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WEST'S

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AMERICAN FOUNDRY PRACTICE.

PRESENTING

BEST METHODS AND ORIGINAL RULES FOR OBTAINING GOOD, SOUND, CLEAN CASTINGS; AND GIVING DETAILED DESCRIPTION FOR MAKING MOULDS REQUIRING SKILL AND EXPERIENCE.

ALSO CONTAINING

A PRACTICAL TREATISE UPON THE CONSTRUCTION OF CRANES AND CUPOLAS, AND THE MELTING OF IRON AND SCRAP-STEEL IN IRON FOUNDRIES.

BY

THOMAS D. WEST,

PRACTICAL MOULDER AND FOUNDRY MANAGER; MEMBER OF AMERICAN SOCIETY OF MECHANICAL ENGINEERS, AMERICAN FOUNDRYMEN'S ASSOCIATION, CIVIL ENGINEERS' CLUB OF CLEVELAND, AND HONORARY MEMBER OF THE FOUNDRYMEN'S ASSOCIATIONS OF PHILADELPHIA AND CHICAGO; AUTHOR "AMERICAN FOUNDRY PRACTICE" AND "METALLURGY OF CAST IRON."

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PREFACE.

ALTHOUGH it is more than two years since the appearance of the first volume, the author cannot refrain from here tendering his most sincere thanks to the press and public of America and England for the cordial reception given his first book. Also, to American foundrymen and moulders the author is greatly indebted for the universally rapid introduction of his work among them.

The compliments which were so kindly tendered the first volume have encouraged and stimulated the author to write this second book.

Many of the original articles here submitted, as in vol. i., appeared in the "American Machinist," and have been revised for this volume. Also, many of these articles have had valuable additions made to them.

The subjects of Cupolas and Melting, also those of moulding in green sand, in dry sand, and in loam, are extensively treated; and this volume, in connection with vol. i., it is thought affords a thorough presentation of each subject.

The author received many communications regretting the lack of a treatise upon cranes in the first volume: hence he has endeavored to present, in this, the practical and essential features to be considered in properly constructing them for foundry use. Jib, post, and travelling cranes are treated, so that ideas of practical value may be obtained, either for engineers or foundrymen.

Wherever the author has thought an engraving would be of any assistance in making his subjects clear, such illustration is given.

As stated in the preface to vol. i., there is certainly a very large field for new ideas and progress in foundry practice; and the author hopes that his studies and advanced methods here presented to the practical moulders of America verify the above statement, and will be as kindly received as those of his first book.

THOMAS D. WEST.

CLEVELAND, January, 1885.

PREFACE TO EIGHTH EDITION.

HAVING recently thoroughly revised "American Foundry Practice" and placed it in keeping with the advance of the general workings of founding, it is but proper that the same interest should be displayed in revising this work. By comparing this edition with the last, readers will find this to have been done in such a manner that all those competent to judge, the author believes, will say that this work is as valuable to the trade to-day as when it was first written in 1885.

THOS. D. WEST.

SHARPSVILLE, PA., August, 1900.

PREFACE TO THE NINTH EDITION.

This edition has been enlarged considerably and the new material which has been added will be found for the most part included between pages 375 and 430. Some of this new material was originally presented in the first and second editions of a treatise on "The Metallurgy of Cast Iron" by the author.

In making this revision the author has endeavored to show the latest improvements in the construction and management of cupolas, most of which is based on his own experience during the past five years. He has set forth the advantages derived from what is known as the center blast and believes that these additions make his present work, in connection with Vol. I, the most complete treatise on American Foundry Practice extant.

Sharpsville, Pa., Aug., 1901.

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THE

ENGINEER AND FOUNDER.

SOUND CASTING.

[Read by the author before the American Society of Mechanical Engineers, New-York City, November, 1884.]

The term *sound* is of far more importance than any other which can be applied to designate a good casting. A sound casting can seldom be judged by its outward appearance. The smooth skin is often nothing but a shell covering defectiveness, and not until a casting is broken is its soundness known.

Soundness is often of more value in determining the strength of a casting, than the quality of iron of which it is made. A casting made of the best of strong iron can easily have its strength annulled through inner defectiveness. Almost all machinery castings are more or less liable to contain holes from sand, or shrinkage, or blow-holes. Castings are often so constructed, that, even were the moulder to turn them out free of sand or blow-holes, the shrinkage-hole would show up, were the casting to be broken, despite all the feeding he could do. The reason for this is best shown through an explanation of Fig. 1. Here we have, as is often the case, a heavy and a light section connected. Now, were it always practicable to have the heaviest part the uppermost, as seen at Fig. 2, so as to be accessible for feeding, then the moulder could justly be blamed were the casting not sound.

No doubt every engineer will at a glance perceive the difficulty in obtaining the perfect soundness of such a section as Fig. 1. Here we have the heaviest portion surmounted by a light body, which will be set much the soonest. The light part having frozen, any feeding-head that may be over it cannot be of any further benefit in supplying the lower heavy portion to feed its solidifying crust, which, by the way, in many cases, may not have begun to set until after the upper light part has nearly solidified. This lower body, having nothing now left to draw from, will draw metal from its uppermost liquid portion; which, in such a section as shown, would leave cavities which would be apt to weaken the casting at *A*.

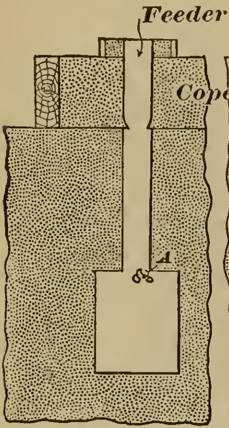


Fig. 1.

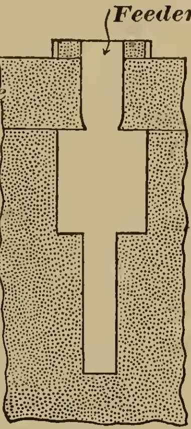


Fig. 2.

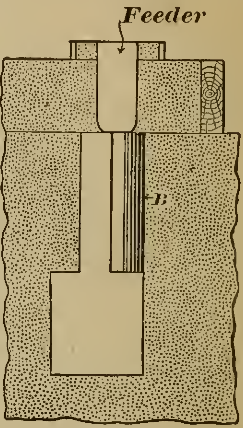


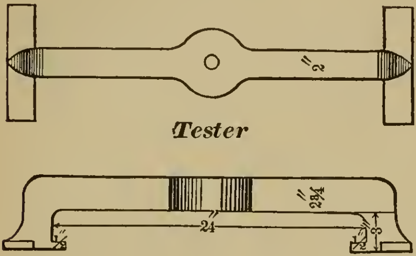
Fig. 3.

In practice, when such sections as at Fig. 1 are thought to be required to stand much strain, it is best generally, when practicable, to have an enlargement made, as seen at *B*, Fig. 3. This gives a body which, by means of a feeding-rod, and by occasionally pouring hot iron in the feeding-head, will remain in a fluid state as long as the heavy portion. This accomplished, it can be readily seen that the formation of a cavity, as at *A*, Fig. 1, is prevented.

(It must be, however, understood, that enlarging a section, as in Fig. 3, is only recommended in cases where it is not practicable to attach independent feeding-heads. Where such a section, as in Fig. 3, is at the outer portion of a mould, and the heavy part to be fed is below the joint of the mould, it may, in many cases, be fed by feeders placed from 6″ to 8″ from the surface of the mould. Connections running from the feeding-heads, if the case would not admit of branch gates being drawn inward or outward, could easily be formed with cores having holes of the size required.)

Now, it is by no means practicable to attain soundness in all castings by the above means; for there are many moulds in which the intended form of the casting would be made almost unrecognizable, were they to have all their heavy sections thus reached and fed by risers. Attending this is often the impracticability of placing over three or four feeders upon a mould; for often the bars of the cope, chaplets, binders, and weights will not permit the use of any more. Then, again, were it practicable to have a cope filled with feeding-heads, there are many castings, which, in order to be sound, would require that more men be taken off from the work of "running off the heat" than foundries at casting-time can generally spare.

It is very evident, from the shapes of existing patterns and castings, that but little thought has been given to this element involved in obtaining an entirely sound casting. The best place to study this error is at the scrap-pile. There one can find the shrinkage-hole in many forms. Often fillets which were intended as factors for strength will be found to be exactly the reverse. The greater part of machinery castings made are more or less filleted; and some designers have the idea that the larger the fillet, the greater the strength given. In cases where the fillet is fed by other metal than that contained in its central body, this may be true. Often fillets are so situated, they cannot be fed by other than the metal contained within their own body; and therefore, as illustrated by Fig. 4, a large fillet in such cases may often be a source of unsoundness.



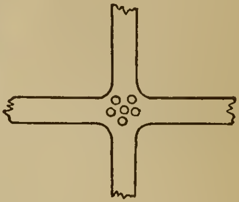


Fig. 4.

A well-proportioned casting should not always be considered only from the standpoint of the strains which its respective parts have to stand. While it is often true that some part may be very light in comparison with others, *it is more often better that the light part be made heavier, in excess of what its strength requires, in order that strains may be avoided, as well as "draw-holes," caused through unequal thickness of parts.*

To give some data as to what extent ordinary cast-iron will shrink, I have lately been experimenting with round balls of different diameters. The sizes of these were respectively about 4″, 5⅜″, 6¾″, and 10⅜″. Two of each size were cast at three different heats, thus making altogether twenty-four balls; and of these, twelve were cast without any feeders, while twelve had them. The feeding-heads for 4″ balls were 2½″ diameter; for 5⅜″ balls, 3½″ diameter; for 6¾″ ball, 4″ diameter; for 10⅜″ ball, 5″ diameter.

For the first three sizes, the height of the head from the flask-joint up to the top of gate was 9″, and for the 10⅜″ balls the gate-head was 12″. The gates which admitted the metal into the moulds were cut broad and very thin, in order that they should freeze a few moments after the mould became full, thereby insuring that metal did not enter through the pouring-gates to supply any shrinkage. In pouring these balls, the iron was medium hot, and the gates were filled up to the heights given. The balls having the feeding-heads were "churned" until they solidified. In cleaning the castings, the feeding-heads were chipped off, so as to preserve the spherical form of the balls as much as possible.

This statement with reference to the manner of moulding and casting the balls is simply given to show the conditions under which the tests were made.

The following is a table giving the weights of the balls, and the difference between the fed and the unfed balls: —

FIRST HEAT.

Mixture of Iron.

200 lbs. ordinary No. 2 pig and 400 lbs. scrap.

DIAMETER OF BALLS.	FED.	UNFED.	SHRINKAGE FOUND.	PERCENTAGE OF SHRINKAGE.
4″	8 lbs. 12 oz.	8 lbs. 10 oz.	2 oz.	1.428
5⅜″	20 lbs. 11 oz.	20 lbs. 8 oz.	3 oz.	0.906
6¾″	39 lbs. 10½ oz.	39 lbs. 4 oz.	6½ oz.	1.024
10⅜″	150 lbs.	147 lbs. 15 oz.	33 oz.	1.375

SECOND HEAT.

Mixture of Iron.

100 lbs. No. 1, Bessemer. A strong coke iron.
100 lbs. No. 1, Hubbard. A strong coke iron.
100 lbs. No. 1, Pine Grove. A strong charcoal iron.
300 lbs. Machinery scrap.

DIAMETER OF BALLS.	FED.	UNFED.	SHRINKAGE FOUND.	PERCENTAGE OF SHRINKAGE.
4″	8 lbs. 13½ oz.	8 lbs. 12 oz.	1½ oz.	1.060
5⅜″	20 lbs. 13 oz.	20 lbs. 9 oz.	4 oz.	1.201
6¾″	39 lbs. 11½ oz.	39 lbs. 6 oz.	5½ oz.	0.865
10⅜″	149 lbs. 12 oz.	148 lbs. 7 oz.	21 oz.	0.876

This second heat was poured with middling fluid iron.

THIRD HEAT.

Mixture of Iron.

400 ℔s. No. 1, Hubbard. A strong coke iron.
200 ℔s. Machinery scrap-iron.

Diameter of Balls.	Fed.	Unfed.	Shrinkage Found.	Percentage of Shrinkage.
4″	8 ℔s. 14¾ oz.	8 ℔s. 12½ oz.	2¼ oz.	1.576
5⅜″	20 ℔s. 14 oz.	20 ℔s. 9¾ oz.	4¼ oz.	1.272
6¾″	39 ℔s. 12½ oz.	39 ℔s. 7½ oz.	5 oz.	0.785
10⅜″	149 ℔s. 8 oz.	148 ℔s. 6 oz.	18 oz.	0.752

In this third heat, with the exception of the 10⅜″ balls, they were all poured with a more fluid metal than was used in the two upper heats. This I would assign as the reason for the 6¾″, 5⅜″, and 4″ balls being heavier than in any of the other two heats shown.

In classing one heat against another, the mixture of the iron must be taken into consideration. Balls from each of the respective heats were split in order to learn, if possible, the cause of the dissimilarity of weight most noticeable in the smaller sizes.

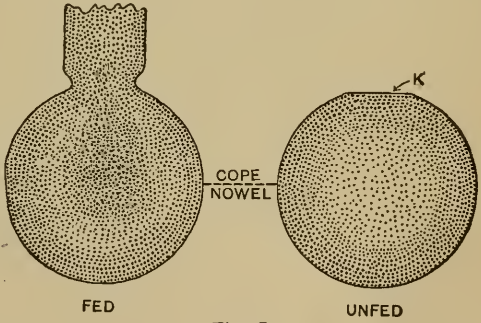


Fig. 5.

The cut at Fig. 5 partly illustrates the fracture of the split balls. The smallest-sized unfed balls showed a very open grain at their centres, gradually increasing in density towards the shell. The unfed $10\frac{3}{8}''$ balls were not only very porous at their centres, but contained large holes as well. The flat place seen at *K* shows about how the top part of the unfed balls looked. This was, of course, formed while the crust remained fluid enough to supply shrinkage. After the crust became set, the balance of shrinkage was then drawn from the innermost fluid portion of the balls, as proved by the porousness and holes found when the balls were split open. The fed balls were the most dense in the middle; the most porous part of them being about midway between the shell and centre, as seen in the cut. The density of some of the fed balls at the centre was remarkable, and was a clear explanation of the cause of their variation in weight. This centre density was, no doubt, mainly caused by the pressure exerted by the feeding-rod, and the occasional supplying of the feeding-heads with hot iron. When feeding a casting, the feeding-rod at the latter end is more or less enlarged, caused by molten metal sticking to it. This may be knocked off, or a new rod used; but, whichever way is used, there will exist variations in the manipulations of feeding, sufficient to cause the dissimilarity in weights seen. It seems reasonable to assert that a thick feeding-rod should exert more of a pressure and disturbance than a thinner rod, and that, the smaller the ball, the more effect could be produced.

In moulding these balls, I was very careful in all the manipulations performed. The ramming, venting, drawing of the pattern, and gating were as near alike as study and care could make them. In feeding, attention was given to the procuring of solid castings. The $10\frac{3}{8}''$ ball would occupy from fifty to sixty minutes to be fed solid; and, although these largest balls show about the lowest percentage in shrinkage, they no doubt give the nearest approximation that it would be practical to assign to shrinkage in the general run of castings, which, if estimated at *one pound for every hundred pounds of casting, would not be far out of the way.*

While it is essential that a casting should be fed solid, to be strong, the temperature of the iron used is also a factor for consideration.

Some time ago I made the assertion, that metal poured at a dull heat would produce the strongest iron (an opinion then held by others beside the writer). Having made this assertion, there could be no one more anxious than myself to have seen this kept a maintained fact. Mr. Gardiner, foreman of Pratt & Whitney's foundry at Hartford, Conn., has informed me, that, through experiments which he had made with test-bars poured dull and poured hot, he found the hot-poured bars the strongest. Thinking that I might be in error, from the fact that the tests I had made were but few and crudely performed (as can be seen from the description then given), I desired to give the question another and a more thorough test. Having no testing-machine, I devised the simple affair shown in Fig. 6 for the purpose of dealing with the subject. In using this machine, bars 1″ square × 24″ long were tested. In all tests, the hot-poured bars stood the greatest load. To make sure that my machine was working correctly, and to know what the results

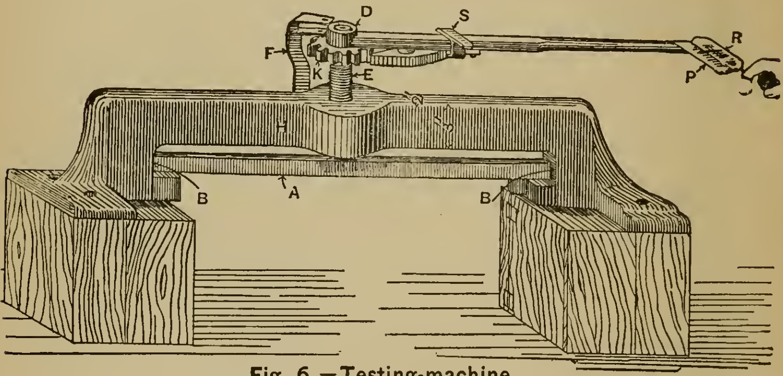


Fig. 6.—Testing-machine.

would be, were heavier bars used than 1″ square, I had some patterns made, measuring 4¼″, 2¼″, and 1¼″ square by 24″ long. When cast they were taken into the machine-shop, and accurately planed up to the respective sizes, 4″, 3½″, 2″, and 1″ square. The following table shows the strength of the dull- and hot-poured bars, as found by tests taken by an Olsen machine at the Otis Steel Works, Cleveland, O.: —

SECTION OF BARS 24″ LONG.		BREAKING LOAD.	SECTION OF BARS 24″ LONG.		BREAKING LOAD.
4″ square.	Hot . .	56,130	2″ square.	Hot . .	9,520
4″ “	Dull . .	49,830	2″ “	Dull . .	6,400
3½″ “	Hot . .	38,470	1″ “	Hot . .	1,050
3½″ “	Dull . .	36,960	1″ “	Dull . .	1,020
2″ “	Hot . .	7,560	1″ “	Hot . .	1,130
2″ “	Dull . .	6,340	1″ “	Dull . .	960
2″ “	Hot . .	8,650			
2″ “	Dull . .	6,810			

The above bars all showed a perfect fracture, with the exception of the 3½″ dull bar, which showed a honeycombed centre. These 3½″ bars were intended for 4″: but as soon as the skin was broken when planing the dull bar, blow-holes were seen; and, thinking that were the bar planed down they might disappear, the machinist was instructed to make the bars 3½″ square. As every cut revealed fresh holes, it was found no cleaner at 3½″ than at the 4″ square.

These blow-holes were readily accounted for by the fact that the iron with which this bar was poured was so dull that it would hardly flow out of the ladle. It was purposely so poured in order to learn how it would stand for strength. The result as shown will no doubt be a surprise to many, as it was to me; for, although this bar showed such a bad fracture, we see that it stood within 1,510 pounds as much as the hot bar, whose fracture was perfect like all the others. It might be well to state that these test-bars were cast vertical, in order to insure their being sound and clean. There would be two bars of the same size moulded; and after one was poured with the hot metal direct from the cupola, the ladle would be allowed to stand until the balance of the metal was just dull enough to insure that the casting should run up full and square. I have omitted the mixtures of which the respective bars were made, for the reason that a knowledge of them would be of no assistance in determining the end sought.

Since making the above tests, it occurred to the writer, that in his first experiments, which showed dull iron to make the strongest bars (seen in vol. i. p. 233), the result was mainly due to the fact of the first test-bars being poured with metal which was, as stated, agitated with wrought-iron rods.

The above bars were all poured with iron which was not in any way agitated, the metal being left to cool off naturally. Therefore the first test may not be in any error, and but simply go to show, that, when practical, it is beneficial to agitate hot metal with wrought-iron rods.

Before closing, I would respectfully call attention to the machine shown in Fig. 6, and at left of Fig. 4.

This machine I invented for the purpose of aiding me to determine the strength of the 1″ square bars above mentioned. As some such machine would be found very useful to many, I studied to make it as presentable as possible. The weight of the whole machine is only about eighty pounds; and any one who may choose to give it a trial would, I think, be pleased with its workings, especially in view of the amount it would cost to make one (which should not exceed six dollars). The machine is best adapted for testing foundry mixtures of iron, and new brands of pig-iron. As seen, it will record the three essential points which foundrymen ought to know about their iron: —

The first is the *contraction* of the iron;

The second, its *deflection;*

The third, its *strength.*

In obtaining the contraction, the pattern *A*, from which the test-bars are to be made, should be just the length of the distance between the standpoints *B B*. Then, when the bars are cast, all that is necessary after one is set in place is to keep it tight to one end, and the space at the other will give the contraction.

