spring or a weight (the spring may take the form of a vacuum dash pot), or the unbalanced pressure of steam, the valve freed from its connection with the wrist plate is quickly closed. The setting of the cam to release the latch is performed by the governor.

This general description can also be adapted with little difficulty to the gears other than corliss which operate on the releasing principle. A positive opening motion is given the steam valve through a latch connection, by an eccentric, tappet or cam. The opening valve which has moved against the resistance of a spring, dash pot or perhaps an unbalanced steam pressure is quickly closed when the latch is tripped by some form of cam set by the governor.

Several general peculiarities applicable to all forms of releasing valve engines are worth considering before attempting to pick out any of the individual differences of particular designs. In the first place it is clear that the governor does not need to be designed for great power. It has no heavy parts to move, and takes no part in the driving of the valve gear. No matter how large the engine or how heavy the service for which it is designed, the setting of the trip cams is a very light task, and so the designer may attack the problem of making a safe, reliable and sensitive governor for almost any conceivable releasing gear engine unhampered by the necessity of transmitting motion to heavy parts, or driving the valves themselves through any part of the governor or its attachments.

In the second place, since the eccentrics or cams if used are not rotated or shifted about the shaft when once the valve adjustment has been made, there is no call to employ a governor of the shaft type. Nearly all engines of this class are governed by belt or gear driven fly-ball governors, and even those special designs in which an inertia governor has been employed secure the governor's rotation by a belt or gearing.

A third characteristic is that all engines of this type are limited to a moderate rotative speed. It is necessary to permit the released valve to close before it is again picked up by the driving gear, a fact which has set an upper limit of speed at about 150 R. P. M. This of course should not be taken as an absolute limit, for it has been exceeded in several instances. However since the advantages of the complicated releasing gear are in large part due to the promptness of closure at cut-off, there ceases to be any great reason for releasing operation when the speed exceeds that at which the closure is prompt in the sense that it is quicker than could be obtained with a non-releasing mechanism, so that for speeds above about 150 R. P. M. other types of engines have proved rather more satisfactory.

A further point common to most releasing gears is that when the governor is in its extreme upper position (or outer position) the trip cam is advanced so far that the gear is prevented from hooking on at all and hence no steam can enter the cylinders. Likewise in the starting position of the governor, the trip cam will be retarded so far that cut off is at its latest point, so that the maximum available power may be developed to bring the engine up to speed or to carry heavy overloads. The exact point of latest cut off may vary with different designs, from not much over half stroke to nearly full stroke, depending on the particular mechanism. This difference is immaterial at this time but will be referred to later in another paragraph.

It is clear that if there could be a position of the governor even lower than the ordinary starting position, and if a second set of cams were formed on the same members as the trip cams, it would be possible to arrange matters so that in the lowest possible position the secondary or safety cams would occupy the same position with regard to the latch trips as the ordinary trip cams occupy at the highest governor position. This merely requires two projections on the cam sleeve, separated by a depression. If the governor is at the top, the working projection prevents the valves hooking on. At any governor position between the top and the bottom, either the trip cam will cause the valve to be released at some point in the stroke between the earliest and latest possible cut-offs, or else the gear will remain "hooked on" throughout the stroke, and will be both opened and closed by the eccentric mechanism. If, however, the governor should fall to the extreme bottom of its travel, then the second or safety cam will operate as we have suggested above. This construction, although absent in a few of the earlier corliss engines some of which may still be found in service, is to be found in some form or other, on practically all modern examples of the type of engine we are considering. This refinement has been developed as a safety device, to bring the engine to rest in the event of a failure in any part of the governor drive, whether it be the breaking or running off of a belt, or the failure of a gear train, as it will act whenever the governor ceases to revolve. It is however necessary to permit the governor to come to rest when the engine is stopped in the normal course of daily operation, at a point high enough above this lower safety position so that the valves may open and the engine obtain a supply of steam for starting. This has led to a number of devices, the simplest of which consist of a pin which may be inserted in the governor column so as to limit the fall when the engine is stopped, or a collar which is thicker on one side than the other, and which may be rotated so that either the thick or thin side will come under a projection of the governor spindle, either preventing or permitting the governor's fall to its safety position. Either of these devices have a common fault, that they must be set in the starting position by the engineer just before shutting down at night, and removed again to the safe position when the engine attains a sufficient speed to raise the governor from its support. To meet this hazard, several ingenious devices have appeared, which are either automatic or semi-automatic in their operation, and these will be treated later.

Not only are there characteristics of design common to all engines of this class, but there are also many operating hazards which are common in the same sense. All that has been said in the previous paper concerning the hazards of the governor drive, friction and lack of care are applicable with equal force to the governors of releasing gear engines. It is necessary to maintain the governor mechanism and drive in the very best possible state of repair and efficiency, and to make sure of proper lubrication. Particular attention should be given the pins used for bearings and in connection with the gear drive, as many of these are under a steady one way thrust and tend to wear flat. We have seen examples of pins which had been allowed to remain in service until they were worn more than half way through, and as they were a vital part of the governor, it will be seen that a considerable hazard was introduced in this way, which was entirely unknown to the engineer until the mechanism was overhauled.

Valve setting, and the adjustment of the reach rods by which the governor controls the position of the trip cams are important matters from the safety standpoint, as well as from that of economy. With practically all engines of this class it is possible to disengage the wrist plate or its equivalent from the eccentric so that the valves may be worked by hand for starting, and also for warming and draining the cylinders. From time to time the engineer will do well to disengage the wrist plate, block up the governor to the top of its travel and work the valves by hand from one extreme of their motion to the other. If the valves pick up or hook on at either or both ends, then the governor reach rods are not correctly adjusted, and should be changed until the admission of steam will be impossible in this position of the governor. After this test, and adjustment if required, the governor should be dropped to the lowest or safety position, and the same test applied. If the valves hook on in this position, the safety cams are incorrectly placed, and should be readjusted.

The correctness of the setting of eccentric and valve driving rods may be tested by placing the engine on centers, checking the valve position (lead) by means of the marks placed for the purpose by the builders, or more accurately and often quicker by the use of the indicator.

The latch gear should receive attention at frequent intervals. Latch blocks and grab blocks should be maintained in good order. If the working edges are rounded and battered, the blocks should be turned to present a new working edge, or removed and ground. Any lost motion in the valve gear may be detected in most cases by the ear, but whether noisy or not all connections should be keyed up to take out any excessive slackness, though of course sufficient freedom is necessary to prevent any chance of binding or gripping. Dash pots in particular need attention. They should operate freely without sticking, and yet must not leak enough to permit any uncertainty in the closure of the valves when released by the trip cams. Dash pots when they do fail are apt to be particularly troublesome, because it is not always easy to detect just where the trouble lies. Fortunately they are not very prone to disorder. Perhaps dirt is the worst enemy of a dash pot, for it contributes both to the gumming of the oil and to the scoring and wear of plunger, barrel and packing. An extra effort to keep them clean is well repaid. If means are provided for regulating the amount of vacuum produced at each stroke of the dash pots by an adjustable air leak device, it is important to maintain this leakage at just the right amount, for if the dash pot should lose its vacuum, by a too wide opening of the regulating by-pass, the engine would be apt to speed up, as the effect would be to give a later cut off than that corresponding to the position of the governor, though not so well defined. On the other hand there is no call to make the engine develop any unnecessary friction load by forcing the dash pot to pull a vacuum all out of proportion to that needed for prompt and certain value closure. Indeed, this procedure not only adds to the friction load, but greatly increases the wear on the valve gear as a whole, causing needless shock.

Releasing valve engines, when called upon to develop a heavy load will slow down enough to let the governor come to a position of late cut off. If the load increases further, the governor may be forced down to the low safety point, when the safety cams will operate to prevent the entrance of steam and the engine will stop. Engineers confronted with peaks of this sort which threaten to shut down the engine at the time when it is most needed, often leave the stop pin or collar in the starting position which will prevent a shut down by any load short of that which will actually stall the engine. If the governor belt should break under these circumstances since the governor would be resting on the stop, no immediate change in the working of the engine would be detected unless the fact that the governor had ceased to revolve attracted the engineer's attention. The duties of an engineer are, however, of so varied a character in many plants, and he is so often called to parts of the power plant more or less remote from the engines to attend to other pieces of apparatus, that this fact might well escape the notice of a careful man for some little time. In the mean time should the load become much lighter, a run away would be inevitable, as the engine would be entirely out of control, and working with the maximum possible power, at latest cut-off. This hazard is the more serious because the starting pin or collar has been deliberately put in an unsafe position to meet a very urgent condition. It is far from sufficient to say that it is a dangerous practice, for it is necessary to devise a substitute practice which will meet the emergency safely. One solution is to attach to the starting pin or collar a link mechanism, attached to a bell crank, one arm of which carries an idler working on the governor belt. Such a device will permit the pin or collar to remain permanently in the starting position so long as the governor belt remains in place. Should it break or run off however, the idler would fall, pulling out the pin or rotating the collar to the safety position, and the governor could fall clear, operating the safety cams.

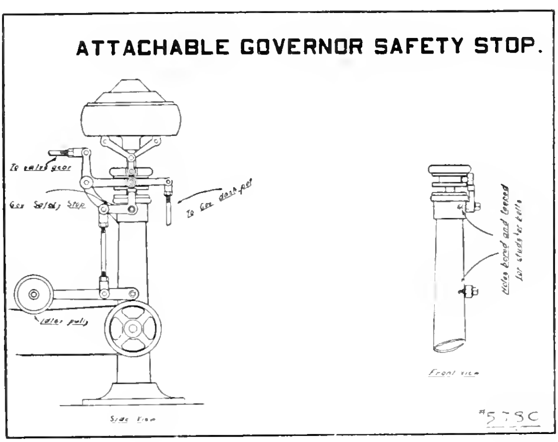


Fig. 1.

When it is known that no normal condition can load the engine above the point which can be provided for at normal speed with the latest cut-off, such precautions are unnecessary, and automatic governor stops may be applied, arranged so that the pin, collar or equivalent member will fall or be moved by some mechanism to the safety position as soon as the weight of the governor is lifted by its rotation on starting. The engineer will then have to rest and *hold in* the device when the engine is about to stop.

Figs. 1, 2, and 3 show suggestions for making devices both of the idler operated and automatic sorts, which may be easily adapted or modified to meet most conditions. Many other devices equally suitable can be arranged by the exercise of a little ingenuity on the part of the engineer. In considering any arrangement of this sort however, it should be kept in mind that the prime requisite is simplicity and reliability under all possible conditions.

In some of the older corliss engines there were no safety cams and hence

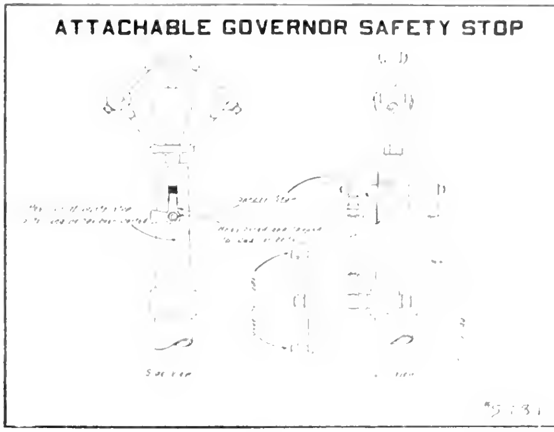


FIG. 2.

no safe position of the governor. Some of these engines were provided with a lever pivoted to the governor column, carrying at its upper end a roll, and at its lower end a finger latch and sector. By means of the latch the lever could be set at will at several different points, and in each position the roll would act as a governor stop, limiting the downward governor motion, but permitting the governor to continue revolving at that low position. By this means, it was possible to carry an overload at any desired cut-off, and at any reduced speed, as the governor could be held up as much as desired. Moreover, it was of no consequence whether the governor revolved or not, as the cut-off would remain at the point to which it had been set. The failure of the governor drive, followed by a decrease in load, has the same effect with this arrangement as we have indicated for the case where the stop pin is left in the starting position by the engineer. Although this mechanism may still be found in operation, it should be recognized as particularly hazardous, and no engine having it ought to be run without the protection of some independent over speed stop. In many cases these old gears have been rebuilt, introducing safety cams and remodeling the governor, which is of course the better method. One device which came to the attention of the writer has always appealed to him as a most excellent one. It was attached to a large corliss engine driven, direct connected refrigerating unit, and consisted of a worm on the spindle of the throttle valve with which meshed a worm wheel. The motion of the worm wheel was transmitted by a rod and universal joints to a small pinion meshing with a circular rack on the periphery of the stop collar. The whole arrangement was so adjusted that the worm came into mesh with the worm wheel during the last half of the travel of the throttle valve stem in opening, which would be the first

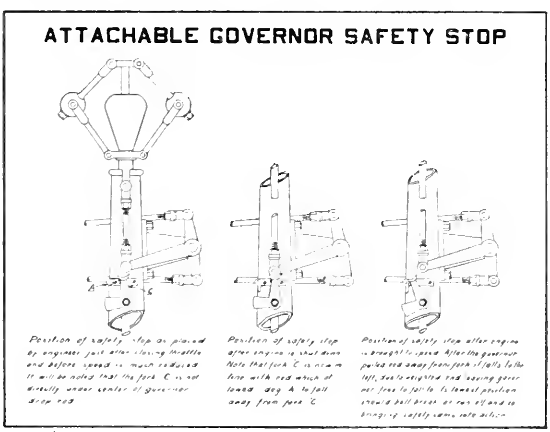


FIG. 3.

half of its travel in closing. Therefore, on starting the engine the throttle would be opened far enough for the engine to warm up and come up to speed, at light load, before the gears began the rotation of the collar. Then as steam was admitted to carry the load the collar would be set to the safety position, to be positively reset by the first movement of the throttle in closing, and it would be completely rotated to the starting position before the speed of the unit had become reduced sufficiently to bring the governor down to it.

Mention has been made above of the fact that the latest possible cut-off varies with different engines. Early corliss engines worked both the steam and exhaust valves from a single wrist plate, oscillated by one eccentric. With this arrangement cut off cannot be much later than half stroke without distorting the exhaust events. For loads greater than that which the engine may carry with the half-stroke cut-off, the valves will not unhook, but will be both opened and closed by the eccentric. Obviously greater overload capacity can be developed by a given cylinder if it can have a long range cut-off than if it is limited to half stroke as a maximum, for any cylinder develops its maximum power, pressure and speed remaining constant, when the steam follows the piston full stroke, or expressing it differently, when it works non-expansively. To provide for this desirable feature, two eccentrics with two wrist plates are attached, one set for the exhaust and one for the steam valves. This makes it possible to set the exhaust eccentric for the best working of the exhaust valves while still permitting enough angular advance to the steam eccentric so that a late cut off may be attained. Following out the same idea engines have been designed with some innovations in the details of the valve motion in which the range of cut off is practically the entire stroke and exceeds that ordinarily provided by the usual two eccentric arrangement, making an engine particularly applicable to service with severe peak loads, as for instance the turning of rolling mill stands. The question of range of cut-off is for the most part more one of adaptability than of safety, but one feature stands out as important. If a long range cut-off engine is operated with the stop pin or collar in the starting position, it will be more dangerous than a short range cut-off engine of the same size, under like conditions, because as it has more power capacity per stroke at its longest cut-off, it is able accelerate faster in the event of a mishap. This point should be considered when attaching any of the various independent over speed stops, as there is a vast difference in the time required to stop the engine by the different types.

Releasing gear engines permit of speed alterations in the same way as has already been described for throttle governed engines, by changing the ratio of the pulley diameters.

The precautions mentioned before, as to the necessity of careful consideration of the strength of the fly-wheel, apply here with equal force. In addition it is necessary to make sure that at the desired increased speed, the dash pots, or whatever form of valve closing device is used, can seat the valve and allow for a slight pause between the time of release by the trip cams and the picking up or hooking on at the beginning of the next stroke. If this speed is exceeded the engine will not govern satisfactorily, and beside will be found to have lost in economy.

Most engines of this class have dash pots of some sort fitted to their governors to prevent too rapid oscillation on sudden changes in load, while offering practically no restriction to the action of the governor in seeking a new level for a steady load change. These dash pots consist of a cylinder with a loosely fitted piston, filled with oil or some viscous fluid such as glycerine and water. It will be sometimes found that in extremely cold weather particularly if the engine is in an exposed location, the fluid will become so thick that the governor will behave as if it had suddenly developed considerable friction. This is dangerous, if the effect is marked, as we mentioned in the previous paper when discussing the friction of throttle governors, and should be remedied at once, either by supplying local heat or perhaps more easily by using in cold weather a lighter oil, or a more dilute solution of the glycerine. If on the return of milder weather the governor shows signs of being too sensitive to sudden changes, the heavier fluid may be introduced again. It is also desirable to ascertain from time to time that the supply of oil in the dash pot is clean and free from gummy deposits, for if it becomes gummy it will introduce a real friction, different from the apparent friction of the too viscous fluid, and more apt to be disastrous in its effect.

The Hartford Flywheel Calculator.

Below is shown a photograph of a little flywheel calculator which has just been published by The Hartford Steam Boiler Inspection and Insurance Company, from a design by Mr. J. P. Morrison, Chief Inspector in the St. Louis office of the Company. While the calculator was prepared primarily for the benefit of the Company's own inspection force, it will appeal to many persons as a desirable time saver, and for this reason, we are describing the calculator and its use at some length. Copies of it may be had by addressing the home office of the Company, enclosing thirty-five cents.

As will be seen, the device is a special slide rule, composed of a bristol board runner in a celluloid case having windows through which the scales on the runner may be read. To operate the calculator it is only necessary to find the point on the "D" scale representing the diameter of the wheel in feet, push the slider along until this point on the "D" scale comes opposite the number of revolutions per minute on the "R" scale, when the rim speed in feet per minute will appear against the arrow at the lower window, and the "rim stress" may be read on the "S" scale opposite that particular arrow attached to the little sketch which represents the sort of wheel construction under consideration. In the cut it will be seen that 16 on the "D" scale is opposite 110 on the "R" scale, indicating a setting of the calculator for a 16-foot wheel at 110 R. P. M. The arrow at the lower window points about .6 of the way from the 5500 ft./min. line to the 5600 ft./min. line, so we conclude that the rim speed is 5560 ft per min., quite close enough for most purposes. A study of the arrows attached to the four type sketches, lettered A, B, C, and D will show that if the wheel is cast solid, the rim stress is 812 lbs. per sq. in., or if it is cast in halves with a link joint, the stress may be assumed at 1375 lbs./sq. in. A sectional wheel with flange joints at the arms would be considered as if stressed to 1650 lbs./sq. in., while an ordinary split pulley with flange joints in the rim midway between the arms would be rated as carrying a rim stress of 3300 lbs./sq. in.

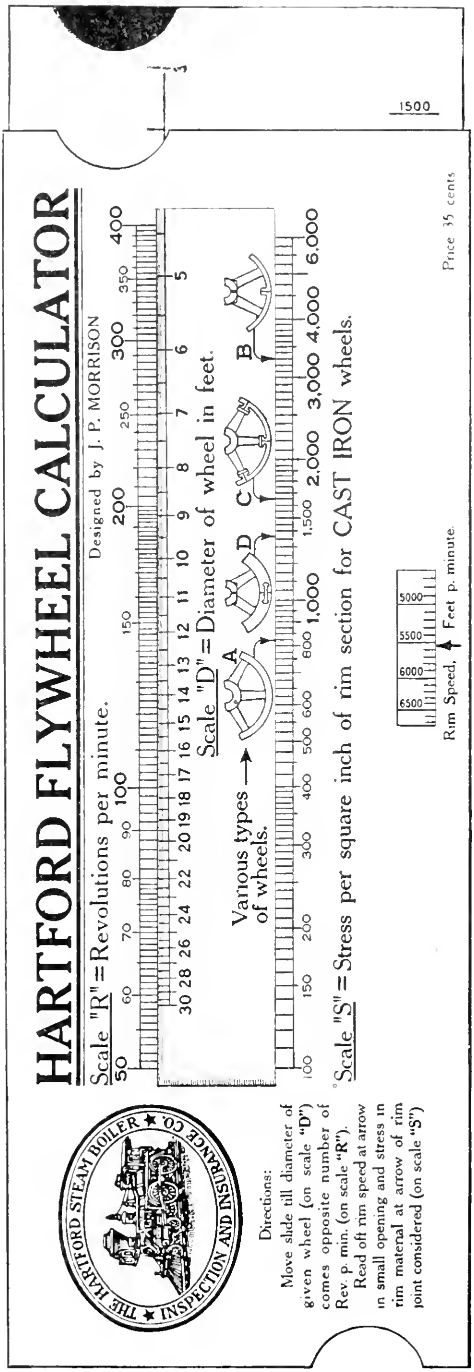


Fig. 1.

A word of explanation is necessary in this connection as we must not be misled by stress calculations of this sort. When a wheel is cast in one piece with solid rim, type A, the effect of centrifugal force upon the particles of rim material is equivalent to an outwardly directed radial pressure, evenly distributed upon the whole inner surface of the wheel rim. (This statement is to be taken as applying to wheels having only moderately thick rims, in thick rimmed or solid wheels, we strike quite a different stress distribution, just as we find the pressure stresses set up in very thick cylinders different to those found in cylinders or tubes of moderate thickness. No undue error will be had in treating the figures indicated by the calculator as applicable to ordinary armed wheels, even when the rims are of the deep type as opposed to the type usually provided for belt drive, but the thick rim condition must be assumed if calculations are required for steam turbine runners or solid disk wheels, such as have been provided on some electric rolling mill drives. — Editor.) This outward centrifugal force results in a tension in the wheel rim, in exactly the same way that the outward pressure in a cylindrical boiler shell results in a tension in the boiler plate, and is calculated in much the same way, so long as we can assume that the stress is a simple tension, not complicated by bending. We are justified in making this assumption for A wheels, in as much as experiments carried out with great care in which models (up to four feet diameter) of flywheels were actually broken by raising the speed and recording the bursting speed, check up with the calculation. That is, a wheel of the A type, made of iron of known strength will break at about the speed indicated by a calculation which takes account only of this tension stress. On the other hand, with the other types of wheels, indicated by the sketches B, C, and D, it was found that the breaking speed was always less than that calculated on the simple tension theory, and that for a given type, the breaking speeds were consistently some definite percent. of the speed so calculated. Which means that in addition to the tension, other stresses of an indeterminate distribution, are present. As one would suppose, these additional stresses are in part at least bending stresses, and the confirmation of this view is to be found in the appearance of portions of the tested wheels after rupture. Unfortunately, as the exact stress cannot be calculated, we are obliged to fall back on the experimentally demonstrated fact that wheels of the types indicated may be expected to fail at a speed less than a corresponding A type wheel, by an amount which will be different for each type in question, but we may come at the same result if we assume that in place of the actual complex mixture of bending and tension stress in any of these wheels, there is an equivalent simple tension, great enough to cause rupture at the experimentally determined bursting speed. That is, a B wheel for example is known to be less strong than an A wheel, and it will burst at a lower speed, we cannot tell exactly how the B rim is stresses, but we do know that it will burst at a speed which will be the same as would obtain if the B rim had a simple tension of a certain amount in excess of that calculated for the A rim, or if our B rim, in place of the actual stresses had the equivalent tension only. It is this equivalent stress which, in all cases except the A type, is indicated under the sketches on the "S" scale. It is quite proper however to use this equivalent stress in determining the safety of a wheel, exactly as if it were an actual rim stress. To illustrate with a numerical case, if we should set the calculator so that the several arrows under the sketches should come successively to the 1500 lbs./sq. in. point on the "S" scale, and find the corresponding rim speeds for that stress (using it as a limiting stress), we would find the A wheel running at 7600 ft./min., the D wheel at 5840 ft./min., the C wheel at 5380 ft./min., and the B wheel only making 3750 ft./min., yet each would have the same equivalent rim stress, and all would at these speeds possess the same factor of safety.

Beside the direct use of the calculator in finding rim speeds and equivalent stresses, many everyday problems connected with flywheels and pulleys may be quickly solved. A few typical cases will be cited as illustrations and they will doubtless suggest others to those interested.

An engine is running at such a speed that its flywheel is considered amply safe. It is desired to substitute a larger (or smaller) wheel of the same type, and it is desired to maintain the same safety factor. To what new speed must the engine be adjusted? Set the diameter of the present wheel under the R. P. M., then the new speed may be read over the new diameter. For instance to refer to the cut, if the present wheel is 16 ft. in diameter, and runs at 110 R. P. M., then a 14 ft. wheel would require 126 R. P. M., and the rim speed, or belt speed if the wheels are for a belt drive would not be altered.

The reverse of the last problem is perhaps more common. An engine does not develop quite all the power required, but it is thought that by speeding it up a certain amount enough power may be obtained from it to enable the owner to put off the purchase of a larger one for a time. What should be the flywheel diameter to keep the belt speed the same and the factor of safety as high as in the case of the existing wheel? Suppose our 16 ft. wheel at 110 R. P. M. represents the present condition, which is to be changed by increasing the engine speed to 175 R. P. M. A glance at the cut will show that at the new speed a 10 ft. wheel will answer the purpose.

The scale of the instrument may be extended by remembering that the stresses in a given wheel at a given speed are identical with those to be expected in a wheel of half the size at double the speed, or of twice the size at half the speed. Thus if occasion called for calculations on say a 36 ft. wheel at 60 turns, the result could be obtained on the calculator by setting it for an 18 foot wheel at 120 turns, and the same process could be used in the reverse order for smaller or faster wheels than are provided for on the scales of the instrument.

One more problem is solved in part by the use of the calculator. It is sometimes required to find the stress in the links or prisoners of the D type wheel or in the flange bolts of other wheels. This may be done if the stress for an A type wheel of the given speed and diameter is multiplied by the number of square inches of cross section in the rim of the actual wheel, and this in turn divided into the number of square inches of material in the cross section of the links or bolts. The first product gives the total load on the links, and the quotient, the load per square inch of section.

Explosion of a Welded Ammonia Absorber.

In The October, 1913, Locomotive we printed with photographs, an account of the failure of a steam separator which had been assembled by the process of oxy-acetylene welding. At that time we called attention to the hazard of the process when used for parts of pressure vessels subject to tensile stress. We also criticized the design of the separator and showed that even if the welding had been sound, there would have remained a considerable hazard due to the design.

We have just received photographs showing the failure of an ammonia absorber made by the same process, having some of the same errors of design, and which failed in exactly the same manner except that in the present instance failure occurred when the apparatus was first put in service and before it had been turned over to the owners by the makers, while the separator succeeded in holding together for some considerable time. The vessel formed part of a refrigerating plant installed in a restaurant, and by its failure liberated large quantities of ammonia gas, overcoming several employees. Four men were so seriously affected that it was necessary to remove them to a hospital, and one was not expected to live. The tank, which was eight feet long, and two feet in diameter was built of half inch plate, both for the heads and shell. The heads were bumped, cut to size with an oxygen torch and joined to the shell with a welded joint which came exactly where the flange turn would be located in a riveted tank. Fig. 1 will make this clear. We are told that a pressure of 154 lbs. per sq. in. could be put on the vessel in the regular course of its operation, but that the pressure at the time of the accident was about 100 lbs. Failure occurred at the joint between the head and the shell, but a brick pier which adjourned the head and received the brunt of the explosion prevented the complete rupture of the seam, the head remaining partially attached to the shell as is shown in Figs. 3 and 4. Fig. 2 shows the edge of the head after the accident. It will be noted that the edges show two distinct characteristics, a narrow, rough and somewhat torn portion, and a wider serrated portion with grooves parallel to each other but at right angles to the surface of the plate. The narrow rougher portion represents the part of the sheet to which the metal added in the process of welding had become actually attached. The grooved portion shows the characteristic appearance of metal cut by the oxygen cutting torch, and had never been incorporated in

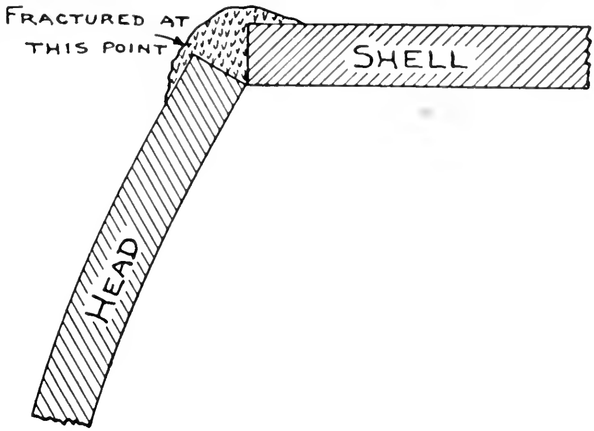


FIG. 1.

FIG. 2. EDGE VIEW OF RUPTURED HEAD.

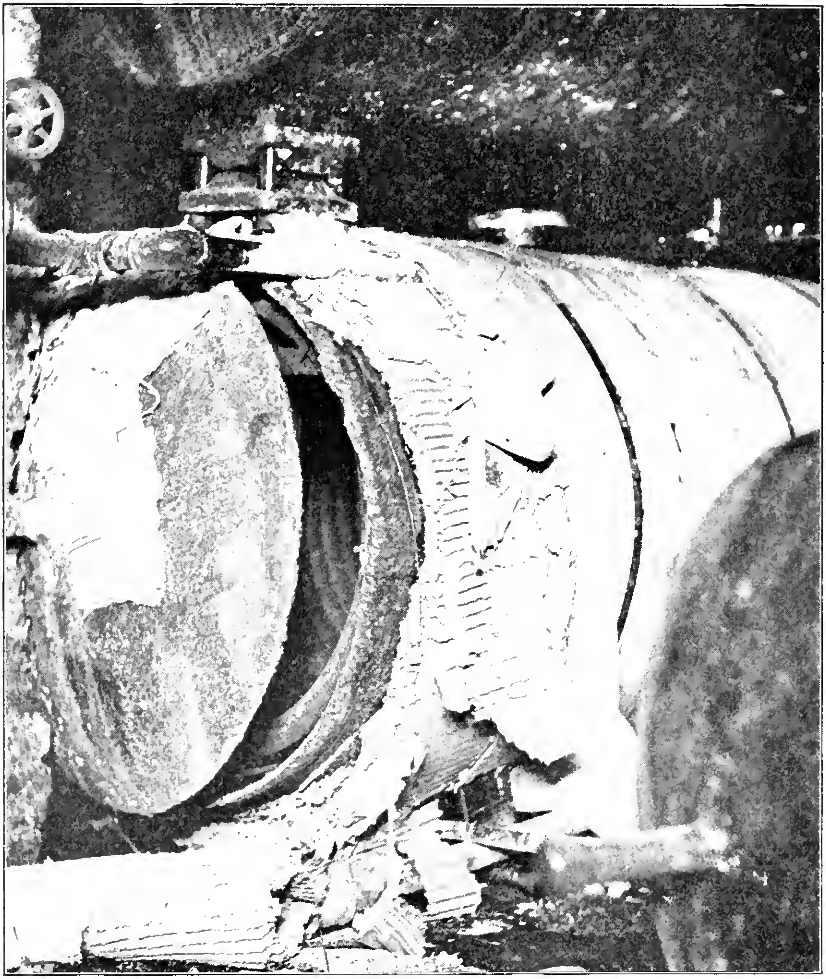


Fig. 3.

the weld at all. The incorporation along the edge of the shell plate seems to have been better, as the weld was not torn away from that plate at all. It has been suggested that failure to chip off or otherwise remove the oxidized surface left on the edge of the head after cutting with the torch is the reason for the lack of bond between the added metal and the head. It seems more likely to us that too great haste on the part of the operator, who appears not to have let his weld clear itself of impurities or to have heated the edges of the head hot enough for them to actually melt together with the added metal, is more likely to be the real cause of the trouble, though as we are not practical welders we must offer this merely as a suggestion. The points we particularly wish to emphasize are not so much the defects in the welding itself, as the errors in design, and the wisdom of employing a welded joint at all for this particular service.

It is well known that all bumped heads on vessels subjected to internal pressure breathe with changes in that presure. This is because of the presence of stresses tending to change the form of the head to a hemisphere of radius equal to that of the shell. The greatest deforming tendency, and therefore the greatest movement comes at the point where the spherical head joins the cylindrical shell, and this tendency can be shown to be a maximum where this change is abrupt, as in the tank in question. If a flange is turned on the head it eases the change in curvature, making the stress distribution more uniform in that it spreads the bending stresses over a greater portion of the material and hence reduces the stress at any particular section. This reasoning is true, regardless of the method employed to join the head to the shell, and has given rise in many instances to minimum radii being specified for the flanges used on given sizes of heads. In a welded tank there is a two-fold weakness if the construction used in the exploded vessel is followed. First the form is inherently weak as we have just pointed out, and secondly the metal which receives the maximum bending action is the added metal of the weld itself.

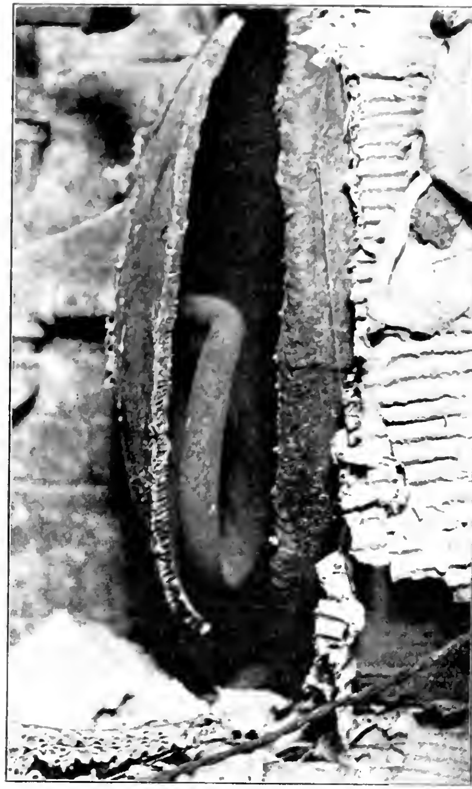


FIG. 4.

So far as we can discover, no one has yet produced autogenous welds, whether by the oxy-acetylene, oxy-gas (of any other sort) or either of the electric arc methods in which the metal of the actual joint retains any considerable part of the ductility possessed by the plates joined. Tensile strength may be pretty well maintained by a skilled operator but the ductility, as evidenced by the elongation and reduction in area of test specimens bears at best about the same relation to that of good boiler plate, as does that of steel castings. To sustain continued deformation of the sort which develops at a head flange requires an extremely soft ductile material, of a high degree of homogeneity, so that under conditions of greatest available skill on the part of the welder, a weld would be out of place at the point under consideration. It would have been far better if a welded tank was to be built, to have flanged the head, and to have welded the flange by a butt weld to the shell of the cylinder, so that the joint was entirely on the cylindrical portion of the vessel.

It is our firm opinion, however, that autogenous welding, owing to the extreme uncertainty attaching to it with regard to the soundness of any job, the lack of ductility which we have mentioned above, and the enormous, but unknown temperature stresses due to local heating, should never be employed for any joint in a boiler or pressure vessel, if the safety of the vessel depends on the integrity of that joint. This statement is far from a condemnation of the welding process, for we recognize fully its tremendous importance, even in boiler work, where if properly employed, in the right place, it may prove a most useful servant.

It is unfortunate that poor design, coupled with poorer workmanship, and what seems to us the misuse of the process should result in accidents of this sort which hinder the progress of the welding art.

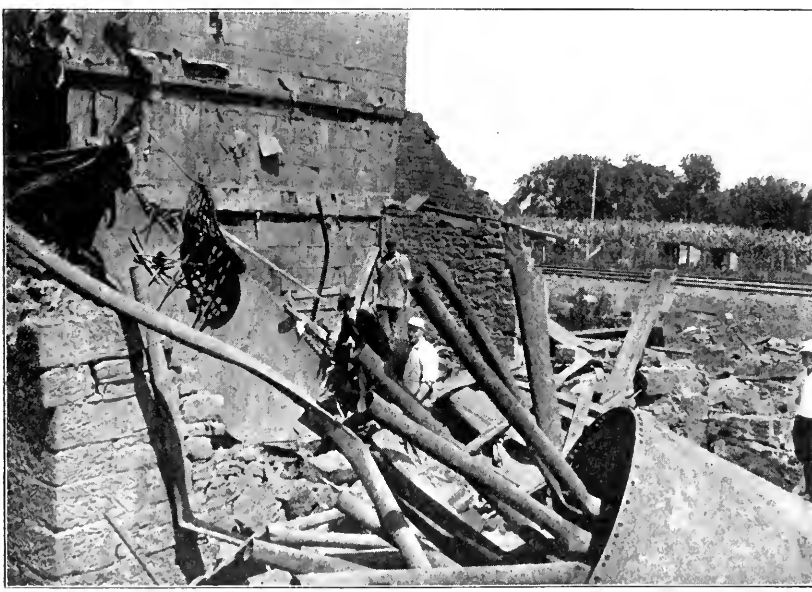


Fig. 1. Exploded Boiler.

Boiler Explosion at Columbus, Kansas.

A horizontal return tubular boiler exploded July 23, at the plant of the Columbus Milling Co., Columbus, Kansas. The boiler, which is said to have been 58 inches in diameter, by 15 feet 6 inches long, of 7-16 inch iron plate, was installed about 25 years ago.

Fig. 2. Wrecked Boiler House at Columbus.

Leakage and wasting finally made a patch necessary at the point where the feed pipe entered, (apparently, if we may judge by the photographs this was through the blow-off) and we are told that from time to time other patches replaced the first. This was not difficult to understand if our surmise is correct that the feed was introduced through the blow-off, since in this case the cause for the wasting and leakage would have continued in spite of the patching. The strains set up by blow-off feeding have been too often pointed out in these columns to require further comment here. The final rupture is said to have started at the patch, where the metal was reduced to a knife edge. The fireman reported two gages of water in the boiler just before the accident, and indeed the violence of the explosion, as shown by the photographs would indicate that this was correct.

It is reported that no insurance was carried on this boiler and that it had never been regularly inspected. Following the accident electric power was secured in place of steam.

It is pleasant to note that no one was injured, though four men were in the mill at the time. A passenger train stood for some time on a siding some 30 feet from the mill, and in line with the greatest force of the explosion. It had proceeded but 800 feet down the track at the instant of the blast, and its escape is one of the almost miraculous happenings which so often attend accidents of this sort.

The Locomotive of THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

C. C. PERRY, EDITOR.

HARTFORD, OCTOBER, 1915.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

The movement now well under way, to secure the adoption of boiler laws with uniform provisions in the several states should enlist the active support not only of boiler owners and boiler makers, but of the public at large.

The reason for desiring boiler legislation of any sort is too well known to need extended comment. Broadly, it is to secure safety to those working in and about power plants and boiler rooms, and to those whose business requires them to be in the general vicinity of steam boilers, for boilers are notorious for their failure to discriminate as to whom they will attack when they explode. In addition to the increased safety of life and limb, comes the protection of enormous property interests, both of the owners of the boilers, and their neighbors. To this end legislation which requires that boilers start right, by being built of sound material according to wise and safe designs, and that they be subsequently kept right through thorough-going inspections seems necessary. The appalling record of lives and property destroyed where no such governmental control exists furnishes a sufficient argument in support of this contention. It is not the necessity for legislation, but for uniformity in legislation which we set about discussing. Assuming that legislation is necessary, why should it be uniform? And why not settle the matter at once as in the case of steam vessels and railway locomotives by placing boiler manufacture and inspection under Federal control? The difficulty is that, aside from any question of politics, such legislation on the part of the Federal government has been held by excellent authorities to be unconstitutional, and in violation of State rights.

The great importance of uniformity in boiler laws has become apparent through the working of those now in existence which are essentially non-uniform. It is manifestly absurd to say that a given boiler is unsafe in one state but safe in another. Engineering deals with facts, and a given boiler worked under given conditions as to pressure etc., is either safe or unsafe, as measured by any accepted standard, regardless of its geographical position.

The fact remains, however, that it is possible to build good honest boilers for registry under any one of the laws now in force, which might not be permitted to operate in another state having a good but different law.

If boiler making was a strictly local industry, and if all who use boilers were strictly localized in their business operations no great hardship would arise, but with conditions as they are at present, a boiler maker cannot manufacture boilers of stock material and to standard designs for his general trade but must build one sort of boiler for Ohio, another for Massachusetts, perhaps a third for Indiana, and any of these or any other kind which the purchaser is willing to buy for most of the other parts of the country. Likewise if a purchaser is to use his boiler at different localities, say in connection with a general contracting business, imagine the difficulty which both he and the boiler maker face in their efforts to produce a single boiler acceptable under all the varying local requirements. It must be understood in this connection that the boiler legislation at present in force is really in force, and that even minute technical departures from the exact letter of the law are not tolerated. Obviously such conditions add to the cost of boilers, and if boilers cost more, manufactured products in whose cost is included the cost of the power used in their production must cost more. So also do electric light and power, and indeed all commodities and utilities which require steam power for their production or operation cost more. And of course it is evident that in the ultimate outcome, this increase in expense is borne by the consuming public. To be sure the whole reason for boiler laws is the public welfare, but we are entitled to obtain our safety provisions as economically as possible, and we have tried to show that diversity in boiler legislation is inherently uneconomical. Moreover, existing boiler laws are at variance in their provisions for the inspection of and reporting upon boilers, and of recording and certifying to boiler data, and in fact the whole method of procedure of those who, like a boiler insurance company, may be engaged in a general boiler inspection business, must vary with the boundaries of each territory having an individual law. This means, in practice, an amount of detailed difference in forms, and methods, as well as a mass of correspondence which would scarcely be credited by most of our readers. All this adds to the cost of boiler insurance, which unlike the increase in the first cost of the boiler, goes on through its life, and is an additional burden to the consuming public.

Therefore as a matter of economics, a real factor in the cost of safe living, all are interested (except perhaps a few of the less desirable sort of politicians), in securing uniform safe boiler laws, with uniform codes of boiler design and as nearly uniform methods of inspecting and reporting upon boilers, and enforcing the legislation as the several State Constitutions will admit. We have tried to show that it is not true that the boiler makers and Insurance Companies are alone affected, though perhaps they feel the effect sooner and more forcibly than others, but it is a live question of economics, general in its effect, and pertinent to all our readers, who can well afford to lend the movement their active support.

The American Uniform Boiler Law Society.

At a meeting held in New York City on July 28, 1915, an organization to be known as the American Uniform Boiler Law Society was formed. The organization includes representatives of practically all the interests which could be affected directly by the enactment of such legislation, such as manufacturers of water tube, fire tube, low pressure heating, cast iron heating, traction engine, hoisting engine, crane and locomotive boilers, the material and supply interests, the radiator and heating apparatus interests, boiler insurance companies and steam users.

The object of the organization is to secure uniform boiler legislation in the several states, and particularly to push the acceptance of the A. S. M. E. Code as the standard for boiler construction to be incorporated in this legislation.

The representative character which the society assumes from the number of interests involved, should give much weight to the movement, and would seem to assure the best possible effort to secure the adoption of the Code as the universal standard for good boiler construction in the United States.

Mr. Thomas E. Durban, General Manager of the Erie City Iron Works, Erie City, Pa., is the president of the new organization, and Mr. Charles S. Blake, Secretary of The Hartford Steam Boiler Inspection and Insurance Company is its secretary.

Convention of Casualty and Surety Underwriters and Agents

The International Association of Casualty and Surety Underwriters, and the National Association of Casualty and Surety Agents held conventions at the Hotel Stattler, Detroit, Mich., from August 24 to 27, 1915.

The meetings of the two bodies were timed to occur simultaneously so that they might enjoy the advantage of holding some of their sessions jointly, and a most successful gathering is reported.

An important event was the award of the George E. McNeil medals to Mrs. Lillian M. Coburn, Susanville, Cal., George C. Poe, Scottsville, Ark., and Dr. James A. Hamma, M.D., Carnegie, Pa. This medal is awarded annually by a committee of the International Association, to persons who have displayed marked heroism in the saving of life, as a memorial to the late George E. McNeil, one of the founders and a past President of the Association.

Mr. H. G. B. Alexander was re-elected to the presidency of the International Association, while Mr. George D. Webb of Chicago was chosen to preside over the Agents' organization for the coming year.

Personal.

We beg to announce the appointment of Mr. A. S. Wickham as Manager of the Philadelphia department of this Company, succeeding the firm of Goodrich & Wickham, General Agents of the Company in that city.

Mr. Wickham will require no extended introduction to our friends in the Philadelphia department, or to the insurance fraternity generally. He first became identified with the Company in September, 1899, as senior special agent in the New York department, which position he held until March, 1908, when he was called to the Home Office to assume the responsibilities of Superintendent of Agencies. On October 1st, 1910, he was transferred to the Philadelphia department and became a member of the firm of Corbin, Goodrich & Wickham, General Agents, and upon the retirement of Mr. E. A. Corbin in August, 1914, the business of the department was continued in the name of Messrs. Goodrich & Wickham, as General Agents. The death of Mr. Goodrich in April last, as previously announced, has brought the full management of the department to Mr. Wickham.

The department was established early in 1867, since which time it has been continuously under the same management, subject only to the changes above noted.

With expressions of appreciation for past favors, we bespeak for Mr. Wickham the continued patronage of our assured and loyal support of our agents.

Safety Valve Piping.

Vol. 1, No. 1 of The Locomotive (Jan. 1867), contained warnings as to the necessity for constant vigilance regarding the size, condition and mode of connection of safety valves. Notwithstanding the wonderful progress of engineering and the widespread dissemination of knowledge concerning mechanical apparatus in the 48 years which have elapsed since then, the necessity for discussing unsafe safety valve connections still exists, as is proved by conditions actually encountered in present day plants. We can scarcely say anything new in this connection. The proper way to attach a safety valve is not difficult either to execute or understand. It may be summed up in the statement that every safety valve should be attached to the steam space of the boiler it protects, at as high a point as possible, by a short, direct, unobstructed passage of area at least equal to that of the valve. The connection should be so located as to permit any water condensed in it to drain back to the boiler, and no valve of any sort whatever should be interposed between the safety valve and the boiler. Wherever it is possible to avoid using a nozzle from which other connections are led, this should be done. If a safety valve is attached to a pipe through which steam is flowing, then there will be a reduction of pressure in the safety valve branch which will be proportional to the rate of steam flow, a fact which is made use of for the measurement of flow in several types of flow meters. This means that at times of maximum steam flow, which are as a rule times of maximum brightness of fires or steam production, the safety valve will not open until the pressure in the boiler is equal to the load on the valve plus the drop in pressure at the point of safety valve connection due to the velocity of the steam flow, or in other words, when the steam consumption is a maximum, the safety valve would require an excess pressure to open it unless the steam flow were suddenly interrupted. This may of course be avoided by utilizing a separate nozzle.

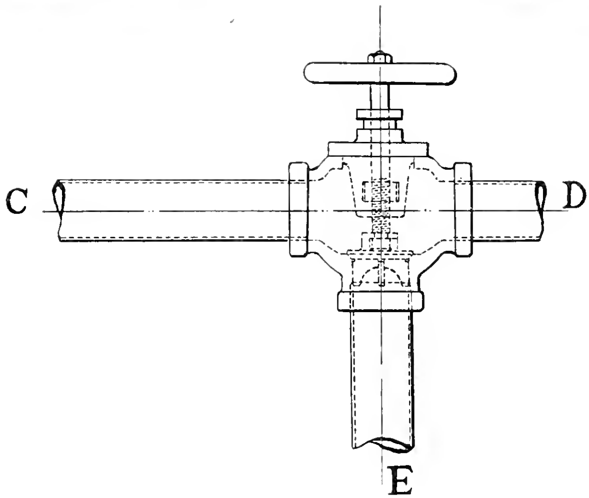


Fig. 1.

Every once in a while an inspector finds a stop valve between a safety valve and the boiler it is installed to protect. These valves are usually installed "to save water and steam" (safety valve leaks), or "to make it possible to overhaul the safety valve without shutting down." Of course the instant recommendation is that the valves be removed. If a safety valve leaks it is easier and cheaper to grind it in or renew injured parts than to gag it with a stop valve, and if a safety valve needs repairs or adjustment, the boiler should certainly be shut down at once until the valve is again a "safety valve." It is sometimes urged, and with some reason by the boiler owners that owing to lack of extra boilers or a rush of particularly important and profitable business, or to the fact that a change in the steam piping may require special fittings or entail a long delay, the ends desired by the inspector may be attained if the spindle and disc of the valve are removed, leaving the body to serve as a filling piece. While urgent conditions may make such a course permissible as a temporary expedient, it must be obvious that so long as a disc may be put back in a valve body the hazard has not been eliminated, and may reappear at any time, perhaps unknown to those in responsible control of the plant if a careless or ignorant operator finds it convenient. This has so impressed our engineering force as to make it a matter of principle to secure the removal of valve bodies, even if the disc is absent, from the connection between the safety valve and boiler.

A curious possibility of this sort was presented by a case recently observed. Here a cross valve (Fig. 1,) was installed on the connection from a boiler to the safety valve and steam header. Originally C was connected to the boiler, D to the safety valve and E to the header. While this connection was far from ideal it did not seem startlingly unsafe. However it was later discovered that in the course of alterations to the piping the valve had been turned about so that E became the boiler connection, D joined the safety valve and C was connected to the header. This connection was obviously dangerous, and suggests that the use of a cross valve under such circumstances may easily lead to serious difficulties if the man responsible for the piping is not too familiar with the construction of the less common types of valves.

Man's Time of Tribulation.

Writer Who Evidently Has Had Experience Tells of the Joys of Cleaning a Furnace.

"A furnace is an ingenious and fiendish device used for heating purposes. It is an asbestos-covered boiler entirely surrounded by pipes, and situated in the darkest corner of the cellar. The idea of the man who puts it in seems to be that a convenient light in the vicinity of a furnace would be detrimental to his interests," says the *Detroit Free Press*. "Further, a furnace is a device that has a hog's fondness for dirt and a healthcrank's mania for cleanliness. It won't heat if it is dirty, and it won't help to keep itself clean. Consequently the poor brute known as husband of the home must be attendant, masseur and rubber to the furnace as well. And these duties he must perform regularly in the dark or aided merely by the faint glow of an eight-candle power lamp that has only one candle power left. To clean a furnace a man must divest himself of all raiment that he ever expects to wear above ground. Then with an iron brush he must attack the innermost vitals of the apparatus, groping hither and thither, now bumping his head on the steel upper jaw of the open mouth, now scraping his knuckles on the lower jaw. Suddenly he is in the dark! The light has gone out! No, it is merely a cloud of dust that he failed to inhale quick enough to prevent its obliterating the eight-candle power lamp altogether. At last with the dust in his lungs, hair, eyes, ears, nose and vest pockets he staggers upstairs, only to have the partner of his joys and sorrows exclaim: 'It seems to me you could clean that furnace without scattering dirt all through the house.'"—*Bull. National Assoc., Master Steam & Hot Water Fitters.*

Flywheel Explosions, 1914.

(23.) — A fly-wheel exploded November 26, at the plant of the Iola Portland Cement Co., Woodbine, Kans. The accident caused the entire plant to shut down.

(24.) — The fly-wheel of an engine at an oil well near Riley, Ind., exploded December 1. One man was instantly killed.

1915.

(1.) — The fly-wheel of an automobile belonging to Harold Black exploded January 1, at Bowling Green, O.

(2.) — A flywheel exploded February 17, at the plant of the Southern Cotton Oil Co., Warrenton, Ga. The property damage amounted to about $3,000, but no one was injured.

(3.) — The hub of a fly-wheel split February 25, at the brewery of Bernheimer and Schwartz, 128th St., and Amsterdam Ave., New York City.

(4.) — The fly-wheel of an air compressor exploded February 20, at the smelter of the Arizona Copper Co., Clifton, Ariz. The engineer was killed.

(5.) — The fly-wheel of a rolling mill engine exploded March 17 at the mill of the Illinois Steel Co., South Chicago, Ill. One man was instantly killed, four more were injured, three of them fatally.

(6.) — On March 9, the fly-wheel of a rolling mill engine exploded at the works of the Pennsylvania Steel Co., Steelton, Pa. The property damage was considerable but fortunately there were no personal injuries.

(7.) — A fly-wheel exploded March 17, at the plant of Davis Brothers, Philadephia, Pa. No one was injured.

(8.) — A fly-wheel fractured March 20, at the plant of the Wanaque River Paper Co., Wanaque, N. J.

(9.) — The fly-wheel on a buzz saw outfit exploded March 31, at Tama, Ia. One man was instantly killed.

(10.) — A fly-wheel burst May 12, at a flour mill at Clarkton, Mo. One man was killed.

(11.) — A fly-wheel attached to a portable grinding outfit exploded June 28, at Philadelphia, Pa. One man was killed.

(12.) — A block of metal was thrown from a fly-wheel attached to a threshing machine at Ovid, Mich., on July 2. Two men were instantly killed.

(13.) — A second fly-wheel split its hub August 14, at the brewery of Bernheimer and Schwartz, New York City.

(14.) — The fly-wheel of an auto-bus exploded August 20, at San Francisco, Cal. Fragments of the wheel passed into the dining room of a hotel, but no one was seriously injured.

(15.) — About August 20, a fly-wheel exploded at the plant of the Jefferson Milling Co., Charlestown, W. Va. The damage amounted to about $2,000.

(16.) — A fly-wheel exploded September 7, at the Galeton Shops of the Susquehanna Railroad Corp., Galeton, Pa.

(17.) — A fly-wheel exploded September 23, at the plant of the Natchez Oil Co., Natchez, Miss. One man was killed.

(18.) — A fly-wheel exploded August 23, at the plant of the Champion Blower and Forge, Co., Lancaster, Pa. One man was killed and two others injured.

(19.) — The fly-wheel of an automobile exploded September 30, at Pottsdam, N. Y.

(20.) — A fly-wheel exploded October 2, at the plant of the Claro Milling Co., Farmington, Minn.

Boiler Explosions.

May, 1915.

(125.) — A blow-off pipe failed May 1, at the plant of the Harvard Electric Co., Harvard, Neb.

(126.) — A kier exploded May 1, at the plant of the Imperial Finishing Co., Bellefont, Cranston, R. I.

(127.) — Lester Crawford, boiler foreman, was seriously injured May 5, at Silvis, Ia., when some sort of an explosion took place as he was inspecting a boiler. From the newspaper account we are lead to believe that the cause of the accident is to be found in the use of oil to wash out the boiler while it was hot, and the ignition of the vaporized oil at the time of the inspection.

(128.) — A boiler exploded May 5, at the Doolittle Bakery, North Platte, Neb. The building was wrecked and one man seriously injured.

(129.) — A valve failed May 10, in the shoe factory of Alden Walker and Wild, East Weymouth, Mass. One man was injured.

(130.) — A tube ruptured May 10, in a water tube boiler at the plant of Morris and Co., Union Stock Yards, Chicago, Ill.

(131.) — On May 11, a tube ruptured in a water tube boiler at the Corrigan and McKinney plant of the Gennesee Furnace and Coke Co., Charlotte, N. Y.

(132.) — A boiler exploded May 12, in the incubator room of the Mooseheart Farm, Elgin, Ill. One man was injured.

(133.) — On May 14, a blow-off pipe failed at the plant of the Loud Lumber Co., Charles, Mich.

(134.) — A tube ruptured May 14, in a water tube boiler at the cotton mills of the Granite M'f'g. Co., Graniteville, S. C.

(135.) — A boiler exploded May 14, in an apartment at Los Angeles, Cal. One man was killed and a woman seriously injured.

(136.) — The boiler of a wrecked freight locomotive exploded May 14, on the B. & O. R. R., at Zanesville, O. It was feared that the number of killed would reach eight though we have no means of judging if the injuries received were due to the boiler explosion.

(137.) — A common kitchen hot water boiler used as a storage tank for compressed air at Topp's Tire Shop, Chicago, Ill., exploded May 14. Two men were injured, one seriously.

(138.) — A boiler exploded May 11, at the tannery of D. C. McKenzie, Dundalk, Ont.

(139.) — On May 17, two sections of a cast iron heating boiler ruptured at the building of the R. C. Taylor estate, 33 Pleasant St., Worcester, Mass.

(140.) — On May 24, a number of tubes failed in a water tube boiler at the plant of the Piedmont Railway and Electric Co., Burlington, N. C. The damage to the boiler was of considerable extent.

(141.) — A boiler exploded May 18, at the pumping station of the Central Railway of New Jersey, Atlantic Highlands, N. J. The building was demolished, but no one was injured.

(142.) — A boiler exploded May 19, at the saw mill of O. B. Doten and Sons, Cranberry Lake, ten miles from St. Stephen, N. B. Two men were injured and the mill demolished.

(143.) — A kier exploded May 19, at the plant of the Nazareth Lace Co., Nazareth, Pa.

(144.) — The boiler of a dredge boat, the Delaware, exploded May 24 near Bordentown, N. J. Five persons were killed and two injured.

(145.) — A boiler exploded in the Leander County Oil fields near Bridgeport, Ill., on May 25, killing on man.

(146.) — A gasoline tank exploded May 27, at the Newbold Iron Works, Norristown, Pa. One man was injured.

(147.) — A tube ruptured in a water tube boiler at the plant of the American Sheet and Tin Plate Co., Chester, W. Va., on May 28. One man was injured.

(148.) — A boiler exploded May 29, in the Ohio Building, Toledo, O. One man was killed.

(149.) — A boiler exploded May 29, in the wood working establishment of James T. Young, Watervliet, N. Y.

(150.) — The boiler of a water heating apparatus exploded May 30, in the home of Mahlon Fretz, Newtown, Pa.

(151.) — A boiler exploded May 30, at plant of the W. J. Bush Citrus Products Co., National City, Cal. One man was injured.

June, 1915.

(152.) — A boiler used for well drilling exploded June 3, at Fairview, Pa. Two men were injured, one perhaps fatally.

(153.) — On June 3, a mud drum ruptured in a water tube boiler at the power house of the Pennsylvania and Ohio Railway Co., Ashtabula, O.

(154.) — A tube ruptured in a water tube boiler June 5, at the Thomaston Cotton Mills, Thomaston, Ga. One man was injured.

(155.) — A boiler exploded June 10, at the plant of the Rogers Rake Co., Pleasant Valley, Ct. Two men were injured, while the property damage was in the neighborhood of $1,800.

(156.) — A boiler exploded June 12, at the cutting of the Meskill Lumber Co., Meskill, Wash. One man was killed.

(157.) — A boiler ruptured June 12, at the plant of the Crystal Laundry, Warren, O.

(158.) — The boiler attached to a gas heater exploded June 13 at the home of Anna M. Weldin, Wilmington, Del.

(159.) — A tube ruptured June 13, in a water tube boiler aboard the U. S. S. Bailey in the Chesapeake Bay. Three men were seriously injured.

(160.) — On June 13, a tube ruptured in a water tube boiler at the plant of the Detroit City Gas Co., Detroit, Mich.

(161.) — A cast iron header ruptured June 13, in a water tube boiler at the plant of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(162.) — On June 17, a tube failed in a water tube boiler on board the dredge Olympia of the Puget Sound Bridge and Dredging Co., Seattle, Wash. Two men were fatally injured.

(163.) — A cast iron sectional boiler ruptured a section June 17, at the Y. M. C. A., Glens Falls, N. Y.

(164.) — On June 21, the crown sheet of a locomotive pulled from the stay bolts at the coal stripper of Kehoe and Co., Hazelton, Pa.

(165.) — The boiler of a steam roller exploded June 22, on the Lake Placid road near Ogdensburg, N. Y. One man was injured.

(166.) — Some tubes ruptured June 24, in a water tube boiler at the plant of the Suffolk Light Co., Southampton, L. I., N. Y. One man injured.

(168.) — On June 24, the boiler of a traction engine owned by Frank Cizek and Son, Germania, Pa., ruptured.

(169.) — A boiler exploded June 25, at the sawmill of Joseph Erick, near Williamsport, Pa. One man was instantly killed.

JULY, 1915.

(170.) — A steam pipe burst July 1, at the Dupont Powder Mills, Haskell. N. J. Four men were scalded, two perhaps fatally.

(171.) — On July 2, a cast iron header ruptured in a water tube boiler at the power house of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(172.) — A tube ruptured in a water tube boiler July 3, at the plant of the Cape May Light and Power Co., Cape May, N. J. One man was injured.

(173.) — The boiler of a portable well drilling outfit exploded July 3, near Fredonia, Kans. One man was seriously injured.

(174.) — The boiler of a Southern Pacific locomotive exploded July 4, at Ogilvie, Ariz. Three men were killed.

(175.) — The boiler of a traction engine exploded July 4, on the farm of Allen Clark, near Springfield, Ill. The engine was destroyed, a house was damaged, but no one was injured.

(176.) — A tube ruptured in a water tube boiler at the plant of the Easly Cotton Mills, Easly, S. C., on July 5.

(177.) — On July 7, a furnace collapsed in a internally fired boiler at the plant of the Western Alkali Manufacturing Co., Green River, Wyo. The boiler was seriously damaged.

(178.) — On July 8, 19 cast iron headers ruptured in three water tube boilers at the plant of the Semet Solvay Co., Dunbar, Pa.

(179.) — A boiler ruptured July 8, at the No. 3 plant of the Savannah Ice Co., Savannah, Ga.

(180.) — On July 12, seven cast iron headers fractured in a water tube boiler at the plant of the American Steel and Wire Co., Waukegan, Ill.

(181.) — A copper hot water tank exploded July 12, at the bakery of Garcia Bros., New Bedford, Mass. One man was instantly killed and two others injured.

(182.) — On July 14, an accident occurred to a boiler at the saw mill of G. H. Bonner and Sons, Quigley, Ark.

(183.) — A blow-off failed July 15, at the plant of the Fonda, Gloversville and Johnstown R. R. Co., Gloversville, N. Y. Two persons were injured.

(184.) — On July 15, a boiler ruptured at the plant of the Beaver Canning Co., South Beaver Dam, Wis.

(185.) — A blow-off pipe failed July 19, at the coal yard of the S. C. Schenck Co., Chicago, Ill.

(186) — On July 20, a boiler ruptured at Station No. 10 of the City Ice Delivery Co., Cleveland, O.

(187.) — A tube ruptured July 22, in a water tube boiler at the plant of the Merrimac M'f'g Co., Huntsville, Ala. Two men were injured, one fatally.

(188.) — A tube ruptured in a water tube boiler at the plant of the Virginia Railway and Power Co., Suffolk, Va. One man was injured, probably fatally.

(189.) — A boiler exploded July 23, at the Columbus Milling Co.'s mill, Columbus, Kans.

(190.) — On July 25, a tube ruptured in a water tube boiler at the plant of the Whitakke-Glessner Co., Portsmouth, O.

(191.) — The boiler of a threshing machine engine exploded July 28, near Albion, Mich. Four men were seriously injured.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1915.

Capital Stock, . . . $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$229,528.21
Premiums in course of collection,		285,417.97
Real estate,		90,200.00
Loaned on bond and mortgage,		1,266,145.00
Stocks and bonds, market value,		3,741,954.00
Interest accrued,		86,619.48
		$5,699,864.66
Less value of Special Deposits over Liability requirements,		40,291.16
Total Assets,		$5,659,573.50

LIABILITIES.

Premium Reserve,		$2,331,531.90
Losses unadjusted,		44,573.69
Commissions and brokerage,		57,083.59
Other liabilities (taxes accrued, etc.),		46,656.55
Capital Stock,	$1,000,000.00	
Surplus over all liabilities,	2,179,727.77	
Surplus as regards Policy-holders,	**$3,179,727.77**	3,179,727.77
Total Liabilities,		$5,659,573.50

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Chief Engineer.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, President, Director Swift & Co.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

MORGAN G. BULKELEY, JR., Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, Johns-Pratt Co., Hartford, Conn.

Incorporated 1866. Charter Perpetual.

The Hartford Steam Boiler Inspection and Insurance Company

ISSUES POLICIES OF INSURANCE COVERING

ALL LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.	W. M. Francis, Manager and Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	Lawford & McKim, General Agents. R. E. Munro, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. Roberts, Manager. Charles D. Noyes, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.	W. G. Lineburgh & Son, General Agents. F. S. Allen, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. Lemon, Manager. James L. Foord, Chief Inspector. J. T. Coleman, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg	W. E. Gleason, Manager. Walter Gerner, Chief Inspector.
CLEVELAND, Ohio, Century Bldg.	H. A. Baumhart, Manager and Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg. Cor. 15th & Champa Sts.	Thos. E. Shears, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. Williams, Jr., General Agent. F. S. Allen, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	Peter F. Pescud, General Agent. R. T. Burwell, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. Gardiner, Manager. Joseph H. McNiel, Chief Inspector. A. E. Bonnet, Assistant Chief Inspector.
PHILADELPHIA, Pa., Cor. Fourth & Walnut Sts	A. S. Wickham, Manager. Wm. J. Farran, Consulting Engineer. S. B. Adams, Chief Inspector.
PITTSBURG, Pa., 1801-1802 Arrott Bldg.	J. J. Graham, Manager. Benjamin Ford, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	McCargar, Bates & Lively, General Agents. C. B. Paddock, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. Mann & Co., General Agents. J. B. Warner, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. Ashcroft, Manager. J. P. Morrison, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. Roberts, General Agent.

The Locomotive

OF

THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

VOL. XXXI.

PUBLISHED BY

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

HARTFORD, CONN.

1916-1917.

INDEX TO VOL. XXXI.—1916-1917.

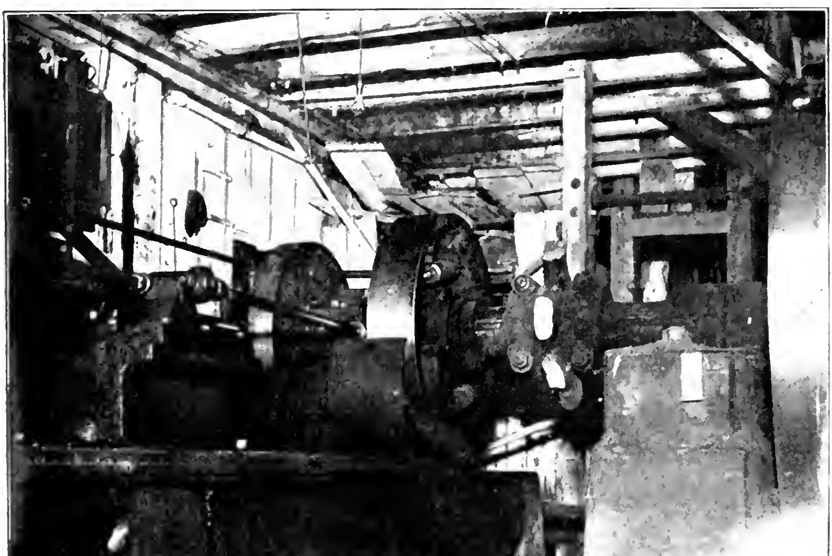
REFERENCES MARKED WITH A STAR (*) ARE TO ILLUSTRATED ARTICLES.

The Locomotive

of

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

VOL. XXXI. HARTFORD, CONN., JANUARY, 1916. No. 1.



FLYWHEEL EXPLOSION, MARQUETTE, MICH., WRECK OF A SHAFT GOVERNED ENGINE.

A Flywheel Explosion on a Shaft Governed Engine.

Our front cover illustrates the condition of an engine at the sawmill of The Schneider and Brown Co., Marquette, Mich., after the explosion of its flywheel on October 5, 1915. The engine was of the shaft governed, slide valve type, operating normally at 120 R. P. M. On the day of the explosion the sawyer noticed an unusual increase in the speed of the mill and pulled a whistle lever to signal the engineer to shut down. Before he could leave the lever the flywheel exploded, and either a portion of the wheel itself, or of the main belt struck the engineer, injuring but not killing him.

This engine furnished power to several machines through a somewhat complicated belt transmission with several countershafts and pulleys. The energy of the explosion seems to have been expended for the most part in tearing through the belts, pulleys and shafts and did not do the amount of damage to the building which sometimes results from similar accidents. To this fact also may be attributed the escape of several men employed in parts of the mill directly in the path of the bursting wheel.

The accident appears to have been due to the loosening of one of the pins which attach a governor weight to the governor wheel. This pin seems to have moved endwise far enough to have caught the eccentric at a point corresponding to late cut-off, and hence permitted the engine to race. The end of the pin was found marked and bruised after the accident in such a manner as to bear out this conclusion. This point should be borne in mind and compared with the statement given elsewhere in this issue in our article on shaft governed engines, as this explosion illustrates one type of failure there considered.

Recording the Extent of Corrosion in Boiler Plate.

It often happens that an inspector finds the metal in a boiler shell corroded over a considerable area. If the corrosion is confined to small patches, leaving a relatively large amount of sound metal intact, the result may not much affect the boiler's safety, but if the wasting is general over a considerable area, and especially if it has proceeded to such an extent that the strength of the plate is much impaired, then it becomes serious indeed, and usually calls either for extensive repairs or the abandonment of the boiler for high pressure operation.

There is one difficult feature of such a case however. It is not always easy, even for a trained inspector, to decide the exact extent of the wasting, when the patch is large. He has little to compare the corroded surface with, and it is sometimes wasted so evenly as not to appear much different from plate of full thickness. If it is hard for an inspector, trained in detecting unsafe boiler conditions, to determine the extent to which corrosion has progressed, it is obviously still more difficult for the average boiler owner to judge of the accuracy of the inspector's report, and so there may arise an honest controversy as to the justice of a demand for reduced pressures. In the case of deep local pits, it is easy to drill a hole at the bottom of the deepest depression, and measure the plate thickness, afterwards filling the opening with a threaded pipe plug, or a rivet. When the corrosion is general, however, many holes may be required to gain any exact motion of the extent of the trouble, and the method becomes less practical. To settle just such a discussion, Inspector J. A. Snyder of the Pittsburg office of The Hartford Steam Boiler Inspection and Insurance Company, devised and built the apparatus illustrated.

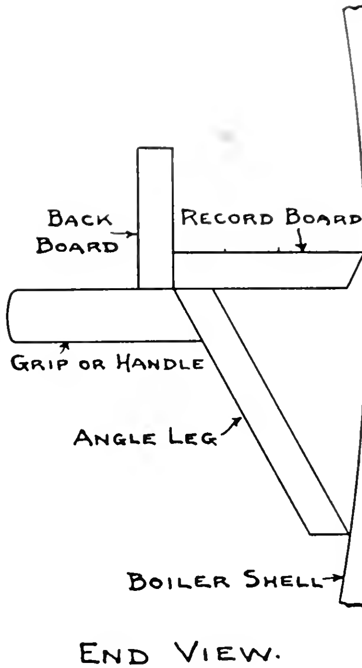


Fig. 1.
Construction of Record Board.

It will be seen that it consists of a flat "drawing board," arranged to be held against the boiler shell by means of a handle, and located in a plane approximately radial to the shell by the angle leg. This arrangement corresponds to the key way scale which a machinist uses to locate and lay out a key way inside the hub of a wheel. Along the back of the bed or drawing board runs a vertical ledge which serves as a guide for the recorder. The drawing board itself, is provided with upwardly projecting pin points, represented by dots in the plan, which serve to hold the record strip in place on the instrument. The recorder is best understood from the sketch which consists first of a board provided to slide on edge along the drawing table with the back of the recorder against the ledge mentioned above. The recording pencil is attached, as shown, to the end of a spring controlled rod, which also carries, in front of the pencil, and rigidly attached to it, a hardened tracing point. As will be seen, the spring is so located, and of such shape, that it serves at once to press the pencil against the paper, and at the same time hold the hardened point in contact with the boiler shell.

The corroded area to be investigated, is divided by equally spaced longitudinal chalk lines, after the manner suggested in Fig. 5. Then the instrument with fresh paper attached, is put in position so that as the recorder is moved along, the pencil will bear on the paper and the hardened point will trace over the first chalk line. It should now be clear, that as the hardened point moves over the contour of the boiler shell the pencil will trace a contour on the paper which is parallel to that traversed by the point, and becomes an exact record of the shell contour along the line traced. After this record is made, and before the paper strip is removed, the instrument is held against an uncorroded part of the boiler, and a similar

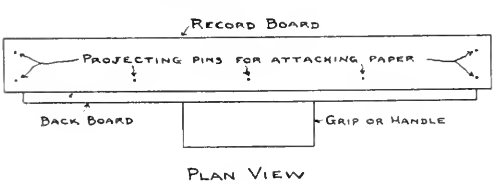
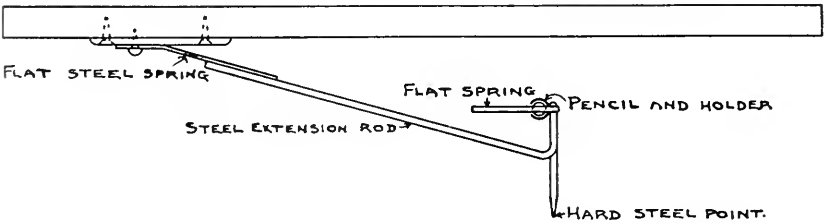
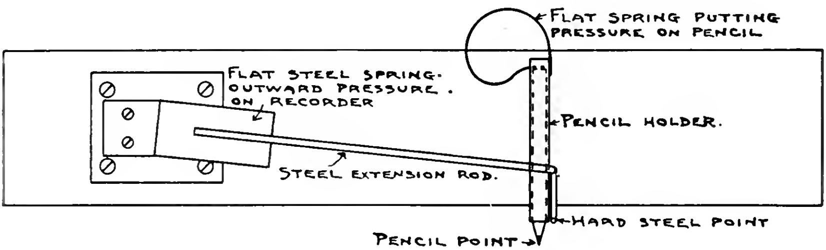


Fig. 2. Reduced Plan View of Record Board.



PLAN.



FRONT ELEVATION.

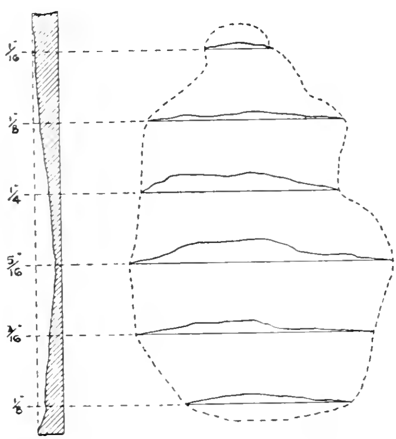


FIG. 5. METHOD OF LAYING OUT AND CORRODED SPOT INDICATING THE WAY IN WHICH SECTIONS MAY BE PLOTTED.

record made. The last line will be a straight line, and the difference between it and the first record will show the extent of the wasting, point by point along the chalk line. If successive records are made for each of the reference lines laid out, and if the records are plotted as shown in the sketch, then cross sections of the corroded plate may be obtained both longitudinally and girthwise. The longitudinal sections may be made at once from the record strips, and the girthwise ones from the plot, in the manner indicated in the sketch. This amounts to a complete topographical survey of the area under investigation and establishes the extent of the wasting without a doubt. Fig. 6 is a half size facsimile of a record made by the original instrument in a corroded boiler.

A House Heating Suggestion.

Here is a hint for those who are heating their houses with a hot water system which has proved exceedingly useful to the writer, and he therefore passes it on for what it is worth.

One of the most serious drawbacks to the use of hot water for house heating is the problem of what to do with the radiators in sleeping rooms at night when the windows are opened. In mild weather it may be safe to nearly close the valve and pass but a small stream of water through the radiator to prevent freezing. This course would not however prevent trouble in the case of a sudden drop in temperature over night. On the other hand, if the radiators are left to themselves with full circulation, they will be safe enough in most cases if a good brisk fire in maintained but they will radiate heat so rapidly that the general temperature level of the water in the system, and hence of the whole house will fall materially by morning. This will necessitate an early opening of the drafts and a considerable coal consumption to bring the house to a comfortable condition by breakfast time. Of course the trouble is in inverse proportion to the outside temperature, and may be serious in extreme weather.

The writer has been able to satisfy his desire for abundant fresh air regardless of the weather without unduly afflicting his conscience, which is peculiarly tender regarding any waste in the coal pile, and still enjoy a warm house at breakfast time by the following means. A thick but inexpensive cotton, stuffed, quilted comforter was purchased for each of the bedroom radiators. At night before retiring the comforter is snugly wrapped about the radiator which is left with the valve full open. This method while preventing any material loss of heat by the water in the radiator during the night permits the occupant of the bedroom to enjoy a fine hot radiator in the morning when the comforter is removed after closing the windows. It also permits of a normal fire being carried without any great drop in the temperature of the rooms whose windows remain closed. The radiator comforter of course occupies a corner of a closet during the day.

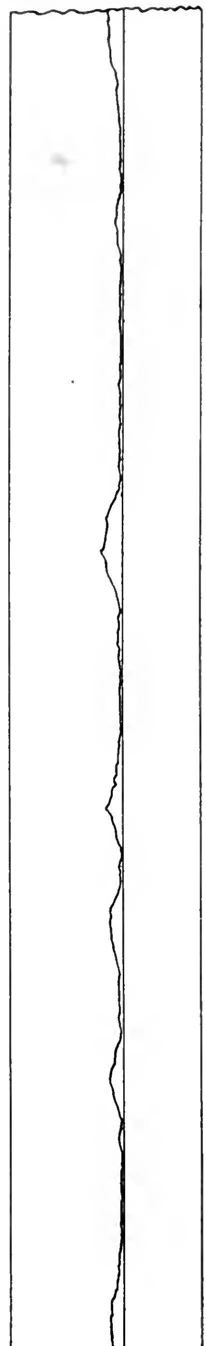


Fig. 6. Half Size Facsimile Corrosion Record.

The Prevention of Fly-Wheel Explosions.

3d Paper; Shaft Governed Engines.

There are several practical solutions of the problem of economically proportioning the work done by a steam engine to the demand of the driven load so that the speed may be kept essentially constant. One solution depends on the fact that with a simple slide valve, any variation, either in the angular position of the valve driving eccentric on the engine shaft, or in the throw of this eccentric, will change the point in the stroke at which cut-off will occur.

If cut-off is altered by varying the angular position of the eccentric, then as cut-off is made later the lead of the valve is diminished, while on the other hand, if the angular position is kept constant and the eccentric throw varied, then later cut-off (coming with an increased valve travel) means a greater lead. Obviously, a combination of these two methods, in which a simultaneous change is produced both in the angular position of the eccentric and its throw, can be arranged which will alter the cut-off with either a constant lead, or any desired lead variation. A class of engines has been developed, each representing an individual solution of the general problem outlined above, frequently spoken of as automatic engines. They are usually provided with a slide valve, (which may take on any one of a large number of forms,) and an eccentric whose angularity and throw are under the continuous control of the governor which for mechanical simplicity revolves about the main shaft, and hence gives rise to the term shaft governed engines, which heads this paper.

It can be easily demonstrated by any of the familiar valve motion diagrams, that if we imagine a line drawn through the center of the engine shaft and the center of the crank pin, (Fig. 1,) and if we consider the position of the eccentric with reference to this imaginary line, seen from the end of the engine shaft, then any mechanism which will permit the eccentric to move relative to the shaft so that the center of the eccentric sheave moves along a line perpendicular to the crank center line drawn through the position of the eccentric center which corresponds to latest cut-off, will alter the cut-off with constant lead.

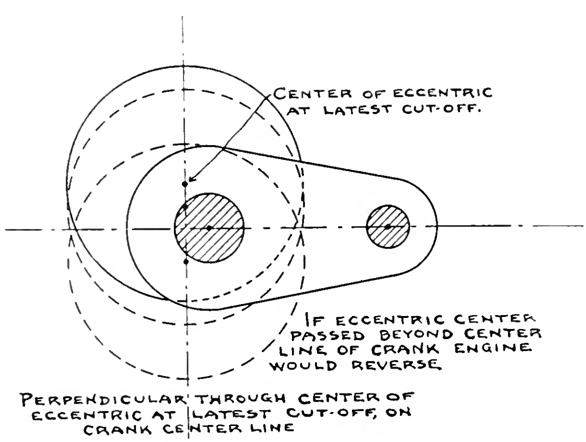


FIG. 1. RELATION OF CRANK AND ECCENTRIC AT DIFFERENT CUT-OFFS.

Moreover, it can be shown that a mechanism which will give the eccentric center a path which departs from this line, will produce an amount of lead variation proportional to the departure from the perpendicular. Further, if the eccentric center passes beyond the center line of the crank, the engine will run in the reverse direction. One group of approximations to this condition places the eccentric, which is a mere hollow ring, on the end of a lever pivoted to a point on an arm or the rim of a pulley, keyed to the engine shaft, so that the shaft passes through the opening in the ring. Now if the eccentric is moved back and forth through the short travel permitted by the difference in the diameters of the shaft and the opening in the ring, its center will describe a circular arc which very nearly coincides with the straight line which we have just considered. Such a motion is easily controled by a governor, and hence can be made to furnish speed control. Another method is to make the sheave of the valve driving eccentric become the strap of an inner eccentric on the engine shaft. (Fig. 2.) If both eccentrics are capable of angular shift, relative to each other and to the shaft, then any throw between the sum and difference of the throws of the two sheaves may be given the combination, as well as any desired angular position, and if the angular position of both sheaves is placed under governor control by a suitable arrangement of links, an exact solution of our problem is possible. That is, this arrangement is capable of giving variable cut-off at constant lead.

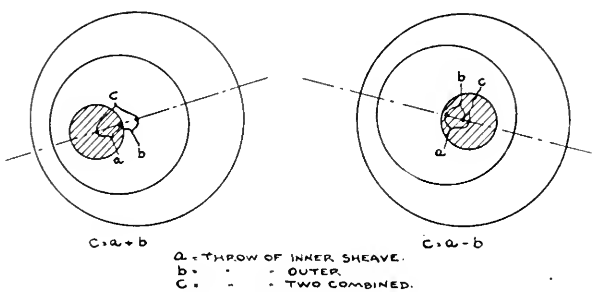


Fig. 2. Double Eccentric Method of Varying Cut-off.

We have gone into the theory of the automatic regulation of a slide valve engine to this extent, because the shaft governor presents a complex combination of simple principles, concerned on the one hand with the effect on the steam distribution which we have outlined, and on the other with the particular means by which speed sensitiveness and power are obtained, which we are about to discuss. It seems wise therefore, to clear up in a somewhat hasty fashion, the reason for the various governor elements and functions before taking up their operating features.

Leaving the question of valve drive and considering only the governor itself, we are confronted with certain underlying principles which must be discribed before we are in a position to discuss actual governors. If we leave out of account clock escapements and fan and friction devices, practically all mechanism for the control of speed which are useful depend on the fact that a mass or weight rotating about an axis, develops a pull tending to separate it from that axis, the strength of which pull varies as the square of the speed of rota-

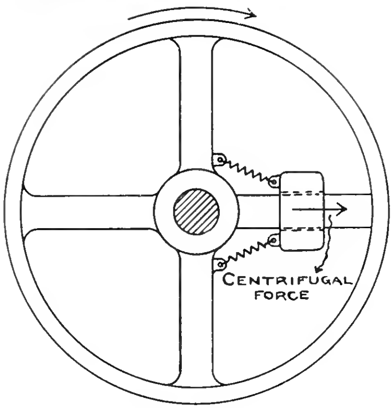


FIG. 3. PURE CENTRIFUGAL FORCE.

