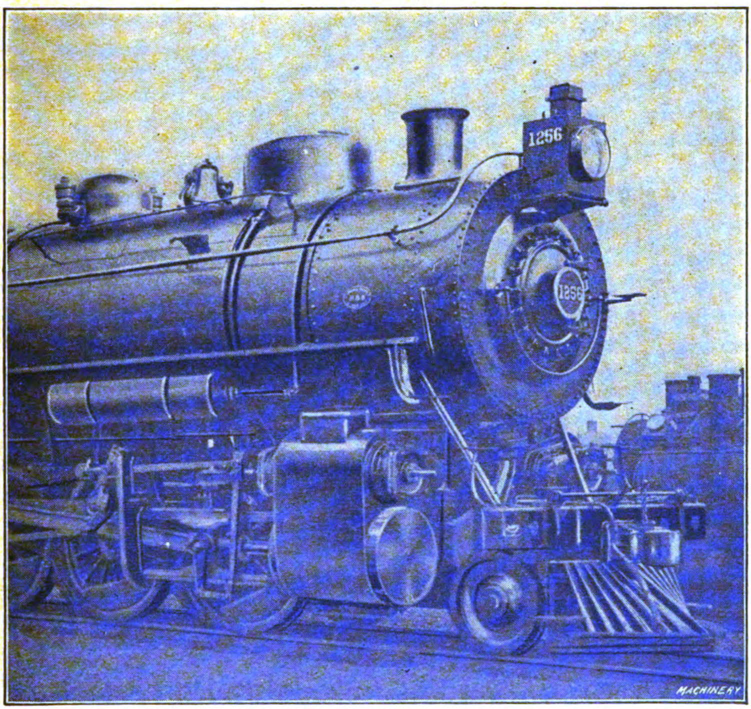
PRICE 25 CENTS

LOCOMOTIVE BUILDING

BY RALPH E. FLANDERS

BOILER SHOP PRACTICE

SECOND EDITION



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NUMBER 83

LOCOMOTIVE BUILDING

By Ralph E. Flanders

Second Edition

PART V

BOILER SHOP PRACTICE

CONTENTS

LOCOMOTIVE BUILDING

BOILER SHOP PRACTICE*

Boiler work has a distinctive character of its own, apart from the other machining operations of the locomotive plant. In fact, it is not composed so much of machining operations as of *tailoring* operations. It has all the characteristics of the tailor's art, though carried out on a much larger scale and with intractable materials. Sheets are carefully cut out to patterns, shaped in turn to suit either rounded or angular forms (both kinds are met with in tailoring). These sheets are riveted together instead of being sewed, but that is a mere matter of detail. This cutting and fitting requires experience, judgment and a certain special knack, if smoothly made and creditable work is

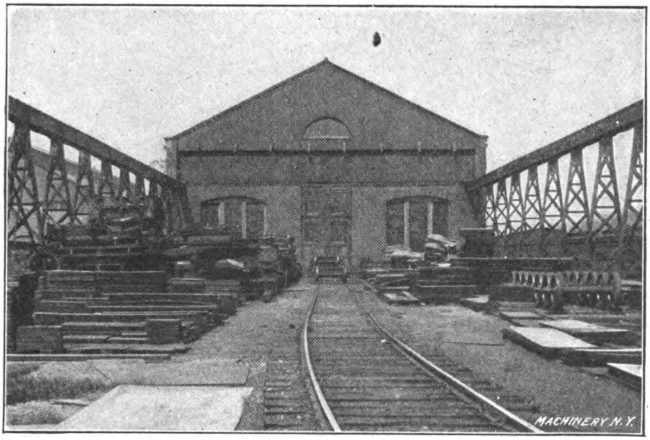


Fig. 1. The Stock Yard of the Juniata Boiler Shop

desired. The more one sees of the boilermaker's work, the more credit one is inclined to give him for his ability to shape heavy sheet metal, especially in the case of so complicated and difficult a structure as the locomotive boiler.

In the first place, the locomotive boiler demands the highest skill of the boilermaker. There is more flanged work, more irregular bending of sheets, more difficult joints to make, than in any other type. Perhaps the Scotch marine boiler comes next in difficulty, but it is by no means a close second. An inspection of the consolidation locomotive boiler shown in Fig. 14, and of the various detail pieces shown in the other engravings, should carry conviction on this point.

*MACHINERY, Railway Edition, November, 1910.

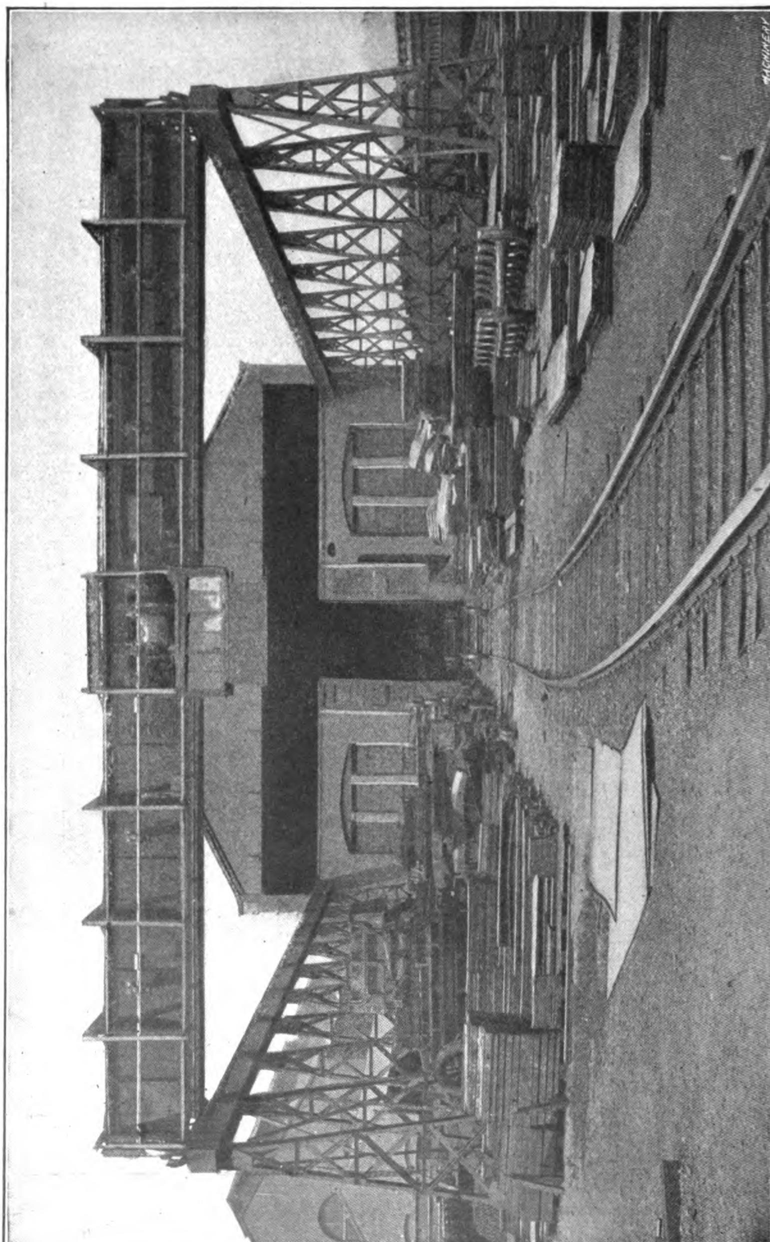


Fig. 2. The Shop Crane run out over the Stock Yard, through Special Doors

This treatise explains in detail the separate operations for each step in the making of a locomotive boiler.

The Boiler Shop

The boiler shop of the Juniata locomotive building plant of the Pennsylvania R. R. is 722½ feet long by 80 feet wide. At the south end, as seen in Figs. 1 and 2, is located the stock yard in which the material to make up the boilers is stored. The regular crane runways of the building are carried out into this yard as shown, special openings in the end wall of the building being prepared to allow the passage of the crane. These openings are covered by swinging doors which may be let down from above; these doors are shown closed in Fig. 1 and open in Fig. 2. Inside the shop the machinery, furnaces, etc., are so arranged that the material passes from the stock yard through to the erecting and riveting floor at the lower end, and thence out into the locomotive erecting shop beyond, without backward moves except in a few unimportant instances. This flow of material is steady and regular, and it is seldom that any one of the three cranes is seen carrying a piece of work backwards for any distance.

Walking down the center aisle, the first thing met with on the left is the laying-out department, where the sheets are marked for trimming and punching. On the right is the lay-out table where flanged work is marked off for punching. Further down on the right and on the left are the punching machines, both for boiler sheets and for the tank work. A large automatic spacing punch is provided for the latter, which, on plain tank work, reduces the time of the punching operations almost to a negligible quantity, doing away with the laying out of the holes and the shifting of the sheets by hand.

Continuing further down we come to the drill presses and the bending rolls, and to the hydraulic flanging presses and furnaces on the left. A short space of the shop on the right is taken up by the tank work, and on the left by miscellaneous operations, such as flue cutting, welding, etc., and pipe bending. Next on both sides of the aisle comes the erecting and assembling space, with the riveting tower at the farther end.

In Fig. 14 is shown a drawing of the boiler of the H-8-B type of consolidation locomotive, illustrated and described in MACHINERY'S Reference Book No. 79, "Locomotive Building, Part I, Main and Side Rods." The important dimensions of this boiler are given, so as to convey an idea of the size of the work. It is probably the largest boiler ever made for consolidation locomotives. It is of the Belpaire type, as shown best in the firebox-end section. Instead of having radial crown stays in this type, the roof and crown sheets *O* and *L* are comparatively flat; the two are stayed together, while the upper edges of the side sheets *N* are stayed across to each other over the crown sheet.