For obtaining the deflection, a piece at *F* has a slot through which a thumb set-screw binds it against the stand *H*. Before commencing to screw down upon the bar *A*, the piece *F* is set down upon the ratchet-wheel *K;* and, being secured by means of the thumb-screw above mentioned, it will, of course, remain stationary. Then, when the bar *A* breaks, its deflection can be told by the space between *F* and the top of the ratchet-wheel. The two arms which *F* is seen to have are for the purpose of holding a small 2″ iron rule, divided into fifty or a hundred parts; and there are slots in the arms for the purpose of holding the rule.

To obtain the strength, the load is applied by means of the screw *E*, which is $1\frac{1}{4}''$, having nine threads to the inch. In the bottom of the screw, there is a steel pin having a bearing-surface of about $\frac{1}{4}''$. The ratchet-wheel *K* is, of course, secured to the screw *E*, and a part of the screw projects up above it so as to leave a pin for the ratchet-lever *D* to work up on. The lever *D* is provided with a ratchet-pawl, so that the operator can stand in the same place while working the screw. Behind the pawl is a spring so as to force it into the teeth of the ratchet. At *S* is a sliding band, which, when pulled back, releases the hold of the spring upon the pawl, thereby allowing the ratchet-wheel, or screw, to be turned back without removing the lever *D*. At the end of the lever is a common twenty-five-cent spring-balance scale. Across its face, at R, is fitted a thin piece of brass or copper plate. A wire is inserted in a small hole which is drilled through the little pin of the balance which indicates the pounds: this wire projects out from this pin upon each side alike. Then, when pulling the balance, this wire squarely pushes up the registering-plate R, so that, when the piece to be tested breaks, the plate will register the load.

The length of this lever, from the centre of the screw to the point from which the balance pulls, is 18″. The reason for having the scales lying in the semicircular frame P is simply to insure that the pulling is always done in the same direction. The scale used with this is the twenty-four-pounds scale; and a load of twelve hundred pounds (which is about the strength of ordinary cast-iron when tested in such sized bars as shown), exerted upon a bar to be broken, will show but about twelve pounds upon the scale.

In using this machine, were it desired to graduate the scale so as to know in actual pounds what load was being applied, all that is necessary is to set the machine upon some rolling platform-scale which will weigh about two thousand pounds. After the machine is bolted or clamped to the lower frame of the scales, and the weight of the machine noted, then turn down the screw, and, as the beam of the platform-scale rises, mark off upon the face of the spring-balance at every hundred a straight mark. Then, after going as high as is desired, the hundreds can be subdivided if preferred. Now, I know that many will object to the use of the screw as a feature of this machine. The machine is certainly one that could not be used as a standard, but it will answer to let a shop know the relative strength of its irons. If the screw is an easy fit, kept clean and well lubricated, the machine should, for such a cheap wrinkle, give good approximate results. At least, the *deflection* and *contraction* are two things which could be counted upon as positive.

When making the test-bars, they should be run by means of skimming-gates; and in moulding them, care must be exercised in order to have them come all alike. The bars I used were made in a flask which had a flat iron bar mortised into each end of the nowel, just as far apart as the pattern is long. By this means the moulds could not be lengthened through any rapping of the pattern.

To know the *strength* of iron, and the amount which it will *contract*, are certainly points of value in aiding to make strong, *reliable* castings; and while it is often impossible to know whether a casting is sound, until it is broken, we may, through a knowledge of the mode adopted in making it, often be guided in placing confidence as to the strength and soundness of the casting produced.

It should not be always looked upon as the culmination of skill to make a casting "peel," and be smooth. Many castings are more easily produced smooth than sound, and the skill and experience generally required to make sound castings will often rank far above that required to make them smooth.

DEFECTS IN STRUCTURAL CASTINGS.

[Read by the author before the Civil Engineers' Club of Cleveland, July 10, 1883.]

The value of sound castings in structural work is best comprehended by those who have suffered losses through their defects.

Formulas and tables upon the limit of elasticity, compression, and tensile strength of cast-iron, might often be called *factors of faith.* For, did the mechanical engineer know how low his factor of safety is often brought through defectiveness, he could not help acknowledging that many massive structures are built more by *faith than by facts;* and while there are a great number of well-ascertained facts and definite laws for the guidance of those engaged in construction, there are often defects, caused through ill manipulation and material, that would seem to make structural formulas and tables *but a starting-point for guesswork.* In the investigation of cast-iron structural or machine accidents, it is rarely the case that the work is found imperfect through its design. The verdict generally given is defective material or poor workmanship.

Castings for structural and machine building, where an injury to them would be more or less apt to cause the loss of life and property, are, as a class, what engineers are required to deal with, and often stake their reputation and welfare upon. As a chain is no stronger than its weakest link, so is a casting no stronger than its weakest defect. Almost every casting made is weaker in some parts than in others; not necessarily so through design, but often through causes that in some cases might be avoided through the aid of practical experience and skill.

Heretofore foundries have generally been looked upon as nothing but *dumping-holes for blockheads, dirt, and pig-iron.* There is no question but that we have them all. But I can safely assert that in many of them there is labor that is worthy of the mature study of our brightest engineers.

Because work is dirty, it is no sign that a thick and muddy brain could do it, or that there is no field for thought or study.

The defects in castings are due to many causes, some of which are generated outside, as well as upon the inside, of foundry walls. Those outside could be classed under the head of *design* and *competition;* inside, under the head of manipulations of *mould* and *metal.*

Competition is often detrimental to the production of good structural castings, for the simple reason that the work is taken too cheap, thereby not allowing the lowest bidder enough margin to spend for good material and labor. In this might be seen one of the reasons why the engineer should familiarize himself with the workings of a foundry, in order that he may be able to correctly judge what different classes of castings are worth in dollars and cents to manufacture. Structural castings cheaply bought are often cheaply made, and may answer for a time; but their steady employment will sooner or later result in some disaster. With reference to the designing of structural castings, the draughtsman's and pattern-maker's work is often a large factor in the procuring of clean and sound castings. This subject can be better understood and taken up by the following discussion of mould and metal. Every structural casting is apt to contain some dirt. This dirt is generated from the mould's surfaces and the metal's impurities. The amount of dirt a filling-mould will collect depends mainly upon three things: the first being *the moulder's ability properly to make a mould;* the second, *the shape and size of a mould;* third, *the style and* *manner in which the mould is poured and gated.* The injury or weakness that dirt will cause to a casting depends upon its bulk, and where it is lodged. There are some castings in which certain portions can contain more or less dirt, and still not materially impair their strength for the purpose intended. The best judge of such defects should be the engineer himself. Now, if this be the fact, it seems but a step farther for the engineer to acquaint himself with the practical moulding of any special job, and thereby cause arrangements to be provided, whereby the moulder could often be assisted in having *receptacles* or *parts* that would catch and hold the dirt in such places that little or no injury could result therefrom.

It would be an impossibility to here give any data that could be used as a standard for the procuring of every casting clean and sound, as what might work well in one case would seldom do for another.

However, there are two or three points, that, if explained, would show principles that might often be applied to greatly assist in the cleanliness of castings, and also give to the novice an idea of means used for collecting the impurities of the metal before it enters the mould. In pouring a mould, the tendency of all dirt, or material, whose specific gravity is lighter than the iron used, is to float or rise toward the surface of the metal. This fact is often taken advantage of by what foundrymen call a *skimming-gate.* To fully show its form and principle, the sketch (Fig. 7) is given. At A is what is commonly called a basin; into this the iron is poured, and the basin filled as soon as possible. From A the metal flows through the channel X to B, from B to E; from E it is carried downward, and flows into the mould as represented by the arrow at K.

Now, it is very evident, that, by having the basin A kept full, the metal in the riser F should be about on a level with that in the basin.

The iron that runs into the mould being taken from the bottom of the liquid metal, as represented at *E*, it must necessarily be free of impurities that, by reason of gravity, have risen to the surface, as shown at *D* and *S*. While this explanation is only to give an idea of the principle, it might be well to state

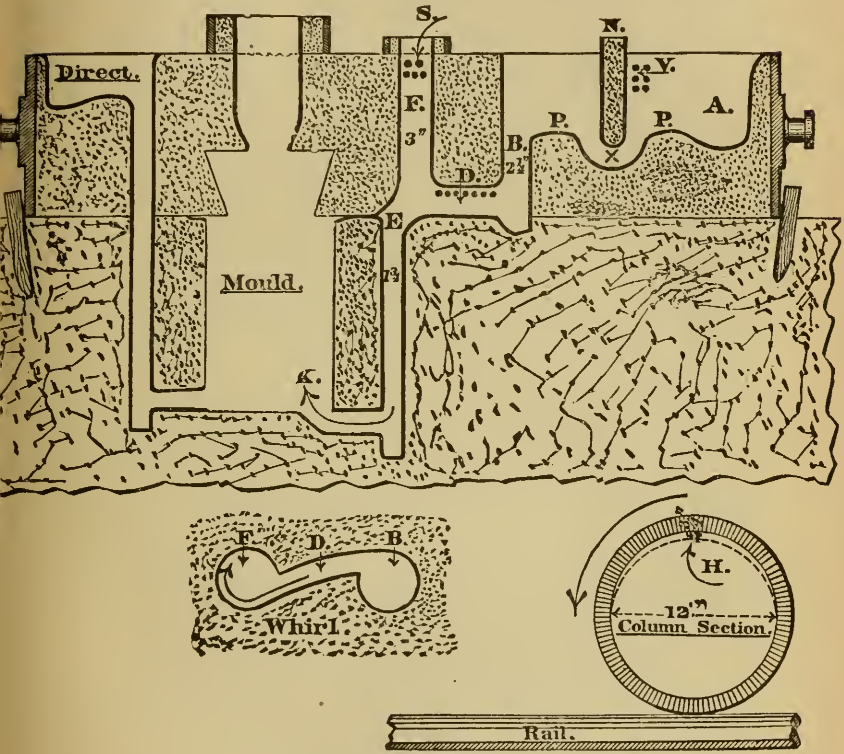

S.
N.
Direct.
Y.
F.
A.
P.
P.
3"
B.
2¼"
D.
E
Mould.
1¾
K.
F
D
B
Whirl.
H.
12"
Column Section.
Rail.

Fig. 7.

that the principle is used in a variety of forms, made to suit different moulds and conditions. The value of skimming-gates is often lost through the moulder's not using judgment in making the gates or runners *B*, *F*, and *E*, having a proper relation to each other. *F* should always be the largest, in order to afford room for the dirt to rise. *B* should be larger than that shown below *E*. If *E* were larger than *B*, it would be a difficult matter to keep the dirt from passing into the mould; for the simple reason that *E* would take iron faster than *B*, thereby not allowing the dirt-riser heads *D* and *F* to be kept full, which must be done in order to collect and hold the impurities as shown. Keeping the riser *F* full is not always a guaranty that the impurities are being collected: the flow of metal may be too fast to give the impurities a chance to be held. A point to be kept in view is, *the longer that metal can be practically maintained in F and D, before passing into the mould, the more purified it should be.* In this cut shown, the *E* $1\frac{3}{4}''$ gate would be better if it were not so nearly under the dirt-riser *F*, as shown. The farther away *E* can practically be carried from *F*, the more effective will such a skimming-gate be in catching and holding the dirt.

The gates or runners, *B*, *F*, and *E*, are supposed to be round; and the sizes shown represent about what relation such skimming-gates should bear to each other. The sketch marked "whirl" shows one of the *wrinkles* sometimes used. The connection *D*, if cut from *B* to *F* in the manner shown, will cause the metal to whirl in *F*, thereby assisting the dirt or impurities to rise up, as shown at *S*. The greater the whirl, the better the results. Another plan, sometimes practised to catch and hold impurities from going into a mould, is as shown at *N*. This is commonly called a skimming-core: it is built or set into the main basin, from 2″ to 6″ lower than the reservoir's bottom, *PP;* below this core is made a basin, as shown at *X;* when this basin is filled with metal, the ladle's dirt is held as shown at *V*, and the clean iron flows through at *X*. The amount of dirt or impurities that a well-contrived skimming-gate or basin will gather and keep from going into a casting is often remarkable. The section marked "Direct" shows the method practised in ordinarily gated moulds, in which there is nothing to prevent the dirt or impurities from passing into the mould, except what is held up by keeping the basin full of metal while pouring. I should like to here treat upon other forms of gates and runners in their relation to special forms of castings; but as my time to prepare even what I have was very short, I shall have to dispense with much that should be brought out in order to fully discuss such a subject as the title implies. It is not intended here to convey the impression, that, by having a well-planned skimming-gate, the casting is sure to be free from defects. In some cases, where the making of the mould is in the hands of a first-class moulder, it might be so; but, as a general thing, the skimming-gate is but a small factor. About all that can be said of it is, *that it aids in collecting the impurities of iron before it passes into the mould.* The engineer has other imperfections that he often needs to be more watchful of than the impurities of the iron; consisting of *scabs*, *blow-holes*, *cold-shuts*, *misplaced cores*, *improper feeding*, etc. Any one of these could form a hidden defect that would reduce a casting to one-twelfth of what should be its ultimate working strength, and maybe greatly exceed that, going from twelfths to twentieths. Such defects cannot be bridled with mathematics in any form: they are *infinite*, *treacherous*, *and beyond human reason to define.* A scab is part of the mould-surface flaked off, the depth of which varies from $\frac{1}{16}''$ up to $6''$ in thickness. When a scab is over $1''$ in thickness, there will be generally more or less visible blowing. Sometimes this mould or casting blowing will become so violent as to tear a mould all to pieces, thereby making the exact form of the intended casting unrecognizable. Such defects as this will, as a general thing, leave but little doubt as to the casting's future use; they, being too apparent to deceive, must necessarily be introduced to the scrap-pile. When a mould scabs, the sand mingles with the iron; some of it may be visible, while some may not; the sand being specifically lighter than iron, it naturally rises until stopped by contact with cores or the mould's surfaces, etc. This is a point in designing castings, that should be remembered; as, with this in mind, the sections that are liable to confine or catch dirt *might often be made thicker than the design would otherwise call for*, *thereby allowing for a probable reduction in strength.*

To further convey this idea, I would call attention to the sketch of a column section. As a general thing, — in fact, I never saw or heard differently, — columns are wanted to be of an even thickness all around. I remember, some twenty-two years back, inspectors testing a lot of columns (they might have been pipes; but the principle involved is the same).[1] The shop where this inspection or testing occurred was at the Portland Locomotive Company's foundry, Portland, Me. In the testing of these castings, two rails were placed parallel; and, after being levelled, the castings were raised, one at a time, and set upon them. The inspectors would then rotate them about one-half their circumference; and, after coming to a stand, they would then be allowed to find their own centre of gravity. By this process, any unevenness of thickness was quickly detected; and if any of the castings, in revolving to their centre of gravity, went faster than the allowed speed, they were condemned.

To the best of my memory, the castings were made in green sand, and cast horizontally. Now, the question in my mind is, Was not the test somewhat in error? In the horizontal casting of any cylindrical-shaped mould, the cope, or top part of the casting, cannot be as sound as the sides or bottom, for the reason that it will be more porous, and contain more dirt than any other portion of the casting.

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[1] Mr. A. C. Getchell stated, during the very interesting discussion which followed the reading of the author's paper, that, being in Portland when the tests were made, he remembered that the columns or pipes referred to as tested at the Portland Locomotive Works were pipes cast horizontally, and that about one-third of them were condemned.

I think it is a safe assertion to make, that if a horizontally cast pipe or column, that was found to stay in equilibrium at any point when being tested upon rails, were given an even internal tension, or end compression strain, until it would burst or rupture, the point of first fracture would be the cope part of the casting.

I should like to hear of such tests being made; for I do think it would result in opening the minds of many to an important factor in the casting of structural work, which is as follows: *Where it is reasonable to expect dirt or porousness in castings, make that section thicker or heavier than the design would otherwise call for, in order to counterbalance the weakening effect caused through the mingling of dirt or impurities with the iron.*

As to how much thicker the cope section of pipes or columns should be than the sides and bottom, this would be rather a difficult question to answer; as it would greatly depend upon the combination of lengths, diameters, and thicknesses, and also facilities for moulding. However, I would say, that, with a pipe or column 12″ diameter, $\frac{3}{4}$″ thick, and fourteen feet long, one-quarter of its thickness added to the cope, as represented by the dotted line *H* in the column-section cut, would then not always be a guaranty of its holding its own in a testing-machine.

In structural castings, the question of proportion, contraction, and quality of metals, contains three very important elements that require careful consideration. But as my limited time would not allow me to now do justice to the discussion of them, I will close with the remark, that to figure for strength in castings is one thing: to know if you have obtained it, is quite another. The former is the work of rules and tables: the latter is only assisted by observation, investigation, and practical experience.

P.S. *Shrinkage* occurs when metal is liquid; *contraction*, when it is cooling off in a solid state.

PROGRESS IN MOULDING.

NOVELTIES IN FOUNDRY PRACTICE.

In the Patent-Office buildings at Washington, are many novelties, some good and some of very little value. Many of them are appliances for mechanical trades, and have been heralded before the public. In this line, the moulder's trade has not been very prominent; whereby the public have been led to believe that, to do moulding, no inventive talent was required.

There are many tools in a foundry that at one time were just as patentable, and, in fact, far more so, than other things that have been patented. One reason why foundry novelties are not patented to any extent is because it would not pay. The greatest novelties in foundry practice are generally got up for some special job, which, perhaps, is not made in a half-dozen foundries in the United States, and even those could generally invent other ways to accomplish the end if they desired. Even if a man has something novel, that every foundry could use, he could seldom make it pay to attempt its introduction: all would look, but few would buy. They would look to steal the idea, from which, in many cases, they could get up something else to answer their purpose.

When a moulder gets up a new tool or rigging, he seldom thinks of getting it patented. There are some things in foundries that require the highest inventive qualities to originate; and it is wrong to suppose, that, because the foundry is not extensively represented in the Patent Office, no invention is required there. If the getting-up of something never before known is patentable, then there are foundrymen who every year of their lives could be applicants for patent honors.

There are many who patent things which eventually they would be glad to give away, in view of their experience at a later date. It is one thing to "*get up a patent*," but quite another to get it introduced, and have it earn money for the inventor: at least, that was the author's experience when he was new at this patent business.

Every tool or rigging now used in a foundry was at one time more or less of a novelty. *Many moulders seem to have the idea that the trade was originated as they found it, and that all that is required of them is to do as they see others do.* The habits and customs of the shop in which they learned their trade are theirs: they get to think that there is only one way that a job can be done, and that is the way they were taught. What a deplorable condition the moulder's trade would be in, were there no exceptions to this rule!

Once in a while we come across men who are original. They have, to our views, odd ways of working; and, if we are fortunate enough to be their shopmates for some years, we will often see them adopt new modes of working. *Such a man cares nothing for what he was taught to do:* to him it is only a stepping-stone. Once under way, he begins to forget what he was taught to do, and commences to do that which he learns by his own experience and study.

"What is that John is getting up now?" says some one.

"Oh! something to draw the boss's attention," replies some jealous sore-head.

Almost every advancement in a foundry is met with more or less ridicule. A progressive moulder is not always welcomed, but is often a target for abuse, especially when he starts in a new shop. It is astonishing how afraid some are of new-comers showing or introducing any novelty into a shop: no matter whether it is original or borrowed, if it is a novelty to them, they will try to ride it down. It is not only the men, but often the foreman as well, that will deride the introduction of any new or strange feature.

A moulder, in travelling to see and learn, may go through a dozen shops, and see nothing very new or strange in them. He may see different classes of work made, but, for all that, see nothing novel to him in the way it is made. It will seem as if one master taught them all. When first starting to work at the trade, we must be taught by others; but, should we wish to become leaders, we must keep it in mind that what we see done was not always so done, but was the result of the inventive and thinking powers of many men. That which others have given to us must be improved upon. Some one says we have nothing to accomplish; it has all been done. *If this were so, then, to the writer's mind, the uncertainty that is attached to the making of good castings would be at an end.* The novelties of the past have mainly been in the way of the introduction of appliances for making and forming moulds. *The novelties of the future should be for the purpose of lessening the present uncertainty in procuring good castings.*

It would be a hard matter for a designer to make a pattern that could not be moulded by some one. If we look through a machine-shop, we can see castings of almost every conceivable form. These were made by some moulder; *but how many times some of them had to be moulded, in order to produce the one seen, is where the trouble comes in.* Bad castings are often caused by the improper handling of material and tools, the proof of this being that the same man will often bring forth good and bad castings by the use of the same tools and material.

To rightly handle materials and tools, is *not to be learned by watching others.* You must have practice, coupled with intelligent study, if you succeed. To intelligently study any subject, it is always a great assistance to know what others think and know of it. To accomplish this exchange of ideas, there has lately grown up the novelty of foundry literature. There are men who scoff at this, who will before long see their error, or be made to feel it, by the advancement of others over them.

There is a large field for the expansion of foundry literature, and whoever interests himself in it cannot but be benefited by it. The interest in this line is rapidly growing, being taken hold of by the best mechanics and workmen. The men that have originated the most novelties in foundry practice have been generally forced to do so through necessity. In out-of-the-way foundries, can often be found more real novelties than in many of our city shops. Foundries that are far away from others cannot borrow or steal ideas: they are forced to use their own brains. There are seldom two men that plan the same, therefore when moulders plan there must needs be variety.