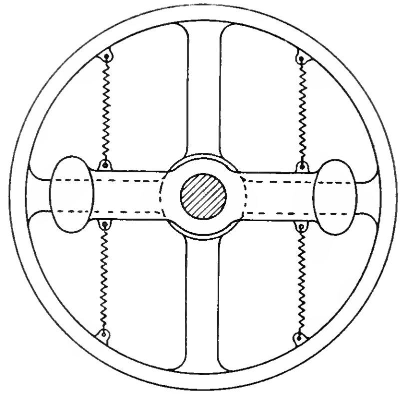


FIG. 6. PURE INERTIA.

tion, and which we call centrifugal force. If the mass is held to the axis by a spring, then as the speed varies, the position of the mass will vary, moving away from the axis with increasing speed. The amount of travel will depend on the speed change, the original distance of the mass from the axis, the amount of the mass, etc. The important consideration is that for any particular mechanism, consisting of a weight and spring with the weight so arranged that it can travel *radially* out from or toward the axis, a particular weight position will always correspond to a given speed, and so such a device may be utilized to control speed. Fig. 3 shows this diagramatically. (In the fly-ball governor, the force of gravity, acting on the balls themselves, and often on an added weight or load, may take the place of the spring, since the governor is mounted for rotation about a vertical axis, but otherwise the argument applies.) Such a governor would be classed as a purely centrifugal governor, since that is the only force utilized in selecting a given position for a given speed.

We shall now show that while it is not always desirable to operate governors by centrifugal force alone, still all governors require the principle of centrifugal force to make them pick out a particular speed to which the engine will return after load changes have produced momentary speed alterations. Purely centrifugal governors do not always act quickly enough to be wholly satisfactory, especially if they are so designed as to provide an abundance of power for moving heavy parts.* Another factor, known as the principle of inertia is therefore often introduced to assist centrifugal force in quickly bringing the engine back to the desired speed. The effect of inertia as a governing principle is easily understood from the following considerations. Suppose two shafts are supported freely in bearings, and run end to with their center lines coinciding. (Fig. 4.) Suppose further that each shaft terminates as shown in a heavy disk, with no rigid connection between the two disks. This is equivalent to the result which one would get if the coupling bolts were removed from the flanges of a heavy flange coupling, joining two sections of a

*This is of course begging the question of the so called parabolic governors, but as these are not well adapted to engine operation, it is of no particular consequence.

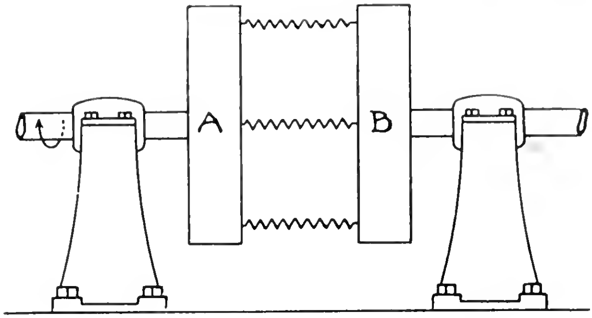


FIG. 4. ILLUSTRATING THE INERTIA PRINCIPLE.

line shaft, and the sections then separated an inch or so endwise. Now suppose several springs are attached to the disks as shown in the sketch, and the disk A rotated. As it gains speed its motion will be transmitted through the springs to B, and after a definite time interval, if A attains a steady speed B will come to the same speed. After this state of affairs has been reached, let A begin suddenly to slow down. For an instant, no effect will be produced in the rotation of B, especially if the disks are heavy, but the springs will be stretched until at last the spring tension forces B to lose speed until both disks are again rotating in unison. In a similar manner, if the speed of A had been suddenly increased, B would have persisted for a time at its former speed, until enough energy had been stored in the stretched springs to bring it in line. It is necessary to note however that slow changes in the speed of the driver A would have produce no great relative differences between the speed of the two disks, and indeed, if the speed of A changed by a slow creep in either direction, B would follow almost without appreciable lag. The difference in speed at any instant between the driver and the driven disk would be proportional to the rate at which the driver and the driven disk would be proportional to the rate at which the speed of A changed, and if the change was very sudden indeed, forces sufficient to break the springs might easily be set up. It only becomes necessary to provide a mechanism, so that when B lags behind A by any amount, the speed of A will be reduced, and as the angular lag will be proportional to the suddenness of the speed change, we will have available a large governing force to deal with big variations, and a gentle one to take care of minor variations. It is of course obvious that the mechanism could be so designed that if a lag of B behind A slowed A down, a corresponding lead of B ahead of A would speed A up. The only drawback to this arrangement as an engine governor, lies in the fact that *very slow* speed changes in either direction might continue unchecked, and the engine might settle down at will to run at either high, low or intermediate speeds. The governor would in other words tend to hold the engine at constant speed, but could not force it to run at a selected speed.

The value of both inertia and centrifugal force are most apparent when they are permitted to act together, each supplying some qualities lacked by the other, and it is such a combination, which is most generally met in the design of shaft governors. To make the matter perfectly clear let us consider some diagramatic arrangement which contain the elements of most shaft governors. Fig. 5 shows a wheel to which is pivoted a heavy weight in such a way that for the limited

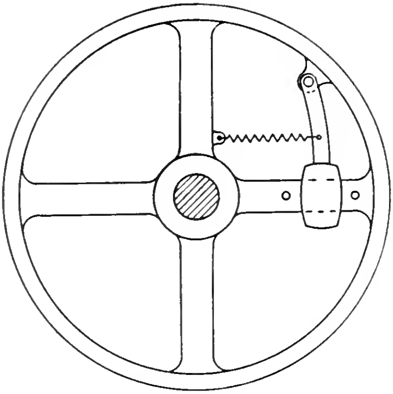


Fig. 5.

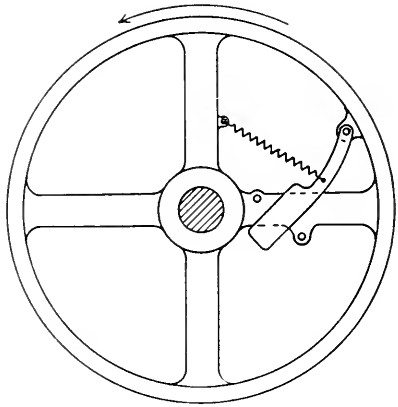


Fig. 7.

motion permitted between the stop pins, the path of center of gravity of the weight is essentially radial. Such a weight, moving against the restraint of a spring, would act under practically pure centrifugal force when the wheel is in motion. Fig. 6 shows a heavy bar, with weights at the ends, pivoted to rotate on the shaft. As no part of this weight can change its distance from the shaft center, centrifugal force could not produce any effect on its motion, but if if were connected to a wheel by springs as is indicated in the sketch, it would lag behind or shoot ahead of the wheel, exactly like the disks of the previous paragraphs if the speed of the wheel were altered. This bar, then, could be utilized for speed control only by virtue of its inertia. Fig. 7 shows a weight similar to that of Fig. 5, but so pivoted that not only is it capable of traveling out and in under the action of centrifugal force, but if the wheel rotates in the direction of the arrow, the weight will tend to fly outward for an increase, and inward for a decrease in the wheel speed by the effect of its inertia. Moreover, a change in the point of attachment of the pivot to the wheel will vary the relative importance of either centrifugal force or inertia, at the will of the designer. Fig. 8, shows a heavy bar, similar in some respects to that of Fig. 6, but which is no longer pivoted on the shaft. Instead, it has been provided with an opening big enough to permit considerable motion of the bar relative to the shaft, and the bar has been pivoted eccentrically, to a point near the hub of the wheel. Owing to the eccentric pivot, the bar cannot swing either way without bringing its center of gravity either nearer to or farther from the center of the shaft, so that it will be acted on to an extent depending on its relative dimensions, the distribution of its mass, and the exact point of support, by centrifugal force. On the other hand, it will lag behind the wheel or shoot ahead of it from the effect of its inertia, to almost as great an extent as the simple inertia bar of Fig. 6, which lacked any centrifugal control. It will be seen that mechanisms embodying the principles of Figs. 5, 7, and 8 might be utilized as governors, and indeed all these types are in use, but the type represented by Fig. 6, could not of itself, as we have said before be so employed.

Let us pass now to the consideration of the operation of shaft governors, and their special hazards. A sort of tradition seems to prevail among engineers and engine owners to the effect that shaft governors are perfect safeguards against flywheel explosions. One often hears the statement that a shaft governed wheel cannot run away because, if the governor fails the engine will stop! We can easily show the absurdity of this statement by considering, as we shall very shortly, several types of failure possible to shaft governors, which are liable to result disastrously to the wheel. Moreover, we can back up these statements with specific cases, most of which have been illustrated at one time or another in the columns of THE LOCOMOTIVE. The origin of this tradition is not known, though we believe it to have arisen somewhat after the following fashion. A casual inspection of shaft governor designs might easily lead one to conclude that practically the only failure to be anticipated in service would be spring breakage. Spring breakage on a governor running at any speed would result in the weights being thrown out to their extreme outer positions. Hence cut-off would be shortened to the earliest possible moment in the stroke, and the engine would experience a safe speed reduction, even if it did not actually stop. Such action would undoubtedly follow the breakage of a spring with some shaft governors. It is possible however, in other cases for the weights to assume a position when released from spring control, such that the eccentric center would be thrown clear across the crank center line, with the result that the engine would slow down, stop, reverse and then speed up in the reverse direction. It is therefore not quite safe to state even in the case of spring breakage that an engine will be invariably shut down by a shaft governor. Further than this, the experience of the Company gained from the inspection and insurance of a large number of flywheels, leads one to conclude that spring breakage is one of the lesser hazards in the operation of shaft governed engines.

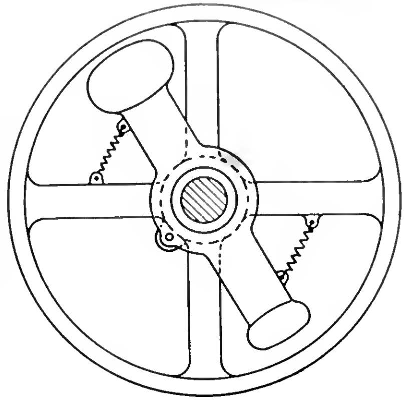


FIG. 8. NOTE: THE SPRINGS ARE THROUGH AN ERROR SHOWN ON THE WRONG SIDE OF THE BAR.

One source of danger where the governor is installed within the engine flywheel and not, as is sometimes done, in separate casings, comes from the possibility of the governor weights being released by the breaking of their attachment, or the failure of their fastenings, so that they may be hurled by centrifugal force against the inner surface of the wheel rim with sufficient force to produce a rupture of the wheel at working speed. Violent and costly accidents have happened from this cause. In one instance a governor weight was secured to a link by a set screw, so that its position on the link might be adjusted. The set screw failed, releasing the weight, and a bad flywheel wreck resulted. In another instance, the heavy weight at the end of an inertia bar of the type shown in Fig. 8, broke off from the bar, wrecking the wheel. In this case it was suspected that the bar might have been gradually weakened and at last fractured, by the blows struck by it on the inside of the wheel rim as the engine passed centers at low speed while starting and stopping. Governors of this type, of several makes, may deliver good solid thumps to the wheel rim for a certain speed interval, whenever the engine is brought up to speed on starting, or stopped. In most cases buffers of rubber or equivalent devices are provided to cushion these blows, but they are not always maintained in a good state of repair, and their useful life is apt to be short. An accident of this nature can only be guarded against by careful and frequent inspection of all parts of the governor mechanism, including all pins, links, bolts, set screws, taper pins, cotters, and the springs with their fastenings and adjusting mechanism. Any suspicion of weakness from incipient cracks, flaws, previous strains or wear should be treated as dangerous, and the suspected part either strengthened, or better, replaced.

Another source of danger present with some shaft governors, though not with all, is to be found in the effect of excessive friction between the eccentric sheave and strap, or in the valve rod stuffing box, or indeed anywhere in the valve driving mechanism. With some governors, excessive friction between the eccentric sheave and strap would tend to throw the weights farther out, acting against the pull of the springs, and would slow the engine down. In this case, the friction might be a nuisance but would not constitute a hazard to the flywheel. With many governors however, including some of the most widely used types, friction between the eccentric sheave and strap would add to the effect of the springs, tend to pull in the weights, and so cause the engine to speed up, and if the friction were great enough, to run away. It is not a very difficult matter for any engineer to determine to which of these classes shaft governed engines under his care may belong. He can test the matter as follows: When the engine is at rest, slack off on the bolts holding the halves of the eccentric strap together. Insert between the strap and the sheave a bit of soft leather, say from an old glove and set up again on the bolts so that the strap is lightly clamped on the sheave. Now bar the engine over very gently, a small amount, in the direction in which it runs. If the governor weights are by this process pressed more tightly against the inner stops, the engine would tend to speed up from the effect of excessive strap friction. On the other hand, if the weights show a tendency to be forced out away from the inner stops, the engine would slow down as a result of friction in the valve drive. In either case, whether the result would be dangerous or not, it is well to take the ounce of prevention represented by careful attention to the condition of the wearing surfaces, their proper clearance, and the securing at all times of a positive and adequate supply of lubrication. In this connection one should not forget that it may be just as dangerous to operate with the gland nuts of the valve stuffing box set up on old and hard packing so as to produce an excessive rod friction, in order to prevent steam leaks, as to permit the engine to run with a hot eccentric strap. Either may result in a burst flywheel.

The problem of lubricating the joints of the governor proper is one that is sometimes very troublesome. As the governor is within a wheel, and rotating at considerable speed it is impossible to give its lubricating gear much attention while the engine is running. It should however be inspected and cleaned, filling all grease and oil cups, *every time the engine comes to rest.* Much trouble has been experienced with some governors of a type similar to that sketched in Fig. 8, due to the fact that the heavy inertia bar is supported by a relatively small pin bearing, giving quite large bearing pressures, which has a tendency to squeeze the oil out endwise. Rubber oil retaining rings are provided to prevent this, but they deteriorate so rapidly in service that every now and then without warning the engines would begin to fluctuate violently in speed in the manner we described in the first paper of this series, when discussing the general question of governor friction. Fortunately these fluctuations were always taken as a warning, the engine shut down and the governor overhauled, but the hazard of a flywheel wreck was always present. An engineer will do well to keep close track of any oil retaining device present on governors under his charge, and should renew them whenever there appears to be the slightest evidence of deterioration, without waiting for them actually to fail, which may easily cause an inconvenient and costly shut down even if no accident results.

One hazard, emphasized by accidents recently brought to our attention, may result from the loosening of any of the pins connecting the various members of the governor linkage to each other or to the wheel. In one instance such a pin which had been secured by means of a set screw, was loosened by the set screw backing out, and worked endwise to such an extent that it caught and held the eccentric in the position corresponding to latest cut-off, and resulted in a violent flywheel explosion. In another case, a pin worked completely out of the governor, but fortunately did not produce so disastrous a result. Careful and frequent inspection, done thoroughly, and not as a mere hurried routine is the remedy for this sort of accident also.

It is not generally wise to alter the engine speed except in accordance with the detailed instructions issued by the makers. Shaft governors are so complex in their action, and the elements of centrifugal force, spring control, inertia force etc., so delicately balanced, that an unwise change in either the spring tension, the point of spring attachment, or the mass of the governor weights may easily result in an unbalanced condition which will prevent the governor from properly controlling the engine, and may result in a runaway. Governors differ so widely in this regard, that no general instructions would be of value, and so we advise implicit dependence on the instructions of the makers, which are in almost all cases perfectly clear and very full.

So far we have confined our attention to shaft governed engines employing simple slide valves. In some engines however, shaft governors are used with a modified form of slide valve known as the riding cut-off valve. This consists of two valves, one working on top of the other (or in the case of piston valves one within the other.) The main valve has ports clear through it from the face to the back, and the cut-off valve travels back and forth across these ports, sliding upon the back of the main valve. The main valve determines the admission of steam to the cylinder, its release after expansion, and the closing of the exhaust port before the end of the return stroke in order to trap enough steam in the cylinder, for a proper amount of compression. Cut-off however is timed by the position of the riding valve, and is independent of the main valve position. Each valve is driven from a separate eccentric. Since only the point of cut-off need be varied to secure speed control, the main valve can be driven by a fixed eccentric, while the lighter riding valve is driven by an eccentric under governor control. If an accident occurs to the riding valve such as the breaking of its valve rod, or a failure of any part of its drive, it is possible for the engine to continue to run though released from governor control. Since the main valve is incapable of cutting off the steam supply to the cylinder except at a point very near the end of the stroke, the engine when released in this way from the control of the cut-off valve is almost certain to run away unless stopped by some over speed device independent of the governor. Engines of this riding cut-off type, then, are especially hazardous, as compared with other shaft governed engines, unless as we have said above, some extra means is provided to stop the engine in case the governor loses control. For this reason, the riding valve, its rod, guides, rocker arm, and all the governor parts should be watched with great care for any evidence of wear or lack of adjustment, and the engineer should anticipate by renewal and replacement, any possible break-down to the riding cut-off valve gear which would appear possible as the result of his examinations.

As a final caution, the engineer in charge of a shaft governed engine should make it a point to check the speed of his engine by actual count, from time to time. At frequent intervals, he should watch his engine when he expects a sudden change in the load, and if possible measure the speed change which results. If any greater change occurs than usual, or if warned of trouble by any indication of sight or sound or even smell, if something is tending to attain too great a temperature, he should watch carefully for any increase in the unusual symptoms. This is particularly easy in case the engine drives an electric generator, as the machine voltage, and hence the brightness of lamps and often the speed of motors, is a constant reminder of any abnormal speed conditions in the generator. In any case, if an engine develops markedly abnormal symptoms of lack of speed control, or if mild symptoms appear to increase, the engine should always be shut down unless it has already attained such an increase in speed as to make this operation likely to result fatally to the engineer, and if the wheel is insured, the insurance company's inspector should be called at once to advise as to the best procedure.

On the occasion of any general overhaul such as most engineers give their equipment at regular intervals, or when moving or reinstalling an engine, look for evidences of wear, bending, bruising or distortion in any part of the governor and repair or replace all defective parts, remembering that the shaft governor is not open to inspection while in motion, and that shaft governed engines are depended upon for continuous long runs during which absolute dependence must be placed upon the proper working of every governor part, no mattter how small or apparently unimportant.

Two Recent Boiler Explosions.

We illustrate two destructive boiler explosions which have occurred recently. The first one happened on September 28, 1915 at the oil refinery of The Pierce-Fordyce Oil Association, Texas City, Tex. This explosion completely demolished the boiler house as is shown by Fig. 1, and threw three other boilers out of their settings so violently that they were damaged beyond reasonable repair. The boiler which exploded had been out of service to permit repairs to its safety valve, which had been reported as sticking to its seat.

Fig. 1. Wrecked Boiler House, Texas City.

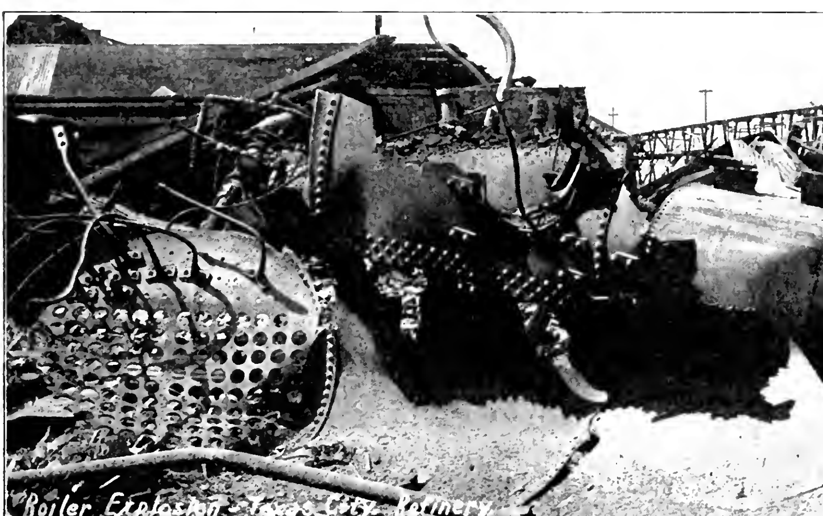


Fig. 2. Exploded Boiler, Texas City.

The chief engineer had cleaned and replaced the valve, but had purposely left it with its adjusting screw backed off so that the stem and spring were loose in order that he might set it correctly at the working pressure when the boiler was again fired up. On the night of the accident the night fireman seems to have fired this boiler contrary to orders and may perhaps have set up the valve adjusting screw himself in order to get his pressure. This can never be known however as the explosion killed the night fireman instantly and the safety valve could not be found after the accident.

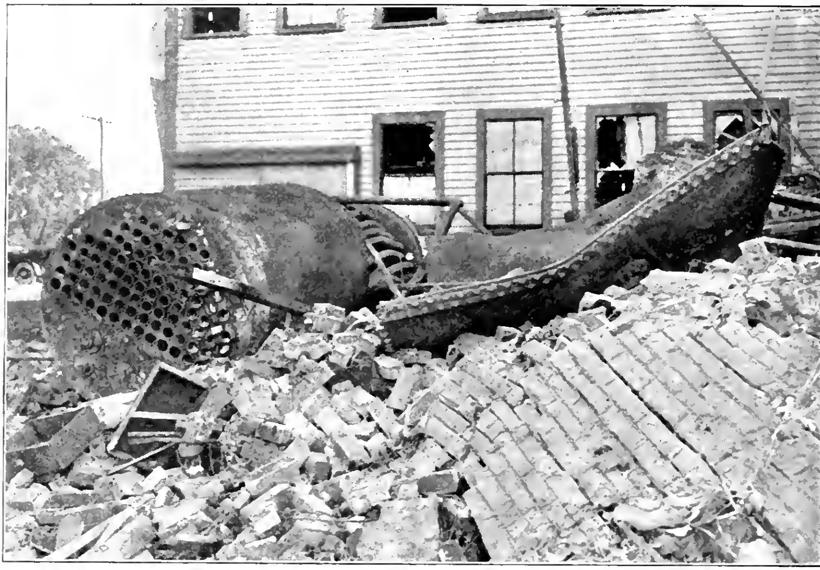


FIG. 3. REMAINS OF THE EAST WEYMOUTH BOILER.

The explosion was of such a violent nature however as to suggest an overpressure, and no weaknesses or defects were apparent in the boiler to contradict this view. The boiler was of the horizontal return tubular type, with cast iron manhole frame. The rupture seems to have started at the manhole and proceeded completely around the boiler, opening it up as shown in Fig. 2. One piece, carrying the dome was thrown a very great distance in spite of the fact that it weighed about half a ton. All this evidence pointed toward a sound boiler with plenty of water, but subjected to an overpressure sufficient to produce rupture.

The second explosion occurred October 5, 1915, at the plant of The George Strong Shoe Co., East Weymouth, Mass. This boiler, also a horizontal tubular, exploded as a result of the formation of a lap crack. The boiler house was demolished as was also the engine room, and considerable destruction was carried into the factory proper, where expensive stock and finished shoes as well as lasts, machines and shoes in process were injured. The plant engineer was killed and eight others injured. Fig. 3, shows the boiler after the explosion and gives an excellent idea of the seam crack, while Fig. 4, shows something of the extent of the damage to the factory.

FIG. 4. WRECKED BOILER HOUSE AT EAST WEYMOUTH.

The Metric System.

Nearly every issue of THE LOCOMOTIVE contains a brief note of a little volume published and offered for sale by The Hartford Steam Boiler Inspection and Insurance Company entitled The Metric System.

This little book size 3 1-2 by 5 3-4 inches contains 196 pages, devoted to a history of the metric system, a discussion of the sources of information and the data used in the compilation of the tables, and finally, comprising by far the greater part of the work, to a set of exceedingly convenient tables for the conversion of quantities in any of the English units to their metric equivalents, and vice versa. No conversion tables have appeared more convenient than these for ready and quick reference and we feel sure than any one not familiar with the book who has occasion to convert from English to metric, or metric to English measure would be surprised at the saving in time gained by its use. Not only are the ordinary measures of length, mass, volume and area tabulated, but those derived units of pressure per unit area, mass per unit volume and indeed all the conventional units employed by engineers, are included; as well as a ready means for instantly converting temperatures from Fahrenheit to Centigrade or the reverse.

This little book is to be had bound in sheepskin by addressing The Hartford Steam Boiler Inspection and Insurance Company, Hartford, Connecticut, inclosing $1.25.

Clippings.

Anyone who thinks himself tolerably familiar with the possible types of accidents which may result from the pressure of steam, or the hazard attending the operation of rotating machinery, even though he has followed boiler and flywheel inspection from youth to a ripe old age is due to have his faith shattered if he undertakes to keep track of the information which may be culled from the daily press.

Two clippings chosen from our daily grist are quoted as proof of this statement. Certainly neither could be called a usual or customary accident. Incidentally if the explosive energy contained in the moisture present in a can of beans is sufficient to seriously injure three persons who can doubt the possibility of say, a heating boiler doing damage in the event of its bursting.

The "beans" accident was as follows:

"Can of Beans Bursts; Three Persons Injured

Three persons were severely injured yesterday afternoon when a can of beans exploded in a restaurant at the Fair. The beans were being heated on a stove in the eating house conducted by the ladies of St. Cecelia church."

The second event while it did not result in human suffering was none the less painful, and suggests the possibility that a switch tender may be a necessary member of the crew of a traction engine engaged in the threshing industry even if the scene of its activity is far from the iron way. The clipping, which speaks for itself, is appended.

"A good mare, belonging to Mrs. Minnie Mangels caught her tail between the belt and flywheel of the threshing machine that was at work at the Henry Kriens place Monday morning, with the result that the switch was entirely pulled off and the stub of the tail badly lacerated. In spite of the great loss of blood she will live, but her value will be greatly reduced.—Fontanelle Observer."

The Cracking of Sections in Cast Iron Heating Boilers.

This is the open season for cracked sections. Glance through the explosion lists in this issue and count them up. The ratio of fractured sections to all other failures is 18 to 124, or 14.5%.

A reason exists for all these fractures, though we are ready to admit that the exact cause of a particular accident is sometimes very difficult to determine. However the common causes are well known and most of them may be avoided. By far the most prolific source of fractured sections is low water, although this condition may arise from a great variety of causes. We do not intend to treat the matter exhaustively here. It is rather our purpose to suggest lines of investigation to heating boiler owners which may lead them to forestall some possible trouble.

If the water disappears from sight in the gage glass of your boiler when the drafts are opened in the morning and the radiators are cold, find the reason. It may be that your boiler is too small and does not store water enough to fill the system. In that case you must add water slowly so as to keep the level in sight in the glass until water begins to flow back through the return pipe, and later blow down the excess, keeping the water level below the top of the gage glass to prevent priming. The only permanent remedy, if the cause is indeed too small a boiler is to add sections, or install a larger heater. However before enlarging the boiler, see if the return pipe is properly laid out and fitted to get the water back as quickly as possible. Make sure that it is not air bonded, that is partly closed off by a cushion or bubble or air which is entrapped and cannot escape. Draw off some of the boiler water into a bucket and see if it is clear or muddy. If very muddy and full of sediment, your boiler probably primes, that is froths so that water is entrained and carried over bodily with the steam which is another way of saying that the boiler "boils over." The remedy for this latter trouble is to draw off and fill up the boiler with clean water, or better yet, wash out the boiler with a hose and then fill it up, so that the sediment and foreign matter is removed from the system. Again, look well for leaks in the return or blow down piping, and be sure that water is not lost from this cause. A slow leak might in time reduce the total water in the system so much that there would not be enough left for starting up.

Sometimes when one boiler of a group all feeding the same heating system, loses its water, it will be found that the others are gaining what the one loses. This is due to slight pressure differences, usually coming from unequal draft. The boiler with the strongest draft will develop the highest pressure and lose its water to its neighbors. Equalizer pipes properly installed will remedy this trouble, and the boiler inspector or a heating engineer should be consulted as to the best arrangement for a particular plant.

One common cause for the cracking of cast iron sections is not connected with a lack of water. It comes from the practice of burning rubbish or papers in the boiler in the summer, when the boiler is cold, but contains water to the steaming level. A hot fire of short duration results which does not develop enough quantity of heat to raise the temperature of the water to any great extent, but still serves to heat the part of the boiler above the water line to quite a high temperature. This creates enough temperature difference between those parts of a section kept cool by the water and the remainder which is not so protected to set up severe expansion strains and frequently crack sections. When it becomes necessary to build a new fire in a cast iron heating boiler which is entirely cold, see that it is filled to the proper level, and then build a *slow fire* adding water from time to time as may be needed to keep the level always in sight in the glass. Be sure that the fire is so slow, that steam can form and all parts of the boiler heat up together, and there will be little chance of broken sections.

Summing up, the whole matter may be put in somewhat this fashion. Watch your boiler. If all goes well with it, and no unusual circumstances arise, you will be repaid by the satisfaction of knowing that things are as they should be. When you do find conditions that appear out of the ordinary, find out the cause if you can and remove it. But take no chances, and if your boiler is insured, consult the inspector. Tell him the trouble, and in nine cases out of ten he can put you on the right track at once. In the tenth case he will probably be able to ferret out and correct the trouble after an investigation. It is much better to prevent accidents than to pay for them, and it is accident prevention which furnishes the reason for boiler inspection. Bear in mind also that not all accidents to heating boilers are mere fractures, but that violent explosions may easily follow abnormal conditions if they are neglected. Let the boiler inspector help you take the stitch in nine, that's what he is for.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. PERRY, EDITOR.

HARTFORD, JANUARY, 1916.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

Stress of unusual industrial conditions means an effort to extract the last possible bit of output from existing equipment. It requires time to install new boilers and engines. Prosperity calls for long hours and heavy duty. Under such circumstances the value of inspection and insurance in preventing trouble becomes almost incalculable; a boiler explosion would be a disaster indeed. For this reason there should exist a maximum of co-operation between the inspector and the assured to safeguard the equipment to the utmost. This kind of service has a real tangible profit producing value just as important as the potential protection afforded by the insurance. These two functions might well be termed, to borrow a simile from the realm of physics, the "kinetic" and "potential" values of insurance. For just as kinetic energy is the energy which a moving body possesses because it is in motion, and potential or "possible" energy is the energy which may be stored up in some mechanical system, so the preventive work of the inspection service is available to the going plant assisting it definitely in maintaining its maximum output, while the insurance or indemnity feature of the contract is stored against the possible unavoidable catastrophe.

It is self evident that no steam user, confronted with the present feverish stress can afford to do without boiler insurance, but it is even more important that he possess that kind of boiler insurance which carries in the largest measure, efficient inspection, or as we have called it, kinetic protection. We believe that no company is today better able to furnish this than The Hartford which is at once the largest and oldest organization doing this sort of work in this country, and at the same time the only organization, all of whose energies are bent to this special end. The necessity for boiler insurance should but emphasize the equal importance of flywheel inspection and insurance. The assured, whose power plant is covered by both sorts of protection in The Hartford has a valuable asset.

The hazard of the toy boiler crops up regularly and gives rise to some three or four of our listed explosions every year. In the list for October 1915 one such accident is reported in which a lad of eight was fatally burned by a toy boiler improvised from an empty powder can. The can had been partly filled with water and then closed up and placed on a fire. This of course resulted in the development of a pressure equal to the bursting load for the can, and the inevitable explosion followed. No one would have permitted the eight year old boy to play with the can when filled with powder, but it is doubtful if many well meaning and careful people would recognize in the can of water any material fraction of the hazard contained in a full can of powder. The fact remains however that the two are not incomparable.

We believe indeed that most of the serious accidents from toy boilers result from the improvised ones, usually consisting of a sheet metal can such as an oil or varnish can. It appears that the regularly manufactured article is fairly well provided with safety appliances. Still it is doubtful if even these should be entrusted to young children without the direct supervision of an older person who is thoroughly familiar with the hazards involved.

Personal.

Ward I. Cornell

Mr. Ward I. Cornell has been appointed Assistant Manager in the Boston Department of The Hartford Steam Boiler Inspection and Insurance Company.

Mr. Cornell entered the service of The Hartford as a Special Agent in the New York office in 1907. In 1910 he left the Company but returned again to the New York office in 1914. In June of that year he was transferred to the Boston district, where his work has been so satisfactory as to earn for him this well deserved promotion.

Obituary.

H. R. Mann

Mr. H. R. Mann, senior partner of the firm of H. R. Mann and Co., General Agents of The Hartford Steam Boiler Inspection and Insurance Co., at San Francisco, Cal., died suddenly on November 9, 1915, of heart failure following an operation for appendicitis.

Mr. Mann had been connected with the San Francisco agency from its inception in 1884, under the name of Hutchinson and Mann. The firm name was changed to Mann and Wilson in 1889, and to H. R. Mann and Co., its present designation, in 1906.

Mr. Mann was a person of large and generous impulses, much esteemed in the business world, and his death comes as a great loss both to the Company and to his friends and associates in San Francisco.

Ernest W. Evans

Ernest W. Evans, inspector for The Hartford Steam Boiler Inspection and Insurance Company at Poughkeepsie, N. Y., was killed in an automobile accident near that place on November 11, 1915.

Mr. Evans, while on his vacation had taken his machine to drive into the country for a hunting dog he had borrowed and on returning seems to have lost control of his car in a sudden attack of illness or a fainting spell. The machine turned, crossed the road, and was stopped by collision with some obstacle. The sudden stopping of the car appears to have projected Mr. Evans against the windshield with great violence, resulting in injuries from which he died. He was found unconscious in the car and died soon after without regaining consciousness.

Mr. Evans was born in Abersychan, Monmouthshire, England, on September 26, 1865. In 1869 he came to this country with his parents who located in Troy, N. Y., where he received his education in the public schools. He served an apprenticeship to the machinist trade at the works of the Burden Iron Co., at Troy and remained with that company until 1895, when he was appointed superintendent of construction at the New York State Capitol, Albany, N. Y. In 1897 he entered the service of The Hartford as an inspector which position he retained until his death. He had been located at Poughkeepsie for about five years.

Mr. Evans was a very competent inspector, well liked by all his associates, and his death will be keenly felt. He is survived by a wife and four children.

Using a Slide Rule.

SYNOPSIS — Simple directions for manipulating the rule to work out problems in multiplication, division and proportion. Practice examples are given, and assuming the reader with rule in hand, he is told how to set the values and where and how to read the answers.

One of the simplest uses of the slide rule is to solve proportions. You know what a proportion is:

$$2 : 6 :: 3 : 9;$$

as 2 is to 6 so is 3 to 9; or $\frac{2}{6} = \frac{3}{9}$.

As you know, there are four scales on the rule, the A-scale at the top, below it the B-scale, the D-scale at the bottom and above it the C-scale. Set your rule with the 2 of the C-scale over the 6 of the D-scale, and you will see that all the values on the C-scale bear the same ratio to those on the D-scale that 2 does to 6. Not only is the 3 over the 9, but everything on the scale is in that proportion. Read them along

$$\frac{1}{3}\ \frac{11}{33}\ \frac{12}{36}\ \frac{13}{39}\ \frac{14}{42}\ \frac{15}{45}\ \frac{16}{48}\ \frac{17}{51}\ \frac{18}{54}\ \frac{19}{57}\ \frac{20}{60}\ \frac{21}{63}\ \frac{22}{66}, \text{ etc.}$$

Put the right-hand index or 1 of the C-scale over the 3 of the D-scale, where the left-hand index now is, and you can read the rest of the scale

$$\frac{4}{12}\ \frac{4.5}{13.5}\ \frac{5}{15}\ \frac{5.5}{16.5}\ \frac{6}{18}, \text{ etc.}$$

All that you need to do then to solve a proportion is to place the first term of the proportion on the C-scale over the second on the D-scale, and under the third term on the C-scale will be found the fourth term on the D-scale.

C D C D
2 : 6 :: 3 : 9

Example: An engine develops 76.5 hp. running at 130 r.p.m. What horsepower would it develop with the same mean effective pressure running at 140 r.p.m.?

The power is directly proportional to the speed, hence

$$\begin{matrix} C & D & & C & D \\ 130 : & 140 & :: & 76.5 : & x \end{matrix}$$

Set 130 on the C-scale over 140 on the D-scale and under 76.5 on the C-scale find the answer 82.4.

Example: A pulley 36 in. diameter running 275 r.p.m. is belted to one 20 in. diameter. How fast does the smaller pulley run?

Here the speeds will be inversely as the diameters. The smaller its diameter the faster the pulley will run. When you state a proportion, put the given quantity which is of the same kind as the answer, as the third term. In this case the answer is in revolutions per minute. The given term of this kind is the 275 r.p.m. of the larger pulley. Write this as the third term. Then consider whether the answer should be larger or smaller than this third term. If it should be larger, place the larger of the other two given terms as the second and the smaller as the first term. If it should be smaller, place the smaller of the other two given terms as the second and the larger as the first. In this way you will be right whether the proportion is direct or inverse. In this case the number of revolutions of the smaller pulley will obviously be greater than those of the larger pulley, which drives it, so we have

$$\begin{matrix} C & D & & C & D \\ 20 : & 36 & :: & 275 : & 495 \end{matrix}$$

Many of the ordinary calculations may be stated as proportions and thus easily solved. The same setting of the rule shows that if we want the small pulley to run 500 r.p.m. the larger must run about 278, etc.

The product of the means, or two, inside terms of a proportion, is equal to the product of the extremes or two outside terms:

$$2 : 6 :: 3 : 9$$

$$\begin{matrix} \text{(means)} & & \text{(extremes)} \\ 6 \times 3 & = & 2 \times 9 \end{matrix}$$

To find either mean it is necessary only to multiply the extremes together and divide by the other mean; or to find one extreme, to multiply the two means together and divided by the other extreme. Thus if we have given

$$\begin{matrix} C & D & & C & D \\ 2 : & 6 & :: & 3 : & x \end{matrix}$$

we can find the unknown term x thus:

$$\frac{\overset{D}{6} \times \overset{C}{3}}{\underset{C}{2}} = \overset{D}{9}$$

Set the divisor (2) on the C-scale over the first multiplier (6) on the D-scale, and under the second multiplier (3) on the C-scale read the answer (9) on the D-scale. The same process is therefore good for ordinary multiplication and division.

Example: A boiler evaporates 8.5 lbs. of water per pound of coal. The factor of evaporation is 1.15; that is, the evaporation of one pound under the conditions of the test is equivalent to the evaporation of 1.15 lb. from and at 212 deg. F. The coal has 8 per cent. of ash. What is the evaporation from and at 212 deg. F. per lb. of combustible?

If 8 per cent, or 0.08, of it is ash, one pound of the coal contains $1 - 0.08 = 0.92$ lb. of combustible. The problem then stands

$$\frac{\overset{D}{8.5} \times \overset{C}{1.15}}{\underset{C}{0.92}} = \overset{D}{10.62}\ lb.$$

Set 92 on C over 85 on D, and under 115 on C read the answer, 10.62 on D.

Sometimes you may have to shift the slide to get the final reading. Suppose you had

$$\frac{\overset{D}{32} \times \overset{C}{21}}{\underset{C}{70}} = \overset{D}{9.6}$$

Set the 70 on C over the 32 on D, then below 21 on C should be the answer. But there is nothing below 21 on C. Put the hair line of the runner over the right-hand 1 of the C-scale. With the runner in this position, slide the C-scale to the left until the left-hand 1 is under the hair line. Then under the 21 of the C-scale read the answer 9.6. You can place the decimal by using a little common sense. It is evident that the answer will be $\frac{32}{70}$ (a little less than one-half) of 21. This is obviously 9.6 and not 96 or 0.96 It is not always easy to locate the point by inspection. Some helpful rules for locating the decimal point were given in *Power,* Apr. 14, 1914, page 551.

A rule made with the C- and D-scales repeated on the top half in place of the shorter scales of the Mannheim rule, but with the index in the center avoids the necessity of shifting the slide. You can always get your reading on either the top or bottom scale, whatever the setting may be.

For the simple multiplication of two numbers, you can use the same form, putting 1 in the denominator, thus

$$\frac{\overset{D}{68} \times \overset{C}{72}}{\underset{C}{1}} = \underset{D}{4{,}896}$$

Set 1 on C over 68 on D and under 72 on C read the answer on D. It will be seen to be almost 490, and as $2 \times 8 = 16$, the last figure must be 6, so it is obviously 4,896. In choosing the 1 on C, use that which will leave the D-scale under the other multiplier. You are taking $\frac{68}{1}$ths of 72 instead of $\frac{68}{144}$ths or some other fraction.

For the simple division of two numbers use the same form again with a 1 in the numerator instead of the first multiplier, thus

$$\frac{\overset{D}{1} \times \overset{C}{72}}{\underset{C}{12}} = \frac{D}{6}$$

Set 12 of the C-scale over 1 of the D-scale and under 72 of the C-scale find the answer 6 on D. You have simply taken $\frac{1}{12}$ of 72. Use the index of the D-scale which will leave some of the C-scale above the dividend.

Practice proportion, multiplication and division in this way. Use your rule often, checking its readings by computation until you get facility with and confidence in it.—*Power.*

With this number of THE LOCOMOTIVE we commence a new volume, No. XXXI. As is our custom, we have prepared an index and title page for the volume just closed, which we shall be glad to send on request to any of our readers who have kept their copies and wish to bind them.

We also have Vol. XXX bound in cloth in a manner uniform with the earlier volumes, which may be had from the Home Office of THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE Co., Hartford Ct., at the regular price, $1.00.

Boiler Explosions.

AUGUST, 1915.

(192.) — On August 2, a tube ruptured in a water tube boiler at the Iowa State Insane Asylum, Mt. Pleasant, Ia.

(193.) — A boiler exploded August 2, at the Piercefield Mill of the International Paper Co., Tupper Lake, N. Y. One man was fatally injured.

(194.) — A boiler exploded August 3, at the Rock Island Southern power house, Cameron, Ill. Two men were injured.

(195.) — An air tank exploded August 4, at the plant of the American Locomotive Co., Schenectady, N. Y. Four men were injured, one very seriously, sustaining a bad skull fracture.

(196.) — A boiler exploded August 4, at an oil well near Elsinore, Cal. No one was injured.

(197.) — Two cast iron headers ruptured August 5, in a water tube boiler at the plant of The Studebaker Corporation, South Bend, Ind.

(198.) — On August 7, a locomotive boiler exploded belonging to the Crossett Lumber Co., Crossett, Ark. The boiler was completely destroyed, the engine greatly damaged, while the fireman and two women who were riding in the cab as passengers were injured.

(199.) — A tube failed on August 9, at the plant of the American Car and Foundry Co., Berwick, Pa. Four men were injured.

(200.) — Two sections ruptured August 10, in a cast iron sectional heating boiler at the plant of the Paper Novelty M'f'g Co., East 36th St., New York City.

(201.) — A tube ruptured August 12, in a water tube boiler at the plant of the Michigan Alkali Co., Wyandotte, Mich. The accident necessitated extensive boiler repairs.

(202.) — The boiler of an Ontario and Western passenger locomotive exploded August 12 near Ferndale, N. Y. The engineer jumped and as a result sustained a fracture of the skull which proved fatal. The fireman stuck to his engine and escaped with only minor injuries.

(203.) — An ammonia pipe burst August 15, at the plant of the Jacob Ruppert Brewing Co., East 92nd St., New York City.

(204.) — An ammonia pipe burst August 16, in the second subcellar of the Hotel Biltmore, New York City. One man was killed and three others injured.

(205.) — On August 16, a section cracked in a cast iron sectional heating boiler at the plant of The Thompson Milling Co., Lockport, N. Y.

(206.) — On August 17, nine cast iron headers ruptured in a water tube boiler at the By-Products Coke Corp'n plant of the Solvay Process Co., South Chicago, Ill.

(207.) — A tube ruptured August 18, in a water tube boiler at the power house of the Desert Power and Water Co., Kingman, Ariz.

(208.) — The boiler of a threshing engine exploded violently on August 18, on the farm of James Collins, Poejoy, Ia. One man was killed and three others seriously injured.

(209.) — A boiler exploded August 18 at the planing mill of T. G. Clark, Dalark, Ark. One man was scalded, probably fatally.

(210.) — On August 20, a tube ruptured in a water boiler at the plant of the Chicago Coated Braid Co., Chicago, Ill.

(211.) — The boiler of a saw mill belonging to Green Burgess, Wharton, Ark., exploded August 21. Mr. Burgess and one other were instantly killed, while two men were seriously injured.

(212.) — A boiler exploded August 22, at the plant of the City Disinfecting and Refining Co., West Nashville, Tenn. One man was killed.

(213.) — A hot water heater exploded August 23, in The Empire Barber Shop, Chattanooga, Tenn. One man was injured.

(214.) — A tube ruptured August 23, in a water tube boiler at the Detroit Iron and Steel Co. plant, of M. A. Hanna and Co., Detroit, Mich.

(215.) — A boiler ruptured August 24, at the plant of the Consumers Ice and Coal Co., Chester, Pa.

(216.) — A cast iron section fractured August 24, in a cast iron sectional heating boiler at the Liberty Theater Building of The Doan Realty Co., Cleveland, O.

(217.) — On August 25, a blow-off pipe failed at the Stedman Foundry and Machine Works, Aurora, Ind.

(218.) — Two tubes ruptured August 25, in a water tube boiler at the plant of Swift and Co., Union Stock Yards, Chicago, Ill.

(219.) — Two cast iron headers ruptured August 25 in a water tube boiler at the plant of The Railway Steel Spring Co., Latrobe, Pa.

(220.) — A boiler exploded August 25 at the cannery of Robert L. Simmons and Co., Andrews, Md. One man was killed, a girl so seriously injured that she was expected to die, and a score of people less seriously injured. The boiler was said to have been an old one, on which a recommendation for pressure reduction had been made, but was operated at 85 lbs.

(221.) — An ammonia tank burst August 25, at the St. Luke's Hospital, St. Louis, Mo. No one was hurt, though some of the patients became panic stricken.

(222.) — A boiler attached to a small corn popping machine exploded August 28, at Peekskill, N. Y. No one was seriously injured.

(223.) — A sulphur retort exploded at the mine of the Mid West Sulphur Co., Cody, Wyo., on August 29. One man was killed.

(224.) — On August 30, a section cracked in a cast iron sectional heating boiler at the restaurant of Horn and Hardert, 106 West 43d St., New York City.

(225.) — On August 31, an agricultural boiler exploded on the farm of Charles Cowan, Bedford, O. Two men were killed and one seriously injured by the explosion, which was said to have resulted because of a defective pressure gage and gagged safety valve.

September, 1915.

(226.) — On September 1, a boiler ruptured at the plant of the Cyclope Steel Co., Titusville, Pa.

(227.) — Five cast iron headers ruptured September 2, in a water tube boiler at the plant of the Bronx Consumers Ice Co., Devoe Avenue and 179th St., New York City.

(228.) — A flue failed on C. N. E. R. R., locomotive No. 101, between Maybrook and Danbury, Ct., on September 2. Three men were severely scalded.

(229.) — A boiler ruptured September 4, at the Electric Light and Water Works, of the City of Rochelle, Rochelle, Ill.

(230.) — On September 4, a tube ruptured in a water tube boiler at the plant of The General Railway Signal Co., Gates, N. Y. One man was injured.

(231.) — A boiler exploded September 4, at the cannery of J. W. Archer and Sons, Wilna, Md. No one was injured. It is stated that a boiler exploded at the same establishment almost exactly one year previously.

(232.) — A section ruptured in a cast iron sectional heating boiler on September 7, at the plant of The Central Casket Co., Buffalo, N. Y.

(233.) — A boiler burst September 9, at the Washburn-Crosby Mill A, Minneapolis, Minn. One man was killed.

(234.) — On September 7, a tube of a superheater attached to a water tube boiler burst at the plant of The Hammermill Paper Co., Erie, Pa.

(235.) — On September 10, a cast iron header ruptured in a water tube boiler at the plant of the Semet Solvay Co., Holt, Ala.

(236.) — A boiler ruptured September 12, at the plant of the Harlem Independent Hygeia Ice Co., foot of 108th St., New York City.

(237.) — A tube ruptured September 13, in a water tube boiler at the plant of Swift and Co., Union Stock Yards, Chicago, Ill.

(238.) — A steam pipe burst September 14, at the Electrical School, Mare Island Navy Yard, Mare Island, Cal. Three men were badly scalded.

(239.) — On September 15, four sections cracked in a cast iron sectional heating boiler at the office building of the Lackawanna Steel Co., Lackawanna, N. Y.

(240.) — The boiler of a ditching machine exploded September 15, at Hilton, N. Y. Steam had been raised while the boiler and machine were still on the railway car, on which they had been shipped from another location, in order that the machine might assist in the unloading operation by its own power. The engineer was badly scalded.

(241.) — A steam vulcanizer exploded September 16, at the garage of The Texas Auto Supply Co., Houston, Tex. One man was badly burned.

(242.) — A tube ruptured September 19, in a water tube boiler at the plant of The Moxley Cold Storage Co., Chicago, Ill.

(243.) — Three cast iron headers ruptured September 20, in a water tube boiler at the plant of The Union Ice Co., Beaver Ave, Pittsburg, Pa.

(244.) — On September 20, a tube ruptured in a water tube boiler at the Perth Amboy, N. J., plant of The Public Service Corp., of New Jersey.

(245.) — Three cast iron headers ruptured September 20, in a water tube boiler at the plant of The Pollock-Becker Co., Ashtabula, O.

(246.) — On September 20, a tube ruptured in a water tube boiler at the plant of the Duquesne Light Co., Pittsburg, Pa. Three men were injured.

(247.) — A contractor's boiler exploded September 20, on a seawall building operation near Normandie, N. J. One man was injured.

(248.) — A boiler exploded September 20, in a Chinese laundry, operated by Pang Bros., Logansport, Ind. No one was injured, though the laundry was badly damaged.

(249.) — A steam valve burst September 21, at the plant of the Frazier Packing Co., Elwood, Ind. One man was fatally scalded.

(250.) — On September 21, a tube ruptured in a water tube boiler at the Williamsburg Power Station of The Transit Development Co., Brooklyn, N. Y. One man was fatally scalded.

(251.) — A section and two manifolds ruptured September 21, at the Simpson Cottage, Wellesley College, Wellesley, Mass.

(252.) — A tube ruptured in a water tube boiler September 21, at the plant of The Heller and Merz Co., Newark, N. J.

(253.) — A section ruptured September 22, in a cast iron heating boiler at The First Church of Christ, Hartford, Ct.

(256.) — On September 24, a cast iron header ruptured in a water tube boiler at the No. 4 Colliery of The Kingston Coal Co., Kingston, Pa.

(257.) — On September 24, a tube ruptured in a water tube boiler at the plant of The American Axe and Tool Co., Glassport, Pa.

(258.) — A boiler ruptured September 24, at the Water and Light plant of the City of Howell, Howell, Miss.

(259.) —A boiler exploded September 24, at the Chicago Boiler Works, Fullerton Ave., Chicago, Ill. Three men were injured.

(260.) — A threshing machine boiler exploded about September 25, at Ipswich, S. D. One man was injured.

(261.) — On September 27, a boiler ruptured at the plant of The Harlem Independent Hygeia Ice Co., foot of 108th St., New York City,

(262.) — A boiler exploded September 28, at the refinery of the Pierce-Fordyce Oil Association, Texas City, Tex. The boiler house was completely destroyed, three other boilers were thrown from their settings and damaged, and one man was killed. The property loss exceeded $11,000.

(263.) — A section ruptured September 28, in a cast iron sectional heating boiler at the office building of Simon Persky, Orange St., New Haven, Ct.

(264.) — A tube ruptured September 20, in a water tube boiler at the University of Illinois, Urbana, Ill. One man was injured.

(265.) — On September 30, a blow-off failed at the Emporium tannery of The Elk Tanning Co., Emporium, Pa.

October, 1915.

(266.) — On October 1, a blow-off pipe failed at the plant of the Yolande Coal and Coke Co., Yolande, Ala. One man was injured.

(267.) — The boiler of the Houston and Texas Central locomotive No. 224 exploded October 3, near Austin, Tex. Outside of the wrecking of the engine, and slight damage to track and nearby property no damage resulted either to property or persons, the engineer escaping with very superficial bruises.

(268.) — A 200 gallon tank, similar to those used for the supply of domestic hot water, which was used as an air reservoir, exploded October 3 at the garage of George E. Nichols, Newton Center, Mass. The tank is said to have carried a pressure of 150 lbs. No one was injured.

(269.) — Six cast iron headers ruptured October 4, in a water tube boiler at the plant of the Utah-Idaho Sugar Co., Salt Lake City, Utah. One man was injured.

(270.) — A boiler exploded October 4, at the plant of The Round Rock Oil Co., Round Rock, Tex. One man was killed.

(271.) — A boiler exploded October 5, at the Georgetown Creamery, Georgetown, Pa. One man was fatally injured.

(272.) — An explosion in the heating plant of the Sacramento, Cal., Y. M. C. A., on October 5, wrecked the building. From the evidence available (press clippings) there seems some doubt whether this was a true boiler explosion, or whether it was due to the accumulation of an explosive gas mixture in the boiler setting.

(273.) — A well drilling boiler exploded October 6, at Evans City, Pa. One man was injured.

(274.) — A tube failed October 7, in a boiler at the plant of the Cincinnati Screw Co., Twightwee, O.

(275.) — A section ruptured October 7, in a cast iron sectional heating boiler at the residence of R. N. Garrett, Eldorado, Ark.

(276.) — A boiler exploded October 8, at the pumping station of the Producers' Transportation Co., Middlewater, Cal. One man was injured.

(277.) — The boiler of a logging locomotive exploded October 10, near Shubuta, Miss. The locomotive was bringing about 60 negroes from the lumber camp into the town at the time of the accident. Three men, a white man and two negroes, were fatally hurt, and 11 others less seriously injured.

(278.) — A boiler accident to a Pennsylvania locomotive occurred October 10, near Shamrock, Pa. Three men were burned.

(279.) — On October 11, a boiler exploded at the shoe factory of The George Strong Co., East Weymouth, Mass. The engineer was killed, eight others injured, and property damaged in excess of $7,000.

(280.) — A section ruptured in a cast iron sectional heating boiler October 11, at the dry goods store of John Ellsworth, South Bend, Ind.

(281.) — A boiler accident occurred October 12, at a grist mill at Geneva, Ky. One man was seriously burned.

(282.) — A gas hot water heater exploded October 13 at the Hotel Tulare, Fresno, Cal.

(283.) — A section ruptured October 14, in a cast iron sectional heater at the Charlesbank Homes, Charles St., Boston, Mass.

(284.) — A section ruptured October 14, in a cast iron sectional heater at the Hight School, Duquoin, Ill.

(285.) — On October 14, a cast iron mud drum, of a water tube boiler exploded at the power station of The Portland Railway Light and Power Co., Portland, Ore. The boiler and setting were damaged to a considerable extent.

(286.) — Eight year old Joseph Goff of Davis, W. Va., was fatally scalded October 15, by the explosion of a toy boiler, constructed from an empty powder can with which he was playing. The can had been partly filled with water, closed up, and placed over a fire.

(287.) — Eight sections cracked October 16, in a cast iron sectional heating boiler at the plant of the Eagle Glass Mfg. Co., Wellsburg, W. Va.

(288.) — A boiler ruptured October 16, at the gin of the Osceola Cotton Oil Co., Luxora, Ark.

(289.) — A steam pipe burst October 16, at the plant of the Lock Moore Lumber Co., Lockport, La. Two men were fatally injured.

(290.) — On October 18, the crown sheet of a locomotive collapsed at the operation of the Louisville and Nashville Lumber Co., River Falls, Ala. The engineer was killed.

(291.) — On October 18, a section ruptured in a cast iron sectional heating boiler at the apartment house owned by the estate of B. E. Hastings, Boston, Mass.

(292.) — A boiler exploded October 18, at the Hironymus sawmill, Mobile, Ala. Two men were injured by flying debris, one fatally.

(293.) — A boiler exploded October 19, at the Westbrook Brick yard, Abbotsford, Mich. Five men were severely injured.

(294.) — A hot water boiler exploded October 19, in the basement of Wm. T. Herlyn's market, Mamaroneck, N. Y. One man was injured.

(295.) — The cast iron necks, connecting the steam drum on two boilers, broke October 19, at the plant of the Leland Compress Co., Leland, Miss.

(296.) — A tube ruptured October 21, in a water tube boiler at the Sioux City Gas and Electric plant of The United Gas Improvement Co., Sioux City, Ia. One man was injured.

(297.) — A valve which was being repaired on a high pressure tank exploded October 21, at the plant of The Cott-a-uay Co., Bound Brook, N. J. Three men were injured, one probably fatally.

(298.) — A hot water reservoir in a kitchen range exploded October 22, at the Milligan stock ranch, near South Park, Colo. A servant was injured.

(299.) — A section ruptured October 22, in a cast iron sectional heater at the Palace Theater, operated by the Loews Theatrical Enterprises, Brooklyn, N. Y.

(300.) — On October 22, a section ruptured in a cast iron sectional heater at the Elliot Hotel, Brookfield, Mo.

(301.) — A tube ruptured October 23, in a water tube boiler at the plant of The Lackawanna Steel Co., Lackawanna, N. Y. One man was injured.

(302.) — A cotton gin was demolished by the explosion of its boiler October 23, at Lovelady, Tex. Three men were killed outright, three fatally injured, and two injured less seriously.

(303.) — On October 24, a water tube boiler exploded at the fanhouse of Shaft 12, Cameron Colliery of the Susquehanna Coal Co., Shamokin, Pa. The boiler house was badly damaged and another boiler thrown from its setting. One man was injured, and the property damage was about $5,000.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1915.

Capital Stock, . . . $1,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$229,528.21
Premiums in course of collection,		285,417.97
Real estate,		90,200.00
Loaned on bond and mortgage,		1,266,145.00
Stocks and bonds, market value,		3,741,954.00
Interest accrued,		86,619.48
		$5,699,864.66
Less value of Special Deposits over Liability requirements,		40,291.16
Total Assets,		$5,659,573.50

LIABILITIES.

Premium Reserve,		$2,331,531.90
Losses unadjusted,		44,573.69
Commissions and brokerage,		57,083.59
Other liabilities (taxes accrued, etc.),		46,656.55
Capital Stock,	$1,000,000.00	
Surplus over all liabilities,	2,179,727.77	
Surplus as regards Policy-holders,	**$3,179,727.77**	3,179,727.77
Total Liabilities,		$5,659,573.50

LYMAN B. BRAINERD, President and Treasurer.

FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.

L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.

S. F. JETER, Chief Engineer.

H. E. DART, Supt. Engineering Dept.

F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, President, Director Swift & Co.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres., The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, Johns-Pratt Co., Hartford, Conn.

MORGAN G. BULKELEY, JR., Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

Vol. XXXI. HARTFORD, CONN., APRIL, 1916. No. 2.

Boiler Explosion, Athol, Md.

The Explosion of a Two Sheet Boiler at Athol, Maryland.

The saw-mill of Graham and Hurley at Athol, Md., was completely destroyed by the explosion of a boiler February 11, 1916. A glance at the photograph which we have reproduced on our front cover will show the completeness of the wreckage. Not a single timber of either the boiler house or the mill proper remained standing and the boiler setting was reduced to a mere heap of dèbris. The boiler was projected in two parts. The heads with the tubes attached were thrown about 110 feet, while the shell, which opened for the entire length of one longitudinal joint, unwrapped from the heads and was hurled nearly 225 feet from the setting. Owing to the temporary nature of the building and the boiler setting the property damage was not great, measured in money value, but the personal injury list was frightful. Practically every person on the premises was either killed or injured. Five men were killed outright, one was not expected to recover, and several were seriously injured, one having both legs broken.

The boiler was of the two sheet variety, built in one course, with a single sheet for the bottom and another for the top of the shell. It was 14 ft. long by 42 inches in diameter. The shell plates were originally 1/4 in. thick, and the heads 3/8 inch. The longitudinal lap seams were double riveted. The heads were braced above the tubes by five 7/8 inch rods as is shown in the photograph on the front cover. These light rods were held in position at the center of their length by a plate. No manhole was fitted anywhere in the boiler, the only means for inspection being a hand-hole in the front head above the tubes. The longitudinal seams were located above the tubes where they would have been accessible for inspection if diagonal braces had been used, permitting a manhole in the shell. The failure seems to have been due to a belt of serious corrosion parallel to the edge of the lap joint, about 1 1/4 in. wide and extending from head to head. This is almost identical with the failure reported in the October, 1915, LOCOMOTIVE, which occurred at Pleasant Valley, Conn., except that in the latter case the seams were placed below the level of the tubes and were not open to inspection although the boiler was fitted with a manhole.

Either a crack or an opening due to corrosion, probably the latter, gave rise to a leak along the longitudinal joint a few weeks prior to the accident. A mechanic was called in who fitted a patch 12 inches long by 4 inches wide to the left hand longitudinal seam about 5 feet back from the front head, covering the leak. A hydrostatic test was applied and the boiler put back in service at about 100 lbs. pressure. The boiler was badly corroded on the shell tubes and heads. The shell plate was reduced to about 3/32 inch in thickness in several places, and was corroded completely through at the point where the patch was fitted. This seems to have been the point of initial rupture from which the sheet tore lengthwise of the boiler from head to head and unwrapped as shown in Fig. 2.

The boiler as far as we could ascertain was never inspected. Indeed it was so constructed, as we have stated above, that at best it could only be inspected with great difficulty. Whether a competent inspector could have seen enough through the single hand-hole to warrant his condemning it we cannot say, but it would seem that such would have been the case.

The lesson to be learned from this accident is clear enough. It is first that boilers should not be permitted in operation which are so built as to

Fig. 2. Shell Plates of Athol Boiler.

preclude proper inspection, and after that, the inspection of all boilers by a competent person should be required. We do not make this statement in a spirit of fault finding or blame toward the owners of this particular boiler. They were without doubt ignorant of the risk they ran. We do not believe that anyone would knowingly expose human life to such a hazard. We hope that the present agitation for sane and uniform boiler legislation in many States will weed out these death traps and make boiler operation as nearly safe as is humanly possible.

The Prevention of Flywheel Explosions.

4th Paper; The Strength of Flywheels.

To exactly determine the forces which are at work to burst a rotating flywheel is indeed a difficult problem, and one which is not readily solved in a complete form. On the other hand it is not difficult to find the forces acting in simple cases and from these, guided by the knowledge gained from tests and experiments, to reason as to the probable distribution of stress in some of the more complicated examples. This statement may be taken as a synopsis of the present article, in which we will endeavor to show as simply and clearly as possible the force action in a very simple case, and to point out the conclusions to which we are led by experiment regarding the probable stresses in the more complex wheels.

A rotating wheel is under stress due to what is known as centrifugal force. Centrifugal force is really a measure of the effort a body makes to resist any restraining influence which tries to make it (the body) move in a curved path. The natural simple path for a moving body is a straight line path, and whenever a departure from such a straight line motion is produced the body resists it. Thus when a train moving along a straight tangent of track strikes a curve, the tendency is for the train to persist along the straight line previously traveled, and it is only when the wheel flanges are forced in contact with the rails so as to overcome this tendency that the train "takes" the curve. The pressure which the wheel flanges exert on the side of the rail head is due to centrifugal force.

It is proved in works on theoretical mechanics that if a body whose weight is *w* pounds, travels at a speed of *v* feet per second, in a path of radius *r* feet, then the centrifugal force which this body exerts against the constraint which keeps it moving in the circular path is $\frac{wv^2}{32.2r}$; where 32.2 is the well known gravitational constant. This value for the centrifugal force will be expressed in pounds.

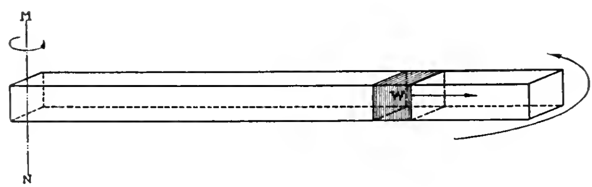


FIG. 1. SIMPLE ROTATING BAR.

If a bar (Fig. 1,) is rotating about an exis *M N* through one end, and if we consider a portion *w* of the bar, this portion will resist the effort which the rest of the bar exerts on it to keep it in a circular path. Every other part of the bar will exert a similar effort, and so there will be a stress along the bar tending to stretch it in a direction away from the axis. In other words the bar will be under tension. If we consider a ring, rotating about an axis through the center of the ring and perpendicular to its plane, Fig. 2, then each little portion of the ring resists the constraint offered by the rigidity of the hoop and tries to get *out* into a bigger and hence a flatter circle, for if it got out so as to rotate in a very great circle indeed, its path would approach a straight line. If every particle of matter in the hoop is trying to revolve in a bigger circle, then the effect will be to stretch the hoop and hence it will be in tension due to its rotation. It is the amount of the ring or hoop tension which will exist in the rim of a rotating flywheel which we are next to calculate. Before proceeding to the calculation, however, let us consider the simple rotating ring again. Each particle in the ring is trying to get away from the center. This same result might be attained in a hoop at rest, if it were subjected to an internal hydrostatic pressure. If we could find the value of the uniform pressure which would set up the same tension in the ring as the centrifugal force due to a given speed of rotation, our problem would be solved, for we know the relation between the pressure inside a boiler shell and the tension in the shell, and we could attack this problem in the same way.

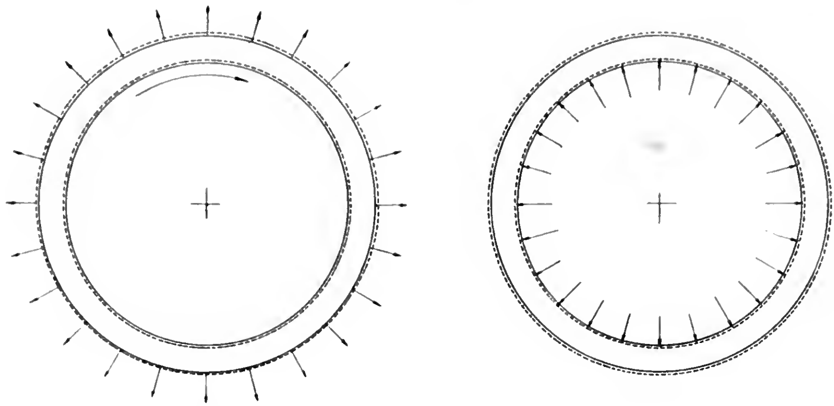


Fig. 2. Hoop Tension Through Centrifugal Force or Internal Pressure.

Suppose (Fig. 3,) we have a ring which is one inch broad, one inch thick, and *several feet* in diameter. Now suppose we consider a portion of the ring just one inch long measured circumferentially. To all intents and purposes we have a little cube one inch on a side, for although the actual shape of the piece is that of the keystone in an arch, the departure from a cube is negligible. The volume of this block is then to a sufficient degree of precision, one cubic inch. If the hoop is of cast iron, which is the common material for flywheel rims, the weight of this little portion would be .26 of a pound. Now if our hoop has a radius of r feet, and if it is rotating at a rim speed of v feet per second, we should expect, applying our formula for centrifugal force, that this little portion would develop a tendency to get away equal to $\frac{.26\ v^2}{32.2\ r}$ lbs. The base of our little wedge shaped block is one square inch. Hence a pressure of $\frac{.26.\ v^2}{32.2\ r}$ lbs.

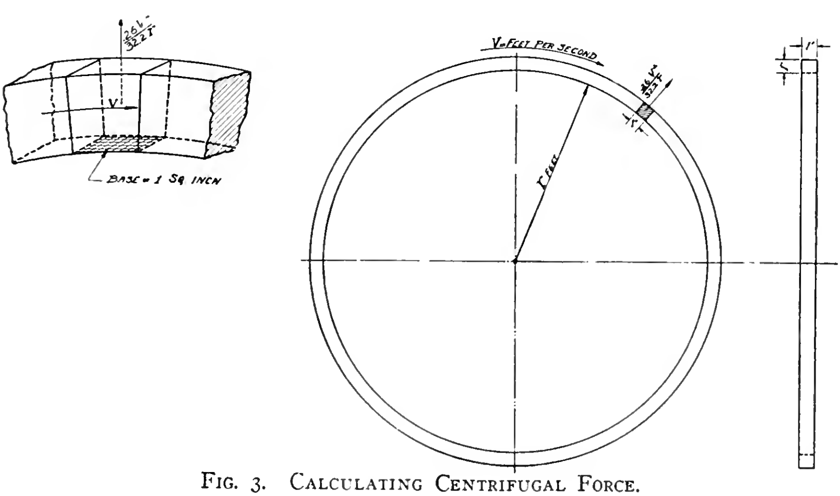


Fig. 3. Calculating Centrifugal Force.

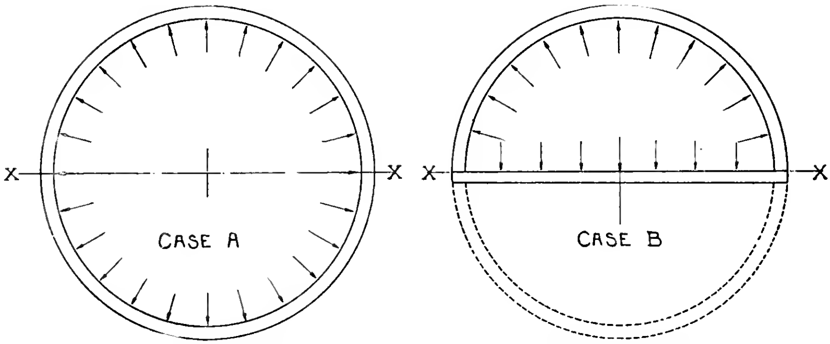


FIG. 4. OBTAINING HOOP TENSION FROM THE INTERNAL PRESSURE.

per sq. inch inside the hoop should produce as much stress in the hoop when at rest as is produced by centrifugal force when it is revolving at a rim speed of v feet per second. Let us suppose that our ring *is* subjected to an internal pressure of $\frac{.26\,v^2}{32.2\,r}$ lbs. per sq.inch. We know that pressure within a boiler (Fig. 4,) exerts the same effort to tear the shall apart along x x when it acts on the whole interior of the shell as would be exerted if the shell were cut in half and bounded on one side by a partition along a diameter. That is, for a given internal pressure, the same effort will be exerted to produce rupture at x x in case *a* as in case *b* Fig. 4. Another way of stating this is to say that the force tending to produce a longitudinal rupture in a cylindrical shell subjected to an internal pressure p, equals the pressure, times the diameter expressed in inches, times the length, also expressed in inches. To apply this to our rotating hoop, the force which would be exerted by the equivalent internal pressure, whose value we have just found, to burst the ring, would be equal to the pressure, which is $\frac{.26\,v^2}{32.2\,v}$ multiplied by the diameter in inches, $24r$, and by the length of the cylinder (the breadth of the ring,) which was taken as one inch. Collecting this all together, the total bursting force $= \frac{6.24\,v^2}{32.2}$. This bursting force is resisted by the metal on the two sides of the ring, or since the ring was chosen to have a cross sectional area of one square inch, the bursting force is resisted by the strength of the metal in two square inches. or the tension per square inch is one half the bursting force or $\frac{3.12\,v^2}{32.2}$ a formula which for approximate calculations is sufficiently well represented by the well known value $\frac{v^2}{10}$.

It will be observed that this final value for the hoop tension contains only the square of the speed and the number 10 That is it does not appear to make any difference what the shape or size of our rim section is, so long as the speed is known. This is true, and the reasonableness of it may be seen if we think of a wheel rim as composed of a bundle of hoops such as the one we have been considering. Each hoop will develop a certain tension in the material of which it is composed. So will each other hoop. If we add hoops, that is make a bigger rim, we add tension making material and tensile strength in exactly the same proportion. To get at the same idea from a slightly different view point, let us suppose we have a pulley on a shaft rotating at a certain speed. There will be a certain tension set up in the rim let us say equal to $\frac{v^2}{10}$. Now suppose an exactly similar pulley put on the shaft alongside the first, so that their rims touch. The new pulley will also develop exactly the same tension as the the first, but its pressure will in no way either increase or diminish the tension in the first one as the stress in the new pulley is resisted entirely by its own metal. So to carry the idea to its logical conclusion, we might weld up the gap between the two rims, and neglecting for the moment any stresses which might be introduced by the welding process itself, we would not change conditions in the least. So we see that we can double the material in a wheel rim without increasing its stress at a given speed, and by a like sort of reasoning it should be clear that we might cut it in half with the same result. In other words, it is entirely reasonable to suppose that the stress in a wheel rim, at least in so far as the simple hoop tension is concerned, is independent of the size of the rim. One limitation is however present, and should be pointed out at this time. We have arrived at our value for hoop tension by analogy to the stresses set up in a cylinder under the action of an internal pressure. The relation which we have assumed to exist between the pressure inside a cylinder and the stress developed is true for relatively *thin* cylinders, but would not be true for very thick ones where the thickness might be a considerable part of the radius. That is we are not justified in applying our ordinary formulas for the stresses in a boiler shell to the case of very thick walled hydraulic pipe of small bore, nor to the stresses in large guns. So also in the case of flywheel rims, we cannot use this simple value for the hoop tension in the case of solid disks, or wheels having very thick rims indeed. We need not however worry much about its applicability to the usual engine wheels and pulleys, though it should *not* be applied to steam turbine disks or solid plate wheels.

We have so far considered only a simple hoop made in one piece. An actual flywheel is provided with arms and a hub, and if of large size must be made in sections to permit of transportation on standard railway cars, through tunnels and under bridges. The sectionalizing of a wheel when large also simplifies somewhat the foundry practice, and may eliminate in some cases a part of the strains set up in cooling. When arms are introduced into a wheel we meet the first complication in our simple theory. Suppose we consider for a moment a one piece wheel, cast with arms, but from which, let us suppose, all strains of every sort which might result from the contraction of the casting have been eliminated so that we need only be concerned with the stresses due to rotation. When this ideal one piece wheel is rotated the rim tries to expand under the action of the tension we have just calculated. In addition to this the arms, behaving like the bar of Fig. 1, are stretched somewhat by the effect of the centrifugal force of the iron in them. If the arms should be so proportioned that the tension set up in them by the arm material itself was just sufficient to stretch the arms to exactly the same length as would correspond to the new radius which the rim would assume when stretched under the effect of hoop tension, then there would be no effect produced in the rim material by the stiffening action of the arms. If the rim should tend to enlarge faster than the arms would lengthen under their own tension, then a further pull would be exerted on the arms, and they might not be stretched enough by this to quite satisfy the lengthening action of the rim. Indeed this is the more common case, especially where the arms are heavy and the rim light. In such a wheel the rim will tend to bow out between the arms when rotating, and bending stresses will be set up in addition to the simple tension which we have calculated. The magnitude of this bending effect depends not only on how much the arms stretch but on how many arms are present. The sections of rim between the arms become stressed as beams just as soon as the arms exert a restraining influence on the rim stretch. A uniform beam fixed at the ends and loaded with a uniform load per foot of length will deflect under the load by an amount depending on its length, the longer the beam, the greater the deflection. Hence if the arms are far apart greater bending will take place than if they are closer together. Let us return for a moment to the case of the simple hoop rotating without arms. If we should attach arms to it which either because of their own tendency to stretch, or because they do not resist the stretch produced by the elongation of the hoop, become as long as the hoop radius under the new (moving) condition we have stated that the stresses in the hoop are unchanged by the presence of the arms, that is, there would only be the simple tension equal to $\frac{v^2}{10}$. Consider now for a moment the opposite extreme, that is a hoop provided with arms so rigid that they do not stretch to the slightest degree. Since the points in the rim where it joins the arms are perfectly rigid, all the combined effect of the centrifugal force of the rim material must be used up in bending out the sections of the rim between the arms. In this case we will have a rim stressed by pure bending stress and no simple tension. Somewhere in between these two extremes all our actual rims may be found. Part of the hoop tension, $\frac{v^2}{10}$, will be developed because the arms will stretch some. Some bending will occur because the arms will not stretch enough to prevent it. Moreover, it is impossible to determine just what the distribution of stress will be without making arbitrary assumptions as to how much the arms will stretch, and just how the rim will be bent.

We can however arrive at some important general conclusions, which may be checked up with experience, and which will prove valuable. For instance if a wheel has a heavy rim, it will exert a heavy outward pull on the arms. Also if a relatively large number of arms are used, the bending will be slight. Hence a wheel with a comparatively large number of not too heavy arms, attached to a heavy rim should approach the condition of the simple armless hoop much more closely than a wheel with fewer heavy spokes and a thin rim. As we shall show directly this statement checks excellently with experiment.

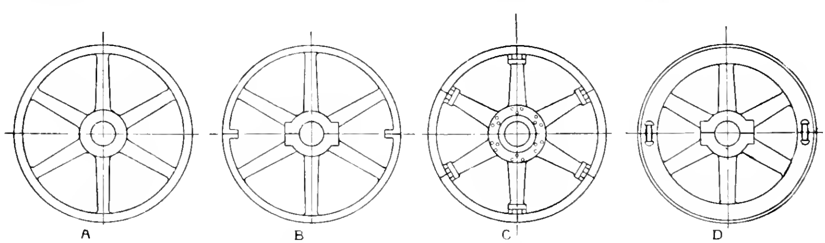


FIG. 5. FLYWHEEL TYPES.

So far we have only considered solid or one piece wheels. It is now necessary to see what effect if any is produced by the segmental construction required, as we have pointed out, for large wheels. In the main, sectional wheels will be found to fall under one of the following classes, which we will arbitrarily refer to as classes B, C and D. We will thus reserve the letter A to represent solid wheels. These types are indicated by the sketches of Fig. 5. Type B will be seen to comprise the wheels cast in halves and joined at the hub by bolts and at the rim by bolted flanges. These flanges are usually located midway between the arms. Class C is distinguished from B by the fact that there are as many rim segments as arms. The joints are made by bolted flanges over the ends of the arms, and the arms are jointed to the rim by bolted pads. In C wheels the arms may be cast solidly to the hub, making a spider, or each arm may constitute a separate casting. and be assembled at the hub by some method of bolting, or by pins, gibs or shrunk bands. D type wheels are made in two or more parts, and joined at the rim by link or prisoner connections at points midway between the arms. The arms are usually cast as a part of the rim segments, and various sorts of hub construction are in use. Sometimes D wheels have a B type bolted flange in addition to the links, with the idea of gaining strength.

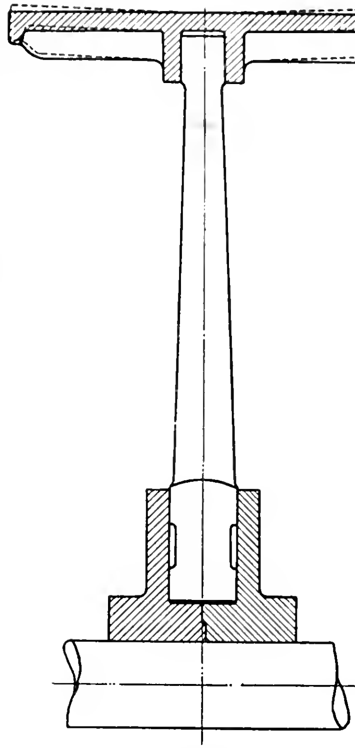


Fig. 6. C Wheel with Excessive Overhang.

With jointed rims new difficulties arise in attempting to analyse the stresses. Take as a case in point the B joint. If the flanges are not heavy and the bolts do not pinch them up to a metal bearing, then the parts of the rim do not receive support against bending from the joint. In this case the two rim portions adjacent to the joint act as cantilever beams, that is, as beams supported at one end only, where they join the arms. The bending is greater than if there were no flange joint, because the flanges exert an added thrust due to their centrifugal force at the point where it will have the greatest effect, that is at the unsupported ends of the beams. The bolts however are not stressed to any great extent by the bending, and have only the tension to carry. On the other hand if the flanges are stiff and heavy to resist bending, and are faced off and securely bolted to a bearing, then the bolts are stressed by the tension in the rim, and in addition, by the bending to an amount which is indeterminate, but which depends in large measure on the design of the joint. This additional bolt stress due to bending will be greater if the line of bolt centers is far from the center of the rim section, and less if they are more nearly in line with the tension, but it will also vary with the depth to which the flanges project below the bolts, provided this inward flange projection is of such a nature that the flanges bear on each other. The weight of the flanges still exerts an added outward thrust due to centrifugal force on the segment of the rim containing the joint. The B type of joint weakens the rim in two ways. First by actually being weaker to resist simple tension than the solid rim, and secondly by introducing an added bending stress at a point which is least able to resist it. This effect may be greater in thin rimmed wheels with few arms than in heavy wheels with more arms, but in any case this construction undoubtedly constitutes the poorest flywheel type. In C wheels, an improvement comes about through putting the joint over the arms where the bending stresses are a minimum, and least likely to be increased by the joint itself. The weakness of this construction arises from the fact that the bolting cannot equal the strength of a similar solid wheel, either circumferentially, that is around the rim, or radially at the ends of the arms, as it is not practical to design the pads and flanges for such large bolts. An added weakness with this construction comes in cases where the wheel face is great and but a single set of arms are employed. This necessitates a liberal overhang of the rim beyond the arms, so that at every spoke there are portions of the rim flange joint which receive no support from the arms. Fig. 6, which is a section of such a wheel will make this clear. When running at speed, the overhanging parts of the flanges are forced outward by the centrifugal force of the metal in them, and the tendency is for the wheel to have less crown while running than at rest or in extreme cases even to assume a grooved or hour glass form. Wheels have been seriously damaged by the development of this weakness. If D wheels did not need to have metal removed to make the pockets into which are shrunk the links or prisoners, and if links of sufficient strength and number could be inserted so that the efficiency of the joint, using the word efficiency in exactly the same sense as in referring to riveted work, could be 100%, then this construction would be nearly ideal, as it does not introduce any new bending stresses. This can be done, and has indeed been done by Mr. John Fritz of the Bethlehem Steel Co., for large rolling mill wheels. To get the increased joint efficiency he made his rim hollow, thickening it internally, by cutting down on the size of the cores in the neighborhood of the joint to just sufficient extent to compensate for the metal removed to make the recesses for the links. In this way he was able to get in links of a strength equal to that of the solid rim, and so produced a wheel which was equal in strength to a solid wheel, but with none of the consequent complications of transportation or machining. In order to get the full benefit of his construction, and also to make the foundry practice as good as possible, he cast a spoke integrally with each rim section, and joined the spokes to the hub in a very strong and workmanlike manner. Fig. 7, represents this wheel. The Fritz wheels are costly and somewhat large for their weight or inertia, but they are unusually strong. No one of them has ever failed even in the severest rolling mill service, and it is doubtful if a stronger cast iron wheel of large size can be designed.