One of the advantages of this type, from the standpoint of the experience of the Pennsylvania R. R., is that it allows the fire-box a better chance to "breathe"; that is to say, it gives it greater flexibility for

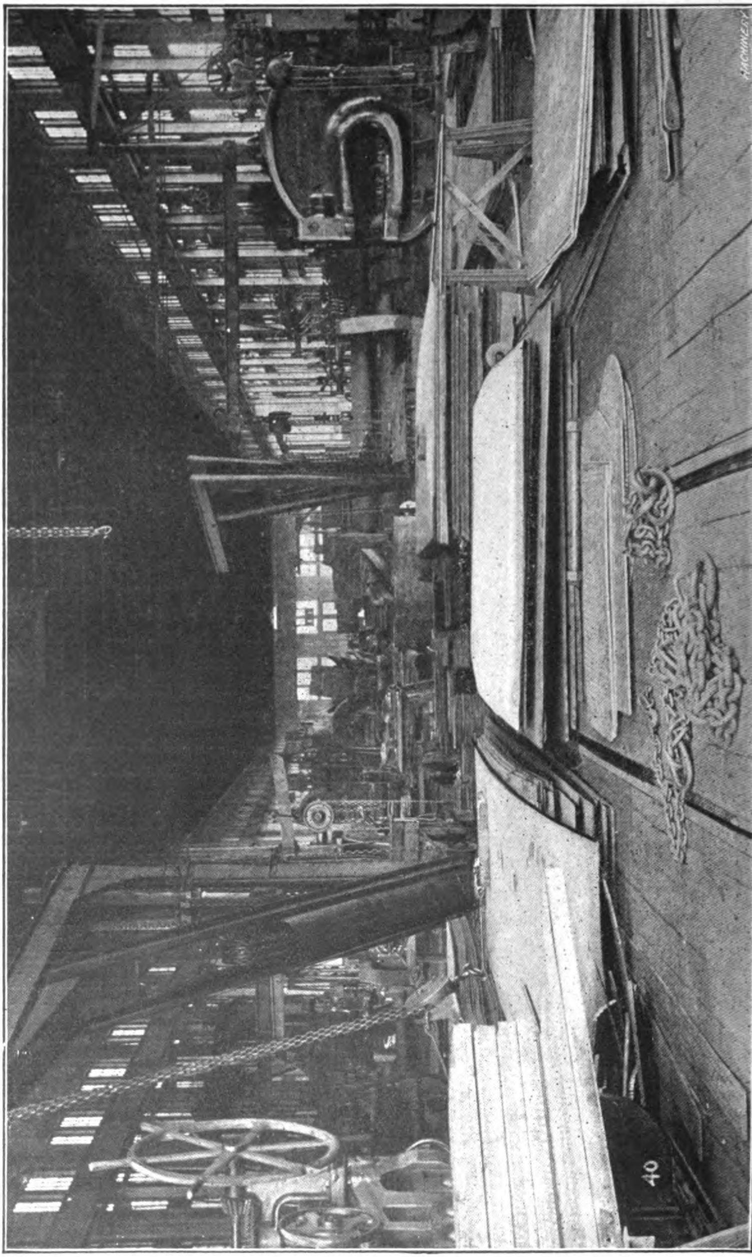


Fig. 3. Lay-out Floor, where Rivet Holes, etc., are transferred to the Sheets

taking care of the distortions that are inevitable when the heat of the fire and the pressure of the steam are applied. For this same purpose of obtaining greater flexibility, it will be noted that all the sheets of the rear end of the boiler are unusually thin. The fire-box and crown sheets, *K* and *L*, are ⅜ inch, as is quite common. The side sheets *N* and the roof sheet *O*, however, are also only ⅜ inch, which is uncommon. With this thin material, it is evident that the whole of the rear end of the boiler depends for its strength even more than usual upon the carefully laid out system of supports provided. But the whole construction gives to this part of the boiler a great flexibility, which it stands well in need of under the trying conditions to which it is subjected. To still further increase the flexibility, some of the more recent designs of boilers now have the back end sheet *P* stayed at the top from the rear barrel *E* of the boiler, next to the dome, instead of from the roof sheet *O*. This gives still greater freedom of movement.

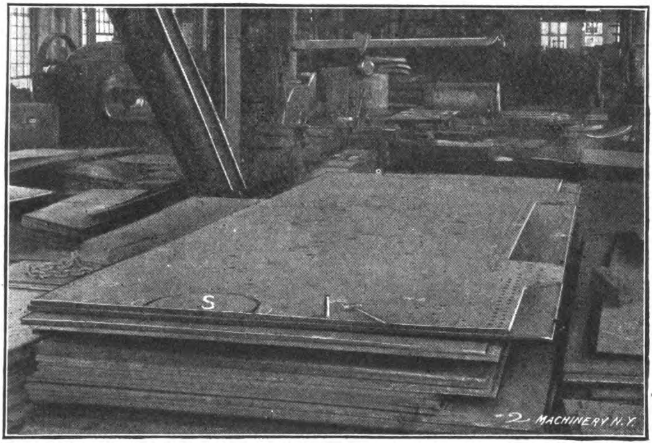


Fig. 4. Transferring the Pattern on a Dome Course Sheet

Some other peculiarities of construction may be noted. One of them is the charcoal iron ring shown at *C*. This forms the connection between the slope sheet *D*, the front flue sheet *B*, and the smoke-box *A*, each of which is separately riveted to it instead of being riveted to each other. This design was adopted because it was found that considerable corrosion took place, for some reason, at this point on the bottom of the boiler; and pure iron is, of course, the most satisfactory boiler material for resisting chemical action.

Laying out, Punching and Trimming the Barrel Sheets

We will begin the description of the shop operations with those of the cylindrical or barrel sheets, as they are the simplest and most easily understood. At this shop the sheets are all received cut accurately to size by the makers at the mill, with a very small allowance for trimming. Piles of these cut sheets are shown in the view of the yard in Figs. 1 and 2. In looking over this material the writer found a sheet laid aside and chalk-marked with the legend "Do not use; no test piece found." Inquiry revealed the fact that every separate sheet used in every locomotive boiler on this road, has two test pieces cut from it at the mill by, or under the supervision of, the railroad company's inspector. These test pieces are numbered to correspond with the sheet, and are sent to the test plant at Altoona. Here they are subject to both physical and chemical tests, the results of which are recorded for future use. No sheets are used whose pedigree is not thus investigated and recorded.

The laying out department is shown in Figs. 3 and 4. A pile of sheets is laid on the horses as shown, and a templet is dropped on the top sheet by a crane. This templet consists of a piece of ⅜ inch (or thereabouts) boiler steel, carefully cut to the proper shape, and with all punched and drilled holes and openings accurately located and machined. The punched holes and the small drilled holes are all

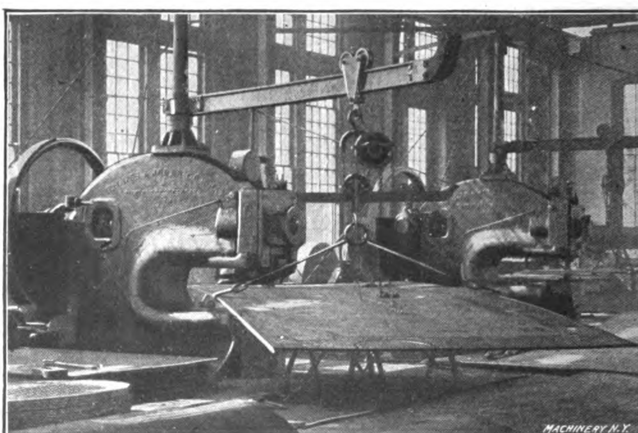


Fig. 5. Punching the Rivet Holes in a Dome Course Sheet

marked through onto the sheet below by means of a prick-punch having a large body, fitting the hole in the pattern. The openings which are to be formed by punching out stock are marked through with a soap-stone pencil. The pattern is lifted out, the marked piece is taken away to be shaped and punched, and the pattern is replaced on the next piece of the pile, which is marked in turn.

A little wrinkle used by the lay-off men enables them to shift the sheets off the pile without the help of the crane, if necessary. By raising the sheet which is to be moved and placing large steel balls under it at different points, the sheet may be readily rolled off from the pile.

After being marked out, the sheets go to the punches. As shown in Fig. 5 these are of both the hydraulic and mechanically operated types. The punch itself is provided with a center point, which must be located in the center marked for each hole in the plate by the men who transferred the pattern. The sheet is hung from the crane so as to slightly over-balance, the edge under the punch being heaviest. The plate handler bears down on the outer edge of the sheet, bringing it up against the punch until he feels the point on the latter entering the center hole punched in the sheet. After the sheet is thus located, the operator presses the lever and the hole is punched.

The next operation on flat sheet work consists in drilling out the punched holes to the required size. Holes are punched 1/16 inch smaller for rivets up to ¾ inch, and ⅛ inch smaller for rivets above that size. The excess metal is then drilled out so that no incipient cracks or other harmful conditions will be left from the punching

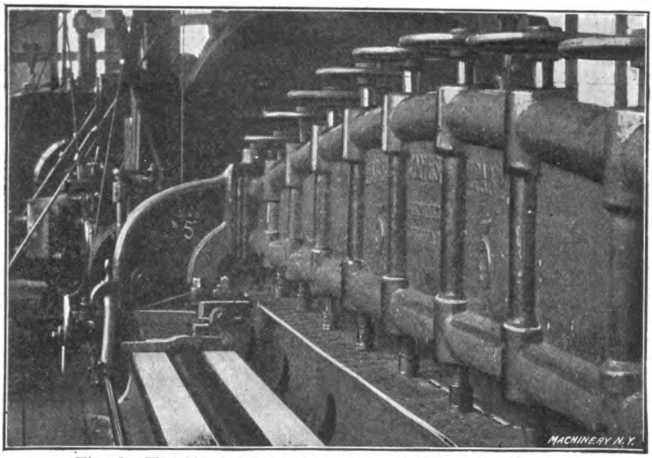


Fig. 6. The Sheet Planer at Work on a Smoke Box Sheet

action. This has been found eminently satisfactory in practice, and avoids the more costly (though theoretically proper) operation of drilling the holes complete.