There are few moulders but would be able to improve or add something to our trade, if they would only make up their minds to make it a study. We should all try to make the trade better than we found it, and remember that the present attainments of our trade only come to exist through progressive thought and study.

MENTAL AND PHYSICAL DEVELOPMENT IN MOULDING.

The art of moulding demands both physical and mental labor, one being as necessary as the other. No one can become a *good*, *reliable*, *expert* workman at the business, unless he is well endowed both *physically* and *mentally*. Physical endowment does not imply that the man shall be an athlete, or possess the strength of a giant. Good health and a sound body are all that are required in this respect. A man cannot do justice to his *mental qualities* unless he is well *physically*.

The physical qualities of a man — *strength*, *endurance*, *dexterity* — may be readily tested; but mental qualities are not so easily put to the test. Circumstances must bring a man to face some problem requiring thought and study, before he can demonstrate his possession of the necessary qualities. Working at the trade of a moulder is well calculated to develop one's physical powers, even in spite of himself; but whether his mental qualities are proportionately developed, will depend entirely upon his *disposition to cultivate them.* It may be possible to drive the moulder into working hard with his hands, but it is impossible to drive him into studying and thinking of his work. It might be better if this were possible.

Bad castings are generally the result of mental errors. *The hands cannot make a move towards making a mould, except they are guided by the mind;* and yet but little attention is paid to the all-important subject of learning to think correctly. It is a good thing to be physically strong, but it is often a better thing to be *mentally strong.*

If a man were to keep his arms tied up in a sling for six months, and then loose and try to use them, he would find them weaker than before. Darwin says that the disuse of a member of the body will in a few generations cause its disappearance. Constant reasonable use develops the members of the body. How many can testify to a similar development of the mind by study?

Many say they are not paid to think. Most workmen are not paid as well as they would be if they thought more and better Mental qualities are, probably, to a great extent inherited; but they are susceptible of cultivation, and to almost any extent.

The greatest mechanical masters have become such by thinking for themselves, and by studying others' *mishaps, as well as their own.*

A moulder may say, "What can I study that will advance me mentally?" *Almost every bad result in making castings can be taken as a lesson.* Some of the lessons will be easy, others hard, but all important. In studying them, it may be necessary to visit libraries, consult the chemist, or ask questions of those who know more than we do. *It may lead us to do things that others will consider foolish.* Many of our greatest mechanical achievements spring from just such "foolish" things. An ambitious moulder can always find abundant material for study, not only in his own mistakes and poor success, but in those of others. Many seem to learn only by their own blunders, while others learn equally from the blunders of others. If we learn only through our own experience, our progress will be slow, and our life full of blunders.

No mechanic should depend on his physical abilities. It is *only by developing his mental qualities, that he can hope for success.* The early morning is unquestionably the best time for the workingman to study: his mind is then clear, and his thoughts will not be handicapped with the day's doings. An hour or two spent in this way every day will show astonishing results in the course of a year. If the morning cannot be devoted to this, then devote the evenings; but, in any case, devote an hour or two each day to studying and reading up in the line of your business.

PERFECTION IN MOULDING.

Perfection in moulding can only be reached through rigid attention to *trifles*. There is nothing grand, or, mechanically speaking, great, about making a mould. *Close attention to small things*, *a little delicate hand-work here and there*, *with the exercise of good judgment*, is all there is of it. If the end is successfully reached, it demonstrates that the necessary skill, judgment, and care controlled the manipulations. Whenever the result is bad, the intelligent moulder can generally trace it to some *trifle neglected*. *Trifles neglected leave chances to be taken*, which is where luck comes in. Trusting to luck is like a lottery: you may win, but the chances are you will lose.

There are often more castings lost through the *neglect of trifles*, than through ignorance, or the want of judgment. A large number of moulders of all classes take chances, and when they succeed it can be said that it is more *good luck than good management*. It is not always the poor mechanic that loses the most castings. There can be found plenty of first-class mechanics, having a large experience, who cannot be called *reliable moulders*. Their castings are generally lost through simple negligence, or in their being too willing to take chances. A careful moulder will always *give a doubt the preference*. If he is not sure, or feels that any thing is not safe, he will, if possible, secure it beyond question.

In moulding, there are possibilities of bad results that one thoughtful moulder may not foresee, which another one would. Some moulders have to thank experience dearly bought for all their good results, while with others experience has but little to do with results. A good, *careful judgment* is the secret of their success.

There may be said to be two classes of trifles, — the *known* and the *unknown*. When a casting is lost through the latter, we can often charge it to ignorance, or the want of *judgment;* when through the former, to negligence.

Whenever there is a new engine or machine to be built, the designers and builders make it as perfect as their experience and judgment teach them. They will give great attention to the details; and, when completed, the machine is given a trial. The first machine is seldom entirely a success. There are generally some little trifling things to be afterwards altered, to make it perfect. The designer or builder would not like to be told that he was ignorant, or had no mechanical ability, as a reason for the first engine or machine being imperfect. *None of us are perfect:* we must all learn by practical experience. In the building of new machinery, there is generally allowance made for the improvement of *trifles*. As the builder or designer requires trials of new work before it can be made perfect, so do the foundry manager and moulder require the same.

Progress in foundry practice is being made every day, and the *uncertainties lessened*. Specialties in foundry practice are having an influence in bringing about better work. The advantages of these are numerous. In such shops, the moulder generally makes the same job over and over; and he must be a poor mechanic that cannot improve or perfect a single job in time.

Ten years ago, almost every machinery foundry did a great deal of jobbing. To-day many of these shops discourage jobbing, and have adopted some special class of work, for the reason that they generally find more money in the manufacture of specialties than in jobbing. As a rule, foundries can nearly double their product by having specialties instead of jobbing, and with less requirement of skill. In jobbing, the first trial must be successful, to make things pay; while with specialties, if there is a miss, there is a chance to remedy the loss in others that follow.

It is not always the moulder that is to blame for his bad results. It may be the foreman's or proprietor's mismanagement, and the manner in which they control their men. *Wherever you find a shop in which the men are not under good management and control, there you will find the largest percentage of bad work.* A man, to be foreman of a foundry, should not only be practical, but also have the best of judgment. He should be able to know what skill and experience any job will require; also, the time it should be made in, and the qualification of all his men. A foreman is very often to blame for the bad results, in not knowing the requirements of a job, and in giving it to a man that is not qualified. There are hardly two foundries managed alike. One is run so that men are obliged to take chances; another is run, leaving every thing optional with the men; while, in another, no *known* chances are allowed to be taken. To discuss the reason for this dissimilarity, would be out of place. Suffice it to say that the class of work done may be the cause; but, as a general thing, it is the management that is responsible.

The best managed and controlled foundries are generally the ones that manufacture specialties. If foundries keep on dropping out of jobbing, and taking up specialties, as they now are doing, moulding must be advanced; as the percentage of bad results will be less, and a better quality of castings made.

Another thing that is helping to advance the *moulder's trade is the interest which is being taken in foundry literature.* By this means, moulders can intelligently discuss others' ideas and experience of the science of the moulder's art, and thereby be better able to arrive at correct conclusions.

The present demand of foundrymen is for more first-class workmen. The foremen are themselves often to blame for their scarcity. To have good workmen, there must be good, intelligent instructors and trainers. The great trouble with foremen is, they do not want to be bothered.

There are apprentices and moulders having the ability, that wish to be advanced; and with proper discipline they will make good workmen, and be a help in getting rid of much of the *uncertainty that is so largely attached to the present making of good castings.*

LOAM AND DRY SAND MOULDING.

GEOMETRY IN THE FOUNDRY.

In nearly all trades, some knowledge of geometry is required. For the moulder, no one seems to have written up that which is applicable to his trade. Some may wonder what moulders want geometry for; and think, if we understand the use of shovel and rammer, it is all we need. This, in many cases, may be true. But often a knowledge of geometry can be turned to as good an account in our trade as in others. It is as essential that many moulders should understand geometry, as it is that pattern-makers should do so. The way it now is, the pattern-maker generally does our geometry for us; and we, through our ignorance, are forced to submit to other tradesmen, to our own detriment. In green-sand, as well as in loam work, moulders are often obliged to call the pattern-maker to explain or to mark out work that requires geometrical knowledge. Moulds are often made requiring the dividing of circles, or marking off of square, oblong, and other shapes; locating of flanges, lugs, or sections of patterns, etc. The lack of geometrical knowledge is often woful. I remember a case where a moulder was sent to bring a pair of trammels, set to the proper length, in order to describe a circle: upon returning with a pattern segment, when questioned, he said the pattern-maker was absent, and, as the segment was upon his bench, he thought that was the thing wanted.

To describe a circle is a simple affair. To divide one into any number of equal parts, is where a knowledge of geometry is found useful. The number of parts into which a circle can be most readily divided is six; because the distance from the centre of any circle to its circumference, as *B A*, Fig. 8, will divide the circumference into six equal parts *F*, *D*, *A*, *P*, *E*, and *S*. To divide the circumference into three, erase every other one of the six points. To divide it into twelve equally, divide each of the six parts. To divide it into four parts, describe a line through the centre, as *K O*, Fig. 9. From the points where *K O* intersects the circumference, with trammels or dividers set at more than two-thirds the diameter, describe arcs cutting each other, as at *N*. A line then drawn from *N* through the centre divides the circle into four parts.

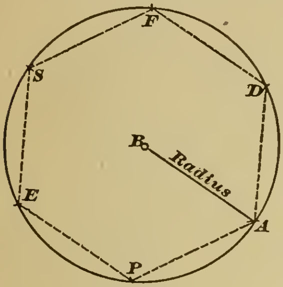


Fig. 8.

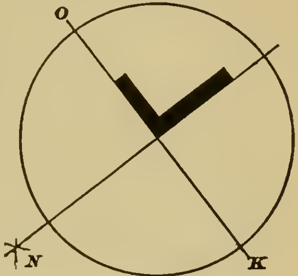


Fig. 9.

For eight parts, bisect each of the four. Many divide the circle into four parts by the use of a square and straight-edge, as shown at Fig. 12, instead of by describing the arcs as at *N*, Fig. 9.

The division of circles into odd or even equal sections can be done as follows. At *H* and *R*, Fig. 10, the radius, or one-sixth of the circumference, is set off. This arc is then divided, by trial, into the same number of sections into which it is desired to divide the whole circle. With the trammels or dividers set to the chord of six of the divided arc points, shown in the arc *H* and *R*, space off the circumference. This will divide the circumference, or circle, into the same number of sections as in the arc, which in arc *H* and *R* is seven. Should it fail to do so, the fault is yours. It must be remembered, that to *exactly* divide the circumference requires very fine manipulation. There are but few men that can go around the circle twice, and come out exactly alike.

Chords one-ninth, one-tenth, and one-eleventh are simply shown to further illustrate the rule. To divide the circle into fifths, the arc is divided into five; and, in order to have the six points, one is added to the arc's length, as shown. If by this rule the circle were to be divided into four equal sections, the radius arc would be divided into four sections; and, in order to have the six points, two would be added to the radius arc's length.

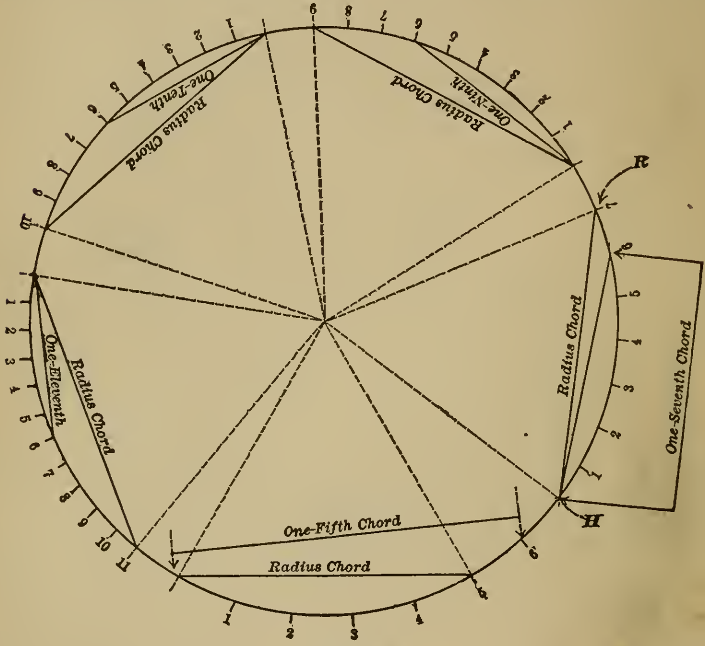

One-Tenth
Radius Chord
One-Ninth
Radius Chord
R
Radius Chord
One-Seventh Chord
H
One-Fifth Chord
Radius Chord
One-Eleventh
Radius Chord
1
2
3
4
5
6
7
8
9
10
11

Fig. 10.

For the divisions of circumference into small parts for the purpose of gear-making, etc., rules implying mathematical calculations, or tables, are required. The plan here given is simple, and such as requires no figures, and can often be used by the moulder to good advantage, and as far as I know is original.

In loam-moulding, plates are required, that in the hands of some moulders will be made without any visible shape of pattern, while others will require almost a full pattern; and the former will often mould up the work almost as quickly as the latter can. There are some loam-moulders who can make any number of loam plates and rings, entirely from the drawings, and not have a mistake in the lot. To be able to lay out a lot of rings and plates, and have them all come right, requires one to understand the reading of drawings, and a few of the elementary rules of geometry, besides sound *judgment*.

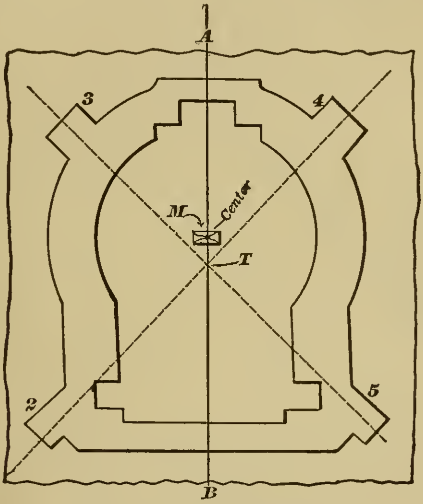


Fig. 11.—Cylinder Ring.

In marking out upon a sand-bed for any ring or plate having irregular shapes, a centre-line to work from is required, the same as the draughtsman requires in making a drawing. The cut showing a cylinder ring, Fig. 11, will to many convey ideas of laying out that may be useful. The bed being made, the first thing done is to drive a centre-stake, *M*. In this stake is made a small hole for the dividers' or trammels' point. Crossing this centre-point is marked the centre-line, *AB*. From this line all right-angled lines and measurements are taken. The circular lines being described, the next to follow is marking and locating the lifting-handles, 2, 3, 4, and 5. This often requires careful consideration, in order that they may be placed in the best position to insure or assist the mould being balanced when hoisted up. In locating lifting-handles upon square or round plates, they should, as a general thing, be set square with each other. This will be better understood by referring to the cuts, Figs. 12 and 13. In Fig. 12, the square and straight-edge seen show the manner of squaring-off the bed. The straight-edge having its edge over the centre, the square is set against it, so as to have it lie at right angles from the centre; the lines *D*, *E*, and *X* are then described, the line *E* being only carried as far as the length of the square, after which the square and straight-edge are removed. The straight-edge then being laid alongside of the line *E*, the line is carried through to *F* and *E*, thereby squaring-off the bed.

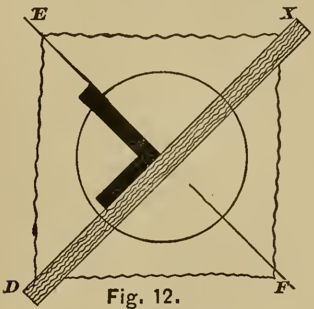


Fig. 12.

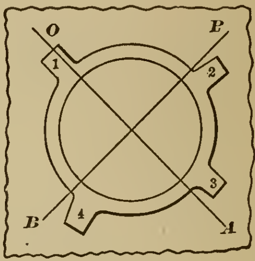


Fig. 13.

In Fig. 13, the lines OA and PB describe the true square, while the handles 1, 2, 3, and 4 are out of square. The objection to such random making of handles is, they will not come plumb under the lifting-cross, which is usually made square; also, handles thus placed upon rings, square or round plates, do not make them uniformly carry their load, thereby giving them a chance to spring, and cause the mould to crack. Some may say that they are often compelled to locate handles out of square, to make them balance their load. This may be true in some cases; but when possible, instead of distorting the square, the centre-point should be moved to where the best *judgment* points out will be the mould's balancing centre.

To illustrate this idea, instead of having the cylinder-ring shown, p. 35, squared from the centre, square it from T. This, while it does not distort the square of the handles, will bring the balancing point wherever desired.

Sometimes plates are required oblong. This does not always call for the handles to be set oblong. If necessary, handles can be set square upon an oblong plate as well as upon a round or square one, as long as the lines are at right angles to each other; coming closer towards the centre does not alter the square. Of course, it is not here advocated to set handles square, at the sacrifice of oblong plates being sprung when their load comes upon them. *The thing to be understood is, what is best, and then to be able to do it.*

Improperly placed handles have been the cause of much trouble in adjusting and balancing moulds, and have caused many moulds to crack. This fault, and other faults, are not so much from carelessness as from the want of a little geometrical knowledge. There are but few loam-moulders, who, from a drawing, are able to order their sweeps, etc., and make the jobs required. Our trade demands something higher than *loam-daubing and shovelling sand*, and he who tries for the highest cannot but find himself benefited.

MAKING CYLINDERS AND CASTINGS TO FINISH.

Steam cylinders are often complicated and difficult to mould, and when made they must be No. 1 castings. A flaw that would not injure many other machinery castings will condemn a cylinder. A cylinder casting may look perfect, without a visible flaw or dirt-spot, before boring or cutting into it; and yet when finished there may be flaws found that will send it to the scrap-heap. Experience has taught the author to be rather shy of extraordinarily smooth-skinned cylinders. To be able to make a cylinder with such a surface, and at the same time have a perfect, sound, clean casting when finished, is an accomplishment worthy of praise. The way some get an extra-smooth skin is by pouring the cylinders with what might be called dull iron. This is a risky plan to adopt just for the sake of an extra-nice skin, as it is likely to *sacrifice soundness for the sake of smoothness.*

A cylinder should be poured as hot as it practically can be the hotter it is poured, the cleaner and sounder it should finish. Cylinders are often poured with dull iron, for no other reason than that the moulder is afraid of his mould; for, if the iron is hot, it may find its way into the vents of the cores, and thereby set the casting blowing, or it may cut or scab his mould. Again, he may be afraid of a poor joint, or the mould or cores may have been burnt in drying. These are the main reasons given for pouring cylinders with dull iron; and, in some cases, the moulder is justified in considering them. By pouring dull he has less risk; and, considering all points, he keeps the most chances in his favor, and trusts to luck for the *machine-shop test*. Some moulders can make a fine mould to look at, but the iron spoils it. *A "fine mould" does not always insure a "fine casting."*

It would be impossible to state the many reasons why cylinders are lost in casting. Sometimes the plan of making the mould is all wrong, and sometimes the moulder's manipulations are wrong. Some will gate and cast a cylinder contrary to all reason. There are many who can make a good-looking unfinished casting, but, when it comes to making a casting that shall be clean after the skin is removed, they are at fault.

The science of making many sound finished castings can generally be told in a few maxims. First, *make a mould that will stand fast and hot pouring;* second, *a casting gated or poured by underneath side or joint runners, or gates, had generally better be gated or run as far as possible from the portion required to be finished;* third, *put good feeders upon the heaviest parts of the casting, and supply them with good hot iron until all the lighter parts are frozen up, and do not leave the heavy parts as long as the iron is liquid;* fourth, *study the science of making runners and gates;* fifth, *never forget that hot iron should make a sounder and cleaner finished casting than dull iron;* sixth, *remember that dirt will rise and lodge at under surfaces or upper portions of a mould.*

In casting cylinders, there are two ways practised. One is to cast them vertically, and the other to cast them horizontally.

A cylinder cast horizontally cannot be as sound as one cast vertically. In casting horizontally, more or less dirt will be caught and held by the under side of the centre-core, as shown at *A*, Fig. 14 ; and also in the cope, as seen at *B*. The author does not wish to be understood to say that good cylinders cannot be made by casting them horizontally. There are some firms that turn out excellent cylinders that are cast horizontally ; and, practically, they are as good for the purpose intended, as if they were cast upon their ends.

An objectionable feature of horizontal casting is, that even if you should have in the under portion of the core stock enough to bore out any dirt, the upper portion of the cylinder *B* will contain more or less invisible dirt, or the iron will not be as dense as in the bottom portion; so that, should the cylinder bore out clean, it cannot be as strong as if it had been cast vertically. Green-sand as well as dry-sand moulds are included in this statement.