The experimental study of flywheels in this country has been largely the result of the efforts of one man. Prof. C. H. Benjamin, working first at the Case School of Applied Science, in Cleveland, O., and later at Purdue University, Lafayette, Ind., aided by various students and instructors, has been responsible for about all the existing test data on wheels of American types. Prof. Benjamin evolved the idea of testing scale models of wheels in a safe enclosure, by speeding them up to the bursting point by means of a driving mechanism which could provide a source of variable but controlled and measured speed. In this way he was able to measure accurately the speed at the instant of rupture and to study carefully the fragments of the wheel and learn from them the story of the weaknesses developed. His experiments

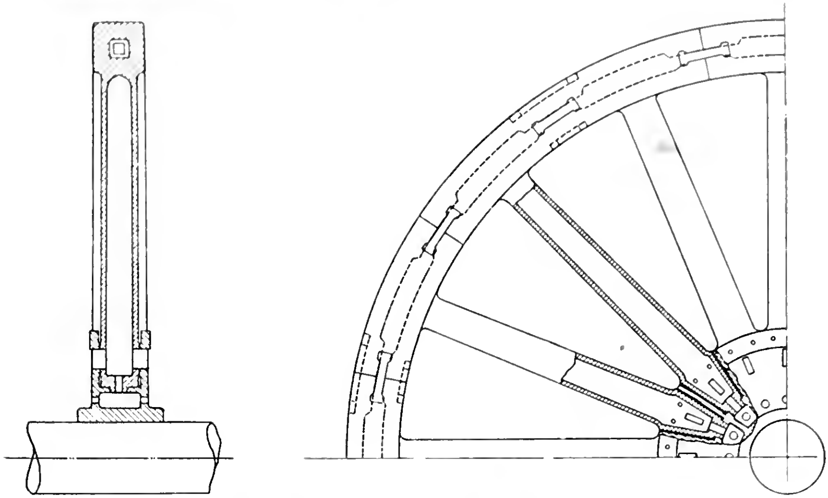


FIG. 7. WHEEL DESIGNED BY MR. JOHN FRITZ.

were not by any means dull or uninteresting and furnished many an exciting moment when his carefully designed bomb proofs proved inadequate to their task of retaining the flying fragments. His first experiments were on small fifteen inch models, each made to scale and of tested material, whose strength was known. Not satisfied with the results obtained from testing such small wheels he tried 24 inch models, and later with a much better equipment, he burst wheels as large as 48 inches in diameter. Larger wheels did not commend themselves to him as safe playthings, in the light of some of his more thrilling experiences with the four foot ones. His work is of the greatest interest, and should be read in his own words by any one interested in a more detailed study of the subject. To this end we have omitted specific references in the text of this paper to the various articles available, but we will append a bibliography of the subject at the end for easy use.

The conclusions arrived at by Prof. Benjamin from his experiments are as follows: A solid wheel of fairly thick rim and sufficient number of arms will break at a speed which indicates that the stress is approximately that to be expected in a simple hoop, that is $\frac{v^2}{10}$. Thinner rimmed belt pulleys with fewer arms are less strong, and often broke in the experiments from the centrifugal force developed by pieces of metal bolted or riveted to the thinnest portion of the rim to balance the wheel. Such a balance weight both adds a concentrated load to the weakest wheel section, and in addition requires the drilling of a bolt or rivet hole to still further weaken this section. B type wheels, with thick rims and many spokes, such as are frequently found as engine wheels, will ordinarily show about 25% of the strength of corresponding solid wheels. Thin belt pulleys of B type are even weaker relative to their solid counterparts. In like manner he found C wheels of usual proportions about 50% as strong as corresponding A wheels, and well proportioned D wheels developed about 60% of the corresponding A wheel strength. The appearance and position of the fragments of wheels inside his enclosures after bursting abundantly confirmed the views on bending stresses which we have discussed above. This was notably so with wheels of the B type. No data was obtained to assist in calculating the exact stress distribution, but because the breaking speeds of wheels of the different classes were consistent, it becomes possible, as was pointed out in the October, 1915, Locomotive when describing the Hartford Fly-wheel Calculator, to determine an equivalent simple tension which would have stressed the wheel to the breaking point, at the actual observed speed, if it could have replaced the complex combination of bending stress and tension which really existed. This equivalent tension is the stress which the calculator indicates under the caption "stress per square inch of rim section" except that the equivalent tension may be obtained by the calculator for any speed, and is not confined to the breaking stress.

Mention has been made of the weakness of the B wheel from the centrifugal force of the rim flanges and the lack of rigidity offered by the sections of the rim containing the joints to resist bending. An effort has been made to overcome this weakness in existing wheels so as to permit of operation at increased speeds, by installing tension tie rods between the rim joints and the hub. The intent of this construction is to put tension members, adjusted by turnbuckles, where they can take up the centrifugal force of the flanges and brace the rim against excessive bending. Most installations of tension rods in B wheels are faulty because the rods have been designed with regard merely to the ability of the rod material to carry the centrifugal force. This does not require a very large rod in most cases, but the fact that steel or wrought iron will stretch much further than cast iron under a given stress is entirely lost sight of. A moment's consideration will show that if the rods are not large enough to carry the imposed loads with practically no stretch, then the rim will have to bend before any of the undesirable load is communicated to the tie rods, and it may well be that the rim would be stressed to near the breaking point before the rods became of any appreciable assistance. Prof. Benjamin found, on testing B wheels so strengthened, that if rods of approximately two-thirds the strength of the arms were used, the wheels were materially strengthened by them, and developed a much greater proportion of the strength obtainable with an A wheel. In passing upon an installation of tie rods, one should see that they are stiff enough, that they are fastened to the hub and to the flanges in such a manner that they do not overload or cripple any of the hub or flange bolts, and that they are set up to as near an equal tension as may be. This should not be a severe stress, only enough initial tension is required to prevent whipping and rattling, and the equality of tension in the different rods may be judged by the pitch of the tone emitted when they are struck with a hammer. They should be "tuned" to speak in unison. One serious consequence of too much tension, improperly distributed among the tie rods of a wheel is to pull it out of true, which will nearly always introduce wholly unnecessary stresses in the wheel material.

The question of practical speed limits for fly-wheels arises at this point. What speeds are to be considered safe for wheels of different types in the light of these experiments and of our knowledge of the bending stresses? In the first place the expression for the simple tension which we would get in an armless hoop, as well as that for the centrifugal force itself which gives rise to all the stresses we have considered contains the quantity v^2. That is the stresses increase as the square of the rim speed v. Since the rim speed is equal to 3.1416 multiplied by the diameter of the wheel expressed in feet, and by the number of revolutions per second, it follows that the stresses are proportional to the square of the number of revolutions per second. Hence if we double the speed we increase the stresses to four times their original value, or if we cut the speed to ⅓, we shall diminish the stresses to 1/9 their former value. Cast iron, even when we are assured that we have a homogeneous specimen, is a material of somewhat uncertain strength. Flywheels are castings which can never be positively asserted to be homogeneous. No one can tell without breaking them in fragments whether they do or do not contain inclusions of weak and porous iron, or even cold shuts and bubbles or blow holes. Even slag and cinder may be present if the skimming of the ladle in pouring has been neglected. Add to this uncertainty the fact that some stresses due to cooling and shrinking are sure to be present, even when the greatest care and skill are exercised, and it will be seen that a high safety factor is imperative. At least 10 is usually considered necessary.

Large A type wheels are considered as always presenting a possibility of shrinkage strains. D wheels are known to be less affected by cooling strains than A wheels but are weakened at the rim joints. It is not good practice, every thing considered, to operate either A or D wheels at rim speeds in excess of 110 feet per second, or 6600 feet per minute.

B wheels present a harder problem. All our reasoning and all our experiments prove them weak members indeed as compared to good wheels of other types. Still, they have been found to operate with fair safety, when well designed, at usual belt speeds, which in the past have had an upper limit at about 5000 ft. per min., or say from 83 to 84 ft. per sec. The modern tendency in belt drives is toward higher speeds, and for this service wheels other than of the B type should be employed. Where a speed of 5000 feet per minute is absolutely required, a good sound B wheel, if it is classed as absolutely A1 by a thoroughly trained inspector may serve. It is desirable however to keep inside this limit and no doubtful or uninspected B wheel should be operated up to this speed. It is far safer to limit thin rimmed B pulleys to from 3000 to 4000 feet per minute, and all counterweights should be treated as suspicious.

C wheels are to be considered usually on their individual merits. If well designed and presenting no excessive overhangs, they may operate safely at speeds between the B and the D or A type, say from 5000 to 6000 feet per minute. Each wheel however should be investigated, together with its driving mechanism before a limit is established.

It will be well, while on the subject of speed limits, to consider in a general way the problem of gears. Gear wheels present the case of a wheel whose strength to resist tension and bending is confined to the solid part of the rim at the root of the teeth. The stress imposed is that due to the centrifugal force of the material both in the solid part of the rim and in the teeth. The teeth in this way add load but do not contribute to the strength, while in addition, stresses are imposed on the solid rim at the roots of those teeth which are in mesh at any instant owing to the thrust of the driven load. Gears will not be treated here any further than to point out that they may never be allowed to run at speeds as great as would be safe for plain wheels of corresponding types of rim joint. The exact limit would require careful analysis of the particular case involved.

One problem which comes up whenever a wheel is under consideration to determine its safe speed limit, is that of the rim bolting. In D type wheels this is a simple matter. One should calculate the hoop tension as if the wheel were an A wheel, that is, calculate $\frac{v^2}{10}$. This value should be multiplied by the number of square inches of cross section of the rim at a point where there are no recesses for links, which will give the total tension. Then add together the cross section of all the links at one joint. Divide the total tension by the link section and the result will be the tension per square inch of link material. It is also well to check the matter by dividing the net cross section of the rim taken through the link recesses by the total tension to see if so much material has been removed in the link pockets as to make the wheel unsafe by concentrating the stress in the remaining cast iron.

C and B wheels are usually checked by a simiiar method. The stress per square inch of bolt section is determined exactly as in the case of the links in the D wheel. It must be borne in mind however that except in the hands of a trained engineer who is accustomed to weigh the characteristics of wheel design this calculation is practically valueless. It does *not* indicate even approximately the stress in the bolts, which is made up of some fraction of this tension, plus a stress of unknown amount due to the bending, plus an unknown initial stress attributable to the strong arm methods of the man who set up the bolts when the wheel was erected. All these things must receive consideration, and so the proper size and number of bolts becomes largely a matter of judgment based on experience with the performance of other wheels.

Bibliography of Some of the More Important References on the Subject of Flywheel Strength.

Topical Discussion on Recent Developments in Wheel Testing.
C. H. Benjamin, Journal A.S.M.E., June, 1910, p. 1099.
The Bursting of Four Foot Flywheels.
C. H. Benjamin, Trans. A.S.M.E., vol. XXVI p. 232.
Bursting of Small Cast-iron Flywheels.
C. H. Benjamin, Trans. A.S.M.E., vol. XXIII p. 168.
A Note on Flywheel Design.
A. J. Frith, Trans. A.S.M.E., vol. XXI p. 317.
A Broken Flywheel and How it Was Repaired.
James McBride, Trans. A.S.M.E., vol. XXI p. 262.
Rolling Mill Flywheels.
John Fritz, Trans. A.S.M.E., vol. XX p. 944.
The Bursting of Small Cast-iron Flywheels.
C. H. Benjamin, Trans. A.S.M.E., vol. XX p. 209.
Note on the Strength of Wheel Rims.
A. K. Mansfield, Trans. A.S.M.E., vol. XX p. 125.
Stresses in Rims and Rim Joints of Pulleys and Flywheels.
Gaetano Lanza, Trans. A.S.M.E., vol. XVI p. 208.
Strength of Rim Joints in Fly-band-wheels.
J. B. Stanwood, Trans. A.S.M.E., vol. XV p. 147.
Strains in The Rims of Fly-band-wheels.
J. B. Stanwood, Trans. A.S.M.E., vol. XIV p. 257.
Development of Flywheels.
C. H. Benjamin, Cassiers' Magazine, vol. XVIII p. 248.

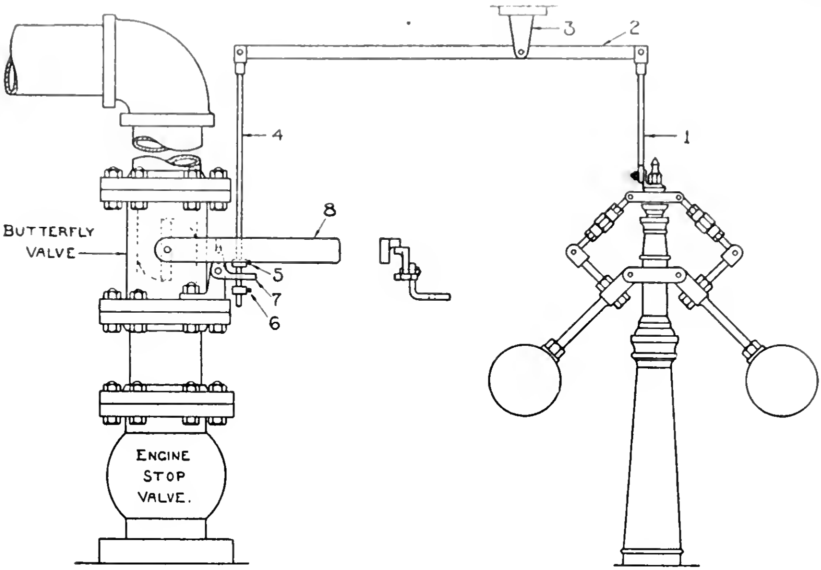


FIG. 1. HOME-MADE ENGINE STOP.

A Home-made Engine Stop.

J. SIMPSON, Inspector.

It is sometimes necessary to devise safety appliances which may be made from materials easily obtained, so that an otherwise satisfactory piece of apparatus may be brought to the requisite standard of safety with a minimum of expense. A problem of this sort was solved by the design of the engine stop illustrated in Fig. 1.

The case involved an engine with a governor which had no stop to act in the event of belt breakage, corresponding to a corliss engine without safety cams. The device as installed consisted of a butterfly valve placed directly above the engine throttle. The disc of the butterfly valve was arranged to be moved by a heavy lever keyed to its stem in such a way that the weight of the lever was sufficient to close the valve. The closing lever was supported in a horizontal position, which corresponded to the open position of the valve, by a projection on the side of the lever which caught on the top of a forked bell crank lever 7. This little lever 7 was pivoted as shown to a small forged bracket fastened to the valve body by one of the flange bolts. A rod, 1, was attached to the top of the governor, and extended upwards to connect with the horizontal lever, 2, pivoted at 3 to a point on the ceiling. The other end of the lever 2 carried a rod which dropped down and hung between the forks of the bell crank lever 7. This latter rod was provided with two collars 5 and 6, which could be set to trip the bell crank and release the valve closing lever whenever the governor reached either the top or bottom of its travel. Thus the device would serve to either stop the engine upon the failure of the driving belt so that the governor would stop revolving and fall to the extreme bottom of its travel, or it would also act in the event of an increase in speed sufficient to send the governor to the extreme top of its range.

The entire device with the exception of the butterfly valve, which was purchased new, was made from materials at hand, mostly from the scrap pile.

The arrangement proved entirely satisfactory, and was retained and re-installed when the engine was erected in a new location. A similar rig could easily be attached to almost any flyball governor, except those so built that the spindle does not rise and fall with changes in speed, and its simplicity and cheapness should commend it.

Kitchen Boilers as Air Storage Reservoirs.

The automobile has done much to add to the convenience of living, but it has also been responsible both directly and indirectly for a considerable increase in the danger of living. The growth in popularity of the automobile has brought to the front the garage industry in every part of the country. The garage stands primarily for service, and not the least of the forms of service gratuitously rendered the passing motorist, with the idea of retaining his good will and future patronage, is that of supplying him with an abundance of air under pressure for tire inflation.

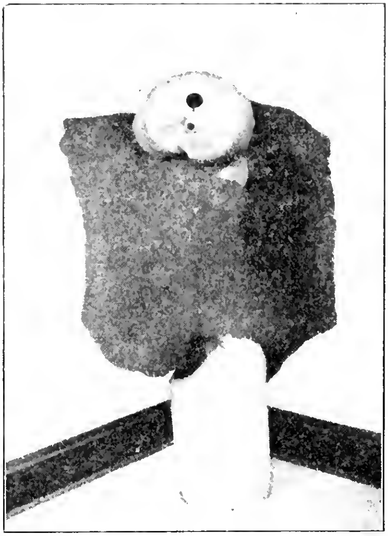
When a garage owner decides to install an air service, he obtains a small compressor and soon finds that a storage tank is a necessary adjunct to the system. Air must be stored at something over 100 lbs. pressure, usually about 150 lbs., to insure the rapid inflation of tires to pressures ranging from 60 to 90 lbs. through small tubes with a large frictional resistance. The air service is ordinarily free hence the proprietor of the small garage endeavors to install his air outfit as economically as possible. Being generally a handy man, he picks up the first tank which offers, which proves in the great majority of cases to be a new or second hand kitchen range boiler. These boilers are light, of about the right size, are fitted with openings tapped for standard pipe connections, and can be had for a moderate cost. Further they are often stamped with test pressures of 150 or 200 lbs. If the garage owner has not had experience with pressure vessels before, he is not to be altogether blamed for his choice. It is a perfectly natural one. However the mortality among these improvised kitchen boiler air tanks is increasing at a very rapid rate, and for perfectly good and well known reasons.

The kitchen boiler will usually fall under one of three types of construction. It may be of steel or iron plate with riveted joints, of steel or iron plate with welded joints, or of copper. The copper tanks are sometimes riveted and sometimes brazed, but as they are relatively expensive, they are seldom installed as air receivers. The welded steel tanks, being a more recent development than the riveted ones are not yet so common, and so by far the greater part of the kitchen boiler air tanks will be found to be of steel or iron plates with riveted joints, galvanized outside and in. The shell plates are commonly about $\frac{3}{32}$ inch thick, longitudinal seams of the lap type single riveted with $\frac{1}{4}$ or $\frac{5}{16}$ inch rivets pitched from $\frac{3}{4}$ to 1 inch apart. The heads are thicker, averaging, say, $\frac{1}{8}$ inch. The top head is ordinarily bumped, while the bottom one is dished to facilitate riveting. A usual capacity is 30 gallons, obtained in a tank a foot in diameter by five feet long.

Nearly every exploded kitchen boiler air tank which has come under our observation has come to grief through the formation of a lap crack. All the conditions are favorable to this when the tank is used as an air receiver, although it is not a common mode of failure for the same type of tank in the service for which it was designed. The reason for this is not hard to find. The tanks are made of extremely light plate and at pressures of from 80 to 125 lbs. will show safety factors ranging from 5 to 3. They are intended to be installed in connection with city service, and to carry a steady pressure equal to that in the service mains. Aside from slight fluctuations as between day and night or week-day and Sunday conditions of water consumption they do not receive either sudden or frequent pressure changes. Hence there is no notable breathing action and the tank will usually fail from corrosion long before it could develop a lap crack. On the other hand, when it is installed as an air reservoir, it is subjected to a sudden fall of considerable amount, and a subsequent rise to full pressure whenever air is used. In this way the breathing will be of considerable amount and will take place frequently. Add to the above the facts of small safety factors and light plate poorly adapted to resist bending, and one can readily see the reason for the prevalence of lap cracks.

It may be well to consider what the safety factor is in a specific case. Many of the single riveted joints used on the longitudinal seams have an efficiency ranging between 53 and 55%. As a case in point let us consider the tank the explosion of which was recorded in the July, 1915, LOCOMOTIVE. Here the plate thickness was $\frac{3}{32}$ inch for the shell and $\frac{1}{8}$ inch for the heads. All joints were single riveted with $\frac{1}{4}$ inch rivets pitched $\frac{3}{4}$ inch apart. The tank was 12 inches in diameter by 70 inches long. The efficiency of the longitudinal joint figures 53%, giving a bursting pressure of 403 lbs. per square inch. Calculated on a safety factor of five, the safe working pressure should be 80.7 lbs. while at the pressure of 150 lbs. usually desired for tire inflation the factor of safety would be not quite 2.7. To be sure this tank was so weakened by corrosion and a previous lap crack that had been *soldered* that it burst at 45 lbs. pressure severely injuring a man, but it would not have been safe in air service when new. Still it is said to have been sold as good for 200 lbs. and very likely had withstood a test pressure of that amount.

To further emphasize the need for care in choosing an air receiver, we have calculated the energy which a 30 gallon tank could turn loose if it should explode when filled with air at a pressure of 150 lbs. per square inch gage. To do this we have made use of the well known formula for the work done by the expansion of a unit volume (1 cu.ft.) of air from 150 lbs. gage to 0 lbs. gage assuming that the expansion would be so rapid that no heat could flow into or out of the expanding air during the process. This assumption is well known to be accurate enough for computing the expansion and compression of air in sound waves and should not be seriously in error in this case. It is known as the adiabatic condition. The calculation, which gives the maximum energy which would result from a very sudden explosion, indicates that the tank we have assumed might develop about 237500 foot pounds of energy. If it weighed



Figs. 1 and 2. Exploded Air Tank in a California Garage.

60 lbs. this energy would be enough to project it about 7000 feet in the air with an initial velocity of 635 feet per second if its flight were unimpeded. It is not so very strange then that damage of a considerable amount should result from these tank failures.

Finally, in proof of the assertion that tanks do fail in the manner which we have just discussed, we present photographs of the remains of a tank which burst recently in a California garage. This tank was 12 inches in diameter by 60 inches long, with 1/8 inch heads bumped to a radius equal to the diameter of the tank. The shell plate was .078 in. thick, single riveted with 5/16 in. rivets, but of unknown pitch so that we cannot calculate the joint efficiency. It probably did not differ materially from the one described above. The working pressure was unknown, no gage or safety valve being attached, and was only limited by the pressure governor or regulator attached to the compressor. The tank went through the side of a building, but as no one was in range there were no personal injuries. Cause: lap crack.

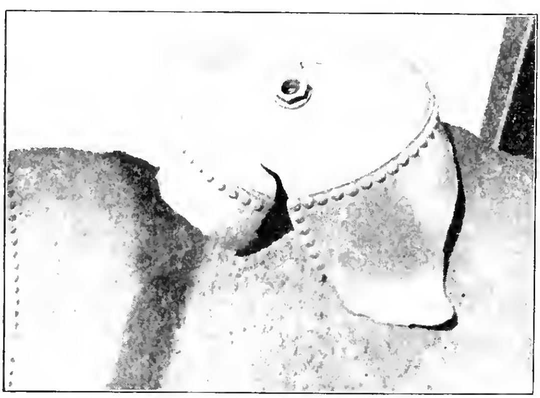


Fig. 3. A Closer View of the Tank Head.

It might be well to add to this article a word as to what we should consider a proper tank for this service. We should recommend a tank built of high grade material at least equal to flange steel, and not less than ¼ inch for the smallest tanks. The heads should be thickened in proportion following the rule used for bumped boiler heads. While we might not consider it necessary to use a butt strapped joint for tanks of small diameter, we should at least require a well designed double riveted lap joint. We think a very excellent tank of small capacity could be made from a piece of 10 or 12 inch extra heavy steam pipe. In any case hand holes should be provided to afford access to the interior for inspection and cleaning.

The Explosion of a Poker.

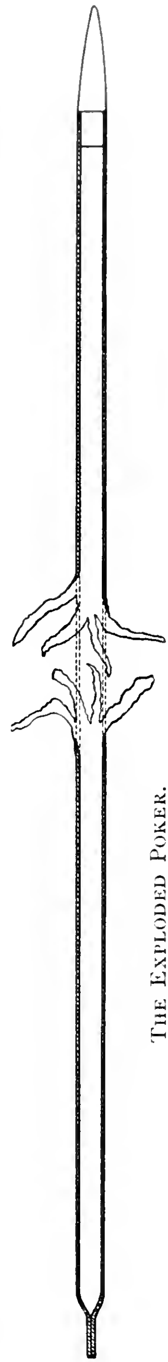
T. F. Connery, Inspector.

From time to time there appear in The Locomotive, accounts of explosions of various things other than steam boilers and flywheels, such of Bed Warmers, Spanish Omelets, etc. Now, my subject relates to a poker, — not of the kind, however, one would imagine used in prodding the fire under a Spanish Omelet to put it in an explosive state, but one that was used in this section at a large central steam heating plant containing three water-tube boilers.

The poker in question was about 10 ft. long, made of heavy tubing ⁵⁄₁₆″ thick, 1½″ outside diameter. This poker had been doing duty for some time with the fire end hammered together, the other end open. After doing its stunt, it would be thrown back on the coal pile in front of the boilers; in this way, no doubt, some fine coal found its way through the open end, but the end being open, it could also give vent to its feelings (or rather that of the gas from it) when the poker got hot. One day it was decided to fix the thing in better shape, so it was taken to a blacksmith's shop and a solid joint welded on the end that had been open, leaving the old fire end closed. On the evening of the day that the supposed improvement was made, the fireman was using it quite frequently; consequently, it became very hot and almost instantly, after drawing it from the fire and throwing it back on the coal pile, there was a terrific explosion, throwing the fireman against the fire door and shaking the whole building, raising a cloud of smoke and dust, the concussion being felt by people living in the vicinity of the plant. The fireman was most fortunate that the ragged edges of the metal did not strike him. The tubing tore in shreds, resembling in a manner, cat-o-nine tails. The sketch will give some idea of what it looked like.

The one used now is capped at the end, so no coal can enter it, a precaution that it always well to take.

A poker such as described is harmless looking enough lying about in a boiler room or beside a brick kiln, but it can become quite ferocious under the conditions mentioned above.



The Exploded Poker.

The Locomotive
of
THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

C. C. PERRY, EDITOR.

HARTFORD, APRIL, 1916.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

We are being impressed with idea of preparedness, preparedness for war, preparedness for peace, military preparedness and industrial preparedness. Boiler inspection and insurance is of the very essence of preparedness, and that regardless of the particular brand of the article understood by the term. Power is the fundamental basis of production, and production, whether of munitions of war or articles of peaceful commerce is the cornerstone of preparedness. Sound power plant, safely installed and operated is the foundation of the industrial structure. It is best secured and maintained with the aid of Boiler and Flywheel inspection and insurance. Reliability of operation may well be of incalculable value in an emergency. It is of the same importance that a manufacturer should insist on the proper protection of his power producing plant as for an army commander to safeguard and protect his supplies and communication. Of course there is but one best form of this particular kind of preparedness, The Hartford's.

Personal.

Mr. C. H. Dennig, Special Agent in the Philadelphia office of the Hartford, has been promoted to the position of Assistant Manager in that department.

Mr. Dennig first joined the agency force of The Hartford in 1902, in the New York Office. He later served in the Denver Department but in 1910, after a short stay at Detroit, he went to Philadelphia, where his service has been of such a satisfactory character as to merit his present promotion.

Obituary.

Richard J. Rice.

Richard J. Rice, one of the older inspectors in the Home Office of The Hartford Steam Boiler Inspection and Insurance Co., died March 18, 1916, at his home in Hartford.

Mr. Rice was born at Chicopee, Mass., November 5, 1857. He learned the trade of boiler making, and later served as a steam engineer before he settled to his life work of boiler inspecting. He joined the inspection force of The Hartford at the Home Office in June, 1886, and continued in that capacity until his death, a service of almost thirty years. A keen inspector, Mr. Rice combined efficient mechanical judgement with a ready wit and a bright personality. He was well liked by everyone. Although his health had not been such for some months prior to his death as to permit him to engage in active work, he was ill but a few days.

Mr. Rice is survived by a wife and ten children, his oldest son, Thomas F. Rice being a clerk in the Home Office of the Company.

Summary of Boiler Explosions, 1915.

We append our usual annual compilation of boiler explosions, listed by months, with the number of explosions, number killed, injured, and the total of killed and injured. While we cannot claim absolute completeness for this list we have endeavored to make it as complete and accurate as possible, and trust it may be of interest to our readers.

Summary of Boiler Explosions for 1915.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January	38	15	18	33
February	39	17	5	22
March	30	8	19	27
April	18	4	7	11
May	26	16	14	30
June	18	3	11	14
July	22	8	13	21
August	34	13	44	57
September	40	3	19	22
October	51	19	46	65
November	38	10	12	22
December	50	16	28	44
Totals	404	132	236	368

Summary of Inspectors' Work for 1915.

Number of visits of inspection made	199,921
Total number of boilers examined	373,269
Number inspected internally	140,002
Number tested by hydrostatic pressure	7,998
Number of boilers found to be uninsurable	790
Number of shop boilers inspected	8,060
Number of flywheels inspected	17,331
Number of premises where pipe lines were inspected	4,922

Summary of Defects Discovered.

Cases of sediment or loose scale	26,808	1,963
Cases of adhering scale	42,673	1,557
Cases of grooving	2,718	302
Cases of internal corrosion	17,843	867
Cases of external corrosion	10,872	932
Cases of defective bracing	973	246
Cases of defective staybolting	1,923	423
Settings defective	9,029	858
Fractured plates and heads	3,371	535
Burned plates	5,310	457
Laminated plates	354	40
Cases of defective riveting	1,516	274
Cases of leakage around tubes	10,670	1,475
Cases of defective tubes or flues	14,156	6,683
Cases of leakage at seams	5,060	420
Water gages defective	4,203	733
Blow-offs defective	5,185	1,616
Cases of low water	412	118
Safety-valves overloaded	1,489	453
Safety-valves defective	1,661	493
Pressure gages defective	7,958	1,050
Boilers without pressure gages	40	40
Miscellaneous defects	3,768	632
Total	178,992	22,077

Grand Total of the Inspectors' Work from the Time the Company Began Business, to January 1, 1915.

Visits of inspection made	3,903,843
Whole number of inspections (both internal and external)	7,850,589
Complete internal inspections	3,082,380
Boilers tested by hydrostatic pressure	332,890
Total number of boilers condemned	24,975
Total number of defects discovered	4,703,061
Total number of dangerous defects discovered	495,399

Summary of Inspectors' Work since 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1876	16,409	34,275	10,669	2,150	16,273	4,275	89
1877	16,204	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595
1895	98,349	199,096	76,744	8,373	144,857	14,556	799
1896	102,911	205,957	78,118	8,187	143,217	12,988	663
1897	105,062	206,657	76,770	7,870	131,192	11,775	588
1898	106,128	208,990	78,349	8,713	130,743	11,727	603
1899	112,464	221,706	85,804	9,371	157,804	12,800	779
1900	122,811	234,805	92,526	10,191	177,113	12,862	782
1901	134,027	254,927	99,885	11,507	187,847	12,614	950
1902	142,006	264,708	105,675	11,726	145,489	13,032	1,004
1903	153,951	293,122	116,643	12,232	147,707	12,304	933
1904	159,553	299,436	117,366	12,971	154,282	13,390	883
1905	159,561	291,041	116,762	13,266	155,024	14,209	753
1906	159,133	292,977	120,416	13,250	157,462	15,116	690
1907	163,648	308,571	124,610	13,799	159,283	17,345	700
1908	167,951	317,537	124,990	10,449	151,359	15,878	572
1909	174,872	342,136	136,682	12,563	169,356	16,385	642
1910	177,946	347,255	138,900	12,779	169,202	16,746	625
1911	180,842	352,674	140,896	12,724	164,713	17,410	653
1912	183,519	337,178	132,984	8,024	164,924	18,932	977
1913	192,569	357,767	144,601	8,777	179,747	21,339	832
1914	198,431	368,788	145,871	8,239	190,882	23,012	756
1915	199,921	373,269	140,002	7,998	178,992	22,077	790

Boiler Explosions

OCTOBER, 1915.

(Continued from Jan. 1916 Locomotive.)

(304.) — On October 24 a section ruptured in a cast iron sectional boiler at the Young Women's Christian Association, Richmond, Va.

(305.) — A boiler ruptured October 24, at the gin of The Rotan Farmers District Gin Association, Rotan, Tex.

(306.) — A section ruptured October 25 in a cast iron sectional heater at the apartment house of The Rocky Crest Realty Co., Morningside Ave., New York City.

(307.) — A tube ruptured October 25, in a water tube boiler at the packing house of Swift and Co., Union Stock Yards, Chicago, Ill.

(308.) — On October 26, the crown sheet of a locomotive collapsed at the saw mill of The Brooks-Scanlon Co., Kentwood, La. One man was injured.

(309.) — A boiler belonging to The Oliver and Myers Lumber Co., exploded October 26, at New Augusta, Miss. Four men were injured, two of them seriously.

(310.) — A blow-off failed October 28, at Mill No. 1, of The Grendell Mills, Greenwood, S. C.

(311.) — On October 29, a tube ruptured in a water tube boiler at the plant of The Empire Gas and Electric Co., Auburn, N. Y. One man was injured.

(312.) — On October 30, a boiled ruptured at The Farmers and Merchants' Gin and Mill Co., plant of The Birge-Forbes Co., Anna, Tex.

(313.) — A tube ruptured October 30, in a water tube boiler at the plate mirror factory of The Zahn and Bowly Co., East Rutherford, N. J.

(314.) — Three sections cracked October 30, in a cast iron sectional heating boiler at the restaurant of The Horn and Hardert Co., W. 42nd St., New York City.

(315.) — On October 30, the crown sheet of a locomotive collapsed on the New Orleans Great Northern Railroad, Bogalasa, La. One man was killed, and one injured.

(316.) — A traction engine boiler exploded about October 29, at Portland, N. D. One man was injured.

NOVEMBER, 1915.

(317.) — On November 1, a tube ruptured in a water tube boiler at the power plant of The Middle West Utilities Co., Newcastle, Ind.

(318.) — A boiler exploded November 1, at the pumphouse of the Lynchburg Collieries Co., Vanetta, W. Va. Two men were killed.

(319.) — The boiler of a traction engine exploded November 3, at the farm of George A. Bean, Lenore, Ky. Mr. Bean was killed, while his engineer was badly scalded.

(320.) — A boiler used in connection with a sheep dipping vat exploded November 4, at Clinton, Mich. One man was injured.

(321.) — On November 5, three cast iron headers ruptured in a water tube boiler at the plant of the Winchester Repeating Arms Co., New Haven, Conn. Two men were injured and the boiler considerably damaged.

(322.) — A cast iron sectional heater ruptured November 5, at the restaurant of Horn and Hardart, 250-252 W. 42d St., New York City.

(323.) — Three men were injured November 8, in a boiler accident at the plant of The Crucible Steel Co., Harrison, N. J.

(324.) — On November 10, three sections of a cast iron sectional boiler ruptured at the moving picture theater of Josephine F. Brown, Danvers, Mass.

(325.) — A section ruptured in a cast iron sectional boiler November 11, at the theater of The Loew's Theatrical Enterprises, 1022 Southern Boulevard, New York City.

(326.) — A boiler exploded November 11, at Stiffler's saw mill near Cross Keys, Pa. Two men were killed and two others injured.

(327.) — A boiler exploded November 12, at the power house of the Oliver Springs Light and Power Co., Oliver Springs, Tenn. One man was injured and the town thrown into darkness pending repairs to the plant.

(328.) — An explosion wrecked the boiler room of Hoffman Hall, at the General Theological Seminary, New York City, on November 12.

(329.) — The heating boiler exploded November 12, in the apartment house at 4024 Clarendon Ave., Chicago, Ill., The newspaper account says that "Vandals let the water out."

(330.) — A tube failed November 13, in a water tube boiler at the plant of the Anderson and Middleton Lumber Co., Aberdeen, Wash.

(331.) — A boiler burst November 13, on the Maine Central R. R., near Ayer's Junction. Three men were injured, one fatally.

(332.) — Six sections crecked November 15, in a cast iron sectional heating boiler at the hospital of the Great Southern Lumber Co., Bogalusa, La.

(333.) — A steam heated tank, used for boiling hog feed, exploded November 15, at the plant of the Thomas Canning Co., Grand Rapids, Mich. No one was injured.

(334.) — On November 16, a section and several nipples failed in a cast iron heating boiler at the office building of H. S. Chase, Des Moines, Ia.

(335.) — A section cracked November 16, in a cast iron sectional heating boiler at The Irving School, City of Ada, Oklahoma.

(336.) — On November 16, two sections cracked in a cast iron sectional boiler at the drug store of W. E. Blood, Beloit Kans.

(337.) — On November 19, a blow-off pipe ruptured at the shingle mill of the Capitol Shingle Co., Tennio, Wash. One man was injured.

(338.) — A tube ruptured in a water tube boiler at the plant of the Montreal Mining Co., Hurley, Wis., on November 20.

(339.) — On November 20, a section cracked in a cast iron sectional boiler at the Fourth Ave. School, Hutchinson, Kans.

(340.) — Six cast iron headers ruptured in a water tube boiler at the plant of The Pollock Becker Co., Astabula, O.

(341.) — A boiler ruptured November 20, at the light plant of the Borough of Grand, Grand, Pa.

(342.) — An air tank exploded under a trolley car at St. Louis, Mo., on November 20. No one was injured, but portions of the tank damaged an automobile and entered the plate glass window of a store front.

(343.) — A boiler exploded November 20, at the plant of the Distilled Water Ice Co., Dixon, Ill. The property damage was stated to be large.

(344.) — A workman who was attempting to tighten a leaking washout plug on an Illinois Central Locomotive, while the engine was under steam, was seriously injured November 22, at Cairo, Ill. The plug was loosened by the hammer blows and blew out, scalding the workman very severely.

(345.) — A hot water boiler exploded November 23, in the basement of the residence of Albert A. Doub, Washington St., Cumberland, Md. The property damage was estimated at $1,500.

(346.) — A boiler exploded November 23, at Boiler House No. 7 of the Mill Creek Colliery, New Boston, Pa. Two men were literally blown to pieces, and the boiler house was demolished.

(347.) — Two sections ruptured November 23 in a cast iron heater at the Primary School, Windsor Locks, Conn.

(348.) — On November 25, five sections cracked in a cast iron heating boiler at the station of The Standard Oil Co. of New York, Hartford, Conn.

(349.) — On November 26, two sections ruptured in a cast iron sectional heating boiler at the restaurant of The Horn and Hardart Co., 106 W. 43d. St., New York City.

(350.) — The crown sheet of a locomotive boiler collapsed November 27, at the saw mill of C. W. Cummings, Cummings, S. C.

(351.) — On November 28, seven sections ruptured in a cast iron sectional heating boiler at the Y. M. C. A. Building, Johnstown, Pa.

(352.) — A hot water boiler exploded November 28, at the house of M. Livingston, electrician at the Pontiac State Hospital, Pontiac, Mich. The house was wrecked but no one was injured, although a bed on which Mr. Livingston's two daughters were sleeping was dropped down through the floor to the story below.

(353.) — A boiler exploded November 28, at the pumping station of the Santa Fe Railroad, Fort Worth, Texas. Two men were fatally scalded.

(354.) — On November 30, a tube ruptured in a water tube boiler at the brick yard of The Harbison Walker Refractories Co., Hays Station, Pa.

(355.) — Seven cast iron headers ruptured November 30, in a water tube boiler at the By-Products Coke Co., plant of The Solvay Process Co., South Chicago, Ill.

December, 1915.

(356.) — On December 1, a section ruptured in a cast iron sectional heating boiler in the building of Howard D. McGeorge, Jersey City, N. J.

(357.) — A tube ruptured December 1, in a water tube boiler at the lumber plant of The Lansing Co., Lansing, Mich.

(358.) — On December 1, the cover plate of a digester disrupted at the plant of The Jessup and Moore Paper Co., Elkton, Md. One man was killed and one other so severely injured that he died later.

(359.) — On December 1, a tube ruptured in a water tube boiler at the plant of the Morton Salt Co., Ludington, Mich. The boiler received severe damage.

(360.) — A hot water heater exploded December 2, in the barber shop of Clayton and Sterns, Sturgis, Mich. The explosion started a fire which gutted the interior of the building.

(361.) — A threshing engine boiler exploded December 2 at the farm of Fred Dodd, near Burlington, Colo. One man was instantly killed and another fatally injured.

(362.) — A paper machine cylinder exploded December 3, at the plant of the Peters Paper Co., Latrobe, Pa. The damage was large, estimated at $50,000. Two men were injured.

(363.) — A cast iron unit exploded December 3, in a cast iron power boiler at the Georges School, Georges School, Pa. One man was scalded.

(364.) — A tube ruptured December 3, in a water tube boiler at the sheet and tin plate mill of The Berger Mfg. Co., Canton, O. One man was injured.

(365.) — On December 3, two sections in a cast iron sectional boiler ruptured at the plant of The Lamb Shirt Co., South Bend, Ind.

(366.) — On December 4, a section ruptured in a cast iron sectional heating boiler at the East Ward School, Seymour, Ia.

(367.) — A boiler exploded December 4, at the gin of James Cox, near Columbus, Miss. One man was fatally injured, and three others seriously injured.

(368.) — A heating boiler burst December 5, in K. G. E. Hall, York, Pa. This hall had been in use as a schoolroom, and the explosion necessitated new arrangements for the sessions of the school.

(369.) — A Burlington locomotive burst its boiler December 5, twelve miles east of Casper, Wyo. One man was killed and two injured, one probably fatally.

(370.) — A kitchen boiler air tank exploded December 6, at the Century Garage, Wichita, Kans. Property damage amounting to $500 was reported.

(371.) — A boiler exploded December 6, at the Grey Machinery Works, Toronto, Can. Two men were killed and three injured.

(372.) — A locomotive boiler belonging to the Krause-Managan Lumber Co., exploded December 6, at Turps, La. One man was killed and another injured.

(373.) — A boiler used to operate a pump for the Mountain Central Railroad, exploded December 7, at High Falls, Ky. One man was instantly killed and a boy badly injured.

(374.) — A tube ruptured December 7, in a water tube boiler at the plant of The Hanging Rock Iron Co,, Hanging Rock, O.

(375.) — A tube ruptured December 8, in a water tube boiler at the plant of The Barney and Smith Car Co., Dayton, O. One man was injured and the boiler considerably damaged.

(376.) — The boiler of a Norfolk and Western freight locomotive burst December 8, near Arthur, Va. One man was killed and three others injured.

(377.) — On December 10, the boiler of a locomotive exploded at the lumber mill of The Brooks-Scanlon Co., Kentwood, La. One man was killed and one other was injured.

(378.) — On December 10, a tube ruptured in a water tube boiler at the Williamsburg Station of The Transit Development Co., Brooklyn, N. Y. Two men were injured while considerable damage resulted to the boiler.

(379.) — A section ruptured December 10, in a cast iron sectional boiler at the office building of The Cunningham Brokerage Co., Kansas City, Mo.

(380.) — On December 11, a tube failed in a cast iron heating boiler at the office and theater building of The Quincy Real Estate Trust, Quincy, Mass.

(381.) — A heating boiler burst December 11, at the Grace Methodist Episcopal Church, Baltimore, Md.

(382.) — Three boilers ruptured December 12, at the sawmill of the Cypress Lumber Co., Apalachiola, Fla.

(383.) — A cast iron header failed December 14, in a water tube boiler at the plant of The Milwaukee Coke and Gas Co., Milwaukee, Wis.

(384.) — A cast iron section ruptured December 14, in a cast iron sectional heating boiler at the East Ward School, Seymour, Ia. This is the second accident reported recently at the same school. The section was a part of the same boiler concerned in the accident reported as No. 366, above.

(385.) — A tube burst in a water tube boiler December 14, at the power house of the Metropolitan Electric Co., West Reading, Pa. One man was fatally scalded.

(386.) — On December 16, four sections ruptured in a cast iron sectional boiler at the plant of the Linde Air Products Co., Philadelphia, Pa.

(387.) — On December 16, a tube ruptured in a water tube boiler at the plant of The Plainfield Union Water Co., Plainfield, N. J.

(388.) — A manifold in a cast iron heating boiler ruptured December 17, at the Public Market of the J. B. Blood Co., Lynn, Mass.

(389.) — A blow-off pipe failed December 18, at the Oakes Light and Power Co. plant of The General Utilities Co., Oakes, N. D. Two men were injured.

(390.) — A boiler exploded December 20, at the saw mill of Sam Dunn, near troy, Ala. Three men were injured.

(391.) — A tube ruptured December 21, in a water tube boiler at the plant of The Barrett Mfg. Co., Chicago, Ill.

(392.) — A boiler explosion which was followed by fire occurred December 20, at the plant of The National Carbon Co., Niagara Falls, N. Y.

(393.) — A boiler exploded December 23, at the plant of The Farmers Petroleum Co., Humble, Tex. One man was killed and two others injured.

(394.) — On December 24, a section ruptured in a cast iron sectional heating boiler at the plant of the Jencks Paper Box Co., Boston, Mass.

(395.) — A boiler exploded December 25, on the J. M. Myers farm, Burlingham, Ill. One man was injured as the result of the explosion. This is stated to be the second accident to a boiler on the same farm in a year. The boiler was used in operating an oil lease.

(396.) — On December 26, a blow-off failed at the Oakes Light and Power plant of The General Utilities Co., Oakes, N. D. This is a second accident to the blow-off on the same boiler reported upon above.

(397.) — A tube ruptured December 26, in a water tube boiler at the Dodge Gas and Electric plant of The United Light and Railway Co., Ft. Dodge, Ia.

(398.) — On December 26, a boiler ruptured at Mine 42, of The Shawmut Mining Co., Browns River, Pa.

(399.) — A boiler exploded December 27, in the greenhouse of John King, Fayville, Ill.

(400.) — An accident occurred to a boiler December 27, at the plant of The Merchants Heat and Lighting Co., Indianapolis, Ind.

(401.) — A boiler used in sawing wood exploded December 28 on the farm of Taylor M. Thompson, Altoona, Pa. A man and a boy were killed.

(402.) — A tube ruptured in a water tube boiler December 30, at the Round House of The Cleveland, Cincinnati, Chicago and St. Louis Railroad, Columbus, Ohio.

(403.) — On December 30, four sections of a cast iron heating boiler ruptured at the apartment building of E. Hugo Friedrich, Holyoke, Mass.

(404.) — On December 30, a section ruptured in a cast iron sectional heating boiler at the plant of The Standard Oil Co., of New York, Springfield, Mass.

(405.) — Five sections of a cast iron sectional heating boiler ruptured December 31 at the Lexington Hotel, Alliance, O.

January, 1916.

(1) — On January 1, five sections cracked in a cast iron sectional boiler at the canning factory of Dickinson and Co., Eureka, Ill.

(2.) — A section failed January 1, in a cast iron sectional heating boiler at the building of the R. C. Taylor Estate, Newton, Mass.

(3.) — On January 3, a boiler ruptured at the plant of The Worcester Salt Co., Silver Springs, N. Y.

(4.) — The boiler of a Santa Fe locomotive exploded January 3, near Lampasas, Tex. Three men were seriously injured.

(5.) — A boiler exploded January 3 at the plant of The North Shore Public Service Co., Chicago, Ill. One man was fatally injured and one less seriously hurt.

(6.) — A tube ruptured January 4, in a water tube boiler at The Merchants Heat and Light Co. plant of The American Public Utilities Co., Indianapolis, Ind.

(7.) — A boiler exploded January 4, at the sawmill of Andy Burnsworth, near Nevada, Mo. Two men were injured.

(8.) — On January 6, the furnace of a marine type boiler collapsed at the plant of The Joplin and Pittsburg Railway Co., Franklin, Kans.

(9.) — A boiler ruptured January 6, at the Baldwin School, District 141, Lewiston, Ill.

(10.) — A boiler exploded January 6, at a road construction camp near Elizabethton, Tenn. Four persons were injured, three of them bystanders.

(11.) — A section ruptured January 7, in a cast iron sectional heating boiler at the office building of The Henry Bosch Co., Chicago, Ill.

(12.) — A boiler ruptured January 7, at the plant of The American Silica Co., Rockwood, Mich.

(13.) — On January 8, a furnace collapsed in a marine type boiler on the dredge Culebra belonging to Johnson and Co., Miami, Fla.

(14.) — On January 8, a blow-off pipe ruptured at the shoe factory of Cushman and Hebert, Haverhill, Mass.

(15.) — A boiler burst January 8, at the Wesley M. E. Church, Phillipsburg, N. J.

(16.) — A valve burst January 8, at the Steul and Thuman mantel factory, Buffalo, N. Y. Two men were scalded.

(17.) — Four cast iron headers ruptured January 9, in a water tube boiler at the plant of The Jos. Dixon Crucible Co., Jersey City, N. J.

(18.) — On January 10, a boiler failed at the plant of The North State Lumber Co., Charleston, S. C.

(19.) — A St. Paul freight locomotive exploded its boiler January 10, near Ripon, Wis. Three men were injured, probably fatally.

(20.) — On January 11, a blow-off failed on a boiler at the hoop and heading mill of The Navasota Cooperage Co., Navasota, Tex.

(21.) — A tube ruptured January 12, in a water tube boiler at the Merchants Heat and Light Co., plant of The American Public Utilities Co., Indianapolis, Ind. This was an accident to another boiler from the one reported above.

(22.) — A blow-off pipe failed January 12, at the plant of The Forsyth Leather Co., Wauwatosa, Wis. One man was injured.

(23.) — The flue of a drier collapsed January 13 at the Plankington Packing Co., plant of Swift and Co., Milwaukee, Wis.

(24.) — A heating boiler failed January 13, at the McNaught shelving factory, Glidden, Ia.

(25.) — A heating boiler burst January 13, at a schoolhouse, Preston, Ia.

(26.) — The boiler of a Philadelphia and Reading freight locomotive exploded January 13, at the Rutherford yards, near Harrisburg, Pa. Two men were injured.

(27.) — On January 14, a cast iron header ruptured in a water tube boiler at the plant of The Winchester Repeating Arms Co., New Haven, Conn. One man was injured.

(28.) — On January 14, a section ruptured in a cast iron sectional heating boiler at the building of the Schulte Realty Co., 125th St. and Lexington Ave., New York City.

(29.) — The hot water heating system in the barber shop of Alex. Smith, Gobeto, Okla., exploded January 14, because of frozen connections. The building was set on fire, and Mr. Smith was fatally injured by the accident.

(30.) — A tube ruptured January 15, in a boiler at the plant of The Semet-Solvay Co., Ensley, Ala.

(31.) — A boiler exploded January 15, in the basement of the drygoods store of B. E. Lilly, Muscatine, Ia. Fire was started by the explosion, which swept through the business section of the town, doing damage estimated at $135,000.

(32.) — An automatic gas water heater exploded January 15, in the Knights of Columbus building, Newburgh, N. Y. No one was injured, but considerable damage was done to property.

(33.) — A boiler exploded January 15, at the plant of The International Talking Machine Co., Chicago, Ill.

(34.) — Five sections ruptured January 16, in a cast iron sectional heating boiler at The House of The Good Shepherd, Utica, N. Y.

(35.) — On January 16, a tube ruptured in a water tube boiler at the plant of The Atlas Coal Co., Burgettstown, Pa.

(36.) — Two sections cracked January 16, in a cast iron sectional heating boiler at the School of The Sacred Heart of Jesus, New Britain, Conn.

(37.) — A section ruptured January 16, in a cast iron sectional heating boiler at the office building of Mrs. C. Kampman, San Antonio, Tex.

(38.) — On January 17, A blow-off pipe ruptured on a boiler at the plant of The Pellston Planing Mill and Lumber Co., Pellston, Mich.

(39.) — The boiler of a railway locomotive exploded January 16, near Sapulpa, Okla. The engineer and fireman were killed.

(40.) — On January 17, a section ruptured in a cast iron sectional heating boiler at the Academy of The Sacred Heart, New Orleans, La.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1916.

Capital Stock, . . . $2,000,000.00.

ASSETS.

Cash on hand and in course of transmission,	$215,107.37
Premiums in course of collection,	421,506.09
Real estate,	90,000.00
Loaned on bond and mortgage,	1,448,245.00
Stocks and bonds, market value,	4,008,399.40
Interest accrued,	92,778.26
	$6,276,036.12
Less value of Special Deposits over Liability requirements,	41,619.80
Total Assets,	$6,234,416.32

LIABILITIES.

Premium Reserve,		$2,473,007.92
Losses unadjusted,		33,988.00
Commissions and brokerage,		84,301.22
Other liabilities (taxes accrued, etc.).		72,365.76
Capital Stock,	$2,000,000.00	
Surplus over all liabilities,	1,570,753.42	
Surplus as regards Policy-holders,	**$6,234,416.32**	3,570,753.42
Total Liabilities,		$6,234,416.32

LYMAN B. BRAINERD, President and Treasurer.

FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.

L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.

S. F. JETER, Chief Engineer.

H. E. DART, Supt. Engineering Dept.

F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, The Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, President, Director Swift & Co.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, The Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres. The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturing Co., South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and General Manager, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, Johns-Pratt Co., Hartford, Conn.

MORGAN G. BULKELEY, JR. Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

The Locomotive

of

THE HARTFORD STEAM BOILER

INSPECTION AND INSURANCE CO.

VOL. XXXI. HARTFORD, CONN., JULY, 1916. No. 3.

VICE-PRESIDENT FRANCIS B. ALLEN OF THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY ON HIS 75th BIRTHDAY, JUNE 1, 1916.

Vice-President Allen's Seventy-fifth Birthday.

On June 1, Vice-President Francis B. Allen celebrated his seventy-fifth birthday. When he arrived at his office, he found two large baskets of carnations awaiting him on his desk, accompanied by a letter from the officers of the Company and the Home Office force, asking him to accept the flowers as an expression of their respect and good will. Later in the day the good wishes tendered in the letter were repeated in person, every one joining in the hope that his present good health would insure for him many active and happy years to come.

The photograph on our front cover shows Mr. Allen seated at his desk with his birthday flowers. When we suggested to him that we would like to present this picture to our readers, he expressed considerable pleasure at the opportunity it would afford him to meet, as he put it, all those members of the Company's family whom he had been prevented in recent years from meeting in person. Mr. Allen said that one of his keenest pleasures throughout his active service had come from the feeling that he knew the force personally. It is therefore a very pleasant privilege for the LOCOMOTIVE to present Vice-President Allen on his seventy-fifth birthday, to his friends.

The Boiler Code of the American Society of Mechanical Engineers.*

S. F. JETER, Chief Engineer, Hartford Steam Boiler Inspection and Insurance Company.

In the invitation to read a paper before your Association on the boiler code of the American Society of Mechanical Engineers, it was specified that a mere paraphrase of the code was not desired, and the object of this paper will be to point out the need for uniform rules governing the construction of steam boilers throughout the United States, and why the steam user will benefit by such uniformity, and to show how the boiler code of the American Society of Mechanical Engineers meets this need. No attempt will be made to elaborate on the specific rules of the code or to show why these particular rules were adopted.

Every member of this Association must be fully aware of the demand for greater safety in the operation of steam boilers made during the past few years, and this demand has resulted in several state laws on the subject of boiler construction and operation. It is no longer a question of whether we shall have laws on this subject, but rather, what these laws shall be.

With the wave of "Safety First" that has swept the country, and consequent public demand for legislation on the subject of boiler construction and operation, it behooves the steam user to take the greatest interest in the movement to see that his interests are not overlooked. It is not meant by this that opposition should be made to any sane legislation on this subject, for the steam

*A paper read before The National Association of Cotton Manufacturers at Boston, Mass., on April 26, 1916.

user should not and will not be opposed to any necessary regulations for safety in regard to either the operation or construction of boilers. With twenty odd years' experience in the insurance and manufacture of boilers, I can say without hesitation that there would be no need of law to secure the adoption of all necessary requirements for safety by the average steam user, providing all steam users should secure equally competent advice as to what represented safe conditions, for the responsible head of an industry is not willing to take unwarranted chances in regard to boiler operation, if he is fully aware of what such chances mean.

It is the general experience in the insurance field that after an accident the boiler user is extremely cautious in regard to the future operation of his boiler equipment, and sometimes over cautious.

The adoption of standards by law is, therefore, necessary primarily to govern individual opinion as to what may be considered safe and what may not.

The boiler user, from a financial standpoint, is mainly concerned in seeing that his competitors do not enjoy immunity from regulations with which he must comply, and the average user would not consider it a particular hardship if he were compelled to adopt measures, the benefits of which might be debatable, providing his competitors were likewise compelled to follow the same rules.

That requirements for safety, either in regard to construction or operation of steam boilers, should be uniform, seems self-evident. If a lap seam is to be considered unsafe design for a new boiler to operate in one state, it should be considered equally unsafe in any other state; and the same reasoning would apply to practically every other feature of boiler construction or method of operation. The question may be naturally asked, "While uniformity may be entirely logical and of some advantage, why is a steam user vitally interested in having one set of rules govern the construction of all boilers?" He may contend that with two sets of rules, of which one demands a slightly different spacing of staybolts from that required by another, and where reasonable safety is provided by either, he should not be interested in the particular set of rules to be used.

Granting that some of the features of any rules may be questioned as to their accuracy or usefulness, still the advocacy of one single set merits the heartiest support of the steam user for his own protection. You, as manufacturers of cotton goods, know full well that if you are to compete satisfactorily in the manufacture of such goods and be able to produce them at a reasonable figure, your mill must specialize. If you had to make cloth to specification, and to meet one or several laws on the subject, as is the practice in the boiler field today in the manufacture of that class of machinery, your cost would rise abnormally.

Suppose, for example, that instead of your mills making only one grade or a few grades at most, that one customer should order five thousand yards of cloth of one kind, and another two thousand yards of a different kind, and so on; and that it would require several orders each day to keep your mill operating. Also, assume that each of these orders is destined for a different state, and according to law, a certain weave must be used for the first order and a different weave for the second, and that the tensile strength of the cloth must lie between very definite limits, but that the limits are to be different for each order. You will then be able to appreciate the position that the boiler manufacturer finds himself in today.

While such conditions are of grave concern to the boiler manufacturer, you know the consumer pays for the extra cost of the product manufactured under such conditions, and in the case of boilers you are the consumer. While it may not be of vital importance to you in the use of a boiler whether the stays are to be spaced 6 inches or 6¼ inches apart, or whether the steel of which the shell is constructed is to have a maximum tensile strength of 60,000 or 65,000 pounds per square inch, or may be of flange or fire box grade; in order for the boiler manufacturer to produce this boiler economically, it is necessary for him to be able to tell beforehand the kind of stock he should order and the draft of rules that may be followed in the construction of the boiler in order to purchase in quantity and handle his product through the shop in an economical manner.

With the general agitation for state laws governing boiler construction, unless uniformity in rules is obtained, each boiler shop will only be able to build for a few states. With the limited number of laws now in force, it is the most difficult problem to design and manufacture a boiler to meet the requirements of the rules of two or more states, and unless uniform rules are adopted, the boiler user is the one who will feel the result of added cost without compensating benefits, and in the purchase of his boilers fair competition and the ability to secure his boiler equipment manufactured under the most economical conditions will be largely eliminated. Since the requirements governing safety in the construction of boilers must be uniform to be logical, and to secure the greatest return to the boiler purchaser, it follows that they should emanate from the same source.

The question naturally arises at once, "From what source shall come rules to govern the construction of boilers for the entire country?" It would appear that if interference with states' rights did not enter the question, the appointment of a commission by the National Government would be the way to decide the matter, but it is my belief that the manner in which the problem will possibly now be solved, if such organizations as your own will lend their full co-operation, is much better than the results that might be expected from the appointment of a national commission. A commission appointed for such purpose would naturally be given authority to decide positively all questions without regard to complaints of those who might be affected by their rulings, and the result might not be as expected or desired.

When a state passes a law governing the construction of boilers, the next step is to prepare a set of rules for the guidance of the boiler manufacturer, and a board or commission is usually appointed to draw up such requirements as may be deemed necessary. With each state acting independently in the matter there can of course be no uniformity in the rules, and none of the rules thus drafted can possibly be the best, for they would not represent the combined wisdom of the different boards drafting them. It is therefore evident that individual state boards, working independently, cannot hope to produce uniform rules, or those that may be considered the best, no matter whether politics enter their formation or not, and it is more than likely to.

The same effect as mentioned above in connection with a national commission is likely to be experienced with the appointment of a state board — that is, a board empowered to draft rules that will have the force of law is not so likely to be as attentive to complaints from those whose interest may be affected as a similar body engaged in the same work, but whose product will stand or fall on its merits without the force of law to aid it. No one person, or small group of persons, no matter how well informed they may be on the subject of boiler construction and operation, is fully capable of drafting a complete set of boiler rules that may be considered the best; and no matter how carefully any set of such rules may be drafted, they cannot be considered as permanently the best; for the art of boiler manufacture, like other lines of industry, is rapidly advancing, and any set of rules governing the construction of boilers must be changed from time to time in order to keep abreast of the advancement in the art.

The American Society of Mechanical Engineers, in 1911, recognizing the chaotic condition that was fast being approached by the separate states adopting rules governing the construction of boilers, appointed a boiler code committee to draft a set of such rules that might be used by the various states as a guide in the selection of rules to govern boiler construction when adopting boiler laws. The original committee was composed of six members, and after much work on the part of this committee, and several public hearings, at which intense interest in the subject was manifested by the representatives of many industries, it was decided to augment the original committee by the appointment of an advisory committee, which increased by four times the committee membership.

In addition to the increase in the size of the committee, which increase was made to more certainly obtain the views of most of those affected, an appeal had been sent to every engineer of prominence known to be posted on the subject of boiler design, to give his views as to how the boiler code should be drafted. It is thus seen that the boiler code of the American Society of Mechanical Engineers represents not alone the views of the boiler code committee of that society, which, with the advisory committee, was composed of several members representing practically every interest to be affected, but it represents the combined views of the engineering fraternity throughout the United States, and a number in foreign countries, and has the approval of the foremost engineering society of this country, as far as that society ever approves a document of this character.

It would therefore appear that the American Society of Mechanical Engineers' boiler code should be superior to any set of rules that has been put out, or may be put out by a state board delegated to perform a similar duty. The Commonwealth of Massachusetts was the first to adopt a complete set of rules governing the construction of boilers, and as pioneers in this field the work of the board of boiler rules of that state deserves the highest commendation. These rules were copied and improved upon by the state of Ohio, and the boiler code of the American Society of Mechanical Engineers had the benefit of the experience with both sets of rules after their practical application; and free use was made of every feature of these rules that had been demonstrated by practice to be good.

As has been stated, no set of rules may be drafted that can be considered permanently the best, and it has been wisely arranged that at intervals of not exceeding two years' time, a revision of the boiler code may be undertaken in order that such changes as have been introduced by advancement in the art of boiler construction may be taken advantage of.

The boiler code is, of course, by no means beyond criticism, and no set of rules for a similar purpose may hope to be drafted without being open to criticism at some points; but it is perfectly safe to state that the American Society of Mechanical Engineers' boiler code is the most complete and logical set of rules governing the construction of steam boilers in existence today, and is advocated and backed by practically every interest connected with the manufacture and use of steam boilers.

The existence of the boiler code of the American Society of Mechanical Engineers and the hope of its nation-wide adoption to govern boiler construction has been mainly dependent on the support of those who would be most seriously affected. All complaints in regard to proposed rules during its compilation were most attentively listened to; and as an indication of the conscientious manner in which this work was done, it is suggestive that the staunchest supporters of this code are those most directly affected by its requirements, and the benefits to be gained by such supporters in its adoption are largely of an indirect character.

Another indication of the careful manner in which the boiler code has been drawn is the fact that so little real opposition has been met with in regard to its provisions. The members of this Association who are also members of the American Society of Mechanical Engineers will no doubt remember that one boiler manufacturer attacked it, and alleged that the code discriminated against his boiler and was to prevent fair competition between himself and a boiler manufacturer whose representatives were actively connected with the code work. No statement could be further from the facts than this. The manufacturers who were actively engaged in the work of compiling the boiler code were without doubt the ones who received the least consideration in regard to the possible effect of the code provisioins on their standard designs or methods of construction. One manufacturer in particular, who was most actively engaged in this work, was compelled by the code requirements to make very extensive changes in his manufacturing equipment in order that he might bring his product up to the code requirements although the changes required in the construction of his boiler were not at all radical.

If your Association should decide to lend its support and influence in securing a nation-wide adoption of the boiler code, where state laws are to be enacted covering boiler construction, those members who are not conversant with the boiler code or who are not familiar with boiler design or the different types used at the present time throughout the United States, may rest assured that the boiler code of the American Society of Mechanical Engineers is absolutely free of the attempt to favor any particular type or design of boiler or particular method of construction. The boiler code has no effect or influence on boiler design except in regard to safety, and as long as the designer keeps within prescribed limits for stresses and uses materials that practice has demonstrated as really reliable for the purpose, his inventive genius will not be hampered in the least.

The boiler code does not attempt to influence the size or pressure required for a boiler intended to meet the particular needs of a steam user and the advice of your engineer in determining such questions is as much in demand as ever; but instead of being occupied in looking after details of boiler design connected with safety your engineer will be free to make a more careful study of the possibilities in regard to economical operation and it is in this direction that you really expect to receive returns from expenditures made in retaining a consulting engineer.

If the need for adopting the same set of rules in each state where laws are proposed to govern the construction of boilers is considered advisable — and it does not seem possible that the least thought on the subject can lead to any other conclusion from the steam users' standpoint then the American Society of Mechanical Engineers' boiler code is practically the only set of rules available for such use. All disputed points in connection with these rules have been fought out with the parties interested and a conclusion reached; and any attempt at selecting a different set of rules would mean that the same ground would have to be fought over again. It is more than likely that in the end practically the same conclusions would be reached if a like amount of care was used, as in the preparation of the boiler code.

The American Society of Mechanical Engineers' boiler code has already the approval of many of the largest steam users in the country, and it is surprising to find the number who are today ordering their new boiler equipment built in accordance with its requirements, when the short length of time that this code has been in existence is considered. The boiler manufacturers throughout the country have approved the code through their different organizations and the boiler insurance interests are unanimous in their approval of its provisions.

It should be thoroughly understood that the boiler code is purely a code of rules by which the construction of new boilers may be governed and the safe maximum allowable working pressure for both old and new fixed, and that it has absolutely nothing to do with the law that is required to compel compliance with its provisions. There is nothing in the boiler code to prevent its use as an alternative for rules already used in a state, and that such an arrangement is entirely practical is evidenced by its use in this manner by the states of Ohio, Wisconsin and Indiana, and the city of Detroit, all of which will accept boilers built under code requirements in lieu of the construction called for by their own particular rules.

On July 1st of this year, the state of Pennsylvania will require that all boilers used in that state, and which are not under municipal law, comply with the provisions of the American Society of Mechanical Engineers' boiler code, and the state of California is to take the same step at the first of the coming year; in fact, every state in the union that has a state boiler law, with the single exception of the Commonwealth of Massachusetts, has either adopted the American Society of Mechanical Engineers' boiler code or will accept boilers built under its provisions in lieu of their own requirements.

Since the boiler code has but recently come into existence, the impression might be gained that it consists of an entirely new set of rules just compiled for the purpose, but this is not so, for the boiler code committee studiously avoided the use in that code of any rule that had not been demonstrated by practical experience or elaborate tests to be sound; and while the rigid enforcement of the code provisions will no doubt indicate the need of slight modification that will be beneficial, it cannot be in any wise regarded in the light of a new and untried experiment.

It was not my intention to specifically mention any of the code rules in this paper, but it would not seem proper to close without calling attention to the sections on braced and stayed surfaces and circular flues and furnaces, which are without doubt the best and most logical rules on these subjects that have thus far been formulated.

In closing, I wish to call attention to the fact that the brunt of the fight for uniform rules to govern boiler construction has been carried on thus far by the boiler manufacturer, but since the steam user is the one who ultimately will derive the greatest benefit by the attainment of the desired end, in that he will secure the greatest return for his investment in boiler equipment, it would seem only right that, as the project has been so auspiciously launched, the steam users, through such associations as your own, should lend their full cooperation in carrying the work to a complete and successful finish. The question is not, whether the steam user shall seek the enactment of boiler laws, but, when such laws are thrust upon him, whether he shall demand that a known set of rules governing boiler construction be used, or be content to sit still and take whatever rules happen to be furnished? Will you feel safe to have the construction of boilers you may purchase governed by a code put out by the foremost engineering society of the country, and like that which will be used by a majority of your competitors and purchased under as favorable conditions, or do you desire special frills that may be demanded by local rules at a considerable advance in price over the standard product?

The American Uniform Boiler-law Society has been organized for the purpose of urging the adoption of the boiler code of the American Society of Mechanical Engineers, where a state is considering the adoption of laws governing boiler construction, and its membership is composed of steam users, manufacturers of all classes of materials used in boiler construction, boiler manufacturers and insurance companies. Individuals, companies or associations may become members of this society. Its purpose is not to secure legislation on boiler construction or operation, but where laws are in effect or are to be enacted for this purpose, to urge the use of the American Society of Mechanical Engineers' boiler code, to the end that uniformity may result. I would suggest a most careful investigation of the aims and work of this society by your Association with a view of becoming a member.

Driers.

J. P. Morrison, Chief Inspector.

The safety and durability of pressure carrying vessels, of the different types now so common in large manufacturing plants, and particularly in those caring for the residue which forms the by-product output, depend, of course, upon the design and material used. Quite frequently the profits of the by-product plant depend upon the durability of the vessels; for in some cases the cost of renewing the parts subjected to wear affects, if it does not completely eliminate, the profits from that class of manufacture.

The meat packing industry is reported to have nearly attained perfection in the saving of all parts of the animal slaughtered, and the processes by which this has been accomplished necessitate the use of vessels of many different materials, designs and constructions.

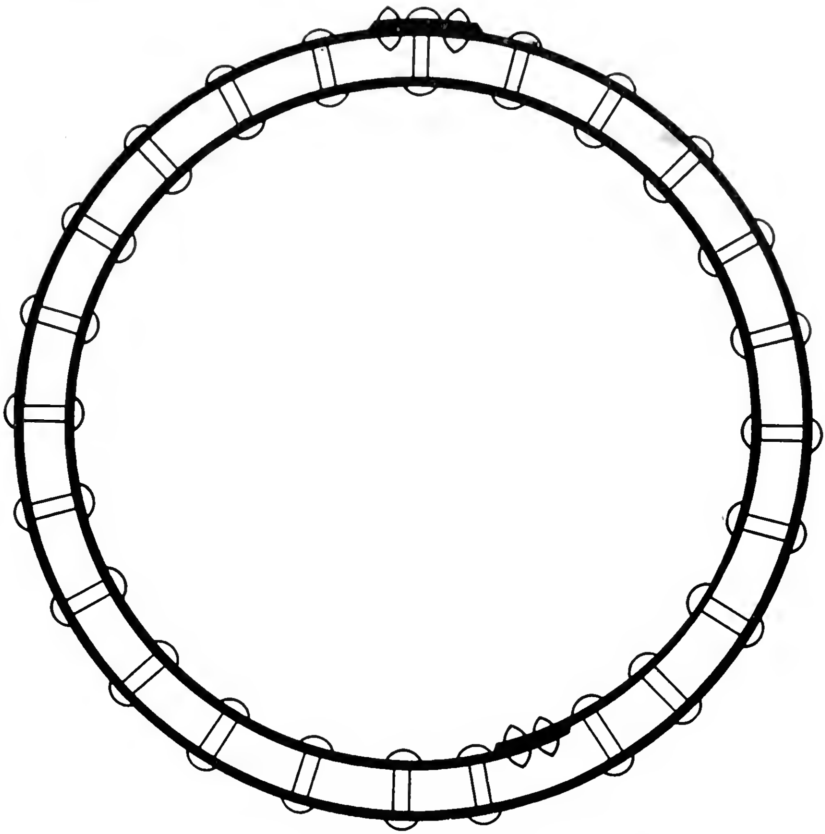


Fig. 1. Cross-section of Common Form of Drier.

Some of the processes are carried on in copper tanks, and others in aluminum kettles, and still others in steel tanks and driers. The driers are, as their name implies, used to free the stock, consisting of a wide variety of substances, from the moisture it contains. One of the most common form is illustrated in Figure (1), and it is of the design of those vessels that we expect to treat in this article.

Steam is admitted to the space between the two concentric cylinders, called the inner and outer shell, and the tankage or stock is conveyed into the inner shell. This contains an agitator, consisting of a series of paddles arranged to sweep the surface of the sheet and move the dry product upward and forward, that its place may be occupied by the unfinished material.

The inner shell is 4″ or 6″ less in diameter than is the outer shell, and is separated from it and secured to it by staybolts. The outer shell plate is customarily 3/8″ in thickness, while the plate used for the inner shell will range 1/2″ to 5/8″. The staybolting most frequently encountered is 7/8″ in diameter at the top of the thread, and pitched 5″, both longitudinally and circumferentially.

Deterioration of the outer shell is hardly worthy of mention, when the vessel is located under proper cover and provided with a jacket of nonconducting material. However along the bottom of its inner surface slight pitting appears after a few years of service, due to the action of the water of condensation on its way to the trap, where it is removed from the vessel.

The inner shell suffers little if any deterioration on the steam side, but on the stock side the action of the agitators and stock rapidly wears the metal, particularly the staybolt heads along the bottom half of the cylinder. The upper part of the sheet is not affected in that way. In fact, so rapidly do the staybolt heads disappear, that in some cases four months after a new drier has been placed in operation, the lower part of the inner cylinder is perfectly smooth — without the sign of a staybolt head. As the wearing of the shell and staybolt continues, ultimately the thickness is so reduced that the sheet pulls from the headless staybolts, unless the condition is discovered in time to prevent such an accident.

The thickness of the plate can best be determined by "drilling" in one or more places, and when the safe minimum has been reached and detected, the life of the vessel may be prolonged by turning it through an angle of 90° or 180°, depending more or less upon the extent of the worn surfaces. When all of the stock surface of the inner shell has reached the minimum thickness permissible, it is necessary to remove the staybolts and worn sheet, to replace with new. This is quite an expensive repair.

Unquestionably the headless staybolts do not possess the same strength as when new and full-headed, so the more dependence must be placed upon the strength of the sheet to resist the pressure which seeks to collapse it. The strength, of course, depends upon its thickness. So the sheets supported by the headless staybolts must be thicker for a given pressure than when the staybolts have perfect heads, and the inner shell of the type of vessel under consideration cannot give the amount of service it could, were the staybolt heads exempt from wear.

Consideration has been given the countersinking of each staybolt hole, so the head could be driven flush with the inner surface of the plate and receive no more wear than other parts of the vessel similarly located, but that practice would result in materially reducing the threaded contact of hole and bolt — which should be as great as possible — to say nothing of the expense involved.

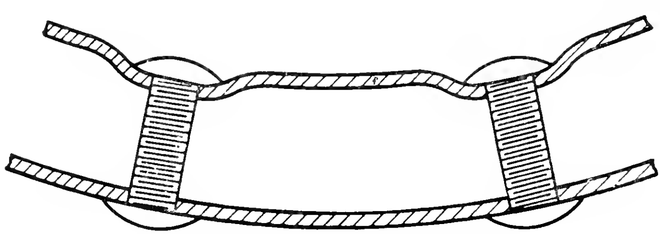


FIG. 2. SUGGESTED CONSTRUCTION.

After several plans for lengthening the life of those vessels were rejected as impractical or undesirable, it was decided to indent the inner shell at each staybolt hole.

This was done after punching and rolling the sheet in the usual way, and then placing each hole in line with suitable dies in an ordinary hydraulic riveter, with which most boiler shops are now equipped. A pressure of 150 tons was sufficient to give the sheet at each hole an off-set of 5-16", the thickness of the staybolt head.

After the inner shell and outer shell had been properly joined with the filling rings, the staybolt holes threaded, bolts inserted, and headed up, the vessel presented an appearance as shown in Figure (2). From which it will be noted the staybolt heads are protected from excessive wear, and the sheet would wear half way through midway between the bolts, by the time the staybolt heads are completely gone. There would then remain the full thickness of the sheet at the staybolt hole in contact with the threaded bolt.

While it is not desirable to operate the vessel until the inner sheet is penetrated, it is believed the life of the vessel will be nearly doubled by the new form of construction, which resulted in very little added expense. The vessels now in operation, although they have not seen sufficient service to determine their possible life, indicate that the new method of construction will be profitable, and may come into universal use.

An Inspection Fish Story.

By Inspector R. D. Metts.

Several inspectors were relating experiences one day in the office when the following was added to the collection by the writer.

"I was sent some years ago by our Company, to inspect a boiler which I found on examination to be so filled with grease and scale as to cause it to leak. I traced the trouble to the fact that no solvents were used to prevent the scale while the grease came from an exhaust steam heating system which was not provided with an oil separator.

"I made out my report and it was sent to the assured, recommending that they discontinue using the returns or else put in a separator to remove the grease. I also recommended that they remove the scale and caulk the boiler to make it tight.

"This boiler was in a bank, and the report came into the hands of its president. After reading it he wrote to the Company, saying that he would like to have an interview with the inspector. In a few days I called and explained the report. After he had grasped the real situation he said, 'Well I am glad it is not due to negligence on the part of our engineer. I must admit I am not a practical man, but I had visited the boiler room on several occasions and had seen the engineer with a long toaster such as would be used for toasting bread or meat. This he used in the boiler furnace for broiling fish.' He was under the impression that this was the explanation for the grease and scales getting into the boiler. When the circumstances were explained, he was quite satisfied and the engineer is still on the job."

A Very Early Corliss Engine.

We are able to illustrate in this issue of the LOCOMOTIVE an example of one of the earliest types of releasing gear engines. This old engine has been continuously in service in its present location since 1863 or '64, and is still jogging along every day, carrying a very creditable load. It will be noted from the photographs that this engine differs from the type which we are accustomed to regard as the early corliss, in that the valves are pulled open by the eccentric against the restraint of a leaf spring, and this spring is the means by which the valves are closed at cut off, instead of the dash pots. It should be noted that while dash pots are fitted, they oppose the closing of the valves, and serve only to cushion the violence of the seating of the valves under the stiff pull of the spring. As the engine is of the single eccentric variety the range of cut off is somewhat limited, but is as great as would be found in any of the single eccentric engines of more usual corliss form.

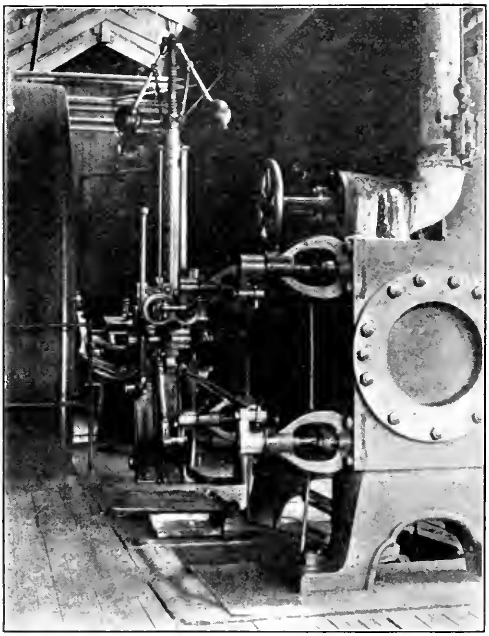


FIG. 1. OLD CORLISS ENGINE.

We were enabled to indicate this old engine, and append the cards (Fig. 3),

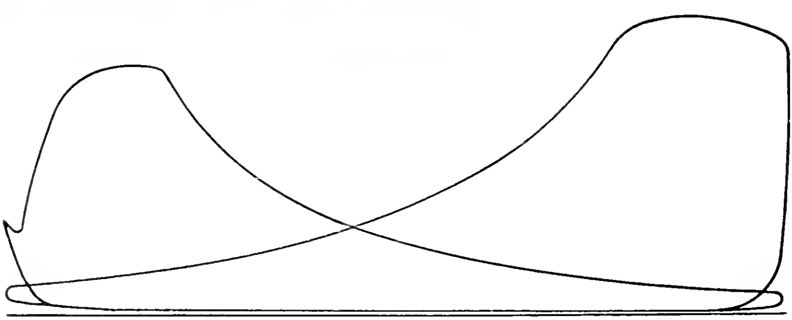


FIG. 3. CARDS TAKEN WITHOUT ADJUSTMENT.

taken just as the engine was found without adjustments or alterations. It will be seen that the head end card shows a very late admission. We were told that the rod from the head end dash pot to the valve bell crank had broken on one occasion, and that after making repairs, the valve had been set as nearly

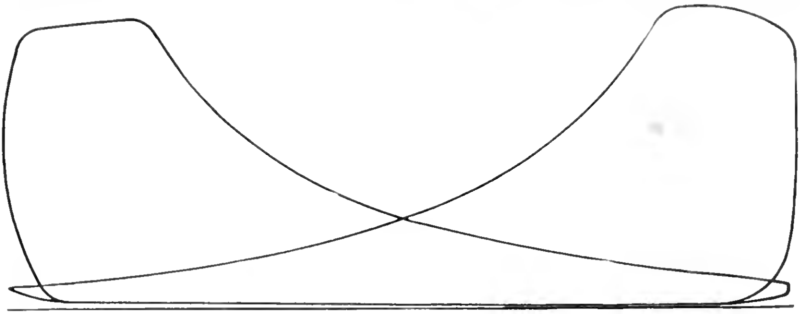


Fig. 4. Cards after changing valve rod length.

as possible to its old place, but that it had been necessary to do this without the assistance of an indicator, which it was thought would probably account for the late admission. When a very slight adjustment in the length of this rod was made, the cards of Fig. 4 resulted, and it is at once apparent that the venerable engine can produce a set of diagrams even though it has not had the benefit of refitting, which are very creditable.

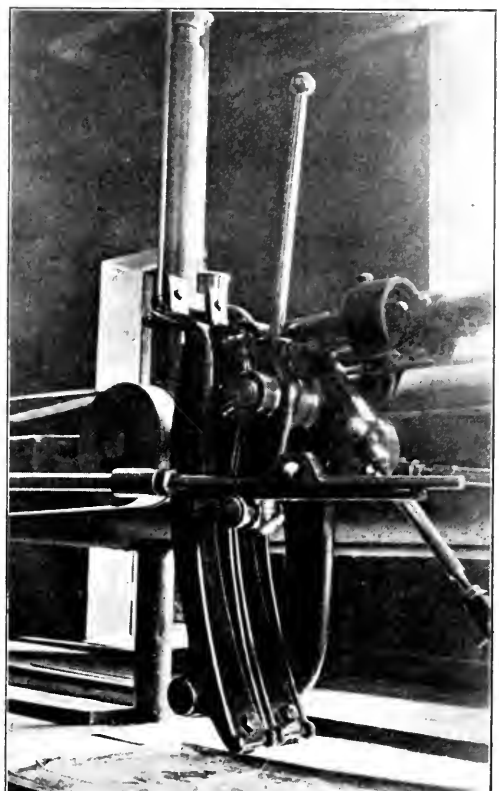


Fig. 2. A Closer View of the Valve Gear. The Eccentric Rod is Unhooked.

The dimensions of the old engine are stroke, 42 inches, cylinder diameter, 16 inches, speed 66 revolutions per minute. The boiler pressure is kept at 100 lbs. per square inch, and the engine exhausts into the atmosphere through a closed heater in the summer time, but supplies exhaust steam to a heating system in the winter. The average horsepower developed is about 106 (indicated). Part of its output is absorbed through belts and line shafting, while the remainder is utilized electrically through the medium of a generator belted to the main countershaft. It should be noted that the governor is guiltless of safety stop, and that a failure of the governor would result in the engine failing to release, and therefore a run away would result unless the connected load offered resistance enough to keep the speed within safe limits.

A Bulged Steam Drum, on a Water Tube Boiler.

M. T. Glenn, Inspector.

While it is not unusual to find bulges upon the tubes of water tube boilers and upon the plating of the fire tube variety, we do not as a rule, look for trouble from this source on the shell plates of the steam drums of the horizontal type of water tube boiler. That bulges may occur at this point is shown however, by the following which relates to one of a battery of five 600 horse power water tube boilers in a power house at Charleston, S. C.