It should be noted particularly that it is the general practice here to punch and ream all the holes in all the sheets before sending them to the erecting department. The patterns are so carefully made and laid out, and the machine work is so accurately done, that the holes at the joints are expected to ream together throughout the whole structure, when the workmen come to build up the boiler out of the separate parts. The only exception to this rule is in the matter of those rivet holes which come on the scarfed edges of sheets where overlapped joints are made, such, for instance, as are found where the throat sheet *G* and neck piece *H* overlap under the side sheet *N* in Fig. 14. As a little extra hammering may have to be done here to make a good fit, it is not safe to punch the holes at the start-off. On the flanged parts also, as will be described later, special conditions are met with which require punching the holes at different times; but in practically all cases this is done before assembling. This practice results in great economy of time and labor over what would be possible if it were required to take the sheets back to be punched and reamed during the fitting operation. The drift pin is, of course, tabooed.

Besides being drilled and reamed, the edges of the sheet have to be trimmed accurately. This is done in the plate planer. For certain edges of no particular importance it is sufficient to leave them as they came from the steel mill. All edges that are to be calked, however, have their edges planed at the proper bevel so as to make a good joint; and the edges on the cylindrical sheets where butt joints are made are also planed to square edges in a similar fashion. The plate planing machine is shown in Fig. 6. This well-known machine is provided with a wide table, and carries a clamping bar having a number of

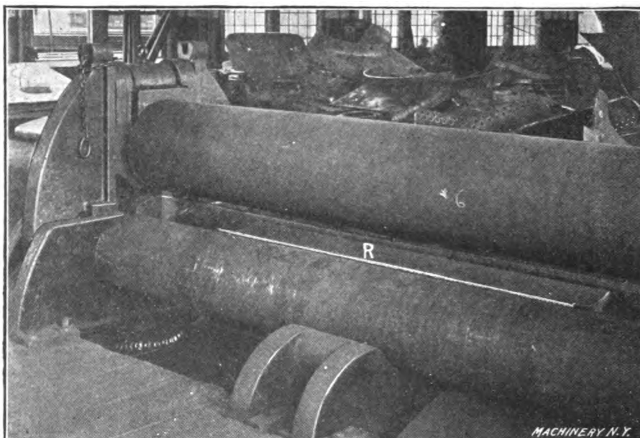


Fig. 7. Special Edge Bending Die in Place on the Rolls

jacks for holding the work in place. The reciprocating tool head carries a reversible holder, so that it cuts both ways. The feed is by hand.

Bending the Sheets

The sheets have next to be accurately rolled to the proper diameter. This is done in the power bending rolls, of which there are two different sizes provided, the largest being shown in Figs. 7 and 8. These rolls are driven by independent motors, with power vertical adjustment for the upper roll. This adjustment may be independently controlled for the two ends if desired, so that the roll may be tipped down at one end to roll conical shapes such as are required for slope sheet *D* in Fig. 14. The large roll is powerful enough to take care of inch-and-a-half metal, although it is not likely, of course, ever to be called upon to handle stock as heavy as this.

One of the difficulties of rolling heavy metal lies in carrying the curvature clear out to the very edges of the sheets, where they butt against each other. It has been customary to form the curves on these ends by hand hammering, or by dies under a special press. The operators of the rolls at the Juniata shops, however, have devised the simple scheme shown in Fig. 7 for accomplishing this in the rolls themselves. The die *R* is shoved in between the two lower rolls, by which it is supported. This die has a curved upper surface, concentric with the curvature of the upper roll. The flat sheet is supported by the crane and placed with one edge on this die, and then the upper roll is brought firmly down against it by power, bending it to the desired initial curvature. The sheet is next turned about and the other end is treated in the same fashion. The die is then removed, and the actual rolling commences.

The sheet is placed between the dies and the rolls, is carefully squared up, and is then passed back and forth between them from

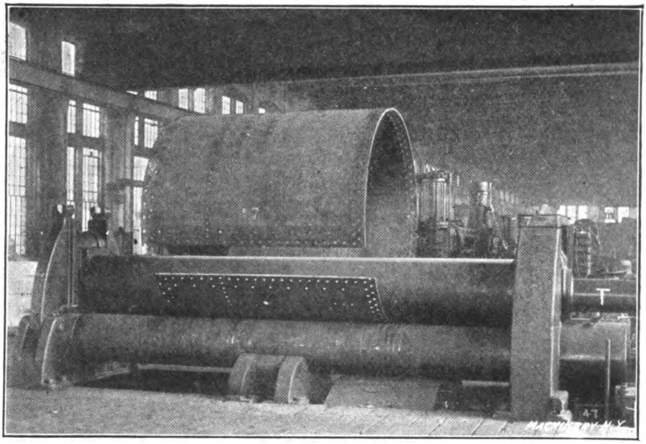


Fig. 8. Rolling one of the Barrel Sheets

one end to the other while the upper roll is brought down closer and closer onto the sheet, giving a decreasing radius. The sheet is rolled to fit the curvature of a templet provided for the purpose, which is usually from two to three feet long. This is tried at various points around the circle to make sure that it will be of exactly the required curvature when the ends of the sheet finally meet in the completed circle. At points where the radius is larger than it ought to be, further passes through the roll will of course reduce it to the desired radius. Where, however, the radius, by some mishap is made too small, about the only possible remedy is to work it back again by hand hammering, and this occasionally has to be done, the sheet being held meanwhile in the rolls.

This matter of getting the sheet bent to an accurate circle is of great importance. If it is not bent to an accurate circle, not only will it not match well with the pieces to which it is riveted, but there is also danger of excessive strains in the boiler. When it is under pressure it tends naturally to take the circular shape, and if it was not in the circular shape in the first place, its struggle to arrive at that condition is sure to make trouble.

In sheets like the smoke-box and dome courses, where large openings have to be cut out for dome, whistle connection, stack, etc., the outlines of these openings are cut around on the punching machine leaving, however, the metal which is to be cut out still connected with the sheet by several "bridges" as shown at *S* in Fig. 4. The purpose of this is to make the bending as even as possible. In the case of the smoke-box sheet, for instance, were there no metal in the stack opening, the stock would bend so easily at that point that it would be given a sharp radius or corner. For this reason it is customary to wait until the sheets are bent before the openings are knocked out. Where, in bending, the edge of one of these pieces of excess metal projects and

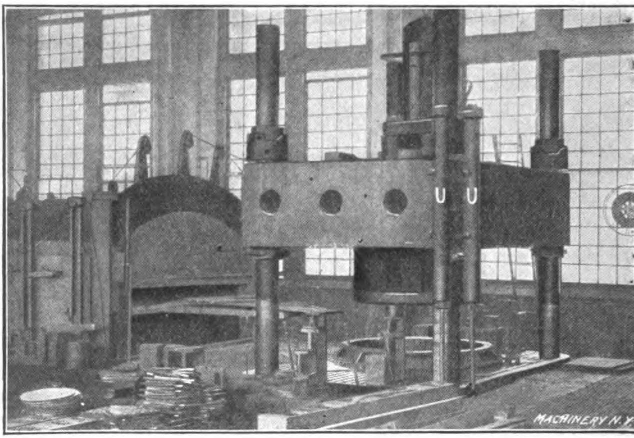


Fig. 9. The 700-ton Hydraulic Flanging Press, and the Furnace by which it is served

causes the plate to slip in the rolls, as sometimes happens, the plate can usually be started by throwing in a little sand between the roll and the plate to give the former a good grip.

The making of the slope sheet (*D* in Fig. 14) is similar to that of the smoke-box and dome courses except that it is rolled tapering. For this purpose the two bearings on the top roll are independently adjusted for height, so that a sheet can be bent to a smaller radius at one end than at the other.

The construction of the roll will be readily understood. The outboard bearing of the upper roll is arranged to be swung apart on either side to permit the finished rolled sheet to be drawn off over the end. The upper roll is meanwhile hung suspended and supported by a screw stirrup which anchors its rearward extension, shown in part at *T* in Fig. 8. The bending operation leaves the various smoke-box, dome course and slope sheets ready for building up into the finished boiler.

The Flanging Presses

In the early days of boiler-making flanging operations were avoided as far as possible. Where a sheet had to be flanged, it was heated locally in the forge and hammered to shape by hand. This was slow, costly and laborious; and it produced internal strains in the work. The locomotive boiler shown in Fig. 14 is pretty well covered with flanged work. This extensive use of irregularly bent sheets is only made possible by the modern hydraulic flanging press, whose use avoids all the disadvantages enumerated above as pertaining to hand work.

There are two presses for this work at the Juniata shops. The smaller of the two is shown in Figs. 11 and 12. It has six rams. The main ram, which supports the platen, is of 140 tons capacity. In addition, there are four adjustable cylinders and rams for holding-on, supporting die-rings, etc., which can exert a pressure of 20 tons each.

The large flanging press (one of the most powerful ever built) is shown by itself in Fig. 9, and in operation in Figs. 20, 21, 26, 27, and 31 to 36, inclusive. This machine has seven rams operating on the work, the arrangement being similar to that of the other press, except

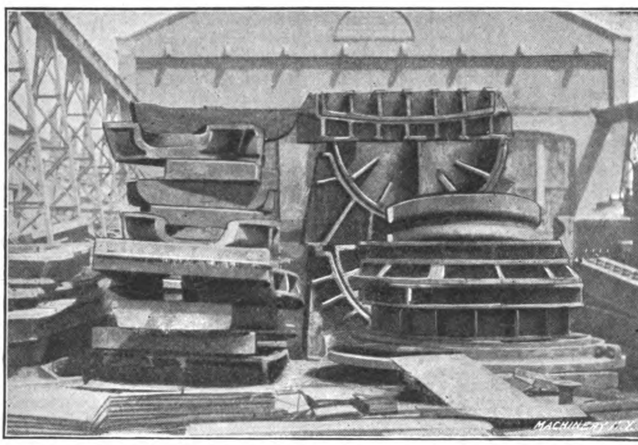


Fig. 10. A Pile of Flanging Dies Stored in the Stock Yard

that there is an additional cylinder and ram on top of the upper platen, which is used for stripping work from the dies, and for forming the work in certain special cases. The main platen ram gives 700 tons pressure, the inner telescopic ram 200 tons, the four adjustable rams 28 tons each, and the upper ram on the top platen 100 tons.