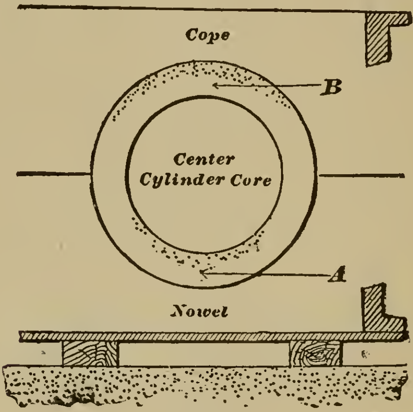


Fig. 14.

In making cylinders in green sand, it is rare that they are cast other than horizontally; while with dry-sand moulds they are cast in both ways. In loam they are always cast vertically; at least, the author never saw or heard of one being cast otherwise. Smoother castings are generally made in loam than in dry sand; and the *smoothness of loam-castings is not nearly as apt to be a sign of imperfections appearing during the machinist test, as in dry-sand castings.*

In pouring any casting, there is more or less dirt accumulated; if not from the mould, it will be from the metal. This dirt does not always come to the surface of the casting, so as to be visible: it may be just under the skin of the casting; and, again, it may penetrate quite a depth into the casting. The fluidity of the metal, and thickness of the parts cast, materially affect the degree to which dirt rises. Did the metal stay as fluid in the mould as when poured out of the ladle, the dirt would in time all rise to the surface; but, as we know that metal commences to get sluggish rapidly as soon as it is in the mould, we must expect that the degree to which the dirt will rise to the upper surface will depend upon how fast the metal loses its fluidity.

When a cylinder is condemned, the fault is not usually in the iron. The trouble is, there are places where there is no iron,—nothing but dirt or holes. If, in the place of this dirt or holes, there were iron, the casting would not be condemned. If there are holes without dirt, the chances are ten to one that something foreign to the iron caused them. If the iron is porous or honeycombed, the cause may be looked for in "mould-blowing," poor feeding, or badly proportioned sections that cannot be reached by iron to take the place of that which is drawn away to supply the shrinkage of other parts.

Of course we have unsound and condemned finished castings, caused directly by the iron, but not so many as are charged to it. Holes containing sand show a fault in the moulding. To keep these sand- or dirt-holes from appearing in sections that are not the uppermost parts of a casting when being made, the hotter the iron is poured the better. *Hot iron will float and let dirt rise up through it quicker than dull iron.* Of course we cannot destroy the dirt or sand by using hot iron; but by using it we are more sure of making the dirt go wherever there might be riser-heads, etc., placed to receive it. The pattern-maker knows, if any part of a casting is to be specially clean, he must make the pattern to mould, as far as plans will permit, so as to hold no dirt on that part, as the iron rises up in the mould.

In pouring moulds that are largely composed of crooks and cores, there is always more or less dirt generated from the mould-surface as the iron runs over it; and these very same crooks and cores may be so situated as to hold and catch dirt that we would like to have pass up into higher portions of the mould. Cores and crooks could often be so placed as to catch dirt, and prevent it from getting to parts that require to be sound and clean.

All unsound castings are not to be laid to the moulder. Many patterns are made in such a way that the required perfect parts cannot be insured. The required parts to be finished should be so marked on the drawing, and before the pattern is made its construction should be based upon the best and surest way to make these parts sound. The foreman moulder should always be consulted in this, as he should know something of the matter. There are often little points, which, when examined by the moulder and pattern-maker together, can be made to the profit of all concerned. One great trouble with some of our foundry foremen is, that they cannot read a drawing, and so the pattern-maker has it all his own way; and, when the pattern is about finished, the foreman can then advise how it should have been made.

Returning to steam-cylinders: the most reliable way to cast them so that they will come perfectly clean when bored is to cast them vertically when practical. In pouring from the top, as at *P*, Fig. 15, there are two advantages over pouring altogether from the bottom, as shown at *H*. The first benefit is, that we have as hot iron filling the top portion of the mould as there is at the bottom. In pouring a cylinder all from the bottom, the iron becomes duller the higher it rises. In pouring cylinders, if we can run or gate them, so as to have the iron as hot in one section as in another, it is a good thing accomplished. Some may think that the plan shown of pouring the locomotive side-saddle cylinder is not consistent with the above; but with a little thought, and close reading of the following, the moulder will see that the principle is one worth remembering. The side-saddle part of the locomotive cylinder is often filled with many crooked cores. and the thickness of iron around them is

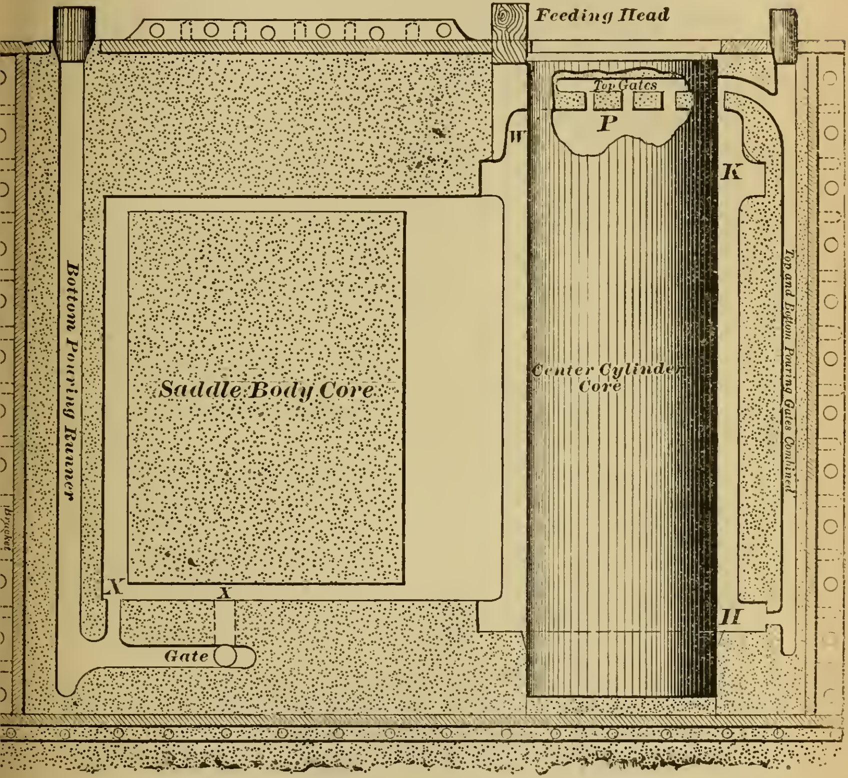

Feeding Head
Top Gates
P
W
K
Saddle Body Core
Center Cylinder Core
Bottom Pouring Runner
Top and Bottom Pouring Gates Combined
X
X
Gate
H
Bracket

Fig. 15.

far less than that around the cylinder centre core. By pouring the casting as shown at *X X*, the metal is admitted into the thinnest sections, from which it runs to the heaviest, thereby giving a far more even temperature all over the mould than were the iron first run into the heaviest, and allowed to flow to the thinnest, portion of the mould.

It may suggest itself, that, in pouring altogether from the bottom, it would be better to have the metal enter as near as practicable to the main body of the cylinder, so as to get the hottest iron in the part that must be clean. In this way, it is true, you would get the hottest metal in the body of the cylinder shown; but there is nothing to arrest the dirt, which is apt to make the casting unsound where it should be sound. It must be understood that the cylinders shown were only poured through the gates at *XX*. The gates at *H* and *P* are given to show how cylinders having no side-saddle are often best poured.

By pouring the saddle-cylinder through the gates *XX*, the liquid metal may be said to be filtered as water is by charcoal: there being so many cores, and the metal in this portion of the casting being the thinnest, nearly all the dirt and scum are arrested, and do not enter the main body of the cylinder. So, even if the iron is duller when it reaches the main body of the cylinder, it is, at the same time, cleaner. In respect to the cylinder shown, the author can recollect making about eighty of them during the course of three years with success, by the plan of the gates *XX*, as shown; although these cylinders finished up clean, it must not be understood that all side-saddle cylinders would turn out clean were they similarly gated or poured. It may, in some cases, be advisable to have a portion of the metal drop from the top after the bottom is well covered with the flowing-in metal. One of the benefits that is derived in pouring from the top is, that the iron is all the time dropping upon the top of the rising metal. By thus doing, it cuts up the dirt or scum in such a manner as to keep it upon the top, and keep it from gathering in lumps or rolling up against the side of the core or mould. In this way the dirt is kept floating upon the top of the rising metal, and thereby is brought up into the dirt-catcher, or riser-head, shown at *W*. *Cylinders poured from the top generally have a rougher skin than those poured from the bottom*, caused by the agitation of the rising metal *against the mould's surface. They are also more liable to be scabbed and cut than those poured from the bottom;* but nevertheless they will, as a general thing, finish up clean. It is often surprising how much a casting poured entirely from the top may scab, and still be clean when finished up. Were the same scabs upon a casting poured from the bottom, the chances are ten to one it would present so many holes as to disgust any one even to count them, especially if the casting were poured by having the metal poured in at the main body of the cylinder through a gate situated similarly to that shown at *H*. *A cylinder poured from the bottom, to finish clean, must at least be free from scabs.*

The plan here shown of having a gate running down to the bottom of the mould, with top runners attached to it in order to pour from the top as well as the bottom, is often a good one for cylinders, as by it you can start slowly to cover over the bottom of the mould, after which the gates can be filled, and the metal be made to enter at the top as well as at the bottom. By first covering over the bottom of the mould, we prevent it from being cut by the falling iron. Some may say this is not necessary; for how is it that long water or gas pipes can be poured altogether from the top, and yet the bottoms not be cut? In pouring such castings, the iron is prevented from falling directly from the top to the bottom by the thinness of the space between the core and mould; the iron, in dropping, going from one side to the other, its friction decreases its velocity, and the force of its fall. When such thin castings are scabbed, it is generally the sides of the mould, and not the bottom. With cylinders or pipes over one inch in thickness, the iron has a freer chance to fall directly upon the bottom, and thereby cut or scab it.

Cylinders similar to the locomotive side-saddle ones, that have large foreign attachments cast on them, are often better cast by having most of the metal go in at the bottom. Should such cylinders as these be poured altogether from the top, the sides of the mould all the way up would be liable to be cut or scabbed, or present a very rough body skin, caused by the agitation of the metal against the surface of the mould, and the length of time required for the metal to rise above any given point. The falling iron, instead of directly filling the body of the cylinder, runs away to fill up the side-saddle or the large attachments; and in the mean time there is danger of the agitation of the metal, causing scabbing of the mould's surface. *In pouring any castings, the sooner the agitation of the metal against the mould's surface ceases, the better for the casting.*

With reference to the general plan adopted in pouring cylinders in loam, they are usually poured from the top, while in dry sand the reverse is true. Often in both instances the top and bottom methods are combined; especially so when the cylinder is over four-foot stroke. There are other points about cylinders that require to be as perfect as the bore, some of which will be found in the following article, "Moulding and Casting Cylinders."

It might be well here to notice the question of unsound riser-heads. Many vertical-cast cylinders have, when their riser-head was cut off, presented a flanged surface full of holes, some of which are often larger than a marble. The writer recalls the case of a foundry where he worked, that had experienced much trouble from this cause. They had tried in every way imaginable to stop the trouble; but when "working in the dark," there is greater liability of aggravating the difficulty than of remedying it. The whole trouble lay in having too large a corner at *K*, and too thin a riser-head. This corner, as is well known, is made for the purpose of allowing dirt to pass up into the riser-head. Now, when this corner *K* is much larger than the riser-head, the latter will solidify first; then, if the body of the cylinder is still liquid, whatever metal is required to feed it will, of course, be drawn from the uppermost liquid portion; so that the addition of the large corner *K* to the flange thickness must result in the accumulation at this point of a body of liquid metal far in excess of that in the lower adjoining body of the cylinder. There is no objection to a large corner at *K*, providing the riser-head is made thick enough to feed it; but if the riser-head is not thick enough, then the cylinder should have feeding-heads made large enough to feed the cylinder, as shown above *W*. Many make a practice of not feeding their cylinders: they "flow them through" a little, and then trust to the riser-head to do the rest. In some cases this may work all right; but the practice of putting on a large feeding-head, and feeding until certain the heaviest portion of the cylinder has solidified, will, in the end, cause the least trouble from unsound top cylinder flanges.

The successful making of cylinder castings is an art that the best men in the business have given much thought and study. Some have succeeded, while others have not; and a thorough practical study of perfect cylinder-making will hurt no one, for its principles are such as can be applied to nearly all sound and clean-finished castings.

In fact, there is this to say of studying up any special subject in moulding, as in other mechanical matters: The information gained cannot be all charged against the job in hand, as it will not infrequently, and perhaps when least expected, be found of even greater value in some other direction. Knowledge has the advantage of almost unlimited application, and will render an equivalent for time spent in its acquisition.

MOULDING AND CASTING CYLINDERS TO PROCURE CLEAN VALVE-FACES.

Two important considerations are involved in making cylinders: one is, that the casting shall be clean in the bore; and the other, that the valve-face shall be clean. In the previous article, the subject was considered with reference to the bore of the cylinder. The object of the present article is to discuss the subject with reference to the valve-face. It is quite as important that the valve-face be sound, as it is that the bore be perfect; and, in considering plans, it is necessary to have both these surfaces prominently in view, in order that one may not be sacrificed to the other, which is often done.

By casting a cylinder horizontally, with the face down, we are reasonably sure of getting that clean; but the chances are that the bore will be dirty. By casting it vertically (properly gated), the chances are the most in favor of the bore. There are plans, the adoption of which will often assist in getting clean faces on vertically cast cylinders, some of which will be referred to. There are many different kinds of cylinders, some of which are of a construction that makes it extremely difficult, if not impossible, to provide for having all parts perfectly clean and sound. The cuts here shown do not illustrate methods that are common, or generally employed, but new methods used by the author and others with good success.

When a cylinder is cast vertically, we generally find the lower cast opening the dirtiest; this part of the face, as shown at *K*, Fig. 16, being the first to catch the dirt. *B* and *A* may catch some dirt, but it is not reasonable to suppose they will catch as

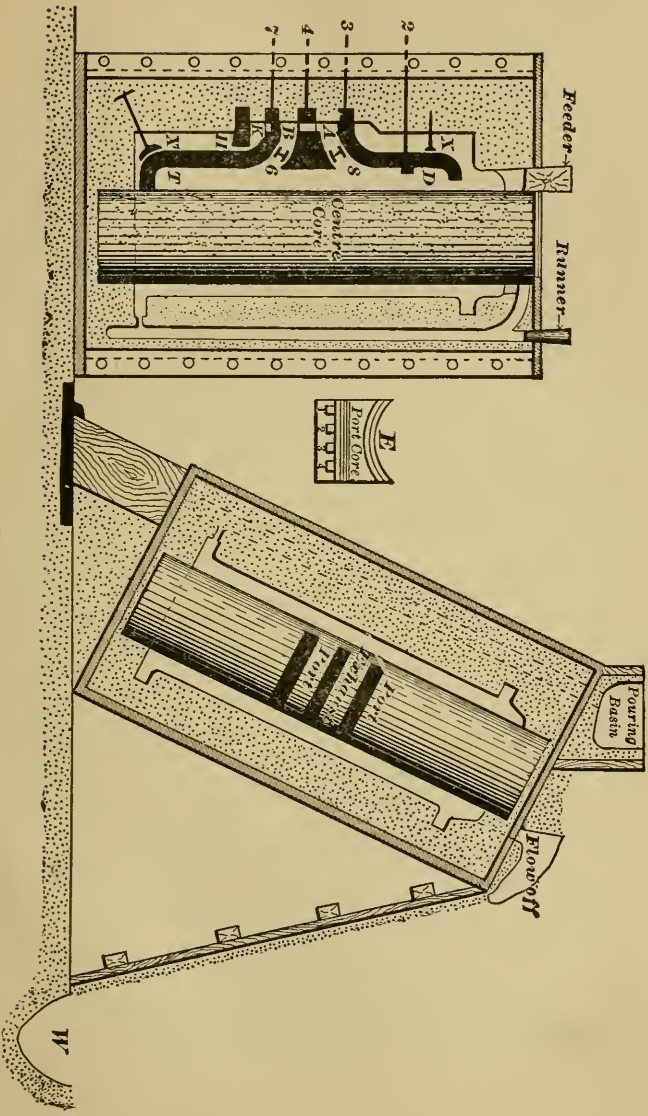

Feeder
Runner
Centre Core
2
3
4
7
A
B
D
H
K
X
X
T
6
8
E
Port Core
1 2 3 4
Port
Exhaust Port
Port
Pouring Basin
Flow-off
W

Fig. 16.

much as *K*. The amount of dirt that the lower core or opening will collect depends upon how clean the mould is, and whether it scabs or not. When the lower portion of such moulds scab, there is danger of extra dirt being collected at *K; and, when there is any scabbing, it is generally in the lower portion of the mould.* This, in connection with the fact that the dirt is collected at *K* from a much larger body of the mould than it is at *B* or *A*, accounts for the part *K* being the dirtiest. Since it is apparent that dirt will lodge at *K*, the question is, how best to prevent it from injuring the casting. The cut presents two plans for doing this. In the first one, the cavity in the lower port core (above *K*) is provided. This cavity extends the entire length of the core, and as the iron rises it floats or forces the dirt into this cavity. This being made purposely for a dirt-receiver, is cut off in finishing the cylinder.

The second plan is shown at *B*. Here, instead of the cavity, we have holes passing through all the cores. When the dirt comes up to the first core, it passes upwards through the others. The port core *E* shows a plan of the holes, Nos. 1, 2, 3, and 4. Of course, the closer these holes can be made, the better the chances of the face being clean.

At *H* is shown a plan, that, in some cases, might be used to advantage. It represents a false core, set for the purpose of catching dirt, thereby preventing it from rising up to *K*. The core is made dovetailing in order to hold Babbitt, or composition, when the hole is filled. Instead of a core, a thin iron plate might be used, the advantage of which would be that it will be left in the casting, thereby avoiding taking off core-vents and filling up the hole with Babbitt, which, even if nicely done, would not leave as neat a face as the plate would when chipped off, for the plate would be placed below the projection of the valve-face, and there could be no damage done, even if the plate caused a chill around it. I have never heard of the above being used; but, as I see no reason why it should not work well in many cases, the idea is given.

The reader will excuse being carried back to the bore question. At *D*, the port core is shown to be kept back from the centre core. Generally, in setting port cores, they are set up close, or nearly so, as shown at *T*. When the upper port core is set, as at *T*, against the centre core, it is sure to catch more or less dirt, thereby making the bore of the cylinder dirty at this point. If the core is kept back from $\frac{3}{8}''$ to $\frac{3}{4}''$, it will allow the dirt to pass upwards into the dirt-riser.

At *X X* are shown two ways of securing these ends, so that they cannot move when the mould is being poured or up-ended. This difficulty of up-ending moulds is very often the reason for their being cast horizontally. A cylinder moulded and cored horizontally requires to be well made and secured in order to safely up-end it to cast vertically. To set cores so they will not be disturbed by turning the mould upside down, or on its end, requires the practice of skill and caution; for the least movement on the part of the cores will be liable to allow the iron to get into the vents.

At the lower letter *X*, the core is shown chapleted up against the centre core. This presses it in the same direction that the metal will; but, as it is already pressed as far as it can go, the pressure of the liquid iron cannot lift it farther. The upper letter *X* shows a chaplet at the back, placed so as to prevent the core from being pressed back. No. 2 represents a bolt for holding the core back against the chaplets *X*, in order that it cannot fall back and close up the opening *D*. Nos. 3, 4, and 7 represent the print ends of the exhaust and port cores, tied so they cannot move out of their place. Where wire is used for tying such cores, it is better to use No. 18 wire doubled and twisted together. This gives a stronger and at the same time a more pliable tie than in the case of a single wire of the same diameter.

At Nos. 6 and 8 is shown how chaplets are sometimes used between the exhaust and port cores, to assist in holding them in place. Chaplets should never be set against the centre core of a cylinder. When thus set, they are likely to produce blow-holes in the bore of the cylinder; or they will make the iron hard around them, thus providing for unequal wear or cutting. Cores can always be secured in some other way, by the exercise of a little judgment. This is equally true of the valve-face. The temptation to set chaplets against the valve-face, or to drive rods into it, should always be resisted. In making cylinders, iron that chills easily is generally used: therefore, when the iron comes in contact with chaplets, it frequently makes it so hard as to be worked with great difficulty.

Having noticed plans that may be employed for securing clean valve-faces on cylinder castings, it is proper to notice the objections to these plans. There is more inconvenience and risk in using cores, as shown at *KB*, than there is in using such cores as ordinarily made, as shown at *A*, for the reason that there is not so good an opportunity to rod and vent the former. The thicker, however, the cores are, the less the inconvenience and risk. The port and exhaust cores are about the most difficult we have to deal with, and there are few that are capable of handling them. The plans I have described will often provide for making good cylinders, where there is trouble with the valve-faces.