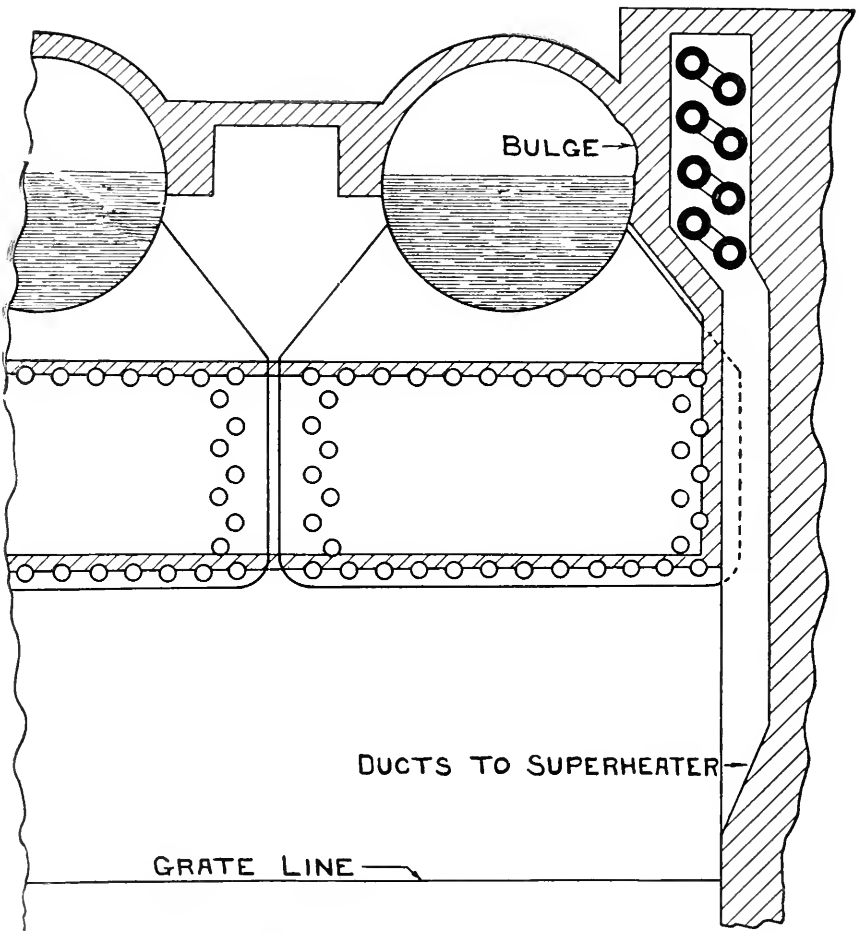


Fig. 1. Location of Bulge on the Steam Drum.

As is shown in the sketch these boilers contained superheater elements in a duct in the brickwork of the setting and the location of the superheater was such that only an eight inch brick wall separated its flue from the steam drum above the water line. It is apparent from the sketch that the intense heat of the gases direct from the furnace to the superheater box, caused the wall to become so hot as to soften the plate, which as will be seen was not protected by water at this point. The action was not unlike the bulging to be seen on the rear head of horizontal tubular boilers if they are set with a rear arch so high as to expose the head to the action of the flue gases at a point above the water line.

In the case illustrated it was recommended that the bulges be driven back (a corresponding bulge occurred on the left hand drum also), and that the plates of all the drums be insulated with 85 per cent. magnesia in addition to the brick work, where they adjoin the superheaters.

The Hazard of Concrete Combustion Chamber Paving.

By J. F. Shank, Inspector.

We were recently called into a plant to investigate an explosion in the combustion chambers of two water tube boilers. The plant originally contained four boilers, but provisions were made for two additional boilers for which the foundations were built.

As this room was desirable to use as a work room the space was filled in and a cement floor laid over the foundations. When the additional boilers were recently installed the cement floor was not disturbed. The walls for the new boilers were built on the original foundations, as it was considered that the cement floor would make a good bottom for the combustion chambers.

When the new boilers were put in service they were equipped with mechanical stokers. Fires were started under them in the morning and slowly fired so that they were cut in line with the other boilers some time in the afternoon. At about seven o'clock in the evening there occurred a slight explosion under one of the boilers, but as there was no evidence of anything serious the fires were kept going and about fifteen minutes later there occurred another slight explosion under the same boiler. Still no attention was given the matter, till about thirty minutes later when there was a heavy explosion under the second boiler which caused the tubes to start leaking. The fires were then drawn and it was found that the cement bottoms under both boilers had blown up with such force that fragments of cement indented several tubes so that it was necessary to replace them. The bridge walls were also considerably damaged by the force of the explosion.

These explosions were caused by the moisture under the cement floor which was generated into steam and finally liberated itself by the path of least resistance. The last explosion was of such force as to cause the tube ends to leak at each water leg though they were not otherwise damaged. They were expanded and left in service.

The writer had a similar experience under a small horizontal tubular boiler. The ash pit had been laid with brick but we decided to remove this and put in a cement floor. After several hours firing this floor blew up with such force that several grate bars were dislodged.

A Successful Improvised Condenser.

The Engineering Department of the Company was recently called upon to make a test at the plant of an assured, in order to advise them intelligently regarding proposed changes in their power equipment. Among other things it became necessary to obtain the water rate of two engines which were supplying the bulk of the power output, before an accurate idea could be had as to whether it would be advisable to repair these engines, or replace them with a more modern unit. The problem resolved itself into engine tests of the two units, together with a partial boiler test, during which both engines were indicated, so that knowing the water rates and the average indicated output of the two engines, together with the total steam produced, the amount of steam used for certain pumps and for manufacturing processes could be arrived at by differences. Two boilers were in use, each supplying one of the engines. The auxiliary steam for pumping and for manufacturing could be

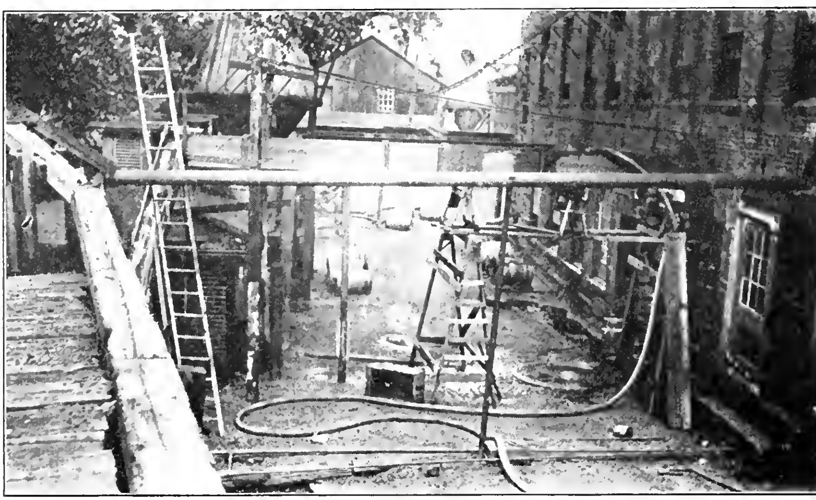


Fig. 1. General View of Exhaust Piping with Condenser in Place.

taken from either boiler at will, but the feed piping was of a somewhat complicated nature, and it did not seem feasible to measure the steam used by either engine by measurements of the feed. Notwithstanding this, it was comparatively easy to install a meter so that the total water passing to both boilers could be measured. Of course temporary feed lines might have been installed, but as changes in the boiler installation were contemplated, and as little, if any, of the temporary piping could be put in place in such a manner that it would be available directly in the new installation, this was looked on as a sort of last resort to be done if no other way opened. This will be clear to almost any one who has attempted a test on an old plant where the piping system is the result of long growth, with no general plan other than to get some particular result each time an addition or change was made.

The two engines were running noncondensing, as the winter demand for exhaust steam in the heating system had passed at the time of the test. On looking over the exhaust piping, the idea presented itself that no great difficulty would be experienced if a condenser were made out of the exhaust pipes themselves. The exhaust connections for both engines were similar, and a description of one will in the main apply to both. The engines, which were of the corliss type exhausted from the bottom of the cylinders. The exhaust was led from an elbow beneath the cylinder, under the floor to a dripped elbow beneath a closed heater, then up through the heater to a tee. On one branch of the tee was a gate valve leading to the heating system by way of a separator, and to the other branch of the tee was connected a back pressure valve which led to the atmospheric exhaust pipe. Both exhaust pipes extended out horizontally from the engine house, starting at an elevation of about fifteen feet from the ground, and running out some fifty or sixty feet to the bank of a stream. This horizontal run was not continuous, however, as each pipe was brought down to a lower level so as to pass under a coal trestle. Figure 1, shows a portion of one of the pipes in front of the box which was built around the other one (as will be described later), and so shows the general disposition of the exhaust piping better perhaps than can be done by a description. The edge of the coal trestle is just to be seen at the extreme left of the picture, but the drop of the uncovered pipe to pass under it is not seen. The scheme which suggested itself was to surround each of these horizontal exhaust pipes in turn with a box, which could be flooded with the circulating water, and so utilize the exhaust pipe itself as a surface condenser, keeping the end open to the air to prevent the formation of a vacuum. A rough preliminary calculation, which was little better than a good guess, made it appear that the part of the pipe at the high level, *i. e.,* that shown in Fig. 1, ought to be enough to give all the surface required. Of course if this did not prove sufficient, a greater portion of the pipe could be enclosed. A box was built therefor, of inch and one quarter cypress lumber, which had an inside cross-section about eighteen inches square. This was set up about the pipe as is shown in the photograph, so that the exhaust pipe was centered longitudinally in the box. At the end against the engine house, the box was built a snug fit to the pipe and the joint where the pipe passed through the box end was made nearly enough water tight with oakum. At the other end, that is right back of the ladder seen in Fig. 1, the box ended in a weir which was arranged to overflow only when the water covered the pipe. The pipe, passing through this end of the box, terminated in an elbow, where its direction was changed, and inclined downward at an angle of about forty-five degrees to the horizontal to another elbow, from which it extended again parallel to its original direction but at the lower level. The overflow from the weir was arranged to flow down a trough which enclosed the inclined part of the pipe. This can be seen beneath the ladder in the illustration, and close inspection will show the water flowing down and submerging this part of the pipe. The water supply was obtained from a fire hose as shown, lead from the nearest hydrant. When the box was finished, water was turned on, the cloud of steam from the exhaust pipe quickly dwindled till but a trace of vapor came out with the condensate, and the success of the scheme was assured.

The length of exhaust pipe which was submerged in the horizontal box or flume was about twenty-five feet, while the inclined portion which was wet

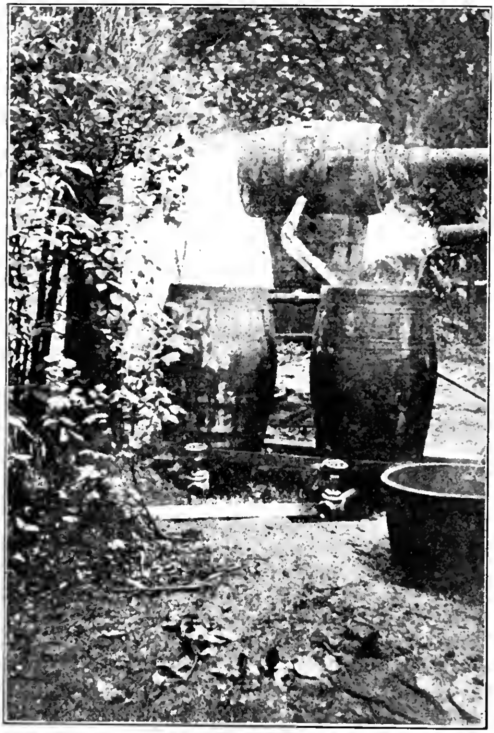


FIG. 2. DEVICE FOR COLLECTING CONDENSATE, AND CALIBRATED MEASURING BARRELS.

by the overflow was about eight feet in length. As the pipe was six inches nominal diameter, this gave a submerged surface of 1.73 square feet per foot of length, or for the thirty-three feet exposed, a total surface of about 57 square feet. No trouble was experienced in condensing an average of 2,100 lbs. of steam per hour for over eight hours, using the flow from a single line of fire hose, somewhat throttled, and supplying condensing water at 58° F. This gives a rate per square foot of 38.8 lbs. per hour. At no time was there the slightest indication that the limit of the condenser was even approached, and it is believed that considerably more steam could have been handled with ease. The temperature (mean) of the condensate was 147.5° F. These figures are mentioned, as it was thought possible that data on the performance of such a condenser might be of service to some one confronted with a similar problem. In discussing the proposed arrangement before the trial run doubt was expressed of its ability to handle the situation, not from lack of surface, but because it was thought that so large a pipe would pass a core of uncondensed steam, which would not get in contact with the walls, and so would not be condensed. It is possible that the reason for the successful operation of the affair in spite of this perfectly logical objection was due to the elbow at the end of the box proper. This elbow would perform, to some extent, the function of a steam separator, and permit the water already condensed to drop to the bottom of the inclined pipe, which would permit the core steam, if present to come in contact with the wet upper surface of this last portion of the pipe, and be condensed. Some such action was evident from the fact that it was necessary to have the water flowing over the top portion of the inclined pipe, to remove the last traces of vapor from the exhaust.

The condensate was collected in a pair of calibrated barrels under the end of the exhaust pipe at the bank of the stream. The first arrangement tried was to tie several layers of burlap over the end of the pipe to check the velocity of the outflowing water and collect the fine spray which was blown out at each stroke of the engine. A tub was then placed under the pipe end, and to further direct the condensate into the tub an overturned box was put over the pipe end, burlap and all. An overflow pipe was tapped into the tub, and from it a hose was led to either of the calibrated barrels at will. The barrels were provided with valved drain pipes in the bottom head, and were connected together at the top with a two inch overflow, made up with a union so that they might be easily separated for weighing. It was then only necessary to weigh accurately the contents of each barrel when filled to the overflow, to get at the weight of the condensate. The only other condition being that the time of filling be longer than that required for emptying. The procedure was then as follows: A barrel was filled till it overflowed, when the hose was passed over into the other barrel, and the full barrel emptied by the drain valve as soon as water ceased to flow through the overflow connection. In this way, the barrels could be alternately filled almost automatically to a fixed level, and only a tally was required. Of course some drips and leakage water had to be caught and measured, such as the drip from the heater and the exhaust pipe beneath the cylinders, as well as the leakage past stuffing boxes and valve bonnets, but all these were gathered together into one drip pipe, and led out through a U bend seal to a bucket, where they could be added to the barrel filling from time to time and so no additional weighings or measurements were required. Fractional barrels may be avoided, when using this method, if it is possible to stop the test when a barrel is just full, and this can usually be arranged with little trouble.

As it was desired to transfer the box to the other exhaust pipe and so test the second engine when the first had been finished, an effort was naturally made to see if the details of the apparatus could be improved. No changes suggested themselves beyond a scheme to somewhat improve the conditions at the end of the exhaust pipe. The pulsations of pressure, during the eight and a quarter hours of the first test, had nearly worn out the burlap by abrasion across the end of the pipe. If this had been completely worn out before the end of the test, it was thought that there might have been a chance for some of the condensate to escape as a spray, and fall clear of the tub. To avoid this the arrangement shown in Fig. 2 was devised, consisting of a third barrel, placed horizontally, with an eccentric hole in one head through which the exhaust pipe entered, and with an overflow pipe in the center as shown, at such a height as to insure some water being carried in the barrel to seal the drain, but not enough to seal the end of the exhaust pipe. In this way every bit of condensate must be caught, if the barrel was tight. No chance was provided for vapor losses if the condensate was very hot except from the surface of the water in the measuring barrels themselves. Moreover, since the exhaust pipe was not sealed, there would be no danger from sucking back slugs of water by the formation of a partial vacuum in the exhaust line. The arrangement worked very well indeed. There proved to be just enough room left about the exhaust pipe where it passed into the barrel to vent it and prevent a vacuum, but as the flow of air was always inward, there was no escape of vapor at this point, and so every bit of the exhaust was caught and transferred to the measuring barrels, which are well shown in Fig. 2.

The Locomotive of THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

C. C. PERRY, EDITOR.

HARTFORD, JULY, 1916.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

In another column we reprint a paper on the Boiler Code of The American Society of Mechanical Engineers, which Chief Engineer Jeter delivered April 27, at the meeting of The National Association of Cotton Manufacturers, at Boston, Mass. The paper was enthusiastically received, and before adjournment, the Association passed the following resolution placing itself on record as in favor of uniform boiler laws and of the A. S. M. E. Code:

"Whereas, the American Society of Mechanical Engineers having prepared a satisfactory code for the standarardization of boiler construction to promote the safety of human life and economy in operation, it is hereby resolved, that the association approves the said boiler code and recommends its adoption by states and municipalities where boiler laws are in force or may be enacted."

We wish to say just a word about the article printed in another column which describes an improvised condenser for engine testing. It will be noticed that none of the data of the test itself are given. The reason for this is that the test presented no unusual or interesting features other than the means employed for obtaining the water rates. There could be no advantage therefore in detailing the performance data of a plant which was neither better nor worse than hundreds of other plants, and from which no deductions of interest except to those immediately concerned could follow. The whole purpose of the article was to show how a common difficulty was overcome in this case at relatively small expense and without in any way interfering with the regular operation of the plant.

It will be noticed that this LOCOMOTIVE contains a rather larger number of contributions from our inspectors than usual. We hope that this will become an interesting and important feature of THE LOCOMOTIVE. Such articles come from the firing line so to speak and give us actual instances of the conditions and difficulties which our field force is continually called upon to overcome.

We reprint below a clipping from the *Hartford Times* of May 19, 1916, which is self explanatory. This constitutes the thirteenth instance in which The Hartford has taken over the steam boiler and flywheel lines of another company. Again we welcome these new policy-holders to The Hartford family, and extend to them all the benefits and privileges of Hartford Service.

HARTFORD STEAM BOILER TAKES OVER $18,000,000 MORE CASUALTY BUSINESS

Flywheel and Boiler Insurance of United States Casualty Company of New York is Secured by Local Concern— Income of $50,000 Annually.

The Hartford Steam Boiler Inspection and Insurance Company has taken over and reinsured from 12 o'clock noon on May 17, all of the steam boiler and flywheel business of the United States Casualty Company, of New York.

The United States Casualty Company commenced business in May, 1895, as a multiple line company, and today it is conducting something like a dozen of the different so-called casualty lines, including the steam boiler and flywheel lines of insurance. The business of the company has been ably managed and conservatively constructed and built up by President Lott, until with respect to the steam boiler and flywheel lines its annual writings now amount to approximately $50,000 annually.

President Lyman B. Brainerd of the Hartford company, stated that while the data and figures pertaining to the business taken over had not been completely assembled, it was estimated that the number of steam boilers and flywheels taken over would amount to about 3,600 and the aggregate of the insurance liability would be between $15,000,000 and $18,000,000. It was believed that these lines of insurance had proved in the past as profitable as it was possible to realize in these times from any given line of insurance, but certain factors influenced President Lott to give up these two lines of insurance, believing that he could use his energy and employ the resources of his company in developing other lines.

A White-Wash Explosion.

Even white-wash is hazardous. The clipping below shows it to be about on a par with baked potatoes.

A mixture of lime and water in a milk can, which was to be applied to the telephone poles along the state road near Tunkhannock, exploded and Corbin Haughn had his eyes so badly burned that it is feared he will lose his eyesight.

Wilkes-Barre Times Leader.

Oil from Cleaner Blisters Tubes.

In a water-tube boiler plant trouble was experienced with blistered tubes. It was at length observed that the tubes showed signs of distortion soon after cleaning, which made the case doubly puzzling. The belief was that sediment was responsible.

A solution of the near-mystery was accidentally found one day when the engineer chanced to see the tube-cleaner operator oiling the rotor of the cleaner for the day's run. The latter explained that he always used plenty of cylinder oil, as a little overflow down the inside of the tube made the machine pass through the tube easier.

The rotor being entered at the top end of the tube (a Stirling boiler), the oil had followed along to the bottom, flowing, in some boilers, into the bottom drum. It seems hardly possible that a man would do such a thing; yet here it was, and the evidence was all too plain. How many other turbine operators flood the rotor with oil?

Philadelphia, Penn. EDWARD T. BINNS.

Power.

A New and Unlooked for Domestic Hazard.

The clipping reprinted below speaks for itself. Potatoes need inspection. All should be pricked with the time honored safety-first fork in the interests of suffering humanity.

POTATO EXPLODES; OVEN RIVETS STARTED.

Lake City, Minn., Sept. 3, 1915.— Mrs. Carl Workman put several large potatoes in an oven to bake for dinner. When they were about half baked there was an explosion which nearly blew up the stove. One of the potatoes had exploded and the inside of the oven was plastered with the mealy substance. Most of the rivets of the stove will have to be reset.

Boiler Explosions

January, 1916 (Continued from April Locomotive).

(41.) — The east school, West Liberty, Ia., was destroyed by fire January 17, which originated in the explosion of the heating boiler.

(42.) — A hot water heater exploded January 17, in the barber shop of Henry Kindle, Crete, Ill.

(43.) — A boiler ruptured January 18, at the New Mexico Penitentiary, Santa Fe, New Mexico.

(44.) — On January 19, a blow-off failed on a boiler at the plant of The Pellston Planing Mill and Lumber Co., Pellston, Mich. This is the second accident within the month to the same boiler.

(45.) — A heating boiler exploded January 18, at the residence of Lloyd V. Bush, Easton, Pa.

(46.) — A section ruptured January 19, in a cast iron sectional heating boiler at the building of Edith M. Clark, 116 W. 75th St., New York City.

(47.) — A tube ruptured January 20, in a boiler at the Avondale Mills, Birmingham, Ala. One man was injured.

(48.) — On January 20, a boiler ruptured at the Sherman Oil Mill of The Birge-Forbes Co., Sherman, Tex.

(49.) — On January 21 a tube ruptured in a water tube boiler at the plant of The Lockhart Iron and Steel Co., McKees Rocks, Pa. The boiler suffered a considerable amount of damage.

(50.) — The heating boiler which supplies heat for the public school of Keota, Ia., exploded January 21.

(51.) — A tube ruptured January 22, in a boiler at the plant of Armour and Co., Sioux City, Ia.

(52.) — A boiler exploded January 22, at the mill of Tenant Brothers, Tenantsville, N. Y. One man was injured.

(53.) — A section cracked January 23, in a cast iron sectional boiler at the apartment building of F. W. Densmore, Minn.

(54.) — A boiler explosion destroyed the plant of the Kelker Blower Co., Buffalo, N. Y., on January 24. Fifteen were reported to have been killed and as many more probably fatally injured.

(55.) — The greenhouses of Harry A. Schroyer were destroyed by a boiler explosion January 24, at Lancaster, Pa.

(56.) — A blow-off failed January 25, on a boiler at the plant of The Nagle Engine and Boiler Works, Erie, Pa. One man was injured.

(57.) — A boiler exploded January 26, at the sawmill of The Shenango Furnace Co., Ligonier, Pa. Four men were injured.

(58.) — The explosion of a boiler wrecked a Chinese laundry January 26, in San Francisco.

(59.) — A section cracked January 27, in a cast iron sectional heating boiler at the store and office building of Simon Persky, and A. L. Starin, New Haven, Conn.

(60.) — On January 27, a tube ruptured in a water tube boiler at the plant of The John B. Stetson Co., Philadelphia, Pa.

(61.) — A drying cylinder exploded January 27, at the Standard Bleachery, Carlton Hill, N. J. One man and two women were seriously scalded.

(62.) — On January 28, a tube ruptured in a water tube boiler at the plant of The Columbia Chemical Co., Barnerton, O.

(63.) — A boiler exploded at the plant of The Bell Telephone Co., Missoula, Mont.. January 29, 1915.

(64.) — A kitchen range boiler exploded January 29, at the home of J. Brower, Missoura, Mont.

(65.) — The boiler of a Mexican Central freight locomotive exploded January 29, near Juarez, Mex. Three men were killed and one injured.

(66.) — Two sections ruptured January 30, in a cast iron sectional heater at the theater and office building of Nathan H. Gordon, Boston, Mass.

(67.) — A tube ruptured January 31 in a water tube boiler at Building No. 70 of Swift and Co., Chicago, Ill.

Boiler Explosions.

FEBRUARY, 1916.

(68.) — On February 1, an accident occurred to a boiler at the laundry of L. J. Rothschilds, Princeton, Ind.

(69.) — Five cast iron headers ruptured February 1, in a water tube boiler at the plant of the Salmon Brick and Lumber Co., Slidell, la.

(70.) — Five sections ruptured February 1, in a cast iron sectional heating boiler at the Waterbury Office of The Southern New England Telephone Co. of the American Telephone and Telegraph Co.

(71.) — On February 2, two sections cracked in a cast iron sectional heater at the Willard School, Ada, Okla.

(72.) — Two sections ruptured February 2, in a cast iron sectional heater at the garage on the estate of Wm. B. Bannigan, Providence, R. I.

(73.) — The boilers of the Ohio river towboat Sam Brown exploded February 2, at Huntington, W. Va. Ten persons were killed, four seriously injured, and the boat completely wrecked by the explosion.

(74.) — A boiler exploded February 2, at the plant of the Howe Rubber Co., New Brunswick, N. J. Two men were killed, four injured and large property damage done as a result of the accident.

(75.) — A brine cooler exploded February 3, at the plant of the Creamery Package Co. DeKalb, Ill. Two men were killed and one other injured.

(76.) — On February 4, a pipe ruptured in a down draft furnace attached to a furnace in the mercantile building of L. S. and S. Loeb, Minneapolis, Minn.

(77.) — A tube ruptured in a water tube boiler February 4, at the Diamond National Bank, 5th and Liberty Aves., Pittsburgh, Pa. Three men, the fireman, chief engineer and a police officer were injured.

(78.) — A hot water boiler burst February 4, in the residence of Mrs. Hugh McMenamin, Hazleton, Pa.

(79.) — On February 4, a hot water boiler burst in the home of John R. O'Donnell, Hazleton, Pa.

(80.) — A boiler exploded February 4, in the greenhouse of R. B. Chapman, Troy, Ala. The greenhouse was totally wrecked.

(81.) — On February 5, eight sections ruptured in a cast iron sectional heating boiler at the Massachusetts Homeopathic Hospital, Boston, Mass.

(82.) — A heating boiler exploded February 5, in the Three Arts Building, Chicago, Ill. Two men were injured, one of them fatally.

(83.) — Four sections of a cast iron sectional heating boiler ruptured February 6, at the store and office building of Simon Persky and Abraham Starin, Congress Ave. and George St., New Haven, Ct.

(84.) — A boiler exploded February 6, at the plant of the Abington Wagon Co., Abington, Ill.

(85.) — A tube ruptured in a water tube boiler February 7, at the Galesburg Ry. and Light Co. plant of the Illinois Traction System, Galesburg, Ill.

(86.) — Six cast iron headers ruptured February 8, in a water tube boiler at the waste heat plant of the By-products Coke Corporation, So. Chicago, Ill.

(87.) — A boiler exploded February 8, at the office building of The Standard Oil Co., Gardner, Mass. The property damage was estimated at $2,500, but fortunately no one was hurt.

(88.) — A boiler exploded about February 9, in the Delta Kappa Epsilon fraternity house at the University of Chicago, Chicago, Ill.

(89.) — A hotwater boiler exploded February 9, at the Charles St. Jail, Boston, Mass.

(90.) — A compressed air tank exploded February 9, at the silver plant of Reed and Barton, Taunton, Mass.

(91.) — On February 10, two sections ruptured in a cast iron sectional heating boiler in the apartment building of Delia Burrell, Fargo, N. D.

(92.) — A boiler exploded February 10, at the saw mill of Graham and Hurley, near Athol, Md. Four men were killed and three others seriously injured. The plant was completely wrecked, and a mule some two hundred feet from the boiler house was killed.

(93.) — A section ruptured in a cast iron sectional heating boiler on February 11, at the building of the Shulte Realty Co., 353 Fulton St., Brooklyn, N. Y.

(94.) — A section ruptured February 12, in a cast iron sectional heating boiler at the office building of John F. Gilbert, Beaumont, Tex.

(95.) — A flue burst in a heating boiler at the Methodist Church, Theresa, N. Y. on February 12.

(96.) — Two cast iron headers ruptured February 12, in a water tube boiler at the plant of the New York Steam Co., 59th St. and East River, New York City.

(97.) — A boiler exploded February 13, at Tomball, Tex. One man was injured.

(98.) — A hot water boiler used to supply heat to a garage, burst February 13, at the residence of Simon Persky, New Haven, Ct.

(99.) — On February 13, an accident occurred to a Scotch marine boiler on the steamer Peerless of the Yazoo and Sunflower Transportation Co., Vicksburg, Miss.

(100.) — A cast iron sectional heater failed February 13, at the plant of the Paper Novelty Mfg. Co., 225 East 36th St., New York City.

(101.) — On February 14, nine cast iron headers ruptured in a water tube boiler at the plant of the Anchor Duck Mills, Rome, Ga.

(102.) — Two sections ruptured February 14, in a cast iron sectional heating boiler at the Arcade Theater, owned by Elise Croger, Ridgefield Park, N. J.

(103.) — Mrs. John Reed was painfully injured February 14, by the explosion of a water back in the range at her home in Seaford, Del. It was surmised that the accident may have been due to frozen pipes.

(104.) — A kitchen boiler exploded February 14, at the home of John Reber, Slatington, Pa.

(105.) — A heating boiler burst February 14, at the Rider, Moore, Stewart Business College, Trenton, N. J.

(106.) — A heating boiler burst February 14, at the station of the Tenth Police district, Philadelphia, Pa. One man was scalded.

(107.) — On February 15, a boiler ruptured at the electric plant of the Park College, Parkville, Mo. The boiler itself was considerably damaged.

(108.) — On February 15, a section ruptured in a boiler at the automatic lunch room of Horn and Hardert, 250 W. 42d St., New York City.

(109.) — A tube ruptured February 15, in a water tube boiler at the plant of The Detroit City Gas Co., Detroit, Mich.

(110.) — A boiler ruptured February 15, at the plant of the Chanute Refining Co., Cushing, Okla.

(111.) — On February 15, a cast iron header ruptured in a water tube boiler at the plant of The Union Stock Yard and Transit Co., Chicago, Ill.

(112.) — By the explosion of a kitchen range boiler in her home, 2205 Bolton St., Philadelphia, Pa. on February 15, Mrs. Harriet Jones and her three children were seriously injured.

(113.) — A kitchen range boiler exploded February 15, in a home at Walden, N. Y. Two women were injured.

(114.) — A kitchen range boiler exploded February 15, in the apartment at 236 Harrison Ave., Harrison, N. J.

(115.) — On February 17, a boiler ruptured at the State House of Correction and Branch Prison, Marquette, Mich.

(116.) — On February 17, a tube ruptured in a water tube boiler at the plant of The Delta Oil Co., Greenville, Miss. One man was fatally scalded.

(117.) — An oxygen tank, used for autogenous welding, exploded February 17, at the plant of the Cincinnati Steel Castings Co., Cincinnati, O. One man was killed and two others seriously injured.

(118.) — A heating boiler exploded February 17, at the apartment house at 1719 Seventy-ninth St., Brooklyn, N. Y.

(119.) — A heating boiler burst February 17, at the St. Stanislaus Polish parochial school, Hazleton, Pa.

(120.) — While an Erie locomotive was standing on a switch on the Caldwell branch, near Overbrook, N. J., on February 19, a flue collapsed, and five men who had entered the cab to get warm were scalded, none of them however received fatal injuries.

(121.) — A boiler burst February 20, at the plant of The American Paper Products Co., St. Louis, Mo. One man was seriously scalded.

(122.) — A boiler burst February 19, at the Stevensville High School, Stevensville, Md.

(123.) — Two tubes ruptured February 21, in a water tube boiler at the plant of the Mark Mfg. Co., Zanesville, O. The boiler was badly damaged.

(124.) — On February 21, a boiler ruptured at the plant of the Fairmont Creamery Co., Grand Island, Neb.

(125.) — The water back in a range exploded February 21, at the home of James Murnuck, Bridgeport, Ct.

(126.) — A shifting locomotive belonging to the duPont Powder Co., exploded its boiler February 22, at Carney's Point, N. J. Two men were killed.

(127.) — On February 23 a blowoff ruptured at the No. 1 Boiler House of the Kewanee Boiler Co., Kewanee, Ill. One man was injured.

(128.) — A tube ruptured February 24, in a water tube boiler at Shaft No. 3, of the Winona Copper Co., Winona, Mich.

(129.) — On February 26, a section ruptured in a cast iron sectional heating boiler at the residence of R. N. Garrett, El Dorado, Ark.

(130.) — On February 27, a tube ruptured in a water tube boiler at the Penn Hospital, Philadelphia, Pa. One man was injured.

(131.) — A tube ruptured February 27, in a water tube boiler at the plant of The Waukesha Gas and Electric Co. a subsidiary of the American Gas Co., Waukesha, Wis.

(132.) — A boiler exploded February 28, at the Conestee Cotton Mills, Greenville, S. C. One man was killed and another probably fatally injured.

(133.) — A boiler used for wood sawing exploded February 29, at Moscow, Ia. Two men were injured.

March, 1916.

(134.) — On March 1, the crown sheet of a locomotive collapsed at the Pine Belt Lumber Co.'s operation, Orville, Ala. Three men were injured, and the engine badly damaged.

(135.) — A radiator exploded March 1, on the Mississippi river steamer Steel City, at Cairo, Ill. The radiator, which is said to have been an ordinary low pressure one, was reported to have been installed on high pressure service without a reducing valve. One young lady, a passenger, was injured.

(136.) — A boiler exploded at the sawmill of Worcester Brothers, Hollis, N. H., on March 1. Two men were injured, and the boiler house destroyed.

(137.) — On March 2, a tube ruptured in a water tube boiler at the Atlantic Gas and Electric Co., plant of the General Gas and Electric Co., Easton, Pa. Two men were killed and one other seriously injured.

(138.) An acetylene tank exploded March 2, in the machine shop of Chester C. Huff, Grand Rapids, Mich.

(139.) — Two sections cracked March 3, in a cast iron sectional heating boiler at the Plazo Hotel, Augusta, Ga.

(140.) — A heating boiler exploded March 3, in the home of Albert Sergeant, Wilmington, Del.

(141.) — An air tank exploded March 3, on a Grand Trunk locomotive, in the round house at Portland, Me. Two men were injured.

(142.) — A steam pipe burst March 3, at the Imperial Laundry, St. Louis, Mo. One man was seriously scalded.

(143.) — A boiler exploded March 3, at a saw mill at Ireland, West Va. Three men were killed and two others perhaps fatally injured.

(144.) — Five sections ruptured March 4, in a cast iron sectional heating boiler at the office building of the Glen Jean Insurance Agency, Mt. Hope, W. Va.

(145.) — On March 6, a tube ruptured in a water tube boiler at the Newberry Cotton Mills, Newberry, S. C. One man was injured.

(146.) — The crown sheet of a fire box boiler collapsed March 6, at the plant of the Northwestern Iron Co., Mayville, Wis.

(147.) — The boiler of a Southern Pacific locomotive exploded March 9, eight miles west of Del Rio, Tex. Two men, the engineer and fireman, were fatally scalded.

(148.) — On March 9, a blowoff pipe failed at the plant of the Diamond Fire Brick Co., Canon City, Colo.

(149.) — A section cracked March 10, in a cast iron sectional heating boiler at the Brushy Plain School, Branford, Conn.

(150.) — A kitchen boiler burst March 10, at the home of Mr. Burke, Walnut St., Hazleton, Pa.

(151.) — A kitchen boiler burst March 10, in the home of Anna Waskavitch, Ridge Street, Hazleton, Pa.

(152.) — A kitchen boiler burst March 10, in the home of John Meneth, Adams St., Hazleton, Pa.

(153.) — A contractor's boiler, belonging to the Stone and Webster Co., exploded March 10, on the construction operation which they are engaged on for the Buffalo General Electric Co., Tonawanda, N. Y.

(154.) — A tube ruptured March 12, in a water tube boiler at the plant of The Federal Rubber Mfg. Co., Cudahy, Wis.

On March 12, a section of the main steam pipe failed at the John T. Lewis and Bro. plant of the National Lead Co., Philadelphia, Pa.

(155.) — On March 12, a tube failed in a water tube boiler at the plant of The Barrett Co., Fairfield, Ala. One man was injured.

(156.) — A boiler exploded March 13, at the Pikeville Planing Mill, Pikeville, Ky. Four men were killed, two others injured, and the plant badly wrecked as a result of the accident.

(157.) — A hot water heating boiler exploded March 13, in the residence of Mrs. Edward Shuster, Milwaukee, Wis. The damage was estimated at $2,500.

(158.) — A freight locomotive of the "Mother Hubbard" type, belonging to the Lehigh Valley railroad, burst its boiler March 14, at North Tonawanda, N. Y. The engineer and fireman were both injured, the fireman fatally.

(159.) — A heating boiler exploded March 14, in an apartment house at 207 Eleventh St., Hoboken, N. J.

(160.) — A traction engine, owned by Carey Gum, exploded its boiler March 14, at Wichita, Kans. Mr. Gum, who was operating the engine at the time was killed.

(161.) — A tube failed March 15 in a water tube boiler at the plant of the Hammermill Paper Co., Erie, Pa. Two men were scalded.

(162.) — A Boston and Albany locomotive boiler dropped its crown shee March 15, near Pittsfield, Mass. Three men were injured, one probably fatally.

(163.) — On March 16, the tubes pulled from the lower head of a vertical tubular boiler at the River Spinning Plant of the Frank A. Sayles Bleacheries, Phillipsdale, R. I.

(164.) — On March 18, a cast iron sectional heating boiler ruptured at the plant of the Danbury Mfg. Co., Danbury, Conn.

(165.) — Four sections ruptured March 18, in a cast iron sectional heating boiler at the department store of Mary E. McGrath, Woburn, Mass.

(166.) — A heating boiler exploded March 19, at the residence of Paul Gallichet, Somerville, N. J.

(167.) — On March 20, several tubes failed in a boiler at the steel casting plant of the Falk Mfg. Co., Milwaukee, Wis. The boiler was badly damaged.

(168.) — A cast iron header ruptured in a water tube boiler on March 20, at the plant of Armour and Co., East St. Louis, Ill.

(169.) — On March 21, a boiler ruptured at the store and office building of Isidore Wise, Hartford, Conn.

(170.) — The boiler used to operate a saw mill exploded March 21 near South Bloomingville, O. Three men were fatally injured.

(171.) — On March 21 a boiler exploded at the Prospect Mills, Batesville, S. C. Three men were injured, and the boiler room, engine room and mill damaged to the extent of about $4,000. The explosion was due to a hidden lap seam crack.

(172.) — On March 24, a cast iron sectional boiler failed at the garage on the estate of Wm. B. Bannigan, Providence, R. I.

(173.) — A section ruptured March 24, in a cast iron sectional heating boiler at the department store of H. H. Sturtevant and Co., Zanesville, O.

(174.) — A tube burst at the plant of the General Chemical Co., New York City, on March 25. One man was fatally scalded.

(175.) — A boiler exploded March 25, at the grist mill of Manuel Riddle, near Pikeville, Ky. Five men were killed outright, and twelve others injured, of whom eleven were thought to be fatally scalded.

(176.) — A heating boiler exploded March 25, at the warehouse of Liggett and Myers, St. Louis, Mo. One man was injured.

(177.) — A hot water heater exploded March 27, at the barber shop of Daniel Dwyer, Easthampton, Mass. The shop was wrecked, but no one was injured.

(178.) — On March 28, a blowoff pipe failed at the plant of the Maryland Coal and Coke Co., Sipsey, Ala. One man was injured.

(179.) — A tube burst in a water tube boiler at the Polar Wave ice factory, St. Louis, Mo., on March 28. Six men were scalded.

(180.) — A boiler exploded March 29, at the Durham coal mines, Chattanooga, Tenn. A boiler maker who was working at the plant was fatally injured.

(181.) — A boiler exploded March 29, at the sawmill of Godwin and Fall, at Houston, Tenn. Three men were killed and one other badly injured.

(182.) — The boiler of a freight locomotive exploded March 31, between Martinsburg and Cumberland, Md. Three trainmen were injured, one probably fatally.

APRIL, 1916.

(183.) — A drying cylinder exploded April 1, on a paper machine at the plant of the Tonawanda Board and Paper Co., North Tonawanda, N. Y.

(184.) — On April 2, a corrugated furnace collapsed in a Scotch marine boiler at the plant of The Wellsburg Ice and Storage Co., Wellsburg, W. Va.

(185.) — On April 3, an accident occurred to a boiler at the plant of The Bloomer Cold Storage Co., Council Bluffs, Ia.

(186.) — An acetylene tank exploded April 3, at the plant of the Otis Elevator Co., Buffalo, N. Y. Twenty-five men were said to have been injured, several of them seriously.

(187.) — A section ruptured April 5, in a cast iron sectional heating boiler at The Country Club, Brookline, Mass.

(188.) — A Monen locomotive exploded its boiler April 6, near Bedford, Ind. Two men were injured.

(189.) — On April 11, a section ruptured in a cast iron sectional heating boiler at the restaurant of Horn and Harddert, 106 W. 43d St., New York City.

(190.) — Five sections ruptured April 12, in a cast iron sectional heating boiler at the plant of the Mosely and Motley Milling Co., Rochester, N. Y.

(191.) — A tube ruptured April 13, in a water tube boiler at the plant of The Empire Gas and Electric Co., and The Central New York Gas and Electric Co., Geneva, N. Y. One man was killed and two others injured, but the damage to property was small.

(192.) — On April 14, a tube ruptured in a water tube boiler at the Lauderdale building of The Butler Exchange Company, Providence, R. I. Three people were injured, and the building considerably damaged.

(193.) — A Missouri, Oklahoma and Gulf locomotive boiler exploded at the railway station at Hoffman, Okla., on April 16. One man was killed, one fatally injured, and two others scalded as a result of the accident.

(194.) — On April 17, a tube ruptured in a water tube boiler at the plant of The Standard Sanitary Mfg. Co., New Brighton, Pa.

(195.) — The boiler of a Burlington locomotive exploded April 20, near Stewartsville, Mo. One man was killed and one injured.

(196.) — A boiler exploded April 21, in the oil fields near Spencer, W. Va. One man was fatally injured.

(197.) — A boiler exploded April 23, at the plant of The Laclede Steel Co., Alton, Ill. One man was seriously injured.

(198.) — Ten sections ruptured April 23, in a water tube boiler at the Pennsylvania Training School, Commonwealth of Pennsylvania, Morganza, Pa.

(199.) — A boiler exploded April 23, in the oil field at Humble, Tex. One man was seriously if not fatally injured.

(200.) — A cast iron mud drum exploded April 25, in a water tube boiler at the plant of Swift and Co., South Omaha, Neb. Six men were injured, one fatally, and the property loss was considerable.

(201.) — A soda water tank exploded April 26, at Seinerman's Restaurant, St. Mark's Ave., Brooklyn, N. Y. The wife of the proprietor was killed by the explosion.

(202.) — A flue burst in a boiler at the plant of the Hazleton Steam Heating Co., Hazleton, Pa., on April 26. No one was injured.

(203.) — Four cast iron headers ruptured April 28, in a water tube boiler at the Samaritan Hospital, The Temple University, Philadelphia, Pa.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1916.

Capital Stock, ... $2,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$215,107.37
Premiums in course of collection,		421,506.09
Real estate,		90,000.00
Loaned on bond and mortgage,		1,448,245.00
Stocks and bonds, market value,		4,008,399.40
Interest accrued,		92,778.26
		$6,276,036.12
Less value of Special Deposits over Liability requirements,		41,619.80
Total Assets,		$6,234,416.32

LIABILITIES.

Premium Reserve,		$2,473,007.92
Losses unadjusted,		33,988.00
Commissions and brokerage,		84,301.22
Other liabilities (taxes accrued, etc.),		72,365.76
Capital Stock,	$2,000,000.00	
Surplus over all liabilities,	1,570,753.42	
Surplus as regards Policy-holders,	**$6,234,416.32**	3,570,753.42
Total Liabilities,		$6,234,416.32

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Chief Engineer.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President. Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, Vice-President, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, President, Director Swift & Company.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres. The Fidelity Trust Co., Hartford, Conn.

ARTHUR L. SHIPMAN, Attorney, Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturers, South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and Treasurer, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, The Johns-Pratt Co., Hartford, Conn.

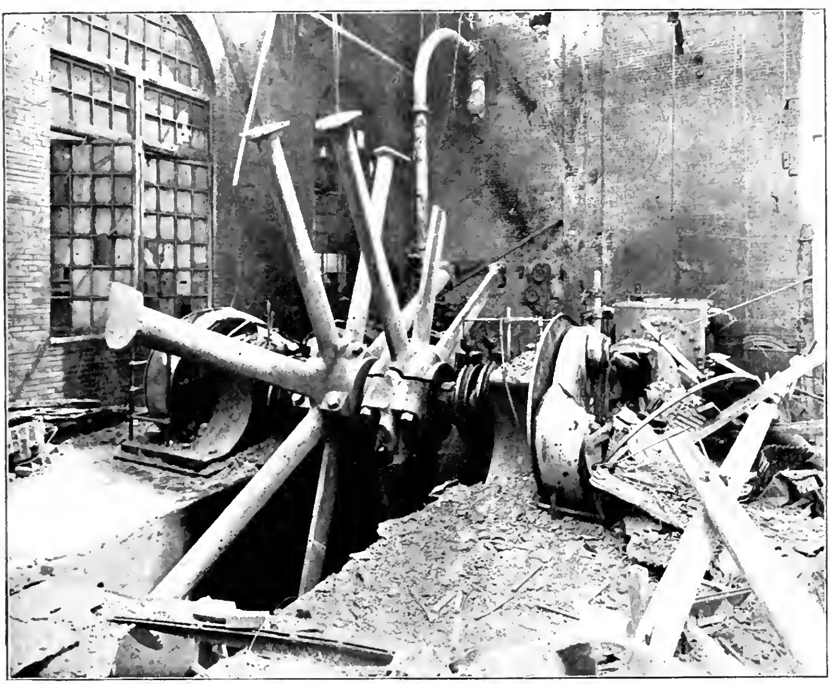
MORGAN G. BULKELEY, JR. Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

The Locomotive

of

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

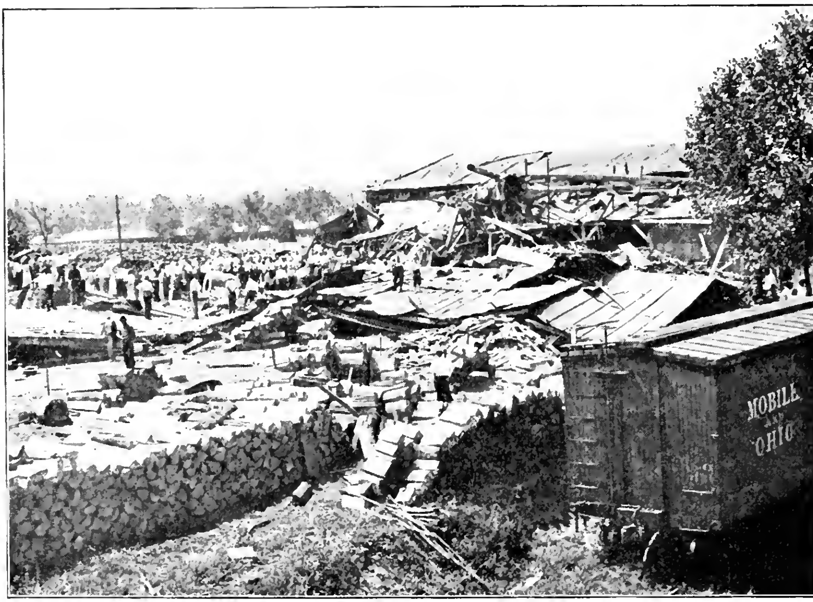
Vol. XXXI. HARTFORD, CONN., OCTOBER, 1916. No. 4.



A Violent Fly-wheel Explosion at St. Louis, Mo.

Flywheel Explosion at St. Louis.

We illustrate on our front cover, what remained of the flywheel on a thousand horsepower cross compound corliss engine at the plant of the St. Louis Portland Cement Co., after its explosion August 23, 1916. The engineer was killed, and five others were injured, in addition to which property was damaged to an extent variously estimated at sums in excess of $20,000. The wheel exploded with great violence, and some idea of the effect on the building is given by the illustration.



The Wreck at Jackson, Tenn.

A Destructive Boiler Explosion at Jackson, Tenn.

A very disastrous and sad accident occurred August 21, 1916, when three horizontal return tubular boilers exploded at the wood working and stave mill of the Harlan-Morris Manufacturing Co., Jackson, Tenn.

The explosion took place at 7:30 A.M., just after the men had commenced work for the day, and was particularly fruitful of personal injuries. Eight men were killed outright, and some thirteen injured more or less seriously. The property damage was large, a glance at the accompanying illustration will show the completeness of the destruction. Portions of the three boilers were hurled for considerable distances, one large part of a boiler going some six hundred feet from its setting. The cause of the accident is not definitely known, and it is doubtful if it can ever be exactly determined. The boilers were apparently in excellent condition prior to the explosion, and none of the usual causes seem to fit the circumstances. That there can be no question of low water is attested by the very violence of the accident.

On Butt and Double Strap Joints for Sulphite Digesters.

A sulphite digester, for the benefit of those of our readers not familiar with this class of vessel, is a large tank, usually vertical, and provided with either ellipsoidal (egg shaped) or conical ends. They vary in size, but may be anywhere from 30 to 60 feet in height, by from 12 to 16 or 18 feet in diameter. Wood chips are introduced into these vessels through a stock opening at the top, and the vessel is then filled say ¾ full of a liquor which is essentially bi-sulphite of lime. The vessel is closed up and steam turned on till the pressure is about 80 lbs., and the temperature comes up to that corresponding to the steam pressure. Passing over the lesser details of the process, the chips are cooked in the hot liquor for periods varying from 7 to 12 hours, according to the sort of product desired, and during this time the gummy or resinous matter is dissolved from the fiber, leaving a mass of practically pure cellulose, known as sulphite wood pulp, and used as stock for paper making.

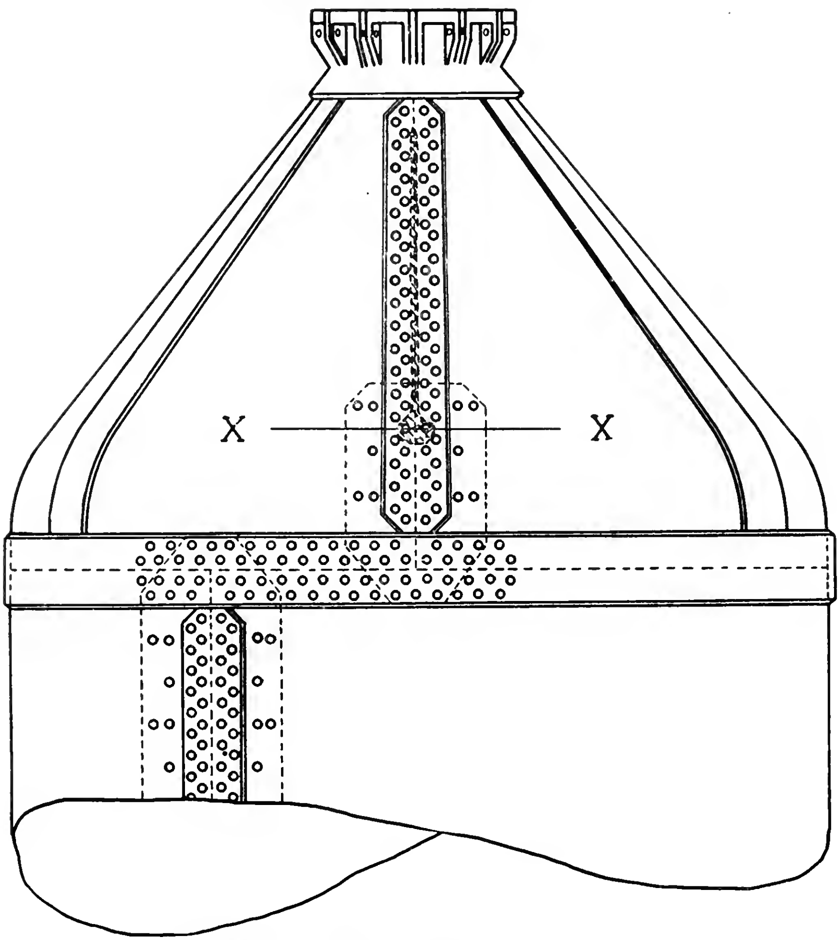


FIG. 1. SHOWING LOCATION OF CORROSION IN LONGITUDINAL JOINT.

The liquor, which is made by acting on lime stone or lime water with a solution of sulphurous acid in water, is very corrosive to steel at the temperature employed in digesters, so that some means of protecting the shell from attack is essential. A common and efficient method is to line the shell with a backing of concrete of special composition, in which sand or gravel is the coarsest aggregate used. This backing if absolutely tight, is a thoroughly satisfactory protection against the corrosive action of the liquor. To give it a resisting surface, however, so that it may better withstand the cutting or erosive action of the stock when blowing down, and the fracturing effect of the water with which the last traces of stock are washed out (which is not always as hot as it might be), a second lining of special acid and heat resisting brick is laid up inside the backing. An acid resisting mortar or lute is used, with which great care is taken to bed the bricks well and to completely fill the joints. Notwithstanding the acid resisting properties of the mortar used and the great care employed in bedding the brick, and pointing up the joints, this inner lining is seldom absolutely acid tight. Hence if a small hair crack exists in the backing, the acid is almost certain sooner or later to penetrate to the steel. This may or may not result disastrously. When the backing is properly applied to the steel the bond between them is almost absolutely perfect, so that it is very difficult, or indeed impossible for the liquor to penetrate for any distance between the backing and the steel shell. The result then of most cracks or leaks in the backing is a small pit directly opposite the defect which grows larger and larger until a hole perhaps only a fraction of an inch in diameter is cleanly eaten through the shell. When the pit extends through the shell, warning is at once given to the attendants by the issuing of a small stream of acid from the hole. Steps can then be taken to locate the defect on the inside of the vessel, usually by applying a garden hose to the leak from the outside, when a man previously sent inside the vessel notes and marks the point at which the water comes through the brick, and proceeds to cut out the lining at that point, until the defect is found and repaired. Such a hole is seldom a serious source of weakness and in most cases no repair to the shell beyond filling the hole with a plug of backing material is required. On the other hand if a space exists between the backing and the steel for any reason and if the minute defect happens to be so located as to penetrate that space, then instead of a small pit, growing into a negligible hole, it is possible for the corrosive action to extend and affect a larger area. Sometimes this results in general corrosion, over an appreciable area, but often the results are grooves, not unlike the burrows of a ground mole, twisting and turning about.

If one of these grooves happens to proceed in an approximately longitudinal direction, the vessel may be dangerously weakened before the groove penetrates deep enough at any one point to pass through the plate and give warning by leaking. To guard against this sort of corrosive action, many digesters have been provided with holes in the shell at intervals of one or two feet both longitudinally and girthwise, of say half inch diameter. It is the purpose of these to permit the efflux of the liquor, without the necessity of eating through the shell, whenever an area which has been penetrated by the acid embraces one of the holes. Of course so long as the weakening of the shell by the test holes does not equal or exceed the necessary weakening at the longitudinal joints, — that is so long as the drilled shell is stronger than

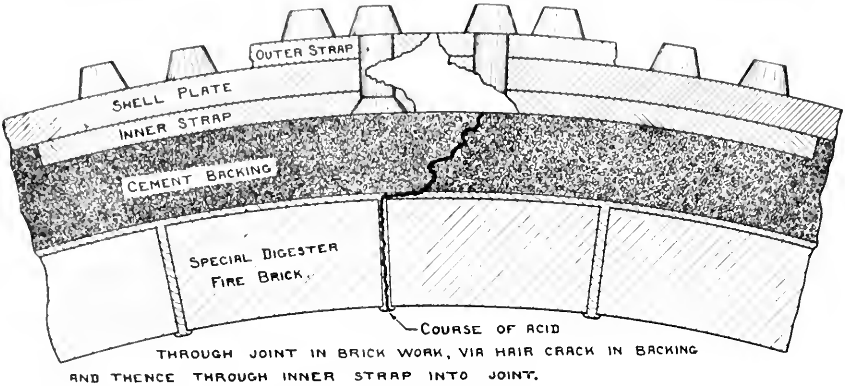


FIG. 2. APPROXIMATE SECTION AT X-X SHOWING THE MANNER IN WHICH CORROSION TOOK PLACE.

the joints, — they have no effect on the pressure which may be safely carried. Experience shows that test holes have justified themselves in many cases, though not all digester owners are willing to concede that they are of material advantage.

Owing to some serious accidents which have occurred to digesters having butt joints with but a single (outside) strap, due to the cracking of the strap by bending stresses of the same sort as those which give rise to the well known lap seam crack in steam boilers, many digesters are now being made with butt and double strap joints. (A discussion of this subject will be found in the LOCOMOTIVE for April, 1913, and April, 1914.) There is no doubt but that this construction is a step on the side of safety as far as the strength of the shell and its ability to withstand pressure stresses is concerned.

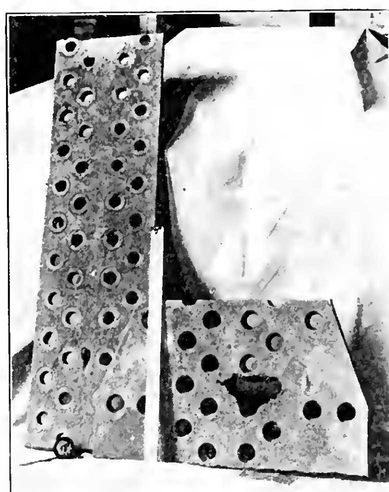


FIG. 3. OUTSIDE SURFACES OF OUTER AND INNER STRAPS (SURFACES WHICH WOULD BE VISIBLE ON AN UNLINED DIGESTER).

A recent occurrence has, however, pointed out one difficulty with this type of construction, and we believe a means for offsetting it, and it is this matter which gave rise to the present paper.

A small defect occurred in the backing of a cement and brick lined digester with double strapped butt joints at a point opposite the center line of one of the inside butt straps, just above the "hip" of the vessel, in the upper cone top, as is indicated in Fig. 1. The liquor penetrated to the steel and commenced to eat its way through the strap. As the cement and steel were in excellent contact at this point, no extensive corrosion, that is over

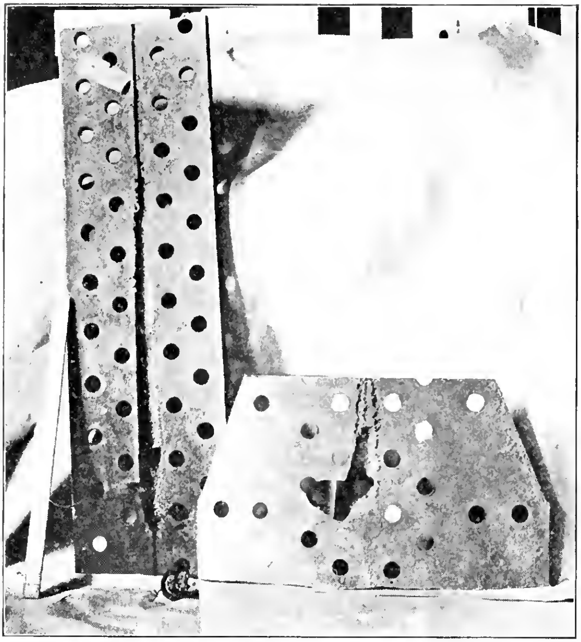


FIG. 4. INSIDE SURFACES OF OUTER AND INNER STRAPS. (SURFACES INVISIBLE TILL STRAPS WERE REMOVED FROM JOINT.)
NOTE: RULE IS 2 FEET LONG.

a large area of the inside surface of the inside strap could take place. The total extent of the corrosion on the surface is well shown in the photograph, Fig. 3. Eating into the strap, however, the liquor soon penetrated to a rivet and passed through, eating the metal of the rivet as well as that at the edge of the hole, gaining access to the space *between the straps*. Here, as is always the case, and especially with thick plates, the shell plates did not meet by say ⅛ inch, leaving a narrow longitudinal channel, of say ⅛ inch by 1⅛ inches (the plates were 1⅛ inches thick), the whole length of the joint, but covered on both sides by the two straps. Through this channel the acid rose for a distance of more than four feet, eating the edges of the plates, and cutting a groove or channel in the overlying outer butt strap, with a corresponding but shallower channel in the underlying inside strap. The approximate position of the beginning of the corrosion, as well as its extent is indicated by the dotted cross hatching in Fig. 1, while Fig. 2, which is a sketch showing the approximate course of the acid through the brick and the backing, and its action on the shell and the two straps at the point where it entered the joint will make the above description clear. The photographs, Figs. 3 and 4, show both sides of the two portions of strap which it was necessary to remove from the vessel, in making repairs. The longer and narrower piece, is from the outside strap. All this corrosion had taken place before the channel in the outer strap became deep enough to penetrate the outer skin and give warning that something was wrong. Yet in spite of this, the outer strap was reduced to less than ⅛ inch in thickness for a considerable distance. It was indeed fortunate that the leak occurred up in the conical part of the vessel. Here the steel casting at the top, together with the strapped girth seam at the base of the cone, greatly stiffened the vessel, tending to compensate in some measure for the weakening of the longitudinal seam. In addition, of course, was the fact that the diameter was rapidly diminishing, and with it the

LYMAN BUSHNELL BRAINERD

Born March 27, 1856 Died October 11, 1916

President

The Hartford Steam Boiler Inspection and Insurance Co.,

From July 12, 1904.

intensity of the pressure stress. It is unlikely that so serious a deterioration of a longitudinal joint could have taken place in the straight part of the shell without serious consequences.

One contributing circumstance, was the fact that in order that a hydrostatic pressure test might be applied to the vessel when it was first erected, and before it was lined, the joints were caulked, and incidentally the test holes were tapped for pipe plugs. The caulking, therefore, served to confine the liquor within the channel between the plate edges, with the results described. The repairs to the vessel were simple, the most weakened parts of the straps were found and removed, and new sections put in their place. Except for some minor difficulties due to the cramped location in which it was necessary to drive the rivets, they present no point of interest. Of course a rather extended portion of the lining had to be removed, and it had to be replaced and made tight after the boiler makers were through.

To prevent, if possible, the occurrence of such an accident in the future, the outside cover straps of the butt joints on this digester, and also on its neighbor, which was an exact duplicate, were drilled on the center line with half inch holes, clear through the outer strap, so as to reach to the space between the plate edges at the butt. These holes were spaced about seven or eight rivet pitches apart, and their effect on the efficiency of the joint was negligible. It is believed that in the future, a leak which penetrates the inner butt strap, will show at the holes in the outer strap, before any corrosion of moment has taken place in that strap, and while the action on the inner strap is confined to a simple hole, of no great moment. This ought to limit the extent of leaks in strapped joints to about the same degree of seriousness as the average small hole eaten through the shell plates away from the joint, where the acid gets no chance to run between the cement and the steel. We shall watch these vessels with especial interest.

Tests of Autogenous Welds of Boiler Plate.

Arranged by the Swiss Society of Steam Boiler Owners.

By E. Höhn, Chief Engineer.

From results of The (Swiss) Federal Laboratory for Testing Materials. With an Appendix by Prof. F. Schüle, of Zurich, Switzerland.

NOTE: The Author uses the term Autogenous to mean only welds made by the gas blow pipe, *i. e.*, oxy-acetylene, blaugas, etc., and does not extend it to cover electrical arc welding, as is common in this country. This distinction has been maintained throughout the translation, and electrical welding will always be found referred to as electrical welding specifically. — *Editor.*

I. Object.

The use of autogenous welding is becoming more and more common in the art of boiler making, both for construction and repair. Not all welds that have been made by this process have been successful. A large number which we have had to inspect and which have come both from Switzerland and from foreign countries have called for serious criticism. We recall the boiler of a cheese factory, described in our 1913 report, pp. 29 and 30, which had a cylindrical furnace with three transverse welded tubes, where the smoke tube was so negligently stuck on to the firebox that the welding did not incorporate a ring of more than 2 to 3 mm. wide. Moreover autogenous welding has become so important and valuable an addition to the art that it ought not to be unreasonably hampered. In this field foreigners have outdistanced the Swiss. We need only cite in this connection the strong and durable welds made on the boilers of steamships, which can only remain in port for short periods. Marseilles seems to have the honor of priority in this matter both as to the date of execution of the first satisfactory work, and in the development of satisfactory methods.

We know that here in Switzerland the principal boiler makers have introduced autogenous welding. Many have used it for several years, and some have acquired very great skill in its application. We might mention the difficult and very successful repair described in the annual report for 1911, pp. 37-38.

To procure for ourselves exact data on the actual status of autogenous welding and to assist at the same time in its development, as far as possible. we decided to get in touch with the houses having welding equipment and to invite their joint participation in some tests. The initiative for these preliminaries is due to our old Chief Inspector, Mons. F. Kyburz. It was his opinion that our Society should take both a practical and a financial interest. The proposition had the sanction of our committee (see annual report 1913, p. 8).

The invitations, to 42 Swiss firms, were sent in December, 1912. They were requested to prepare and send to the Federal Laboratory for Testing Materials, at Zurich, test plates, all exactly alike. Thirteen concerns doing autogenous welding and later one using the electric process gladly responded to the appeal. The sheets were welded during the course of 1913, and tested in 1914. Diverse and unforeseen circumstances have unhappily caused delays, and the work of examination has taken on proportions not thought of at the beginning.

The following concerns (arranged alphabetically), participated.

Ateliers de constructions méchanique de Vevey, at Vevey.

Federal Railways, Olten shops.

" " Zurich shops.

Ruegger, A., Boilermaker, Aarbourg.

Soc. Anonyme, Chaudronnerie Richterwil.

Soc. anonyme Alb. Buss & Co., mechanical and hydraulic shops at Bale.

Soc. anonyme des acieries, ci-devant Georges Fischer, at Schaffhouse.

Soc. anonyme des ateliers de constructions méchaniques, Escher Wys & Co.. Zurich.

Soc. anonyme des ateliers de constructions méchaniques de Theodor Bell & Co., at Kriens.

Soc. anonyme L. Wolf, Fabrique suisse de gaz liquide, Zurich.

Société Suisse pour la construction de locomotives et de machines. Winterthour.

Sulzer frères, société anonyme, Winterthour.

Vogt-Gut, H., société anonyme, Arbon.

Vogt & Schaad, machine shop, Uzwil.

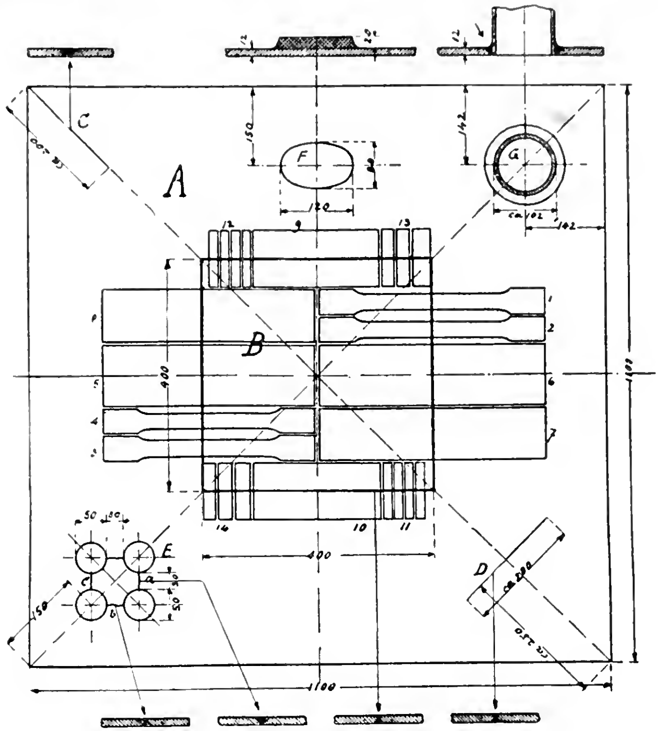


Fig. 3.

Test Plate for Autogenous Welds.

Unfortunately not all the houses which employ autogenous welding on boilers were willing to participate in these tests and indeed one of the most important was numbered among these absentees.

Each concern received a number for its test plate, but not in the alphabetical order. The subsequent tests are recorded under these numbers. We (the Society) furnished the plates for welding together with one extra plate for comparison. They were of Simens-Martin mild steel, quality FI, 12 mm. (½ inch) thick, all from the same heat and furnished by the steel works at Thyssen.

Fig. 3, together with the following program, gives the data on the nature of the test plate.* The most difficult task was welding in the square piece B, 400 mm. on a side. Then by means of several imitation cracks made with saw cuts and drilled holes, opportunity was given to weld from one side or from both sides of the sheet, and on the flat or at right angles.

II. Designation of the Welds.

A. Plate of mild steel 1100 by 1100 by 12 mm. } welded on both sides.
B. " " " " 400 by 400 by 12 mm. }

* The program for the tests of the materials was drawn up jointly with Prof. Schule, and the problem for welding came from Mons. Kyburz.

C. Cracks (cuts) made with a saw, welded on one side.

D. Saw cuts welded on both sides.

E. Saw cuts between four holes simulating cracked bridges in a tube sheet. a and b welded from one side, and c and d from both sides.

G. Short piece of standard 4" high pressure tube welded in the direction of the arrow, Fig. 3.

III. EXAMINATION OF THE TEST PLATES.*

1 to 4 tensile tests.

5 and 6 cold bend.

7 and 8 hot bend.

9 and 10 enlargement by forging and drifting.

11 and 12 Impact tests on notched bars.

13 and 14, etch test by acid attack.

When the test plates were returned they showed great differnces in external appearance. Some were neat and smooth, others were rugged and indented, while the poorest even showed displaced joints. Fig. 1 shows half of one of the best test plates, and Fig. 2, one of the worst.

In the comparative tables the results of the tests on the 13 plates autogenously welded are grouped together, although one plate was welded with "liquid gas" and 12 were oxy-acetylene welded. The results on the electrically welded plate XV are kept separate, as are those on the unwelded sheet U, which served for comparison. Sheet IV was not returned. The specimens for tension and impact tests were machined only on the edges and the results (for ultimate strength, apparent elastic limit, work of deformation, etc.) are referred to the section *outside the weld.* This was the only way of arriving at a common basis for comparison, as in the tension tests the failure took place outside the weld in some cases and at the weld in others. Furthermore, some of the plates were somewhat thickened at the weld, and others less so. With the electrically welded plate the thickness was nearly doubled, while with the autogenously welded specimens it was in general only slightly increased.

As to the elongations (2), partial elongations were measured both on 20 cm (8 inch) lengths and also on 5 cm. (2 inch) lengths chosen so as to lie outside the point of rupture and outside the weld. In this manner the effect of the very great elongation right at the point of rupture, which was especially marked if the point of rupture happened to coincide with the weld, was eliminated and the values obtained were more certainly comparable.

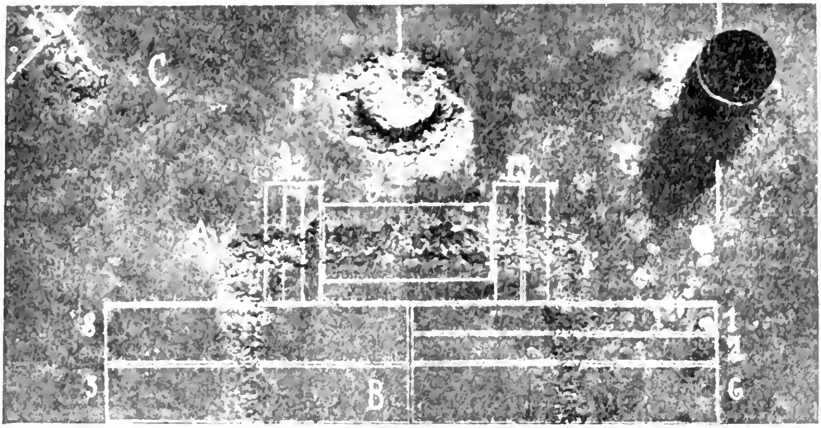
TEST RESULTS.

IV. TENSILE TESTS.

The 14 welded plates and the comparison plate which was not welded furnished 60 tensile specimens, of which 54 came from plates with autogenous welds. The specimens were 3.6 cm. in cross section (3 cm. wide by 1.2 cm. thick) outside the welded spot, and had a length of 20.0 cm. between the reference marks. (Gaged length). Of 52 tensile specimens from plates with autogenous welds, 27 (52%) broke outside the weld, while 25 (48%) broke

* Tests 1 to 8, 11 and 12 were made by M. Brunner, chief of section at the Federal Laboratory for Testing Materials. 13 and 14, as well as the microscopic researches were by M. Zschokke, Associate Director. The Society took charge of tests 9 and 10, under the direction of M. Kyburz. We express our appreciation of the efforts of all those who have assisted us.

Fig. 2.



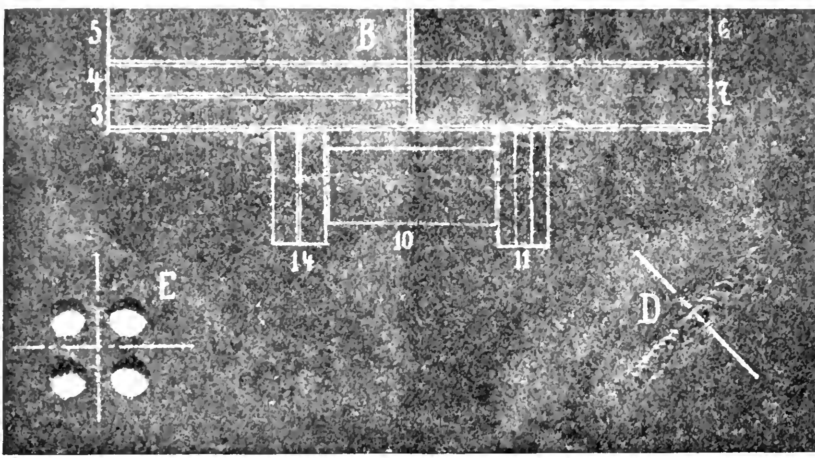


Fig. 1.

Plates Excellently and Poorly Welded. (half of each of Two Plates.)

at the weld itself. Of four specimens electrically welded, 3 broke outside and 1 at the weld. The direction of rolling, which was unknown, could not be taken into consideration.

The tensile tests and their average values are detailed in Table I. A study of these results shows less resistance for the welded bars than for those from the comparison plate. Taking the latter (comparison plate) as a base with a value = 100% we find for the 52 specimens with autogenous welds:

Apparent elastic limit	87%
Ultimate strength	82%

Reduction in area	71%
Elongation (8 inches)	58%
" (in 2 inches outside rupture and weld)	53%
Tetmajor's Coefficient of quality	50%

It is the elongation and the quality coefficient which have been most reduced. This last (quality coefficient) devised by Tetmajor, represents the product of the tensile strength by the elongation, divided by 100.

If we compare the 27 specimens which broke at the weld we get:

	Mean of 4 tests of unwelded bars, U.		Mean of 27 bars, ruptured outside the weld.		Mean of 25 bars, ruptured at the weld.	
	Value.	%	Value.	%	Value.	%
Apparent elastic limit, lbs. per square inch	37834	100	33425	88	32003	84
Ultimate strength	55045	100	47791	87	42101	76
Reduction in area	60.1	100	62.3	104	21.88	36
Elongation, in 8 inches	27.6	100	22.1	80	9.42	34
Elongation, in 2 inches outside weld .	20.0	100	13.2	66	7.76	39
Coefficient of quality	1.07	100	0.75	70	0.30	28

It will be noticed that the specimens which broke at the weld, and which were obviously of an inferior quality, possessed on an average only 76% of the strength and 39% of the elongation (2 inch length outside the weld and outside the point of rupture). This is an important loss in these properties from the original values. The results on the 27 tests which broke outside the weld yield 87% tensile strength and 66% elongation, which is also a rather great reduction in quality.

Plates I and XIII have a particular interest because all the test pieces broke outside the weld, while V and XII are to be noticed for the opposite characteristic, that is all the test pieces from these plates broke at the weld. These two groups permit other comparisons which would not have been possible between plates some of whose specimens broke outside and some at the weld, to which reference will be made later.

In examining the tensile strength, the fact that the plates were annealed should not be lost sight of as it is well known that this process produces a modification in the structure of the metal. Generally the ultimate strength falls off and the elongation increases. Summed up, the toughness of the annealed metal is greater than of that not so treated. Tetmajor's quality coefficient, $C = \frac{\beta\lambda}{100}$ (where β = the tensile strength expressed in tonnes per square centimeter, and λ = the elongation) is proportional to the work done on the test piece in breaking it. (This work is given by the area of the deformation diagram whose coordinates are the load and the deformation.) It represents approximately the work done in deforming a unit volume of the test piece.

If the average of 52 tests shows a reduction in tensile strength to 82% of the former value, it is true that annealing may have contributed to this result, but on the other hand we should expect to find the elongation increased. Such was not the case however, as the average elongation fell to 53% of that of the comparison plate. Hence the conclusion is forced that the quality of the metal has suffered. Of the 25 tests in which rupture occurred at the weld the quality coefficient was only 28%, while for the other 27, it was 70% of the coefficient of the unwelded material. The mean of the quality coefficients for plate I, which gave the best results, is C = 0.83, or 78% of the unwelded plate U (C = 1.07) and the mean of plate V which showed the poorest results is C = 0.03, 3% of the unwelded plate. We can here see the considerable difference between "welding" and "welding."

The electrically welded plate XV furnished slightly better results in the tensile tests but it should be observed that the ratio of breaks outside the weld to breaks at the weld for this sheet was as 3 : 1 as against 27 : 25 and this fact prevents a direct comparison. The considerable thickening of this plate at the weld also had a marked influence. We cannot then draw conclusions from the electrically welded plate as was done for the gas welded ones since but a single plate was available.

The influence of heat treatment (annealing) is further demonstrated in

V. Tests by the Brinnell Process

of which the results in general parallel those of the tension tests. These results in figures, are arranged in Table II for comparison. While the specimens of plate U gave a mean value of the hardness, H = 115.6, the mean for the 25 tests with autogenous welds fell to 102.8 when measured outside the weld, which was but 89% of the hardness of plate U. If measured at the weld, the mean hardness was found to be 108.2 which is 94% of the hardness of the unwelded plate.

The diminution of 11% in hardness represents about what could be attributed to the annealing, and although at the weld itself the metal was somewhat harder than outside it, the difference was only 5%.

The softest of the autogenously welded plates was No. I, the hardest, No. VI, which also had the highest tensile strength ($\beta = 49639 \frac{\text{lbs.}}{\text{sq.}}$ in. = 90% of U.) while No. I had the greatest elongation, $\lambda = 20.2\% = 101\%$ of the unwelded plate.

(All specimens of No. I (4), broke outside the weld, while 3 of No. VI broke outside the weld.)

The electrically welded plate was harder than all the others, especially at the weld.

As an important addition to the tensile tests, we have the

VI. Impact Bend Teste on Notched Bars

As is shown in Table III, these tests were made on six bars from each plate, prepared as shown in Fig. 4, and machined on the top and bottom edges. The impact was in every case applied at the weld and in the longitudinal direction of the joint. There were 78 bars autogenously welded and 6 bars from each of the other plates.

The average value for each plate as well as those for the groups are calculated and are given at the bottom of Table III. They have the following ratio to the unwelded plate U: (The average angle of bending is here determined from the lowest test values, as these show the impact at which the breaking just commenced, and are the most important).

Work of deformation	32%
Angle of bending	22%

Thus we have shown that the metal has suffered a degree of weakening as regards its tenacity, which is greater than that shown in its tensile strength.

Plate II attained the highest values in the impact test and plate I the lowest. (Leaving aside the electrically welded plate XV.)

It is worthy of note that plate I, which occupies about the first place considered from the standpoint of the execution of the welds and leads all the others for elongation and malleability, descends to the last place when classed according to its resistance to impact.

On the other hand, plates which yielded poor results in the tensile tests did very well under the impact test. This was the case for plate V. It appeared that as far as resistance to impact is concerned, some of the less homogenous and more fibrous welds were superior to those which were of a more uniform structure.

The observation that the best plates considered from the standpoint of the tensile tests are poorest in the light of the impact tests is confirmed by comparing plates I and XIII, where the tensile specimens all broke *outside the welds*, with plates V and XII, all of the tension tests of which broke *at the weld.*

	Unwelded plate U.		Plates I and XIII rupture outside.		Plates V and XII, rupture at weld.	
	Value.	%	Value.	%	Value.	%
Elastic limit, lbs. sq. in.	37834	100	32856	87	29869	79
Tensile strength	55045	100	47222	86	36127	66
Reduction in area	60.1	100	63.	105	13.62	23
Elong. (8 in.)	27.6	100	22.5	82	4.74	17
Elong. (2 in.)	20.0	100	14.1	70	3.8	19
Coefficient of quality	1.07	100	.74	69	.13	12
Hardness number, H: outside the weld	115.6	100	95.6	83	104.70	90
at the weld	....	....	105.5	....	104.75	....
Work of deformation, ft. lbs. sq. in.	870	100	109.6	12.5	242.5	26
Angle of bending	29°.6	100	4°.4	15	5°.7	19

The impact bend tests on the notched bars electrically welded all gave poor results. In spite of the thickness, which was nearly double at the weld, and the more maleable metal, the test bars were very weak. The contrast in quality noted during the tensile tests was confirmed here.

Although they are not provided for in the official specifications for the acceptance of material, impact bend tests have here again proved their importance. They should become in the future an important test method for those engaged in autogenous welding, both because the test yields information as to the character of the weld itself, through the appearance of the fracture, and because in tensile testing a weld is recognized as good if the specimen breaks outside the weld.

The impact test is the one best adapted to yield information in a very simple manner as to the effect of heat treatment (see Chap. XI, Hammering and annealing). For the sort of fractures which one should try to obtain, see Chap. VII, Appearance of the fracture.*

VII. Cold and Hot Bend Tests.

For these tests we refer to Table IV. It goes without saying that the poorly welded plates gave poor results here. The average values are less than for the unwelded plate. In explanation of the value x, it should be said that $x = 100$ when the radius of bending $r = \frac{s}{2}$ (s = thickness) and the specimen permits of bending through 180°.

Here as in the tests by hammering and drifting, Table V, the appearance of the specimen is of much more value than a description. It should be said however that the ordinary bend tests are not always in agreement with the impact tests, as can be seen for instance by comparing plate I. In other plates also, it well be seen that the impact test demonstrated defects that the ordinary bend tests failed to detect.

VIII. Fractures.

We find indications as to this subject in Tables I and III. Further several characteristic fractures are represented in Figs. 5-10 (tensile tests), and Figs. 11-14 (impact tests).

Fig. 5 U gives the fracture of the unwelded plate U as tested in tension. It is characterized by considerable reduction in area, fine grain, and raised edges (cupped fracture) which are only found in tough material.

Fig. 6 V shows that the weld which was made from both sides did not reach the center, and in addition the metal about the weld is burned.

Fig. 7 VI shows a brilliant coarse grained fracture which indicates that the grain is burned, moreover the center is poorly welded.

Figs. 6 and 7 show a complete lack of reduction in area. Fig. 8 XI presents a laminated structure as does Fig. 9 XII, but in the latter the weld is imperfect in other ways and contains oxide.

Fig. 10 XV, electrically welded, great increase in thickness (doubled, *i. e.*, 24 mm.), laminated structure, the metal burned in spots.

In Fig. 11 U, from the non-welded plate, one is struck by the contraction and crushing caused by the impact test. The compression fibers (on top) are

* Dr. Schmid of Zurich recommends the impact test to determine if iron (steel) has been forged at the blue heat. This test has been successful with him when tensile tests, ordinary bend tests, and even microscopic examinations have failed. (Meeting of the Swiss members of the International Association for Testing Materials, 1913, No. 10.)