Fig. 9 plainly shows at *U* two small, long stroke cylinders attached to the nearest corner of the upper platen, a similar pair of cylinders is mounted on the corner diagonally opposite. The pistons of these cylinders are attached by rods to the movable platen, and are used for adjusting it to position, ready for applying the pressure. The costly high-pressure water service is thus not wasted on the idle movements of the machine. The hydraulic pressure is generated and stored by a pump and accumulator in the central power house.

Internal strains, such as might possibly be generated in the flanging operations by the working of the metal, are avoided by a subsequent annealing. All flanged work is annealed the last thing before being removed from the flanging department. This is done by placing it in the heating furnace, seen in the background of Fig. 9, raising it to an even light red, and then removing it and laying it aside to cool in some place sheltered from drafts of air.

A great point is made of having the machine flanging so accurate that no local heating of any kind will be needed for hand flanging or other operations. Local heating introduces strains which are difficult to reckon with or remedy. Making the sheets as nearly right as possible in the beginning thus results in better work, as well as in work that is less expensive in the long run as a manufacturing proposition.

In Fig. 10, which shows a portion of the storage yard illustrated in Figs. 1 and 2, is seen a pile of dies for the flanging work. Their number (only a few of them are here seen) and their size will give some indication of the importance of this work in modern locomotive boiler construction. Specific information on the way in which these

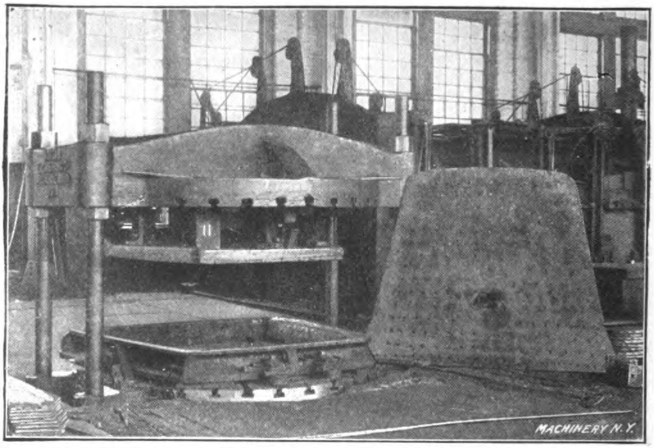


Fig. 11. A Fire-door Sheet, and the Dies with which it is flanged

dies are used will be given in describing the making of each of the different flanged parts.

The Back Head and Fire-door Sheets

These sheets, as shown at *P* and *M* in Fig. 14, and in Figs. 13 and 17 are flanged around the edges, and have the door opening flanged in them as well. The blanks are laid off to templets or patterns, the same as for the various barrel sheets previously described. Only the holes for rivets, staybolts, etc., in the face of the sheet are marked, however, as it is evident that the stretching of the metal in the flanging would make it impossible to locate the holes in the flanges. These are left until later. A fire-door sheet all trimmed, punched and reamed, and with the fire-door hole blanked out, is shown ready for the press in Fig. 11. The dies are plainly shown in place on the small press.

The operation is very simple. The dies are lined up and clamped in the press, the male die on the upper platen, and the female die on the lower or movable platen. Only the main plunger is used. In Fig. 12 the blank is shown lined up on the lower die, with the upper die just about to strike it and force it through, turning over the flange as required. A similar die, though on a much smaller scale, is used for

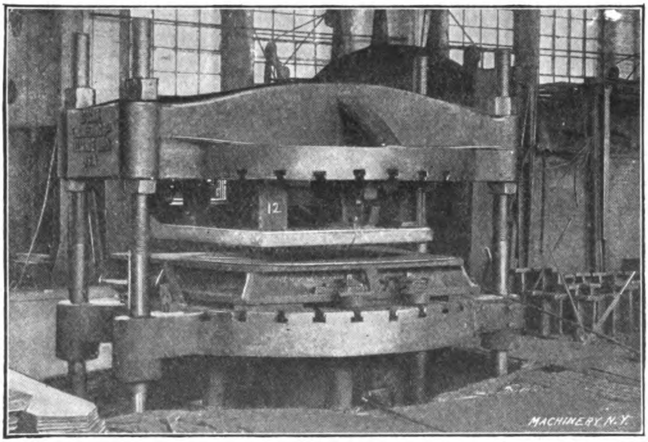


Fig. 12. The Fire-door Sheet in the Small Flanging Press

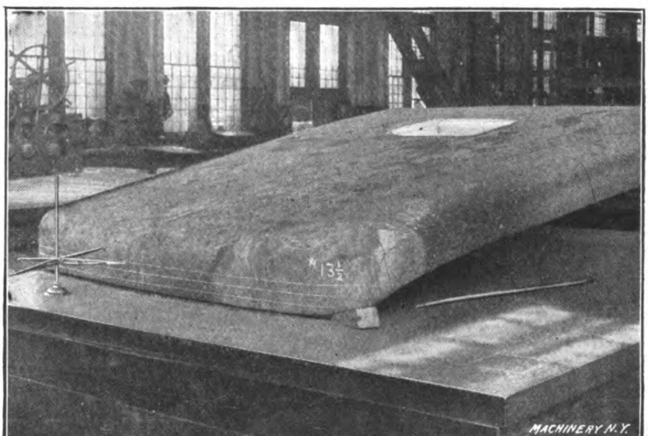


Fig. 13. The Fire-door Sheet on the Lay-out Table, for Locating the Holes in the Flanges

flanging the fire door opening. This is done in a separate hea..

After the flanging, the sheet is taken to the lay-out table to have the rivet holes in the flange laid out. The sheet is set up at the proper angle so that the holes can be laid out directly from the vertical line on the drawing, and the locations are marked by surface gage, scale and scriber. This is shown in Fig. 13. For designs which are made

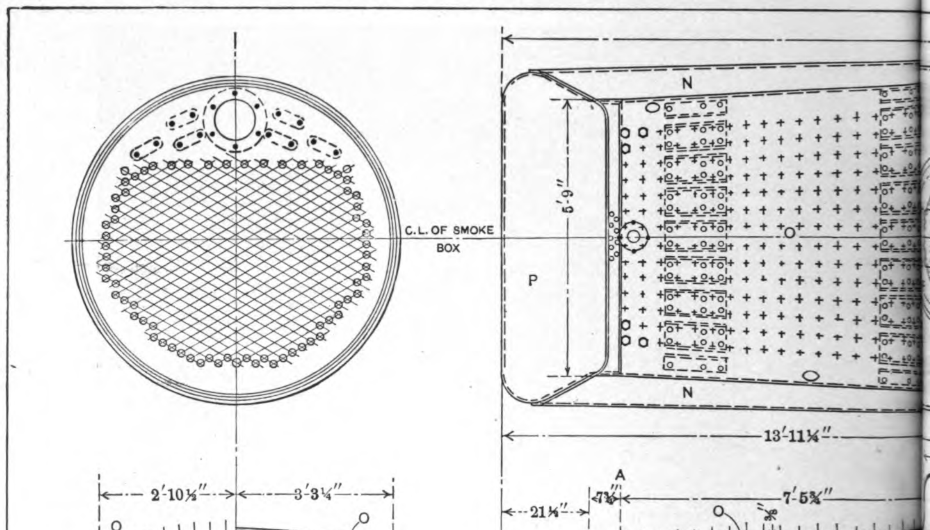
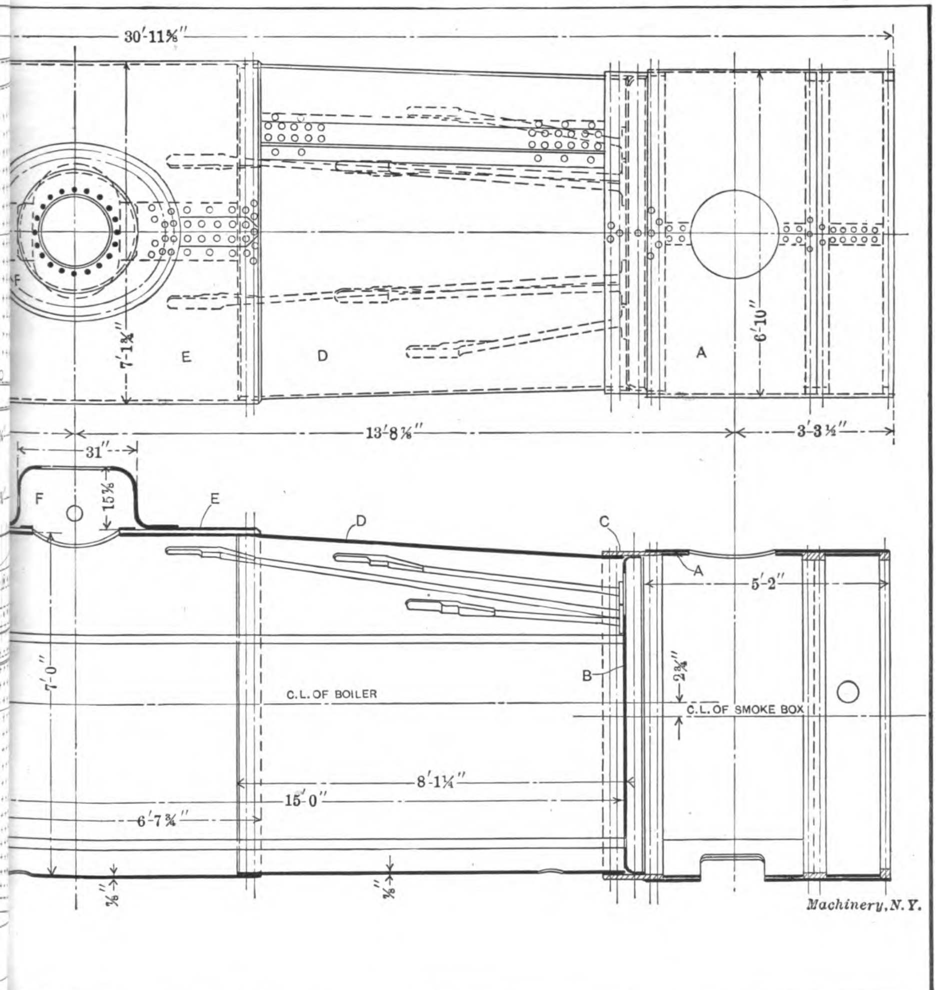


Fig. 14. A Sample of Juniata Boiler Sh



for a Heavy Consolidation Locomotive

in large quantities, templets are used for laying out these holes, as seen in Fig. 15. Here the surface gage is used simply for scribing a location for the templet.