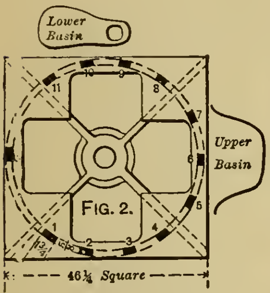
The right-hand figure represents a plan of casting locomotive cylinders that my stepfather, Andrew Baird, employed in the Portland Locomotive Company's Works foundry (Portland, Me.), a shop in which I served half of my six-years' apprenticeship. The cylinders were cast slanting to get a good face, the inclined position of the cores allowing dirt to be washed upwards. These cores were made as shown at *A*; my memory being quickened in this respect from the fact that three or four of them were broken over my head because I allowed them to get burned. It may be argued that this way of casting is sacrificing the bore to the valve-face, but a little consideration will show that it was about equally dividing the chances between the valve-face and bore. The plan proved a success. These cylinders did not have any side-saddle cast on them, and they were poured altogether from the bottom. About six hundred pounds of iron flowed through, and ran down to the pig-bed *W*. This is something that should be done with most cylinders that are poured entirely from the bottom, as by so doing it assists in raising the dirt upwards, and helps to make *solid casting*, especially when feeding is omitted.

CASTING WHOLE OR IN PARTS, AND POINTS IN CYLINDER MOULDING.

The making of the low-pressure cylinder for a marine compound engine, to be described, involves points which will be interesting to moulders and foundry managers. It is not so very far back, when, if one successfully cast a cylinder alone, much praise would be awarded. Some one, in order to save labor and receive more credit, cast the cylinder with one head. Another, to beat this, cast the cylinder head and cap together. To beat this, some genius will be trying to cast an engine complete, — a thing which, from looking at some of our modern engines, seems nearly accomplished. The saving of making joints or connections in all classes of machinery is, at the present day, a point well worth studying. Many of our progressive machinery manufacturers are making improvements in this direction; well knowing that the nearer whole a machine can practically be cast, the cheaper it can be sold. By practically, I mean where parts can be cast without causing excessive strains, and where the cost of moulding does not exceed the expense of connecting the parts if cast separate.

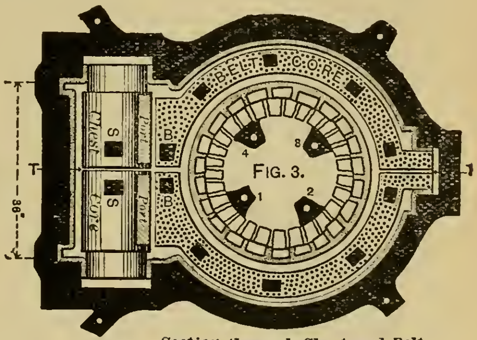
There are many cases where intelligently casting parts together increases the strength of the whole; and I think that casting the head and cap with the cylinder, as shown, is not only a saving in cost, but increases the strength of the body of the cylinder as well. The manner in which this cylinder was cast will, I think, be approved by practical men as being simple, and as good a one as could be adopted. All the parting required is at *R R*, Fig. 20. A plan of the parting ring is seen at

Fig. 18: the thickness of such a sized ring should be at least 2½". Were it less than this, having such a load to lift, it would be very likely to spring. In green-sand work, moulds may spring, and do no harm; but with loam-work springing of moulds is, as a general thing, very injurious. Casting the head and cap up, brings the steam-chest well down towards the bottom. This assists in getting sounder and cleaner chest and valve openings than if the cylinder were cast the other end down, as is sometimes done. The reason of this is, that the higher the chest is from bottom of mould, the more body there is for dirt to be collected from; therefore, the nearer the bottom the chest is, the less chances of its being dirty.



Plan of Cap and Gates.

Fig. 17.



Section through Chest and Belt.

Fig. 18.

Another point, which I think practical men will approve of, is the style in which the cores are constructed. As will be seen, the half-chest and port core is made in one piece. Generally, in such cases, the chest core is made with prints into which the port and exhaust cores are secured, as shown in Fig. 19. By such a plan, there is, with the best of care, more or less danger of iron getting in the vents; and still another objectionable feature to such a plan is the tendency of the valve-openings to be cast out of parallel, thereby often requiring much chipping to get them true, or perhaps preventing the

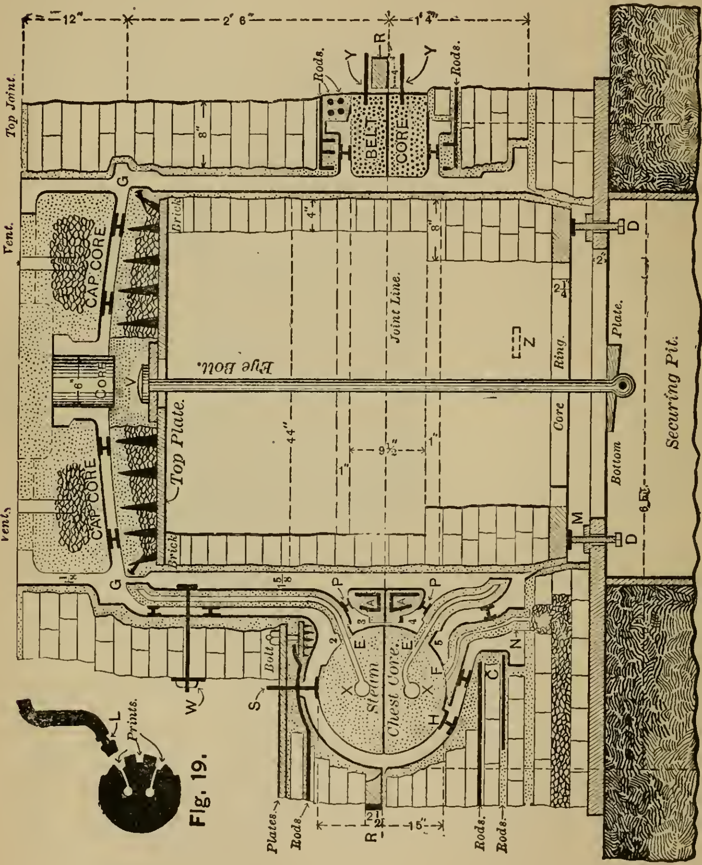

12"
2' 6"
1' 4"
Top Joint.
Vent.
Vents
Rods.
Y
R
Y
Rods.
BELT
CORE
8"
G
CAP CORE
CAP CORE
CORE
6"
V
Brick
Brick
4"
8"
Joint Line.
Eye Bolt.
Top Plate.
44"
1"
9½"
1"
Z
Ring.
Core
2¼
2
Plate.
Bottom
D
D
M
Securing Pit.
G
1⅝
P
P
A
A
3
4
2
E
E
5
Bolt
Steam
Chest Core.
X
X
F
H
N
C
W
S
L
Prints.
Plates.
Rods.
R
2¼
15"
Rods.
Rods.

Fig. 19.

CYLINDER MOULD.
Fig. 20.

intended width of port openings. The cylinder here shown, the author lately cast in the Cuyahoga Works; and it well illustrates the advantage of making chest and port cores as described, when practicable.

For convenience in handling and making cores, and also to save pattern-making, the steam-chest and belt cores were made in what might be termed half-core boxes. This will be better understood by reference to *T T*, Fig. 18. The belt core at *B B*, Fig. 18, has no prints; this end being held in place by top and bottom chaplets, seen at *P P*, Fig. 20. The black squares on belt core, Fig. 18, represent chaplets, and show in what order they were placed above and below the core. The steam-chest core was held in place by chaplets at *H* and *S*, Fig. 20. The core *N*, below *F*, was made independent of the steam-chest, and was the first core set. As it was to cut through to steam-chest, the opening made a very good bearing for the chest core to rest upon. The lower half of the chest core being set, the next to follow was the belt core, after which the upper half of the chest core was set. In setting the halves of the chest core, care was taken to see that the valve-face portion was true and in line. Of course, had the chest core been whole, or not parted, as shown at *T T*, this care would not have been required, nor the chaplets *H* and *S* needed.

After these cores were set, as described, the cope, or upper-cheek portion of the mould, was lowered to place. Then a bolt as seen at *W*, near Fig. 19, was placed in order to firmly hold the port core back against the chaplets. The belt core was then chapleted to hold it down: this completed the setting of these cores. After securing the vents, the next operation was ramming up the mould in the pit. This having been done, the mould was cleaned out, and preparation made for lowering in the centre core. The preparation consisted mainly in placing the set screws as seen in the securing-pit at *D D*, the purpose of which is described in the article "Moulding a Jacket Cylinder," p. 60. Six short pieces of candles being lighted, and placed upon the bottom flange, the centre core was then lowered into its print. (The manner in which this core was lifted will be understood by "Revolving Core and Under-Surface Sweeping" article, p. 66.) The core having been adjusted to show equal space all around the top, by the use of four set screws *D D*, the space between the bottom plate and core ring, at *M*, was then securely packed with mud and bricks, in order to prevent any chance run-out. After this, the eye-bolt was placed for the purpose of assisting in holding down the core. The space *V* being now filled with moulding-sand, the 6″ core was centred and set. Twelve chaplets — three for each of the four cap cores — now being set, the cap cores were placed upon them in position to have their arms come square with the mould, and the outer circumference kept so as to give the required thickness. This completed the setting of all cores. A straight dry-sand cope was then set on, and the vent-holes made. Then, being closed for good, the mould was finished and got ready for casting. In making the chest and port cores, vents were formed, as shown at *X*, Fig. 20, which clearly represents the manner in which they are arranged. The vents were obtained by the use of straight rods, and the core irons were welded frames. The vents of the chest and port cores were taken off at the print end, the same as shown for the belt core at *Y Y*. The belt core was vented by partly filling the space between the cast-iron pricked frames used for the core rods, as seen at *A A*, with fine cinders. By this plan there are no joint vents. This is something I always try to avoid as much as possible. Taking off vents through the joints of cores is always more or less risky. Hot iron is about as bad as steam for penetrating cracks or joints.

In building up this mould, sweeps were used for the plain cylindrical portions, and patterns for the chest, etc., such as are ordinarily used. In building under the steam-chest, cinders were laid to carry off the vent from core *N*. Between the lower flange and steam-chest, rods were laid to assist the bricks in firmly holding the small body *C*. The body over the chest was held and lifted by being secured with the rods and plates shown. The style adopted in building up around the steam-chest was different from that generally employed: instead of oiling the pattern, and building it up in soft loam, the bricks were kept back about two inches from the face of the pattern, as shown; and a dry-sand mixture, similar to that which would be used for dry-sand moulding, rammed between the bricks and the face of the pattern, the bricks having their faces rubbed with a little wet loam in order to make it certain the sand would stick to them. This plan is used with much of our work, and it gives good results. With this explanation, the practical loam-moulder will be able to account for the building-in of the rods over the chest and at *C*, as shown.

In making the centre core, the brickwork being built up to the height shown, the top-plate, after being set on, was partly filled up with cinders, over which a mixture of dry sand was rammed to form the top portion of the core. The corners, *G G*, are well nailed to assist in holding the projection seen, and to help prevent the falling iron, when pouring the mould, from cutting the sand.

In pouring the cylinder, we let about two thousand pounds go in at the bottom gate, shown by dotted entrance *Z*, Fig. 20. When about fifteen hundred pounds had been poured in, we then started pouring in from the top, through the eleven gates shown in plan, Fig. 17. The size of these gates was $\frac{5}{8}'' \times 1\frac{3}{4}''$. At *K* is represented the feeding-head, which was placed over the steam-chest side. The casting did not present any scabs or sand-holes: the skin was a dark-blue color, and as smooth as a piece of stove-plate. This cylinder is not shown to represent large work, but simply because its making involved points thought to be of general interest.

MOULDING A JACKETED CYLINDER.

At the left of the engraving (Fig. 21) is shown a section of a jacketed cylinder, which will be recognized by the practised moulder as being a somewhat difficult casting to make. The outside of the casting is a simple affair enough; the difficulties being confined almost entirely to the centre core, which is shown in section on the right, together with the sweep and other accessories used in its making.

In making the mould, the outside was made first, not because it is customary to do so, but because we had to build it up and dry it in a pit, from a lack of oven-room. At *K* is shown the bottom plate; also a holding-down hook, of which there are four. The plate was set on a solid sand foundation; and, in order to leave a pit below, a cast-iron ring *F* was used. This pit was required to provide room for a man to operate screws for centring the centre core, as will be explained farther on.

In making the outside mould, there were five 6″ round blocks distributed so as to equally divide the circumference, for making vent-holes, as at *H*. At *Y* is represented a plate placed upon the top of the mould to stiffen and hold the brick-work together. After the mould was finished and blacked, it was then prepared for drying by laying four railroad-bars across, so they would rest upon the pit about 4″ above the top of the mould. On top of these were placed sheet-iron plates, and the open portions of the pit, between the rails, were bricked up to prevent the escape of heat. Charcoal and coke were used for drying, the charcoal being on the outside and the coke on the inside. For the first twenty-four hours, there was a fire

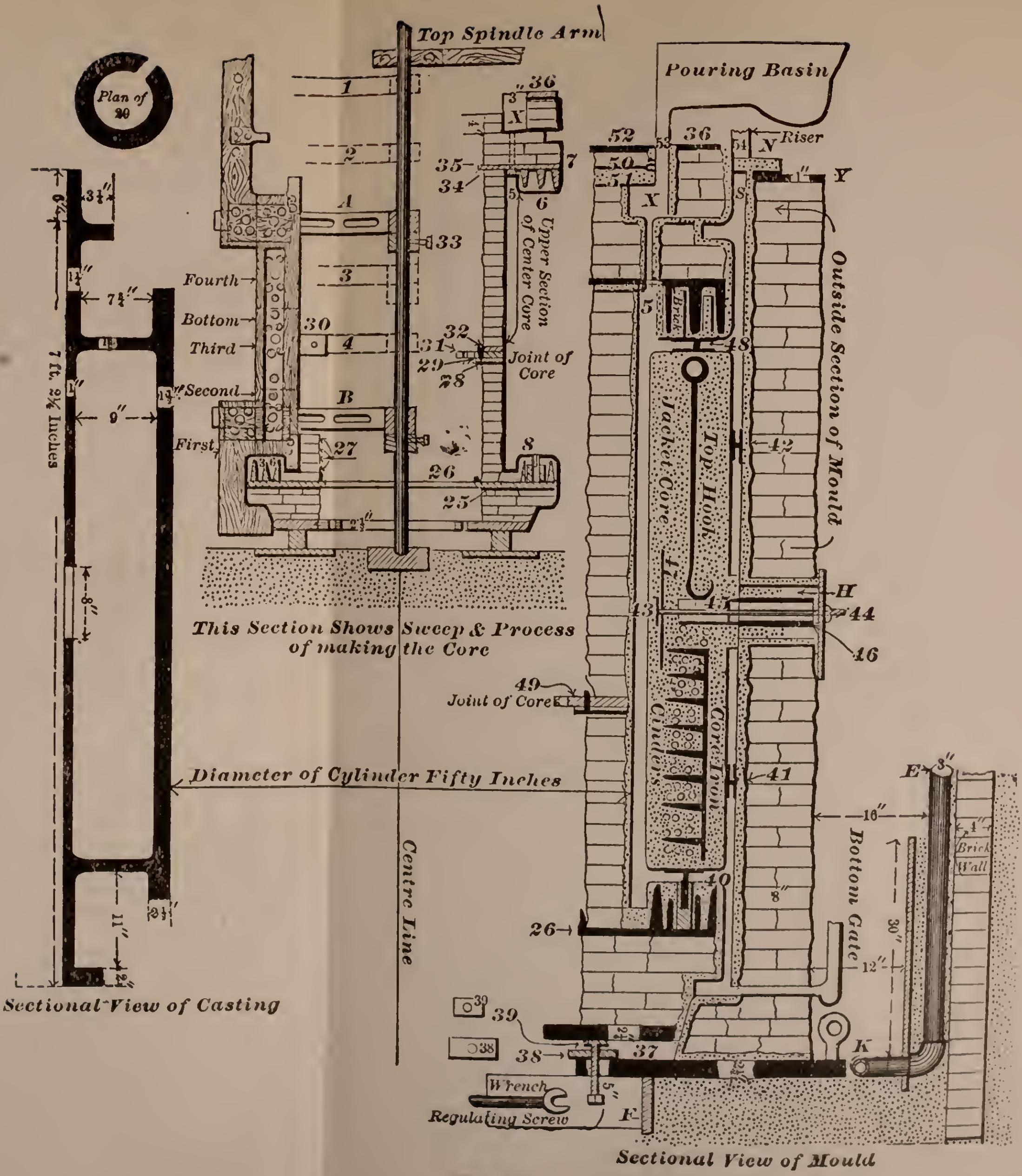
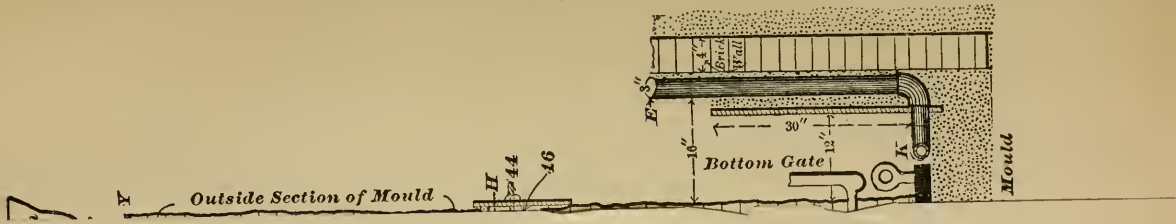

Top Spindle Arm
Pouring Basin
Plan of 29
1
2
3
4
A
B
30
33
36
35
34
7
6
5
X
Upper Section of Center Core
32
31
29
28
Joint of Core
Fourth
Bottom
Third
Second
First
27
26
25
8
2¼″
3¼″
1½″
7½″
9″
1¼″
7 ft. 2¼ Inches
8″
11″
2¼″
This Section Shows Sweep & Process of making the Core
Sectional View of Casting
Centre Line
Diameter of Cylinder Fifty Inches
52
50
51
53
54
N
Riser
Y
S
Outside Section of Mould
Brick
48
Jacket Core
Top Hook
42
47
43
45
H
44
46
49
Joint of Core
Cinders
Core Iron
41
E
3″
16″
4″
Brick Wall
Bottom Gate
30″
12″
40
26
39
38
37
K
Wrench
Regulating Screw
5″
F
Sectional View of Mould

Fig. 21.


Y
Outside Section of Mould
H
44
46
E
3″
4″
Brick
Wall
16″
30″
12″
Bottom Gate
K
Mould

upon the outside only, because both fires would, at the beginning, have been likely to blister the mould. The coke fire was made in a perforated boiler-iron kettle, about 18″ diameter and 24″ deep; the kettle having an open top and fire-grate bottom, and being let down until the top of the fire was about even with the bottom of the mould.

The pit was originally some fifteen feet in depth, having been made for other purposes, and then filled up so as to be eight feet deep. The bottom of the small inner pit *F* was three feet below the bottom of the large pit, the diameter of the small pit being 42″. The diameter of the large pit was 13 feet. Upon the bottom of the large pit, a boiler-iron curb was placed. This was to make the pit smaller at and towards the bottom, to confine the fire, and also to save work in ramming up. The distances of the mould from the pit, given in engraving, are not the actual ones, but are those it would be desirable to have for convenience of operations with such a mould.

It may be asked, Why, if there is room enough at the bottom of the pit, should it not be made the same size at the top?

In answer, it may be said that the sand requires harder ramming at the bottom than at the top of a mould, and sand can more readily be rammed solid in a small space than in a large one. Besides, while it is practicable to ram the small space at the bottom, if this space were continued to the top there would not be room to work to advantage.

In fitting up old pits for drying moulds, where a natural draught cannot be had, a blast-pipe may be laid all around the bottom, having a branch *E* passing up to the top, through which connection is made with a blower or fan. The 4″ brick wall seen upon the outside of the blast-pipe *E* is the pit's wall. While it is only shown as of a small height, it is, of course, to be understood that its depth is about the height of the mould.

In firing up on the outside of this mould, six to eight bushels of charcoal were evenly distributed on top of the blast-pipe *K*, which had small holes bored in it. The fire was started by throwing hot coals on the charcoal and putting the blast on.

After the fire was well under way, the blast was shut off. The mould was uncovered every twenty-four hours, and fresh fuel added, until it was found to be dry.

In making the centre core of this mould, the sweep was in sections, so that parts could be detached as required.

In commencing, the sweep was secured to the arms *A* and *B*, as shown. The bottom plate having been levelled and centred, the core was then built up to a point indicated by the figures 25. The first section of the sweep was then temporarily removed, and the plate 26 put on.