FRACTURES (PAGE 111)

FIG. 5. U 6. V 7. VI 11. U 12. I

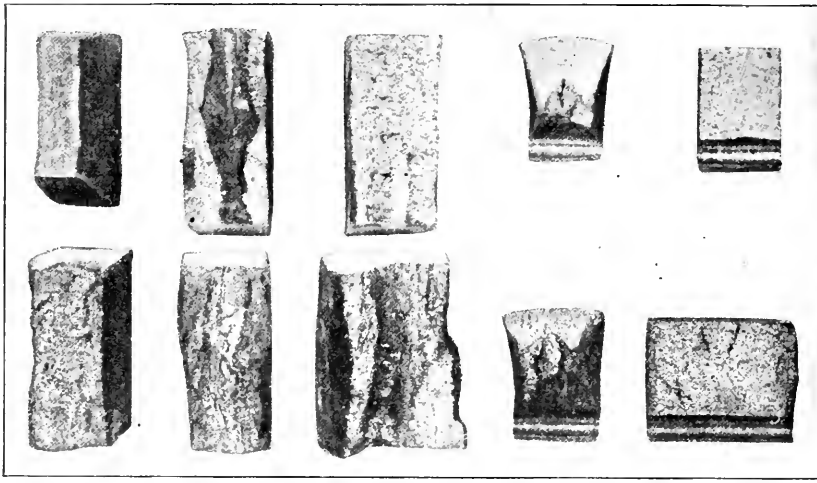


FIG. 8. XI 9. XII 10. XV 13. II 14 XV.

crushed to the sides while the tension fibers at the bottom above the notch are contracted toward the center. This only occurs with tough material. Moreover the grain of the fracture is very fine, only one flaw is visible. The fracture of plate II, Fig. 13 is almost identical. This is the metal which gave good results on the impact test while that shown in 12 I and 14 XV (the latter electrically welded), show no contraction. Furthermore, the grain of these fractures is large and brilliant. In No. XV, a group of blowholes is seen and portions are burned. Its thickness is practically doubled.

The character of the fracture in Fig. 11 should serve as a model to those engaged in autogenous welding, to use in the tests at their works. This fracture shows tough (tenacious) material.

IX. TESTS BY ETCHING WITH ACID

Twelve etch tests were made on the metal from each plate, altogether 180 single tests. In illustrating these we only wish to show the most characteristic aspects. We have therefore preferred to present line sketches rather than photographs.

Figs. 15 to 21 represent sections of welds made from both sides, Figs. 22-28, sections welded clear through from one side, Figs. 29-32, welds at right angles (pieces of tube welded into the sheet) and Figs. 33-35 pieces welded on to the sheet (reinforcing bosses). The roman numerals give the number of the plate, and the letters the point where the weld was made as in Fig. 3. This means of representation makes the quality of the welds sufficiently recognizable. The best are naturally those where the original metal and that added in welding are carefully incorporated, the one with the other, as in Fig. 16 I or again, if an increase in thickness is permitted (which is always

Autogenous Welds.

from both sides

Fig. 15. X

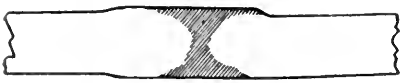


Fig 16. I

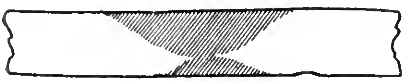


Fig. 17. IX

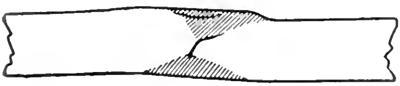


Fig. 18. VI

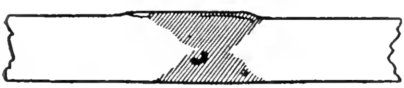
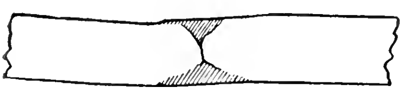


Fig. 19. V

Fig. 20. V



from one side

Fig. 22. XIII

Fig. 23. VII

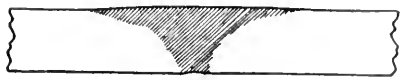


Fig. 24. III

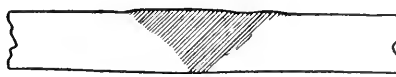


Fig. 25. XII

Fig. 26. XI

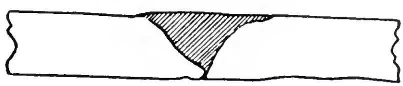
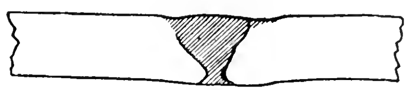


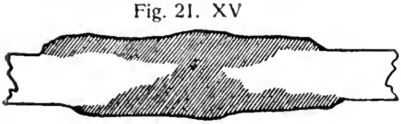
Fig. 27 XI



Electric Welds.

from both sides

Fig. 21. XV



from one side

Fig. 28. XV

Autogenous Welds.

G. Short piece of 4" high pressure tube welded into plate.

Fig. 29. I

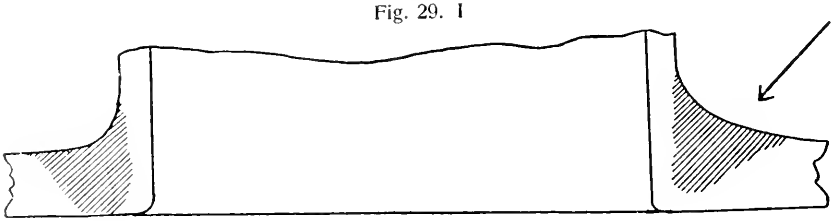


Fig. 30. IX

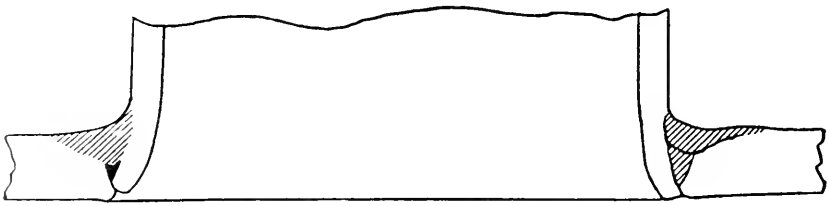


Fig. 31. VIII

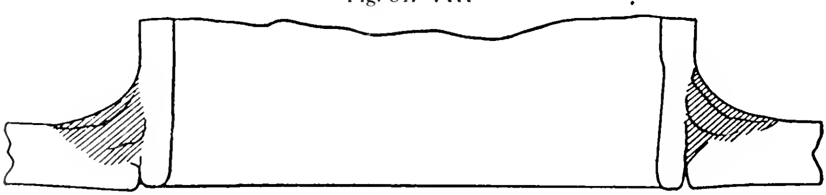
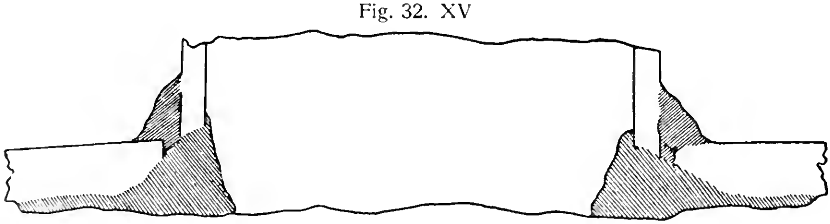


Fig. 32. XV



Electric Weld.

desirable in boiler work), as in Fig. 15 X, or as in Figs. 22 XII, 23 VII, 24 III, and 33 I.

The other sketches represent defects in the welds, defective joints, inclusions of scoriæ, and oxides, blowholes, crevices, also roughness (indentations), overflows, etc. In these views overheating, burns and carburization are not well shown. The most frequent defects are defective joining of the

Fig. 33. I

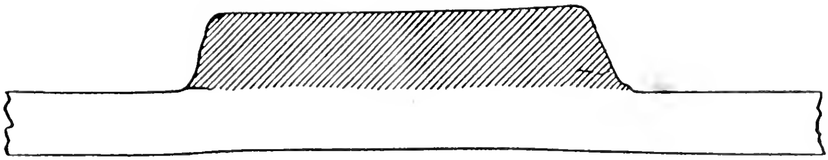


Fig. 34. XIV

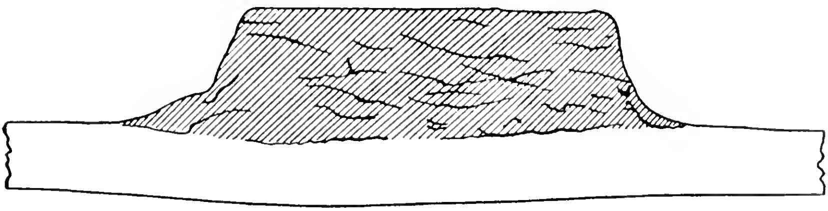
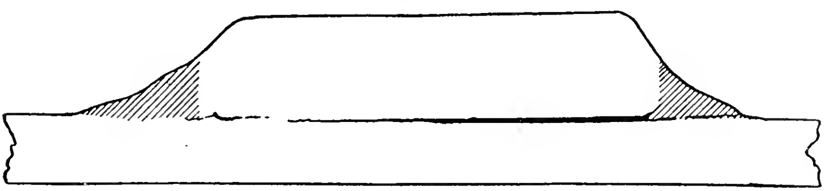


Fig. 35. X



F. Boss Autogenously Welded to Plate.

original metal to the added metal, or between successive layers of the added metal, when it is more nearly "pasted" than welded. The principal cause of these defects is that the edges to be welded are too close together.

This brings us to a fundamental error which is made by autogenous welders. The angle of the opening (chipped or burned out), which they prepare for welding should be *at least* 90°, *and the width at the bottom of the V ought to be at least* 4 *mm.* (3/32") *for sheets* 12 *mm.* (½ *inch*) *thick.* It is clear that if the angle is too acute, the flame in welding cannot penetrate to the bottom in an effective manner. It is pushed and frequently blown out. The upper edge is then alone welded to the filling material, as is seen in Fig. 19 V, 20 V, 26 XI, 27 XI, etc. If on the other hand the slot is wide enough and open at the bottom, the flame reaches all the surface with its full force, and produces a prompt fusion of the edges of the plate, throughout their entire extent. Although the expenditure of time, metal and gas seems greater for a wide opening than for a narrow one, such in reality is not the case. In fact the opposite is true if one wishes to secure a sound weld in a narrow opening. The properly welded pieces are all without exception made in widely opened slots, as in Fig. 16 I, 23 VII, and 29 I.

For all acetylene welds a simple rule may be deduced. Prepare the work for welding in a proper manner, and make sure that the slot chipped out is wide

(*Continued on page* 118)

The Locomotive

of

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

C. C. PERRY, EDITOR.

HARTFORD, OCTOBER, 1916.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

In this issue of THE LOCOMOTIVE we begin the publication of a translation of a report by the Chief Engineer of the Swiss Society of Steam Boiler Owners, describing tests made by that Society on autogenous welds. This program of tests seems to us at once the most complete, scientific, and fair effort to arrive at a notion of the value of autogenous welding for boiler and pressure vessel construction which has come to our attention. We felt that the whole report was of sufficient interest and value to warrant presenting it to our readers, including our own inspection force, in its complete form. Therefore we have decided to publish the entire translation rather than a brief abstract. This will necessitate its appearance in installments through two or perhaps three LOCOMOTIVES and we would suggest that those among our readers who are interested preserve their copies so that they may have the whole report in complete form for reference. The tables mentioned in the text will be printed with the final installment. The original report was accompanied by an appendix in the form of a critical study of the material tests by the Director of the (Swiss) Federal Laboratory for Testing Materials, Prof. F. Schule, and we will translate this for a future issue of THE LOCOMOTIVE, so that the whole matter may be complete and accessible to our readers in English. We are not especially proud of our translation, it is not so smooth a piece of English literature as we might have desired, but we present it as an accurate if not an elegant representation of the author's meaning.

In the light of the above report, we wish to call attention to the large number of explosions recently reported as coming from welded tanks and receivers of one sort and another. The number has become so great, and the damage to life and property so tremendous, that we have thought it wise to mention in our list of explosions the fact that an exploded tank was of welded construction, if we are in possession of information to that effect. This should not of itself be taken as an arraignment of the welding, as that cannot always follow from the mere fact that an exploded tank was so made, there are of course many causes for explosions beside defective welds. On the other hand we have seen so many cases where the welding *was* defective, either in execution or in the design of the joint, that there is at least a reasonable doubt of such construction in many cases, a conclusion concurred in by the report which we have translated. It becomes therefore a matter of interest to collate data on the explosion of welded vessels, and we shall attempt in the near future to present the facts in the case of those explosions of which we may have sufficient knowledge.

Obituary.

Thomas J. McGovern.

It is with sincere regret that we are obliged to announce the death of one of our old and most trusted inspectors, Mr. Thomas J. McGovern, who expired suddenly about eleven o'clock P. M. July 20th, 1916.

Mr. McGovern was apparently in good health when he left the office for home at about 5.30 P. M. on the date of his death. The end came suddenly and with little warning as the result of an attack of acute indigestion.

Mr. McGovern was born at Minersville, Schuylkill County, Pa., on February 9, 1859. He learned the trade of boiler-maker with Mr. Jacob Naylor of Philadelphia and joined the inspection force of The Hartford on November 1st, 1887. He continued in that capacity until his death, a period of nearly twenty-nine years. Mr. McGovern was held in high esteem by all who knew him and was a trusted and conscientious inspector. A widow and three children survive him.

Mr. William D. Miers.

It is with sincere sorrow that we announce the death of Mr. William Daniel Miers of Allentown, Pa., who for about twenty-two years has represented The Hartford Steam Boiler Inspection and Insurance Company as Special Agent in his home city.

Mr. Miers had been apparently in perfect health until Friday, August 4th. At about midnight on that date he was suddenly stricken with paralysis which affected his entire left side and passed away on Sunday morning without regaining consciousness.

Mr. Miers was fifty-four years old, and was born in Mauch Chunk, Pa. After completing his education he moved to Allentown and accepted a position with the Allentown Rolling Mills, now known as the Aldrich Pump Co. Later he entered the service of the Lehigh Valley Railroad Company as auditor. After being with this company for several years, Mr. Miers engaged in the fire insurance business securing the agency for a number of the leading companies.

He was appointed a special agent of The Hartford in the fall of 1894 and his personality and sterling business methods enabled him to build up a very large business for us in his territory. He was one of the leading fire insurance men in his section of the state and was a director of the Penn Mutual Life Insurance Co.

Mr. Miers is survived by his wife and three sons, Paul H., Robert W., and C. Garrett.

In Mr. Miers' will he expressed the wish that the business be continued by Mrs. Miers and Paul H. Miers, and we are glad to be advised that this course will be pursued. There is perhaps no city in the country where HARTFORD policy holders form a larger percentage of the whole number of steam users than they do in Allentown, and we feel confident that Mr. Paul H Miers will be extremely successful. He is a young man of much promise and a wide acquaintance in Lehigh County. We bespeak for him the continued patronage of our Lehigh County friends.

TESTS OF AUTOGENOUS WELDS.

(*Continued from page* 115)

enough, it is only from this start that one can proceed successfully. As for deciding as to whether it is better to weld from one side only or from both sides, this depends principally on the thickness of the sheet. When welding from one side, the space for the reception of the added metal is greater than if the welding is done from both sides, and one is tempted to say that the consumption of welding metal will be greater. In practice, however, this is not the case except to a very slight extent. In welding from both sides it is of the greatest importance that the welding be done *and finished at a single heat*, a matter which is only possible when welding from one side in the case of thin or moderately thick plates. In welding thick plates from both sides, the two sides ought to be welded and hammered simultaneously. One other cause of poor welding ("pasting") is insufficient preheating of the parts to be welded. An example of this is shown in Figs. 30 IX, 31 VII, and 34 XIV. This defect arises either from lack of experience or attention, for a welder who knows his trade should know the instant when the pieces of metal to be welded are in a condition to melt or flow together.

Fig. 35 X shows a piece of metal stuck on the plate, only the edges of which are welded. Such a pad could not be recognized as well done.

Other grave faults were developed by the etch tests, such as blowholes deposits of oxide, soft (weak) structure, etc. (See Fig. 18 VI, 25 XII, 30 IX.) These defects also arise from lack of skill. We still have for consideration the development of oxides during the welding. Iron, raised to a high temperature absorbs oxygen rapidly from the air, and every country blacksmith recognizes the fact. Since to make autogenous welds we employ oxygen directly, the formation of oxides is much greater if the flame carries an excess of oxygen. It is necessary then to regulate correctly the mixture of gases in the torch. Since acetylene is a reducing agent, that is, it destroys oxides, one ought to arrange things so that the flame has an excess of acetylene, but this brings a new difficulty for acetylene carburizes liquid iron, and transforms it into a material with a different chemical composition (steel). One must then regulate the blowpipe flame exactly right, which will be done when the core of the flame is white, very luminous, and somewhat limited in size, but not too short. If the core is short and the flame tinged with violet, oxygen is in excess, and when it is extremely luminous acetylene is in excess. When the flame is well regulated the preheating of the oxygen tends to steady the flow, although trouble may arise from the condensation of water which forms in the tubes. Oxides are eliminated by agitating the molten metal with the welding wire, which brings them to the surface. Powder (flux) is no longer used in welding mild steel to reduce the oxides (cast iron presents a different problem). Skilled use of torch and welding rod will of itself avoid oxidation. If possible the welding wire should never have actual contact with the flame, but both should be in motion and in such a way as to mutually avoid each other.

The etch tests permit certain conclusions as to the structure of the metal Thus the tests on plate I, and in part on plate X give a regular appearance of brilliant silver, like well polished tool steel. Plate VIII shows the welding metal blackened, and plate XIII shows in spots a brilliant coarse grain resulting from overheating.

Burned metal results from too high a temperature. It is facilitated when the flame carries an excess of oxygen. An oxidization and partial decarburization of the iron is produced, for which the iron itself (by its combustion) furnishes part of the heat. The action of the cutting torch depends also on a greater consumption of oxygen by this torch than by the welding torch.*

The welding torch is an apparatus possessing great energy and the art of welding consists in part in just extracting enough heat to melt the iron.**

In this respect the distance from the core of the flame to the weld is of great importance. As is well known, iron melts at about 1500°C (2732°F).

As for the electrically welded plate, it had no preparation of the joints by chipping the edges of the sheet as was done for all the acetylene welded plates. On account of the enormous heat of the arc the edges of the plate, which touched roughly, were melted and then filled in with the welding metal. This is shown in Table VI, and also in Figs. 21 XV, 28 XV, and 32 XV

The fractures and etch tests showed a somewhat porous structure, and this is the cause of their weakness.

We cannot finish the chapter on etch tests, which form such an important means for the welder to keep track of his work without giving some indication as to the method to be employed in its application.***

The surface which it is desired to etch should be carefully polished with 000 emery paper, washed thoroughly with a tooth brush in an alcoholic solution of caustic potash or caustic soda, then rinsed with water. After removing all greasy impurities in this manner the piece is plunged into the corrosive solution and moved about for from one to three minutes. The composition of the etching liquid: to 1 liter of water, add 200 grams of potassium iodide, and 100 grams of sublimed iodine. As the different elements in the iron structure

* The oxidation of iron at a high temperature takes place according to the equation $2FE + 3\ O = Fe_2\,O_3$. When it takes place about 1750 calories per kilogram of iron are liberated. As a figure for comparison the calorific power of a kilogram of carbon, burned to $C\ O_2$ is 7860 to 8140 calories, according to the allotropic modification of the carbon.

** A cubic meter of acetylene has a calorific power depending on its purity of 12000-13000 cal. The flame of the acetylene torch should reach a temperature of 3000°C (5400°F.), while the flame of hydrogen gives but 1900-2000°C. (3450-3600°F.). (See Zeitsch. Ver. deutsch, Ing., 1908, p. 66.) In practice these high temperatures are not reached. Thus Baumann, at Stuttgart, welding with the acetylene flame, found a temperature of 1474-1655°C. (2687-3029°F.) (Forschungsarbeiten des Ver. deutsch. Ing., Vol 83-84, p. 54). The temperature depends on the distance from the inner flame (core) The electric arc reaches a temperature of 3000°C., (5400°F.).

*** This data is from M. B. Zschokke, of the Federal Laboratory for Testing Materials, Zurich. See also Die praktische Nutzanwendung der Prüfung des Eisens durch Ätzverfahren und mit Hilfe des Mikroskops, von Dr. Ing. E. Preuss.

are attacked to different degrees by this liquid, a very distinct pattern is produced on the polished metal. The free carbon which separates out and forms on the surface a fine coating of blackish yellow should be removed with a bit of cotton wadding under a stream of water. To preserve the etched surface from rusting, it must be dried, as soon as it is completely washed, with blotting paper, and then wet with absolute alcohol, followed with ether. If it is desired to preserve the specimen, the etched surface is varnished by means of a soft brush, with a solution of gum dammar in toluol. This colorless and transparent coat dries in a few minutes and preserves the etched surface from rusting for years if the specimen is stored in a dry cupboard.

X. Microphotographic Studies.

In certain cases where the structure seemed unusual, a microscopic examination was of interest. Several of the impact tests which gave striking results as compared with the tensile tests from the same plates, gave rise to these examinations. Fig. 36 U, shows the structure of the unwelded plate U (magnification 160 diameters). It is composed mainly of ferrite* with pearlite arranged in lines. The structure in lines comes from the rolling, and from the presence of numerous simultaneous inclusions of scoriæ.

Fig. 37 shows with a magnification of 46 diameters, the transition portion of a welded joint. Above is seen the welded (added) material, and below the plate. The difference which exists between the two ends, which is visible with the naked eye, is much more striking under the microscope. The plate is composed of ferrite with some little pearlite disposed in lines, while the added metal is pure ferrite.

Fig. 38 I, was taken just back of the break on an impact specimen from plate I. It shows welded metal, the fracture of which somewhat resembled cast iron. (Compare with Fig. 12.) This plate was very well welded and gave excellent results for tensile strength and elongation. The image of the structure of the added metal magnified to 160 diameters, shows only pure ferrite.

Fig. 39 II shows the structure of the metal in the weld from an impact bar from plate II (one of those which gave the best results in these tests), magnified to 160 diameters. The fracture is shown in Fig. 13.

* The microstructure of metals is made up of crystaline grains like that of rocks for the most part of irregular form. Mild steel and ordinary steels contain, when not hardened, one, two or three of the following constituents according to their carbon content: viz., ferrite, cementite, and pearlite.

Ferrite is the characteristic component of iron low in carbon. Upon the etched and polished surface it appears as polyhedral crystals, uncolored and of irregular form.

Cementite is a chemical combination of iron and carbon called by the chemists iron carbide, Fe_3C. It is not found as a free component of the structure except in very hard steels having more than .9% carbon. On the etched and polished surface it appears in the form of needle shaped uncolored crystals.

Pearlite is an intimate mechanical mixture, the co-called eutectic mixture, of ferrite and cementite. On the etched and polished surface it forms irregular figures which under feeble magnification seem to constitute homogeneous bodies of gray or blackish color, but which under a higher power are seen as a mixture of fine laminæ of alternate ferrite and cementite.

The composition

of extra soft steel	is exclusively ferrite.
of soft or half hard steel	ferrite with a variable amount of pearlite.
of very hard steel (more than .95% carbon)	pearlite and a variable amount of free cementite.

MICROPHOTOGRAPHS.

Fig. 30. U X 160

Fig. 37 X 46

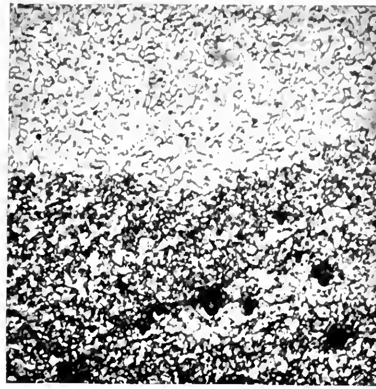


Fig. 38. I X 160

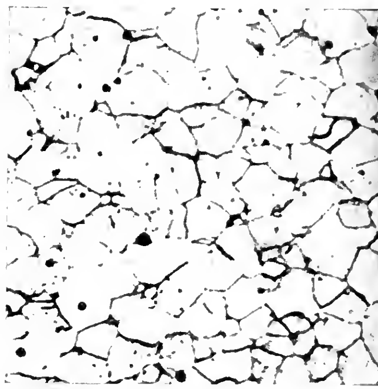


Fig. 39. II X 160

Fig. 40. VIII X 160

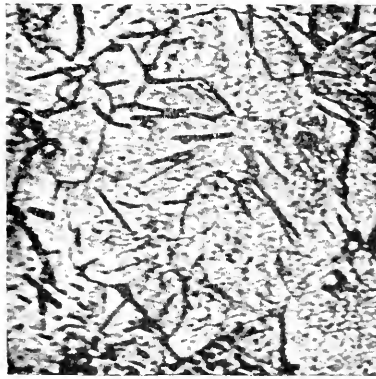


Fig. 41. VIII X 550

Fig. 39 II resembles Fig 38 I in that both contain only pure ferrite, but they have some differences. Although 39 II strongly resembles the unwelded plate, Fig. 36 U, Fig. 38 I shows an intermediate structure between that of 39 II and 40 VIII. It should be noted that plate II, which gave the best results on the impact tests, and whose fractures resembled those of plate U, also resembles the model in microstructure if the unwelded plate, Fig. 36, is so taken.

Nevertheless, it would be impossible to say what the welder should do to attain this end when welding. This must remain for future investigation. We do not even believe that the welder of plate II had this aim in view, it was entirely the result of a lucky chance.

Figs. 40 VIII and 41 VIII represent metal of the weld in plate VIII magnified 160 and 150 times respectively. These illustrations as well of those of Fig. 43 XV, furnished by metal from the electrical weld on plate XV, possess a definite character which differs widely from the others. In these cases we see within the mass of pure ferrite innumerable needles of black color. separated, and here and there ranged parallel to each other. Such formations have been observed previously by other investigators who considered them to be crevices or cracks.* Nevertheless, we cannot share this view, because the needles in question are always absolutely straight, and of nearly equal length.

To clear up this question we tried to prepare such needles intentionally. For this we had prepared three test pieces 33 cm. long by 12 mm. thick with autogenous welds as follows:

No. 1 with the welding flame in the normal condition.

No. 2 with a flame having an excess of oxygen.

No. 3 with a flame having an excess of acetylene.

These pieces were neither hammered nor annealed. From each weld several sections were cut to examine the structure under the microscope. It was established that bars 1 and 3 had the normal ferrite structure, which proved that in No. 3 no carburization had been produced.

Several sections of No. 2 had the structure of ferrite but with the needles as in Fig. 44 (magnification = 160 diameters) which is more distinctly shown in Fig. 45 with a magnification of 550 diameters. Since this phenomenon was produced in plate XV, electrically welded, also in the supplementary test No. 2, welded with an excess of oxygen, and since moreover both cases represent work done at excessive and abnormal temperatures, one is led to assume that the metal is partly burned. The electrically welded plate XV seems to indicate this also as much scoriæ was included, manifested by black stains in Fig. 43 XV. Moreover the formation of these needles in both cases indicates that probably considerable quantities of oxides, dissolved in the welding metal at fusion, have crystallized out on cooling in the needle form. A final definite opinion on these needles could be formed only through further and more extensive study.

We must remark at the same time that the specimens for the supplementary tests, Nos. 1-3 (4 pieces for each, making 12 in all), were submitted to the impact test and gave practically identical results, in spite of the difference in the welding flame.

* Compare with "Mitteilungen über Forschungsarbeiten auf dem Gebeite des Ingeneurwesens," published by the Ver. deutsch. Ing., vol. 83 and 84, pp. 18-20.

The structure Fig. 42, is that of metal welded on plate XIII. This plate showed on the etch test many overheated spots. Fig. 42 shows such a region. The abnormal size of the ferrite grains is typical of overheating. The pearlite grains are lacking. (See also chapter on Annealing.) Fig. 46 shows the structure, magnified 160 diameters, of the Swedish charcoal iron wire used as welding metal. This wire is composed of pure ferrite with slight inclusions of scoriæ.

The microscopic examination of all the autogenous welds showed that the plate consisted of ferrite with a little pearlite but that the added welding metal contained only pure ferrite. This should be softer than metal containing pearlite and ferrite. If in spite of this the welds in the Brinnell Hardness tests gave hardness numbers a little higher than the plate (H = 108.2 ave. at the welds and 102.9 ave. outside) this comes probably from the different heat treatment. For the rest, the excellent appearance of the welded metal permits the conclusion that all the welding wire was of good quality.

(To be Continued)

Boiler Explosions.

MAY, 1916.

(204.) — On May 1, a tube ruptured in a water tube boiler at the plant of The American Steel and Wire Co., Waukegan, Ill.

(205.) — Two tubes ruptured in a water tube boiler May 2, at the plant of the Baltic Mining Co., Redridge, Mich.

(206.) — On May 8, the water connection between the boiler and the water column failed at the shirt factory of Berkowitz Bros., Brooklyn, N. Y.

(207.) — The boiler of a well drilling outfit exploded May 8, near Kokomo, Ind. Two men were scalded, one probably fatally, and the outfit was demolished.

(208.) — Three sections cracked May 9, in a cast iron sectional heating boiler at the Charlesbank Homes, apartment house, 333-343 Charles St., Boston, Mass.

(209.) — A tube ruptured May 9, in a water tube boiler at the N. R. Allen's Sons Co. plant of the Central Leather Co., Kenosha, Wis. One man was injured.

(210.) — The boiler of a donkey engine exploded May 10, at the plant of the Newport Turpentine Co., near Pensacola, Fla. Nine men were badly injured.

(211.) — On May 12, a tube ruptured in a water tube boiler at the plant of the American Steel and Wire Co., Donora, Pa. The boiler was considerably damaged.

(212.) — A hot water heater exploded May 12, at the Springdale plant of the Stamford Rolling Mills, Stamford, Ct. Two men were severely burned.

(213.) — A boiler exploded May 13, at the Fullbright sawmill, Blandys township, North Carolina. Three men were injured and the mill destroyed.

(214.) — On May 14, an elbow failed in a main steam line at the glass manufacturing plant of the H. C. Fry Co., Rochester, Pa.

(215.) — A tube ruptured May 17, in a water tube boiler at the Inman Mills, Inman, S. C.

(216.) — An autogenously welded ammonia tank exploded May 17, at the plant of the Hygenic Ice and Cold Storage Co., Birmingham, Ala. One man was killed and another injured.

(217.) — A kier exploded May 17, at the plant of the Georgia Fibre Corporation, Atlanta, Ga. The plant was badly wrecked, but no one was injured.

(218.) — On May 18, a tube ruptured in a water tube boiler at the plant of the Detroit City Gas Co., Detroit, Mich. The boiler was badly damaged.

(219.) — A corrugated furnace collapsed in a Scotch marine type boiler on May 21, at the Hotel of William Baird, Cambridge Springs, Pa.

(220.) — Four cast iron headers ruptured May 22, in a water tube boiler at the plant of the Gulfport Creosoting Co., Gulfport, Miss.

(221.) — On May 25, an elbow broke in the feed line to the boiler at the Hillgrove Tannery, Elk Taning Co., plant of the Central Leather Co., Ridgeway, Pa.

(222.) — The boiler of a steam shovel, engaged in cleaning out the bed of the Genesee river exploded May 26 at Belfast, N. Y. Two men were killed and four injured.

(223.) — A boiler exploded May 29, on an oil lease between Humble and Moonshine Hill, Texas. One man was killed and one injured.

(224.) — On May 30, two tubes ruptured in a water tube boiler at the plant of the McKeefrey Iron Co., Leetonia, O.

(225.) — An autogenously welded tank on a tar wagon exploded May 30, at the plant of the Aufrichtig Copper and Sheet Iron Works, St. Louis, Mo. The tank which was a new one, was being tested with compressed air. It exploded, fatally injuring one, and seriously injuring another.

(226.) — On May 31, the main stop valve ruptured in the steam line at the plant of the Empire Brick and Supply Co., Stocksport, N. Y.

(227.) — A cast iron heating boiler ruptured May 31, at the theater of the Comet Amusement Co., a part of Loews' Theatrical Enterprises, N. Y. City.

JUNE, 1916.

(228.) — A boiler exploded June 3, at the plant of the T. R. Miller Mill Co., Brewton, Ala. The explosion was a very violent one. One man was killed and two others were badly injured as a result.

(229.) — A feed line burst June 3, at the power house of the Adirondack Electric Power Corporation, Utica, N. Y. Street car service in Utica was badly crippled for several hours as a result of the accident.

(230.) — On June 5, a tube ruptured in a water tube boiler at the Hamilton Club, Brooklyn, N. Y. The damage was small.

(231.) — On June 9, six sections ruptured in a cast iron sectional heating boiler at the dry goods store of Nichols and Frost, Fitchburg, Mass.

(232.) — A tube ruptured June 7, in a water tube boiler at the Chittenden Hotel, operated by the Iroquois Co., Columbus, O.

(233.) — The boiler of a traction engine exploded June 9, on the Wilkinson farm, near Danville, Va. One man was killed and three injured.

(234.) — The door of a vulcanizer blew off June 9, at the plant of the Electric Hose and Rubber Co., Wilmington, Del. Three men were badly scalded.

(235.) — On June 12, a boiler ruptured on Digger No. 2, of the Ohio River Sand Co., on the Ohio river, near Louisville, Ky.

(236.) — On June 12, a stop valve ruptured in the main steam line at the wholesale dry goods store of The Mackey Nesbit Co., Evansville, Ind.

(237.—A water tube boiler ruptured June 13, on Oil Truck No. 230 of the Standard Oil Co., of New Jersey, Newark, N. J. The boiler was entirely destroyed.

(238.)—A boiler exploded June 13, at the Stopper saw mill, Fairfield, Ill. One man was killed and two boys badly injured.

(239.)—On June 14, two cast iron headers ruptured in a water tube boiler at the plant of the Grasselli Chemical Co., Grasselli, Ind.

(240.)—On June 14, a tube pulled out of the drum of a water tube boiler at the Atlantic Gas and Electric Co. plant of the General Gas and Electric Co., Easton, Pa. One man was kiled and two injured.

(241.)—A tube ruptured June 16, in a water tube boiler at the Clarion Mill of The York and Pennsylvania Co., Johnsonburg, Pa.

(242.)—The blower cap on the boiler of New York Central switch engine No. 138 blew off in the storage shed of R. H. Bennett and Co., No. Tonawanda, N. Y., on June 17. No one was injured, but severe damage was done by escaping steam to dressed lumber stored in the shed.

(243.)—The crown sheet of a locomotive type boiler collapsed June 20, at the saw mill of Joseph Byers, Racine, W. Va. No one was injured.

(244.)—On June 25, a boiler ruptured at the plant of the Clark Boiler and Engine Co., Kalamazoo, Mich.

(245.)—A blow-off pipe failed June 26, at the plant of the Orange Cotton Mills, Orangeburg, S. C. One man was injured.

(246.)—Four men were injured June 28, when a boiler exploded at the plant of the McCabe Boiler Works, Newark, N. J.

(247.)—Fire Station No. 21, Seattle, Wash., was wrecked by the explosion of a boiler in the basement, on June 30. One man was injured.

July, 1916.

(248.)—On June 3, the boiler of the steam yacht Helibird exploded in the Delaware river, near Penn's Grove, N. J. Five were drowned and eight are missing, due to the sinking of the boat after the explosion.

(249.)—On July 4, the crown sheet of a locomotive type boiler collapsed at the plant of the Menominee and Bay Shore Lumber Co., Soperton, Wis.

(250.)—Eight cast iron headers ruptured July 4, in a water tube boiler at the plant of the Atlantic Steel Co., Atlanta, Ga.

(251.)—A blow-off pipe failed July 6, at the plant of the Viscosity Oil Co., Chicago, Ill.

(252.)—On July 6, a tube pulled out of a drum on a water tube boiler at the plant of the Michigan Alkali Co., Wyandotte, Mich. The boiler was considerably damaged.

(253.)—On July 8, a boiler failed at the laundry of Wonnacott Bros. and Co., Carbondale, Pa.

(254.)—On July 8, the main steam pipe failed at the plant of the Danaher Lumber Co., Tacoma, Wash.

(255.)—A non-return valve burst July 8, at the hat factory of the John B. Stetson Co., Philadelphia, Pa.

(256.)—On July 10, a boiler ruptured at the pumping station of the city of Monticello, N. Y.

(257.)—On July 10, a boiler ruptured at the gas plant of the Muskegon Traction and Lighting Co., Muskegon, Mich.

(258.) — A blow-off valve failed July 10, at the plant of the McKim and Cochran Furniture Co., Madison, Ind. One man was injured.

(259.) — The boiler of a threshing machine exploded July 11, at Wichita, Kans.

(260.) — An autogenously welded ammonia tank exploded July 13, at the corner of Macon St. and Sumner Ave., Brooklyn, N. Y. The explosion, which was very violent, wrecked a four-story building, killed five persons and injured fourteen others.

(261.) — A tube ruptured July 15, in a water tube boiler at the plant of the Superior Steel Co., Carnegie, Pa.

(262.) — A boiler exploded July 15, at a sawmill on the farm of Eli Scarborough, Eagle Rock, N. C. Two men were killed.

(263.) — On July 17, a tube ruptured in a water tube boiler at the plant of the Superior Steel Co., Carnegie, Pa. One man was injured.

(264.) — Two tubes ruptured July 17, in a water tube boiler at the plant of the Purity Distilling Co., Cambridge, Mass. Two men were injured.

(265.) — On July 18, a tube pulled out of the tube sheet of a water tube boiler at the No. 9 Mine of the Old Ben Mining Co., West Frankfort, Ill.

(266.) — An ammonia tank exploded July 19, at the plant of the American Refrigerating Co., New York City.

(267.) — A boiler exploded July 17, at the saw mill of the Leona Lumber Co., Drain, Ore. Several were injured.

(268.) — A boiler exploded July 24, at the power plant of the Western Ohio Railway, St. Mary's, O. Two men were killed and one injured.

(269.) — The boiler of a well drilling outfit exploded July 24, near Cedar Hill, Tenn. One man was injured.

(270.) — On July 26, two tubes ruptured in a water tube boiler at the office building of Geo. H. Holt, Chicago, Ill.

(271.) — A tube ruptured July 27, in a water tube boiler at the plant of The National Brake and Electric Co., Milwaukee, Wis. Two men were injured.

(272.) — A tube ruptured July 28, in a water tube boiler at the plant of the Standard Steel Car Co., Butler, Pa.

(273.) — On July 28, a cast iron mud drum ruptured on a water tube boiler at the Charlestown power station of the Boston Elevated Railway Co., Charlestown, Mass. The boiler was considerably damaged.

(274.) — On July 28, the crown sheet of a locomotive type boiler collapsed at the plant of Riggi Bros. Co., Brooklyn, N. Y. The boiler was practically destroyed, other property was damaged and one man was fatally injured.

(275.) — A boiler ruptured July 31, at the plant of the Jamaica Consumers Ice Co., New Hyde Park, L. I., N. Y.

The Hartford Steam Boiler Inspection and Insurance Company

ABSTRACT OF STATEMENT, JANUARY 1, 1916.

Capital Stock, ... $2,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$215,107.37
Premiums in course of collection,		421,506.09
Real estate,		90,000.00
Loaned on bond and mortgage,		1,448,245.00
Stocks and bonds, market value,		4,008,399.40
Interest accrued,		92,778.26
		$6,276,036.12
Less value of Special Deposits over Liability requirements,		41,619.80
Total Assets,		$6,234,416.32

LIABILITIES.

Premium Reserve,		$2,473,007.92
Losses unadjusted,		33,988.00
Commissions and brokerage,		84,301.22
Other liabilities (taxes accrued, etc.),		72,365.76
Capital Stock,	$2,000,000.00	
Surplus over all liabilities,	1,570,753.42	
Surplus as regards Policy-holders,	**$3,570,753.42,**	3,570,753.42
Total Liabilities,		$6,234,416.32

LYMAN B. BRAINERD, President and Treasurer.
FRANCIS B. ALLEN, Vice-President. CHAS. S. BLAKE, Secretary.
L. F. MIDDLEBROOK, W. R. C. CORSON, Assistant Secretaries.
S. F. JETER, Chief Engineer.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President. Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, Vice-President, United States Bank, Hartford, Conn.

LYMAN B. BRAINERD, President, Director Swift & Company.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres. The Fidelity Trust Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturers, South Manchester, Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and Treasurer, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

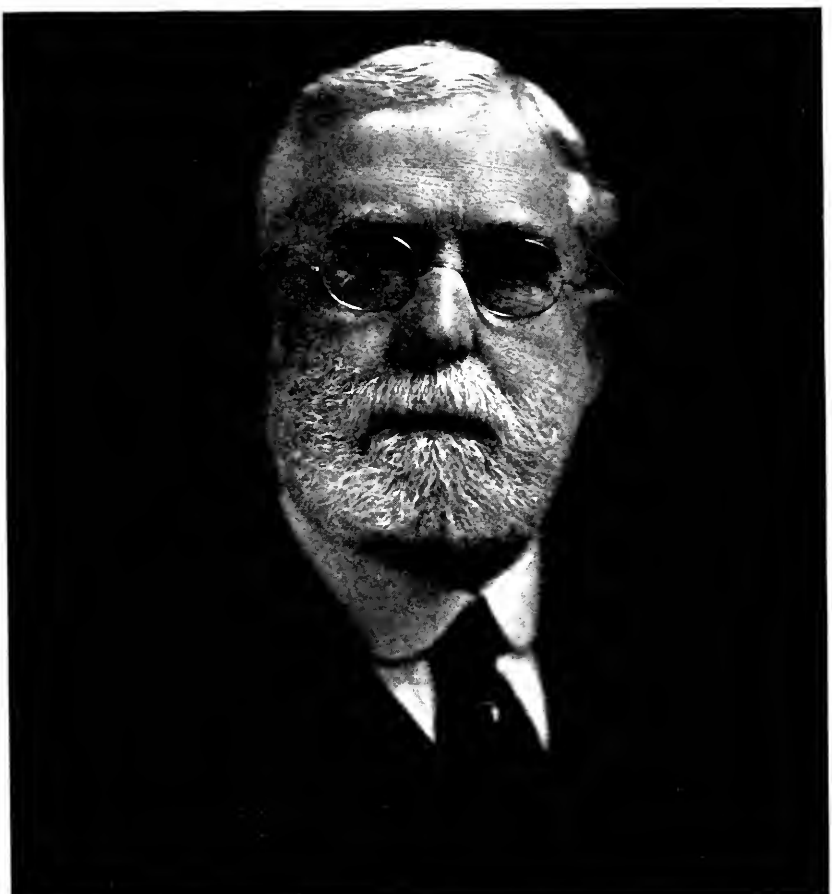
EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, The Johns-Pratt Co., Hartford, Conn.

MORGAN G. BULKELEY, JR. Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

The Locomotive
of
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXXI. HARTFORD, CONN., JANUARY, 1917. No. 5.



President CHARLES S. BLAKE

PRESIDENT CHARLES S. BLAKE.

On Monday, November 20, 1916, Mr. Charles S. Blake, Secretary of the Company, was chosen a Director and elected to the presidency of The Hartford Steam Boiler Inspection and Insurance Company, to fill the vacancy caused by the death of Mr. Lyman B. Brainerd.

Mr. Blake was born in Windsor Locks, Ct., October 25, 1860. He was educated in the public schools of Springfield, Mass., and Jersey City, N. J., and after a brief career in newspaper work, he studied engineering and worked out an apprenticeship with the Central Iron Works, at Jersey City, fitting himself for marine engineering. After a few years practice he entered in 1884 the Engineering Department of a large boiler insurance company, which he served for over nine years. In 1894 he entered the service of The Hartford Steam Boiler Inspection and Insurance Company at Chicago, Ill., but resigned to engage in the manufacturing business, at the same time forming a connection as Consulting Engineer for another steam boiler insurance company. In 1898 he re-entered the service of The Hartford Steam Boiler Inspection and Insurance Company as General Agent, since which time he has served the Company in the capacity of Supervising General Agent, Second Vice-President and Secretary.

He has been President of the Steam Boiler and Flywheel Service and Information Bureau since its organization in New York, nearly four years ago. He is a member of The American Society of Mechanical Engineers, a member of the Administrative Council of the American Uniform Boiler Law Society, an organization specially formed to advocate and assist in the drafting of uniform laws governing boiler construction. He is a Director of The Boiler Inspection and Insurance Company of Canada, and last year was a Vice-President of the International Association of Casualty and Surety Underwriters.

His experience in the steam boiler business has extended through all its branches. As an expert on boiler insurance, he has written more or less upon the subject and read papers before engineering and insurance societies.

SECRETARY WILLIAM R. C. CORSON.

The Directors also elected Assistant Secretary William R. C. Corson to the vacancy made through the advancement of Secretary Blake.

Mr. Corson joined the force of The Hartford Steam Boiler Inspection and Insurance Company in 1907 as assistant to Mr. Frank S. Allen in the mechanical engineering department, and on February 9, 1909, he was elected Assistant Secretary of the Company. We quote the following short account of Mr. Corson's life from THE LOCOMOTIVE for October, 1907. Mr. Corson was graduated from Yale in 1891, and in the fall of that year he entered the employ of the Eddy Electric Manufacturing Company, of Windsor, Connecticut, working first in the shop and then in the engineering department, after which he successively occupied the offices of engineer, superintendent, and secretary of the corporation. When the Eddy company was discontinued, Mr. Corson established himself as a consulting engineer at Hartford, and built up a large private practice. Among his clients are numbered many of Hartford's manufacturing concerns, for whom he has planned systems of power, lighting, or heating. The electric and power installation of the Groton & Stonington Street Railway, of Connecticut, and that of the Northern Electric Street Railway Company, of Scranton, Pennsylvania, were planned in his office. He was chief consulting engineer of the Berkshire Power Company, of Canaan, Connecticut, and he designed and constructed the new water supply system of the Windsor Water Company, Windsor, Connecticut.

Mr. Corson is a member of the Connecticut Society of Civil Engineers and the American Electro-Chemical Society, and an associate member of the American Institute of Electrical Engineers. He is also identified as a director or trustee with many of Hartford's institutions, among them the Ætna National Bank, the Wadsworth Atheneum, the Watkinson Library, the Retreat for the Insane, and the American School at Hartford for the Deaf.

ASSISTANT SECERTARY E. SIDNEY BERRY.

Mr. E. Sidney Berry, Counsel of the Company, was advanced by the Directors to the position of Assistant Secretary. His new title is in addition to his former one of Counsel, and he will now be known as Assistant Secretary and Counsel.

Mr. Berry was born in Titusville, Pennsylvania, December 3, 1866, and was graduated from Harvard University and later from the Harvard Law School. He subsequently practiced law in Boston where, for a period of thirteen years, he assisted in the local, general and legal work of the United States branch of the Employers' Liability Assurance Corporation, of London. In June, 1903, he removed to New York City, where he represented the Ætna Life Insurance Company for five years, as attorney and counsel. In March, 1908, he organized the Florida department of that company, for handling its liability claims, selecting its legal representatives and claim adjusters throughout the state.

Mr. Berry was appointed Counsel of The Hartford Steam Boiler Inspection and Insurance Company, on April 1, 1908, and now adds the new duties to those he has performed so well.

TESTS OF AUTOGENOUS WELDS OF BOILER PLATE.

(Continued from the October, 1916, Locomotive.)

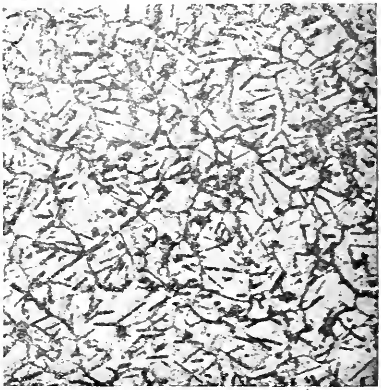
XI. Hammering and Annealing.

Several test plates were returned out of shape, and some with displaced edges. This shows that the welders lacked the skill necessary to align and fix the parts to be welded. The melted iron at the joints in cooling exerts a tension and if the pieces to be welded are not fastened together solidly their edges are displaced, even during the progress of the welding itself. On cooling internal stresses remain which cause the plate to curve (buckle). Two

MICROPHOTOGRAPHS

Fig. 42 XII x160

Fig. 43 XV x160



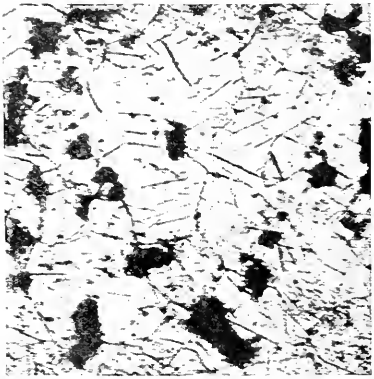


Fig. 44 x160

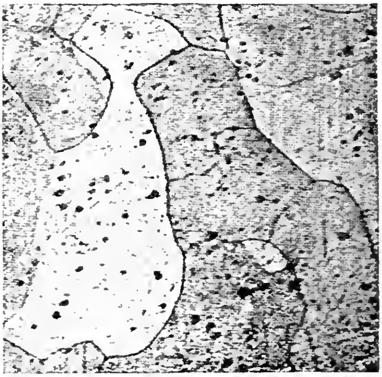


Fig. 45 x160

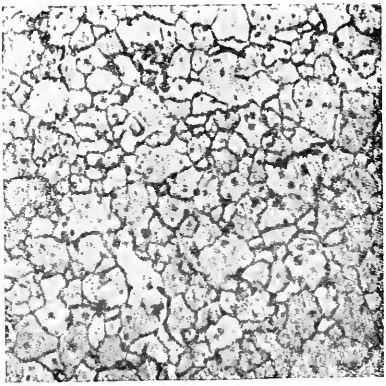


Fig. 46 x160

(See Oct. 1916 Locomotive, p. 123)

firms have, at our suggestion, measured the effect of the contraction set up in welding, and they have found that for plate 12 mm. thick, it was from .5 to 3.3 mm. One of these firms has stated moreover that on annealing this shrinkage diminished and became from .3 to 2.3 mm. It is obvious that these were not measurements of great precision.

It is possible during welding to counteract this contraction to some extent by hammering, and then later on a further diminution can be obtained by annealing. Hammering can also be done at the time of annealing.

Hammering with small hammers while the metal is still red hot improves the metal, as rolling and forging improve structural iron. The structure is condensed in this way. But if the hammering is done at a temperature lower than a red heat there is danger of working the metal at the blue heat, which must always be avoided.

Fig. 47

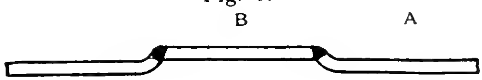


Fig. 48.

One of the firms mentioned above demonstrated skillful hammering. When welding the square piece B into the piece A, they slightly raised the interior edges of A, and after welding they laid back the whole joint while the metal was hot by means of the hammer, as is shown in Figs. 47 and 48. Through this process the joint was strongly compressed and the internal stresses relieved. The workman at the same time retained his ability to control the form of the work. This is the only firm which has solved the problem in a technically satisfactory way, and its process should serve as a model. Problems of this nature present themselves very often in using autogenous welding (for instance, in joining two tubes together).

On annealing after welding, a compensation of the residual internal stress is obtained and the annealing further improves the metal, giving it a finer grained structure.

The annealing temperature for welded plates is evidently between 700 and 800°C. (1292-1472°F.), and but little higher.

Annealing is best done in an annealing furnace. If that is impossible it can be done with the torch. The question of the heat treatment of iron, to which this leads us is as important as it is complicated.

The changes of internal structure which takes place when iron cools show the influence of high temperatures. Soft (mild) steel, a liquid poor in carbon (boiler plate, for example, contains only from .05 to .10% C.), solidifies at a temperature of from 1500 to 1450°C. (2732-2642°F.). Below the solidification temperature and from it down to 900-820°C. (1650-1500°F.), the iron is nothing but a mass without internal structure, a solid solution of carbon in iron. It is only at a temperature below 900-820°C. that the microscopic crystallization begins with the formation of ferrite crystals composed of pure iron which separate out. In exact proportion to the rate at which these crystals increase, the remaining mass which contains the carbon diminishes and its carbon content (in %) increases until it has attained about .9%. When the temperature has fallen to 700°C. (1292°F.) this remaining mass forms a mechanical mixture of carbide of iron, or cementite, Fe_3C, and ferrite and this mixture is called pearlite. *No further changes in internal structure take place* below 700°C. Boiler plate is composed entirely of crystals of ferrite with small amounts of pearlite.

An inverse process is produced by heating iron from ordinary to high temperature. Heyn, at Berlin (see Zeitsch. Ver d. Ing. 1902) published important researches on the connection between high temperatures, above 900°C. (1652°F.), the microstructure, the grain and the resistance of iron to impact on notched bars.*

The most important results of his experiments are as follows:

(1) If homogenous iron, low in carbon is heated above 1000°C. (1832°F.), it is overheated, and if this temperature is maintained for a certain time, its tenacity falls off and its brittleness increases. The latter is shown in the impact bend tests by the diminished number of bendings sustained. Moreover its fracture is coarse grained and its microstructure shows strikingly large grains of ferrite.

(2) By proper annealing, the brittleness caused by overheating can be suppressed. If the annealing is of short duration, a half hour for instance, it is absolutely necessary for the temperature to exceed 900°C. (1652°F.). If the annealing is for a long time, as for instance 6 days, a temperature of 700-800°C. (1292-1472°F.) is enough.

(3) Homogenous iron (mild steel) which should have a sufficiently long anneal at the temperature T, and which would thus become brittle on cooling, will lose its brittleness during the time while it is dropping from the temperature T to a bright red heat, if it is worked, either by rolling or hammering. By this mechanical working, the effect produced by the overheating is annulled.

(4) As we have already said, the fracture of overheated iron generally shows a coarsened grain, but this is not necessarily always the case. The method of breaking produces an important effect here as does also the rapidity of cooling. Iron annealed 15 days at a temperature of 700-800°C., which gave an increased number of bendings (Bz) as for instance, 4, nevertheless shows a coarse structure.

(5) Iron overheated at a very high temperature, 1300-1500°C. (2372-2732°F.) approaches the point of fusion and burns. Such iron shows marked irregularities in structure, coming in part from the partial fusion and in part from the strong oxidation. This iron has a crystalline grain of marked coarseness and is very brittle. Unlike iron which has been simply overheated, it cannot be reclaimed by heat treatment at a lower temperature, it is and remains ruined. It is known that low carbon steel should not be forged at the blue heat, 200-320°C. (392-608°F.) because of its becoming very brittle.

To improve the quality of mild steel, either forged or rolled, so as to make it less brittle, it is always necessary to anneal it in a correct manner.

* A test bar 60 mm. long by 6 mm. wide and 4 mm. thick was notched at the center of the broad face by planing. The notch was ½ mm. in depth. Then the bar was gripped vertically in a vise, at the notch, and bent through 90° with a hammer. It was then straightened and bent through 90° in the opposite direction, and each 90° bend was counted. The count was referred to as Bz. For hars with autogenous welds the notch was made at the center of the weld. For exact work, the Heyn method is not so convenient as the method indicated in Fig. 4, which is based on an international convention.

To get the right temperature so that the desired result may be had, account must be taken of its carbon content and of the mechanical and thermal treatment it has already received.

Oberhofer in the techical journal "Stahl und Eisen" designates a temperature of 850°C. (1562°F.) for one sort of mild steel and 890°C. (1643°F.) for another sort as the best ones to employ. Steel so treated becomes softer and gains in tensile strength. Further he found that a temperature of 920°C. (1689°F.) gave the best results in increasing the resistance to the impact bend test.

It was desirable to clear up the question of annealing by additional small tests and we found two firms, whom we shall designate as A and B among those who had already furnished test plates, that were ready to furnish the Federal Laboratory for Testing Materials with the following supplementary material, for which we express our thanks.

(1) One piece of ordinary plate, neither welded nor annealed. It should be noted here that all the material for these tests, both the soft steel plate FI, 12 mm. thick, and the Swedish iron wire were furnished by firm A to firm B. These tests were made therefore on the same metal, the differences coming solely from the welding and heat treatment.

(2) One piece of plate, welded but neither hammered nor annealed.

(3) One similar piece welded, air cooled, then annealed for an hour at red heat and recooled slowly.

(4) One piece similar to No. 3, but hammered after welding and then annealed.

Piece 1 furnished one tensile test specimen, and one for impact, tests 2, 3 and 4 each furnished one tensile and two impact specimens. Tables VII and VIII give the results of these tests.

The tensile tests do not show much, for all these specimens broke outside the weld, showing that all the pieces were thoroughly welded. On the other hand the impact tests show that in group B there was an increasing improvement in the metal, while in group A there was no appreciable modification. If we call the work of deformation, 121.8 meter kilograms per square centimeter, on the unwelded plate B 1 100%, the welded piece B 2, with 5.5m.kg./cm² reached 25%, the welded and annealed piece B 3 with 11.0m.kg./cm², was 50%, and the piece B 4, which was welded, hammered and annealed, with 13.7m.kg./cm² had 63% of the strength of the unwelded plate. Thus annealing alone improved the metal 25%, and hammering and annealing increased it 37%, expressed in terms of the work of deformation of the unwelded plate, for the mean results of tests A and B, the result would be somewhat less. At the same time that the resistance to impact of the metal was improved, the grain was made finer as is seen in Figs. 50, 51 and 52, showing the fracture of the impact test pieces from plates B2, B3, and B4 (magnified 1½ diameters). While the results produced by annealing alone is remarkable (see Fig. 51 as compared with Fig. 50) plates B3 and B4 (Figs. 51 and 52) also show an increasing reduction in area which is such an important proof of tenacity. In this respect these pieces approach the ideal. The appearance of the fracture of the unwelded plate B1 is shown in Fig. 49 (as A1 had exactly the same appearance, we have not reproduced it). On the other hand, Figs. 53 and 54, showing the fractures of A2 and A4 only show a slight refinement of the grain, and table VII does not show any greater

FRACTURES

Fig. 49. B1 50. B2 51. B3 52 B4

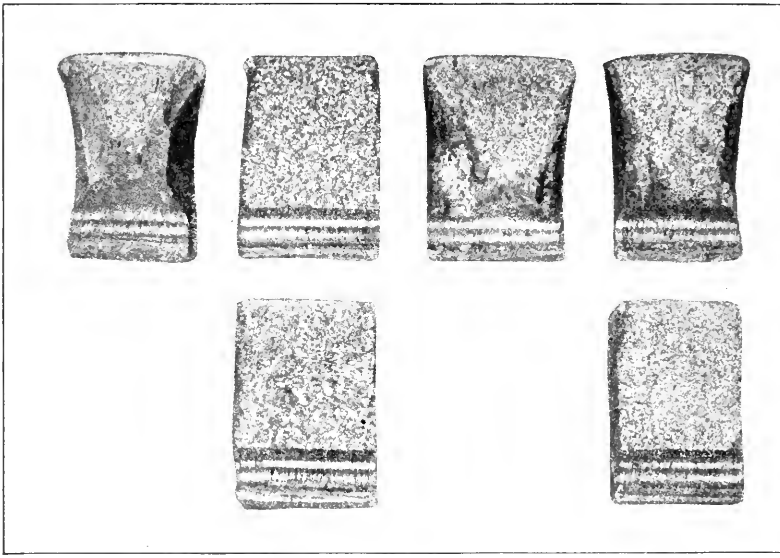


Fig. 53. A2 54. A4

increase in the power to resist impact.

The difference in the grain size in the impact test specimens of firm A and firm B (Fig. 54, compared to Fig. 52), arise without doubt, in the light of the preceding statements, from a difference in the heat treatment. On this subject we have been unable to obtain exact information. Each firm claims to have annealed the piece for an hour at red heat and then to have put them aside. All the welds were good, and yet the difference in the resistance to impact was remarkable. We can only attribute this to differences in the heat treatment.

Lack of time prevented the making of other tests beside those just mentioned on the influence of hammering and annealing. Extensive additional tests are needed to clear up the subject. This end could best be attained by concerted action among those doing autogenous welding.

It seems in the light of this investigation that it is not enough to make a sound weld, but that the metal must be in addition submitted to *a heat treatment or a simultaneous heat and mechanical treatment (hammering and annealing), which will give it the best possible mechanical qualities, and above all great toughness (resistance to impact)*, which is best demonstrated by the impact test on notched bars. As we have seen, in annealing the exact temperature plays an important part. Relatively small differences of from 40-60°C. (75-100°F.) may have a considerable influence on the brittleness of the material. We should then, recommend strongly that these firms provide themselves with a proper annealing furnace and that they control its temperature carefully. The technical worker is provided today with a whole series of exact apparatus for measuring high temperatures, such as the thermo-couple of Le Châtelier, the Féry optical pyrometer and many others beside which are excellent for the purpose. In many cases they could use Seger cones.

When one is forced to anneal with the welding torch, it is best to give the preference to a short anneal at a high temperature. One test, made in the Materials Testing Laboratory, with the object of refining the coarsened grain of some welded bars, showed that if the duration of the annealing is only a half hour, a temperature above 900°C. (1652°F.) is required to change the interior of the structure. This is a confirmation of the experiments of Heyn, p. (2d point).

Let us again glance at table VI which gives the data on

XII. The Preparation of the Materials for Welding.

We here encounter the fact that for the most satisfactory welds, the consumption of oxygen, and hence of gas, has been most rapid, while the poorest welds have been made with the least gas. This clearly indicates that whoever tries to economize in gas, risks making a poor weld. Further, there was no control of the gas. It is well enough known that the gas should be pure and fresh to get a good weld. Above all it should contain neither sulphur nor phosphorous, for fear of making a weld either hot short or cold short. This is why we do not endorse the use of illuminating gas by welders in place of acetylene, as has been recently suggested. Illuminating gas does not seem to us to be pure enough.

As welding wire, for the same reason, only the best pure iron should be used, for example, Swedish charcoal iron.

XIII. Conditions for a good Weld.

The conditions which in the light of the above data permit one to obtain good welds are the following:

Good gas, pure, dry and fresh.

A proper torch, correct as to both design and size.

Pure charcoal iron wire as added metal.

Sufficient preparation, in the way of correct chipping or other working of the joints to be welded both to secure correct angles, and correct distance apart, and solid fastening for the parts to be welded.

Exact flame mixture.

Preheating of the pieces to be welded.

Avoiding oxidation by properly managing both the torch and the welding wire. Removing the oxide which forms in spite of all precautions.

Do not economize too much in gas.

Hammer after welding.

Anneal at once.

We recommend etch tests and impact tests on notched bars.

XIV. The Admissibility of Autogenous Welds under the Hamburg Standards.

The Hamburg standard specifications for 1905, mention the following requirements for welded metals (Chapter II):

"(3) The strength of lap joints, properly welded, can be computed at 70% of the strength of the plate."

"(4) It is recommended that a joint called upon to support either a bending or a tension stress be not welded unless it is possible to anneal the metal after welding."

"(5) In special cases, safety cover plates (straps) may be required for the longitudinal joints of boilers."

"(6) Every welded piece should be well annealed if possible."

As we have stated previously, the averages of the results of the tests obtained with autogenous welds, as well as with electric welds were less than the values for the unwelded plates as is shown in the following table:

TENSILE STRENGTH.

	Ten. Str. %	Elong. %	Coeff. of Quality %
AUTOGENOUS WELDS.			
Mean of 52 tests (52 specimens) . . .	82	53	50
Mean of 25 tests, rupture at weld . . .	79	39	28
Mean tensile strength of the best test plate (4 bars)	90	....	....
Mean tensile strength of the worst test plate (4 bars)	58	....	....
ELECTRIC WELDS.			
Mean of four tests	86	62	52

IMPACT TESTS ON NOTCHED BARS.

	Work of deformation %	Angle of bend %
Mean of 78 tests of autogenous welds	32	22
Mean of 6 tests of electric welds	practically 0	practically 0

In these tests the ultimate strength (in tension) of the solid or unwelded plate was, averaging 4 tests, 3.87 t/cm² (55045 lbs./sq. in.). If we compare the welds with the solid plate we must keep in mind in the first place, that the Hamburg specifications allow 3.6 t/cm² (51204 lbs./sq. in.) in calculations on soft steel for which no special figures are available. For the comparison to follow, the difference of .27 t/cm² (3804.3 lbs./sq. in.) favors the weld. Still we have not taken it into consideration.

The Hamburg specifications speak only of properly welded lap joints, such as welds by fire or water gas, for which they require a strength of at least 70% of that of the sheet. The questions as to whether autogenous welds are of equal value, must be answered in the affirmative, in the light of the above figures, as we obtained 82%, and in the worst case 76% of the relative strength.

Another result of these trials is the marked difference in the quality of the welds among the different firms who made them. If the results were more uniform it would scarcely be possible to refuse to accord autogenous welding an equal place with forge (fire) welding. In the actual case, the examining official is forced *to make individual differences,* which might put him in a very difficult position. Since on the other hand boiler inspection associations cannot run the risk of being charged with opposing progress, there should be some practical means of accurately applying the fundamental principles of the Hamburg standards regarding welds, which are rather broadly drawn. In view of the rather great weakness to resist impact, of the joints made by autogenous welding, the rejection of such welds seems absolutely necessary wherever bending stresses could arise.

In spite of the skepticism regarding autogenous welding, it is impossible to exclude it from consideration along with other sorts of welded and riveted joints, for parts which only support simple tension stresses, especially in the case of repairs. On the other hand it is necessary to consider the minimum requirement of strength which should be made to secure the necessary measure of safety. Hence, the ratio of strength of joint to that of solid plate ($=Z$), for longitudinal boiler joints, should be reopened for discussion. Instead of allowing the efficiency of a double rivet (lap) joint, $Z=70$, it is possible to go back toward that of a single riveted joint, $Z=56$: *We propose, $Z=60$.*

In the 1905 Hamburg specifications, there is no rule for the factor of safety (x) to be adopted for welds. They (the Hamburg standards), generally set $x=4.5$. The choice of a slightly higher safety factor seems proper to us, say $x=4.75$, as required for hand riveted lap seams. On these assumptions, the highest tension at the weld, which for that matter is the same as in the solid plate, would be $\frac{3600 \text{ x } .60}{4.75}=455$ kg./cm² (6472 lbs./sq. in.). If we take further account of the additional millimeter thickness required at welds by the Hamburg standards, the tension is still further diminished. (With $z=70$, and $x=4.5$, the tension would be 560 kg./cm² (7965 lbs./sq. in.).)

This requirement is possible and that without loss to the maker, as autogenous welding is not employed for objects of large volume, or subjected to high pressure, and for such articles a rather heavy plate is used in any case. For large objects, the limit $z=.6$ would be prohibitive, which is not to be regretted from the standpoint of safety. The hammering of autogenous welds, and their annealing, if possible in an annealing furnace should be rigidly required. A thickening of welded joints is recommended. Another safety measure is a hydrostatic test at highter pressure, say double the working pressure. On the occasion of this test the welded joints should be vigorously hammered.

The choice of a higher ratio of weld strength to strength of plate would put the examining official in the very delicate position of having to determine for himself the minimum strength. There are enough other difficulties in deciding the nature and size of objects to which autogenous welding is applicable.

There has been much discussion in recent years concerning electrical welds* and in Germany there are many inspection associations which greatly prefer electrical welds to autogenous welds. The tests which we have just made do not prove this superiority. But our knowledge is restricted, the average

*See the last transactions of the congresses of the International Union of Associations for the Inspection of Steam Boilers at Brussels 1910, Munich 1912, Moscow 1913, Chemnitz 1914, as well as the annual reports of the Associations.

Fig. 55

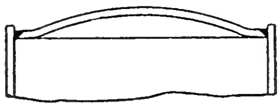
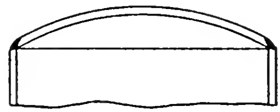


Fig. 56



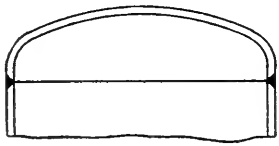


Fig. 57

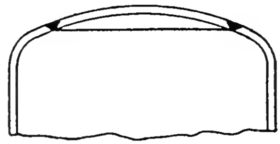


Fig. 58

results from one plate electrically welded have not the weight of the 13 plates autogenously welded. Moreover the firm which did this electrical welding does not do welding on boilers, but confines its activities to the exclusive field of its own product, steel castings. They were very busy when they made these test welds and this may have had an influence on the results. Under such circumstances no definite comparison can be drawn between the electrical welds and autogenous welds. Nevertheless the possession of an electrically welded plate added to the value of our studies, and enables us to approach the subject in a systematic manner.

We wish to draw attention to one difference between electric and autogenous weldings. That is the difference in temperatures set up by the torch and by the electric arc. As far as energy is concerned, if there is sufficient electric current available, the arc leaves the torch far behind. But there are two sides to consider, first the advantage of the arc which melts the metal more easily and quickly, and leads to true welding instead of simple "sticking," and on the other hand the danger of overheating the metal, which is much more to be feared than with the better controlled heat of the torch. We have already examined this point, and decided that a weld by a constant gradual heat has greater chances of being sound than if it is made by rapid local heating.

XV. Field of Application.

The field of application for welds in general is limited by article 4, *Chap. II of the Hamburg Specifications,* which stipulates that joints which must support either a bending stress or a tension should not be welded.

The growing use of autogenous welding, as we have said, necessitates that the cases be designated where exceptions may be admitted. But we strongly doubt if welded longitudinal joints will ever be tolerated in steam boilers (except in small boilers).

A welded joint always carries something hidden and uncontrollable. One can never see with satisfaction welded joints where riveting could have been used without difficulty. There remain plenty of places where for reasons of construction, for lack of room, or because great strength is not required autogenous welding will find employment.

For objects not under the legislation which applies to boilers, it is possible to go further, and permit welds supporting fairly severe tensions. In this, much depends on the intelligence with which such work is carried out. When a head is welded to a drum as shown in Fig. 55 (which has been done), it is in opposition to good practice. Welding the edges as in Fig. 56 as in now done quite generally by workmen, is no better, because it is right at the turn or at the edges that the bending strains are set up. Welds like Fig. 57 or 58 are recommended.

When welding one piece to another we recommend the procedure described above, see page. . To join a tube to another or to a plate, the edges should always be relieved. (Contrary to Figs. 29-32, which only represent a manner of examining the weld, and not a mode of construction.)

The true field for welds is *on objects whose joints must resist compression* as in furnace tubes, iron fireboxes, etc.

The possibility of producing an important thickening of the joints, which exists equally for the electrical and for the autogenous welding should be considered an important advantage.

XVI. Literature.

An abundant literature exists, treating of autogenous welding and of welding in general. To mention the more recent, we refer in the first place to tests of welds made in the fire, and with coke; made on two test sheets by Zwieauer, in Vienna and published in the Zeitsch. d. Ing., 1912, p. 877. In these tests Zwieauer found the relation

$$\phi = \frac{\text{tensile strength of welded bars}}{\text{tensile strength of bars of smaller section, unwelded}} = .92 - .99,$$

which is higher than the results of our tests.

Diegle found that welds made with water gas are far superior to those made with acetylene. He believes that for lap welds made with water gas, the percent. of strength admitted under the Hamburg Standards could be raised from 70% to 80%.

Since 1907, the Transactions of the Congresses of The International Union of Associations for the Supervision of Steam Boilers have been largely given up to autogenous welding and electrical welding.

Professors Bach and Baumann, at Stuttgart have published the most systematic and important work in the field of autogenous welding. These have appeared in part in the Proceedings of the International Union of Associations for the Supervision of Steam Boilers, Congress held at Lille, in 1909, and in the "Forschungsarbeiten, Ver. des Ing., vols. 83-84 for 1910. They treat acetylene welds in a comprehensive manner, as well as those made with water gas. The report on one plate into which a piece was welded, as in the tests carried out by our Society, has a particular interest for us. It comes from the Lyons Association of Owners of Steam Appliances, Lyons, France. The discussion of that report would take too much space.

The conclusions of these communications are a repetition of those of the International Union of Associations for the Supervision of Steam Boilers, formulated by Prof. Bach, at Wiesbaden, in 1908.

"*In the present status of the question, it is recommended that in the construction of steam apparatus use should be made of autogenous welding only with the greatest prudence, and that the work should be done by reliable firms and under the supervision of the inspection societies. Even then, it is necessary above all, to take account of the fact that through the heating of the edges in welding, and the cooling of the metal melted, tensions are set up in the iron which are of a sort to produce accidents of more or less gravity.*"

Joints should not be welded which are called upon to resist tension and bending stress through external forces or changes in temperature, except when it is possible to anneal the piece after welding.

At present descriptions are in print of gigantic acetylene installations for the welding shops of metallurgical plants. This is an indication, that autogenous welding by the oxy-acetylene process is gaining ground.

XVIII. Conclusions.

We have indicated above, in Chap. XIV the conclusions which we have drawn as to the actual status of autogenous welding in Switzerland. If we were to generalize our opinion, we could today only repeat that of Wiesbaden, in 1908. The opinion formulated by Prof. Bach is still valuable, as well as the following reservation: Those persons whose task it is to watch over the safety of steam boilers and steam vessels have many reasons for acting with extreme caution. But the experience up to this time neither justifies the absolute condemnation nor the rejection of autogenous welding.

Autogenous welding is in fact still a recent acquisition to the arts, which should develop itself without hindrance. To those firms employing it, many of whom have made much progress towards its perfection, we would advise a careful choice of their personnel and a careful examination of their work, to make constant progress in this field.

We express our appreciation to the firms which so willingly collaborated with us in these tests. They have rendered the tests possible for the common good, both by the work of preparation of the plates, and by their valued contributions to the expense. Our thanks are also due above all to Prof. Schüle, Director of the Federal Laboratory for the Testing of Materials, Zurich, and to his associate, M. Zschokke, for the skill and care they have brought to the examination of our test material, as well as for their moderate charges.

Table I.

Comparative table of tensile tests. All test pieces are 200 mm. long, 30 mm. wide, and 12 mm. thick, at points outside the weld. They were only machined at the edges. The elastic limit and ultimate strength are referred to the section outside the weld.

	Plate U unwelded. Test bars Nos.				Plate I Test bars Nos.			
	1	2	3	4	1	2	3	4
Elastic limit lbs. sq. in.	39114	39399	36269	36127	30011	29158	29300	33710
Ultimate strength "	55471	54760	54760	55044	47790	47506	45942	47506
Reduction in area %	60	59	60.5	61	65	66	71.5	71
Elongation (8 in.) %	28.6	27.0	27.1	27.8	27.1	25.7	24.8	23.7
" (2 in.) %	17.5	20.4	18.0	24.0	26.6	25.2	14.8	14.4
Quality Coef. . .	1.11	1.05	1.04	1.08	0.91	0.86	0.80	0.87
Point of rupture .					outside	outside	outside	outside
Fracture	1. Finely fibrous, traces of laminated flaws. 1–4. Double contraction on the surfaces.				Slightly fibrous, without defects. All ruptures outside weld. Weld very slightly reinforced. Surface: Traces of hair cracks on bar.			

Table I — (Continued)

	Plate II Test bars Nos. 1	2	3	4	Plate III Test bars Nos. 1	2	3	4
Elastic limit lbs. sq. in.	29585	29585	31291	32002	34989	33852	34705	34847
Ultimate strength "	40821	45372	48498	42955	46084	50493	50209	40252
Reduction in area %	13	69	66.5	19.5	19.5	63	63	35.5
Elongation (8 in.) %	9.6	22.0	23.0	7.9	9.3	25.9	24.1	6.8
" (2 in.) %	8.0	11.2	16.4	6.4	8.8	18.8	20.6	5.4
Quality Coef.	0.28	0.70	0.85	0.24	0.30	0.92	0.85	0.19
Point of rupture	at weld	outside	at weld	outside	at weld	outside	outside	at weld
Fracture	1. Surface of weld: Fibrous, indented; with defects in weld. 2–3. Slightly fibrous, without defects. 4. Surface of weld fibrous, with brilliant granular spots, defects in weld. Surface: all bars and hair cracks, No. 2 strongly so, and line of weld much reinforced.				1. Weld surface large brilliant indented spots. 2. Fine fibre, laminated flaw. 3. Fibrous, no defects. 4. Fibrous, large inclusions of oxide, large transverse crack, clear across. Surface: all bars, strong traces of hair cracks, welds strongly reinforced.			

	Plate V Test bars Nos. 1	2	3	4	Plate VI Test bars Nos. 1	2	3	4
Elastic limit lbs. sq. in.	23994	32291	30722	28874	36554	35686	37123	35416
Ultimate strength "	35843	32291	30722	28874	49782	49782	50351	48644
Reduction in area %	7	7	12	9.5	68	66	65	6.0
Elongation (8 in.) %	1.8	6.5	2.3	1.4	19.4	17.1	17.2	8.1
" (2 in.) %	2.6	0.4	0.4	0.4	6.4	5.2	7.6	9.0
Quality Coef.	0.04	0.01	0.05	0.03	0.68	0.60	0.61	0.28
Point of rupture	at weld	at weld	at weld	at weld	outside	outside	outside	at weld
Fracture	1. Surface of weld on broad sides, brilliant granular, other parts oxidized. 2–4. Outside surfaces of welds coarse fibered, other parts oxidized. Large voids. Surface: all bars show more or less hair cracks.				1–2. Slightly fibrous, traces of laminated flaw. 3. Fine fibered, no defects. 4. Surfaces of weld at sides brilliant coarse grain, other parts rough and fine fibered. Surface: slight traces of cracks.			

TABLE I — (Continued)

	Plate VII Test bars Nos.				Plate VIII Test bars Nos.			
	1	2	3	4	1	2	3	4
Elastic limit lbs. sq. in.	31576	30154	30154	30580	29585	29016	32856	32999
Ultimate strength "	47222	40536	46372	45657	47079	49212	47923	43523
Reduction in area %	63	15	67	66	27	65	65	20
Elongation (8 in.) %	19.9	7.1	21.8	22.5	13.5	24.5	24.9	10.0
" (2 in.) %	9.6	6.0	7.4	8.0	9.8	13.4	15.2	9.0
Quality Coef. . .	0.66	0.20	0.70	0.72	0.45	0.85	0.84	0.31
Point of rupture . .	outside	at weld	outside	outside	at weld	outside	outside	at weld
Fracture	1. Fine fibre, laminated flaw. 2. Defects at weld, fibrous, indented. 3–4. Fine fibre, no defects. Surface of weld for the most part free from hair cracks. One bar shows them strongly. Slightly thickened.				1. Fibrous, indented, defects in weld. 2. Fibrous, no defects. 3. Fibrous, laminated flaw. 4. Fibrous, granular on one side, much oxidized. Surface in general shows traces of hair cracks. Slightly thickened.			

	Plate IX Test bars Nos.				Plate X Test bars Nos.			
	1	2	3	4	1	2	3	4
Elastic limit lbs. sq. in.	33567	35843	34278	33852	36981	35700	36123	35985
Ultimate strength "	48075	48501	40110	41248	47933	46368	47506	48217
Reduction in area %	63	61	21.5	20	68	6.5	63.5	66.5
Elongation (8 in.) %	25.3	24.4	8.4	9.0	22.8	10.0	22.5	23.9
" (2 in.) %	18.0	17.0	6.0	7.4	11.6	10.5	10.0	10.0
Quality Coef. . .	0.86	0.83	0.24	0.26	0.77	0.33	0.75	0.81
Point of rupture . .	outside	outside	at weld	at weld	outside	at weld	outside	at weld
Fracture	1. Fine, fibrous, laminated flaw. 2. Fine, fibrous, laminated flaw. 3–4. Fibrous, serrated, oxidized spots. Surfaces show traces of hair cracks. Joints slightly thickened.				1. Fine fibered, laminated flaw. 2. Granular, parts are fibrous and serrated. 3. Fine fibered, laminated flaw. 4. Fine fibered, no defects. Surfaces: minute hair cracks. Joints slightly thickened.			

TABLE I — (Continued)

	Plate XI Test bars Nos.				Plate XII Test bars Nos.			
	1	2	3	4	1	2	3	4
Elastic limit lbs. sq. in.	29300	31007	32429	33994	27309	29016	27877	29300
Ultimate strength "	47790	49782	49212	49068	39397	38972	40252	43666
Reduction in area %	23	60	21.5	25.5	16.5	18	17.5	21.5
Elongation (8 in.) %	14.3	23.6	13.0	11.5	7.0	7.3	7.4	9.8
" (2 in.) %	12.2	17.2	14.8	12.4	6.0	5.4	6.4	8.8
Quality Coef. . .	0.48	0.83	0.45	0.40	0.20	0.20	0.21	0.30
Point of rupture . .	at weld	outside	at weld	at weld	at weld	at weld	at weld	at weld
Fracture	1. Fibrous, serrated, large seam. 2. Fine fibered, laminated flaw. 3–4. Fibrous, serrated. Surfaces: 3 bars show traces of hair cracks, joints slightly thickened, in places too slight.				1. Fibrous, serrated, partly oxidized. 2, 3 and 4, ditto. Surfaces show hair cracks on all bars. Joints very irregularly thickened.			

	Plate XIII Test bars Nos.				Plate XIV Test bars Nos.			
	1	2	3	4	1	2	3	4
Elastic limit lbs. sq. in.	35843	35843	34847	34847	35558	36981	32856	34563
Ultimate strength "	47933	47364	47364	47222	49355	50067	47079	41675
Reduction in area %	59.5	54	58	58	63	62	27	24
Elongation (8 in.) %	18.4	17.6	20.5	22.2	26.3	27.6	12.8	7.2
" (2 in.) %	9.0	6.6	7.2	9.2	20.0	21.2	11.8	6.0
Quality Coef. . .	0.62	0.59	0.68	0.74	0.91	0.97	0.42	0.21
Point of rupture . .	outside	outside	outside	outside	outside	outside	at weld	at weld
Fracture	1. Slightly fibrous, laminated flaws. 2, 3 and 4, ditto. Traces of hair cracks on all bars. Joints thickened normally.				1. Slightly fibrous, laminated flaws. 2. Slightly fibrous, no defects. 3–4. Surfaces of weld fibrous, serrated. Medium to strong hair cracks. Joints of irregular thickness, in parts, too thin.			

TABLE I—(Continued)

	Plate XV, Elect. Welded Test bars Nos. 1	2	3	4
lbs.				
Elastic limit sq. in.	30152	29727	29727	29011
Ultimate strength "	47790	47079	46937	48075
Reduction in area %	67	68	19.5	69
Elongation (8 in.) %	18.5	18.8	10.3	19.5
" (2 in.) %	13.2	11.6	14.0	11.2
Quality Coef. . .	0.62	0.62	0.34	0.66
Point of rupture . .	outside	outside	outside	at weld
Fracture	1. Slightly fibrous, no defects. 2. Slightly fibrous, no defects. 3. Fibrous, serrated, with spots finely granular and brilliant. Traces of seams in weld. 4. Fine fibered, traces of laminated flaws. Three bars show traces of hair cracks, the fourth, none.			