Fig. 16 shows the methods and machine used for punching most of this flanged work. The riveter is of the horizontal, hydraulic type, to which the work is presented by a swinging crane. The sheet is suspended from it through a swivel hook, and may thus be easily turned to present any part of the flange to the riveter without readjustment of the support or of the work itself.

After the fire-door opening has been flanged, the rivet holes are punched in it by means of the hand screw hydraulic punch shown in Fig. 17. This is the only tool compact enough to work in the confined space which here has to be reckoned with. The punching of the corre-

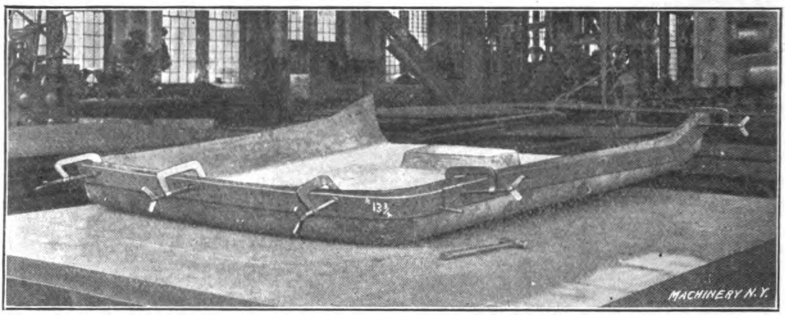


Fig. 15. Templets Clamped to the Flanges for Marking out the Rivet Holes

sponding holes in the inside fire door sheet is left until later, as this set of holes is one of the very few which has to be marked in place during the erecting, and punched afterwards.

The Flue and Throat Sheets

Both front and back flue-sheets, as shown in Figs. 14, 18 and 25, are flanged; the former is a plain circle, while the latter is bent to quite an irregular shape. As in the case of the fire-door and back sheets, the various flue, rivet and brace connection holes in the faces of the sheet are laid out with templets at the beginning, leaving the holes in the periphery to be laid out and punched after flanging. The operations in general are the same as in the preceding case.

The holes for the flue sheet are originally punched to a diameter of 1⅞ inch for a 2-inch flue, leaving ⅛ inch to be taken out in a counter-boring operation. This is the last machining operation, and is shown in Fig. 18. Fig. 25 shows a back flue-sheet with all the machine work completed.

One of the nicest pieces of work on the whole boiler is that of flanging and laying out the throat sheet. The blank for this is shown in Fig. 19. None of the holes are punched in this previous to flanging, as the whole sheet is of irregular form and is more or less drawn in the flanging operation. The dies are shown in place in the large press in Fig. 20. In the operation of flanging, the hot sheet is laid on top of the lower die, which is next raised up into contact with the upper die by the lifting cylinders *U* shown in Fig. 9.

The continued raising of the platen then bends the sheet down into the form between the upper and under dies, bringing it to the proper shape at one operation. The operation is shown completed in Fig. 21.

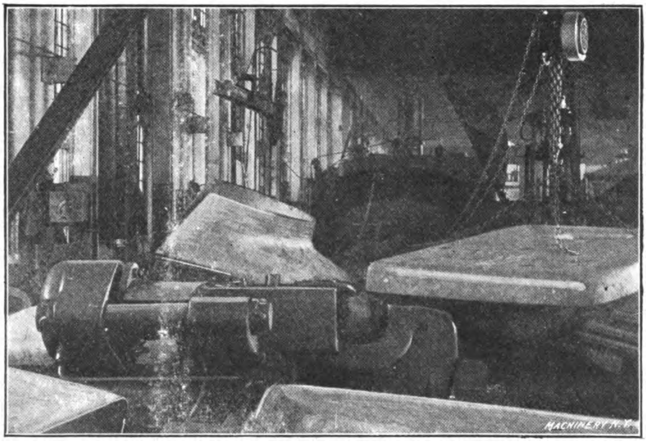


Fig. 16. Punching the Flange Rivet Holes in the Horizontal Hydraulic Riveter

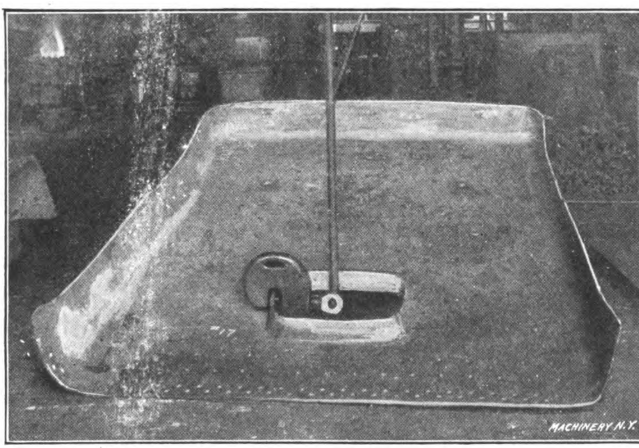


Fig. 17. Punching the Fire-door Flange Holes with the Hand-operated Screw Punch

This job of flanging the throat sheet is one of the most particular in the lot, in the matter of getting the dies to the proper shape. To get some notion of the best way to form the dies in a new design, it is the custom at the Juniata shops to make model dies to a scale of say, 1/8 full size, and operate them in a hand press on a sheet of lead of the proper relative thickness. These miniature dies are made of hard wood, and are very carefully worked up by the die pattern maker, who works out the final full-sized pattern from which the actual steel dies are made. This man has to be a skilled workman, as the boiler designer does not usually lay out absolutely the full shape of the throat piece from every viewpoint. The case is, for instance, the same as if a ship builder should receive plan, longitudinal and end views of the hull of a vessel, and should then be required to determine the shape from this information.

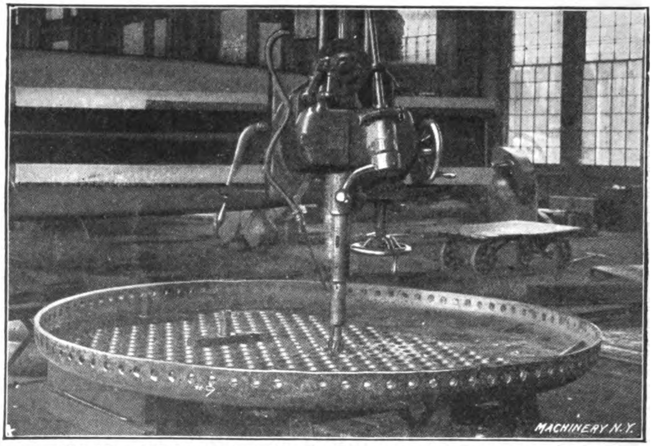


Fig. 18. Counterboring the Flue Holes in the Front Flue Sheet

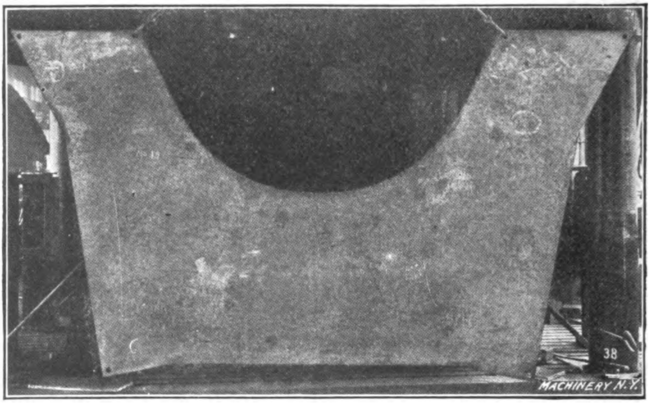


Fig. 19. The Blank for the Throat Sheet

One of the points he has to be careful about is to so shape the die that it will not draw the metal at points where the strength of the structure requires the full thickness of the original sheet. Questions of this kind are determined very readily by scribing off the surface of the model blank into regular squares. These lines will still appear on the finished model made in the wooden dies; and where the model has been drawn down, the squares will have been correspondingly distorted. It is thus possible to predict the exact behavior of the full-size dies in actual work, without risking the possibility of making them wrong in the first place, and producing spoiled work.

Tests were recently made with model dies and throat sheets for a new boiler in which the throat sheet is of unusual length and difficulty. It was found necessary in this case to tip the dies out of the

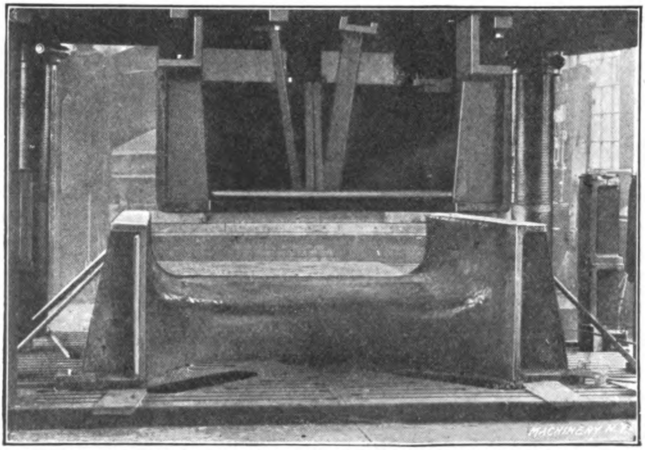


Fig. 20. The Throat Sheet Dies in the Big Flanging Press

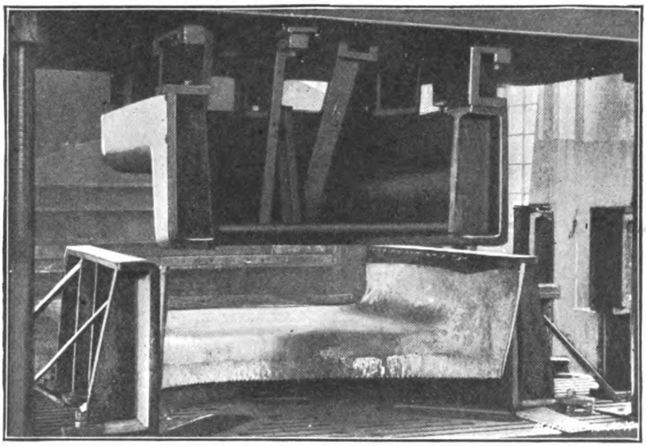


Fig. 21. The Throat Sheet in the Dies at the Conclusion of the Flanging Operation

horizontal plane, to prevent the sheet from creeping as the dies were brought together. The models revealed this necessity, which would otherwise have had to be learned at a considerable expense, after the manufacture of the parts was actually begun.