The space between the prickers 3 and 6 was packed with bricks, with a good layer of cinders under them. Bricks 27 were then built up, after which this portion was loamed up. The first section of sweep was then permanently removed, and the arm *B* moved up to 4. The core was then bricked and finished up to the joint 28. The lower tying ring 29 was then set on, which was done without removing the top spindle-arm, because of the opening in the ring seen at the top in the left-hand side of the cut. The ring being in place, a small sweep at 30 was bolted to the arm, and a level joint swept up. This sweep was then taken off, and the second section of sweep unscrewed and taken off permanently. The bottom bed, 8, was then covered with parting sand, over which was placed 2″ of moulding sand. This was done to protect this part of the mould from pieces of brick and from wet loam, liable to fall when building the upper part of the core.

In the next operation *B* was moved up to 3, and after being bolted the sweep was run up above the joint. The top spindle-arm being removed, the joint lifting ring 31 was lowered by the crane to place, there being three pins, one of which is shown at 32, for guides. The sweep was then let down to place, and the top arm secured; the collar 33 not having been moved, the sweep was necessarily in the correct position.

The core was then built and finished up to arm 3, the third section of sweep taken off, and arm *A* moved up to 1, and arm *B* up to 2. The core was then built and loam-finished up to 34, the fourth section of the sweep taken off, the top arm removed, and sweeps and arms *A* and *B* taken off the spindle. The ring 35 was then set on, the arms and sweep reset, and the top arm secured; then the ring 35 was centred. The fourth section of the sweep was then reset, the bottom being omitted. The under and side portions of 35, as at 5, 6, and 7, were now swept up or loam-finished.

It may be here stated that ring 35, before being set, had the space between the prickers packed with brick, and the surface daubed with loam, the whole being dried in the oven. This provides a body for absorbing moisture, making the sweeping at 5, 6, and 7 practicable.

The underneath sweeping being completed, the fourth section of the sweep was permanently removed. Arm *B* was now carried up close to *A* (which, it must be remembered, is now up at 1), and the remainder of the core finished.

The location of the top arm should be higher than shown, to allow of completion of the core without further moving-up of the sweep arms.

In building and finishing the portion above 35, a layer of cinders was used on top of the plate. The dotted lines, extending from *X* to 5, show the position of runner gates, built about 15″ apart. *X* represents a basin made when building the upper part of the core. At 36 a ring plate is represented, which was used for the purpose of giving support and a body from which to wedge down the core in getting ready to cast. The completed core was then parted, and after the joint was finned and finished it was placed in the oven to dry.

The sectional view shows the mould closed, to be prepared for casting. In starting to close, the centre core was lowered, a section at a time, into the mould. Then by four regulating screws, one of which is shown at the bottom plate, the core was adjusted to show equal space all around the riser-head *S*. After the core was centred, the space between the plates, as at 37, was carefully and solidly packed with brick and loam, as a safeguard against run-outs.

At 38 and 39 are shown a plan and section of nuts for the regulating-screws. The two views, 39, show a block with a conical hole to allow the point of the screw to move, thereby preventing throwing the bottom of the core out of the centre of the mould when clear of the print. After the bottom joint had been secured as described, the upper section of core from 49 was hoisted, and all the side chaplets 41 and 42 set. There being five cores to set so as to leave a thickness of iron between them all, the chaplets required to be divided equally. The bottom chaplets, shown at 40, were set in an iron stand, which fits into still another stand that is cast with plate 26. This plan makes the moving of chaplets impossible. The chaplets had $\frac{3}{4}''$ stems, with plates $4'' \times 6''$, and for each core three bottom chaplets were used. Four side chaplets were used for the back of each core, two of which are shown at 41 and 42. A half-inch bolt, as at 43 and 44, was used to hold the cores against the chaplets. At 45 is represented a vent-hole connected with cinders, and at 46 a tube $3\frac{1}{2}''$ diameter, with the end tapered to fit tightly in the core vent-hole. The space *H*, between the tube and mould, was rammed all around with sand to prevent the metal getting into the vent-tube. At 47 is a plate $3''$ wide, $\frac{1}{2}''$ thick, and $18''$ long, placed in the core, when being made, to give support to the bolt-head 43. The space in front of the bolt-head was filled with beer-sand, and made level with the surface of the core.

The cores being secured, the next operation was to arrange for chapleting down the cores, as at 48, which was done as follows: On top of each core, three clay balls were set. The upper jointed section of the centre core was lowered down, its joint being at 49. This section was then hoisted, and chaplets were made $\frac{1}{16}''$ shorter than each clay ball measured. All the clay balls were numbered, and only two or three removed at a time, so as to insure against getting them mixed, as any blundering in this respect would probably result in losing the casting. When all the chaplets were placed upon the exact spots previously occupied by the clay balls, and a little flour put on to insure their touching, the upper section of the centre core was lowered to its place, after which the riser-head *S* was covered with segment cores, as at *N*. The runner-basin *X* was not covered over as represented, until after the core was dried. The segments covering cores 51 were dry when set; but in order to dry out the course of loam and bricks at 50, the core was given one night's firing, to expel any dampness the course of brick 50 might contain.

At 52 is shown an iron ring, used in combination with 36 for wedging down the core against the high-head pressure.

The pouring-basin had one runner gate, 4″ diameter, leading to basin *X*, as seen at 53. The cylinder weighed a little more than eight tons; there being flanges that are not shown, as they would serve to confuse the subject. The whole mould was secured by a cross-beam and slings, chains coming down to four hooks, one of which is shown at *K*. Enough iron was poured in at the bottom of the mould to fill it above 40 before any was poured in at the top. After the mould was poured, and sufficiently cool, the basin *X* was uncovered, and the basin iron broken up to assist the contraction as much as possible. The casting, when finished, was clean and without perceptible flaw.

REVOLVING CORE AND UNDER-SURFACE SWEEPING.

In vol. i., p. 187, is an illustrated article upôn "Sweeps and Spindles." The engraving shown is that of a rigging for under-loam surface sweeping. Loam cores are often of such shape that some such rigging is almost indispensable. Having in our foundry a very simple arrangement, that is not only adapted to under-sweeping, but to other purposes as well, and which is in some respects superior to the rigging previously shown, it is thought a description of its workings may be of value.

The advantage of this rigging over the common run of spindles could seldom be better displayed than in making the condenser core seen in Fig. 23. The spindle is so designed, that after the core is swept it is then hoisted by the same spindle, as shown in Fig. 23. This spindle having a collar *F*, and a key-hole *G*, Fig. 24, provides for securing to it any plate or ring, as seen at *H* and *K*, Figs. 25 and 26. When the ring *K* is wedged up tight against the collar, by the keys *M*, the building foundation of the condenser core is formed.

The steel pin *N* being set in the step *P*, the spindle is then set up and secured by the top centring and holding-arm *R*. This arm is so constructed that it can in no way be sprung. The elevation and plan view of arm show its construction in outline. After the spindle has been secured, the next operation is that of securing the sweep.

In setting the sweep, an arm is bolted to step *P*, as seen at *V*. (The cap of this arm is not shown, in order to show the

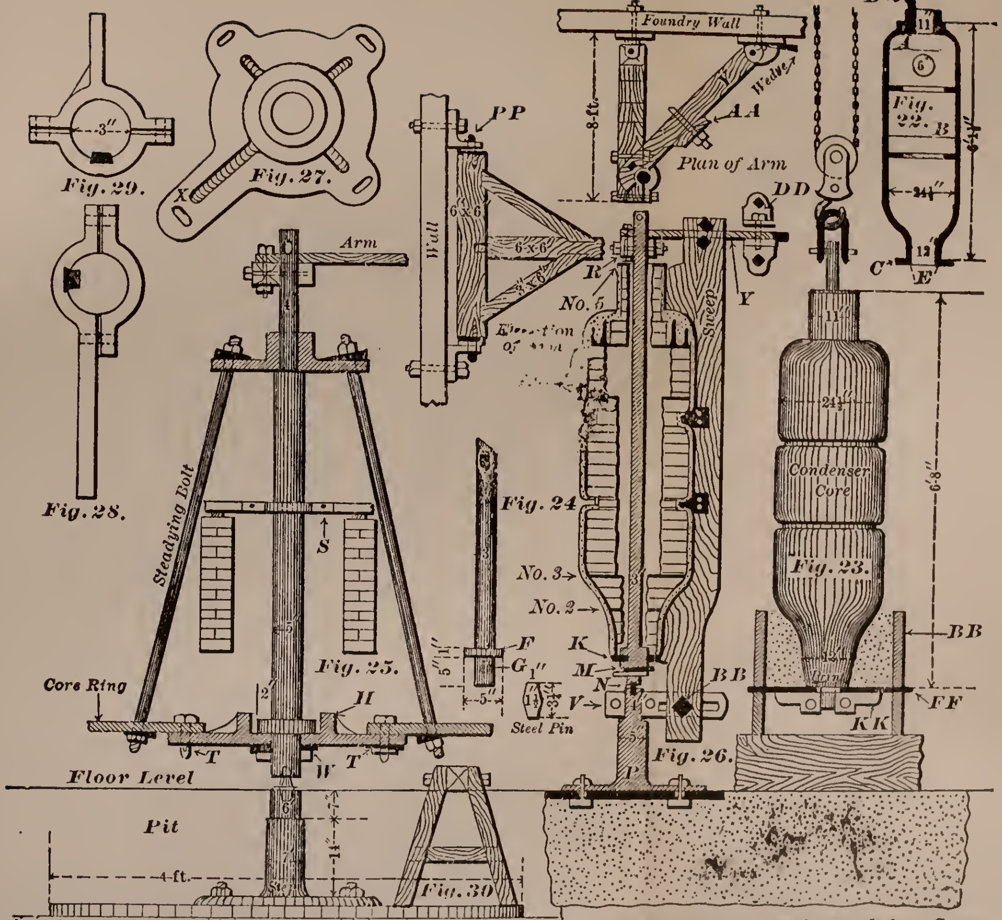


Fig. 29.
3″
Fig. 27.
X
Fig. 28.
Arm
Steadying Bolt
S
Fig. 25.
Core Ring
H
2″
T
T
W
Floor Level
Pit
6
7″
14″
4-ft.
Fig. 30
Wall
PP
6 x 6″
6 x 6
3 x 6″
Elevation of Arm
Fig. 24
F
G
5″
1″
1″
5″
1½
3″
Steel Pin
Foundry Wall
8-ft.
AA
Wedge
Plan of Arm
DD
R
No. 5
Sweep
Y
No. 3
No. 2
K
M
N
V
BB
P
Fig. 26.
D
11
6
Fig. 22.
B
6′4″
24½″
12
C
E
11″
24½″
Condenser Core
Fig. 23.
6′8″
BB
FF
KK

Stationary Sweep and Revolving Core

Spindle Step and Steadying Rigging

i
s

c
c
a
a
h
s
u
ti

s
T
T
o
ti

V

step and steel pin more fully.) This arm is set so as to be parallel with the top of sweep-holding arm *Y*. The manner of bolting the sweep to this arm is more fully shown at *AA*, in plan of arm. The bottom of sweep being secured by the bolt *BB*, and the sweep found to be gauged right, all is then ready for building up the core, which is done as follows: Pieces of bricks being built up as high as No. 2, a thin cast-iron ring is then laid on, after which the core is built up to No. 3, the plate there shown being then laid on; bricks are then built up, and, the two plates at No. 4 being set, bricks are laid up to the end of the core, on top of which is a ring No. 5. This is used for the purpose of blocking upon, to hold down the core when casting. The inside of the core was filled with clean, small cinders, lightly rammed, as it was built up. The core, being completed, was hoisted up and lowered on a plate *FF*, Fig. 23. On this plate was set an iron ring *BB:* this was packed with sand. The bottom of the spindle, where it projects through the plate *FF*, was clasped by a cap having laps as seen at *KK*. This being firmly bolted around the spindle, the core and its attachments were then hoisted and set on the oven carriage. While many may never have such a core to move, the plan shown will no doubt be worth remembering, for the principle is applicable to other work.

This condenser core is one which practical loam-moulders will concede to be rather a difficult core to make. Had the core been larger, the risks in making it would have been greatly lessened. The form of the casting made with the above core is seen in the section, Fig. 22. The outside portion of mould was jointed in two parts, at the respective heights *A* and *B*. The casting was run entirely from the bottom, the metal going in through two gates at the flange *C*. At *D*, upon the riser head, is a feeder. The situation of the gates will, of course, show that the mould was cast vertically. The dots at *E* represent the print, which was swept in the mould for the print seen on core to set into. This guided and centred the bottom. The top was held centrally by three double-headed chaplets, placed in the riser head portion.

For sweeping up outside moulds, we use revolving spindles. In their ends is a hole, so that they can be worked upon the same step as the spindles here shown. In sweeping the moulds, the spindle and sweep revolve, the mould remaining stationary. In these spindles there is what some would call a key-seat, running the entire length. A plan of the arms, which are used with these spindles, is seen upon the left, at Figs. 28 and 29. The steel projections, shown in black, fitting into the spindle's key-slot, cause the arms to be exactly parallel to each other when two or more arms are used. This little wrinkle is one our president originated. We find that it saves lots of labor in setting sweeps, and it also makes a certainty of obtaining true vertical lines that by the old method are laborious to be obtained.

As a general thing, loam-cores are swept by having the sweep revolve. I doubt if there could be found six foundries in the United States that do not follow this practice; in fact, so far as I know, our shop is the only one that makes a practice of sweeping cores with stationary sweeps, as shown. The plan was established long before I ever saw the shop; and, as I find it a good one, it is still used. The advantage of having the sweep stationary is, that the core is certain to come to whatever diameter the sweep is set to; also, there is no raising or lowering of spindle-arms to clear the brickwork as it is built up, as is often necessary when the core is stationary and the sweep revolves. Having cores come larger or smaller than intended, or one end not right with the other in size, is no uncommon occurrence. Having to change the position of the arm, as is often necessary with revolving sweeps in sweeping long cores, one is apt to move the sweep; and as the brickwork is more or less between the sweep and spindle, there is no handy means of ascertaining it. We, of course, can caliper the core after it is swept up; but to then change the sweep's diameter is often objectionable, for loam scraped off or put on in thin layers may cause surface scabs. I might say, "Sweep only two small spots to test the diameter, then, if found right, sweep up the core." This, in many cases, is a good plan, and should be practised when exact sizes are wanted. But, as a general thing, when a moulder sets the sweep, he thinks of nothing but driving ahead; and if the core is not found to be the right size when set into the mould, he often can easily make himself and others believe that the right sizes or gauges to set the sweep by were not obtained.

In our shop, all cores are calipered with long, wooden-legged calipers, simply to make sure that our gauges or measurements were right when setting the sweep to sweep them. Our president, J. F. Holloway, is very particular in knowing that all parts have the thickness the drawing calls for; and, did they not come so, an intelligent reason would have to be given.

Did the receivers of swept-up loam-castings know how often the intended thickness is increased or decreased in the castings they receive, they might be surprised. In jobbing loam-work, no one can, day in and day out, sweep all his moulds so as to measure to $\frac{1}{32}''$ of what the draught calls for. As little as $\frac{1}{16}''$ off or on a thickness is but a small matter with the general run of work; but when it comes to adding or subtracting from $\frac{1}{4}''$ to $\frac{1}{2}''$, the value of establishing ways of insuring correct thickness is seen. While the cores generally need the most attention, the outside part often requires measuring to insure correctness. A good plan to insure the thickness wanted is, to take the size of the first part swept upon a narrow stick when the mould or core is finished or blacked; then, when sweeping the second part, gauge the mould or core, as the case may be, by the measurement taken from the first part. By this means, if one does not get the first part the size called for, he has at least a chance to insure obtaining the proper thickness.

A third advantage the plan of sweeping shown has over the revolving sweep is, that the moulder can stand still; thereby saving labor and the making of a circus-pedestrian of himself. A stranger to this plan would be surprised to see with what ease heavy cores can be revolved. Cores as large as nine feet in diameter, and seven feet high, have been swept here by revolving them. For heavy or high cores there are two plans shown in Fig. 25, one of which it is sometimes found necessary to adopt in order to steady the core when being swept up with loam. One of these is to use steadying-bolts, as shown, or swivel-screws. Three or four such bolts or screws may be used, running from the bottom ring up to a top-steadying flange, as shown. This is a good plan to adopt for cores of large diameter. The brickwork seen inside of these bolts is to represent a high core being held steady by a top brace bolted to the spindle, as seen at *S*, and then wedged. Such braces are generally required when cores 18″ to 72″ diameter are longer than four to five feet. It should be remembered that the braces are not used during the bricking-up of the mould, but only during the rubbing-on of the loam. It keeps the core rigid, so as to assist in its being swept true. The size of the spindle given, Fig. 25, is that for cores ranging from four feet up to nine feet diameter. The spindle at Fig. 24 is for work under the above sizes.

The floor-level and pit marked shows how we use the arrangement. A pit of the depth shown is very handy for our general run of work. The diameter of the pit being about ten feet, there is room to walk around. The mud and bricks are kept on the floor, so that, in first starting to build, there is no stooping down to reach material. Then, when the core is built two or three feet, the pit is readily planked over to enable reaching up higher. The pit was originally made in order to procure more height for hoisting: of course, where the crane is high enough, one could dispense with the pit if it were desirable. Before removing the top arm for placing on plates, or to hoist the core, it is generally necessary to have the under side of core blocked. For this purpose wooden horses come very handy. The one seen at Fig. 30 will be suggestive of how they may be placed. Fig. 27 is a plan view of *H*, Fig. 25. The long arm *X* is attached, simply to show that the same rig can be used for larger cores, by extending the lugs. It was by such a rigging that the centre core shown in the article upon "Casting Whole or in Parts," p. 56, was made and lowered in the mould. When the core was trued by the set-screws there described, the keys at *T T* were taken out; and after this, those at *W*, which let the plate *H* fall down to the bottom of the pit. The spindle, now being released, was hoisted out, and the hole in top of the core filled up as there described. For that job the 3″ spindle was the one used.

SWEEPING GROOVED-CONE DRUMS.

The machine shown (p. 73) is intended for sweeping either right or left hand grooved drums of cylindrical, conical, or curved shape, and of any pitch desired.

The originator of this device, S. B. Whiting, M.E., of Pottsville, Penn., first used it in 1867 or 1868, since which time a great number and variety of grooved drums have been reported as made with it. At the right are sections of what were no doubt *very large cone-castings to make.* The one in Fig. 32 was of twelve and twenty feet diameters, with a height of about six feet. Our trade is under obligations to Mr. Whiting. Among our best moulders, but very few have any knowledge or idea of cone-drum sweeping; and upon reading this many will, like the author, feel like tendering Mr. Whiting thanks for allowing the publication of his device.

The engravings are from photographs taken from a model, therefore the proportions will differ somewhat from those of a full-sized working machine; and, while to many the three views will give a clear idea of the machine, there are those for whom it might be well to give a detailed description.

A, Fig. 33, is a spindle that is held stationary in the base. Fitted to work upon and around this spindle is a sleeve *K*. To guide and hold the arm *E* at a right angle to *K*, is the cross-head centre *P*. The arms *R* and *X* are firmly secured to sleeve *K*, and therefore will cause the latter to rotate around the spindle *A* when operating the machine. The cross-head *P* slides up or down upon the sleeve *K*, being controlled in its motion by the screw *D*. The bar *E* (carrying at its end the former or sweep *F*) slides in the cross-head guides *SS*, and is controlled in its movements, lengthwise, by the bar or former

T, which may be set at any angle, and may be straight, curved, or of an irregular form. The gear *H* being fast to the spindle

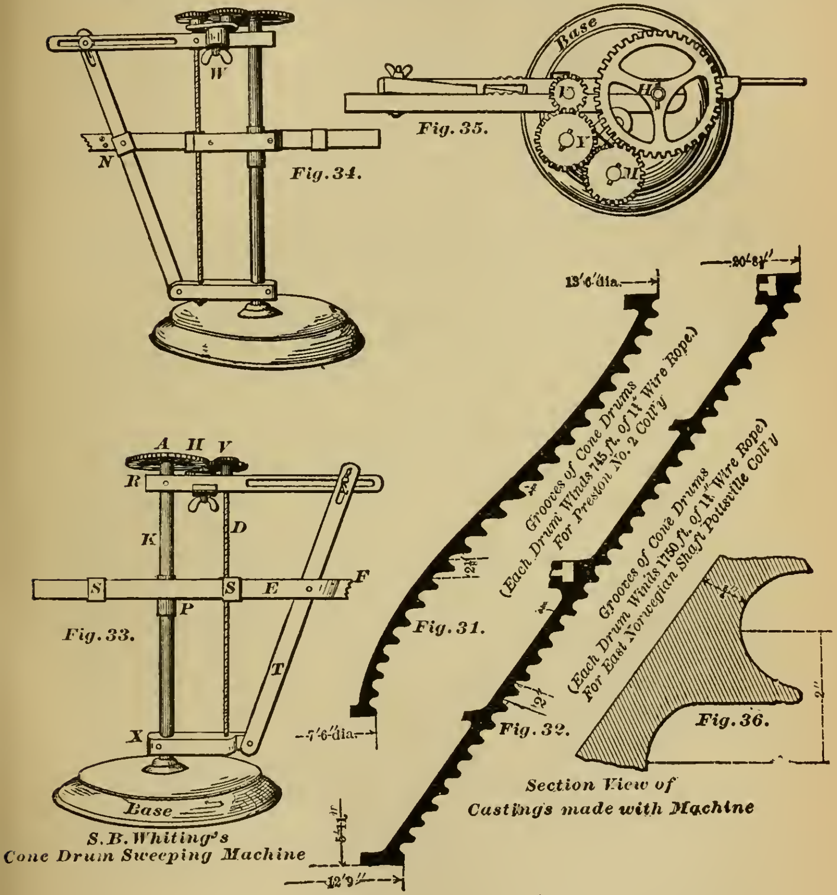

W
N
Base
D
H
Y
M
A H V
R
K
D
S
S
E
F
P
X
T
Base
13′6″dia.
20′8½″
Grooves of Cone Drums
(Each Drum Winds 745 ft. of 1½″ Wire Rope)
For Preston No. 2 Coll'y
Grooves of Cone Drums
(Each Drum Winds 1750 ft. of 1½″ Wire Rope)
For East Norwegian Shaft Pottsville Coll'y
2⅛″
2¼″
7′6″dia.
5′4½″
12′9½″
1½″
2″

Fig. 34.