Averages

Plate Number	I	II	III	V	VI	VII	VIII	IX
lbs.								
Elastic limit sq. in.	30570	30570	34563	31291	36411	30570	31149	34278
Ultimate strength "	46795	44377	46795	31718	49497	44661	46937	44519
Reduction in area %	68.4	42.0	45.2	9.0	51.0	52.7	44.2	41.4
Elongation (8 in.) %	25.3	45.6	16.5	1.54	15.4	17.8	18.2	16.8
" (2 in.) %	20.2	10.5	13.4	0.9	7.0	7.7	11.8	12.1
Quality Coef. . .	0.83	0.52	0.56	0.03	0.54	0.57	0.61	0.55
Plate Number	**X**	**XI**	**XII**	**XIII**	**XIV**	**I—XIV Auto-genous**	**U Not Welded**	**XV Elect. Weld**
lbs.								
Elastic limit sq. in.	36127	31718	28447	35274	34989	32856	37834	29869
Ultimate strength "	47506	48028	40536	47506	47079	45088	55045	47506
Reduction in area %	51.1	32.5	18.4	57.4	44.0	42.3	60.1	55.9
Elongation (8 in.) %	19.8	15.6	8.0	19.7	18.5	16.6	27.6	16.8
" (2 in.) %	13.5	14.1	6.6	8.0	14.8	10.6	20.0	12.5
Quality Coef. . .	0.66	0.54	0.23	0.66	0.63	0.53	1.07	0.56
						52 tests	4 tests	4 tests

TABLE II

Comparative table of Brinnell Hardness tests. (Imprint of ball)

Diameter of ball=9.5 mm.(.374 in.) Pressure on ball=1000 kg. (2205 lbs.)

$$\text{Hardness}=\text{H}=\frac{\text{weight on ball}}{\text{area of imprint}}$$

Plate No.		I	II	III	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV		U	XV
Test outside weld,	1	96	105	110	105	117	93	104	99	102	106	100	95	98	Mean	114	94
on transverse sec-	2	98	99	103	102	121	93	104	95	102	108	100	97	99	of Plates	116	96
tion	3	92	107	111	106	109.5	104	99	99	105	113.5	108	99	104	I-XIV	115	97
	4	99	105	107	112	111.5	99	102	93	106	111.5	105	89	98		117.5	93
Mean, 1-4		96.3	104	107.7	106.2	114.7	97.2	102.2	96.5	103.7	109.7	103.2	95	99.7	102.8	115.6	95
Test at weld on .	7	93	110	118	130	124	105	107	108	102	113.5	99	125	113.5	Mean	......	85
transverse section .	8	95	95	101	95	116	106	102	113.5	103	110	95	109	126	I-XIV	......	73
Mean, 7-8		94	102.5	109.5	112.5	120	105.5	104.5	110.7	102.5	111.7	97	117	119.7	108.2	......	79

NOTE: Plates I–XIV autogenously welded. Plate XV electrically welded, and Plate U unwelded.

(Continued on page 149)

The Locomotive
of
THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

C. C. PERRY, EDITOR.

HARTFORD, JANUARY, 1917.

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

Lyman Bushnell Brainerd, late President of The Hartford Steam Boiler Inspection & Insurance Company, died at his home in Hartford on October 11th, 1916. At that time the October number of THE LOCOMOTIVE was printed and ready for distribution. We held it up only long enough to provide an insert containing a portrait of Mr. Brainerd with the facts of his death, and this number with his portrait has gone generally to all usual recipients of our magazine.

In November, 1916 we brought out a special memorial number entirely devoted to recording the events of our late President's life and death and the many tributes of appreciation which had been offered by friends and business associates. This special number was a limited edition and was not circulated as widely as are our general issues of THE LOCOMOTIVE. If any friend of the Company who failed to receive a copy of this special memorial number, desires one, we shall be glad to furnish it upon his application to the Hartford office of the Company.

On October 19, 1916, Chief Inspector Frank S. Allen, of the Home Office celebrated the 45th anniversary of his connection with the Company. A basket of American Beauty roses, the gift of his office associates, adorned his desk on his arrival at the office that morning. During the day his many friends expressed their congratulations and wished him many more years of useful activity. Chief Inspector Allen is one of the old boiler inspectors of the country. His experience has been broad indeed, and he is widely known as an expert in boiler and power plant matters. The plants which owe their origin to his plans, or their successful operation to his suggestions cover New England. His advice is still eagerly sought by a host of friends in every branch of industry.

Tests of Autogeneous Welds of Boiler Plate

(Continued from page 147)

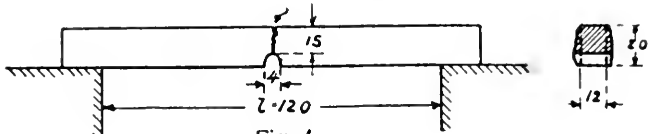


Fig. 4.

Table III

Comparative table of Impact Bend tests

Bars machined on edges only. Ram weighs 53 kg. (116.85 lbs.) Blow directed on weld. Work of deformation is referred to cross section above notch.

Note: Where two bend angles are given, the small one is that at which a crack occurs, the large one that of failure.

	Unwelded—Plate U						Plate I					
	11	..	..	12	..	..	11	..	..	12	..	..
Work of deformation ft. lbs./sq. in.	896	957	816	905	854	794	55.9	23.3	28.0	42.0	37.3	32.6
Angle of bend °	49 ..	30 68	24 50	26 62	20 49	29 53	1 ..	0 ..	0 ..	3 ..	1 ..	1 ..
Fracture	Granular tension side fibrous, comp. side	Granular tension side fibrous, comp. side	Granular tension side fibrous, comp. side	Granular tension side fibrous, comp. side	Granular tension side fibrous, comp. side	Granular tension side fibrous, comp. side	Slightly fibrous, no defects	Slightly fibrous, no defects	Slightly fibrous, no defects	Slightly fibrous, no defects	Slightly fibrous, no defects	Slightly fibrous, no defects

	Plate II						Plate III					
	11	..	..	12	..	..	11	..	..	12	..	..
Work	754	679	447	583	523	812	237	41.9	475	237	293	466
Angle	17 59	16 46	8 43	.. ..	15 39	27 49	60 24	2 ..	14 37	13 39	0 32	14 39
Fracture	Fibrous serrated defects at weld	Fibrous serrated defects at weld	Fibrous serrated defects at weld	Irregular	Fibrous, slightly granular	Fibrous, slightly granular	Fibrous, slightly granular	Granular	Fibrous, granular	Fibrous, serrated	Fibrous, serrated	Fibrous, serrated

TABLE III — (Continued)

	Plate V						Plate VI					
	11	..	..	12	..	..	11	..	..	12	..	..
Work	423	256	414	121	41.9	219	27.9	9.31	41.9	18.6	69.9	89.5
Angle	21 39	4 22	7 50	4 30	0 6	5 14	2 ..	0 ..	1 ..	6 ..	1 ..	1 ..
Fracture	Fibrous, serrated	Fibrous, serrated defects	Fibrous, serrated defects	Partly granular on tension side	Partly granular on tension side	Partly granular on tension side	Grained, brilliant	Grained, brilliant	Grained, brilliant	Grained, brilliant	Grained, brilliant	Grained, brilliant

	Plate VII						Plate VIII					
	11	..	..	12	..	..	11	..	..	12	..	..
Work	9.33	186	452	32.6	69.9	88.5	419	144	102	154	130	452
Angle	0 ..	3 45	5 47	0 ..	0 25	0 35	11 44	0 36	0 23	8 42	0 38	12 46
Fracture	Granular	Fibrous, serrated, granular	Fibrous, serrated, granular	Fibrous, serrated, granular	Granular, poorly defined	Granular, poorly defined	Fibrous, serrated, granular crevices	Fibrous, serrated, granular crevices	More numerous granular crevices	More numerous granular crevices	More numerous granular crevices	Fibrous, tension side, defects in weld and granular comp. side

TABLE III—(Continued)

	Plate IX						Plate X					
	11	..	..	12	..	..	11	..	..	12	..	..
Work	349	391	69.9	461	321	443	28	14.0	18.6	634	247	331
Angle	9	0	0	11	5	6	0	0	1	28	18	13
	40	37	17	43	55	29	..	..	..	40	..	23
Fracture	Fibrous, tension side, defects in weld, granular, comp. side.	Fibrous, tension side, defects in weld, granular, comp. side	Granular all over	Fibrous, tension side, defects in weld, granular, comp. side	Fibrous, granular	Fibrous, granular; also defects in weld	Granular	Granular	Granular	Fibrous, tension side, granular, comp. side	Generally fine grained, small defects in weld	Generally fine grained, small defects in weld

	Plate XI						Plate XII					
	11	..	..	12	..	..	11	..	..	12	..	..
Work	14	18.6	32.7	279	209	41.9	434	149	172	102	228	121
Angle	0	3	2	13	5	2	13	4	7	0	4	0
	..	..	..	32	30	23	44	20	39	28	32	22
Fracture	Granular	Granular	Granular	Fibrous, granular	Fibrous, granular	Granular all over	Fibrous, serrated, granular	Fibrous, serrated, granular	Fibrous, serrated, granular	Fibrous, serrated, granular; also defects in weld	Granular, and slightly so at edges	Granular

TABLE III—(Continued)

	Plate XIII						Plate XIV					
	11	..	..	12	..	..	11	..	..	12	..	..
Work	69.9	149	69.9	74.5	23.3	717	419	610	414	265	479	437
Angle	2 22	6 28	4 23	0 31	0 10	35 ..	20 35	21 48	8 29	0 30	15 41	5 28
Fracture	Granular, edges slightly so	Granular, edges slightly so	Granular, edges slightly so	Defects in weld	Granular	Fibrous, tension side, otherwise granular, no defects.	Fibrous, tension side, otherwise granular, serrated	Fibrous, tension side, otherwise granular, serrated	Fibrous, tension side, otherwise granular, serrated	Fibrous, tension side, otherwise granular, serrated	Fibrous, tension side, defects in weld	Fibrous, tension side, defects in weld

	Plate XV. Elec. Weld.					
	11	..	..	12	..	..
Work	..	..	..	..	23.3	..
Angle	0 ..	0 ..	0 ..	0 ..	1 ..	0 ..
Fracture	Brilliant, fine grain, little defects in weld	Brilliant, fine grain, little defects in weld	Same without the defects	Same, small defects in weld toward comp. side	Same, small defect in weld at notch	Same, small defect in weld at notch

Table III — (Concluded)

Averages

Plate No.	I	II	III	V	VI	VII	VIII	IX
Work	37.2	634	293	247	218	139	233	330
Angle	1.0	16.6	8.1	6.8	1.8	1.3	5.1	5.1
Plate No.	**X**	**XI**	**XII**	**XIII**	**XIV**	**I—XIV**	**U**	**XV**
Work	209	97.9	214	183	437	279	870	3.73
Angle	10.0	4.1	4.6	7.8	11.5	6.4	29.6	0.16

Note: Plate U, unwelded; Plate XV, electrically welded.

(To be concluded)

Boiler Explosions.

August, 1916.

(276.) — On August 4, a tube ruptured in a water tube boiler at the power house of the Lackawanna and Wyoming Valley R. R. Co., Scranton, Pa.

(277.) — The boiler of a passenger locomotive belonging to the New York, Lake Erie and Western R. R., exploded seven miles west of South Bend, Ind., on August 4. Two men were killed and several injured.

(278.) — On August 5, the crown sheet of a fire box boiler collapsed at the ore mine of the Shook and Fletcher Supply Co., Cedartown, Ga.

(279.) — An air tank exploded August 5, at the plant of the Hamilton Foundry and Machine Co., East Hamilton, O. One man was killed and one fatally injured.

(280.) — A boiler exploded August 6, at the plant of the A. E. Turner Turpentine Co., Pensacola, Fla. One man was killed, one fatally injured and property damage done to an extent estimated at $8,000.

(281.) A boiler ruptured August 9, at the plant of the Arkansas and Texas Consolidated Ice and Coal Co., Pine Bluff, Ark.

(282.) — On August 11, a blow off pipe failed at the planing mill of Henderson and Molpus, Philadelphia, Miss. The fireman was slightly injured.

(283.) — The boiler of a freight locomotive exploded on the Santa Fe road near La Rose, Ill., on August 12. Three men were killed.

(284.) — A tube ruptured August 14, in a water tube boiler at the plant of The United States Gypsum Co., Fort Dodge, Ia.

(285.) — On August 15, a boiler ruptured at the Fort Smith Ice and Cold Storage Company's plant, Fort Smith, Ark.

(286.) — On August 17, the steam main running from the boilers to the engine failed at the New Top Mill of the Arlington Mills, Lawrence, Mass. A property loss of over $4,000 resulted.

(287.) — A cast iron header failed August 20, in an economizer at the plant of the Columbia Chemical Co., Barberton, O.

(288.) — A tube ruptured August 20, in a water tube boiler at the plant of the Inland Steel Co., Indiana Harbor, Ind.

(289.) — On August 20, a rupture occurred in the firebox of an internally fired boiler at the plant of the Bass Foundry and Machinery Co., Rock Run, Ala.

(290.) — On August 21, a boiler exploded at the stave and heading factory of the Harlan-Morris Mfg. Co., Jackson, Tenn. Eight men were killed and sixteen injured. The property damage was in the neighborhood of $12,000. The cause of the accident has never been fully determined.

(291.) — A cast iron header ruptured August 21 in a water tube boiler at the plant of the Philadelphia Rapid Transit Co., 33d and Market Sts., Philadelphia, Pa.

(292.) — A gas fired hot water heater exploded August 21, in the Castle Apartments, Los Angeles, Cal.

(293.) — On August 22, a tube ruptured in a water tube boiler at the fruit and cold storage plant of the Haley-Neeley Co., Sioux Falls, So. Dakota.

(294.) — A steam generator burst in the plant of the Western Newspaper Union, Milwaukee, Wis., on August 22.

(295.) — On August 22, a tube ruptured in a water tube boiler at the Western Ohio Railway Co. plant of the Aurora, Elgin and Chicago R. R. Co., St. Mary's, Ohio. One man was injured.

(296.) — A tube ruptured August 23, in a water tube boiler at the Paterson and Passaic Gas and Electric Co. Plant of the Public Service Corp. of New Jersey, Paterson, N. J. One man, the fireman, was injured.

(297.) — The boiler of a threshing machine outfit exploded August 23, at the Theodore Stevens farm, near Litchfield, Ill. Two men were dangerously, and perhaps fatally injured.

(298.) — A tube ruptured August 25, in a water tube boiler at the plant of the Marion Paper Co., Marion, Ind.

(299.) — On August 25, the crown sheet of a firebox boiler collapsed at the plant of the Blackwell Lumber Co., Fernwood, Idaho.

(300.) — A boiler exploded August 29, at the brick yard of E. H. Long, Sturgis, Ky. One man was injured so severely that he was not expected to recover.

(301.) — A tube ruptured August 29, in a water tube boiler at the ice plant of C. N. Avery and M. L. White, Austin, Tex. One man was injured.

(302.) — On August 29, a blow off pipe failed at the plant of the Oceanside Electric and Gas Co., Oceanside, Cal. Two men were injured.

(303.) — On August 29, a tube ruptured in a water tube boiler at the plant of the Superior Steel Co., Carnegie, Pa.

(304.) — A derrick toppled over and burst a contractor's boiler in an excavation under the tracks of the Philadelphia and Reading Railway, at Kensington, Philadelphia, Pa., on August 30. Ten workmen were injured.

SEPTEMBER, 1916.

(305.) — On September 1, a section failed in a cast iron sectional heater at the Cleveland Worm Gear of the Broc Realty Co., Cleveland, O.

(306.) — An autogenously welded ammonia tank exploded September 1, at Neuer Bros. market, Kansas City, Mo. Three men were killed and three others injured, one probably fatally.

(307.) — The crown sheet of a firebox boiler failed about September 1, at the N. L. Heaney stone quarries, Point Pleasant, Pa.

(308.) — On September 4, a cast iron header ruptured in an economizer at the plant of the Columbia Chemical Co., Barberton, O.

(309.) — A boiler ruptured September 5, at the plant of the Leesburg Grain and Milling Co., Leesburg, Ind.

(310.) — William Wagner, six year old son of Michael Wagner, of Alliance, O., died September 5, of injuries received when a toy boiler improvised from a syrup can burst. The can was plugged with a cork.

(311.) — A tube ruptured September 5 in a water tube boiler at the William H. Grundy and Co., worsted yarn manufactory, Bristol, Pa. Two men, the engineer and a coal passer were injured.

(312.) — On September 7, a tube ruptured in a water tube boiler at the plant of the Lilley Coal and Coke Co., West Brownsville, Pa. One man was injured.

(313.) — A boiler ruptured September 8 at the cannery of the Ryder Packing Co., Freetown, Ind.

(314.) — A tube ruptured September 9, in a water tube boiler at the plant of the Inland Steel Co., Indiana Harbor, Ind.

(315.) — The boiler of a peanut roaster exploded September 10 at Forest Park, Little Rock, Ark. A 14 year old boy was dangerously scalded.

(316.) — On September 11 a boiler ruptured at the water works and electric light plant of the City of Marshfield, Marshfield, Wis.

(317.) — A tube ruptured September 12, in a water tube boiler at the Merchants Light and Heat Co. plant of the American Public Utilities Co., Indianapolis, Ind. The boiler was considerably damaged.

(318.) — On September 14 the shell of a water tube boiler ruptured at the Penn. Iron and Coal Co. plant of M. A. Hanna and Co., Canal Dover, O.

(319.) — An autogenously welded ammonia tank burst September 14, at the plant of the Interstate Milk and Cream Co., Newark, N. J. Six men were killed including the president of the company.

(320.) — On September 16, a cast iron sectional heater failed at the plant of the Pittsburg and Conneaut Dock Co., Conneaut Harbor, O.

(321.) — A tube ruptured September 16, in a water tube boiler at the Fisk Street plant of the Commonwealth Edison Co., Chicago, Ill. Four men were injured but the property damage was not large.

(322.) — On September 16, an accident occurred to a water tube boiler at the Fitzgerald Cotton Mills, Fitzgerald, Ga., resulting in considerable damage to the boiler.

(323.) — The boiler of a threshing outfit exploded September 15, at the farm of John Scurron, near Washita, Ia. One man was killed.

(324.) — The boiler at Glenn's Gin, Walls Ferry, Ark., exploded September 17. Two men were hurled some distance but received only minor injuries.

(325.) — On September 19, several tubes pulled out of the tube sheet of a water tube boiler at the plant of the Nekoosa-Edwards Paper Co., Port Edwards, Wis. The boiler required extensive repairs.

(326.) — A blowoff pipe failed September 21, at the plant of the Gulf Brewing Co., Utica, N. Y.

(327.) — On September 21, a tube failed in a water tube boiler at the plant of the Union Lumber Co., Union Mills, Wash.

(328.) — On September 22, a malleable iron header ruptured at Shaft No. 3 of the Winona Copper Co., Winona, Mich.

(329.) — A boiler ruptured September 22, at the cannery of J. B. Andrews and Co., Hurlock, Md.

(330.) — A heating boiler exploded September 23, in the basement of the Exchange Place Building, Rochester, N. Y. The damage was confined to property only, though passersby had narrow escapes.

(331.) — On September 23, an accident occurred to a boiler at the Mt. Vernon Electric Light and Power Co. plant of the Birmingham Water Works Co., Mt. Vernon, Ind.

(332.) — A cast iron header ruptured in a water tube boiler on September 25 at the plant of the Scovill Mfg. Co., Waterbury, Ct.

(333.) — On September 25, a nozzle on a boiler failed at the laundry of Thomas J. Frothingham, Portland, Me.

(334.) — A boiler ruptured September 25, at the lath mill of C. Fortier, Duluth, Minn.

(335.) — On September 25, a number of tubes pulled out of the tube sheet of a water tube boiler at the plant of the Dow Chemical Co., Midland, Mich. The boiler sustained extensive damage.

(336.) — A tube ruptured September 25, in a water tube boiler at the plant of the American Steel and Wire Co., Waukegan, Ill.

(337.) — A boiler used for agricultural purposes exploded September 25, on the Wilcox farm, Little Falls, N. Y. One man was instantly killed, while two others were slightly injured.

(338.) — On September 26, a tube ruptured in a water tube boiler at the plant of the Middle West Utilities Co., Watseka, Ill.

(339.) — A steam pipe exploded September 28, at the plant of the Crucible Steel Co., Pittsburg, Pa. Three men were injured, two fatally.

(340.) — A tube ruptured September 29, in a water tube boiler at the plant of the Dow Chemical Co., Midland, Mich. The boiler was considerably damaged.

(341.) — A boiler exploded September 29, in the basement of the Boston Store, Massillon, O.

(342.) — A domestic hot water heater, fired by gas, exploded September 30, at the home of Mrs. Marie S. Wiggins, 316 W. 139 St., New York City. Mrs. Wiggins, a friend who was staying with her, a pet parrot and a canary were all killed by gas which escaped when the flame of the burner was extinguished by the force of the explosion.

(343.) — On September 30, a boiler ruptured at the cotton gin of John B. Claunch, Marked Tree, Ark.

October, 1916.

(344.) — A boiler exploded October 1, at the Spring Valley Pumping station, San Carlos, Cal. The engineer of the station lost the sight of both eyes.

(345.) — On October 2, a tube ruptured in a water tube boiler at the plant of The Dow Chemical Co., Midland, Mich.

(346.) — A tube ruptured October 2, in the Merchants Heat and Light Co., plant of The American Public Utilities Co., Indianapolis, Ind.

(347.) — A tube ruptured October 3, in a water tube boiler at the plant of The Washington Steel and Ordnance Co., Giesboro Manor, D. C.

(348.) — On October 6, a boiler ruptured at the plant of the Bloomer Cold Storage Co., Council Bluffs, Ia.

(349.) — An elevator pressure tank exploded October 7, at the Read House, Chattanooga, Tenn. One man was killed.

(350.) — On October 8, a tube ruptured in a water tube boiler at the Wheeling Steel and Iron Co., Wheeling, W. Va.

(351.) — A hot water heating boiler exploded October 12, at the Baptist Church, Flemington, N. J. A meeting of the Men's Club was in progress at the time, but fortunately no one was injured, although the property damage was extensive.

(352.) — A boiler exploded October 12, at the Kight Cotton Gin, Hico, Tex. The gin was badly wrecked, but only one man was injured, and his injuries were only of a minor character.

(353.) — On October 13, the furnace flue collapsed in a heating boiler at the office building of the B. O. Kendal Co., Pasadena, Cal.

(354.) — On October 14, a tube ruptured in a water tube boiler at the Southern Indiana Power Co. plant of the Middle West Utilities Co., Williams, Ind.

(355.) — A hot water boiler exploded October 14 at the home of Paul Comins, Strafford, Pa. A woman and child were fatally burned, and two others seriously injured.

(356.) — A tube ruptured in a water tube boiler October 14, at the plant of the Midvale Steel Co., Nicetown, Philadelphia, Pa.

(357.) — A cast iron section ruptured October 14, in a heating boiler at the apartment house of Helen A. Donovan, Brookline, Mass.

(358.) — On October 15, four sections ruptured in a cast iron heating boiler at the apartment house of the Trio Improvement Co., East 17th and Payne Sts., Cleveland, O.

(359.) — A tube ruptured October 15, in a water tube boiler at the plant of The Dow Chemical Co., Midland, Mich. Considerable damage was done to the boiler.

(360.) — On October 16, a tube ruptured in a water tube boiler at the plant of the United States Gypsum Co., Oakfield, N. Y.

(361.) — On October 16, a tube ruptured in a water tube boiler at the plant of The Dow Chemical Co., Midland, Mich. The accident necessitated extensive repairs.

(362.) — On October 17, a tube ruptured in a water tube boiler at the plant of The Columbia Chemical Co., Barberton, O.

(363.) — A steam pipe burst October 17, at Broadlawn Farms, Newtown Square, Pa. Two men were caught in the room where the accident occurred but were rescued in time to save their lives, although severely burned.

(364.) — On October 19, a tube ruptured in a water tube boiler at the plant of the Mobile Light and R. R. Co., Mobile, Ala.

(365.) — An accident to a boiler at the plant of the Western Meat Co., South San Francisco, Cal., on October 19, resulted in the burning of nineteen men by escaping steam. Two of the injured died within a short time, and two others were said to be in a very serious condition. Newspaper accounts said that the safety valve blew off from the boiler.

(366.) — A section cracked October 19, in a cast iron sectional heating boiler at the school of the Sisters of St Joseph, Clinton, Mo.

(367.) — A section ruptured October 19, in a cast iron heating boiler at the St. Joseph's Church, Fremont, O.

(368.) — A boiler used by A. J. Yauger and Co., on contracting work at Sidney, O. exploded October 20. Two men were killed and one other injured.

(369.) — A tube ruptured October 20, in a boiler at the plant of The Adirondack Power Co., West Utica, N. Y. Two men were scalded.

(370.) — The crown sheet of a locomotive boiler collapsed October 22, at the lumber mill of the Manly Moore Lumber Co., Fairfax, Wash.

(371.) — A boiler ruptured October 26, at the Mississippi State Insane Asylum, Jackson, Miss. The fireman and two patients who were helping him in the fireroom were injured, while considerable damage was done to the boiler.

(372.) — On October 26, a tube ruptured in a water tube boiler at the plant of The American Magnesia and Covering Co., Plymouth Meeting, Pa.

(373.) — A heating boiler exploded October 26, in the building of the Shreveport Athletic Club, Shreveport, La.

(374.) — A gas heated domestic (kitchen) hot water boiler exploded violently on October 26 at the home of Michael Hollander, Newark, N. J. By a strange coincidence no one was injured, though the house was badly wrecked and the accident occurred at a time when people in it were asleep. The newspapers attributed the accident to the familiar check valve in the supply.

(375.) — On October 28, a boiler ruptured at the electric light and power station of the Town of Sibley, Sibley, Ia.

(376.) — On October 28, two tubes pulled out of the tube sheet of a water tube boiler at Eureka Mine No. 35, of the Berwin-White Coal Mining Co., Windber, Pa. The fireman was somewhat injured.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1916.

Capital Stock, ... $2,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$215,107.37
Premiums in course of collection,		421,506.09
Real Estate,		90,000.00
Loaned on bond and mortgage,		1,448,245.00
Stocks and bonds, market value		4,008,399.40
Interest accrued		92,778.26
		$6,276,036.12
Less value of Special Deposits over Liability requirements,		41,619.80
Total Assets,		$6,234,416.32

LIABILITIES.

Premium Reserve,		$2,473,007.92
Losses unadjusted,		33,988.00
Commissions and brokerage,		84,301.22
Other liabilities (taxes accrued, etc.),		72,365.76
Capital Stock,	$2,000,000.00	
Surplus over all liabilities,	1,570,753.42	
Surplus as regards Policy-holders,	**$3,570,753.42**	3,570,753.42
Total Liabilities,		$6,234,416.32

CHARLES S. BLAKE, President.
FRANCIS B. ALLEN, Vice-President. W. R. C. CORSON, Secretary.
L. F. MIDDLEBROOK, Assistant Secretary.
E. S. BERRY, Assistant Secretary and Counsel.
S. F. JETER, Chief Engineer.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.

Board of Directors.

ATWOOD COLLINS, President. Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, Vice-President, United States Bank, Hartford, Conn.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres. The Fidelity Trust Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturers, South Manchester Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and Treasurer, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, The Johns-Pratt Co., Hartford, Conn.

MORGAN G. BULKELEY, JR. Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

CHARLES S. BLAKE, President, The Hartford Steam Boiler Inspection and Insurance Co.

Incorporated 1866. | Charter Perpetual.

INSURES AGAINST LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

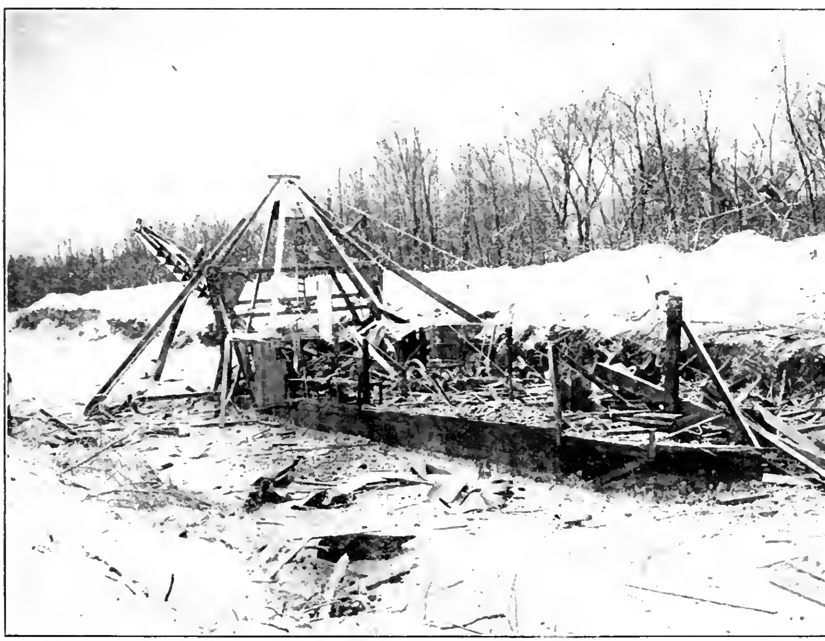
Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg	W. M. FRANCIS, Manager and Chief Inspector. C. R. SUMMERS, Ass't Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	LAWFORD & McKIM, General Agents. R. E. MUNRO, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. ROBERTS, Manager. CHARLES D. NOYES, Chief Inspector.
BRIDGEPORT, Ct., No. 1 Sanford Bldg.	W. G. LINEBURGH & SON, General Agents. F. S. ALLEN, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. LEMON, Manager. JAMES L. FOORD, Chief Inspector. J. T. COLEMAN, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. GLEASON, Manager. WALTER GERNER, Chief Inspector.
CLEVELAND, Ohio, Leader Bldg.	H. A. BAUMHART, Manager and Chief Inspector. L. T. GREGG, Ass't Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg. Cor. 15th & Champa Sts.	THOS. E. SHEARS, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. WILLIAMS, JR., General Agent. F. S. ALLEN, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	PETER F. PESCUD, General Agent. R. T. BURWELL, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. GARDINER, Manager. JOSEPH H. McNEILL, Chief Inspector. A. E. BONNETT, Assistant Chief Inspector.
PHILADELPHIA, Pa., Cor. Fourth & Walnut Sts.,	A. S. WICKHAM, Manager. C. H. DENNIG, Ass't Manager. WM. J. FARRAN, Consulting Engineer. S. B. ADAMS, Chief Inspector.
PITTSBURGH, Pa., 1807-8-9 Arrott Bldg.	J. J. GRAHAM, Manager. BENJAMIN FORD, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	McCARGER, BATES & LIVELY, General Agents. C. B. PADDOCK, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.,	H. R. MANN & Co., General Agents. J. B. WARNER, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. ASHCROFT, Manager. J. P. MORRISON, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. ROBERTS, General Agent.

50TH ANNIVERSARY NUMBER.

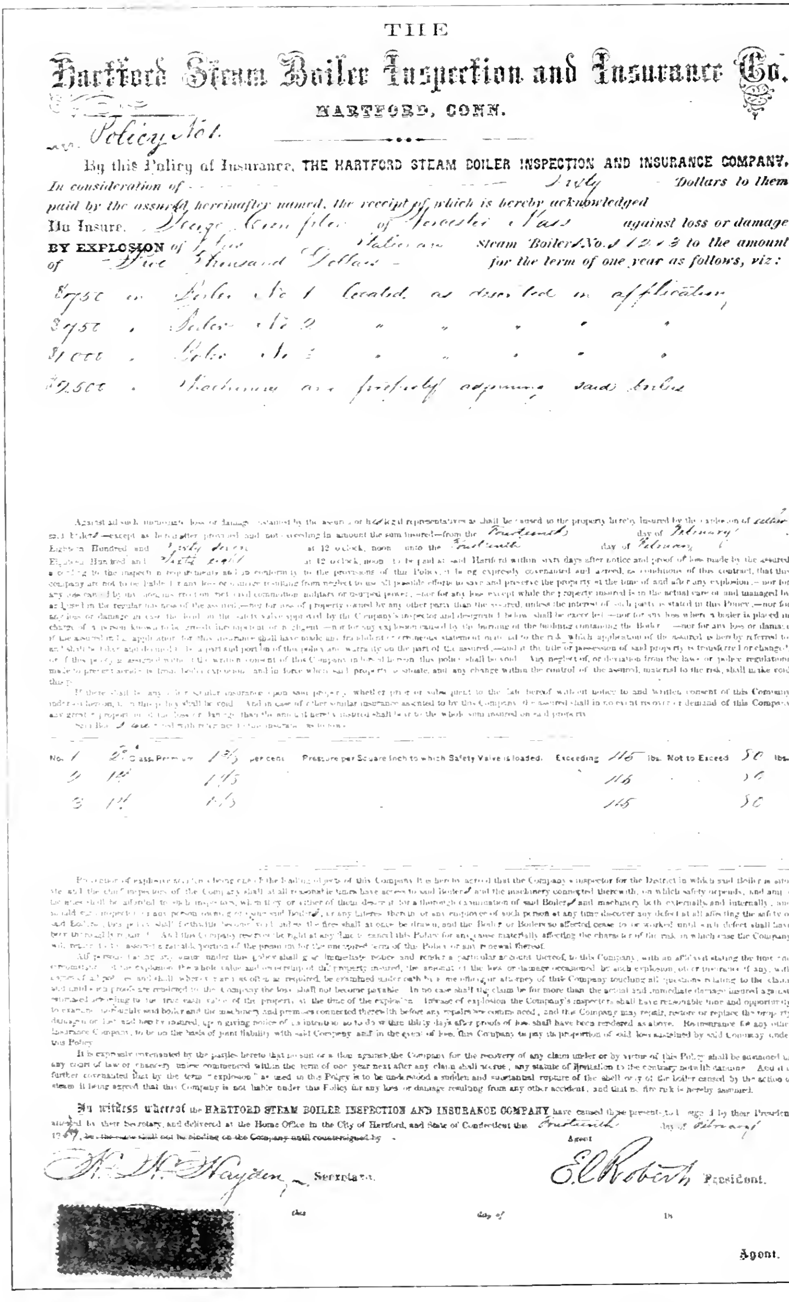
The Locomotive

of THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. ~~XXXIX.~~ 31 HARTFORD, CONN., APRIL, 1917. No. 6.



Explosion of a Dredge Boiler, Judicial Ditch No. 51, Norman County, Minnesota.



THE

Hartford Steam Boiler Inspection and Insurance Co.

HARTFORD, CONN.

Policy No. 1.

By this Policy of Insurance, THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY, *In consideration of* - - - - - - - - Sixty - *Dollars to them paid by the assured hereinafter named, the receipt of which is hereby acknowledged* Do Insure, George Crompton of Worcester, Mass. *against loss or damage* BY EXPLOSION of three stationary *Steam Boilers No. 1, 2, & 3 to the amount of* Five Thousand Dollars — *for the term of one year as follows, viz:*

$750 on Boiler No 1 located as described in application

$750 " Boiler No 2 " " " "

$1000 " Boiler No 3 " " " "

$2500 " Machinery on premises adjoining said boilers

Against all such immediate loss or damage sustained by the assured or his legal representatives as shall be caused to the property hereby insured by the explosion of either of said Boilers—except as hereinafter provided and not exceeding in amount the sum insured—from the Fourteenth day of February Eighteen Hundred and Sixty seven at 12 o'clock, noon, unto the Fourteenth day of February Eighteen Hundred and Sixty eight at 12 o'clock, noon, to be paid at said Hartford within sixty days after notice and proof of loss made by the assured according to the inspection requirements and in conformity to the provisions of this Policy, it being expressly covenanted and agreed, as conditions of this contract, that this company are not to be liable for any loss or damage resulting from neglect to use all possible efforts to save and preserve the property at the time of and after any explosion,—nor for any loss caused by invasion, insurrection, riot, civil commotion, military or usurped power,—nor for any loss except while the property insured is in the actual care of and managed by [illegible] in the regular business of the assured,—nor for loss of property owned by any other party than the assured, unless the interest of such party is stated in this Policy,—nor for any loss or damage in case the load on the safety valve approved by the Company's inspector and designated below shall be exceeded,—nor for any loss where a boiler is placed in charge of a person known to be grossly incompetent or negligent,—nor for any explosion caused by the burning of the building containing the Boiler,—nor for any loss or damage if the assured in the application for this insurance shall have made any fraudulent or erroneous statement material to the risk, which application of the assured is hereby referred to and shall be taken and deemed to be a part and portion of this policy and warranty on the part of the assured,—and if the title or possession of said property is transferred or changed, or if this policy is assigned without the written consent of this Company indorsed hereon, this policy shall be void. Any neglect of, or deviation from the laws or police regulations made to prevent accidents from boiler explosions, and in force where said property is situate, and any change within the control of the assured, material to the risk, shall make void this p[illegible]

If there shall be any other similar insurance upon said property, whether prior or subsequent to the date hereof without notice to and written consent of this Company indorsed hereon, then this policy shall be void. And in case of other similar insurance assented to by this Company, the assured shall in no event recover or demand of this Company any greater proportion of the loss or damage than the amount hereby insured shall bear to the whole sum insured on said property.

Said Boilers are [illegible] with reference to this insurance as follows:

No. 1	2d Class. Premium	1⅓ per cent.	Pressure per Square Inch to which Safety Valve is loaded.	Exceeding 115 lbs.	Not to Exceed	50 lbs.
2	1st	1⅓		115		50
3	1st	1⅓		115		50

Prevention of explosion being one of the leading objects of this Company, it is hereby agreed that the Company's inspector for the District in which said Boiler is situate and the chief inspector of the Company shall at all reasonable times have access to said Boilers and the machinery connected therewith, on which safety depends, and ample [illegible] shall be afforded to such inspectors, when they or either of them desire it, for a thorough examination of said Boilers and machinery both externally and internally; and should the inspector or any person owning or using said Boilers, or any interest therein, or any employee of such person at any time discover any defect at all affecting the safety of said Boilers, this policy shall forthwith become void, unless the fires shall at once be drawn, and the Boiler or Boilers so affected cease to be worked until such defect shall have been thoroughly repaired. And this Company reserves the right at any time to cancel this Policy for any cause materially affecting the character of the risk, in which case the Company will return to the assured a ratable portion of the premium for the unexpired term of this Policy or any renewal thereof.

All persons having any claim under this policy shall give immediate notice and render a particular account thereof to this Company, with an affidavit stating the time and circumstances of the explosion, the whole value and ownership of the property insured, the amount of the loss or damage occasioned by such explosion, other insurance if any, with copies of all policies; and shall, when and as often as required, be examined under oath by some officer or attorney of this Company touching all questions relating to the claim, and until such proofs are rendered to the Company the loss shall not become payable. In no case shall the claim be for more than the actual and immediate damage insured against, estimated according to the true cash value of the property at the time of the explosion. In case of explosion the Company's inspectors shall have reasonable time and opportunity to examine thoroughly said boiler and the machinery and premises connected therewith before any repairs are commenced, and the Company may repair, restore or replace the property damaged or lost and hereby insured, upon giving notice of its intention so to do within thirty days after proofs of loss shall have been rendered as above. Reinsurance for any other Insurance Company, to be on the basis of joint liability with said Company, and in the event of loss, this Company to pay its proportion of said loss sustained by said Company under this Policy.

It is expressly covenanted by the parties hereto that no suit or action against the Company for the recovery of any claim under or by virtue of this Policy shall be sustained in any court of law or chancery unless commenced within the term of one year next after any claim shall accrue, any statute of limitation to the contrary notwithstanding. And it is further covenanted that by the term "explosion" as used in this Policy is to be understood a sudden and substantial rupture of the shell or [illegible] of the boiler caused by the action of steam, it being agreed that this Company is not liable under this Policy for any loss or damage resulting from any other accident, and that no fire risk is hereby assumed.

In witness whereof the HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY have caused these presents to be signed by their President, attested by their Secretary, and delivered at the Home Office in the City of Hartford, and State of Connecticut, the Fourteenth day of February 1867, ~~but the same shall not be binding on the Company until countersigned by~~ Agent

H. H. Hayden, Secretary. E. C. Roberts, President.

[redacted] this day of 18

Agent.

THE FIRST POLICY ISSUED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

THE FIFTIETH ANNIVERSARY OF THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

On February 14, 1867, fifty years ago, the Hartford Steam Boiler Inspection and Insurance Company wrote its first policy, a reproduction of which appears on the opposite page. In commemoration of that event, a booklet was published on February 14, 1917, in which the Company's history was outlined, together with articles outlining the growth and scope of the various service departments, such as the departments of Inspection, Engineering, Chemistry, and The Locomotive. As The Locomotive reaches a considerable list of the Company's friends, we have decided to include in this issue, a very full abstract of the historical material which appeared in the booklet, feeling sure that it will prove of interest to Locomotive readers.

HISTORY OF THE HARTFORD

Up to about the middle of the nineteenth century, boilers were generally designed for working pressures of less than 50 pounds, but from 1850 to 1860 pressures commenced to increase, so that by the latter year it was not uncommon to find boilers carrying from 80 to 100 pounds per square inch. By that time the age of steam was well started on its course. With its extension and the increase of pressures was an accompanying increase of disastrous boiler explosions. This danger of steam boilers was a matter of grave apprehension to those who depended on their power and among them, and among scientific men generally, much serious thought and discussion was given to the cause of such explosions and means for their prevention.

A number of such men had in 1857 in the City of Hartford an organization which they called the Polytechnic Club. Its purpose was the study and discussion of scientific and mechanical problems and its membership consisted of men well qualified to take part in such activities. Among them were many who then already had or afterwards attained distinction in their life work, such as Elisha K. Root, who became president of the Colt's Fire Arms Company, Francis A. Pratt and Amos W. Whitney, who formed the well-known firm of Pratt & Whitney, Prof. C. B. Richards of Yale University, and J. M. Allen, who was early elected the president of this Company. This club gave much time to the investigation of boiler explosions and to the discussion of domestic and foreign theories and preventative measures. Its deliberations were interrupted by the Civil War but were resumed after its close, and further consideration was given the subject which all regarded as of great importance. The conclusion finally reached was that the best way to prevent explosions was by a system of inspections, which should discover defects in boilers and have them remedied before they caused disaster.

This method of safeguarding boilers had been practiced in England since 1855 when "The Association for the Prevention of Steam Boiler Explosions and for Effecting Economy in the Raising and Use of Steam" was organized and commenced its operations. Other similar associations had followed in that country and their success and the value of their service was known to the members of the Polytechnic Club. Some of these English associations, too, had provided in connection with contracts for inspection service a guaranteed indemnity in case an explosion occurred. This feature had a strong appeal for the members of the club who were living in Hartford at a time when that city was becoming famous as an insurance center, with insurance companies of many kinds formed or being formed, and insurance thought and talk in the air. In such an atmosphere, it was natural that the plans of these men should be directed along underwriting lines and that they should include, not only a provision for inspection service, but also the assumption of liability for failure to prevent explosions by means of a policy of insurance.

Through the efforts of the members of the Polytechnic Club a number of manufacturers and business men became interested in the project and determined to form a corporation to carry out the ideas which had been suggested. In 1866, E. N. Kellogg, John A. Butler, Henry Kellogg, T. C. Allyn, Elisha T. Smith and Charles M. Beach, residents of Hartford or of its vicinity, sought a charter from the legislature, which was granted in that year for a company to be known as The Hartford Steam Boiler Inspection and Insurance Company. It is significant of the importance which the incorporators attached to the inspection feature of the business that the word "inspection" precedes the word "insurance" in the title. This was natural because the inspections were to be the prime object of the Company, and today we realize how far-sighted the incorporators were, for the inspection service has been and ever will be the underlying principle of steam boiler insurance.

Owing to the usual formalities attending the organization of a new corporation, several months elapsed before the Company was ready for business. It elected Mr. Enoch C. Roberts its first president and Mr. H. H. Hayden its first secretary. The economy and modesty with which this executive staff prepared for business is reflected in the minutes of a meeting of the directors wherein is approved a monthly rental of $20 for the first office and in a record of the expenditures of $14 for the president's desk.

By February, 1867, all preliminaries had been completed and all legal requirements for the transacting of business in the states of Connecticut and Massachusetts had been complied with and the first policyholder was sought. He was found in the person of Mr. George Crompton, a director of the Company who owned three boilers in Worcester, Mass. The policy was issued on February 14th, 1867, in the sum of $5,000, with varying specific limits, as shown by our fac-simile of it.

President Roberts resigned on account of his health in July, 1867, and in September of that year Mr. Jeremiah M. Allen, one of the members of the Polytechnic Club who had been especially enthusiastic for the boiler inspection and insurance scheme, was elected to the vacancy. Mr. Allen entered his office with unbounded confidence in the value of thorough inspection of steam boilers, and he had the ability to impress others with his views. He commenced at once to organize an inspection department, and before the end of the year had secured the services of Robert K. McMurray as engineer and inspector, located in New York, of R. S. Stedman, in Hartford, and of William G. Pike, in Philadelphia. These men, with W. J. Farran, who joined the inspection force of the Philadelphia office in 1869, and Frank S. Allen, who came to the Hartford office of the Company in 1871, formed the nucleus of The Hartford's inspection organization. Mr. McMurray continued in charge of the New York inspection department until his death in 1910, and during that period had gained general recognition for his engineering ability from the boiler owners of his state. Mr. Farran is still with our Company as consulting engineer in its Philadelphia office, and Frank S. Allen continues as chief inspector at the Home Office of the Company.

President Allen had a charming personality and was especially fitted by training and temperament to develop the Company in its early period. He was a man of keen scientific mind and of shrewd business ability. No one person contributed so much to the success of the company in its early years as did he. It was no easy task to convince the public that the new and untried line of insurance, which the Hartford Company advocated, would be of benefit and successful. Business could only be attained by a process of education, for there was a feeling prevalent that boiler explosions were of mysterious origin and this feeling had to be overcome. President Allen solicited business personally from town to town, often meeting with rebuffs and ridicule which were most discouraging.

In 1869, Mr. Hayden, who had been secretary of the Company, resigned and Mr. Theodore Babcock was elected in his place. In 1873, Mr. Babcock gave up this office to accept a position of manager in the New York office, and was succeeded, as secretary of the Company, by Mr. Joseph B. Pierce, who continued in that position until his death in 1907. To Mr. Pierce belongs a goodly share of credit for the success the Company has attained. Under his careful direction the organization of the Company for underwriting insurance and for the carrying on of the business was developed and perfected.

In 1872, there entered the service of the Company, Francis B. Allen. Mr. Allen had received a mechanical training and had been an engineer in the Navy during the Civil War with the rank of Lieutenant, Engineer Corps. He was with Admiral Farragut in his engagement at Mobile Bay and in several other important naval actions. At the close of the war, he was detailed by the government to assist in experiments in the expansion of steam and in this gave valuable service. He joined the Company as special agent in the underwriting department of the New York office. In that capacity his intimate knowledge of mechanical principles placed him at an advantage in the solicitation of boiler insurance. After ten years in that office he was called to the Home Office to take the position of supervising general agent and in this capacity had charge of The Hartford's field force. In 1888, Mr. Allen was elected second vice-president of the Company, and on February 9th, 1904, became its vice-president. In these executive positions he has been in charge of the inspection and mechanical features of the business, responsibilities for which his own engineering training and experience had fully fitted him. The development of our inspection service and methods along the lines which have gained so excellent a reputation for the Company is largely due to the ability and continuous effort of Vice-President Francis B. Allen.

By the efforts of the founders of the Company, and its early officers, the public was gradually convinced of the dangers of steam boiler operation and of the necessity for safeguarding it, and showed recognition of the value of the service which The Hartford offered by its increasing patronage. Business came slowly at first but each year in increasing volume. The first offices for the sale of insurance and for the operation of the inspection service were, as has been mentioned, in Hartford, New York and Philadelphia. From time to time others were established until with the co-operation of an enthusiastic and loyal organization of agents and solicitors the entire country became the field of the Company's operations. With the growth of its business, the Company grew also. Its resources increased and the benefits of its insurance protection were broadened. That first policy, it will be recalled, was one providing specific amounts of insurance applied to specific classes of property. Such was then the practice with fire insurance (and generally is today) and undoubtedly that first policy was modeled on fire underwriting methods. The Hartford continued to issue policies of similar character, against property loss only, for nearly twenty years, but about 1887 it commenced to add to its protection, provisions for the payment to the assured of sums for the benefit of persons killed or injured by the explosion of a boiler. This was in a way personal accident insurance against a specific peril, but because the indemnity was payable to the boiler insurer for the benefit of the injured, it involved too some conception of the owner's liability for those injuries. This form of policy also abandoned the application of specific insurance to named classes of property. It merely limited the total liability of the Company to the amount of insurance afforded, and gave specified limits of indemnity for the death or injury of any one person. There was also included about this time compensation to the insurer for loss through his liability for damage to another's property due to boiler explosion. It was not until about 1893 that the policy was arranged to cover personal injuries along the lines recognized by liability insurance, but in that year a form was issued which insured in a blanket sum loss of the assured's property, his liability for damage to property of others, and also his loss caused by the death or injury of any person from the explosion of his boiler. This form of coverage also recorded a specific limit of indemnity applicable to loss from the death or injury of any one person. With some minor changes to meet modern conditions, it continues today to be the standard coverage of steam boiler insuring companies generally.

President Allen died on December 28th, 1903. A man of intellect and enthusiasm, he had had a broad vision for his Company. His energy and courage had carried it through many vicissitudes, and he had lived to see his vision realized and his Company firmly established and finally successful. His administration was one of creation and organization, and with it ended what may be considered the development period of the Company's history.

The administration which followed was also an important period for the Company. It is marked by the rapid growth of the already-established institution, both in usefulness and in financial strength. Following the death of President Allen, Lyman B. Brainerd had been elected to the presidency of the Company. Mr. Brainerd had joined the Company's staff in 1894 as assistant treasurer. Five years later he became treasurer. He continued in that position and in the management of the Company's finances even after his election as president and throughout his administration. At the time of his advancement to the highest office in the Company, insurance practices were becoming much more complicated than in earlier years. Larger policies were demanded and the enactment of workmen's compensation and boiler inspection laws presented many new problems of underwriting. In their solution President Brainerd's knowledge of insurance principles was of great value and enabled the Company to meet the new conditions with increased advantage to its patrons. Under him fly-wheel insurance was undertaken and became an important line of the Company's business. The insurance of the use and occupancy of property from fire and other disasters has been a recent demand on the part of the public. Realizing that this was a legitimate insurable loss and that it was seriously threatened by the boiler and fly-wheel hazard, the Company provided for its coverage and, within the last few years, has afforded a broad line of protection for many power users who would suffer from the interruption of production by an explosion of boiler or wheel.

All of this broadening of the Company's field required a strengthening of the Company's resources. Large policies only give confidence if the financial strength of the Company behind them justifies it. President Brainerd realized this and devoted much of his effort and his marked ability in financial matters to conserving and increasing his Company's resources. His success in this has placed the Company in its present strong financial position.

Our Company has and still does confine its business operations to the United States. In 1907, however, it purchased the entire capital stock of The Boiler Inspection and Insurance Company of Canada which had been for several years sustaining a precarious existence in the boiler underwriting field of that country. The Hartford in acquiring this Company gave strength to its position and to its policies of insurance by its guarantee of them. The inspection service of the Canadian Company is now modeled on that of the Hartford Company and under its supervision, so that in the Dominion of Canada now The Boiler Inspection and Insurance Company affords insurance and inspection service on a par with that of the parent Company in the United States.

The Home Office of the Company had for nearly forty years been in rented quarters. As has been stated, these quarters were very modest to start with, but, of course, have been increased with the growth of the Company. In 1907, it was manifest that they were again proving inadequate. At the same time, opportunity afforded for the purchase of a building which would furnish to the Company, not only ample space for its requirements of that time, but also for any probable expansion for years to come. The Company took advantage of this opportunity, and in January, 1908, moved into its own building on the corner of Prospect and Grove Streets. This building it continues to occupy and in it has commodious quarters and facilities for all of its departments. President Brainerd's administration is thus marked not only by the growth of the Company and increasing success, but by its establishment in a home of its own. That administration almost completed the fiftieth year of the Company's business existence. It was terminated by President Brainerd's death in October, 1916, an event which meant a great loss to our Company and the sorrow of which is still fresh in our hearts.

With that event this fifty years' history of our Company should close, except perhaps to mention those on whom its administration devolves at the present time. On November 20th, 1916, Mr. Charles S. Blake was elected to the presidency to succeed Mr. Brainerd. Mr. Blake's connection with the Company has been a long and useful one. He was appointed general agent of the Company in 1898, and became successively supervising general agent, second vice-president, and on the death of Secretary Pierce in 1907, was elected his successor.

Mr. Blake has been engaged in the underwriting, mechanical and claim branches of the steam boiler business for over thirty years and thus brings to the office of president a ripe experience and complete knowledge of the business.

The other officers of the Company are the following:

Vice-President Francis B. Allen, who was identified with the early history of the Company and of whom mention has already been made in this history, William R. C. Corson, who was elected secretary to succeed Mr. Blake in November, 1916, Assistant Secretary, Louis F. Middlebrook, and Assistant Secretary and Counsel, E. Sidney Berry.

We would supplement the foregoing story of the Company and of the men who have made it with the following brief record of its financial growth in the fifty years. It started in 1867 with a cash capital of $100,000. This was ample for its early liabilities, but as these liabilities increased, the capital from time to time was increased also, sometimes by subscriptions and sometimes from the accumulated earned surplus of the Company, so that at the end of President Allen's administration it amounted to $500,000. This was increased during President Brainerd's administration to $2,000,000.

To show the building up of the Company's premium income and its assets, the following figures indicate its growth in each five years from 1867 to, and including, 1916. Until 1881 the fiscal year ended on August 31st, since which time it has corresponded with the calendar year.

Date.	Premiums written.	Assets.
Aug. 31, 1871,	$89,615.67	$537,789.98
Aug. 31, 1876,	178,096.59	251,994.91

The reduction in assets here shown is due to the reduction in 1875 of the capital stock from $500,000 to $200,000.

Dec. 31, 1881,	$235,633.60	$363,907.62
Dec. 31, 1886,	455,065.49	687,225.49
Dec. 31, 1891,	721,703.57	1,391,830.64
Dec. 31, 1896,	910,054.34	2,108,211.62
Dec. 31, 1901,	1,160,693.59	2,880,726.44
Dec. 31, 1906,	1,349,841.91	4,034,534.40
Dec. 31, 1911,	1,316,957.60	5,045,874.60
Dec. 31, 1916,	1,974,285.91	6,805,287.75

The Company at its beginning in 1867 was the only boiler insuring company in this country. It continued to occupy that unique position for several years, but gradually its success influenced the entrance of others into the same field. A number of companies who did thus try to imitate The Hartford, became discouraged at their slow progress, and in this fifty years, at least twelve companies have withdrawn from the boiler underwriting field and reinsured their business in whole, or in part, with The Hartford. Today, while there are many companies competing with it in the boiler and fly-wheel underwriting field, The Hartford still maintains the position which it has constantly occupied during these fifty years as the writer of more insurance in those combined lines than all its competitors together. It is also a fact that The Hartford is today the only stock company in America transacting an exclusive steam boiler and fly-wheel business.

The Company's Service Departments.

Lack of space prevents our presenting the articles on the Inspection Service, prepared by Chief Engineer Jeter; on the Engineering Department, prepared by Superintendent Dart; on the Chemical Department, by Chemist Shailer; or on THE LOCOMOTIVE so fully as we have given the above historical sketch. We cannot however leave this story of the Company without some account of these important branches of its activity.

THE INSPECTION SERVICE

As has been so often stated the first object of the Company was to inspect boilers. Insurance was considered a necessary adjunct to act as a guarantee of the inspection work. At the start there was no inspection force, nor were there available men trained for such work who could be organized into an inspection force. Inspectors must be developed by experience in inspecting and the training of such a force as now represents the Company was a tremendous task.

There is no authentic record of who made the inspection of the first risk secured by the Company, but tradition has it that a machinist in the employ of the New Haven and Hartford Railway, by the name of Gibbs was the man secured to perform this duty. However Mr. Gibbs evidently did not have a full conception of the methods that should be used in making a boiler inspection, nor did he adopt the methods to be pursued by his followers, for he is said to have visited the plant for the purpose of inspection attired in a frock coat, high hat and wearing kid gloves.

The work soon required men who would devote their entire time to inspecting and the records show that three men were so employed during 1867. They were R. S. Steadman at Hartford, R. K. McMurray at New York, and Wm. G. Pike at Philadelphia. While others may have assisted in the work at times, the next two regularly employed inspectors were W. J. Farran, now consulting engineer at Philadelphia, and Frank S. Allen, who has so long been Chief Inspector at the Home Office. Mr. Farran began his work in 1869, and Mr. Allen in 1871.

From such a start the service has grown till at present 265 men, all salaried employees engaged solely in the inspection of boilers and fly-wheels constitute the inspection force of The Hartford. The Company long ago abandoned the idea of using any but specialists to make its inspections. With the large force now employed the most exacting requirements of the steam user even in remote sections of the country are promptly attended to. Our inspectors are constantly on the go from the Canadian border to the Gulf, and from the Atlantic to the Pacific coast.

The assured, although they value the inspection service highly, seldom appreciate fully of what it actually consists. When an assured does become closely acquainted with the work, he often remarks "how can so much service be furnished in addition to the insurance protection afforded by the policy of the Company for the small premium outlay?"

Summarizing the qualifications for an inspector, briefly, it may be said that they consist, first of reliability and integrity. He must thoroughly understand boilers, their construction, their ills and the remedies to apply. He must have sound judgment as to what is or is not safe enough for insurance, because his recommendations may involve the expenditure of large sums of the assured's money, as well as the amount of risk assumed by the Company. He must be tactful, but also have sufficient force of character to secure the adoption of the safety measures he consider necessary. Last of all he is required to pass judgment through the external inspections, on the maintenance and operation of the plant and its safety appliances by the plant personnel.

Since 1910 the Company has added the inspection of fly-wheels to the duties of the force, and wheels and engines now receive the same careful scrutiny in every particular affecting the safety of the wheel which is accorded boilers.

The general direction of the inspection service is from the Home Office at Hartford, while there are fifteen department offices throughout the country. Each department office is in charge of a Chief Inspector and four of the fifteen also require an Assistant Chief to aid in directing the activities of the inspections. This division of the business into departments renders prompt attention to the exacting requirements of our patrons possible and secures for the inspector a source of prompt information and instruction when confronted with unusual conditions.

The compilation of the inspection service rendered by the Company since 1870, printed on page 179, will show the volume handled and give an idea of the results accomplished up to the present time.

THE ENGINEERING DEPARTMENT

"The Hartford Steam Boiler Inspection and Insurance Company is prepared to furnish gratis to those of its patrons who are about to replace worn-out or wasteful boilers, drawings and specifications of the most approved boilers, their settings and attachments." The sentence above quoted was the beginning of a short announcement which appeared in THE LOCOMOTIVE in January, 1879. Some plans and specifications had been drawn and issued by the Company previous to this date but there had been no organized effort to furnish such service: it, therefore seems probable that the Engineering Department as such was started about twelve years after the Company began to do business.

To a man of President Allen's foresight the necessity for establishing and maintaining an Engineering Department must have been anticipated very early in the Company's history,— perhaps even before the Company started to do business. Since the Company proclaimed itself as an aggregation of experts in boiler design and operation, and since people came to rely on the recommendations of the Company's representatives concerning the operation and repair of old boilers, it was but natural that they should seek advice from the same source, when called upon to buy new equipment, as to the best kind of boiler to buy and the best way to install it. Therefore the Engineering Department started as a logical, even inevitable consequence of the Company's success in its chosen field.

The service was appreciated and the designs proved successful and satisfactory. The Department from the start aimed at safety in design but coupled with that went always a desire "to render the use of steam economical as well as safe," to borrow a phrase from an early LOCOMOTIVE article describing this particular activity of the Company. The Department of course was aided by the exceptional opportunities afforded the Company through its mechanical representatives to collect valuable data and experience.

The Engineering Department's influence is perhaps best shown in its success in pushing the development of the horizontal tubular type of boiler over the older types prevalent when the Company began its work. Not only did it assist in the introduction of this boiler as a safer and more economical type, but it went further and greatly improved both its safety and economy. Similarly boiler settings were attacked and a better and more economical method developed which has become popularly known as the Hartford setting.

The Department has not by any means confined its activities to boilers of the horizontal tubular type, but has designed boiler of many sorts. Its records though incomplete for the early years show that about 10,350 boiler specifications covering the construction of over 17,000 boilers have been issued, and as far as the Company's information goes, not one of these boilers ever exploded,— a record of which the Company is justly proud. Many vessels other than boilers, such as air tanks, elevator tanks, rendering tanks, bloff-off tanks, wood pulp digesters, rotary bleachers, vulcanizers, etc., have also been designed with complete drawings and specifications.

In addition to the work in designing boilers and pressure vessels, a very large amount of general mechanical engineering has been done. Plans and specifications have been furnished for chimneys and smoke flues (over 200) ; heating systems for churches, schools, factories, hospitals, business blocks, clubhouses, colleges, stores, residences, and even jails (nearly 300 systems) ; over 125 specifications for piping have also been prepared together with plans for boiler houses and complete power plants.

At present a central heating plant is being planned to replace three present plants in three large buildings. Five boilers will replace nine, and all the construction of boiler house, stack, flue, steel encased boiler settings, a 1,500 foot concrete subway, concrete bridge, spur track, facilities for handling and storing coal, the installation of smoke consuming devices, pumps, feed water heater and complete piping system with steam flow meters reducing valves, insulating covering and all accessories are included. The work will cost in excess of $200,000.

It can easily be seen from the foregoing that the value of the services rendered by our Engineering Department to the assured has been very great indeed. How great this has been can perhaps be best realized when it is stated that at no time has there been a charge made for plans and specifications for boilers, settings or pressure vessels.

THE CHEMICAL DEPARTMENT

In the January, 1880, issue of The Locomotive is found the announcement that "The Hartford Steam Boiler Inspection and Insurance Company is now prepared to examine water (gratis for its patrons) as to its fitness for use in steam boilers." The article further gives brief directions as to the correct manner in which samples should be collected and shipped for examination.

At that time very few persons realized the value of such a service and they were slow to avail themselves of it. Almost any water was considered fit for boiler purposes and people were skeptical as to the value of chemical analysis and recommended treatment, so that many of the early samples were sent in through curiosity or because the inspector had advised it. Little by little however it was seen that where the treatment advised had been followed the operating conditions were improved, and as the advantages to be derived from the company's offer of free analysis were appreciated, more and more samples were presented, till in a few years waters had been examined from all parts of the country. Along with the increase in water samples, a considerable amount of scale was sent in for analysis so that treatment could be recommended for its removal and future prevention.

Through the inspection department and otherwise the results of any feed water treatment were carefully watched and noted. If unsuccessful, the treatment was modified until the bad condition was improved or the water shown to be absolutely unfit for boiler use. From the experience thus gained the Chemical Department has accumulated a vast amount of data and information, an equipment which enables it to undertake the solution of feed water problems with every assurance of success.

The work of the Department has grown rapidly until at present about 300 samples are examined annually. Record of every analysis has been carefully kept so that it is possible to prophesy with a marked degree of certainty as to the quality and general character of the water that one would expect in almost any locality in the United States.

About a year ago it was decided that the scope and usefulness of the laboratory should be enlarged as it seemed that much could be learned regarding the failure of tubes in water tube boilers by the aid of a chemical analysis of the material at or near the point of rupture. This step necessitated larger quarters for the Department and the purchase of much additional equipment. We are now ready to proceed with this work and believe that valuable data will be obtained.

THE LOCOMOTIVE

The Locomotive first appeared in November, 1867. It was at that time a four page leaflet, nine by eleven and a half inches in size, and its purpose was stated in the following editorial:

"The object of this paper is to bring before the public from time to time information of a scientific and practical nature that will be both entertaining and useful, and although we shall aim in each number to furnish our readers with at least one good article in some one of the branches of natural science, our chief object will be to discuss practical questions and more particularly, *steam power* and its applications. We propose to keep a careful record of all Steam Boiler Explosions, together with such facts and circumstances attending each, as we are able to obtain, and the various theories of Steam Boiler Explosions, with all the obtainable information bearing upon the subject, will be placed in our columns. The range of scientific information is so wide, and the field over which it extends, so large, that there can always be found something to interest and instruct. Many valuable suggestions by practical men are entirely lost to the public from the want of some medium by which to communicate them. We hope to make this a paper that will recommend itself to every intelligent person under whose notice it may come, and if we succeed in furnishing *light* to any, our labors will be amply repaid."

At that time steam users needed educating. They were not yet fully awake to the value of boiler inspection, and The Locomotive was conceived as a means toward that awakening. Later when there was less need to preach the necessity of inspection, The Locomotive was used, as it is today, as a medium of communication between the Company and the steam using public. Through its columns people have been shown unsafe constructions and practices, and have been helped to understand why they were unsafe and how safer methods might be substituted. The Locomotive files are indeed almost a history of the art of boiler design and operation, covering fifty years.

The form has changed at times. The large four page leaflet of 1867 was changed in 1880 to the present size but the monthly publication date remained. Later (in 1904) the paper became a quarterly but the number of pages was increased to give substantially the same amount of material annually. The scope and purpose has remained with little change. We still aim to give our readers all the information we can which will enable them to get greater safety and better service from their equipment. To present in direct, understandable form as many of the latest and best ideas of mechanical engineers, relating to boilers and flywheels as possible.

Concerning Superheaters.

One of the peculiarities of steam well known to the chemist, is the possibility of its being split up at temperatures of from 1300°-1500° F., by red hot iron into its component elements oxygen and hydrogen. The oxygen does not appear as a separate and distinct product, because it unites with the hot iron as fast as it is formed, producing the black or magnetic oxide of iron, Fe_3O_4, as distinguished from the red oxide so familiar as the product of ordinary rusting. That this phenomenon is possible has been known for a very long time, and it has been utilized at times as an experimental means for obtaining hydrogen. In THE LOCOMOTIVE for September, 1868, an article was presented on the behavior of superheated steam, in which mention was made of an attempt to use this method for the commercial production of hydrogen, as one constituent of illuminating gas. Iron pipes were partially filled with iron borings, and through these, after they had been heated to redness, the steam was led. Hydrogen was produced without difficulty, but the scheme had to be abandoned as the iron parts of the apparatus would not last longer than two or three days.

It should be noted that the only conditions necessary for this action are hot iron (or steel) in contact with hot steam. At a sufficiently high temperature the action will always follow, being limited only by the duration and intensity of the temperature, the amount of iron available, and the quantity of steam present for decomposition. Of course in most boilers the temperature of both the metal container and its contents is limited intentionally by the fact that water is maintained in greater quantities than are required to supply the maximum steam production. Any increase in the heat transfer is met by a corresponding increase in the amount of steam formed, and with proper means of pressure limitation, the pressure and hence the temperature of the steam and water will not appreciably exceed that of the boiling point corresponding to the maximum pressure. The temperature of the metal container will of course vary somewhat with the rate of steaming, but will never reach a value approaching redness in any well designed boiler, since care is taken to limit the surface exposed to the fire to that which can be effectively protected with water.

In superheaters, however, steam is heated above the temperature of formation. It is necessary therefore to take precautions so that under ordinary conditions of working, the tubes or other iron parts in contact with the steam will remain at all times at a temperature well below that at which decomposition of the steam will begin.

Efficiency as well as safety demands that the steam shall be led past the iron surfaces in such a way as to effectively take up the heat transmitted from the furnace, and while different designers have arrived at different solutions of the problem, all successful superheaters are arranged so that the steam will pass through in sufficient amounts to absorb the heat from the iron so rapidly as to prevent a dangerous rise in temperature when working normally.

If, however, through abnormal or unusual conditions the steam flow is diminished in the whole or a part of a superheater, at a time when sufficient heat is being supplied from the furnace to heat the iron to redness, deterioration will take place, the extent to which it will proceed being determined by the length of time during which the condition prevails.

Superheaters may be broadly divided into two groups, those which are installed as an integral part of the boiler unit, placed directly in the path of the gases through the boiler setting, and therefore operated always in conjunction with the particular boiler to which they are attached; and those which are so set as to be heated by a separate and independent furnace in a setting distinct from that of the boiler or boilers. Such superheaters may serve more than one boiler, and are capable of independent control and operation.

In the case of superheaters of the first, or attached, type, the chances are against this sort of deterioration. In the first place the superheaters are so proportioned relative to the boilers to which they are attached that the temperature of the steam will be raised a certain definite amount, and as the rate of firing is governed by the steam output, periods of intense heat will correspond to periods of great steam flow, and therefore there will be little opportunity for the iron to assume a dangerously high temperature. Two things should however be guarded against. One is the choking or plugging of one or more superheater tubes with scale or sediment, and the other is the possibility of the steam being shut off from the superheater intentionally. The first of these dangers will ordinarily be confined to boilers which prime. Priming is associated with a high content of solid matter in the feed water which is not precipitated by heat or solvents in the boiler proper, or in feed heaters, water softeners or purifiers. Indeed solvents may in certain cases aggravate the trouble, especially if liberally used. (This is not to be construed as an argument against the use of chemical treatment for boiler waters. The cases referred to are found in connection with troublesome waters and require the control of a careful chemist.) In this connection it is perhaps well to point out a difference between the formation of scale in boilers and in superheaters. Many different sorts of solid matter may be dissolved in water, but it is convenient to divide all the dissolved matter into two classes. One of these represents all the material which is rendered insoluble at the temperatures found in a steam boiler and therefore is deposited as scale. The other consists of all the solid matter which stays in solution at boiler temperatures, and does not make scale. Chemists call the first sort insoluble solids, or incrustants, and the second sort soluble solids or non-incrustants always referring however to boiler conditions where some water is always present as *water*. If we draw a sample of water from the blow-off pipe of a steaming boiler, and filter out any sediment it carries, it will naturally have little or none of the scale-making solids. They will be left in the boiler. It will contain however the full amount of soluble or non-incrusting solids. If now we boil the sample from the blow-off till all of it has turned to steam, evaporate to dryness as the chemists say, the non-scale-making, or soluble solids will be thrown down as a scale or precipitate.

Coming back to the case of a boiler and superheater, let us trace the scale-forming activity of a small portion, say a pint, of water in its passage from the feed line to the superheated steam main. Our pint of water enters the boiler and is heated by the surrounding water to boiler temperature. After a time at this temperature, the scale-making stuff which it had in it at the start will be floating about in the boiler in the form of small particles of sediment, which as they pass along with the circulation attach themselves to the boiler structure as scale, or else are deposited in the boiler bottom or mud drum as a sludge. The water, freed from its scale-making matter, evaporates, leaving its non-scale-making material behind it as a legacy to the water remaining in the boiler. Hence the amount of dissolved solid matter in a boiler constantly increases in concentration, in proportion to the rate of steaming. The only way to get rid of the soluble solids is to blow off a portion of the boiler water and replace it with fresh feed. We have assumed that our pint of water evaporated quietly into dry steam. It is well known however that if the soluble matter in a boiler gets too concentrated either because the feed is heavily charged to start with or because the blow-off has not been used sufficiently, the evaporation becomes less and less quiet, and the boiler is said to be "foaming." If the boiler foams badly, the steam picks up and carries along small particles of water in the form of spray, and the boiler is then said to be "priming." Now when wet steam from a priming boiler passes through a superheater the water entrained in the wet steam evaporates in the superheater and deposits its solids in the form of an incrustation. Hence a priming boiler will scale up a superheater, but the scale deposited by a particular water in the boiler would be different from that deposited from the same water in the superheater, since the boiler would get the insoluble or incrusting solids while the superheater would get the soluble or non-incrusting solids.

In designing superheaters for high efficiency, one solution of the problem of getting the greatest amount of heat into the steam per square foot of superheater surface consists in passing the steam over the surfaces in thin layers. This means restricted passages, and hence a priming boiler might deposit scale enough in time to choke off a part of a superheater. As soon as this happens the steam flow through that element is diminished, and may fall so low that it can no longer keep the iron below a red heat if the furnace is hot enough. Then the steam is certain to be decomposed with the result that the iron will be oxidized and rendered worthless for use as a container for steam under pressure. It is necessary therefore, when superheaters are attached to a boiler, to so control the character and concentration of the feed water as practically to eliminate priming if all danger of choking the superheater passages is to be avoided. This can be done in most cases by the frequent and judicious use of the blow-off, though some waters may require special treatment. It is significant in this connection to note that the newest large plants, built to use high pressure steam, highly superheated, have made provision that nothing but condensate or carefully distilled make up feed shall be used in the boilers.

The other hazard to a direct connected superheater, mentioned above, would occur in cases where only a part of the total steam produced is superheated. If under such conditions it should happen that frequent calls for maximum boiler output should coincide with minimum drafts of superheated steam (that is, periods of minimum flow in the superheater would correspond with maximum furnace temperatures), then we should expect to find the superheater exhibiting decomposition. Such a case was illustrated in THE LOCOMOTIVE for October, 1913, in which the superheater was entirely destroyed.

With separately fired superheaters, it would seem that in the absence of any automatic thermostatic devices operated by the steam temperature which could be depended upon to absolutely control the fire, the only safeguard is to be found in eternal and intelligent vigilance, coupled with careful design and installation. The design should be such that at all rates of steam flow possible, there should be an ample flow of steam over all the superheater surface, and no elements should be robbed of their share by eddies or through a too rapid flow through the headers, as it has been found that if the velocity

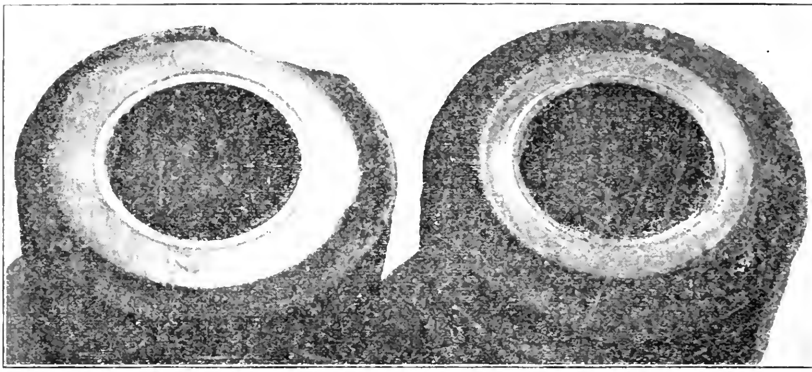


Fig. 1. Fig. 2.

Normal and Oxidized Sections of Superheater Tube.

through the headers is too great, some of the tubes will fail to take their share of the steam current. The furnace and combustion chamber, with their attendant checker work and baffles should be so designed that the flow of heat to the superheater elements will be uniform, with no excessively hot spots or corners to develop local troubles. For the rest, a careful and constant watch must be kept of the steam temperature, and the fires must be controlled accordingly. At every opportunity the elements should be inspected internally where possible, to see if there is any surface indication of the formation of a black oxide coating. If it should be found, it will be well to see if the conditions which led to its formation cannot be overcome, and if not it must be carefully watched so that every affected tube may be renewed before the disintegration has progressed so far as to menace the safety of the structure, With all separately fired superheaters, care should be taken when heating up from cold, to see that steam is flowing before the tubes have had any chance to acquire a dangerous temperature. In the same way, it is necessary when shutting down the superheater, to be certain that the steam flow is maintained for a sufficient time after the fire has been checked, to prevent any dangerous temperature rise.

Figure 2 is a photograph of a section of a superheater tube which ruptured because it became so weakened by oxidation as to be no longer able to resist the stresses produced by the steam pressure. It will be noted that this tube consisted of a steel inner tube for strength, surrounded by a flanged or ribbed cast iron shell designed to act as a heat absorber. Careful inspection will show that the inner steel tube had become almost entirely oxidized on one side (the hotter side). It will also be noted that the inner tube on the hotter side is apparently thicker than on the less oxidized side. This is due to the fact that the volume occupied by the oxide is greater than that of the metal from which is was formed. Fig. 1 is a section of an exactly similar tube which had not suffered deterioration. It is reproduced for comparison so that the change in the oxidized tube may be more readily observed.

The tube which failed had been in service for less than a year in a separately fired superheater, using gas as fuel. It was located in the first or hottest row of tubes, and the oxidation was confined to the middle third of the tube length. It was stated that when the superheater was first installed, the gas regulation was such that too great temperatures were obtained, so that the destruction of the tube in question doubtless started at that time. Just what combination of circumstances in the operation of the superheater led to the continuation of the trouble with the subsequent tube failure is of course difficult to determine, but careful temperature observations, intelligent operation and inspection will doubtless prevent a recurrence of the difficulty.

Summary of Boiler Explosions, 1916.

We append our usual annual compilation of boiler explosions, listed by months, with the number of explosions, number killed, injured, and the total of killed and injured. While we cannot claim absolute completeness for this list we have endeavored to make it as complete and accurate as possible, and trust it may be interest to our readers.

Summary of Boiler Explosions for 1916.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January	67	30	28	58
February	66	25	36	61
March	49	40	33	73
April	21	7	39	46
May	24	6	23	29
June	20	4	14	18
July	28	23	25	48
August	29	18	37	55
September	39	17	15	32
October	33	7	15	22
November	60	13	23	36
December	63	9	87	96
Totals	499	199	375	574

Hartford Inspection Service During 1916.

On the pages following we print our annual tabulation of the work of our Inspection Department for the year just past as well as the customary comparative table of Inspectors' work since 1870. As we have so often pointed out in the past, it will be seen that by far the greater portion of the defects discovered were due to impure feed water. The large number of cases of scale, sediment and corrosion, bear out this statement.

Summary of Inspectors' Work for 1916.

Number of visits of inspection made	204,863
Total number of boilers examined	386,245
Number inspected internally	146,971
Number tested by hydrostatic pressure	8,273
Number of boilers found to be uninsurable	926
Number of shop boilers inspected	9,620
Number of fly wheels inspected	18,059
Number of premises where pipe lines were inspected	4,756

Summary of Defects Discovered.

Nature of Defects.	Whole Number.	Dangerous.
Cases of sediment or loose scale	28,212	1,593
Cases of adhering scale	42,877	1,612
Cases of grooving	2,568	315
Cases of internal corrosion	19,008	793
Cases of external corrosion	10,968	814
Cases of defective bracing	984	266
Cases of defective staybolting	2,049	504
Settings defective	9,401	814
Fractured plates and heads	3,711	563
Burned plates	5,361	498
Laminated plates	278	27
Cases of defective riveting	1,448	201
Cases of leakage around tubes	12,554	1,581
Cases of defective tubes or flues	15,080	4,939
Cases of leakage at seams	5,537	373
Water gages defective	4,192	714
Blow-offs defective	4,262	1,337
Cases of low water	420	123
Safety-valves overloaded	1,386	235
Safety-valves defective	1,695	358
Pressure gages defective	8,351	815
Boilers without pressure gages	32	32
Miscellaneous defects	4,261	662
Total	184,635	19,219

Grand Total of the Inspectors' Work from the Time the Company Began Business, to January 1, 1917.

Visits of inspection made	4,108,706
Whole number of inspections (both internal and external)	8,236,834
Complete internal inspections	3,229,351
Boilers tested by hydrostatic pressure	341,163
Total number of boilers condemned	25 901
Total number of defects discovered	4,887,696
Total number of dangerous defects discovered	514,618

Summary of Inspectors' Work since 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1876	16,409	34,275	10,669	2,150	16,273	4,275	89
1877	16,204	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	303
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595
1895	98,349	199,096	76,744	8,373	144,857	14,556	799
1896	102,911	205,957	78,118	8,187	143,217	12,988	663
1897	105,062	206,657	76,770	7,870	131,192	11,775	588
1898	106,128	208,990	78,349	8,713	130,743	11,727	603
1899	112,464	221,706	85,804	9,371	157,804	12,800	779
1900	122,811	234,805	92,526	10,191	177,113	12,862	782
1901	134,027	254,927	99,885	11,507	187,847	12,614	950
1902	142,006	264,708	105,675	11,726	145,489	13,032	1,004
1903	153,951	293,122	116,643	12,232	147,707	12,304	933
1904	159,553	299,436	117,366	12,971	154,282	13,390	883
1905	159,561	291,041	116,762	13,266	155,024	14,209	753
1906	159,133	292,977	120,416	13,250	157,462	15,116	690
1907	163,648	308,571	124,610	13,799	159,283	17,345	700
1908	167,951	317,537	124,990	10,449	151,359	15,878	572
1909	174,872	342,136	136,682	12,563	169,356	16,385	642
1910	177,946	347,255	138,900	12,779	169,202	16,746	625
1911	180,842	352,674	140,896	12,724	164,713	17,410	653
1912	183,519	337,178	132,984	8,024	164,924	18,932	977
1913	192,569	357,767	144,601	8,777	179,747	21,339	832
1914	198,431	368,788	145,871	8,239	190,882	23,012	756
1915	199,921	373,269	140,002	7,998	178,992	22,077	790
1916	204,863	386,245	146,071	8,273	184,635	19,219	926

The Locomotive
of
THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

C. C. Perry, Editor.

HARTFORD, JANUARY, 1917.

Single copies *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
The Locomotive of The Hartford Steam Boiler I. & I. Co.

Book Review

Riveted Boiler Joints. A Treatise on the Design and Failures of Riveted Boiler Joints, with Numerous Original Diagrams Enabling the Designer to Design any Desired Joint Without Calculations. By S. F. Jeter, B. S.; M. E., Member of The Boiler Code Committee, American Society of Mechanical Engineers, Chief Engineer of The Hartford Steam Boiler Inspection and Insurance Company. The McGraw-Hill Book Co., Inc., 155 pages, 8 by 11, 75 diagrams and numerous illustrations. Cloth, $3.00.

This book will undoubtedly prove of service to engineers and others concerned with the design or calculation of boiler joints as a tool for constant reference. It contains a set of 75 original diagrams from which any practical joint can be entirely determined from the charts alone, if it is to be calculated under the conventions established in the A. S. M. E. Code, that is for values of the tensile strength of plate = 55,000 pounds per square inch, crushing strength of plate = 95,000 pounds per square inch and shearing strengths for rivets of 44,000 and 88,000 pounds per square inch respectively for single and double shear.

Not only may the efficiency be found to a sufficient degree of precision but it can be seen at once whether a slight change in pitch either way would yield a higher efficiency with the same plate and rivet size, and whether the pitch chosen is within practical limits for driving and caulking. One other diagram gives either the bursting pressure or the working pressure, based on a safety factor of five, for any cylindrical vessel whose plate thickness, joint efficiency and diameter are known.

In addition to chapters explaining the use of the diagrams a simple and complete analysis is given of joints, with examples worked out in the usual way. A discussion is introduced of the subject of limiting pitches and a chapter is presented showing how joints of maximum efficiency, of any number of rows of rivets may be calculated. Moreover the fact is demonstrated that a simple formula will serve to give the efficiency of every joint of maximum efficiency.

The construction of the diagrams is explained from the standpoint of the analytical proof of their correctness and also a treatment in non mathematical language is added so that any one with a knowledge of arithmetic should be able to draw the charts for any desired conditions differing from those used as a basis for the charts printed.

It would seem that this book would be almost indispensable to boiler and pressure vessel designers and boiler inspectors, as well as to all others having riveted work to calculate.

Personal.

GEORGE N. DELAP

Mr. George N. Delap, an Inspector in the Home Office territory since 1889 has been appointed a Special Agent, following the death of Special Agent James P. Hagarty. Mr. Delap's wide acquaintance among the steam users of the district, his mechanical experience, and his personality should all contribute to the success of his efforts in his new line.

Obituary.

JAMES P. HAGARTY

James P. Hagarty, Special Agent for The Hartford Steam Boiler Inspection and Insurance Company, at the Home Office, died Thursday evening, January 18, 1917, at St. Francis Hospital, Hartford, after an illness of six days. Mr. Hagarty's wife was also at the same hospital, where a daughter had been born to them a few days before his death.

Mr. Hagarty was born in Hartford February 7, 1877, and was therefore in his fortieth year. He attended the St. Peter's school, and learned the machinist's trade at The Colt's Patent Fire Arms Mfg. Co. In 1906, he entered the mechanical department of The Hartford Steam Boiler Inspection and Insurance Company as draughtsman and assistant to Chief Inspector Frank S. Allen, remaining in that position until August, 1913, when because of his special aptitude for salesmanship and the fact that his health had become somewhat impaired by his close application to the confining duties of the drawing room he was transferred to the agency force as Special Agent.