Fig. 22 shows the throat sheet after the flanging operation, set up on the lay-out table at the upper end of the room. This laying out of the flanged parts accounts for the bulk cf the cases where the work has a backward movement; and this moving back is here justified by the results. The man at the lay-out table sets the throat sheet up in the same position as it will occupy in the boiler, and marks the position of every hole (whether for stay-bolts, rivets, or other connections) over

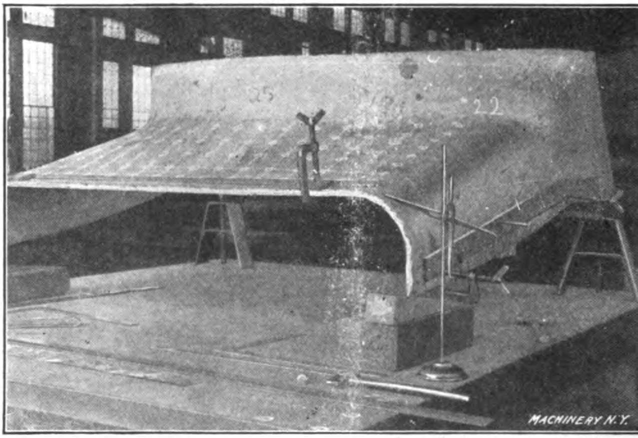


Fig. 22. Throat Sheet on Lay-out Table, for Marking off Rivet and Stay-bolt Holes, etc.

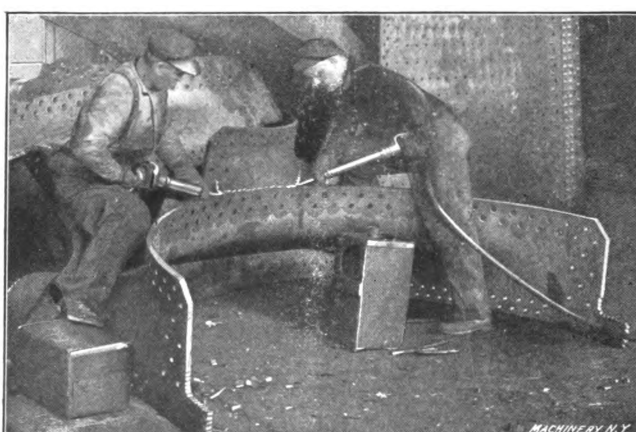


Fig. 23. Trimming the Edges of the Throat Sheet with the Pneumatic Hammer

the whole sheet; the only holes not marked are the few rivet holes which pass through the scarfed joint where the throat sheet and neck piece come together. As previously explained, these holes are marked and punched in place. The ability to lay out all these holes on the table speaks volumes for the accuracy of machine flanging, and for the accuracy, as well, of the numerous other operations which go to make up the various parts with which this throat sheet must match.

Irregular work like this cannot, of course, be trimmed in the plate planer, so the pneumatic hammer is resorted to, as shown in Fig. 23. Fig. 25 shows the completed throat sheet after it has been drilled and punched ready for assembling. It should be noted that many of the stay-bolt holes on the under side of the throat are drilled at a considerable angle with the face of the sheet. In such cases, instead of punching and then enlarging the hole with a drill as usual, the hole is first put through with a small drill, located by a center hole punched to a considerable depth; then the hole is machined out to the full diameter by a counterbore guided by a pilot fitting the preliminary

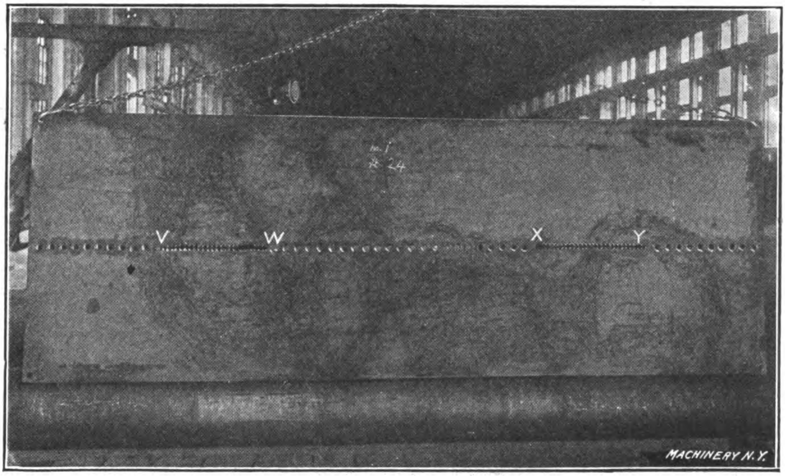


Fig. 24. The Blank for Making Two Neck Pieces

small hole, the same as for the tube sheet in Fig. 18. This prevents the slope of the throat sheet from forcing the hole away from the location given in the layout.

The neck piece, shown at *H* in Fig. 14, is characteristic of the Belpaire boiler. It occupies, on top of the boiler, a position corresponding to the throat sheet underneath, and has somewhat the same general form. It is naturally more difficult to flange, however. Nevertheless, this difficulty has been overcome by the exceedingly ingenious method adopted in this shop.

The illustrations Figs. 24, and 26 to 30 practically tell their own story. At the lay-out table the sheet is marked out for punching as shown in Fig. 24, the sheet being divided practically in two, as two finished parts are to be obtained from it. The space from *V* to *W*, and from *X* to *Y* is entirely open, while the rest of the blank is held in shape by bridges between the holes.

In Fig. 26 are shown the dies which, as may be seen, are direct in their action. The blank is placed in them, and is forced into the form by the ascent of the platen and lower die, as shown in Fig. 27. Figs. 28 and 29, showing interior and exterior views of the finished job of flanging, give away the secret. The difficulty lies, of course, in the forming of almost square corners at the top of the sheet without

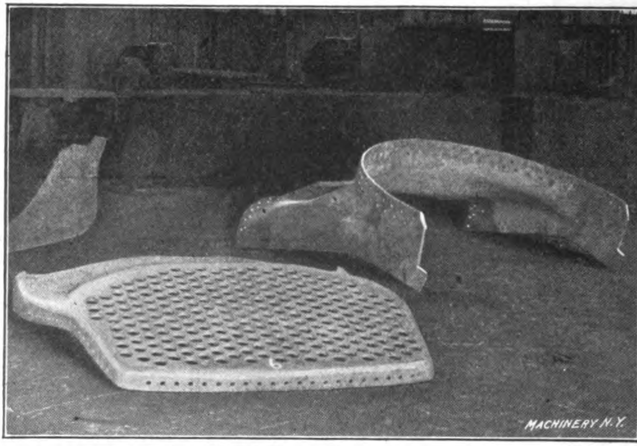


Fig. 25. Completed Throat Sheet and Back Flue Sheet

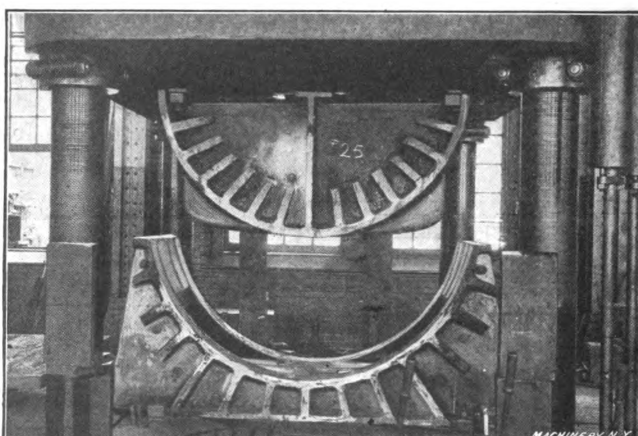


Fig. 26. The Dies for Flanging Two Neck Pieces at one Operation.

drawing out the metal to a dangerously thin section. By flanging two pieces at a time, with the holes punched as described, the metal is held together on each side everywhere, except at these corners. Here the blank has been cut entirely through, so that the metal is allowed to spread and draw into the corners, retaining practically its normal thickness over the whole extent of surface.