Fig. 35.

Fig. 33.

Fig. 31.

Fig. 32.

Fig. 36.

S. B. Whiting's
Cone Drum Sweeping Machine

Section View of
Castings made with Machine

A, the screw *D* will be turned whenever the bar *E* is swept around the mould. By changing the gear on the screw *D* and spindle *A*, any pitch may be obtained; and, by inserting either one or two intermediate gears, a right or left hand pitch may be obtained. The opposite side-view of Fig. 33 is shown in Fig. 34. As will be seen at *N*, the bar *E* is there guided, as well as at *SS*, Fig. 33. Fig. 35 is a plan view of the intermediate and principal gears. As there are four wheels, the use of the two, *Y* and *M*, may not appear plain. These gears (*Y* and *M*) neither increase nor decrease speed, but are simply for making either right or left drums or pitches. Were wheels required for one-hand sweeping only, then these gears would not be required, unless the centres *A* and *V* were so far apart that they were necessary to transmit motion.

As shown, the intermediate gear *M* is the one engaged with the large wheel *H*, and will produce a right-hand drum or pitch. To produce a left-hand drum, the thumb-screw *W*, Fig. 34, is loosened, and the gear *Y* is made to engage direct with the large wheel *H* and pinion *V*.

The screw *D* should, according to the diameter of the mould, be set to balance the bar *E*, in about the relation to the centres between the sleeve *K* and bar *T*, as here shown. In other words, the screw *D* should be set so as to balance, at an average, the bar *E* in its up or downward movement.

When arranging gears for moulds of large diameters, the gears *Y* and *M* could, to save using a large centre-wheel and pinion, be reversed so as to stand between the pinion *V* and large wheel *H*. To make an opposite hand drum, the two pinions would require to be replaced by three smaller ones. For making small-sized moulds of right-hand pitch, only the gear *H* and pinion *V* may be required.

In figuring the relation of gears to give desired-sized moulds, the pitch of the leading screw *D* will be the regulator. As an example, we will suppose the leading screw *D* to have ½″ pitch. (By pitch is meant that every time the screw revolves once, the thread would cause a nut to rise in height ½″.) Now, supposing there was to be a cone made having a 2″ pitch, as seen in section, Fig. **36** : the arrangement should be such as to cause the sweep *F*, Fig. 33, to rise in height 2″ every time the sweep revolves once. Knowing that the leading-screw rises $\frac{1}{2}''$ every revolution, the gears must be made so that, in every revolution of the sweep, the leading-screw will revolve four times, in order to raise the sweep 2″ in one revolution. Now, knowing that the leading-screw pinion *V* must revolve four times in order to raise the sweep 2″ in one revolution, it will be seen that the large wheel *H* must contain four times the number of teeth that the pinion has ; therefore, if the pinion has, say, twelve teeth, the large wheel must have forty-eight teeth.

Did one wish to make a mould having grooves of 3″ pitch, by using the same $\frac{1}{2}''$ pitch leading-screw, the gears *V* and *H* would require changing so as to cause the pinion *V* to revolve six times to once of the sweep.

To construct a 1″ pitch with the above leading-screw, the gears would require changing so as to cause the pinion to revolve twice to once of the sweep. For the construction of any fraction of the above pitches, the gears would, of course, require proportionally changing.

The pitch for the leading-screw would, for general work, be better if $\frac{1}{4}''$. The $\frac{1}{2}''$ pitch could, of course, be used, but such a coarse feed for fine pitches is objectionable. For grooves above 2″ pitch, $\frac{1}{2}''$ pitch leading-screw would be best.

The spindle *A* is not necessarily secured in such a base as shown. The idea is simply that it must be firmly held in something that will remain stationary. While the spindle is shown here self-supporting, it would be better for general work were the top supported by a brace. To do this, the spindle would require to be prolonged farther above the wheel than here shown.

While there are no sizes given, any one requiring such a machine can very readily, from the views and description, proportion and construct such a machine as the size of a job may require.

SWEEPING GROOVED DRUMS IN LOAM.

The two engravings, one on p. 77 and the other on p. 79, each representing a different plan of sweeping a large grooved drum in loam, are not only instructive in so far as they represent practical processes, but are interesting, in connection with that shown on p. 73, as showing that the trade of the moulder demands the exercise of talents of a high order. I am indebted to the courtesy of David Matlock, manager of the I. P. Morris Company's foundry, Philadelphia; and Homer Hamilton, of the Hamilton Works, Youngstown, O., — for being able to present to my readers these plans, which are well worth the consideration of practical men.

In the plan adopted by Mr. Matlock (Fig. 38), a spiral groove, as shown, is cut for nearly the entire length of the spindle. The pitch of this groove is made the same as the pitch of the grooved drum is intended to be; and a set screw projects through the arm of the sweep, and enters the groove in the spindle. Of course it is plain, that, in revolving the sweep, it will have a corresponding spiral movement.

Mr. Hamilton's plan (Fig. 37) involves the use of a plate *B*, the working-face of which is turned up in a screw-cutting lathe to the desired pitch. At *F* is represented a piece about 8″ long, dowelled to the main plate so as to be readily removed. The roller at *E* permits the sweep to be easily revolved. The drums, for the making of which this plan was originated, were 14 feet in diameter, and 7 feet 4″ in length. They were stiffened by inside ribs and flanges, and had 6″ outside flanges at ends. They were poured by dropping the metal from the top, and, when done, were said to be first-class castings.

I will not dwell upon forming the inside of drums, as that is a matter of secondary importance compared with sweeping the outside or groove portion of drums.

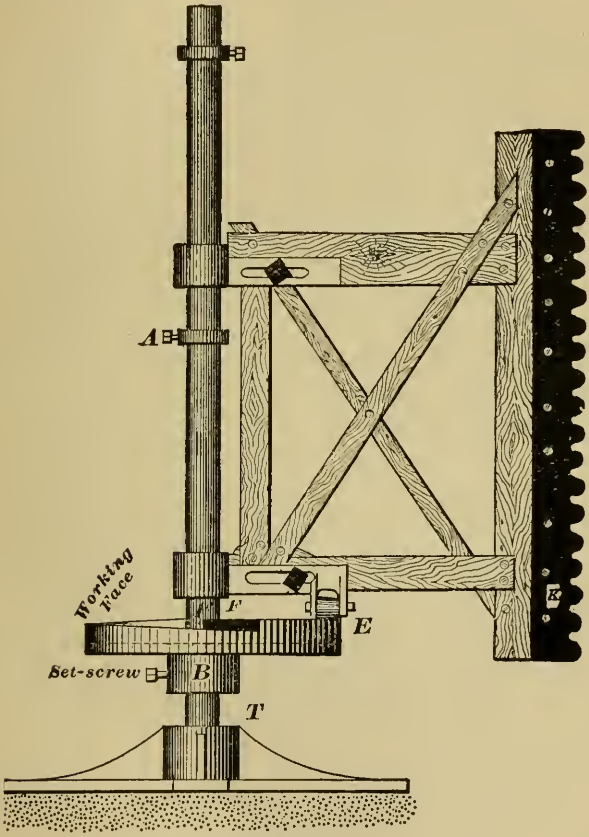


Fig. 37.

In the loaming or sweeping-up of a mould, a straight sweep is generally first used; after which this is detached, and the sweep for forming the grooves attached. In both cuts, the grooved portion of the sweep is shown in black. This portion of the sweep could be made of sheet or boiler iron plates, as the projections are very easily broken if of wood; or this portion could be wood, faced with a thin sheet-iron plate, as represented at *Y* (Fig. 38). This strengthens the wood, and prevents the working-edge of the sweep from rapidly wearing away. At *V* the working portion of the sweep is shown to be all iron, made so as to be removed, thereby allowing for attaching either a straight or a grooved sweep, as shown at *M* and *K*.

The cut of Mr. Hamilton's rigging shows the inclined plate in place ready to sweep the grooves. This plate is not so placed until after the mould is roughly swept up with the straight sweep, which is done by letting the sweep rest and revolve upon the collar *A*, which, as now seen, is dropped out of contact, in order to show the position of the sweep when forming the grooves, the inclined plate *B* having been lowered to the bottom holding-step *T*. Then, after the straight sweep has done its work, the inclined plate is raised to its proper position, and held by the set screw shown in *B*, after which the collar *A* is dropped out of contact, so as to allow the sweep to travel in a spiral direction. The sweep starts at *F;* and when it has passed away from *F* this piece is removed, allowing the sweep to travel more than the whole circumference of the grooves. The sweep is then returned, *F* being replaced, and another revolution is made; and so on to the end. This plan causes the sweep to be turned back over the same surface every revolution it makes, and is very objectionable, for it is apt to tear and rough up the surface of the mould. To avoid this, the dowelled piece *F* can be left out, and, when the sweep comes to the step, let it drop down upon the starting-point of the incline. To do this, there will of course be left a narrow strip the entire length of the sweep, that cannot have the grooves formed: as this strip needs to be but ½″, or such a matter, wider than the sweep, it can very readily be filled up after the balance of the grooves are finished; and then, after leaving the starting-point, the piece *F* can be set so that when the sweep gets around, it

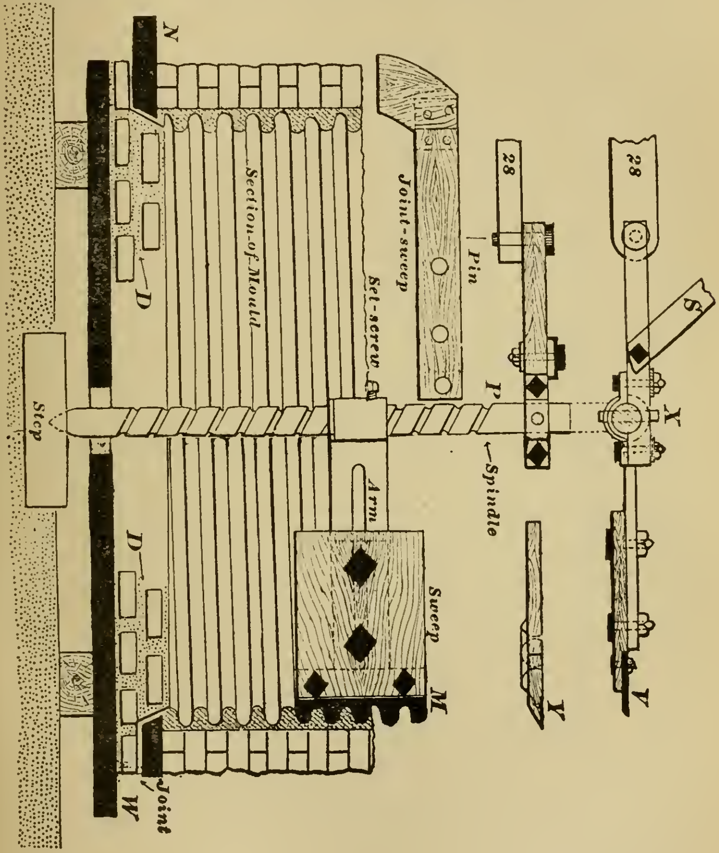

N
Section-of-Mould
Joint-sweep
Pin
28
28
S
D
D
Set-screw
P
X
Stop
Spindle
Arm
Sweep
M
Y
V
W
Joint

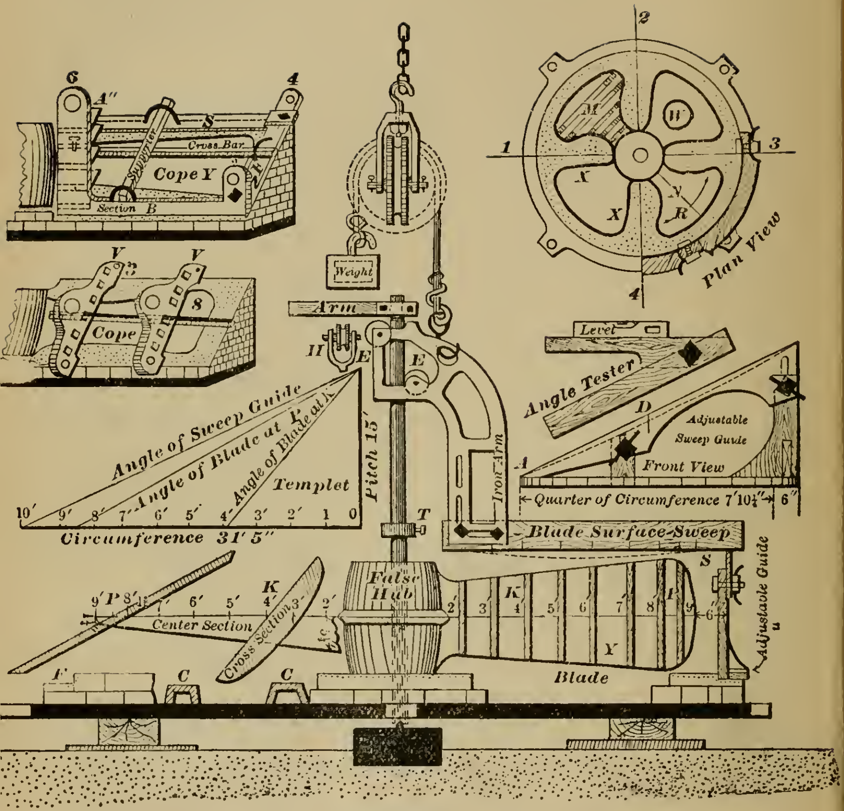
Fig. 38.

can be made to travel more than the whole circumference. thereby sweeping off that portion or strip of the grooves which was filled up. By this plan the sweep is always travelling in the same direction, and the little strip to be filled can be swept with one revolution if the job is intelligently performed. Of the two plans, the latter one is decidedly the best to adopt.

In loaming or sweeping up the grooves, the method adopted should depend upon the size or pitch of the grooves, and also upon the nature of the loam. If the grooves are not over $\frac{3}{4}''$ deep, and the loam a fair stiffening kind, the grooves may be swept up without much delay. But should the loam be a slow stiffening kind, it might be advisable to partly dry the inside of the mould with a basket fire, having the top of the mould covered over with sheet-iron plates to keep in the heat. This plan in the case of larger grooves, with the best of loam, might often be advisable. Of course, the reader is to understand, by drying the mould before sweeping the grooves, that the mould has been swept by a straight sweep; and, by partly drying the loam forming the straight part, it presents a dry body to absorb the moisture of the loam used when forming the grooves.

In the case of very large grooves, it might be necessary to use the groove sweep when building up the brickwork, so as to build the bricks projecting into the grooves, which would, of course, often necessitate breaking the bricks. Again, for forming grooves, loam bricks or cakes might be made the circle and thickness wanted, and when building up the mould use a four-inch common brick wall upon the outside of the loam-cakes. The cakes being made the proper size for the job, there should be very little time lost in waiting for the loam to stiffen when sweeping up the mould. The above plans are only given as ideas, as I could not recommend any plan unless the special requirements of a job are known. However, they are all worth remembering; as, with a little judgment, it would be but a simple matter for one to know which would be the best to adopt for his special job.

The details of any work of this character call for the exercise of individual judgment on the part of the moulder, as no cast-iron rules can be made for jobs that in each case will probably possess peculiar features.



6
A″
4
S
Cross Bar
Cope Y
Sweep
Section B
V
V
8
Cope
2
1
3
M
W
X
X
N
R
4
Plan View
Weight
Arm
H
E
E
Iron Arm
Pitch 15′
Angle of Sweep Guide
Angle of Blade at P
Angle of Blade at K
Templet
10′ 9′ 8′ 7′ 6′ 5′ 4′ 3′ 2′ 1 0
Circumference 31′ 5″
T
Level
Angle Tester
D
Adjustable Sweep Guide
A
Front View
Quarter of Circumference 7′10¼″
6″
Blade Surface-Sweep
S
Adjustable Guide
9′ P 8′ 7′ 6′ 5′ 4′ 3′ 2′
K
Center Section
Cross Section
False Hub
2 3 4 5 6 7 8 9
K
P
6″
Y
Blade
F
C
C

Fig. 39.

MOULDING PROPELLER-WHEELS IN LOAM.

The making of propeller-wheels has, perhaps, in the devising of rigging and plans, brought about more study and thought than any other class of castings. To a man not practised in the art of moulding, a propeller-wheel, from its general crookedness, seems to present many difficulties; but to a moulder accustomed to making such wheels, the job seems simple enough. What troubles loam-moulders not accustomed to making wheels, is to devise rigging with which to make them. Give them the rigging, and they will do the job more easily than I can write an article on so crooked a subject.

The principle of a propeller-wheel is that of a screw working in a nut, the water forming the nut; but, while the ordinary screw working in a metal nut is a true screw, in the case of the propeller-wheel it is not always a true screw; and sometimes, on account of this irregularity, it will be made from a pattern instead of being swept up.

The engravings represent making a propeller-wheel nine feet diameter and fifteen feet pitch — true or regular pitch. Some of the different plans of moulding, as well as means for determining the angle and pitch of blades, are also given.

The right-angled triangle shown is for the purpose of illustrating the method of obtaining the angles of different sections of a blade. In a wheel of true pitch, the angles are not the same at any two points in its length. This will be better understood by reference to the blade-sections *K* and *P* (Fig. 39). *K* shows the angle at a distance of four feet, and *P* at about eight feet and a half in diameter. To determine the angle at any other diameter, it is only necessary to draw a line from the assumed diameter to the top of the pitch or angle. In making a templet to obtain the angle for any desired blade, it is immaterial how large or how small the blade is. It is only requisite to have the circumference and pitch lines drawn at right angles to the same scale; then, by equally dividing the circumference or base-line into feet or inches, as the diameter answering to the circumference calls for, we can then get the angle at any required diameter. The right-angled triangle, or "templet," here shown has its circumference, or base line, laid off for ten feet. Some may wonder why ten feet is used, when the wheel is only nine feet. The diameter inscribed by the "adjustable guide" is, as shown, one foot larger than that of the wheels; therefore, as the sweep works upon the "adjustable guide," and the angle of the wheel or pitch is formed by it, the desired distance from the centre, when striking off the blades, must be the working-base taken in laying off the pitch or angle of the wheel.

In moulding propeller-wheels in loam, a section, or sometimes the whole of the level bed, is first swept up. At the outer edge, some will sweep a seat as shown at *F*, or in its place make the bed level, and at this point scribe a mark by passing around the bed-sweep. This mark is for the purpose of setting the "adjustable sweep-guide," shown on the side opposite *F*. The adjustable feature is something that I believe to be an improvement over any plan I have ever seen used. After this bed is swept, and divided off into as many blades as required, the false hub is swept up with bricks and loam. Around this hub a V-bead is swept, to assist in marking off the blade. After the hub is finished, the hub-sweep is removed, and the sweep for the surface of the blade is attached to the iron arm. Where this arm works against the spindle, two sheaves, *EE*, are shown. Another view of this is shown at *H*.

So far as I know, this idea of using the sheaves is original, as I have no knowledge of their being so used. It seems reasonable, however, that, if used in this way, there would be greater freedom of up-and-down movements than when there is simply a round hole through the arm.

When the blade-sweep is secured in place, the "sweep-guide" is set so that its base point *A* (seen in the front view) is at the dividing-line mark, as seen at 4 in the plan view. Or this guide may be set by a centre mark, as shown in the front view at *D*. The blade-sweep being let down until its working-edge is at the centre or V-bead on the hub, the sweep-guide is moved until the centre *D* is directly under the working-edge of the blade-sweep, which, by the way, should also radiate from the centre of the spindle; this point being provided for in making the arm.