As an agent he was signally successful, possessing a cheerful and persuasive manner, great honesty and sincerity, and a strong initiative. His death makes a serious break in the Company's staff.

Mr. Hagarty is survived by his wife, three young children and two brothers, Thomas J. Hagarty and Mayor Frank A. Hagarty of Hartford.

BOILER EXPLOSIONS.

November, 1916.

(377.) — On November 2, a cast iron sectional heating boiler failed at the apartment house of Helen A. Donovan, Middlesex Circle, Brookline, Mass.

(378.) — Eight sections of a cast iron sectional heater failed November 2, at the office building of The Supreme Council of the Royal Arcanum, 407 Shawmut Ave., Boston, Mass.

(379.) — A tube ruptured November 2, in a water tube boiler at the Farrell Works of The Carnegie Steel Co., Farrell, Pa. One man was injured.

(380.) — A boiler exploded November 3, at the saw mill of The Longleaf Yellow Pine Co., Chiefland, Fla. Three men were killed, and several injured.

(381.) — On November 3, a tube ruptured in a water tube boiler at the plant of The Blackstone Valley Gas and Electric Co., Woonsocket, R. I. One man was injured, and the boiler was considerably damaged.

(382.) — A blow-off pipe failed November 3, at the lumber plant of The Pickrel Walnut Co., St. Louis, Mo. The boiler was damaged to a considerable extent.

(383.) — Five sections cracked November 4, in a cast iron sectional heating boiler at The Augusta Opera House, Augusta, Me.

(384.) — On November 6, a Scotch Marine type boiler failed at the Grand Island College, Grand Island, Neb. The damage was small.

(385.) — Two sections failed November 6, in a cast iron heating boiler at the Pantheon Apartments, owned by E. D. and T. J. Glynn, San Francisco, Cal.

(386.) — A blow-off pipe failed November 7, at the tannery of The Crohan and Roden Leather Co., Grand Rapids, Mich.

(387.) — On November 7, a blow-off pipe failed at the tannery of The Crohan and Roden Leather Co., Grand Rapids, Mich. (These are separate accidents, to different boilers.)

(388.) — A tube ruptured November 7, in a water tube boiler at The Consolidated Light and Power Co., Kewanee, Ill., plant of The American Gas Co. The boiler was considerably damaged.

(389.) — A boiler exploded November 8, at the sawmill of D. S. Branham, Gillett, Ark. Three men were injured.

(390.) The boiler of a steam road roller exploded November 9, on the road between Sumneytown and Geryville, Pa. The engineer was injured, while the boiler was destroyed.

(391.) — On November 9, a tube ruptured in a water tube boiler at the Avondale Mills (cotton mills), Avondale, Ga.

(392.) — A cast iron section failed November 9, in a sectional heating boiler at the residence of E. B. Chandler, San Antonio, Tex.

(393.) — On November 9, a cast iron sectional heater failed at the Park Avenue School, Piqua, O.

(394.) — A tube ruptured November 11, in a water tube boiler at the Belvidere, Ill., plant of The Middle West Utilities Co. Two firemen were injured.

(395.) — On November 11, a cast iron sectional heater failed at the office building of E. P. Earle 22-26 Clinton St., Newark, N. J.

(396.) — A steam pipe pulled out of a trap at the Eagle Steam Laundry, St. Paul, Minn., on November 11. The damage to the building was unusually great for an accident of that nature.

(397.) — Two cast iron headers failed November 14, in a water tube boiler at the Ashtabula Round House, of The New York Central R. R., Ashtubula, O.

(398.) — On November 14, a boiler failed at the plant of The Rockford Paper Box Co., Rockford, Ill.

(399.) — A cast iron header ruptured November 14, in a water tube boiler at the power house of The Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind.

(400.) — A section ruptured November 14, in a cast iron sectional heater at The Ward School, Indiana Borough, Pa.

(401.) — The boiler of a freight locomotive, on the Delaware, Lackawanna and Western Railroad, exploded November 14, near Hainesberg, N. J. Three men were instantly killed and one other fatally injured.

(402.) — A blow-off pipe failed November 15, at the St. Mary's Training School, Feehanville, Ill.

(403.) — On November 15, a blow-off failed at the heating plant of The New York Central R. R. Co., Chicago St., Buffalo, N. Y. One man was fatally scalded.

(404.) — On November 16, four sections failed in a cast iron sectional heating boiler at the moving picture theatre of J. A. Evans, Memphis, Tenn.

(405.) — A cast iron section failed in a heating boiler November 16, at the apartment house of Rebecca Shuldiner, Surf Ave., Coney Island, N. Y.

(406.) — On November 16, a tube ruptured in a water tube boiler at the City of New Castle Water Co. plant of the Birmingham, Water Works Co., New Castle, Pa. Two men were injured.

(407.) — Two sections cracked in a cast iron sectional heater November 17, at the apartment house of Mrs. Georgianna Crabb, 326 Lennox Ave., New York City.

(408.) — On November 17, a section failed in a cast iron sectional heater at The Monadnock Apartments, Densmore Realty Co., Minneapolis, Minn.

(409.) — On November 18, eight cast iron headers failed in a water tube boiler at the plant of The Salmen Brick and Lumber Co., Slidell, La.

(410.) — On November 18th, a tube ruptured in a water tube boiler at the Jackson Railway and Light plant of The American Utilities Co., Jackson, Miss.

(411.) — Two cast iron sections failed November 19, in a sectional heating boiler at the Park Hotel, Great Falls, Mont.

(412.) — A blow-off pipe failed November 20th, at the Emporium Tannery of the Central Leather Co., Emporium, Pa. One man was injured.

(413.) — On November 20, a boiler ruptured at the Dothan Steam Laundry, Dothan, Ala.

(414.) — An explosion, supposed to have been that of a heating boiler, followed by fire, wrecked the Dorn Apartments, 6238-46 Dorchester Ave., Chicago, Ill., on November 20.

(415.) — The Tug Rambler was sunk by the explosion of its boiler at the dock, foot of Commercial St., New York City, on November 20. The captain and engineer were killed and four others injured.

(416.) — A tube ruptured November 21, in a water tube boiler at the plant of The Illinois Traction System, Des Moines, Ia. The boiler was considerably damaged.

(417.) — A hot water heating boiler exploded November 22, in the basement of Charles Scholl's Cafe, 166 Crown St., New Haven, Ct. The building was considerably damaged, and large plate glass windows were wrecked as the result of the accident.

(418.) — On November 24, a tube ruptured in a superheater at the East St. Louis plant of Armour and Co.

(419.) — On November 24, a tube ruptured in a water tube boiler at the plant of The Western States Portland Cement Co., Stichville, Ky.

(420.) — A gas heated kitchen water boiler exploded November 24, in the home of Henry Franck, 10 Elsdon St., Rochester, N. Y.

(421.) — A section cracked November 25, in a cast iron sectional heating boiler at the grocery of Sommer Bros., Omaha, Neb.

(422.) — On November 26, a section failed in a cast iron sectional heating boiler at St. Wendelin's Church, Cleveland, O.

(423.) — A tube ruptured November 26, in a water tube boiler at the plant of the Dow Chemical Co., Midland, Mich.

(424.) — A boiler exploded November 26, in a greenhouse on the estate of John D. Rockefeller, Tarrytown, N. Y.

(425.) — On November 27, a section failed in a cast iron sectional heater at the Adirondac Apartment, Densmore Realty Co., Minneapolis, Minn.

(426). — A tube ruptured November 27, at the Southern Board and Paper Mills, Vernon, Cal.

(427.) — A boiler burst November 27, at the Stuart School, Springfield, Ill.

(428.) — On November 28, a cast iron section failed in a sectional heating boiler at the apartment house of E. D. and T. J. Glynn, San Francisco, Cal. This is a second accident at this apartment, within the month.

(429.) — On November 28, an accident occurred to a boiler at the National Home of the Junior Order United American Mechanics, Tiffin, O. The boiler was considerably damaged.

(430.) — A section failed November 28, in a cast iron sectional heating boiler at the store of the Jonston and Larimer Dry Goods Co., Wichita, Kans.

(431.) — A threshing machine boiler exploded about November 28, at Davenport, Ia. One man was injured.

(432.) — The boiler of a "dinky" engine exploded November 28, at the plant of the Kittanning Iron and Steel Co., Kittanning, Pa. One man was fatally scalded and two others less seriously injured.

(433.) — On November 29, a tube ruptured in an economizer at the Glasgo Mills of The American Thread Co., Glasgo, Ct.

(434.) — A boiler exploded November 29, at a sawmill near Connelsville, Pa. Two men were killed and one other injured.

(435.) — On November 29, a tube ruptured in a water tube boiler at the plant of The Allentown Portland Cement Co., Evansville, Pa.

(436.) — On November 30, a stop valve failed in the main steam line at the plant of The Midvale Steel Co., Nicetown, Philadelphia, Pa.

December, 1916.

(437.) — A boiler exploded December 2, at the sawmill of Charles Detwiler, Bullskin, near Connelsville, Pa. Two men were killed and another painfully injured by the explosion.

(438.) — On December 3, a tube ruptured in an economizer at the Waukegan plant of The American Steel and Wire Co., Waukegan, Ill.

(439.) — On December 6, the furnace of a vertical boiler collapsed at the Lancaster Cotton Mills, Lancaster, S. C. Four men were slightly injured.

(440.) — A tube fractured December 6, in an economizer at the plant of The American Steel and Wire Co., Waukegan, Ill. This is a second accident.

(441.) — A tube ruptured December 7, in a water tube boiler at the plant of The Western Ohio Railway Co., St. Mary's Ohio, — a part of The Aurora, Elgin and Chicago Ry. Co. Three men were injured, and considerable property damage done as a result of the accident.

(442.) — On December 7, two headers ruptured in an economizer at the plant of The Columbia Chemical Co., Barberton, O.

(443.) — A boiler exploded December 7, at Allen's sawmill, near Lyerly, Ga. Two men were injured.

(444.) — A cylinder head was blown from an engine at the plant of The Morris Paper Mills, Morris, Ill., on December 8.

(445.) — An explosion in a boiler at the Tacony plant of the Philadelphia Electric Co., Philadelphia, Pa., on December 10, resulted in the injury of five men, one of whom received injuries believed to be fatal.

(446.) — On December 10, an accident occurred to a boiler at the restaurant of The Horn and Hardart Co., 50th St. and 11th Ave., New York City.

(447.) — A section failed December 11, in a cast iron sectional heating boiler at the Y. W. C. A., Richmond, Va.

(448.) — On December 11, a section cracked in No. 1 cast iron sectional heating boiler at the plant of The Cooper Paper Box Co., Buffalo, N. Y.

(449.) — A section cracked December 11, in a cast iron sectional boiler at the Hofbrau Restaurant of the Lubelski Catering Co., Buffalo, N. Y.

(450.) — Three sections cracked in a cast iron sectional heating boiler on December 12, at the building of R. C. Peters, South 16th St., Omaha, Neb.

(451.) — On December 12, a tube ruptured in a water tube boiler at the plant of The American Steel and Wire Co., Anderson, Ind.

(452.) — A heating boiler burst December 12, at the Hotel Columbus, McSherrystown, Pa.

(453.) — A tube ruptured December 13, in a water tube boiler at the plant of The Midvale Steel Co., Nicetown, Philadelphia, Pa.

(454.) — On December 13, six sections failed in a cast iron sectional heating boiler at the plant of The Electric Specialty Co., Stamford, Ct.

(455.) — On December 13, a boiler ruptured at the plant of The South Hills Floral Co., near Carrick, Pa. The boiler was ruined.

(456.) — Four men, working in an empty boiler at the Torresdale Pumping Station, Philadelphia, Pa., were badly scalded by the explosion of the stop valve between this boiler and a live steam line, on December 13.

(457.) — The S. S. Powhatan, of The Merchants' and Miners' line, was sunk, after the explosion of her boilers, on December 13, near Thimble Shoals Light. The accident to the boilers followed a collision with an unknown vessel. Forty-six members of crew and passengers were injured.

(458.) — A section fractured December 14, in a cast iron sectional heating boiler at the apartment house of The Rocky Crest Realty Co., Morningside Ave., New York City.

(459.) — On December 14, a tube ruptured in a water tube boiler at the plant of The Milwaukee Light, Heat and Traction Co., Racine, Wis.

(460.) — On December 15, two sections of a cast iron sectional heating boiler failed at the hospital of St. Mary's Academy of Leavensworth, Ks., Grand Junction, Colo.

(461.) — A cylinder head blew off from an engine at the Alger-Smith Mill, Duluth, Minn., on December 15. Two men were injured.

(462.) — On December 16, a locomotive boiler exploded at the plant of The Great Southern Lumber Co., Columbia, Miss. One man was killed, three others injured and the locomotive badly damaged.

(463.) — A section failed December 15, in a cast iron sectional heating boiler at the Calder School, Harrisburg, Pa.

(464.) — On December 16, a firebox boiler exploded on a dredge located on Judicial Ditch No. 51, Norman County, Minn., operated by the Security Dredge Co. The boiler and dredge were damaged to the extent of about $4,000. Fortunately the men operating the dredge were at supper at the time, so that no one was killed or injured, which would probably been the case if the dredge had been working at the time of the explosion.

(465.) — On December 17, a tube ruptured in a water tube boiler at the Country Alms House, Westcoeville, Pa.

(466.) — On December 18, a manifold of a cast iron sectional heating boiler fractured at the Grove Hotel, Emil F. Kuithan, Prop., Burlington, Ia.

(467.) — A tube fractured December 18, in an economizer at the plant of The American Steel and Wire Co., Waukegan, Ill.

(468.) — On December 18, the firebox of a locomotive portable boiler ruptured at the sawmill of W. G. Felton, Florence Township, O. The owner and his fireman were injured, the latter quite seriously.

(469.) — A boiler exploded December 18, at the plant of J. Spaulding and Sons Co., Tonawanda, N. Y. The damage was estimated at $10,000.

(470.) — A tube ruptured December 19, in a water tube boiler at the plant of the Alexander Smith and Sons' Carpet Co., Yonkers, N. Y.

(471.) — On December 19, a tube ruptured in a water tube boiler at the plant of The United Pierce Dye Works, Lodi, N. Y.

(472.) — A blow-off pipe failed on December 19, at the plant of the Simmons Mfg. Co., Kenosha, Wis., injuring the fireman.

(473.) — On December 19, a boiler ruptured at the plant of the E. M. Hulse Co., couch and lounge manufacturers, Columbus, O.

(474.) — A boiler exploded in the basement of the Jefferson public school, Pittston, Pa., on December 19. The building was shaken and the basement wrecked, but none of the pupils were injured.

(475.) — A steam pipe exploded December 19, at the Asheroft Oil Mills, East Florence, Ala. Three men were scalded.

(476.) — A tube ruptured December 19, in a boiler at the Old Lexington Club Distillery, Nicholasville, Ky.

(477.) — On December 22, a boiler ruptured at the furniture factory of the Kroehler Manufacturing Co., Bradley, Ill.

(478.) — On December 19, a boiler ruptured at the plant of the Continental Gas and Electric Corp., Malvern, Ia.

(479.) — A section ruptured December 20, in a cast iron sectional heating boiler at the furniture store of Silberger Bros., Niagara Falls, N. Y.

(480.) — A boiler exploded December 21, in the S. S. Princess Anne, Norfolk to New York, off Lambert's Point, Va. Three men were killed and several others injured, while the ship was forced to put back to Norfolk.

(481.) — Two sections of a cast iron sectional heating boiler ruptured on December 23, at the packing house agency of Kingan and Co., Jacksonville, Fla.

(482.) — On December 23, two sections ruptured in a cast iron sectional heating boiler at the automobile sales rooms of Oscar Rosenberger, Woodward Ave., Detroit, Mich.

(483.) — A tube failed December 23, in a water tube boiler at the plant of The Superior Steel Co., Carnegie, Pa.

(484.) — On December 23, a tube ruptured in a down draft furnace connected with a boiler at the plant of the Alexander Smith and Sons' Carpet Co., Yonkers, N. Y. One of the firemen was injured.

(485.) — On December 23, several flues collapsed in two boilers at the plant of The Star Furnace Co., Jackson, O.

(486.) — A boiler exploded, owing to a fire being built in it when the connections were frozen, on December 22, at the home of Mrs. E. J. Mulvihill, Chicago, Ill. Three persons were injured.

(487.) — A boiler exploded December 22, at the plant of the Ora Home Milling Co., Taylorville, Ill.

(488.) — On December 24, a boiler ruptured at the quarry of the Conklin and Foss Co., Rockland Lake, N. Y. The boiler was completely ruined.

(489.) — On December 24 a tube ruptured in a water tube boiler at the plant of the Lehigh Portland Cement Co., Mitchell, Ind.

(490.) — On December 26, a tube ruptured in a water tube boiler at the Peninsular plant of The American Car and Foundry Co., Detroit, Mich.

(491.) — On December 26, an accident happened to a boiler at the plant of the Malt Diastase Co., Brooklyn, N. Y.

(492.) — On December 26, the crown sheet of a locomotive boiler collapsed at the plant of The Emporium Lumber Co., Galeton, Pa. Two men were killed and three injured, while the locomotive required a new firebox.

(493.) — On December 26, a tube pulled out from a drum in a water tube boiler at the Consolidated Light and Power Co., plant of The American Gas Co., Kewanee, Ill.

(494.) — A sectional cracked in a cast iron sectional heating boiler on December 27, at the tailoring establishment of G. A. Balisle, Baton Rouge, La.

(495.) — On December 29 a tube pulled out of a header in a water tube boiler at the plant of the Miller Lock Co., Philadelphia, Pa.

(496.) — A boiler exploded December 29, in the Goose Creek oil field, near Houston, Tex. Two men were scalded.

(497.) — A tube ruptured December 30, in a water tube boiler at the plant of the Light, Heat and Power Co., Connersville, Ind.

(498.) — On December 31, a boiler ruptured at the Sanatorium of The Oxford Retreat Co., Oxford, O.

(499.) — On December 31, a nozzle in the connection between the boiler and steam header ruptured at the plant of the Pacific Lumber Co., Scotia, Ala.

BOILER EXPLOSIONS

JANUARY, 1917.

(1.) — On January 1, a blowoff pipe failed at the Lawrence Hotel, Erie, Pa.

(2.) — A boiler exploded January 3, at Olson's hand laundry, 1529 Wells St., Chicago, Ill. The explosion together with the fire which followed did damage to an estimated extent of $30,000.

(3.) — A boiler exploded January 3, at the plant of The Baltimore Manufacturing Co., Baltimore, Md. A boiler maker, working on an adjoining boiler was injured.

(4.) — A tube ruptured January 3, in a water tube boiler at the Nadine Station of The Penn. Water Co., Nadine Station, Pa.

(5.) — On January 3, a tube ruptured in a water tube boiler at the Merchants Heat and Light Co., plant of The American Public Utilities Co., Indianapolis, Ind. Two men were injured.

(6.) — On January 4, a blowoff ruptured at the restaurant of the Horn and Hardart Co., 600-612 West 50th St., New York City.

(7.) — On January 4, two sections ruptured in a cast iron sectional heater in the building of the Schulte Realty Co., East 23d St., New York City.

(8.) — On January 4, a boiler ruptured at the plant of the Constantine Board and Paper Co., Constantine, Mich.

(9.) — A tube ruptured January 4, in a water tube boiler at the By Products Coke Corp. plant of The Solvay Process Co., South Chicago, Ill.

(10.) — One section in one cast iron sectional boiler, and two sections in another ruptured on January 5, at St. Stanislaus' Church, Erie, Pa.

(11.) — A boiler exploded January 5, at the shop of the Tulsa Boiler and Sheet Metal Works, Tulsa, Okla. Two men were injured, probably fatally.

(12.) — On January 6, a section cracked in a cast iron sectional heating boiler at the Hotel Strand, L. M. Quitman, Prop., Cottage Grove Ave., Chicago, Ill.

(13.) — Five sections ruptured January 7, in a cast iron sectional heating boiler at the office building of Jos. Cohen and Co., Hennepin Ave., Minneapolis, Minn.

(14.) — On January 7, a section failed in a cast iron sectional heating boiler at the Alcott School, of the School District of Hastings, Hastings, Neb.

(15.) — The boiler of a New York Central freight locomotive exploded January 7, near North East, Pa. Two men were killed and one other badly injured.

(16.) — A heating boiler exploded at the C. S. P. S. Lodge building, Traverse City, Mich., on January 9. No one was injured.

(17.) — A heating boiler burst January 11, in the city jail building, Oklahoma City, Okla. The newspaper clipping states that the jailer was laid off by the Mayor, because it was a part of his duties to keep the heating apparatus in shape, and he was therefore held responsible for the accident.

(18.) — A cast iron header failed January 12, in a water tube boiler at the plant of the National Malleable Castings Co., 26th St. Station, Chicago, Ill.

(19.) — The boiler of a large Frisco freight engine exploded January 13, near Grandview, Mo. Three men were killed.

(20.) — Two sections failed January 13, in a cast iron sectional heater at the building of Johana S. Seitz, North Santa Fe St., Selina, Kans.

(21.) — On January 13, a section ruptured in a cast iron sectional heating boiler at the automobile sales rooms of Oscar Rosenberger, Woodward Ave., Detroit, Mich.

(22.) — On January 13, six cast iron headers ruptured in a water tube boiler at the plant of the Klots Throwing Co., South Cumberland, Md. Two men were injured.

(23.) — On January 15, several tubes ruptured in a cast iron heating boiler at the public hall and office building of the Quincy Real Estate Trust, Quincy, Mass.

(24.) — On January 15, a tube ruptured in a water tube boiler at the Rensselaer Polytechnic Institute, Troy, N. Y.

(25.) — An acetylene cylinder exploded January 16, on the fifth floor of the Boley Building, Kansas City, Mo. One man was killed, one fatally injured, and some 52 others received less serious injuries.

(26.) — A boiler exploded January 16, at the S. R. Hanby sawmill, Day Fork, Ark. One man was killed and three persons injured.

(27.) — On January 16, two sections failed in a cast iron sectional heating boiler at the apartment house of Edmund H. Freidrich, Brookline, Mass.

(28.) — Eight headers ruptured January 17, in a water tube boiler at the Cameron Quarry of The Susquehanna Coal Co., Shamokin, Pa.

(29.) — The heating boiler at the Court House, Columbia, Tenn., exploded January 17.

(30.) — A boiler exploded about January 18, at the South Perkasie clothing factory, South Perkasie, Pa.

(31.) — A hot water heating boiler exploded January 20, in the home of the Rev. W. J. Bone, Newtown, Pa. The accident was attributed to the freezing of the expansion tank.

(32.) — A section ruptured January 20, in a cast iron sectional heating boiler at the greenhouse of A. M. Stackhouse, Minerva, O.

(33.) — On January 22, a 16" cppper expansion bend in a steam line exploded at the cotton mill of the Fall River Iron Works, Fall River, Mass.

(34.) — On January 22, a boiler ruptured at the creamery of the Clover Leaf Dairy Co., Metamora, O.

(35.) — A boiler exploded Janary 22, at the plant of the Buch Run Paper Mill, Coatesville, Pa. One man was badly scalded.

(36.) — On January 23, a boiler ruptured in the laundry of Mohn Bros. Electric Laundry Co., Pittsburg, Pa. The boiler was considerably damaged.

(37.) — A blowoff pipe ruptured January 23, in the department store of Bonwit, Teller and Co., 5th Ave., New York City.

(38.) — A heating boiler explosion, followed by fire wrecked the apartment building at 544 Wellington St., Chicago, Ill., on January 24.

(39.) — A heating boiler exploded January 24, at the Imperial Hotel, Lancaster, Pa.

(40.) — A tube ruptured January 25, in a water tube boiler at Building No. 70, Union Stock Yards, Swift and Co., Chicago, Ill.

(41.) — On January 26, two tubes ruptured in a water tube boiler at the Delphos Light and Power Co., plant of The Federal Power and Light Co., Delphos, O. Considerable damage resulted to the boiler.

(42.) — A blowoff pipe failed January 27, at the main boiler house, House of Correction, Detroit, Mich. Three men were injured, one fatally.

(43.) — On January 28, two sections ruptured in a cast iron sectional heater at the Tacoma Apartments, owned by Robert Rodel, California Ave., Pittsburg. Pa.

(44.) — On January 28, six malleable iron headers ruptured in a water tube boiler at the Secor Hotel, Toledo, O.

(45.) — A boiler ruptured January 27, at the Boody House. Toledo, O.

(46.) — A steam pipe exploded January 28, at plant of the Mississippi Valley Iron Co., St. Louis, Mo. One man was killed and another injured.

(47.) — On January 30, a circulating pipe attached to a boiler failed at the plant of the Buckeye Cotton Oil Co., Selma, Ala. Four men were injured.

(48.) — On January 30, a tube ruptured in a water tube boiler at the plant of the Midvale Steel Co., Nicetown, Philadelphia, Pa.

(49.) — A sectional cracked January 31, in a cast iron sectional heating boiler at the dancing academy of H. Chalif, 57th St., New York City.

(50.) — On January 31, a boiler ruptured at the plant of The International Refining Co., Cushing, Okla.

The Metric System

Nearly every issue of The Locomotive contains a brief note of a little volume published and offeed for sale by The Hartford Steam Boiler Inspection and Insurance Company entitled The Metric System.

This little book size 3½ by 5¾ inches contains 196 pages, devoted to a history of the metric system, a discussion of the sources of information and the data used in the compilation of the tables, and finally, comprising by far the greater part of the work, to a set of exceedingly convenient tables for the conversion of quantities in any of the English units to their metric equivalents, and vice versa. No conversion tables have appeared more convenient than these for ready and quick reference and we feel sure that any one not familiar with the book who has occasion to convert from English to metric, or metric to English measure would be surprised at the saving in time gained by its use. Not only are the ordinary measures of length, mass, volume and area tabulated, but those derived units of pressure per unit area, mass per unit volume and indeed all the conventional units employed by engineers, are included; as well as a ready means for instantly converting temperatures from Fahrenheit to Centigrade or the reverse.

This little book is to be had bound in sheepskin by addressing The Hartford Steam Boiler Inspection and Insurance Company, Hartford, Connecticut, inclosing $1.25.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1917.

Capital Stock, . . . $2,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$346,803.88
Premiums in course of collection,		388,276 03
Real Estate,		90,000.00
Loaned on bond and mortgage,		1,554,570.00
Stocks and bonds, market value		4,362,015.45
Interest accrued		98,141.14
		$6,839,806.50
Less value of Special Deposits over Liability requirements,		34,518.75
Total Assets,		$6,805,287.75

LIABILITIES.

Premium Reserve,		$2,738,563.68
Losses unadjusted,		67,528.30
Commissions and brokerage,		77,655.20
Other liabilities (taxes accrued, etc.),		166,969.55
Capital Stock,	$2,000,000.00	
Surplus over all liabilities,	1,754,571.02	
Surplus as regards Policy-holders,	**$3,754,571.02**	3,754,571.02
Total Liabilities,		$6,805,287.75

CHARLES S. BLAKE, President.

FRANCIS B. ALLEN, Vice-President. W. R. C. CORSON, Secretary.

L. F. MIDDLEBROOK, Assistant Secretary.

E. S. BERRY, Assistant Secretary and Counsel.

S. F. JETER, Chief Engineer.

H. E. DART, Supt. Engineering Dept.

F. M. FITCH, Auditor.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President, Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, Vice-President, United States Bank, Hartford, Conn.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres. The Fidelity Trust Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturers, South Manchester Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and Treasurer, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, The Johns-Pratt Co., Hartford, Conn.

MORGAN G. BULKELEY, JR. Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

CHARLES S. BLAKE, President, The Hartford Steam Boiler Inspection and Insurance Co.

Incorporated 1866. Charter Perpetual.

INSURES AGAINST LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg	W. M. FRANCIS, Manager and Chief Inspector. C. R. SUMMERS, Ass't Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	LAWFORD & MCKIM, General Agents. R. E. MUNRO, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. ROBERTS, Manager. CHARLES D. NOYES, Chief Inspector.
BRIDGEPORT, Ct., 404-405 City Savings Bank Bldg.	W. G. LINEBURGH & SON, General Agents. F. S. ALLEN, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. LEMON, Manager. JAMES L. FOORD, Chief Inspector. J. T. COLEMAN, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. GLEASON, Manager. WALTER GERNER, Chief Inspector.
CLEVELAND, Ohio, Leader Bldg.	H. A. BAUMHART, Manager and Chief Inspector. L. T. GREGG, Ass't Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg.	THOS. E. SHEARS, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. WILLIAMS, JR., General Agent. F. S. ALLEN, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	PETER F. PESCUD, General Agent. R. T. BURWELL, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. GARDINER, Manager. JOSEPH H. MCNEILL, Chief Inspector. A. E. BONNETT, Assistant Chief Inspector.
PHILADELPHIA, Pa., 142 South Fourth St.	A. S. WICKHAM, Manager. C. H. DENNIG, Ass't Manager. WM. J. FARRAN, Consulting Engineer. S. B. ADAMS, Chief Inspector.
PITTSBURGH, Pa., 1807-8-9 Arrott Bldg.	J. J. GRAHAM, Manager. BENJAMIN FORD, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	MCCARGAR, BATES & LIVELY, General Agents. C. B. PADDOCK, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.,	H. R. MANN & Co., General Agents. J. B. WARNER, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. ASHCROFT, Manager. J. P. MORRISON, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. ROBERTS, General Agent.

The Locomotive

of

THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXXI. HARTFORD, CONN., JULY, 1917. No. 7.

Boiler Explosion at Crow's Run, Pa.

FIG. 2. A CLOSER VIEW OF THE WRECKED BOILER.

The Explosion of a Two Sheet Boiler.

The lap seam boiler has been a fruitful source of steam boiler accidents in this country, and of lap seam boilers, perhaps no class has been more subject to disaster than that made in a single course with two sheets, one above and one below.

The accident illustrated herewith occurred Saturday, May 5, 1917, at the brick making plant of The Pennsylvania Clay Co., Crow's Run, Beaver County, Pa. There were four boilers installed in the plant in a brick boiler house with a square brick chimney. Two boilers were set to the right and two to the left of the stack, numbered from left to right, Nos. 1, 2, 3 and 4. No. 4 boiler was the one which exploded. It was of lap seam construction, in one course of two sheets, 66 inches in diameter, 16 feet long, and the shell plate was originally ⅜ inch thick. As the exploded boiler left the boiler house, it threw No. 3 boiler from its setting and turned it partly around as is well shown on our front cover, which is a view of the wrecked boiler house after the accident. The No. 4 boiler ruptured along a line parallel to and about ¾ inch below the left hand longitudinal seam, and tore apart for the entire length of the boiler. The shell plate then tore from the heads and in its final condition, was opened out practically flat. The whole boiler landed about 75 feet from its starting point, the shell on the ground with the heads and attached tubes on top, as is shown in Fig. 2. In its flight it wrecked the boiler house, practically demolished a small blacksmith's shop and shed, and in turning the No. 3 boiler from its setting apparently hurled it against the chimney in such a way as to crush and crack it (the chimney) to some extent, although not to such an extent as to require replacement. The three remaining boilers were not seriously injured.

One man, the engineer, was instantly killed, the fireman was so seriously injured that he died later, and two other men were slightly injured.

THE MISUSE OF WRENCHES IN TIGHTENING COVER BOLTS ON PRESSURE VESSELS.

There is a large group of vessels used for subjecting materials to high temperatures and pressures which must have doors or stock openings of relatively large size in order to facilitate the entry and removal of the materials treated, and which further require that the door or opening be frequently opened and closed in the course of its regular use. Among such may be noted a few characteristic vessels which will indicate the general class we have in mind. We will instance vulcanizers and devulcanizers, certain types of kiers, brick hardening cylinders, some forms of digesters, and impregnating tanks for electrical work as typical cases though no attempt has been made to make the list complete in any sense.

These doors or covers as a class are furnished with a flange matching a somewhat similar flange on the shell of the vessel proper and fastened to it by a large number of bolts, usually swinging back into slots to facilitate the rapid release and securing of the door. In the July, 1905, Locomotive we considered at great length the question of the strength of such doors and devised a means for calculating the maximum fiber stress in the flanges, and it is not our purpose at this time to enter into a discussion of that phase of the subject. What is now occupying our attention relates to the use of the vessel in service rather than to its design.

We have recently experienced the failure of a large cover eight feet in diameter through the breaking of its reinforcing flange which permitted the cover to blow off with explosive violence although the pressure inside the vessel did not probably much exceed thirty pounds per square inch. The flange in question seems to have been wrecked not so much by the stresses imposed by the working pressure within the vessel as by the practice of the operatives in closing up the vessel preparatory to cooking. The wrenches customarily used for this purpose were 54 inches long. The cover was secured by thirty-two 1⅛ inch bolts. It was ascertained that the usual practice was as follows: After centering the cover over the vessel and making sure that the jointing or packing ring was clean and in place, and that the bolt slots were opposite those on the vessel, the cover was lowered into place and the bolts swung up into the slots. Then two men proceeded to secure the cover. One man started to run down the nuts by hand. The other started right behind him and tightened the nuts with the long wrench. So they proceeded completely around the vessel which as we stated above was eight feet in diameter. It requires no great imagination to foresee that any slight irregularity in, or projection of the packing would cause the cover to cock up to one side when the first few nuts were tightened down. Then as the bolting proceeded when the man with the wrench reached the portion of the cover opposite to that at which he started an enormous strain could be produced in the effort to get a tight joint. The proper method in such a case is of the utmost importance for it is quite as necessary to use judgment in bolting up a cover of this kind as it is to secure a safe design when it is built.

The first requisite for safety is to see that only such wrenches are available as will not permit an excessive strain to be put on the bolts. Socket or end wrenches, of the correct length, and so formed that they do not adapt themselves to lengthening with a piece of pipe are satisfactory, and at least two should be provided. If there is a generous knob or ball forged on the handle end of the wrench, it will tend to greatly discourage the lengthening process referred to above. Two men should then start running down the nuts by hand to a bearing, beginning at opposite sides of the cover and working in the same direction so that each will end where the other began. Then each should take a wrench and set up slightly, about half tight, on one or two bolts at points opposite each other. They should then tighten a group of two or three bolts each at points midway between those first set up. (The quarter points.) Then all the bolts in opposite quadrants, first one pair and then the other should be tightened. After all the bolts have had a preliminary setting up in the manner just described, the process should be repeated in every detail except that at this time the nuts may be set down as tightly as is felt will be required to get a tight job, *and no more*. Of course it necessitates the exercise of some judgment to determine the exact stress in the bolts needed to overcome leakage, with no appreciable overstrain in the bolts. This "judgment" however should be under the supervision of some one capable of instructing the operatives properly. In any event if the cover joint leaks when pressure is applied the reason should be found and the remedy applied with pressure off the vessel and in no case should the nuts be set up in an endeavor to secure tightness while the pressure exists.

Leakage after reasonable tightening of the bolts, especially when the method just outlined has been followed with a view to getting a uniform stress around the vessel, usually indicates either defective packing or the presence of some foreign matter between the surfaces in contact. Excessive bolt strain may effect an apparent cure by embedding the foreign matter in the yielding packing material but it can only do so by setting up local stresses in the flanges which are of wholly unknown amounts, are sure to be of a destructive nature, and if repeated often enough always lead to failure by cracking. There is also the further exceedingly great hazard, that the particular stress set up by the man with the wrench will be the proverbial last straw, to set off the vessel, in which case the man is quite likely to terminate his career at that time.

It should be borne in mind that the working stress is all that the material should be called upon to carry, that such additional stress as we have just described is always in addition to the working stress and that it is the sum of the two which is available to destroy the flange.

In this connection attention should be called to the fact that many vessels of the classes here considered have reinforcing or joint rings of cast iron. This material in every case should be carefully watched. It is much less trustworthy than the cast steel which replaces it in the best designs and much more likely to fail by cracking if abused by the operatives. It is advisable that master mechanics or shop superintendents look over the flanges of vessels of this class from time to time. Any cracks, no matter how small, are suspicious. If the vessel is insured and such a crack is found it has probably developed since the last visit of the inspector, and he should be notified at once, so that he may determine what course of procedure is necessary to secure safety.

THE PROOF OF THE PUDDING.

CHIEF INSPECTOR J. P. MORRISON.

In the ordinary course of examining boilers our inspectors quite frequently encounter plants which are not above criticism, although in many cases the recommendations made have a bearing on the economical and undisturbed operation of the plant, and of course the owner's compliance is left to his discretion. However in many cases the condition of the boilers examined is such that repairs having a direct bearing on its safety are immediately necessary.

It is quite interesting to note the gradual improvement made in a plant where the management responds to the advice received. It is equally interesting but not so satisfactory to observe at each subsequent inspection how neglected boilers and appliances have deteriorated. While the retrogression may be hastened by poor feed water and inattention, under ordinary conditions the change is a slow one — extending in many cases over a number of years — as a result of which our inspectors can advise the owner of the changes which have occurred and of those which may be expected, so that new equipment may be installed before the old ceases to be serviceable, enabling the owner to avoid the expense and annoyance of providing a new power plant on short notice after a failure has occurred.

The expert who is accustomed to make complete examinations of all accessible parts of a boiler has no interest at stake other than the safety of the vessel. Those who give the matter proper consideration realize that this is so and are guided accordingly. But as might be expected in view of the wide range of human nature we sometimes receive a remonstrance from the owner of a boiler the safety of which has been questioned, although in most cases where objection is made the boiler has not been accepted for insurance or has been under our supervision for but a short time so that the owner does not have confidence founded on long acquaintance and resents criticism which has a bearing on the value of his property. For instance, in one recent case an owner rejected as unsatisfactory the inspector's advice to install a new boiler but followed the recommendation less than five months later after the boiler had exploded resulting in the death and the injury of two persons as well as considerable property damage.

However the owner of the particular boiler we have in mind exhibited a greater interest in the safety of his plant, although his efforts were misguided to say the least, in view of the subsequent developments, indicating that the man who gave a favorable report was considered an oracle.

The boiler was of the horizontal tubular type, 60″ in diameter by 14′ in length and contained 62 3½″ tubes 14′ long. The shell was when new 5/16″ in thickness and was composed of three rings or courses, there being two sheets used to form each ring. The longitudinal seams were of the double riveted lap joint type, while the girth seams and head seams were, as is usual, single riveted. The builder of the boiler ceased operation several years ago and the age of the boiler could not be definitely determined, nor could its history be obtained, although the design of the seams, number of sheets used and type of bracing signified beyond a doubt that the boiler was extremely old — probably 25 years or more, and its condition suggested a varied career and abuse.

Our report dealing with this boiler, which was offered to us for insurance together with several others, after referring to the corrosion and weaken-

FIG 1. EXHIBIT "Z." THE BOILER WHOSE END WAS ANTICIPATED BY THE INSPECTOR.

ing of the various parts concludes: "This is an old boiler and the use to which it has been subjected and the conditions under which it has been operated has caused a deterioration which cannot be remedied. The boiler is not in safe operating condition. We recommend that steps be taken towards purchasing a new boiler, and by so doing the annoyance of buying and installing a boiler in a hurry will be avoided."

It is needless to state the boiler was not accepted for insurance, but on account of our declining to assume the risk the application for insurance on the other boilers, part of which were acceptable, was recalled by a letter from which we quote:

"Relative insurance covering steam boilers . . . beg to say that the application for insurance included boilers which were declined on account of Inspector's report. Not being satisfied with his report I had another Inspector go over them carefully and he reported them O. K. I then had him go over them again and cautioned him to use extra diligence as I wanted to be sure he was right. Again he reported them all right."

We have no knowledge of the experience or skill of the other inspector, but the boilers were not placed under our supervision and protection, so we had no record of any of them until the following news item appeared in one of the daily papers:

BOILER BURSTS AT GIN PLANT.

DOME IS BLOWN INTO AIR, FALLS THROUGH ROOF OF CHURCH AND ROLLS OUT INTO STREET

"Special to The News.

Oct. 12.—A boiler at the gin plant at — seven miles from this place, exploded this morning and destroyed the entire plant. The dome was blown high into the air and fell through the roof of a church and rolled out into the street.

The engineer had gone to the far end of the gin building and was not hurt. A piece of flying timber struck Mr. ————, a merchant, on the chin, inflicting slight injuries.

Two men were loading seed when the explosion occurred and a portion of the roof fell on the team of horses. A large rock, weighing about 100 pounds, fell in the wagon."

The accompanying photograph which we have marked Exhibit "Z" was sent us by one of our assured in the vicinity.

No doubt the owner of the boiler deeply regrets that the recommendation of our Inspector was not acted upon, inconvenient and expensive although it may have appeared. Those who have so promptly followed the expert inspector's advice when the safety of their plant was involved, even when less experienced men may have counseled otherwise, may obtain from the reproduction of this photograph a great deal of satisfaction, as it illustrates just what they may have escaped. In a matter of this kind each is willing that some one else should determine whether or not "The proof of the pudding is in the eating."

A STEAM BOILER EXPLOSION ONE HUNDRED YEARS AGO.

From the Louisiana Gazette and New Orleans Mercantile Advertiser, July 8th, 1816.

"The steamboat Washington started from Wheeling, Va., on Monday, June 10th, 1816, and arrived at Marietta on Tuesday evening at 7 o'clock, and came safely to anchor, where she remained until Wednesday morning.

The fires had been kindled and the boilers sufficiently hot, preparatory to her departure, when the anchor was weighed and the helm put to larboard, in order to wear her in a position to start her machinery; but only having one of her rudders shipped at the time, its influence was not sufficient to have the desired effect, and she immediately shot over under the Virginia shore, where it was found expedient to throw over the kedge at the stern to effect it. This being accomplished, the crew were then required to haul it on board, and were nearly all collected in the quarter for that purpose. At this unhappy fatal moment, the end of the cylinder toward the stern exploded, and threw the whole contents of hot water among them, and spread death and torture in every direction. The Captain, mate and several seamen were knocked overboard, but were saved, with the exception of one man, by boats from the town, and by swimming to the shore. The whole town was alarmed by the explosion, and all the physicians, with a number of citizens, went immediately to their relief. On going on board, a melancholy and truly horrible scene was presented to view — six or eight persons were nearly skinned from head to foot, and others scalded, making in the whole seventeen. In stripping off their clothes the skin peeled off with them to a considerable depth. Added to this melancholy sight; the ears of the pitying spectators were pierced by the screams and groans of the agonizing sufferers, rendering the scene horrible beyond description.

The cause of this melancholy catastrophe may be accounted for by the cylinder not having vent through the safety valve, which was firmly stopped by the weight which hung on the lever having been unfortunately slipped to its extreme, without its being noticed, and the length of time occupied in wearing before her machinery could be set in motion, whereby the force of the steam would have been expended. These two causes united confined the steam until the strength of the cylinders could no longer contain it, and gave way with great violence.

Six of the unfortunate sufferers died on Wednesday night and one or two others are not expected to survive."

Tests of Autogenous Welds of Boiler Plate.

(Concluded from the January, 1917, Issue.)

In the October, 1916, Locomotive we began the publication of a translation of a report from the Swiss Society of Steam Boiler Owners on autogenous welds of boiler plates. This report was so long that it was continued from the October to the January number, and was there completed as to text. There remained, however, a series of tables giving important data as to the tests which we could not crowd into the January issue. These should have been published in April but there again important matter relating to the fiftieth anniversary of the Company made it inadvisable to grant them the needed space. We feel, however, that the report is too important and valuable a document to leave incomplete. Its value moreover is largely for reference as it contains such a large quantity of detail. This reference value would be in part lost if the tables were not appended and so we conclude the report in this issue with the remaining tables. We advised our readers at the time when the first portion of the report was printed to save their Locomotives, and if they have done so they can add the present on to the list and so have the report complete for their files.

We always endeavor to make our Locomotive articles either complete in one issue or else arrange that they belong to a series, each installment of which is in itself complete. We must therefore ask your indulgence for the disjointed manner in which this important article has necessarily appeared.

TABLE IV
Comparative table of bend tests (ordinary.)

	Plate I				Plate II				Plate III				Plate V				Plate VI				Plate VII			
	cold		hot		cold		hot		cold		hot		cold		hot		cold		hot		cold		hot	
	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8
Angle of bend and	180	180	180	180	180	180	180	55	180	180	180	104	180	20	180	170	180	180	180	180	180	180	180	180
rad. of curve, r cm.	.66	.72	.73	.66	2.64	1.43	.77	5.17	1.70	1.27	.77	4.19	2.15	5.87	1.03	2.25	2.35	1.42	.75	.75	1.15	1.47	.72	.75
$N = 50\frac{s}{r}$	100	100	100	100	27	54	100	14	45	525	100	17.5	35	13.5	75	33.5	31.5	55	100	100	65	49.5	100	100
Observations	Intact	Intact	Intact	Intact	Cracks formed	Cracks formed	Traces of cracks	Cracks	Cracks	Cracks	Traces of cracks	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Intact	Intact	Cracks start	Cracks start	Cracks start	Intact

	Plate VIII				Plate IX				Plate X				Plate XI				Plate XII				Plate XIII			
	cold		hot		cold		hot		cold		hot		cold		hot		cold		hot		cold		hot	
	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8	5	6	7	8
Angle and . . .	180	180	180	150	180	180	180	180	180	73	180	180	180	180	180	180	180	100	180	110	180	180	180	180
Radius r	1.67	1.87	1.05	3.29	2.57	1.20	.81	.81	.73	3.30	1.13	2.28	1.29	1.29	.70	1.00	1.01	3.31	.83	3.72	.79	.80	.78	.78
$N = 50\frac{s}{r}$	43.5	39	71.5	23	32.5	67	100	100	100	22.5	68	31.5	55	55	100	70	78	24	100	22.5	100	100	100	100
Observations	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Intact	Intact	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Trace of cracks	Cracks start	Cracks start	Cracks start	Cracks start	Cracks start	Trace of cracks	Cracks start	Cracks start	Trace of cracks

TABLE IV (Continued)

	Plate XIV				(not welded) Plate U				(elect. weld) Plate XV				Averages: I — XIV		Averages: Not welded U		Averages: XV elect. weld	
	cold		hot		cold		hot		cold		hot		d	hot	cold	hot	cold	hot
	5	6	7	8	5	6	7	8	5	6	7	8						
Angle and	73	180	180	180	180	180	180	180	18	26	90	42	162.5	162	180	180	22	66
Radius r	4.20	.70	.77	.70	.60	.60	.60	.60	0.75	8.48	2.61	7.67	1.83	1.43	.60	.60	9.12	5.14
$X = 50\frac{s}{r}$	16.5	100	100	100	100	100	100	100	11	13	45.5	15	56.4	78	100	100	12	30.25
Observations	Cracks start	Cracks start	Intact	Intact	Intact	Intact	Intact	Intact	Cracks start	Cracks start	Cracks start	Cracks start						

TABLE V

Comparative table of test by forging and drifting. Method of the Wurzburg Standards

	I		II		III		V		VI		VII		VIII		IX		X		XI		XII		XIII		XIV		XV (Electric weld)		U (Unwelded plate)	
Number	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10	9	10
Enlargement % . .	70	68	65	67	72	72	72	72	85	63	85	77	79	63	63	74	69	60	87	88	74	62	90	90	85	97	52	40	60	..
Remarks	Cracked at weld	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Intact	Cracked in two places at edges, 2 cm. deep		Intact	Intact
Drifting																														
Remarks	Intact	Intact	Crack starts	Almost broken	Slight crack	Cracks	Cracked from	Hole to hole	Cracks	Broken	Almost broken	Slight cracks	Failed	Failed	Intact	Failed	Slight cracks	Slight cracks	Failed	Failed	Failed	Failed	Failed	Cracked	Slight	Cracks	Cracks	Cracks	Intact	Intact

Average: I — XIV enlargement = 74.5%

TABLE VI

Data on the execution of the work at the shops of the participating firms, as far as it could be obtained.

Plate No.	I	II	III
Torch system	firm's own	Soc. for autog. metal working	"Fouche"
Kind of gas	dissolved acet.	acet. (Zinser)	dissolved acet.
Preparation of pieces and openings, for welding	joints, 90° angle, 4 mm apart at bottom, joints slightly planed	angles, 50 to 70°. distance apart. 1.5mm.	angles, 90 "morticed edges" distance = 0.
Hammered?	well hammered, small hammer	well hammered	worked with small hammer
Annealed?	annealed 12 hours	an. 4 hours	an. ½ hour
Straightened?	yes	yes	yes
Time employed in hours	45 hr., incl. cooling, anneal. and straightening	16 hr. incl. straightening	56 hr. incl. cool. and anneal.
Oxygen, liters	21000	14460	14700
Ratio, O to gas, Oxy. = 1	1 : .86	1 : .49	......
Gas used, liters	18000	7000	......
No year workman has welded	2	½	½
Special training of workman?	at firm's shop	none	yes
Former tests?	none	several	one

Plate No.	V	VI	VII
Torch system	Zinser	Zinser	Record
Kind of gas	Zinser acet.	Zinser acet.	Dissolved acet.
Preparation of pieces and openings, for welding	angles about 60° distance about 1–2 mm	angles, 70° edges, 1–2 mm apart	angles, 60–70° distance, 1 mm.
Hammered?	reheated, not hammered	not hammered	hammered, with small hammer
Annealed?	slight anneal.	an. before and after welding	annealed only with torch
Straightened?	yes	yes	yes
Time employed in hours	5½	14	34
Oxygen, liters	5125	10500	18000
Ratio, O to gas, Oxy. = 1	1 : .55	1 : .88	1 : .89
Gas used, liters	2800	9300	16000
No year workman has welded	3	3	1
Special training of workman?	no	no	yes
Former tests?	one	one	one

TABLE VI — (Continued)

Plate No.	VIII	IX	X
Torch system	Zinser	Sirius	Endress
Kind of gas	Zenser acet.	Dis. acet.	Acetylene
Preparation of pieces and openings, for welding	angles, 60–70° distance, 1 mm	angles, 60° "edges morticed"	angles, 70 distance 1–2 mm.
Hammered?	not hammered	light hammering	not hammered
Annealed?	an. ½ hr.	an. 1 hr.	an. ½ hr.
Straightened?	yes	yes	yes
Time employed in hours	14	12	13
Oxygen, liters	10000	20000	5600
Ratio, O to gas, Oxy. = 1	1 : .4	1 : .9	1 : .87
Gas used, liters	4000	18000	4800
No year workman has welded	½	½	3
Special training of workman?	no	no	no
Former tests?	none	none	none

Plate No.	XI	XII	XIII
Torch system	Picard	Patent No. +65299	Picard
Kind of gas	Acetylene	Liquified gas	acet. (Endress)
Preparation of pieces and openings, for welding	angles, 70° distance 1–2 mm.	angles, 60–70° distance of edges at weld, o = 1 mm.	angles, 50–60° distance, 1 mm.
Hammered?	not hammered	lightly hammered	not hammered
Annealed?	an. ½ hr.	an. 8 hr.	only annealed with torch
Straightened?	yes	yes	no
Time employed in hours	28	4½	20
Oxygen, liters	5600	7400	20000
Ratio, O to gas, Oxy. = 1	1 : 1.3	1 : .68	......
Gas used, liters	7500	5000	......
No year workman has welded	4	½	4
Special training of workman?	no	no	yes
Former tests?	one	one	two

Table VI — (Concluded)

Plate No.	XIV	XV
Torch system	Fouche	Electric arc.
Kind of gas	acet. (Keller & Knappich)	......
Preparation of pieces and openings, for welding	angles, 70. distance 1–2 mm.	none whatever
Hammered?	not hammered	not hammered
Annealed?	annealed 1 hr.	heated to a clear red heat in a plate annealing furnace, and set one side
Straightened?	yes	yes
Time employed in hours	15	17
Oxygen, liters	6400	(arc welded)
Ratio, O to gas, Oxy.= 1	....	E. M. F. 80–90 volts.
Gas used, liters	....	....
No year workman has welded	3	10
Special training of workman?	yes	no
Former tests?	none	none

TABLE VII

Table of Supplementary Tension Tests. Bars the same as in Table I

	1. Neither welded nor annealed			2. Welded			3. Welded and annealed			4. Welded, hammered and annealed		
	A	B	Mean	A	B	Mean	A	B	Mean	A	B	Mean
Elastic Limit lbs. sq. inch.	33709	33567	33638	32714	33282	32997	30722	31007	30865	31860	29585	30722
Ultimate Strength "	46795	47364	47079	46510	48075	47222	46370	48227	47222	46653	44092	45372
Reduction in area % . .	59	64	61.5	66	68	67	71	68	69.5	66.5	72.0	69.2
Elongation, 8 in. % . . .	30.5	31.3	30.9	22.4	22.9	22.6	28.0	25.8	26.9	27.5	28.4	27.9
Elongation, 2 in. % . . .	20.8	24.0	22.4	20.0	17.2	18.6	24.0	21.6	22.8	22.4	25.6	24.0
Coef. of Quality . . .	1.00	1.04	1.02	.73	.77	.75	.91	0.87	.89	.98	.88	.93
Point of Rupture . . .	......	....	....	out	side	....	out	side	....	out side		.. ....
Remarks	Surface: intact. Fracture shows traces of laminated flaws.	Surface: intact. Fracture, fine fibrous, traces of flaws.		Double contraction, fine fibrous fracture, no defects.	The same, except traces of flaws.		Same as 2a.	Same as 2a.		Same as 2a.	Same, but without defects.	

TABLE VIII

Supplementary Impact Tests on Notched Bars. Weight of Ram, 120 Kg., (44.09 lbs.). The other conditions were the same as in Table III

	1. Neither welded nor annealed		2. Welded					
	A	B	A			B		
	1	1	2	2a	mean	2	2a	mean
Work of deformation ft. lbs. sq. inch. . . .	969	1015	74.5	32.6	51.3	41.9	471	256
Angle of bend° . .	30	36	1.5	1.5	1.5	2	21	11.5
	65	72	....	....	....	7	....	......
Remarks	Edges fibrous, center brilliant, fine grained.	Fibrous compression side, brilliant, fine grain.	Brilliant, medium grain.	Same, coarse fibre, one side.		Brilliant, medium grain.	1st blow, crack starts; 2nd blow, tension side fibrous, rest fine grain.	

	3. Welded and annealed.						4. Welded, hammered and annealed					
	A			B			A			B		
	3	3a	mean	3	3a	mean	4	4a	mean	4	4a	mean
Work of deformation ft. lbs. sq. inch. . . .	60.6	41.9	51.3	443	583	513	28.0	65.3	46.6	779	449	638
Angle of bend° . .	2	0	1	12	9	10.5	0	4	2	44	21	27.5
	28	20	......	49	39	......	17	20	......	47	36	......
Remarks	Brill. medium grain, coarse serrated fibres on edges.	Brill. medium grain, coarse serrated fibres on edges.		Tension side fibrous, rest brilliant fine grain.	1st blow, large cracks. 2nd blow fract. tension side fibrous, serrated, rest fine grain.		Edges serrated, rest brilliant rather fine grain.	Edges serrated, rest brilliant rather fine grain.		Serrated, fibrous tension side, rest fine brilliant grain.	Serrated, fibrous tension side, rest fine brilliant grain.	

Averages

	1	2	3	4
Work of deform .	993	169	282	343
Angle of bend . .	33	6.5	5.7	14.7

First Conference of Department Heads, of The Hartford Steam Boiler Inspection and Insurance Company, at Hartford, June 11-14.

Beginning Monday, June 11, The Hartford Steam Boiler Inspection and Insurance Company held it first conference of Department Heads at the Home Office, Hartford, Ct. Managers, General Agents and Chief Inspectors were present from every department of the Company in the United States as well as representatives from The Boiler Inspection and Insurance Company of Canada. The morning and afternoon conference sessions were held in the Home Office building each day, the closing session being held on the afternoon of Thursday, June 14. The morning sessions were devoted to the presentation of short papers on problems of the agency and insurance end of the business, including discussion of policy forms, questions of management, relations between the departments and the home office, etc. The papers were well prepared and forcefully presented, and all brought out spirited and timely discussion.

The afternoon sessions were devoted to the discussion of nearly all phases of the inspection and engineering side of the Company's activity. The same method, short papers and full discussion prevailed as in the morning sessions. Attendance at all the meetings was full. So many of the men in the selling end of the business have at some time or other been attached to the Company's Technical staff that nearly every one found matters of interest and helpfulness in the papers and discussions of both branches. The conference as a whole was an unqualified success and cannot but result in a closer and more intelligent co-operation between the home office and the field force. It is safe to say that every one carried away with him a better understanding of the problems and viewpoint of his colleagues.

Lunch was provided each day at the Hartford Club, and on Tuesday and Wednesday evenings entertainments were arranged, a theater party on Tuesday night, and a most delightfully informal dinner Wednesday evening at the Hartford Golf Club, while the out of town visitors were given a short automobile trip about Hartford and the surrounding country between the close of the Wednesday afternoon session and the dinner hour.

On Tuesday morning the conference patriotically subscribed to a substantial number of $50.00 Liberty Bonds, although most if not all those present had previously subscribed, either through the Company or through their home banks.

Wednesday evening at the close of the dinner, the members of the conference presented a handsome silver water pitcher, appropriately inscribed, to Vice-President Francis B. Allen, in token of their love and esteem for him and his years of faithful service to the Company. Flowers were also sent Mrs. Allen in appreciation of the cordial invitation extended by Mr. and Mrs. Allen to consider their residence "open house" during the conference period. It is to be hoped that conditions due to the war will not intervene to prevent the repetition of this most successful meeting of the Department Heads of the Company.

On the following page is shown a group photograph of those attending the conference, taken on the steps of the Home Office building. It is to be regretted that the limitations of the size of our page, made it necessary to so reduce the picture that the faces are not as distinct as might be desired.

CONFERENCE GROUP ON THE STEPS OF THE HOME OFFICE.

Bottom row: H. A. Baumhart, H. M. Lemon, Geo. H. Ward, C. E. Roberts, A. S. Wickham, J. J. Graham, Francis B. Allen, C. B. Paddock, Chas. S. Blake, Wm. R. C. Corson, W. G. Lineburg, Walter Gerner, Wm. J. Farran, A. E. Edkins, O. E. Granburg, W. E. Gleason, W. M. Francis. 2nd row: C. C. Gardiner, E. Sidney Berry, C. D. Noyes, Jas. L. Foord, R. T. Burwell, J. B. Warner. 3d row: C. D. Ashcroft, A. L. Thalheimer, S. F. Jeter, R. E. Munro, H. E. Dart, Jos. H. McNeill. 4th row: F. M. Fitch, Thos. E. Shears, E. Mason-Parry, Geo. N. Delap, S. B. Adams, W. I. Cornell, C. C. Perry. 5th row: J. J. Caraher, H. J. Vander Eb., L. F. Middlebrook, Arthur Koppleman, C. E. Ripley, J. P. Morrison, F. H. Williams, Jr. 6th row: N. F. Shailer.

With the Colors.

The following list, which is now very likely incomplete, has been sent us in response to a request for the names of all men in the various Departments who have entered the service of their country. In future issues we shall revise the list and endeavor to keep it up to date.

Atlanta Department:

Special Agent, E. M. Murray, enlisted in Co. K, Georgia National Guard.

Boston Department:

Inspector A. H. Baker, Lieutenant Commander in U. S. naval service.

Inspector Samuel Rubin, Lieutenant.

Inspector A. H. Morris, Lieutenant.

Inspector A. R. Chambers, Lieutenant.

All these men have entered the naval service in the engineering department and are on service with the fleet.

Hartford:

A. Gordon Merry is at Plattsburg.

Inspector John Ross, Machinist Connecticut Naval Militia, is on service with the fleet.

Henry E. Gerrish, ambulance driver Enlisted Reserve Corps, United States Army, assigned to Base Hospital Unit No. 3.

Elmer B. Haines, Medical Enlisted Reserve Corps, U. S. A.

New York Department:

Inspector Edward S. Van Wart, Ensign, U. S. N. R. F.

Also, from the Chicago Department, about a year ago, Inspector W. Byrtt, a British subject, resigned to enlist in the Canadian Forces, and is now a Captain in the Canadian Overseas Battalion.

The Liberty Loan.

The Company, by letter, urged every employee to subscribe to the Liberty Loan Bonds, pointing out the need for such action and the desirability also of placing the subscription through local agencies as far as possible so that each locality might receive proper credit for the subscription. Realizing however that many employees of the Company would be glad to subscribe if opportunity offered to do so on convenient terms, the Company generously offered to place the subscriptions of any of its employees, buy the bonds for them, and extend to them the privilege of paying for the bonds in convenient installments, the payments to be taken from the individual employee's salary account. An adjustment of interest will be made at the end of the installment period. While a very considerable subscription is known to have been made to the loan through local agencies the offer of the Company was also responded to to the extent of about $10,000.

The Locomotive
of
THE HARTFORD STEAM BOILER
INSPECTION AND INSURANCE CO.

C. C. PERRY, EDITOR.

HARTFORD, JULY, 1917

SINGLE COPIES *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
THE LOCOMOTIVE OF THE HARTFORD STEAM BOILER I. & I. CO.

The conservation of manufacturing resources is as essential as the conservation of natural resources and almost as essential as the conservation of food in these times of national stress. We can think of few disasters more disheartening to a manufacturer than a failure of the power supply through a boiler or flywheel explosion, coupled as this is almost certain to be with extensive damage to other parts of the plant and its equipment. Replacement of plant was never more difficult than it is today and it is a matter of national economic necessity for every owner of power appliances to secure the maximum possible freedom from the need for such replacements. It is much simpler to avoid trouble than to repair damage. Nothing will so certainly contribute to this desired end as the thorough, periodic inspection of competent inspectors. Argument is certainly not required to support this statement at this time, and this brief paragraph is meant merely as a reminder to the anxious and busy executive that such service is his, for his profit and advantage by carrying boiler and flywheel insurance. In this connection we would like to suggest the advisability of a scrutiny of the plant which is already protected with this kind of insurance to see if additional apparatus, or apparatus which perhaps has been overlooked in the past has been properly covered. Your boilers may have been insured and inspected for years but how about those other insurable pressure vessels which may be nearly if not quite as hazardous as the boilers? Should they not also be covered and safeguarded?

In connection with the subject of conservation which we have touched upon in the preceding paragraph it may be well to point out one way in which boiler owners can conserve both their boilers and their resources with perhaps as little expenditure as in any way we know. That is by strenuous and continued efforts toward cleanliness both external and internal. Nothing can more certainly contribute to an excessive fuel consumption than a foul boiler and there is but little to choose between external and internal uncleanness. Moreover a surprisingly large number of apparently diverse boiler defects have their origin in conditions arising out of unclean heating surface, either from scale sediment or soot. Corrosion, overheating, burned and bulged plates or tubes, cracked plate edges on fire sheets, leaking seams and tube ends, split and burst tubes, external wear and tear to say nothing of grooving and cracking all *may* result from various sorts of foreign matter. We do not for a moment wish to make the bald statement that clean boilers never develop any sort of defects for that is not so, nor do we wish to be quoted as saying that cleanliness is the beginning and the end of economy, but we know from long experience that cleanliness is the greatest single factor in promoting fuel economy and freedom from trouble, granted a reasonably safe and sound installation to start with. At the present time with the enormous difficulty entailed in getting adequate fuel or supplies, no one can afford to let up on the eternal drive for clean heating surface. Moreover the more difficult cleanliness is of attainment owing to local conditions of water supply, character of fuel or construction of boilers or furnaces the more fundamentally important it is to make an abnormal effort to obtain it. This is peculiarly true of plants at considerable distances from boiler shops and repair supplies.

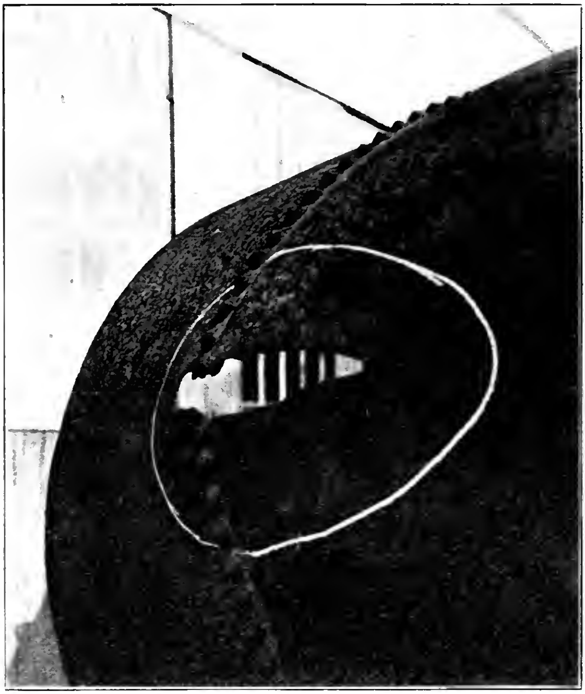
Personal.

Mr. J. J. Graham, until recently Manager at the Pittsburg Department of The Hartford Steam Boiler Inspection and Insurance Company, has been called to the Home Office to fill the important position of Superintendent of Agencies. Mr. Graham started as an inspector in the Cleveland Department in 1906. He later became a Special Agent in the Cleveland office where his success was marked. In 1913, he was appointed to the position at Pittsburg, and is now again promoted to his new position at Hartford.

Mr. George H. Ward, who has been our Resident Agent at Detroit for several years, goes to Pittsburg, to take the position vacated by Mr. Graham, and Mr. Ward's former place at Detroit will be filled by Mr. L. L. Coates from the Chicago office.

Keep Water in Your Boiler.

We have preached the doctrine of conservation in the paragraphs on the editorial page, and on the following page we show a boiler the fire sheet of which has been utterly ruined by low water. Low water accidents are of the preventable sort, and no one would want at this time to feel that he had made the purchase of a new boiler at an almost fabulous price, necessary, when the old one might have served for many years to come if there had not been a lapse in its supply of feed water. Low water was never more inexcusable than it is today.



A LOW WATER RUPTURE.

Boiler Explosions.

FEBRUARY, 1917.

(51.) — On February 1, two sections cracked in a cast iron sectional heating boiler in the office building of Paul M. Ellenburg, St. Louis, Mo.

(52.) — A boiler exploded February 1, at the home of William H. McDonald, near Macomb, Ill. One man was fatally injured.

(53.) — A tube ruptured February 2, in a water tube boiler at the plant of The Winona Copper Co., Winona, Mich.

(54.) — On February 2, a tube ruptured and three cast iron headers failed in a water tube boiler at the plant of The Susquehanna Coal Co., Shamokin, Pa. One man was slightly injured.

(55.) — A cast iron sectional heating boiler ruptured February 2, in a building in Lincoln Park, Chicago, Ill.

(56.) — On February 2, a cast iron sectional heating boiler ruptured at the D. W. Gooch School, Melrose, Mass.

(57.) — A boiler exploded February 2, in the residence of Mrs. Lobstein, La Grange, Ill.

(58.) — A boiler exploded February 2, in the Dessinger Electric Shop, Ft. Dodge, Ia. The damage was said to be slight.

(59.) — A boiler exploded February 2, in the basement of No. 1853 7th St., Washington, D. C.

(60.) — An ammonia tank exploded with great violence February 2, in the meat market of C. A. Huff, Wichita, Kans.

(61.) — On February 3, a tube ruptured in a water tube boiler at the plant of the Victor Chemical Co., Chicago Heights, Ill.

(62.) — On February 3, a tube pulled from a drum in a water tube boiler at the plant of The Central Hudson Gas and Electric Co., Poughkeepsie, N. Y. One man was injured.

(63.) — A tube ruptured February 3, in a water tube boiler at the plant of The McKeefrey Iron Co., Leetonia, O.

(64.) — On February 3, two sections failed in a cast iron sectional heating boiler at the Uxbridge High School, Uxbridge, Mass.

(65.) — A kitchen range boiler exploded February 3, in the home of Alfred Martin, 704 Washington Ave., Philadelphia, Pa. The accident was attributed to frozen connections and a fresh fire.

(66.) — A water back exploded February 3, in a range at the residence of Mrs. William J. Syms, 104 North 6th St., Darby, Pa. Mrs. Syms was severely injured and the house badly wrecked by the explosion.

(67.) — On February 4, a section cracked in a cast iron sectional heating boiler at the restaurant of Louis Bannay, Bridgeport, Conn.

(68.) — Four cast iron headers cracked February 4, in a water tube boiler at the plant of the Borden's Condensed Milk Co., New York City.

(69.) — A boiler exploded February 4, in the basement of the Methodist Church, Fair Haven, N. Y. The sexton of the church was firing the boiler at the time of the accident and was very seriously scalded, while a large amount of damage was said to have been done to the building.

(70.) — A boiler exploded February 4, in the basement of the Elks Club, Tulsa, Oklahoma.

(71.) — On February 5, a section cracked in a cast iron sectional heating boiler at the department store of H. H. Sturtevant and Co., Zanesville, O.

(72.) — On February 5, a boiler ruptured in the harness factory of The Gilliam Manufacturing Co., Canton, O.

(73.) — Four sections cracked February 5, in a cast iron sectional heating boiler in the barn at the farm of Dr. W. Seward Webb, Shelburn, Vt.

(74.) — A boiler exploded February 5, in the basement of the building at Nos. 15, 17 and 19 West 37th St., New York City.

(75.) — A boiler exploded February 5, in the basement of the residence of William T. Parrott, Falls Church, Va.

(76.) — A boiler exploded February 5, in the basement of the residence of C. G. Davis, 2540 Hall Place, Washington, D. C.

(77.) — A boiler exploded February 6, in the new Burdick Hotel, Kalamazoo, Mich. Three men were injured, one very seriously.

(78.) — A range boiler exploded February 5, in the home of Julius Shulman, Tottenville, Staten Island, New York. Mrs. Shulman and two children were seriously injured, one of the children not being expected to live.

(79.) — On February 7, a tube ruptured in a water tube boiler at the plant of the Carbon Steel Co., Pittsburgh, Pa.

(80.) — Two tubes pulled from junction boxes February 7, in a water tube boiler at the candy factory of The George Zeigler Co., Milwaukee, Wis.

(81.) — A section cracked February 7, in a cast iron sectional heating boiler at the plant of the Cling Surface Co., Buffalo, N. Y.

(82.) — A tube burst February 8, in a boiler at the plant of the Merchants' Ice and Cold Storage Co., Cincinnati, O. One man was injured.

(83.) — On February 9, an accident occurred to a boiler at the plant of the Farmers' Co-operative Creamery and Supply Co., Omaha, Neb.

(84.) — A boiler exploded February 9, at the saw mill of Brandon, Craig and Co., near Jonesboro, Ark. Three men were instantly killed and two others badly injured.

(85.) — On February 20, a tube pulled from a drum in a water tube boiler at the Minnesota Steel Co., plant of The United States Steel Co., Duluth, Minn.

(86.) — A vulcanizer exploded February 10 at the plant of The Luzerne Rubber Co., Trenton, N. J.

(87.) — A hot water boiler exploded February 10, at Stewart Laury's Hotel County Avenue, Secaucus, N. J.

(88.) — A tube failed February 10, in a water tube boiler at the Oskaloosa Traction and Light Co., plant of The Illinois Traction System, Oskaloosa, Ia. One man was slightly injured.

(89.) — A section cracked February 11, in a cast iron sectional heating boiler in a garage belonging to the estate of Wm. B. Bannigan and Emma T. O'Connor, Cranston, R. I.

(90.) — The boiler of a St. Louis and San Francisco freight locomotive exploded February 11, near Thayer, Mo. The engineer and fireman were both killed.

(91.) — A tube collapsed February 12, in a boiler at the power plant of the Illinois Maintenance Co., Chicago, Ill.

(92.) — Two headers failed February 12, in a water tube boiler at the plant of The Silk Finishing Co. of America, Inc., New York City.

(93.) — A boiler exploded February 12, in a school house at Warren, Ill.

(94.) — A heating boiler exploded February 12, in the basement of the residence of G. R. Buck, Lapeer, Mich.

(95.) — On February 13, four sections cracked in a cast iron sectional heating boiler at the plant of The Parks Sausage and Provision Co., Boston, Mass.

(96.) — A section cracked February 13, in a cast iron sectional heating boiler at the building of The Lubelski Catering Co., Buffalo, N. Y.

(97.) — A boiler exploded February 13, at the Bannon Wet Wash Laundry, Davenport, Ia. The boiler traveled three blocks in its flight from the laundry building.

(98.) — On February 14, three sections failed in a cast iron sectional heating boiler at the garage owned by Harriet M. Howe, Harford, Conn.

(99.) — A kichen boiler exploded February 14, at the home of Miss Sarah P. Williams, Dobbs Ferry, N. Y.

(100.) — On February 15, a boiler ruptured at Mine No. 18 of The Clemons Coal Co., Pittsburg, Kans.

(101.) — On February 15, a section failed in a cast iron sectional heating boiler at the apartment house of Rebecca Shuldiner, Coney Island, Brooklyn, N. Y.

(102.) — Four sections failed February 15, in a cast iron heating boiler at the Church of the Consistory of the Reformed Protestant Dutch Church of South Bushwick, Brooklyn, N. Y.

(103.) — On February 16, nine sections cracked in two cast iron sectional heating boilers at Burton Hall, Dana and Center Streets, Cambridge, Mass.

(104.) — A New York Central locomotive boiler exploded February 17 at Cleveland, O. A section gang were working right at the scene of the accident and two men were killed while nine others were injured.

(105.) — On February 19, a tube ruptured in a water tube boiler at the plant of the Buckeye Cotton Oil Co., plant of Proctor and Gamble, Atlanta, Ga.

(106.) — An accident occurred to a boiler at the Edison School, Tacoma Wash., on February 19.

(107.) — A B. & O. R. R. locomotive dropped its crown sheet near Poplar, Md., on February 18. Three men were severely scalded.

(108.) — On February 20, a section cracked in a cast iron sectional heating boiler at the tobacco warehouse of A. and S. Hartman, Hartford, Conn.

(109.) — A boiler exploded February 20, at the West End Bottling Works, Lansford, Pa.

(110.) — Four cast iron headers failed February 20, in a water tube boiler at the plant of The Roswell Gas and Electric Co., Roswell, N. Mex.

(111.) — A steam pipe failed February 22, at the Larkin plant, Buffalo, N. Y. One man was scalded.

(112.) — A boiler exploded February 23, in a garage owned by the Hannan and Henry Motor Car Co., Ogdensburg, N. Y. One man was killed and three others injured of whom two were not expected to live.

(113.) — A boiler ruptured February 24, at the No. 4 mine of The Clemons Coal Co., Mulberry, Kansas.

(114.) — A boiler ruptured February 24, at the plant of Meiklejohn Lumber Co., Cheraw, S. C.

(115.) — A boiler on a Mass. Central locomotive exploded February 24, near Clinton, Mass. Two men were injured.

(116.) — A hot water boiler burst February 25 at the home of George R. Cornwall, Rye, N. Y. One person was injured.

(117.) — A non-return valve ruptured February 26, at the Venice, Ill., plant of The Illinois Traction System, Venice, Ill.

(118.) — A steam pipe failed February 27, at the plant of the Nagle Steel Co., Glasgow, Pa. Three men were killed instantly and one other fatally injured.

(119.) — The boiler of engine No. 263 of the I. and G. N. railroad exploded February 24, near Houston, Texas. One man was killed and one painfully injured.

(120.) — On February 27, two tubes ruptured in a water tube boiler at the plant of The Scoville Mfg. Co., Waterbury, Conn. Two men were killed outright, six injured, and of the latter one died later from the injuries he received. The boiler was considerably damaged.

(121.) — On February 27, a tube ruptured in a water tube boiler at the plant of the Allentown Portland Cement Co., Evansville, Pa.

MARCH, 1917.

(122.) — On March 2, a tube cap failed on a water tube boiler at the plant of The Eastman Kodak Co., Greece, N. Y. The water line was lowered so quickly as to cause the failure of 12 headers before the fires could be deadened.

(123.) — A heating boiler failed March 2, on the station of the 23d police district of Philadelphia, Pa.

(124.) — On March 3, a tube ruptured and a header was blown from two tubes in a water tube boiler at the plant of the Winona Copper Co., Winona, Mich.

(125.) — A small boiler, apparently improvised, and used by a plumber as a source of steam for the thawing of water pipes in a trench, exploded March 3 at Wilkes Barre, Pa. Henry T. Murray, a bystander, was killed.

(126.) — On March 3, a section cracked in a cast iron sectional heating boiler in the County Court House of Greene County, at Carrollton, Ill.

(127.) — A section cracked March 3, in a cast iron sectional heating boiler at the West Virginia (state) Collegiate Institute.

(128.) — A tube ruptured March 4, in a water tube boiler at the plant of the Winona Copper Co., Winona, Mich.

(129.) — On March 4, a crown sheet collapsed in a locomotive type boiler at the plant of the Standard Textile Co., Glens Falls, N. Y. One man was injured.

(130.) — On March 5, the feed pipe failed between the boiler and a stop valve at the plant of the South Bend Dowel Works, Inc., South Bend, Ind.

(131.) — On March 6, the boiler of a locomotive belonging to the Little River Lumber Co., Townsend, Tenn., exploded. One man was killed and eight others injured, one of them seriously.

(132.) — Four sections cracked in a cast iron sectional heating boiler on March 6, at the Wallace School, District No. 10, Sterling, Ill.

(133.) — An arch tube failed March 6, in the boiler of locomotive No. 247 of the Pennsylvania railroad at Altoona, Pa. Two men were injured.

(134.) — On March 7, a boiler exploded at the Patch Foundry, Clarksville, Tenn. Two men were very seriously injured.

(135.) — A boiler exploded March 8, in the Sacred Heart Parochial School, Jersey City, N. J. The children to the number of 800 were taken out of the building through the aid of their fire drill.

(136.) — On March 9, a tube ruptured in a water tube boiler at the office building of The Pullman Co., Chicago, Ill.

(137.) — A blow-off failed March 9, on a boiler at the Milwaukee Reliance Boiler Works, Milwaukee, Wis.

(138.) — A section ruptured March 10, in a cast iron sectional heating boiler at the Conservatory of Music, Corning, N. Y.

(139.) — Two men were fatally scalded March 11, in the basement of 1340 Cherry Street, Philadelphia, Pa., through steam being turned on a boiler in which they were at work. The fireman in charge of the boiler was arrested for criminal negligence.

(140.) — On March 11, an accident occurred to the main stop valve on a boiler at the plant of The Athletic Mining and Smelting Co., Webb City, Mo. One man was injured.

(141.) — A boiler exploded March 12, at a sawmill at Petersburg, Tenn. One man was fatally injured.

(142.) — On March 13, a tube ruptured in a water tube boiler at the Merchants' Light and Heat Co. plant of The American Public Utilities Co., Indianapolis, Ind.

(143.) — A section failed in a cast iron sectional heating boiler at the apartment house of Louville N. Niles, 362 Mass. Ave., Boston, Mass., on March 16.

(144.) — A boiler was reported to have exploded on the P. and R. R. R. tug, Gettysburg, while under way from Philadelphia to Boston. The tug had to cast adrift her tow and proceed back to port.

(145.) — The crown sheet of a locomotive boiler collapsed March 18, in the yards of the Inland Steel Co., Indiana Harbor, Ind.

(146.) — On March 19, a tube ruptured in a contractor's portable boiler belonging to Charles Zih, located at Bridgeport, Conn.

(147.) — A flange failed March 19, in the connection between the boiler and a steam drum at the plant of the Clark Pratt Cotton Mills Co., Prattville, Ala.

(148.) — A boiler exploded at the Benty Hen Mine, Joplin, Mo., on March 20. Two miners were standing beside the boiler as it exploded and were hurled into a cave fifty feet deep. Both were fatally injured.

(149.) — A tube ruptured in a water tube boiler March 22, at the Henry R. Worthing Works of The Worthington Steam Pump and Machinery Co., Harrison, N. J. One man was fatally injured.

(150.) — On March 23, a section cracked in a cast iron sectional heater at the Vonhof Hotel, Button and Ozier, Props., Mansfield, O.

(151.) — Seven cast iron headers cracked March 24, in a water tube boiler at the watch case factory of Joseph Fahy's and Co., Inc., Sag Harbor, L. I., N. Y.

(152.) — On March 25, two tubes failed in a water tube boiler at the plant of The Winona Copper Co., Winona, Mich.

(153.) — A tube ruptured in a water tube boiler on March 25, at the plant of The Beveridge Paper Co., Indianapolis, Ind. One man was injured.

(154.) — An accident occurred to an internally fired boiler March 26, at the roundhouse of the Mississippi, Hill City and Western R. R., Hill City, Mich.

(155.) — On March 26, a tube ruptured in a water tube boiler at the plant of The Winona Copper Co., Winona, Mich.

(156.) — The boiler of a Northwestern locomotive exploded March 26, near Janesville, Minn. One man was fatally injured and one other seriously scalded.

(157.) — On March 26, the boiler of a C. M. and St. P. locomotive exploded at M'Laughlin, N. D. One man was killed and one seriously injured.

(158.) — A section failed March 27, in a cast iron sectional heating boiler at the greenhouse of Homer D. Hunt, Mansfield, O.

(159.) — A header fractured on a water tube boiler on March 27, at the plant of the National Malleable Castings Co., Chicago, Ill.

(160.) — A tube ruptured March 28, in a water tube boiler at the plant of The Scovill Mfg. Co., Waterbury, Conn.

(161.) — An accident occurred March 30, to the boiler of the lighthouse tender Jessamine, off Sparrows Point, Md.

(162.) — Five cast iron headers ruptured March 31, in a water tube boiler at the Edinburg, Ind., plant of The Middle West Utilities Co.

APRIL, 1917.

(163.) — On April 2, a tube ruptured in a water tube boiler at the Williamsburgh power station of the Transit Development Co., Brooklyn, N. Y. One man was injured.

(164.) — The boiler of a Santa Fe locomotive exploded April 3, at Gise, New Mexico. Two men were killed and one other fatally injured.

(165.) — A tube ruptured April 4, at the plant of the Harshaw Fuller and Goodwin Co., Cleveland, O. One man was slightly injured.

(166.) — A cast iron section cracked April 4, in a heating boiler at the State Normal School, Athens, Ga.

(167.) — On April 5, a manifold failed on a cast iron sectional heating boiler at Loew's New 42nd St. Theater, New York City.

(168.) — A tube ruptured April 5, in a water tube boiler at the plant of the Columbia Chemical Co., Barberton, O. One man was injured.

(169.) — An accident occurred to the boiler at plant of the Brammer Mfg. Co., Davenport, Ia., about April 6.

(170.) — On April 8, a tube ruptured in a water tube boiler at the Westville, N. J., power house of The West Jersey and Seashore R. R. Co. One man was injured.

(171.) — A valve ruptured April 9, at The Hub, Henry C. Lytton and Sons, Chicago, Ill.

(172.) — A boiler exploded April 9, in the Rutland Apartments, 5400 Locust St., Philadelphia, Pa.

(173.) — A small boiler exploded April 9, at the plant of the New System Wet Wash Laundry Co., Syracuse, N. Y.

(174.) — A boiler exploded April 10, at the mine of The Old Ben Coal Corp., West Frankfort, Ill. One man was killed.

(175.) — A boiler exploded April 10, at the sash and door factory of Farley and Loetscher, Dubuque, Ia. Two men were killed and two others probably fatally injured. The property damage was said to have been large.