This ingenious flanging scheme likewise has the advantage of making a symmetrical job of drawing, so that there are no side strains on the dies, as is the case on the throat sheet, for instance, in Figs. 20

and 21. Altogether, these photographs are worthy of considerable study and thought on the part of readers interested in heavy flanging operations. They illustrate principles which should be useful in other difficult work. The double sheet, after being separated into its two

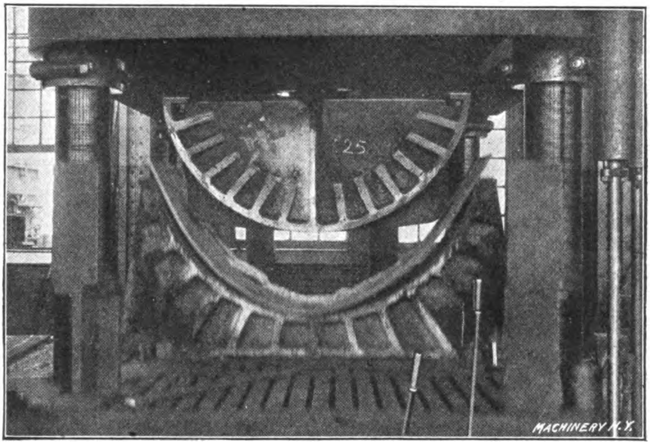


Fig. 27. The Flanging Dies at Work on the Neck Piece Sheet

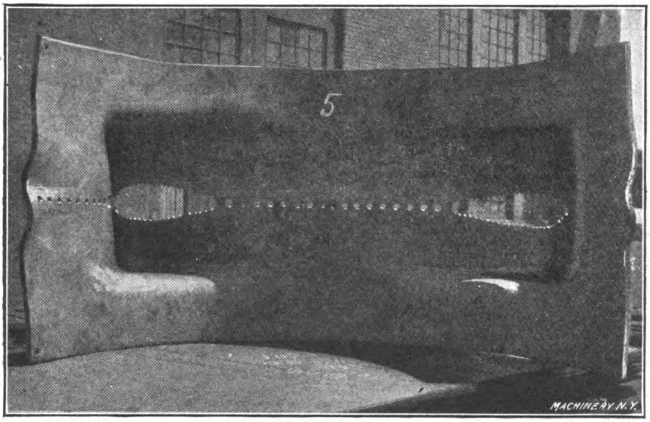


Fig. 28. Interior View of the Neck Piece Sheet after Flanging

component parts, is taken to a lay-out table and is treated the same as the throat sheet, the finished work being shown in Fig. 30.

The Making of Solid Drawn Steam Domes

While considering this matter of flanging, it would be well to call attention to another unusual job, which is regularly performed in this shop. That is the drawing of steam domes from a flat sheet. This is illustrated in Figs. 31 to 37, Fig. 31 shows a blank and the first operation dies, in which the dome portion is drawn out. At *Z* is the telescoping plunger of the ram, fitted with a punch *A* rounded to the desired contour for the head of the dome. At *B* is the lower supporting ring of the die, mounted on the four clamping plungers *C*. At *D* is the upper ring die, clamped to the lower face of the top platen. The stripping plunger in the center of the upper platen is used for forcing the work out of the die at the conclusion of the stroke. *D* has a rounded corner on the inner edge of the die opening, so that the sheet will bend up into it smoothly, and with as little friction as possible.

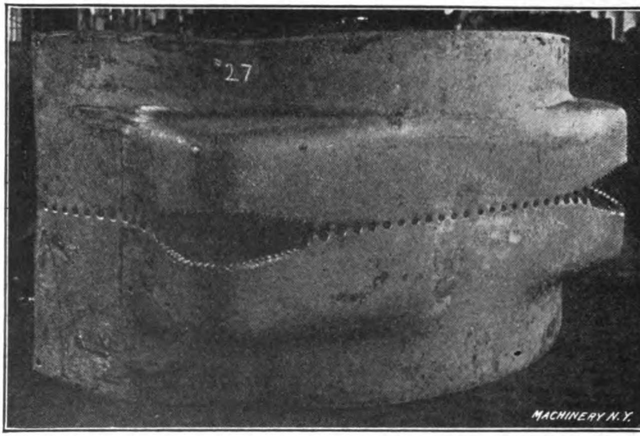


Fig. 29. Exterior View, showing Drawing away of Metal at Corners

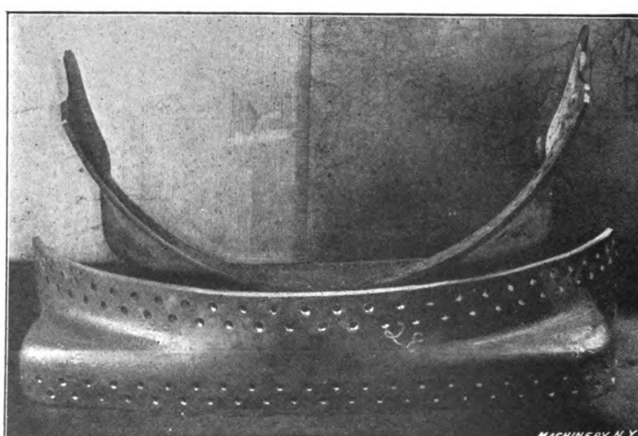


Fig. 30. The Two Neck Pieces Separated and Completed

Figs. 32 and 33 show the actual operation on the work. The great point is, of course, to avoid buckling and crinkling at the point where the flange joins the dome. This is avoided by the careful manipulation of the dies, and is done by bringing the upper and lower ring dies, *D* and *B*, just far enough apart at each successive operation, so that the metal is formed up into the dome shape by the plunger without crinkling. This is a matter of judgment on the part of the operator. It usually takes about three heatings and press operations to finally bring the dome to the condition indicated in Fig. 35 where it is shown in place on the second operation or flanging dies.

The purpose of the second operation dies is, of course, to bend the circular flange of the dome to fit the cylindrical sheet of the boiler.

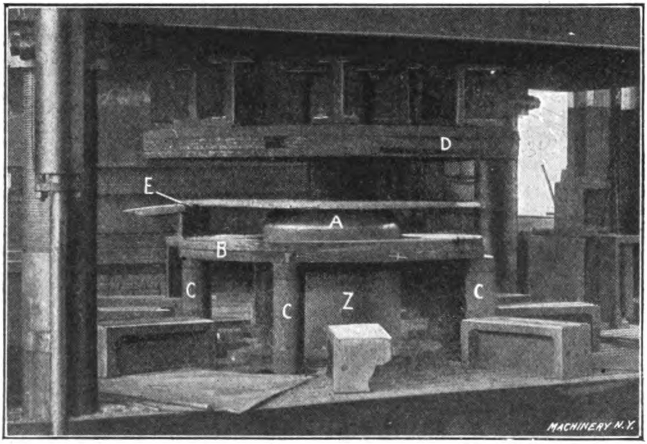


Fig. 31. Circular Blank for Steam Dome in Place on Flanging Dies

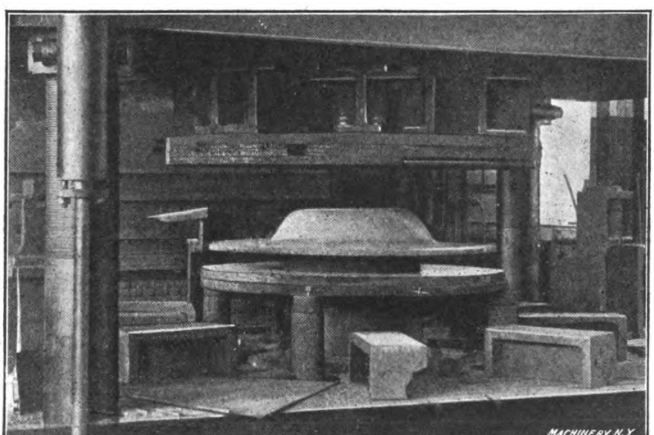


Fig. 32. Steam Dome Blank after First Drawing Operation.

This is done in a single heat. Fig. 34 illustrates the dies. In Fig. 35 the blank is in place, ready for flanging, and in Fig. 36 the operation is completed.

Sheet *E* has been placed over the lower die to enlarge the radius of curvature given to the flange of the dome. By use of loose sheets like this on both upper and lower dies, the same set of dies can be used for domes for boilers of slightly varying diameter.

The finished dome, all punched, reamed and machined, with its various pop valve, whistle and throttle connections, is shown in Fig. 37. This particular dome is 31 inches in diameter by 15⅞ inches high above the top of the boiler. It is formed out of 1⅛-inch steel. This is by no means the limit of drawing on work of this character,

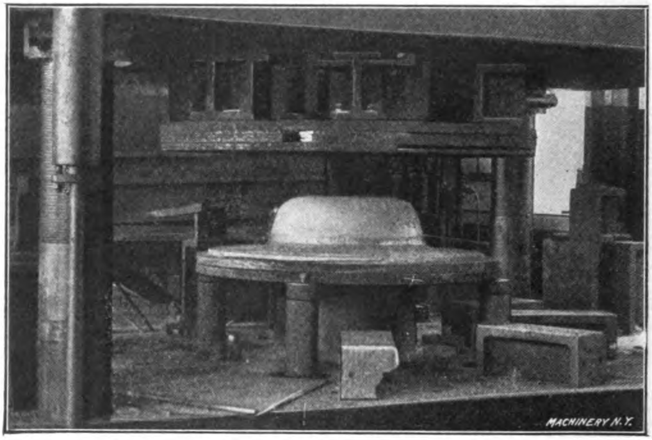


Fig. 33. Blank after Second Drawing Operation

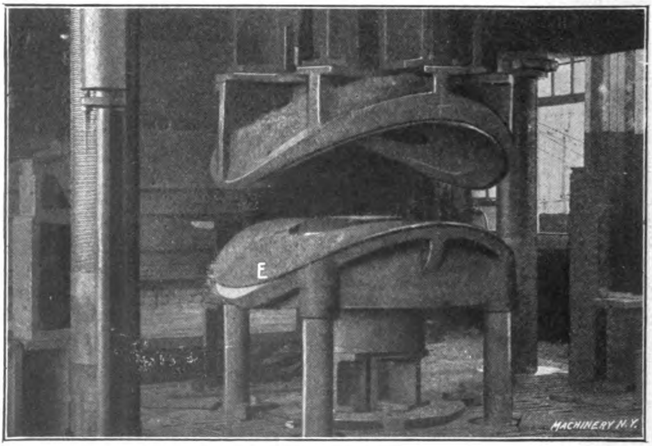


Fig. 34. The Dies for Forming the Flange

however, for domes have been successfully made in this way up to 30 inches in diameter and 24 inches in height, out of 1⅛-inch stock.

Miscellaneous Sheets and Other Parts

Fig. 39 shows the side sheet. This follows the same routine as the other plain sheets which have been decribed, about the only difference met with in its construction being the method of rolling it to the proper shape. As may be seen from Fig. 14, the back end of the regular Pennsylvania Belpaire fire box is out of square in every direction. It is narrower at the fire-door end than at the flue sheet. It is narrower at the top than at the bottom. It joins at the back end onto a straight sided fire-door sheet, while at the front end it is riveted to three sections, the upper one being the rectangular-shaped neck piece, the central section being the circular dome course of the barrel, while below it joins onto the flanges of the neck piece, which taper inward

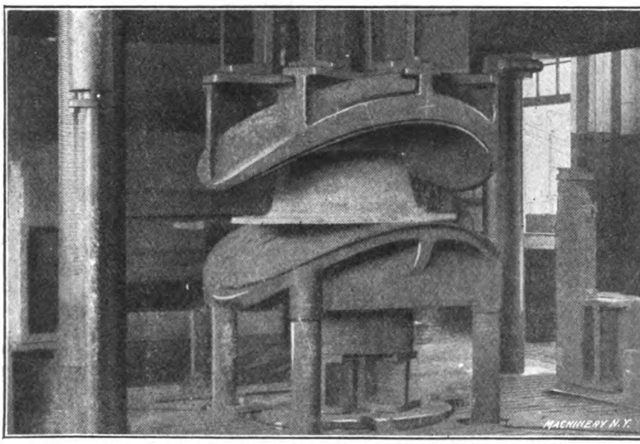


Fig. 35. The Dome in Place on the Flanging Dies

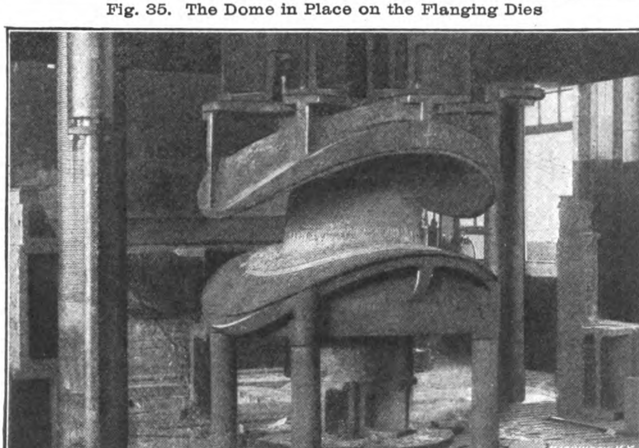


Fig. 36. The Completed Dome ready for Removal from the Die

somewhat. This irregular contour at the front end has to blend into the straight section at the back end, evenly and gently over the whole surface—and this job of blending is up to the man with the bending rolls.

In work of this kind, there is comparatively little rolling to be done. The machine is used as a press instead, the power being applied by the heavy screws which adjust the height of the top roll. The operator shifts the sheets from one position to another in the rolls, bringing the roll down with just the proper pressure to give the desired effect. He has, of course, templets to go by in making the bends, but even with templets the job is one that the amateur had better beware of. The irregular shape of the sheet also affects the lay-out of the rivet and stay-bolt holes in the templet. In the preliminary lay-out operation

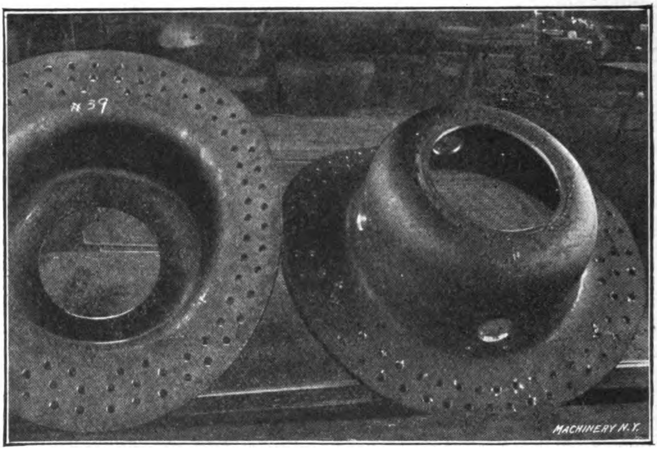


Fig. 37. Steam Dome Machined, ready for Mounting on the Boiler

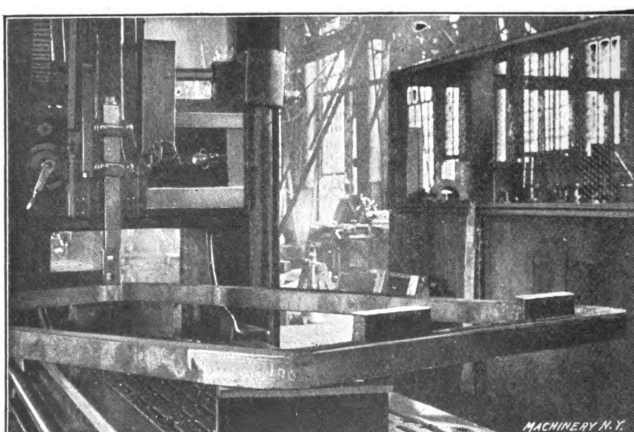


Fig. 38. Finishing the Foundation Ring on the Frame Slotter

on this sheet, the pattern has to be so made that the holes, as laid out on the flat will come in the proper position after the sheet is bent to the complicated form given to it.

The fire-box sheet shown in Fig. 40 is similar to the side sheet, only it is not so difficult to make. The crown sheet, Fig. 41, is similar; its shape is given to it by the bending rolls; it is accurately tested by templets during the bending operation. Here, as may be seen, a

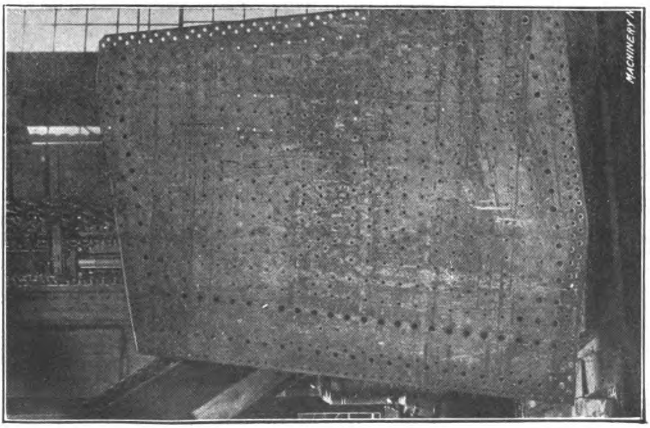


Fig. 39. The Side Sheet Trimmed and Punched, ready for Flanging

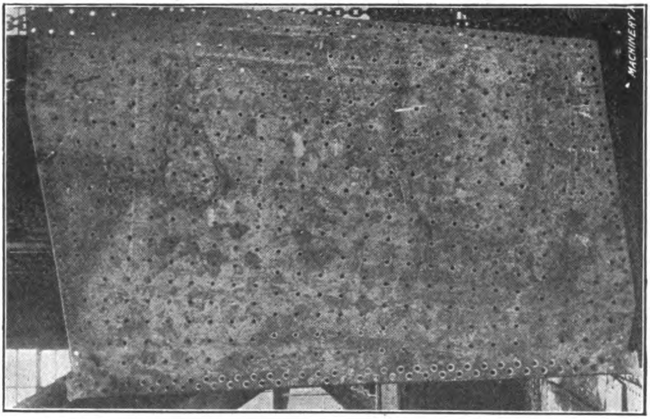


Fig. 40. The Completed Fire-box Sheet

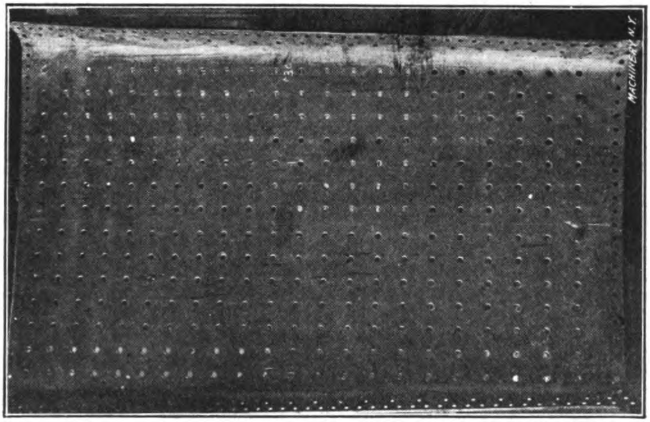


Fig. 41. The Completed Crown Sheet

bend of large radius is given over the top, while a small radius combined with straight edges, is used for the corners. The roof sheet shown in Fig. 42 requires the same handling.

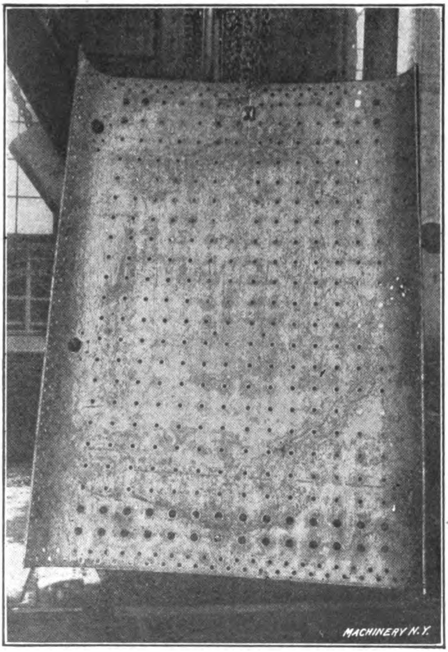


Fig. 42. The Completed Roof Sheet

The foundation ring (or "mud ring" as it is perhaps more commonly called) is shown at *Q* in Fig. 14. This is a wrought-iron forging, finished accurately to dimensions, with its inner and outer peripheries machined all around. This machining includes the rounded inner and outer corners, which are finished to the proper shape so as to make a good fit when the time comes to rivet on the side, throat, fire box and other sheets. In Fig. 38 the foundation ring is shown mounted on the frame slotter, in the machine shop, having its corners fitted.

Other machine shop work is done on various boiler details. The front flue sheet, for instance, has its flanged edge trimmed and beveled to the proper angle for calking, by being mounted on the boring mill table, where it is accurately centered and turned. The charcoal iron ring (see *C* in Fig. 14) is similarly machined to accurate dimensions.

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