(176.) — A steam pipe burst April 11, at the plant of the D. & H. Coal Co., Wilkes-Barre, Pa. One man was badly scalded.

(177.) — A section cracked in a cast iron sectional heating boiler April 11, at the garage owned by Anna L. Townsend and Gladys E. Macfarlane, Bridgeport, Ct.

(178.) — On April 2, a section failed in a cast iron sectional heating boiler at the furniture factory of Julia E. Goldsmith, Grand Rapids, Mich.

(179.) — The main steam pipe burst April 13, in the boiler room of the Municipal Light Plant, Pasadena, Cal.

(180.) — A kier exploded April 15, at the River Spinning Co. plant, of F. A. Sayles, Woonsocket, R. I. Five men were injured and there was considerable damage to property.

(181.) — Several cast iron headers failed April 17, in a water tube boiler at The Hollenden Hotel, Cleveland, O.

(182.) — A hot water boiler exploded April 18, at the Prospect Park branch of the Y. M. C. A., Brooklyn, N. Y.

(183.) — An oxygen tank exploded April 18, at the shops of the Louisville and Nashville Railroad, Louisville, Ky. Three men were killed and three others injured.

(184.) — A section failed April 19, in a cast iron sectional heating boiler at the apartment house owned by the Dekalb-Thompkins Co., Brooklyn, N. Y.

(185.) — Two boilers exploded April 20 at the plant of the Henderson Lumber Co., Leilerton, Ga. Five men were seriously injured, two of them perhaps fatally.

(186.) — A tube ruptured April 21, in a water tube boiler at the plant of the American Palace Steam Laundry Co., Buffalo, N. Y. One man was slightly injured.

(187.) — A log locomotive boiler exploded April 21, on the operation of the Aycock Lumber Co., near Round Lake, Fla. Two men were killed and two others seriously injured.

(188.) — A section failed April 23, at the Royal Restaurant, belonging to the estate of Philip Flinn, Pittsburgh, Pa.

(189.) — A kitchen range boiler exploded April 24, at the residence of Benjamin R. Rush, near Keansburg, N. J.

(190.) — The boiler of the only locomotive belonging to the Susquehanna River and Western Railroad exploded April 24. The road, which runs between Duncannon and New Bloomfield Junction, Pa., was forced to suspend operations, pending the obtaining of another locomotive from the Pennsylvania road.

(191.) — On April 25, a tube ruptured in a water tube boiler at the chemical works of The Diamond Alkali Co., Fairport, O. One man was injured.

(192.) — A non-return valve ruptured April 25, at the plant of the Atlantic Refining Co., Franklin, Pa.

(193.) — A section cracked April 25, in a cast iron sectional heating boiler at the Walker-Gordon Laboratories, belonging to Samuel M. Shoemaker, Washington, D. C.

(194.) — On April 26, a section failed in a cast iron sectional heating boiler at the store of the Consolidated Poultry and Egg Co., Omaha, Neb.

(195.) — A blow-off failed April 26, on a boiler at the plant of the Monroe Binder Board Co., Monroe, Mich. One man was injured.

(196.) — A boiler ruptured April 25, at the Abbeville Cotton Mills, Abbeville, S. C.

(197.) — Another boiler ruptured April 26, at the Abbeville Cotton Mills, Abbeville, S. C.

(198.) — On April 27, an accident occurred to the boiler of a Chicago, Great Western Railroad locomotive at Mason City, Ia. One man was injured.

(199.) — The boiler at Charles L. Addison's rendering works, Walnut, Ia., exploded April 27. Mr. Addison was injured.

(200.) — A boiler ruptured April 30 at the plant of The Acme Brick and Sand Co., Barton, Wis.

(201.) — On April 30, a tube ruptured in a water tube boiler at the power house of the Terre Haute, Indianapolis and Eastern Traction Co., Terre Haute, Ind. One man was injured.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1917.

Capital Stock, . . . $2,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$346,803.88
Premiums in course of collection,		388,276 03
Real Estate,		90,000.00
Loaned on bond and mortgage,		1,554,570.00
Stocks and bonds, market value		4,362,015.45
Interest accrued		98,141.14
		$6,839,806.50
Less value of Special Deposits over Liability requirements,		34,518.75
Total Assets,		$6,805,287.75

LIABILITIES.

Premium Reserve,		$2,738,563.68
Losses unadjusted,		67,528.30
Commissions and brokerage,		77,655.20
Other liabilities (taxes accrued, etc.),		166,969.55
Capital Stock,	$2,000,000.00	
Surplus over all liabilities,	1,754,571.02	
Surplus as regards Policy-holders,	**$3,754,571.02**	3,754,571.02
Total Liabilities,		$6,805,287.75

CHARLES S. BLAKE, President.

FRANCIS B. ALLEN, Vice-President. W. R. C. CORSON, Secretary.

L. F. MIDDLEBROOK, Assistant Secretary.

E. S. BERRY, Assistant Secretary and Counsel.

S. F. JETER, Chief Engineer.

H. E. DART, Supt. Engineering Dept.

F. M. FITCH, Auditor.

J. J. GRAHAM, Supt. of Agencies.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President. Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, Vice-President, United States Bank, Hartford, Conn.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres. The Fidelity Trust Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturers, South Manchester Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and Treasurer, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, The Johns-Pratt Co., Hartford, Conn.

MORGAN G. BULKELEY, JR. Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

CHARLES S. BLAKE, President, The Hartford Steam Boiler Inspection and Insurance Co.

Incorporated 1866. — THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO. — Charter Perpetual.

INSURES AGAINST LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg	W. M. FRANCIS, Manager and Chief Inspector. C. R. SUMMERS, Ass't Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	LAWFORD & MCKIM, General Agents. R. E. MUNRO, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. ROBERTS, Manager. CHARLES D. NOYES, Chief Inspector.
BRIDGEPORT, Ct., 404-405 City Savings Bank Bldg.	W. G. LINEBURGH & SON, General Agents. F. S. ALLEN, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. LEMON, Manager. JAMES L. FOORD, Chief Inspector. J. T. COLEMAN, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. GLEASON, Manager. WALTER GERNER, Chief Inspector.
CLEVELAND, Ohio, Leader Bldg.	H. A. BAUMHART, Manager and Chief Inspector. L. T. GREGG, Ass't Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg.	THOS. E. SHEARS, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. WILLIAMS, JR., General Agent. F. S. ALLEN, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	PETER F. PESCUD, General Agent. R. T. BURWELL, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. GARDINER, Manager. JOSEPH H. MCNEILL, Chief Inspector. A. E. BONNETT, Assistant Chief Inspector.
PHILADELPHIA, Pa., 142 South Fourth St.	A. S. WICKHAM, Manager. C. H. DENNIG, Ass't Manager. WM. J. FARRAN, Consulting Engineer. S. B. ADAMS, Chief Inspector.
PITTSBURGH, Pa., 1807-8-9 Arrott Bldg.	GEO. H. WARD, Manager. BENJAMIN FORD, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	MCCARGAR, BATES & LIVELY, General Agents. C. B. PADDOCK, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.,	H. R. MANN & Co., General Agents. J. B. WARNER, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. ASHCROFT, Manager. J. P. MORRISON, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. ROBERTS, General Agent.

The Locomotive
of
THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

Vol. XXXI. HARTFORD, CONN., OCTOBER, 1917. No. 8

Ruptured Boiler at Battle Creek, Mich.

Ruptured Boiler at Battle Creek, Mich.

The boiler shown on our front cover was installed in a laundry at Battle Creek, Mich. On the morning of August 27, the fire was broken up by the watchman in order that steam might be available for the day's work. After the fire had been worked for about an hour the boiler ruptured as is shown in the photograph. The setting was badly damaged so that the boiler fell onto the grates, and the fire was scattered igniting the wood work and requiring the services of the Fire Department to extinguish the blaze. The accident was apparently the result of overheating, following low water. The plate edges were drawn to knife edges where the rupture occurred and both plate and tubes showed the characteristic blue color usually associated with overheating.

Combustion and Fuel Economy.

THE PRINCIPLES OF COMBUSTION.

A boiler plant uses heat to boil water. It has two main functions the making of the heat, and the putting of the greatest possible amount of the heat produced into the water. It will be our purpose finally to investigate to some extent, both these functions, but for the present, we will confine ourselves to the former, the heat producing function, which is the office of the furnace as opposed to the boiler proper.

The raw materials used by the furnace in the production of heat are air and fuel, and its problem is to burn all the fuel that is burnable, using enough air for that purpose and no more. A pound of fuel can, under ideal conditions, liberate only a certain definite quantity of heat. When liberated, this heat passes to the setting and the furnace walls in part, some of it goes direct to the boiler by radiation, but the great bulk of it remains in the products formed when fuel and air unite.

As fuel is not all able to burn, we divide it into two parts called ash and combustible. Likewise air, which is a mixture of various gases, mostly oxygen and nitrogen is not all useful in burning the fuel. Only the oxygen is consumed and the refuse consists of the nitrogen and the other gases. A new product or group of products is formed by the union of the oxygen from the air and the combustible of the fuel. These substances are for the most part gases or vapors but may include some tarry liquids and solids, and are usually termed the products of combustion.

Let us see what becomes of the heat generated in the fire. First as we have said the surrounding bodies are heated, i.e., the setting, brickwork, etc., and some heat is transmitted direct from the fire to the boiler without the gases entering into the transaction. This latter process is called heating by radiation. The greater part of the heat however remains in the stuff which burned, that is in the "products of combustion," the ash, and the "air refuse." One of the fundamental facts in the behavior of bodies when heated is that a given amount of material of any kind can hold only a certain amount of heat at a given temperature and as a fixed amount of heat is set free when a fixed amount of fuel has completely burned, then the less the amount of air refuse and gaseous products of combustion formed, the hotter they will be, only subject to the common sense condition that the gases cannot be hotter than the fire itself, for heat, like water does not flow "up hill," or in other words will not of itself flow from a region of lower temperature to one of higher temperature. This statement is in accordance with our experience, for we all know that hot bodies will of themselves cool off to the temperature of the surrounding bodies, but that to cool a cold storage room below the temperature prevailing about it requires the expenditure of energy. One more important fact, closely related to the above, and important in the design and operation of boilers and furnaces is that the flow of heat from a hot body to a cooler one takes place at a rate which is greater the greater the temperature difference. It is on this account that it is desirable to have the gases formed in burning fuel as hot as possible, for although the amount of heat given off by the fuel may all be contained in the gases, regardless of whether they are at the highest possible temperature or at a slightly lower one, the amount of this heat which can get into the boiler in a given time, will be greater the higher the gas temperature, for a given steam pressure. This is the same as saying that that boiler which is operated to have the hottest gases for a given amount of fuel burned, will, other things being equal have the highest efficiency. We are not to discuss this side of the problem at this time, but mention the matter merely to explain the necessity of getting the heat developed by the furnace into the least amount of stuff possible, so that the heated stuff may have the highest possible temperature.

From what we have said, it should be apparent that a simple statement of the function of a perfect furnace would be about as follows: To take fuel and air, burn them together using only enough air to burn all the fuel, and so get the heat transferred to the smallest amount of material (gases) possible. The boiler part of the outfit then comes into play and its function is to safely absorb as much as possible of the heat produced by the furnace and to utilize it in making steam of the desired quality and pressure.

Let us now inquire into the several steps in the process just outlined in greater detail. We must begin with the process of burning itself. Combustion consists in the rapid or active chemical union of the combustible part of the fuel with the oxygen of the air. If just enough air is supplied and all the other conditions are perfectly favorable, it is possible for every bit of the combustible to be burned and for nothing to be left except ash, defined as the non-combustible part of the fuel, combustion products formed by the combination of the oxygen of the air and the combustible of the coal, and nitrogen which represents the non-combustible part of the air, or as we have called it just now, the "air refuse." This suggests at once that if there is a trace of unburned fuel in the ash or of unconsumed oxygen in the chimney gases, then either the combustion has been incomplete, or else in the case of the chimney gases, air has leaked in after the completion of the burning process, through leaks in the setting or flues. This test would not however be sufficient to prove that combustion was complete. It is possible for fuel to burn with an amount of air, and hence of oxygen, less than that required for complete combustion, leaving no trace of unburned combustible in the ash, but yielding a gas which is itself a fuel and which might have burned if enough additional air had been admitted to complete the burning process. This halfway product, which represents the results of a process of burning but which could not be made if the combustion were complete, is the chief constituent of producer gas, and is known to the chemists as carbon monoxide, frequently expressed by the symbol CO. It is the poisonous colorless gas which proves so deadly when an automobile is allowed to exhaust into a small closed garage, and it is the substance which burns with a pale blue flame when fresh hard coal is put on a fire in a range or furnace. We may therefore make a more accurate statement of the conception of a perfect furnace by saying that it will burn all the fuel so as to leave nothing unburned in the ash, nothing unburned in the chimney gases and no free oxygen in the chimney gases. No furnace in practice fulfills these conditions, but the nearness of the approach to these limits is a measure of the fuel economy as far as the production of heat goes. This of course takes no account of the waste of heat that might take place if a poorly designed boiler were attached to the perfect furnace on which we are for the moment concentrating our attention. It is also to be noted in passing that such an ideal furnace would be smokeless.

The chief constituent of the combustible portion of practically all fuels is carbon. Associated with it may be found hydrogen and a whole group of compounds of carbon and hydrogen which may be either gaseous, liquid, solid or semi-solid tarry substances, all of which are combustible given proper furnace conditions and a proper air supply. It is not true however that all these hydro-carbons as they are called can be burned in an average boiler furnace with equal facility.

Taking coal as a typical fuel we find if we turn to any of the carefully prepared tables of the average chemical properties of different grades of coal as published for example by the United States Bureau of Mines that it is represented as made up of "fixed carbon," "volatile matter," "moisture," "ash," and "sulphur," or at least these are the headings under which its composition is given in the tables marked Proximate Analysis. It will be our aim to try and show just what is meant by these different terms. The moisture reported is the percentage of water contained in the coal at the time of the analysis and it will be necessary to find out where the sample was taken to know just what this means. For example if the sample was taken at the mine face, and freshly mined coal was sealed up in a water tight container, then the moisture reported is that in the coal as it lies in the vein under ground. This is the basis of the moisture determinations in the Government analysis. On the other hand if the analysis was made on coal as received, or on coal as fired, the moisture content would differ from that obtained at the mine face. It might be more or less, and would depend on whether the coal had been handled in wet weather, exposed to the elements, or dried out in storage. From the standpoint of the heat developed in burning, moisture is undesirable. It must be turned into steam at the furnace temperature by some of the heat produced, and it will carry off to the stack a large part of this heat. It has been stated that since at high temperatures water is turned into the gases oxygen and hydrogen, and in the exact proportion for the hydrogen to burn with the oxygen, its presence should be of benefit by the exact amount of heat developed in the burning of this hydrogen. As hydrogen is a substance which burns with the evolution of a great deal of heat, those who have advanced this argument have always stated that the benefit to be derived by burning wet coal was of a high order. They forget however that before the hydrogen can be burned in the furnace it must first be set free, and here is the fly in the ointment, for it takes just exactly as much heat to set free from water a given amount of hydrogen and oxygen, as that amount of the two gases will give back when they recombine. Therefore we are not in the least concerned whether water turns to hydrogen and oxygen, to later burn in the furnace, for there will be no net gain or loss of heat by that transaction, but there will be a distinct loss of heat for every pound of water fed into the furnace as moisture in the coal due to the fact that all that moisture must be evaporated into steam and superheated to the temperature, at least of the gases as they enter the stack. On the other hand moisture may at times prove a benefit in other ways. Very dusty coal, or coal which clinkers badly may behave better on the grate if wet, and this better behavior, by permitting the use of a cheaper fuel, may well offset the losses due to evaporating the contained water.

The fixed carbon is the body so to speak of the coal. It is that solid combustible part of the coal which does not turn to gas or vapor at high temperatures, but burns on the grate, forming the body of the fire. With it is mixed the ash, which is simply the non-combustible earthy matter present as impurities in the coal. In regard to the ash, it may be said that its amount is not altogether a matter determined by the composition of the coal in the vein. Much of the matter present as ash in the coal as used, could have been removed by careful methods of handling at the mine. The operation of rejecting slate, clay, shale, sulphur, etc. at the mine, by sorting or picking, and by careful methods of mining, is known to the trade as the "preparation" of coal. Poorly prepared coal may easily have an ash content much in excess of the average of a sample taken from the same coal as it exists underground, while a carefully prepared sample of an inherently inferior coal, may excel a poorly prepared sample of superior coal in this particular. In this connection it may be well to state that in certain localities, and with certain coals, it has been found profitable to wash coals, or to treat them with water in such a way as to greatly lower the percentages of ash. Contrary to general belief, this process does not of necessity increase the moisture content to any great extent.

As its name implies, the volatile matter comprises all the tarry or waxy constituents of the coal which turn to combustible gases or vapors when the coal is heated, and in the process of burning, the volatile matter which is evolved on the grate, burns above and beyond it if at all. The presence of volatile matter is responsible in large degree for the need of combustion space in furnace design.

Sulphur is present in coal in varying amounts. Although it will burn, it adds very little to the fuel value, and may contribute very undesirable properties. There has been much controversy as to whether sulphur actually makes coal more likely to burn spontaneously in storage, and it is not our purpose to enter into that matter here. It certainly adds nothing to the keeping quality of the coal, it assists external corrosion of the boiler and flues whenever moisture is present, as sulphur in the coal leaves a residue in the soot and fine ash which in combination with water yields free sulphuric acid.

These components, fixed carbon, volatile matter, moisture, ash and sulphur are present in varying amounts in all coals. The percentage of fixed carbon and volatile matter however are variables of a sort which divide coal into distinct classes. Thus coals which are high in fixed carbon and low in volatile are hard, break with a clean fracture, etc., from which we at once recognize them as belonging to the class known as anthracite. As the percentage of fixed carbon diminishes and that of volatile increases the coals become progressively softer and are classed as semi anthracite, semi bituminous, bituminous, sub-bituminous, lignite, etc. The high carbon low volatile coals burn with little or no flame, are practically smokeless, do not coke, are difficult to ignite but burn readily with, in most cases but little clinker. They are cleanly to handle and permit of accurate sizing. Also they may be stored without danger from spontaneous combustion or marked deterioration from the weather. As the percentage of volatile matter increases, the coals burn with greater freedom and with increasing flame length as well as progressively greater tendency toward the production of black smoke. They become more difficult to store both because of the danger from spontaneous combustion, and because of the fact that they deteriorate on exposure. This question of weathering is not entirely a matter of carbon and volatile however but is somewhat more complex, although of course dependent on the composition of the coal.

When coal is placed on a hot fire the first effect is for the temperature of the fresh coal to rise, and as it rises the various gases and vapors comprising the volatile matter are set free, the more easily vaporized ones first and the more difficultly vaporized ones later. This process is frequently called distillation. As it progresses the solid residue of fixed carbon and ash gets hotter and hotter until a point is reached where the carbon having attained its ignition temperature, it kindles and burns. The volatile matter has been swept on by the "draft" by this time and if it gets in contact with enough air, is properly mixed with the air, if further it remains for a sufficient time in contact with the air and in a region of sufficiently high temperature, it will burn. The above sentence is about as cumbersome and involved an expression as one often uses, at least in English, but it was constructed with malice aforethought, in an attempt to give a conception of the difficulty which really surrounds the efficient burning of the volatile matter from high volatile coals in a boiler furnace. If any of these conditions are lacking, that is insufficient air, improper mixing, lack of time or too low a temperature due to premature cooling, the volatile matter will not all be burned and the available heat in the coal will be but partially developed.

Smoke is largely a mixture of tarry vapors (unburned volatile matter) and of soot produced by the incomplete combustion of the volatile matter, so that the proportion of black smoke emitted is greater as the combustion of the volatile matter is more imperfect. The converse of this is not however always true, and it cannot be stated as a fact that a clean stack invariably means an economical furnace.

The whole question of the completeness of combustion as well as that of getting the most economical composition in the waste gases is largely a question of the control of the supply of air, and of its distribution to those parts of the furnace where it is needed. It may be well to state the requirements in this regard: Air must be supplied in the requisite quantity, to the right point and at the right time relative to the progress of the combustion on and over the grate. It must be properly mixed with the fuel, whether solid or gaseous, and must also be brought to the proper temperature so that it will not arrest the combustion by chilling any part of the combustible (solid or gaseous), below its ignition temperature. In addition to which the leakage of air into the setting or flues after combustion is complete should be prevented by all possible means.

Theory can be called upon to tell us exactly how much air is needed to supply oxygen enough to burn a given amount of coal of a known sort. If it were possible to so intimately mix this theoretical amount of air with the burning coal and the volatile gases that every trace of the theoretical amount of oxygen came in contact with exactly the right amount of the fuel at exactly the right time and place we would get perfect combustion with no excess of air. This would produce the greatest amount of heat possible per pound of coal burned, and in addition, would put that heat into the minimum weight of combustion products, which would therefore have the highest possible temperature under the circumstances. With solid fuel such as coal, coke, wood waste and other waste fuels this ideal may not be very closely approximated owing chiefly to mixing difficulties, therefore an excess of air is always necessary to burn any of the fuels completely. With liquid or gas fuels however, the mixing process may be brought to a much higher degree of perfection, and hence it is not necessary to use so great an excess of air over the theoretical requirement. Also pulverized coal, of the consistency of ground portland cement, that is, fine enough for 85% of it to pass a 200 mesh sieve permits of a very great reduction in the amount of excess air used without impairing the completeness of the combustion. The pulverized coal is blown out into the furnace in a cloud, mixed with the air required and the combustion takes place with great rapidity throughout the furnace volume. Although many very grave difficulties have attended use of pulverized coal under stationary boilers, it has for some time been practically standard practice to employ it in the firing of cement kilns, and it has now been applied to railway locomotives with great success, being cleanly, economical, smokeless and reducing labor to a minimum.

Proper control of the air supply should begin with the design and installation of the furnaces. Every fuel has its own characteristics and furnaces should be designed to accommodate such peculiarities if they are to be efficient. Thus wood and woodworking waste burn on the surface. Air is required above rather than through the fire and space is necessary for the completion of the burning of the gases formed, as is shown by the long flame. Hard coal and coke, being largely fixed carbon, need air through the fire from the ash pit, so that the carbon may burn on the grates. Air is also needed to some extent above the grates, to burn the producer gas formed by the hot bed of burning carbon acting on a part of the air supplied through the fire, but as there is little volatile matter, combustion space, though necessary, is not so vital a matter as with some other fuels. Softer coals as is hinted above, will require both air through the grates, and in addition an increasing amount of air over the fire, as the amount of volatile increases. With high volatile matter, it is not enough to admit the air required above the fire. Provision must be made to secure an intimate mixture of this air with the combustible gases, space must be provided both for the mixing and for the subsequent burning, and this space must be lined with some material as firebrick which will retain enough heat to ignite the gases. It may in some cases even be necessary to provide some means to retard the rate at which the volatile matter is given off by the fresh coal, by the use of stokers or some change in the method of firing, if coals containing a large amount of volatile matter are to be burned with economy. Gas and oil fuels require volume or space in which to burn. They also require an intimate mixing with the air needed for their combustion, but this is not difficult of attainment. It is of importance that the burners be so directed that the combustion may take place as evenly as possible throughout the combustion space, as it is sometimes a very serious matter to handle a furnace in which the effects of an oil flame are localized.

We have attempted to outline in the above pages, the general problem of combustion. In the articles to follow, we will endeavor to apply the principles just developed to the economical installation and operation of furnaces under boilers, using the different kinds of fuel. If by this means we shall have simplified the understanding of the process of combustion to any of our readers and so helped them to save fuel we shall be indeed satisfied.

An Old-Time Explosion Preventive.

An interesting and curious advertisement has been recently brought to our attention. It appeared in the Pittsburgh "Daily Morning Post" for September 10, 1842, which was Vol. L, No. 1, of that journal.

This advertisement was headed "Evans Patent Safety Guard.—To Prevent The Explosion of Boilers." Then follows a crude wood cut, too indistinct for reproduction, showing the device. Just how it operated cannot be made out. It is shown attached to a two flue boiler. An arm runs horizontally from an attachment of some sort on the crown of the flue, out through the shell and apparently passes through some sort of stuffing box. Outside the boiler the arm is attached to something which has the appearance of a spring balance. It is impossible to tell from the crude cut, with no description, just what the device was intended to do, but we have guessed, after studying the thing, that it was some sort of float device to indicate low water. We imagine that the affair shown resting on the top of the flue was a float arranged to cause the horizontal arm to rotate and register on the spring balance, which would indicate the water level. We know that water glasses were not in general use at that time; we know further that the gage cocks were located on the rear head of the boilers and were operated by striking them with a club of about the size and shape of a ball bat. And further, we have been told by Chief Inspector F. S. Allen that at a slightly later date a device was in use by which a float rotated an arm which carried at its outer end a bar magnet. All this mechanism was inside the boiler, or at least exposed to boiler pressure, hence no stuffing box was required. The magnet caused a hand, located outside the boiler, and separated from the bar magnet by some sort of non-magnetic material, as copper or brass, to rotate parallel to the magnet inside, and by its movement over a graduated dial, to indicate the water level. We imagine that the arrangement in the advertisement served the same purpose as the one just described, though it does not appear that it was magnetically operated. The ad. itself is worthy of preservation, and it is reprinted below:

"TRAVELERS TAKE NOTICE—That all boats provided with the Safety Guard have their show bills printed with the figure of the apparatus and be careful you are not deceived by misrepresentations of Agents stating their boats to be provided with the Safety Guard, when they are not so secured against explosion.

The following is a list of boats supplied with the Safety Guard at the Port of Pittsburgh—all except the two first on the list have the improved apparatus with which apparatus it is impossible for an explosion to occur:

SAVANNA	FORMOSA
RARITAN	ILLINOIS
NIAGARA	DU QUESNE
ORLEANS	JEWESS
CANTON	MONTGOMERY
LADY OF LYONS	CADDO
VALLEY FORGE	INDIAN QUEEN
FORT PIT	GALLANT
BREAKWATER	QUEEN OF THE SOUTH
EXPRESS MAIL	DUKE OF ORLEANS
ALPS	BRILLIANT
CASPIAN	ECLIPSE
IDA	VICTRESS
WEST WIND	MICHIGAN
MARQUETTE	OSPREY
TALLYRAND	PENELOPE
PANAMA	ROWINA
CICERO	AGNES
SARAH ANN	MESSENGER
NARAGANSETT	SARATOGA
AMARANTH	ORPHAN BOY
MUNGER PARK	OHIO
NEPTUNE	CECILIA
ADELAIDE	J. H. BILLS
NORTH BEND	GALENA
MARIETTA	MENTOR

The traveling community are respectfully requested before they make a choice of a boat, to reflect a moment and see whether it would not be to their advantage and security to choose a Safety Guard boat both for passage and freight, in preference to one not so guarded against explosion — and that they will bear in mind that this invention has the unqualified approbation of *fifty* steam engine builders — gentlemen whose business it is to understand the subject, and who are entirely disinterested — besides a number of certificates from scientific gentlemen and others — all of which can be seen at my office, No. 10 Water Street, where it would give me pleasure at all times to exhibit my invention to any one who will take the trouble to call.

Cadwallader Evans."

In these war times if we could find some equally positive assurance of freedom from being torpedoed, we imagine that the "boats would have their show bills printed with a figure of the invention" and if we had the unbounded faith of this older inventor, in the newer project, we think we could do a considerable business on the basis of the guaranteed safety, if the whole edition were not suppressed by the censor.

The Conservation of Food.

The most important job of each one of us at the present moment is to help win the war. We must answer the call to the colors if it comes, if we are selected, but all of us will not be selected and all of us must serve in some capacity. We can all save food, most of us can save fuel, and we can all without exception take some part in the Liberty Loans.

No opportunity should be lost to further the cause of food conservation. Every person eats, and every periodical printed, if it is read at all, reaches people whose duty it is to help out the food administration. Therefore let us add our appeal to all the other voices raised in this cause. Look to your food buying and your eating. Save the wheat, save fats, save sugar, and let nothing useful find its way into the garbage pail. A full garbage pail gives comfort to the enemy. As heads of families and employers of eaters your influence may be extended widely in furthering this movement which is a large part of the price of ultimate victory. Fuel conservation is as vital as food conservation. If we have filled the pages of The Locomotive nearly full of fuel saving, it is because we feel that we will have fallen short of "doing our bit" if any help which we can give in this important matter has been withheld.

The New Food Pledge.

A new form of food pledge for men and all those not directly in charge of a household has been adopted by the United States Food Administration and will be the basis of a national campaign during the week beginning October 21, when every resource of publicity and organization will be enlisted to secure signatures to the food pledge all over the United States.

This new form, which is printed below, may be published in the columns of any periodical, with instructions to readers to sign, clip, and send to the United States Food Administrator in your State or to the Food Administration, Washington, D. C. Publication of this pledge is a patriotic service.

To the United States Food Administration:

I pledge myself to use the practical means within my power to aid the Food Administration in its efforts to conserve the food supplies of the country, and, as evidence of my support, I wish to be enrolled with yourselves as a volunteer member of the Food Administration.

Name ....

Street ....

City ....State ....

There are no fees or dues. We want your help, in the form both of your personal efforts to economize food and your influence with others toward food economy and wise control of our national supply. If you will give this help it will be a direct service to your country.

As member of the United States Food Administration you can directly aid the Food Administration and help win the war by: (1) Eating as little wheat bread or other wheat products as circumstances permit, and, if possible, not more than once daily; (2) eating meat (beef, mutton, or pork) not oftener than once a day; (3) economizing in the use of butter and discouraging the excessive use of other fats; (4) cutting your daily allowance of sugar in tea or coffee, and of sweet drinks, candy, and in other ways helping to lessen the consumption of sugar; (5) eating more corn, rye, vegetables, fruit, fish, and poultry in place of wheat and meat; (6) avoiding waste of all kinds; and (7) urging in your own home or the restaurants you frequent the necessity of economy in food, and requesting the observance of these pledges by other persons.

Our problem is to feed our allies this winter by sending them as much food as we can of the most concentrated nutritive value in the least shipping space. These foods are wheat, beef, pork, dairy products, and sugar.

Our solution is to eat less of these and more of other foods of which we have an abundance, and to waste less of all foods.

What the United States Food Administration Says.

A sufficient and regular supply of food for the maintenance of the great field armies of our fighting allies and of their no less great armies of working men and working women in the war industries, and, finally, for the maintenance of the women and children in the home, is an absolute necessity, second to no other, for the successful prosecution of the war for liberty. In the providing of this food for the great allied food pool the United States plays a predominant part, for we have long been the greatest granary, food store, and butcher shop in the world.

We can not and we do not wish, with our free institutions and our large resources of food, to imitate Europe in its policed rationing, but we must voluntarily and intelligently assume the responsibility before us as one in which everyone has a direct and inescapable interest.

Extending the Life of Cast Iron Boilers.

The open season for the cracking of cast iron sections in heating boilers is upon us. The cast iron heating boiler needs to have conservation applied to it at all costs this year. With shipping facilities congested and directed toward the necessities of the Government, and with the high cost of all iron and steel products coupled with the need of diverting all available iron and steel to war uses, a special duty rests on the operators of cast iron heaters.

It is not only to be borne in mind that the breakage of sections is expensive and troublesome, but this year it is likely to result in a prolonged shut down of the heater, perhaps at a critical time when it can be spared only at the expense of discomfort, or even suffering.

It may be accepted almost as an axiom that clean cast iron boilers with the proper amount of water in them seldom crack sections, with perhaps a single exception. Cast iron steam boilers, if cold, may have sections cracked by the building up of a too intense fire of wood or refuse, which will heat the upper portion of the boiler above the water line to a considerable temperature before the water has time to become heated. This results in the differential expansion of the sections. The upper part, not being cooled by water or steam, since steam has not had time to form, expands while the lower part is prevented from expanding by the still cold water and the result is frequently to be found in one or more cracked sections, which were unable to stand the strain.

Therefore it is well to start your fires slowly, and to then keep plenty of water in the boiler, in this way you will have gone far toward the prevention of cracked sections.

The water will sometimes leave a heating boiler, due to several causes. A bit of scale may have lodged in the blow-off, preventing the tight closing of the valve. The boiler and piping may become foul from sand and foreign matter lodged in new radiators or in the boiler sections if new. This should be gotten rid of at the beginning of the season by washing out the system, which is perhaps best done by changing the water in the system at intervals of a few days until it comes away clean and free from sediment. The reason for this is that as steam flows out to the system and condenses, afterwards returning to the boilers, it loosens and carries back the dirt from all parts of the piping and connections. The dirt will not all come back at once, however, some of it will resist the softening action of the steam and hot water longer than other portions, and will only be washed out by the repeated loosening of small parts of the deposit. Thus it is easy to see why it is essential to change the water several times at intervals of a few days before the system is quite clean. If the dirt is allowed to remain in the boiler it will be apt to cause trouble in two ways, first it will make the boiler froth and foam, like a tea kettle boiling over. When this happens, the steam flowing out of the boiler, especially when it is flowing rapidly, will pick up this water froth and carry it along with it to the pipes and radiators. Now it is easy to see that if the usual amount of steam is flowing from a boiler, and if each pound of steam is carrying with it several ounces of water, the lowering of the water level in the boiler will be much more rapid than ordinary. This trouble will be experienced most markedly when the drafts are opened in the morning and the steam is flowing rapidly out into the piping to heat up radiators which have become cold over night. At this time the flow of steam will in most cases be the greatest that will be reached during the day's operation. Now the faster the steam flows the more the water foams, and the more foam will be carried away from the boiler. In addition to this, the cold radiators condense almost if not quite all the steam which is sent to them during the time when the building is heating up to the day's temperature. As this steam is condensed in the radiators, there is a tendency for the pressure in the radiators to be less than that at the boiler, and the water formed from the condensed steam often "hangs up" for a while before it starts to flow back freely to the boiler. On this account it is often the case that the water level in the boiler will always drop considerably during the draft of steam which follows the morning start up, even if the water is clean and boils quietly. The operator usually knows that this will happen, he knows about how high the water should stand before the draft of steam begins, so that it shall not get dangerously low before the water starts flowing back, and all goes well, but let dirt from new castings get into the boiler, in the way we have spoken of above, and the result is that the steam carries water out of the boiler with it, the water hangs up in the pipes as usual, but since the steam has drained the boiler of so much more water than ordinary, the level may very well reach so low a point that a section is cracked before the operator is aware that there is any trouble. That this is a probable result is seen from the fact that it will take place when the drafts are open and the fire is hot, and that it will occur at a time when the fireman is accustomed to see his water line lowering, and so he may easily fail to note that the water is dropping at an unusual rate until the hot fire has done the damage.

Another trouble is that the mud if it remains in the boiler and fails to cause foaming enough to make its presence known, will gravitate to the hottest part of the inner surface, from which most steam is formed, and there bake on into a hard coating of scale. The longer the material remains in the boiler the harder it will get and unless it is of a very porous character, it will serve as a check to the flow of heat from the fire to the water. When this happens, the metal of the section, receiving heat at the old rate, but unable to give it up as fast as formerly, will get hotter and hotter, until in many cases the difference in temperature between the clean and dirty parts of the section will cause expansion strains sufficient to cause a fracture. Even if a failure does not result, the fact that it is harder for the heat to enter the water will result in a waste in coal, which at the present time is quite as unpatriotic, and perhaps as expensive as a waste of sections.

Low water, resulting in cracked sections may come from other causes than a dirty boiler. It may result if two boilers arranged to work together on a system are not correctly piped, or it may follow in severe weather from attempting to force a boiler too small for the system. If there is the slightest difficulty experienced in retaining a safe amount of water in the boiler at all times, the matter should be investigated, and if it is not obvious what has caused the trouble, some one competent to analyze the situation should be called upon for advice. If the boiler is insured, the inspector should be notified so that he may investigate conditions and suggest the proper remedy.

Keeping the Wheels Turning.

The recommendations of the boiler inspector are always of value. During war times, however, they should attract and hold the attention of owners and managers as never before. A full co-operation between steam users and boiler inspectors should if intelligently directed prolong the life of equipment and greatly diminish shut downs and delays incident to repairs.

Our attention is being focussed on the question of fuel saving, but it is well to stop a moment and consider the parallel problem of boiler saving. Fortunately many of the measures for promoting the one end further the other and it is quite possible to make a sort of survey of the condition of a boiler plant which will at one and the same time look toward stopping fuel leaks and aid in increasing boiler safety. It will be perhaps enlightening in this connection to study the table of defects discovered by Hartford inspectors in 1916. Defects which were reported and investigated from the standpoint of boiler safety rather than economy, and see how they might be expected to affect the economical performance. It will be perhaps a new viewpoint for some of our readers and we believe it will give food for profitable reflection.

It must always be remembered that many sorts of defects would have an adverse effect on fuel economy long before they would be noted as dangerous by the inspector, and that in some cases, as for instance, the troubles reported under the head of defective settings, there might be a tremendous disparity between the degree of defectiveness which would prove very uneconomical and that which would endanger the safety of the boiler.

Following through the defect list in detail, we find that the first item is one of 28212 cases of sediment or loose scale, of which 1593 were reported dangerous at the time of inspection. Every one of these more than 28000 boilers was making steam by sending heat through both metal and mud before reaching the water, not to mention the probability of an additional layer of soot on the outside of the boiler, for except in bad water districts where sediment can be ameliorated but not altogether avoided, it is not unusual to find that the boiler which is dirty inside is dirty outside as well.

The next item on the list, closely related to the first, is of 42,877 boilers showing adhering or hard scale, of which 1612 were reported dangerous. We would expect the adhering scale to be more detrimental to the flow of heat from the metal into the water than the loose scale or sediment, as it forms a definite layer preventing contact of the water with the metal, while the loose scale or mud may be in motion due to the circulation of the water. Loose scale however usually becomes hard and adherent if permitted to remain in the boiler and so all these cases represent conditions at once wasteful and tending toward a shortened life for the boiler. Hence an inspection report pointing to such a condition should be given instant attention.

The next two items on the list are grooving and internal corrosion, with 2,568 cases of grooving and 19,008 of internal corrosion. Neither of these troubles would of itself effect the economy of operation except as they affect the strength and therefore the safe pressure which the boiler may carry. Grooving is due both to mechanical action, dependent on the design of the boiler, and corrosion. Therefore it is well to consider the two cases together. Internal corrosion is of course like scale and sediment, a feed water trouble, and in many if not most cases the means best fitted to allay scale will tend to arrest the corrosion, although in the case of some very pure waters serious corrosion may result with no scale and here water treatment would be required for corrosion where it might not be needed otherwise.

External corrosion, the next item on the list is the result usually of leakage and soot. Wet soot is capable of forming free sulphuric acid, which is of course, corrosive. Here the defect follows other troubles, and in removing the cause of the leakage and cleaning up the soot, it is almost certain that the steaming economy will be improved at the same time that the life of the boiler is extended.

Defective bracing does not in itself effect economy excepting as it limits the safe pressure, but it should nevertheless be remedied so that the life and output of the boiler may be prolonged. The same reasoning applies to defective staybolts, with the additional fact that they sometimes become defective from the presence of excessive scale or corrosion. In any case the removal of the cause, if possible, and the renewal of the defective bolts will add to the useful life of the boiler.

Defective settings is an item which is equally important from the standpoint of economy and safety. Slight defects which admit air leakage, defective baffles and arches which permit the hot gases to short circuit to the stack without traversing the heating surface for the designed distance, defects which permit of poor combustion or unequal draft, the accumulation of soot and fine ash, all these things will tremendously affect the coal consumption long before they menace the safety of the boiler. It is only when the defects have proceeded far enough to threaten to allow the boiler to become displaced on its brackets or suspension, or to permit a cold air blast or a blast of flame or hot combustion products to reach an unprotected but vulnerable part of the boiler's anatomy which is not supposed to receive such treatment that we become concerned from the safety standpoint. It is not possible to over emphasize the necessity for constant care in avoiding air leaks, defective bridge walls, arches, baffles, etc., if coal economy is to be had. Air leaks go on all the time, and losses from a defective setting continue in action every instant that the boiler is steaming, while they do not diminish in extent if left to themselves. (Incidentally the same may be said with equal force of defective flues and dampers.)

Fractured plates and heads usually require attention to enable the boiler to remain in service. Their causes are of so many sorts that it is hardly possible to analyze them here, and fortunately they are not among the more frequently found defects. In a great many cases, however, the conditions which cause fractured plates are those which would correspond with uneconomical working, although of course the trouble may arise from defects incident either to the manufacture of the material or the design and workmanship of the boiler.

Burned plates usually come from careless operation, dirty boilers or defective settings, and therefore usually accompany waste. If the causes of burning are removed, therefore, it is easily seen that a step will have been taken toward greater efficiency. Laminated plates need no mention here, they are clearly defects of the material and manufacture, and in the same way defective riveting is just as clearly a matter of defective boiler making, and does not enter into the present discussion.

Leakage around tubes, the next item on the list, is a prolific source of trouble. 12,554 cases were reported in 1916, of which 1,581 were reported as dangerous. Tube leakage is frequently due to scale or oil in the boiler, which, collecting around the tube ends permits of local overheating which loosens the tube in the sheet. It is obvious that the removal of the cause of this difficulty will add to the economy of operation as well. Defective tubes and flues are numerous, and they often result in costly accidents with severe personal injuries or even loss of life. 15,080 cases, of which 4,989 were dangerous were found in 1916. The causes of tube defects are complex and often baffling but much of the trouble may be avoided by strict attention to cleanliness of the boiler and the maintenance of the setting and baffles in a high state of repair, with careful attention to the water level, all of which are at the very foundation of efficient steam production.

Leakage at seams may be placed in much the same category, for while seams may leak from defects in boiler design and workmanship, they may also follow low water, dirty heating surface, or defects in the setting which permits a too intense heat to be concentrated on a sensitive spot. The economical advantage of removing all these possible causes of trouble is in the light of what has been said above, too obvious for repetition.

Of the remaining items on the list, defective water gages and blow-offs, and cases of low water may often represent cause and effect that is the low water may be a result of the defective blow-off or water gage. Carelessness is of course the most common cause for low water, but no boiler plant which is operated with either a defective blow-off, a defective water gage, or in a manner so lacking in intelligence as to permit of a shortage of water is apt to shine as a producer of maximum amounts of steam from minimum quantities of fuel.

Defects in water gages and blow-offs, together with those to safety valves and pressure gages, including inaccurate gages and over loaded safety valves are of such vital importance to the existence of the boiler and boiler plant and to the lives of the operating force that no steam user would knowingly permit them to remain unremoved.

The purpose of the present article has been to point out in how many cases the defects found in a single year by HARTFORD inspectors have had their origin in conditions which are under the control of the steam user. Leaving out the defects due to materials, workmanship and design, the list is largely composed of troubles which can be avoided or minimized by cleanliness of the boiler and setting and attention to the small details of upkeep. Such care will pay double dividends by its saving of both plant and fuel.

The Use of Pulverized Fuel on Locomotives.

By JOHN E. MUHLFELD, New York, N. Y.

As the limiting factor of a modern steam locomotive is the evaporation and superheat production capacity of the boiler, the rate and effectiveness of the combustion become the controlling elements. While there is no limit to the amount of fuel that may be mechanically supplied to a locomotive firebox, there is a decided limitation to the amount of fuel that can be burned on a given grate area and effectively utilized.

When coal is burned on grates a rate of about 50-lb. of run-of-mine grade, — or about 60 lb. of lump grade of bituminous coal, — is the maximum allowable per sq. ft. of fire surface per hr. for the greatest practical boiler efficiency. However, as this rate of firing limits the consumption to a total of from 3000 to 6000 lb. per hr. for the average modern locomotive of great power, and as the actual coal that must be supplied to the firebox by mechanical stoking in order to maintain the boiler pressure frequently reaches a rate of 150 lb. per sq. ft. of grate area per hr., or a total of from 9000 to 15,000 lb. per hr., the boiler efficiencies often run as low as from 55 to 45 per cent. and even less.

The necessity for eliminating grates if much over 12 lb. of water is to be evaporated per sq. ft. of water-heating surface per hr., is therefore quite apparent provided reasonable efficiency is to be obtained, and this brings us to the problem of burning solid fuel in a manner that will overcome the principal deficiencies in the steam locomotive, and enable it to maintain its present position in the steam-railway field and to assist further in reducing the high cost of railway living.

As I presented before the 1916 Annual Meeting of the Society an exhaustive report on Pulverized Fuel for Locomotives, which, with the discussion, was abstracted in THE JOURNAL,[1] I will make this paper quite brief.

When solid fuel is burned on grates in a modern locomotive, from 45 to 70 per cent. of the heat is absorbed by the boiler. Of that which is wasted the majority is due to incomplete combustion, sparks, cinders, smokebox gases and combustible in the ash. Owing to the necessary limited grate area, the high draft essential to induce sufficient air through the grates for combustion causes these enormous losses through unburned gases and fuel that are exhausted from the stack or carried into the smokebox and ashpan.

Generally speaking, it is necessary to break up any fuel to such uniform size that the oxygen in the air can unite perfectly for combustion. A

[1] THE JOURNAL A. S. M. E. December 1916, p. 983; January 1917, p. 48; February 1917, p. 141.

deficiency in this respect results in some portions of the fuel passing off as unburned hydrocarbons, and other portions being left as incompletely burned coke. For the best results coal should be sized to about 3-in. cubes for burning on locomotive grates, but as this is now quite impracticable, due to the methods of mining and the cost, a mixture of fine and large coal is usually supplied, which tends to burn irregularly and results in a reduction of boiler capacity and efficiency.

As a 1-in. cube of coal exposes but 6 sq. in. of area for absorbing oxygen and liberating heat, but when pulverized to the proper fineness will expose from 20 to 25 sq. ft., the first essential for complete combustion is the breaking up of the fuel into dry minute and uniform particles. Then, by diffusing these so that each may be surrounded with the right quantity of air for complete combustion, it will be possible to burn practically all of the available combustible, regardless of the percentage of non-combustible.

Any solid fuel that, in a dry pulverized form, has two-thirds of its content combustible, is suitable for pulverizing, and to produce the best results should be mechanically dried and milled so that it will be of about the same dryness and fineness as portland cement. The total cost to prepare pulverized fuel properly in a suitably equipped plant will range from 15 to 45 cents per ton, and for a railway coaling station of average capacity will be less than 25 cents per ton.

In the process of burning pulverized fuel the fuel in the enclosed tank gravitates to the conveyor screws which carry it to the fuel and pressure-air feeders where it commingles with the air. It is then blown through the connecting hose to the fuel- and air-delivery nozzles and blown into the burners. Additional air is supplied and the mixture is drawn into the firebox by the front-end draft. Additional air is supplied in the furnace where complete combustion of the fuel in suspension takes place. The liquid ash runs down the under side of the roof and the sides and ends of the furnace and is precipitated into the self-cleaning slagpan, where it solidifies into a mass that can be readily dumped.

The blower is driven by a constant-speed steam turbine which requires no regulation or control. The fuel conveyors, feeders and comminglers are driven by a variable-speed steam turbine which is controlled by the fireman by means of a handwheel conveniently located in the cab.

The smokebox-gas analysis will average between 13 and 14 per cent. of CO_2 when coal is fired at the rate of 3000 lb. per hr.; between 14 and 15 per cent. at the rate of 3500 lb. per hr.; and between 15 and 16 per cent. at the rate of 4000 lb. per hr., so that as the rate of combustion increases there is no falling off in the efficiency, as obtains when coarse coal is fired on the grates.

The waste of fuel from the stack, where coal having a large percentage of dust and slack is used; the lowering of the firebox temperature and draft, due to opening of the fire door; and the resultant variation in steaming and general results under high rates of burning fuel on grates, where all of the foregoing factors are involved, are entirely eliminated.

The uniformity with which locomotives can be fired is indicated by the fact that the regularly assigned fireman can maintain the steam within a variation of 2 lb. of the maximum allowable pressure, without popping off.

While the smokebox temperatures have varied between 425 and 500 deg. fahr., the superheat in the steam will vary between 200 and 325 deg. fahr., depending upon the rate of working.

With pulverized fuel a locomotive having the boiler filled with cold water may be brought under maximum steam pressure within an hour, and the fuel feed then stopped until it is called for service. When standing or drifting at terminals or on the road the fuel feed can also be discontinued, as the steam pressure can always be quickly raised. After the trip or day's work the locomotive can be immediately stored or housed, the usual ashpit delays being entirely eliminated.

From the actual operation of steam locomotives in regular train service, the use of pulverized fuel has demonstrated in particular the practicability of eliminating smoke, cinders, sparks and fire hazards; increasing drawbar horsepower per hour per unit of weight; reducing non-productive time at terminals; improving the thermal effectiveness of the steam locomotive as a whole; utilizing otherwise unsuitable or waste fuels; eliminating arduous labor; providing greater continuity of service, and producing more effective and economical operation and maintenance.

Journal A. S. M. E.

Save Fuel in the Heating Boilers.

The first principle of fuel economy in heating as in power boilers is cleanliness. The boiler should be scrupulously clean, inside and out. There should be no mud or deposit to hinder the flow of heat from the metal into the water on the inside, and no soot blanket to shut out the heat from the fire to the metal on the fire side. Soot hinders the flow of heat, checks the draft by accumulating in narrow spaces, and helps shorten the life of the boiler in many cases by giving corrosion a chance to start. The smoke pipe or flue should be clean and tight. If there is a gap where it joins the boiler or where it enters the chimney, a little asbestos plaster, wet up with just enough water to form a stiff mortar and applied will make a tight and lasting job. See that the dampers are not warped, broken or rusted so that they fail to operate easily or close tightly. Clean-out doors have a bad habit of gathering rust which prevents tight closing. This allows air to leak in and may be remedied by cleaning the seating of the door and frame. Look over lagging and pipe covering. Perhaps it needs repair, if so remember that the little heat leaks mean fuel leaks and that they work twenty-four hours a day during the heating season. See that damper regulators are free, well adjusted and working properly. The diaphragms especially may need attention. See that chains and pulleys connected to the damper gear are clear and free. Cleanliness and good order here will save many a shovelful of coal later. Perhaps a fine adjustment of the fire by the damper regulator is hard to secure under your conditions. Would a thermostat arranged to maintain a constant temperature in an average room help? Uniform temperatures reached through steady fire conditions save much fuel as well as temper. Finally in running a fire see that when the fire is checked, it is done at the check draft instead of the fire door. Remember that a stream of cold air into the chimney through the check draft will stop the "pull" on the fire just as well as the same current of cold air through the fire door, but it will *not* all pass over the hottest parts of the interior of the heater, to take up chimney the heat which has been expensively absorbed from the burning fuel.

The best scheme for regulating a fire is to set the smoke pipe damper each day so that when the ash pit damper is open, the fire will burn up to the maximum brightness needed, as determined by the outside temperature and wind intensity. When less fire is wanted, open the check draft and at the same time close the ash pit damper. (When a damper regulator is applied it will, if working properly, take care of the last operation.) By this means you will draw in the least cold air through leaks around cleanouts, etc. for you will always have the least practical "draft" on the fire pot. When the smoke pipe damper is open, all the pull of the chimney is exerted on the furnace. If at the same time the ash pit damper is closed without opening the check draft, since the flow of air into the furnace through the grate is checked, the chimney will tend to remove the gases from the furnace,— suck them out if you like,— and the result is that every crevice immediately begins to leak a stream of cool air into the furnace, chilling the boiler surface. If the fire is controlled by shutting the smoke pipe damper as far as may be for the fire needed that day, as outlined above, and then further checking when needed by the check damper and ash pit damper acting together, then although the effects of leakage will not all have been removed, the amount of leakage will have been reduced to the minimum possible. If in addition to this, leaks have been stopped as far as possible, then a very appreciable saving of fuel is sure to result.

One more item is worth careful attention. It is to keep the ash pit cleaned out at all times. Ashes accumulating under the grate check the flow of air to the grate, producing generally an uneven and wasteful fire, they tend to let parts of the grate overheat and warp or burn out, and they hinder the method of damper control just outlined. If only a slow fire is needed, it will do no hurt to let a layer of ashes accumulate *above* the grate, and indeed it is good practice to keep the thickness of the fire and ash layer on top of the grates about the same. In mild weather, a thicker layer of ashes and a thinner fire, which is simply the result of less shaking of the grates, will be used, while in cold weather, the ashes will be shaken out more completely, and a thicker fire will be carried, but the level of the top of the fire will always be about the same. This makes for economy, and especially for easy damper control, for the changing layer of ashes on the grates will help out the needed adjustment of the smoke pipe damper, and make that matter less troublesome than might at first seem possible.

Fuel may be saved also in the application or use of the heat. We should carefully refrain from heating unnecessary rooms. Steam radiators should be turned off at night or whenever windows are opened. *Hot water* radiators however must not be shut off when there is danger of their freezing. They may be effectually prevented from "heating all out doors" by covering them with a thick blanket or comforter when windows are open, then on closing the windows and removing the blanket, a hot radiator is at hand to start immediately the work of reheating the room.

Uncovered pipes, in basements, unlagged heating boilers, wasteful firing methods, poor judgment in handling drafts, and above all dirty heaters, leaking smoke pipes and dampers or damper controls out of repair are evidences of a lack of patriotism which far outdistances any detriment that may occur because of them to the pocketbook of the owner or operator.

The Locomotive of The Hartford Steam Boiler Inspection and Insurance Co.

C. C. Perry, Editor.

HARTFORD, OCTOBER, 1917.

Single copies *can be obtained free by calling at any of the company's agencies.*
Subscription price 50 cents per year when mailed from this office.
Recent bound volumes one dollar each. Earlier ones two dollars.
Reprinting of matter from this paper is permitted if credited to
The Locomotive of The Hartford Steam Boiler I. & I. Co.

The Locomotive welcomes friendly criticism. It is glad to be called to account for its shortcomings and gives consideration to suggestions as to its policies, even if it does not always agree with the reasoning expressed by its friends. From time to time suggestions come to it regarding either the form or the scope of the material printed in the monthly lists of boiler explosions. A while back some of our readers expressed a desire for more detailed information regarding the types and makes of boilers to which the reported accidents happened. We replied in these columns that the sources of our information were such that we could not furnish this information in many cases, and in others it was not felt to be feasible for us to distinguish between makers. We had therefore established the proceedure of indicating the type of boiler, as water tube, locomotive type, vertical tubular, etc., if known to us, but not the manufacturer, a method which was fair to all concerned. Then at various times it has been suggested that we did not sufficiently differentiate between the different degrees of accident lumping them all together as explosions. This as we have frequently shown, is not the case. While the lists are headed Boiler Explosions, and have been so headed continuously for fifty years, it has been and is still our practice to indicate the gravity of the accident by the wording of the notice. We have been careful to reserve the word explosion as far as lies in our power to accidents known or credibly believed to be violent, whereas the slighter accidents have always been described as fractures, ruptures, cracked parts, as headers sections, etc., the particular expressions used being chosen with care to represent as nearly as our information permits the true nature of the occurrence. Now some of our friends are calling us to task for including under the general heading of Boiler Explosions the failure by cracking or simple fracture of cast iron heater sections. Our position in this regard is exactly what it has been in the past. We use the heading Boiler Explosions in the same broad sense that it is used in interpreting the meaning of contracts of boiler insurance. This we have done for years. Our friends recognize, we think, just what we mean, and we doubt if any real confusion results from it. Under this broad heading we print our lists, which have become well known and thoroughly established as a source of accurate information, and have been available, as we have just said, during a period of fifty years. The individual items will continue to be as carefully worded as we can make them and we have never described a cracked section in these statements as an explosion unless our information regarding the accident was so faulty as to genuinely mislead us as to what had happened. We think that even those of our readers who express the dissatisfaction will concede this point. Believing therefore that our position is logical and not calculated to mislead anyone we see no reason for changing our established precedent at this time.

With The Colors.

Chief Inspector James L. Foord of the Chicago Department, who was for many years prior to the war Chief Engineer of the Illinois Naval Militia, and on its reserve list at the outbreak of the war, has been recalled to the active list and is now on duty in the Federal service on the Great Lakes with the rank of Lieutenant-Commander.

A. R. Winters of the Chicago Department has enlisted in the Marine Corps, and is now on active service at sea.

Graham R. Hart, from the Home Office drafting room, has enlisted for the aviation branch of the army, and is now stationed at San Antonio, Tex.

"Life in Trenches."

An interesting letter describing the experiences of a member of a Canadian pioneer battalion in active service in France and some of the difficulties of actual life in the trenches, on some of the busiest fronts, has been received by Lieutenant-Commander J. L. Foord, formerly chief inspector of the Chicago department of the Hartford Steam Boiler Inspection & Insurance Company and now senior engineer officer on the *U. S. S. Essex,* on special duty on the Great Lakes.

The letter was written by another employe of the Hartford company, W. Byrtt, formerly one of the inspectors in the Chicago department and now with the 10th Battalion, Canadian Pioneers, Company C, in France.

"I have been on the point of writing to you many times," Brytt wrote Lieutenant-Commander Foord, "but like 'Micawber' I was waiting for a certain something to turn up. It hasn't up to the present, but I don't think it will be very long now.

"Shortly after my battalion arrived in England from Canada, it was split up and divided among several battalions, and I was assigned to the 10th. Toward the end of February, this year, we were orderd to France as a pioneer battalion. Unfortunately, or fortunately, the very day the battalion was to leave one of the men in my hut got the mumps, so all of us in with him were quarantined and had to remain behind and it was a couple of months later before we joined our battalion over here.

"Since I have been in France I have so far got through without a scratch, although I have had several narrow escapes, on two occasions shells bursting not more than 15 yards from where I happened to be, and as Fritzie's high explosive shells have a radius of action from 500 to 600 yards, I consider myself very fortunate.

"When I first came over here our dug-outs were at the base of a very famous ridge. There isn't a foot of ground around there for miles that hasn't been torn up by shells, or trenches, and covered thick with barbed wire. The towns and villages there are a heap of ruins — in some not even a wall remains. It is a sad sight to contemplate, but the saddest of all I think are the graveyards, with their wrecked shell-torn graves, and their monuments scattered around in fragments.

"It is nearly impossible for anyone who has not been there to realize what the inhabitants of that part of France have suffered in the past and are still suffering.

"We left there sometime ago, and are now in another part where the country is not quite so much devastated, but the artillery fire both from us and from Fritzie is terrific. It puts a terrible nerve strain on men — bad enough in daytime; but when you are in a dug-out at night, trying to sleep with shells shrieking over you and bursting near you, knowing what would happen should one make a direct hit, it requires more nerve control, than I have ever experienced, and I have been in one or two tight corners during my sea life.

"Now that the U. S. A. is in it, I am sure many of your friends will be coming across.

"No man should come here unless he is in perfect health. Living in dug-outs the air is bad; the weather here at present is one day hot as you have it in Chicago, the next a downpour of rain, so that one day your clothes are wet through with sweat, and the next day worse with rain, not to speak of mud (one of the most trying things we have to contend with). Even now we are almost up to the knees in it at times, so you can guess what it is like in winter and early spring. The trouble is to keep your clothes dry. It is a hard proposition now, and impossible in winter.

"Again, there is the food. There isn't much to complain about, at least not for me, who has had experience on the British tramp steamers, but there are no 'T' bone steaks, plenty of bully beef, hard tack, pork and beans, ham, etc.

"No doubt you have heard of the plagues of vermin, and it is true there are a few millions, if not billions, around, but it is partly due to the men themselves, as one man who will not look after his personal cleanliness may contaminate 100. Since I have been over here I have been entirely free from them, except for a very short period at the beginning, and I don't use any patent killers.

"I would like to tell you a lot more, but will reserve it for the next time I write. Suffice it to say we have it all over old Fritz, all along the British front, in men, artillery, ammunition and in the air, and all the appliances that go to make modern war.

"I think the U. S. A. is showing great foresight in devoting so much to aircraft, as undoubtedly had we enough we could soon finish this war. I can never forget the pleasant days I spent in Chicago and the pleasure it gave me to serve under you."

Thoughtlessness in Power Plants.

The thoughtless man in the power plant is the type that opens the valve on the wrong boiler and traps a fellow employee inside in a cloud of sizzling steam, who blows down the boilers with the blow-off connection open to a dead boiler with men working inside, who unthinkingly closes the wrong switch or grabs hold of a live high voltage circuit, or numerous other things that could be mentioned. He is thoughtless because he is so busy thinking about what he did yesterday or what he expects to do tomorrow, or puzzling his brains about problems foreign to his work, that he has no time to keep his mind on what he is doing and as a result jeopardizes the lives of his fellow-workers and the equipment under his care.

NEVER DRAPE A LIVE SWITCHBOARD.

Not long ago several painters were painting the ceiling and walls of a large power house. At this particular time they were working above the switchboard. To keep the board and wiring from becoming spattered with paint, they had draped a large piece of canvas over the board and busses. About this time a friend dropped in to visit the chief, who had also come in. He gave one glance at the canvas over the switchboard and then asked the chief what would happen if one of the circuit-breakers should open on a heavy short circuit. The chief saw the point and started to draw the switchboard operator's attention to the dangerous condition when the thing happened.

The system was 600 volt direct-current, and the circuit-breakers were mounted at the top of the board. The old canvas, soaked with paint, oil, benzine, etc., was hung on top of the board and draped down over the front, probably not being over two inches from the carbon contacts of the breakers. It seemed only an instant after the breaker opened before the canvas was a mass of flames. The smoke and fumes blinded the men, who were working directly above, so they were unable to do anything to save themselves, and to add to the situation one of them dropped a small iron bar which went end first through the canvas and fell across the busbars. There was a flash and a roar as the circuit breakers for the machines blew out and shut the whole system down. The men, terror-stricken, jumped to the floor. Two of them were seriously injured, one having both legs broken, and another an arm broken in two places besides several ribs; the rest escaped with minor injuries. The switchboard operator had allowed the painters to cover the switchboard according to their own discretion and had paid little or no attention to how they did it, because he was busy laying out a wiring diagram for a friend's garage.

In another instance several electricians were rearranging the lighting system in a large refrigerating plant. At this particular time they were working above a machine that was of the twin-cylinder, single-acting type. The watch engineer was regaling the foreman of the electricians with some of his escapades of the previous evening when the chief came along and ordered him to start this particular machine, it being shut down at the time. He had the oiler start the water over the condenser and see that the valves on the condenser were open, while he went around and opened up the oil cups and got the machine ready, keeping up a running conversation with the foreman all the time. After he had the machine ready he rocked it back and forth a few times to warm it up while he was waiting for the oiler to come back from the condenser. As soon as the oiler returned he told him that everything was all right and to go up on the deck and open the suction valves as soon as the machine was turning over. The oiler did as he was ordered, and the machine had turned over but a few revolutions when the relief valves operated on both cylinders, which, as stated before was directly below the electricians. Two of them with a little more presence of mind than the others held their breaths while they caught a rope around a girder and slid to the floor. Of the other two, one was overcome by the fumes and dropped to the deck of the machine and was not brought to for over two hours, and was laid up for several weeks; the other jumped to the deck, breaking his leg.

THE CHIEF MAKES A SERIOUS ERROR.

The signal circuit of one of the old style "type A" solenoid-operated, remote-control switches in a large substation became inoperative on account of an open circuit, and the chief operator was ordered to repair it. He removed the disconnecting clips from one side of the switch and proceeded to repair the signal circuit. The high tension side of the system of the station was operated at 6600 volts, three phase and 60 cycles. When he had the circuit repaired and the switch operating properly as indicated by the signal lights, he left it in the open position, as shown by the signal light, and ordered one of his assistants, both of whom were new men at this kind of work, to replace the disconnecting clips while he directed the man as to the proper procedure. To thoroughly impress the new man with the hazard of this operation, he related a number of instances where dire disaster had overtaken operators that had neglected to take the proper care in the operation.

When everything was ready, the clip for the first phase was placed without trouble, as this did not close the circuit, but when the attempt was made to place the clip for the second phase, there was a blinding flash and a roar and the station was shut down. The switch instead of being open as the chief supposed it to be was closed.

Unless one takes the trouble to look closely at this type of switch, it is not a simple matter to determine if it is closed or open. There was a standing order to every operator on the system to closely inspect this kind of switch before placing or removing the disconnecting clips, in order to determine the position of the switch. When repairing the signal circuit, the chief had reversed the connections so that the switch showed open when it was closed. Being busy with impressing the new men with the danger incident to the operation he neglected to inspect the switch to determine if the signal circuit indicated correctly, and the result was that the man was laid up for several weeks with severe burns, the switch was badly damaged, and the station was shut down for nearly half an hour.

These are but a few striking examples. Anyone can cite such instances, more or less serious, and all of them avoidable if the operator had but kept his mind on what he was doing, instead of performing the operation mechanically. The absent-minded man has no business in the modern power plant, and if he is unable to take enough interest in his work to keep his mind on what he is doing, he had better look for a less exacting vocation where the results of his mistakes are not of much consequence.

E. W. MILLER, in *Power.*

Spontaneous Combustion.

When we speak of spontaneous combustion we usually refer to that peculiar form wherein ignition takes place without evidence of the employment of any external agent. When ignition has taken place combustion follows the same laws, whether of spontaneous or other origin, and these laws always represent more or less complex chemical actions. Almost all chemical actions are attended with the liberation of considerable heat, and the quantity of heat set free is constant, whether the action be relatively slow, as in the decaying of a piece of wood, or whether it be rapid, as in the combustion of a similar piece of wood in a furnace, the products of combustion being identical in either case. Combustion, as we usually understand it, is the union of a substance with oxygen, but there are numerous instances where oxygen is not involved at all. The velocity of combustion increases with marvelous rapidity with rise of temperature, a rise of 200° F. increasing the velocity one thousand-fold.

Perhaps one of the commonest forms in which spontaneous combustion manifests itself is in the ignition of a piece of cotton waste or an old rag saturated with oil and left lying in a warm place. Only certain oils possess the property of spontaneously igniting, and of these the most dangerous is linseed oil, the boiled variety being much worse than the raw, due to slight changes in its chemical structure which have been effected by the boiling, and due also to the presence of metallic salts (such as lead acetate, litharge, and manganese dioxide), which tend to accelerate the process of "drying" by acting as oxygen carriers. When spontaneous combustion results from an oil-soaked rag (or an oil mop, for instance), having been left carelessly in a warm room or in the sun, it is caused by the rapid oxidation of the oil spread out over the large surface afforded by the folds of the cloth — the greater the exposed surface the more rapid the oxidation — and as the oil continues to combine with more and more oxygen from the air, the temperature gradually rises until sufficient heat has been developed to cause the mass to burst into flames. Mineral oils are not considered dangerous in this respect, and are sometimes added to quick-drying oils to lessen the danger of spontaneous ignition.

The reason why a can of linseed oil does not ignite when left uncovered is that the small surface exposed to the air cannot develop heat with sufficient rapidity to raise the whole body to the required temperature. Many other forms of spontaneous ignition occur, such as the ignition of finely divided particles of combustible substances suspended in the air, the oxidation of iron pyrites in soft coal, the slow oxidation of heaps of organic matter, as manure and hay and others. In all of these the surface-volume conditions play the important part in governing the relation of heat generation and dissipation upon which depends the rise in temperature.

Jour. Frank. Inst.

Boiler Explosions 1917.

May, 1917.

(202.) — The boiler of a Pennsylvania R. R. locomotive exploded May 1, at Philadelphia, Pa. Five men were killed and two others injured.

(203.) — A tube ruptured and three headers failed May 1, in a water tube boiler at the plant of the National Malleable Castings Co., Toledo, O.

(204.) — The boiler of a Santa Fé locomotive exploded May 2, near Holbrook, Arizona. The exploding engine wrecked another engine with which it was coupled, making a "double-header," and also the entire train. One man was killed and two others injured.

(205.) — An acetylene tank exploded May 2, at the plant of The Buffalo Dry Dock Co., Buffalo, N. Y. One man was killed and three others hurt.

(206.) — A boiler exploded May 3, at the Girard grain elevators, Girard Point, Philadelphia, Pa. Two men were injured.

(207.) — A blow-off pipe failed May 3, at John G. Fester's mill, Federalsburg, Md. One man was critically injured.

(208.) — On May 4, a blow-off failed at the Evans Hotel, Hot Springs, S. Dak. One man was seriously scalded.

(209.) — A boiler ruptured May 4, at the plant of the Diamond Coal and Coke Co., Diamondville, Wyo. The boiler was so badly damaged as to require replacement.

(210.) — A valve on a steam line failed under 200 lbs. pressure May 4, on the *U. S. S. Nakomis,* foot of Arsenal St., St. Louis, Mo. Seven men were scalded, one probably fatally.

(211.) — A boiler exploded May 5, at the plant of The Pennsylvania Clay Co., Crow's Run, Pa. The boiler was badly wrecked, one man was killed, one fatally injured, and two others slightly injured as a result of the accident. (See July, 1917, LOCOMOTIVE.)

(212.) — On May 6, a section of a main steam pipe failed at a threaded joint at the Market St. gas plant of The Public Service Corporation of New Jersey, Newark, N. J.

(213.) — On May 8, a section cracked in a cast iron sectional heating boiler at the plant of The Sterling Engine Co., Buffalo, N. Y.

(214.) — A boiler exploded May 8, at the plant of the Albany Ice Cream Co., Albany, Ga. The fireman was fatally injured, and considerable damage done to the plant.

(215.) — On May 9, the boiler of a Northern Pacific locomotive exploded at Kennedy, Wash. One man was instantly killed and two others injured.

(216.) — A boiler ruptured May 9, on the lighter "Success," owned by Frank C. Taylor, and engaged on contract construction at New Bedford, Mass.

(217.) — A tube ruptured May 9, in a water tube boiler at the Union Stock Yards plant of Swift and Co., Chicago, Ill.

(218.) — On May 10, a boiler ruptured at the plant of the Luxora Water and Light Co., Luxora, Ark.

(219.) — On May 11, five sections failed in one cast iron sectional heating boiler and three in another at the Convalescent Children's Home of the Children's Aid Society, Chappaqua, N. Y.

(220.) — A header fractured May 14, on a fuel economizer at the plant of the Columbia Chemical Co., Barberton, O.

(221.) — Five headers failed May 14, on a water tube boiler at the plant of the Chicago Consolidated Bottling Co., Chicago, Ill.

(222.) — On May 22, two sections failed in a cast iron sectional heating boiler at the cigar factory of William H. Kildow, Tiffin, O.

(223) — A tube ruptured May 22, in a water tube boiler at the plant of the Inland Steel Co., Indiana Harbor, Ind.

(224.) — On May 23, a tube ruptured in a water tube boiler at the plant of The Atlantic Refining Co., Fairport, O.

(225.) — Two sections failed May 23, in a cast iron sectional heating boiler at the Boys Hotel, 136 E. 127th St., New York City, operated by the Children's Aid Society.

(226.) — On May 25, the crown sheet dropped on a vertical tubular boiler at the plant of Kraeuter and Co., Inc., Newark, N. J.

(227.) — A blow-off failed May 25, at the Evans Hotel, Hot Springs, S. Dak. This is a distinct accident from the one reported above at the same location.

(228.) — A steam kettle, exploded May 26, at the plant of the W. N. Clark Canning Co., Rochester, N. Y. Two people were slightly injured.

(229.) — On May 29, two tubes pulled from a junction box in a water tube boiler at the plant of The George Ziegler Co., Miilwaukee, Wis.

(230.) — A hot water boiler exploded May 30, at the picking house on the duck farm of A. B. Soyars, Riverhead, L. I., N. Y.

(231.) — On May 31, a tube ruptured in a water tube boiler at the Williamsburgh power plant of the Transit Development Co., Brooklyn, N. Y.

June, 1917.

(232.) — A boiler ruptured June 1, at the plant of The R. Inglis Sons Co., Youngstown, Ohio.

(233.) — On June 2, a blow-off failed at the plant of D. C. Berry, St. Jo, Texas. A five-year old boy, who was at the plant was killed, while his older brother and father were scalded as a result of the accident.

(234.) — A tube ruptured June 3, in a water tube boiler at the water works and light plant of the City of Oxford, Oxford, Miss.

(235.) — On June 4, a tube ruptured in a water tube boiler at the plant of the Pacific Gas and Electric Co., Oakland, Cal.

(236.) — Four sections cracked June 9, in a cast iron sectional heating boiler at the plant of the Clarke Baking Co., Jamestown, N. Y.

(237.) — Three headers failed June 14, on a water tube boiler at the plant of The American Water Works and Electric Co., Birmingham, Ala.

(238.) — An accident occurred to a locomotive boiler June 14, at the plant of the Andrews Steel Co., Newport, Ky. One man was fatally scalded.

(239.) — On June 14, a tube ruptured in a water tube boiler at the electric light plant of The Public Service Corporation of New Jersey, Patterson, N. J. One man was injured.

(240.) — A blow-off failed June 8, at the plant of the Blosset Lumber Co., Burnsville, Ala. One man was seriously scalded while the fireman was fatally injured. They were said to have been working on the blow-off valve at the time of the accident.

(241.) — The boiler of Erie freight locomotive No. 1742 exploded June 11, near Markle, Ind. Three men were killed.

(242.) — On June 12, the steamboat Chrystenah of the line running between New York City and Keansburg, N. J., became disabled off Hoffman Island through the failure of several boiler tubes. She was towed to port in safety.

(243.) — On June 13, an explosion occurred in the steam apparatus used for drying sugar at the Williamsburgh plant of The American Sugar Refining

Co., Brooklyn, N. Y. Fire followed the explosion, and it was feared that twenty people lost their lives.

(244.) — A boiler ruptured June 15, at the plant of The Standard Bleaching Co., Carlton Hill, N. J.

(245.) — The boiler of a locomotive belonging to the Pittsburg, Chartiers and Yougiogheny Railroad exploded June 21, near Thornburg, Pa. Three men were killed and considerable damage done to surrounding property.

(246.) — On June 24, a header fractured in a water tube boiler at the municipal water works plant of the City of Grand Rapids, Grand Rapids, Mich.

(247.) — A header failed June 24, in a water tube boiler at the plant of The Heermance Storage and Refrigerating Co., New York City.

(248.) — The boiler of a saw mill owned by John Burkhard, and operated by him on the farm of Joseph Haynes, near Bloomfield, Ky., exploded June 25. Mr. Burkhard and one other were seriously injured, while his son was instantly killed. One of the injured men was not expected to recover.

(249.) — A tube ruptured June 29, in a water tube boiler at the plant of the Columbia Chemical Co., Barberton, Ohio.

July, 1917.

(250.) — A boiler exploded July 1, at the Edgar Thomson Steel Works, Braddock, Pa. One man was fatally injured.

(251.) — A boiler exploded July 1, at the R. M. Rodoman Morris Canal Dry Dock, a subsidiary of the Weehawken Dry Dock Co., Morris Canal Basin, Jersey City, N. J. One man was scalded and a stubborn fire started at the dock and amongst the shipping in the basin, which was very difficult to control.

(252.) — On July 2, a tube ruptured in a water tube boiler at the plant of the Susquehanna Coal Co., Wilkes-Barre, Pa.

(253.) — A tube collapsed and ruptured in a horizontal return tubular boiler on July 5, at the plant of the City Ice Co., Mobile Ala. One man was fatally scalded.

(254.) — The boiler of a thrashing machine outfit exploded July 6, on the farm of T. C. Jones, South Christian, Ky. One man was seriously scalded and property was damaged to the extent of about $1,000.

(255.) — On July 7, the crown sheet collapsed in a locomotive boiler on the Helena, Parkin and Northern Ry., Parkin, Ark.

(256.) — A tube ruptured July 9, in a water tube boiler at the plant of the Superior Steel Co., Carnegie, Pa.

(257.) — A tube ruptured July 9, in a water tube boiler at the plant of the Columbia Chemical Co., Barberton, Ohio.

(258.) — A boiler exploded July 10, in the Big Hill Oil Field, near Matagorda, Tex. Two men were seriously scalded.

(259.) — A saw mill boiler exploded July 10, near Rowlesburg, W. Va. One man was killed and two others were injured.

(260.) — An accident occurred to a steam line July 10, at the plant of the Schofield Lumber Co., Humbert, Pa.

(261.) — A boiler ruptured July 12, at the plant of W. R. Francis and Bro., Richmond, Va.

(262.) — On July 12, a tube ruptured in a water tube boiler at the plant of the Public Service Corporation of New Jersey, Trenton, N. J. One man was injured.

(263.) — A boiler exploded July 14, near Crawford, Ala. Two men were killed and a third was probably fatally injured.

(264.) — Fifteen headers failed July 14, in a water tube boiler at the plant of the Diamond Alkali Co., Fairport, Ohio.

(265.) — A small boiler exploded July 16, in a laundry near Nashville, Tenn. A man and his wife, who had gone to the laundry to prepare a washing, were scalded, the man fatally and his wife so seriously that doubts were expressed as to the possibility of her recovery.

(266.) — Four headers cracked July 18, in a water tube boiler at the plant of the Howell-Hinchman Co., Middletown, N. Y.

(267.) — On July 18, two tubes ruptured in a water tube boiler at the plant of the Atlantic Refining Co., Franklin, Pa.

(268.) — A locomotive type boiler ruptured on a steam shovel used in connection with quarrying operations by the Commissioners of the Pallisades Interstate Park, Rockland Lake, N. J.

(269.) — On July 20, a header cracked in a water tube boiler at the plant of the Diamond Alkali Co., Fairport, Ohio.

(270.) — A boiler ruptured July 20, at the plant of the Fairmont Electric Light and Water Co., Fairmont, Neb.

(271.) — The boiler of a C. and A. locomotive exploded July 24, at Mason City, Ill. The engineer was badly scalded.

(272.) — Thirteen headers failed July 28, in a water tube boiler at the plant of the Colonial Iron Co., Riddlesburg, Pa.

(273.) — On July 31, four tubes pulled from the tube sheet in a water tube boiler at the plant of the Duquesne Light Co., Pittsburgh, Pa.

The Hartford Steam Boiler Inspection and Insurance Company.

ABSTRACT OF STATEMENT, JANUARY 1, 1917.

Capital Stock, . . . $2,000,000.00.

ASSETS.

Cash on hand and in course of transmission,		$346,803.88
Premiums in course of collection,		388,276.03
Real Estate,		90,000.00
Loaned on bond and mortgage,		1,554,570.00
Stocks and bonds, market value		4,362,015.45
Interest accrued		98,141.14
		$6,839,806.50
Less value of Special Deposits over Liability requirements,		34,518.75
Total Assets,		$6,805,287.75

LIABILITIES.

Premium Reserve,		$2,738,563.68
Losses unadjusted,		67,528.30
Commissions and brokerage,		77,655.20
Other liabilities (taxes accrued, etc.),		166,969.55
Capital Stock,	$2,000,000.00	
Surplus over all liabilities,	1,754,571.02	
Surplus as regards Policy-holders,	**$3,754,571.02**	3,754,571.02
Total Liabilities,		$6,805,287.75

CHARLES S. BLAKE, President.
FRANCIS B. ALLEN, Vice-President. W. R. C. CORSON, Secretary.
L. F. MIDDLEBROOK, Assistant Secretary.
E. S. BERRY, Assistant Secretary and Counsel.
S. F. JETER, Chief Engineer.
H. E. DART, Supt. Engineering Dept.
F. M. FITCH, Auditor.
J. J. GRAHAM, Supt. of Agencies.

BOARD OF DIRECTORS.

ATWOOD COLLINS, President. Security Trust Co., Hartford, Conn.

LUCIUS F. ROBINSON, Attorney, Hartford, Conn.

JOHN O. ENDERS, Vice-President, United States Bank, Hartford, Conn.

MORGAN B. BRAINARD, Vice-Pres. and Treasurer, Ætna Life Insurance Co., Hartford, Conn.

FRANCIS B. ALLEN, Vice-Pres., The Hartford Steam Boiler Inspection and Insurance Company.

CHARLES P. COOLEY, Vice-Pres. The Fidelity Trust Co., Hartford, Conn.

FRANCIS T. MAXWELL, President, The Hockanum Mills Company, Rockville, Conn.

HORACE B. CHENEY, Cheney Brothers Silk Manufacturers, South Manchester Conn.

D. NEWTON BARNEY, Treasurer, The Hartford Electric Light Co., Hartford, Conn.

DR. GEORGE C. F. WILLIAMS, President and Treasurer, The Capewell Horse Nail Co., Hartford, Conn.

JOSEPH R. ENSIGN, Vice-Pres., The Ensign-Bickford Co., Simsbury, Conn.

EDWARD MILLIGAN, President, The Phœnix Insurance Co., Hartford, Conn.

EDWARD B. HATCH, President, The Johns-Pratt Co., Hartford, Conn.

MORGAN G. BULKELEY, JR. Ass't Treas., Ætna Life Ins. Co., Hartford, Conn.

CHARLES S. BLAKE, President, The Hartford Steam Boiler Inspection and Insurance Co.

Incorporated 1866. Charter Perpetual.

INSURES AGAINST LOSS OF PROPERTY

AS WELL AS DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES DUE TO EXPLOSIONS OF STEAM BOILERS OR FLY WHEELS.

Department.	Representatives.
ATLANTA, Ga., 1025-1026 Hurt Bldg.	W. M. Francis, Manager and Chief Inspector. C. R. Summers, Ass't Chief Inspector.
BALTIMORE, Md., 13-14-15 Abell Bldg.	Lawford & McKim, General Agents. R. E. Munro, Chief Inspector.
BOSTON, Mass., 101 Milk St.	C. E. Roberts, Manager. Charles D. Noyes, Chief Inspector.
BRIDGEPORT, Ct., 404-405 City Savings Bank Bldg.	W. G. Lineburgh & Son, General Agents. F. S. Allen, Chief Inspector.
CHICAGO, Ill., 160 West Jackson St.	H. M. Lemon, Manager. James L. Foord, Chief Inspector. J. T. Coleman, Assistant Chief Inspector.
CINCINNATI, Ohio, First National Bank Bldg.	W. E. Gleason, Manager. Walter Gerner, Chief Inspector.
CLEVELAND, Ohio, Leader Bldg.	H. A. Baumhart, Manager and Chief Inspector. L. T. Gregg, Ass't Chief Inspector.
DENVER, Colo., 918-920 Gas & Electric Bldg.	Thos. E. Shears, General Agent and Chief Inspector.
HARTFORD, Conn., 56 Prospect St.	F. H. Williams, Jr., General Agent. F. S. Allen, Chief Inspector.
NEW ORLEANS, La., 833-835 Gravier St.	Peter F. Pescud, General Agent. R. T. Burwell, Chief Inspector.
NEW YORK, N. Y., 100 William St.	C. C. Gardiner, Manager. Joseph H. McNeill, Chief Inspector. A. E. Bonnett, Assistant Chief Inspector.
PHILADELPHIA, Pa., 142 South Fourth St.	A. S. Wickham, Manager. C. H. Dennig, Ass't Manager. Wm. J. Farran, Consulting Engineer. S. B. Adams, Chief Inspector.
PITTSBURGH, Pa., 1807-8-9 Arrott Bldg.	Geo. H. Ward, Manager. Benjamin Ford, Chief Inspector.
PORTLAND, Ore., 306 Yeon Bldg.	McCargar, Bates & Lively, General Agents. C. B. Paddock, Chief Inspector.
SAN FRANCISCO, Cal., 339-341 Sansome St.	H. R. Mann & Co., General Agents. J. B. Warner, Chief Inspector.
ST. LOUIS, Mo., 319 North Fourth St.	C. D. Ashcroft, Manager. J. P. Morrison, Chief Inspector.
TORONTO, Canada, Continental Life Bldg.	H. N. Roberts, General Agent.

7