All being now ready for building the nowel brickwork or bottom part of the mould, this may be done in different ways. One way would be to build up brickwork to about 1″ of the intended bottom of the mould, and then the space from this to the intended cope surface could in the thickest parts be partially filled with loam-cakes to absorb the moisture from the wet loam. The thinner parts of the blade and joint could be made up entirely of soft loam.

Another plan is to screw a thickness sweep to the blade-cope surface sweep, which should project below its working-surface at an angle equal to the distance of the thickness of the blade at its centre section. With this sweep the loam can be swept off so as to give a bottom to build a thickness on.

Still another plan would be to make the bottom surface and thickness of all dry-sand mixture. To do this the bricks should be kept about 4″ at the bottom and 9″ at the top below the intended bottom surface of the blades. This space should then be partly filled with cinders; thus avoiding the building and drying of a large body of brickwork, besides permitting the blades to be properly vented, — a very essential feature. Over these cinders the dry sand is rammed and struck off to form the surface of the blades and the joint. It is not necessary that the central portion *W* should be built up, in building up the blade thickness in dry sand or loam. All that is necessary is to have surface enough to mark out the blade, and have a solid joint.

In marking off the blade, a centre line is struck by stopping the sweep at the centre of the hub.

It may be here remarked, that to prevent mistakes it would also be well, in connection with the V-bead, to make a mark on the base *F*, which may be done by dropping a plumb-bob from the sweep before the building-up is begun. This mark can be easily preserved; and if the V-bead is broken, or the sweep moved, it is left to work from.

After the centre line is drawn, as shown on the plan view at *N*, the diameter of the wheel is marked by running up the sweep, to which is screwed a sharp-pointed scriber at *S*. Inside the diameter another mark, *R*, is scribed for points from which to describe the rounded corners of the blades.

After this, any number of radius lines required for laying off the width of blade at different points can be made.

In some wheels, the boundaries of the blades are radial lines to the rounded corners, as shown at *XX*.

To assist in getting the form of irregularly shaped blades, it is well to have a thin wooden or tin frame templet made to bend to the shape of the joint; this templet being the shape of the blade, and centred from the line *N*. The form of the blade is then marked off, and the thickness cut out by either of the following plans.

In the first plan (which is the best for those unused to making propeller-wheels), on the blade as shown at *Y*, are eight wooden gauges, each representing the thickness at different diameters, as *P* and *K*. The proper positions having been marked by the scriber, each gauge is bedded into the blade-bed so as to be even with the surface. This being done, the sand or loam between the gauges is taken out, and one by one the gauges are removed and the blade finished up. In the other plan, less gauges are used, the eye being more depended upon for the shape: hence this plan requires practice.

After the blade has been finished, the thickness is filled up with moulding-sand, the surface again swept off and sleeked. The blade-sweep and guide are then removed, and the rest of the nowels or bottoms of the blades swept up.

The joint or parting being ready, the next thing is building the cope. Two plans are shown: the upper one, *Y*, will first be considered. This cope is made in three sections, *B*, *F*, and *S*, held together with bolts. The section *B* has a number of projections cast on it, which increase in length from the bottom up, the projection *A″* being about on a level with the top of the hub. These projections are for the purpose of supporting crossbars to carry the brickwork. The bars may be 2″ square, and placed about 4½″ apart. The ends nearest the hub are tied to the supporter, shown, to assist in lifting the hub-end when the cope is hoisted. The cope is lifted by the handles 2, 4, and 6.

On the section *F* are staples, one being shown with a cross-bar through it. There should be as many of these staples as the width of blade requires cross-bars. After the cross-bars are all in, and firmly wedged, the space is filled with loam and bricks: the brick being set endwise will make the thickness of cope about 9″. These bricks must be firmly laid, and the space above and below the cross-bars should be solidly filled with pieces of brick and loam. When all the bricks in the cope are laid, the surface is plastered over with a coat of loam, to add to its strength and make an even surface.

In the lower cut, a plan of making the cope is represented that involves less labor. In this plan, *V V* are bars about 2″ thick, 8″ wide, and long enough to lap over each side of the joint about 3″.

The two large holes seen are for passing a strong bar through to hoist the cope off. These holes are above the centre, to leave the bottom the heaviest. At the bottom of these bars are two small round holes. Into these are hitched swivels, so that by adjusting them the cope can be lifted evenly. The square holes are for the insertion of cross-rods, shown at 8.

At the outer end of these cross-rods, stout wire is often wound to help in holding the brickwork. The brickwork is built the same as in the instance of the cope first mentioned.

After the copes are all built up, the joints are loam marked, and the false hub taken out. Before the copes can be lifted, they must be partially or wholly dried. In some shops that are provided with proper facilities for handling and drying such a wheel, the whole would be dried at once; and when about dry, it would be taken from the oven, the copes hoisted and turned up, and the mould surface finished. The nowels also being finished, both parts are again run into the oven, and thoroughly dried, after which the mould is got ready for casting.

When such moulds cannot be hoisted with a crane, or where the oven is not large enough to take the whole mould in, a sheet-iron curb, or, in case of large moulds, a temporary brick wall, is built around them, and some fireplaces made, so that a hot steady fire can be kept up with coal or coke without the necessity of uncovering the mould, as must be done if the fire are built inside the curb or wall. Charcoal and sometimes wood are used, not only at the bottom of the mould, but at top of the copes as well.

Sometimes, when oven room will not permit holding of both cope and nowel, after the mould has been dried sufficiently to lift the copes, it is uncovered, the copes lifted and finished, and run into the oven to complete the drying. Then the nowels are finished; and, being covered over, the fire is again started, and kept up till they are thoroughly dried.

Another plan in making large wheels is to build each blade on a separate plate; then, after marking them, they can be placed in the oven to dry. This plan involves a little more labor, but it may often be more than balanced by convenience in drying.

Wheels are cast in two ways. As above described, the working-side of the blade is cast up, which is objected to by some on account of the dirt. But few changes are required to cast the working-side down. In casting this side down, instead of using the wooden sections, as seen at blade Y, to cut out the blade thickness as above described, they are reversed; and, after being set in place, a few nails are placed in the sides and end to prevent their moving. The space between them is then filled with moulding-sand; which being struck off, the shape of the blade is formed, over which the cope is built. By this plan, there is more certainty of the blade having its proper shape on the back, and more nearly correct shape of section. For irregularly shaped blades, this plan is generally preferable. The forming of the nowel, or working-side of the wheel, is done when this part is built by the use of the sweep shown.

At the bottom of the "blade-surface sweep," is shown a dotted curved line; also at the working-edge of the "adjustable sweep-guide." These are for showing that propeller sweeping is not confined to straight lines.

The hanging sheave, usually hung from a beam overhead, should be as nearly over the spindle as possible. It is used, as will be inferred, for raising and lowering the sweep when forming a blade. Some, in using a sweep-lifter, have it connected with the top of the spindle. The spindle is made longer than here shown, and, having a long pin projecting above its end, admits of cheeks containing two sheaves revolving upon it.

The weight shown is a hollow iron box; which is weighted as required, as it is very important that the weight be accurately adjusted to the requirements.

In getting the mould ready for casting, some fasten down the copes by means of a cross placed over the mould, so as not to interfere with the gates. From the cross-ends, slings or bolts will be secured to the four bottom handles.

Then, again, some will secure the copes by bolting them to staples cast in the bottom plate, as seen at *C C*. Instead of these staples, some have oblong holes cast in the bottom plate, and, by inserting T-headed bolts, fasten down the copes. Of the two plans, the latter is the better, as the staples stick up and are in the way more or less.

In securing the circumference of the mould, if it is not rammed up in a pit, wrought-iron sheet-curbing is bolted together, and the space of about 8″ allowed between it and the circumference of the mould rammed-up with sand, — similar to the ramming up of any ordinary loam-mould. The wheels are generally poured by dropping the metal from the top of the hub of the wheel; and flow risers are generally placed, one upon the surface of each of the upper edges of the blade.

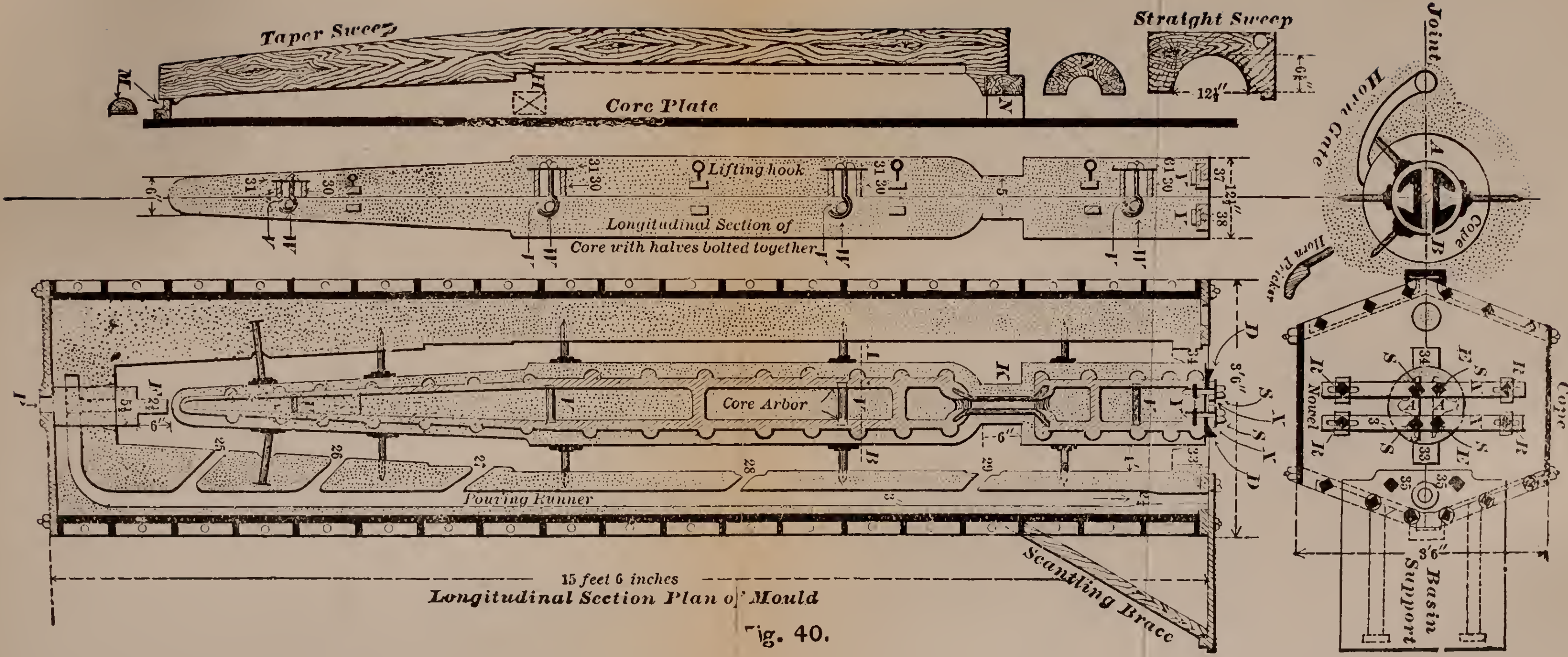

Taper Sweep
M
Core Plate
Straight Sweep
12¼″
6¾″
Joint
Horn Gate
A
B
Cope
Horn Pricker
Lifting hook
Longitudinal Section of
Core with halves bolted together
6″
31
30
12½″
37
38
Core Arbor
Pouring Runner
25
26
27
28
29
D
3′6″
S
X
K
Nowel
R
E
33
34
35
6″
15 feet 6 inches
Longitudinal Section Plan of Mould
Scantling Brace
Basin Support
3′6″

Fig. 40.

Cope

MOULDING AN HYDRAULIC HOIST CASTING IN DRY SAND.

The engraving (Fig. 40) herewith shown presents ideas of gating and coring that may often be found useful. The casting, when done, was finished its entire length to an exact size, and required to be clean and sound. The mould was made by the use of a sweep attached to a spindle, one end of which had a bearing in the journal *P*, and the other end in a strap, not shown, which was bolted to the end of the flask through the holes *E E*, seen in the end view.

Before blacking the mould, the runner and gates were cut. One gate admitted the metal at the bottom; and, as the mould filled up, the metal entered through the side gates. These gates were made slanting from the runner upward, in order to help to prevent the mould from cutting or scabbing. With a gate thus cut, it is very evident that little or no iron can run into the mould until the metal has risen in the mould nearly up to the slanting gates. If this can be accomplished, there is very little danger of the core or mould surface being cut upon the metal entering the mould, which would, of course, be very liable to spoil the casting.

Some one may feel like asking, Why are there so many side gates? and could not the mould be run entirely from the bottom gate? The mould could be run by one bottom gate; but by its use alone the metal, as it rose upwards, would be sluggish and dull, thereby retarding the dirt from floating up to the top of the casting, about six inches of which is cut off. By having the gates as shown, there will be about as hot metal to fill the top portion of the mould as there is at the bottom, thereby assisting the dirt to float up to the riser head.

The upper portion of the pouring runner will be seen to be 2¼″, while below it is 3″. The idea I had in making the upper part smaller was to assist the slanting inlet gates in preventing the metal from running into the mould until the proper time. Had the runner been 2¼″ for its entire length, it would most likely have filled, so as to make one unbroken column of flowing metal, thereby causing the metal to run into the mould through every side gate. By having the runner as shown, it is evident that the 3″ portion would take metal faster than was admitted through the 2¼″ part, thereby assisting in preventing the metal in runner from rising much higher than that in the mould.

Some may think it would be a good plan to use horn-gates, as seen attached to the cope section, *A B*, in the place of the straight gates. It would certainly assist the dirt to rise if the metal whirled; but if the horn-gates were used, the extra labor they would make would hardly be paid for in what little benefit might be derived; especially as the chaplets would tend to stop the whirling of the metal. However, if used, they would require to be set slanting upwards.

The gates, Nos. 28 and 29, are shown cut into a projection, a wrinkle founded upon a principle that could be applied to the making of many castings. The first one of these castings I made had a defect, in the shape of a hole about ¾″ deep in front of each of the upper gates, 28, 29. By the use of a little common-sense, I saw what I should have thought of before, which is simply that a light body of iron will contract faster than a heavy one. The runner being much the smallest body, its length would naturally contract faster than that of the casting; and, in doing this, the weakest point must break. In this case, the weakest point was where the gate connected with the casting. The surface of the casting being in a half-molten condition, the gate would carry away a portion of it. By enlarging the casting about $\frac{3}{4}''$ at this point (which was about the depth of hole the withdrawal of gate would leave), there was no further trouble. The projection, in cleaning the casting, is, of course, chipped off, which would then leave it, at this point, full and sound.

In the core as set into the mould, there will be seen two small necks, *F* and *K*. The diameter at *F* being only $2\frac{1}{2}''$, I did not think it would safely support the weight of the upper core when the flask was upon its end; therefore I devised the plan of hanging the core from the flask, as shown.

With the exception of the wrought-iron rods, shown in the neck *K*, and at *V*, the core-arbor is all cast-iron. In making this arbor, its form was marked off on a level bed, and then cut out with a gate-cutter; the rods *K* and *V* being set in. The horn-pricker shown was then pushed into the sand at about every 9″ along the length of the mould, as seen by the projections on the arbor. In the upper end of each arbor, there were cast two nuts, *Y*. Into these were screwed bolts, *S S*, the heads of the bolts being screwed up tight against the wrought-iron plates, *X X* (the thickness of which is one inch). Between these plates and the end of the core-arbor were placed wrought-iron wedges, *D D*. The plates *X X* not only held up the core, but they also held down the core when the mould was poured, as will be seen by the four bolts at *RRRR* on the end view of flask. These four bolts are screwed into holes tapped into the end of the flask, and the plates screwed down tightly, thereby making a firm, reliable rigging for the purpose intended.

Another point of interest is the plan by which the core was made. Ordinarily a full core-box would be made, and this might be the cheapest plan were there many cores to make; but for the few wanted, their construction by the use of sweeps was a saving of at least fifteen dollars. In making the core, the core-plates were levelled and firmly set upon the oven carriage. The centre of the plate was then found, and a line drawn. The length of the core, from the end *F* to the neck *K*, was then laid off, the blocks *M* and *N* placed on; and after being set and marked around, these blocks were lifted, and about one inch thickness of core sand placed upon the plate. The core-arbor was set upon this, and, after being centred and found to be otherwise correct, the blocks *M* and *N* were set on their marks and the core rammed up. For forming the longitudinal straight portion of the core, the straight sweep shown was used. For the taper longitudinal portion of the core, the taper sweep shown was used. The dotted line on this sweep represents the straight portion of the core. The taper sweep was cut out, as represented, in order to clear the portion of the core formed by the straight sweep. The taper sweep could have been used half its length, had there been another block like *N* placed at *H*. After being dried, the halves were blacked and rolled over, after which a vent was filed along their centres. The top half of the core was then rolled back; and, being hoisted by the four lifting-hooks, it was lowered upon the bottom half, and gently rubbed until a close joint was formed.

It might be well to state that the sweep and blocks were made about $\frac{1}{8}''$ out of a true circle, being the largest in the direction of the vertical section. This is indicated by the difference between the vertical and horizontal measurements on the "straight sweep," and was to allow for the core sagging and for rubbing down. Had this not been allowed for, the core would have been far from being a round one. Rubbing it down made a close joint, which assisted in keeping the metal from getting into the joint-vent of the core.

After being rubbed and found to be all right, the top half was hoisted, and the joint brushed off and carefully spread with flour-paste. It was then again lowered, and the two halves bolted together, as shown in the longitudinal section.

No. 30 shows a section of cut tubes, 3″ in diameter, placed when the core was made. This is for the purpose of making a clean, firm hole, upon which to lay the washers, 31, for screwing down the bolts *W*.

The section *AB*, marked "cope," shows the position of the chaplets around the core; and the longitudinal sectional plan of mould shows the number that were used for securing it lengthwise. The two lower chaplets were placed at the joint's surface in order to give the core about the same hold sideways at the lower end as the print gave at the upper end.

Before setting the nowel and cope chaplets, the core was carefully calipered, and the diameter of the mould measured. At every bearing-place of the chaplet, the mould and core measurements were compared, and thereby the exact thickness of metal obtained, so that when the core was set it would be in the centre of the mould.

The cope was then tried on; there being flour under the cope chaplets on the top of the core, to see if they touched as they should to make a safe, reliable, chapleted core. In closing the flask (there being no pins), the only guides were the bottom spindle-journal *P*, and feeling the joint at the top through the risers 33 and 34. When the cope was hoisted, and every thing found to be right, the iron joint was pasted, and the cope lowered for good. After being firmly secured with bolts and clamps, the joint was carefully packed with wet loam, especially at the lower end, in order to prevent any run-out. The riser-holes and pouring-runner were stopped with waste to keep out dirt; and the flask was then hoisted upon end, and placed in the pouring-pit.

The pit being only about nine feet deep, it was necessary to build staging for reaching the pouring-basin and feeding-head; and also, to pour the mould, the basin support shown was made because of having to pour so high above the ground.

The nuts 35 and 36 were screwed into tapped holes in the flask; and, to assist them in holding up the basin, scantlings were placed, running from the outer edge of the plate on a slant to the flask. The ends of the scantlings rested upon the handles of the flask, which are not shown. With the exception of the first defect mentioned, the castings came sound and clean.

CRUSHING AND FINNING OF DRY-SAND AND LOAM CASTINGS.

Having discussed the joints of green-sand moulds, p. 155, in order to conclude the subject, the question in relation to dry-sand and loam moulds would appear to be in order, the considerations of each branch being measurably distinct. A green-sand mould, if the joint is not disturbed, will close as nearly air-tight as it is before parting. Even if there are irregularities in the surface, they will often yield and bed themselves in a way to make the joint tight. In a dry-sand or loam mould, incompressibility of the material, and the fact that the joint is more or less distorted in drying, will prevent this, so that the joint will either be kept apart, or will crush in closing. "*It is better to have a fin than a crush*," is an old adage that has frequently to be learned by sad experience.

With dry-sand and loam moulds, then, it may be said that they should generally have a fin to prevent the probability of bad results. For this purpose the edges of the joint are cut or sleeked down, leaving an opening, shown at *K*, Fig. 41. In sleeking for a fin, there are three ways in which it can be done. Sometimes it can be sleeked down at the edge of the pattern, as shown at *P;* then, after the cope has been rammed up and lifted off, the cope-joint shows a raised edge, as at *B*. This raise is then cut off, as represented at *E*, after which it is sleeked down, the same as the nowel at *P*. This makes a thick fin, which, for some jobs, is the safest, and often the best; as, for instance, when there is a possibility of the joint being torn up in drawing the pattern, or when the flask is not well fitted.

The second plan, and one that makes a neat fin, is, not to sleek down the joint as at *P*, but leave it level, as at *A*. After

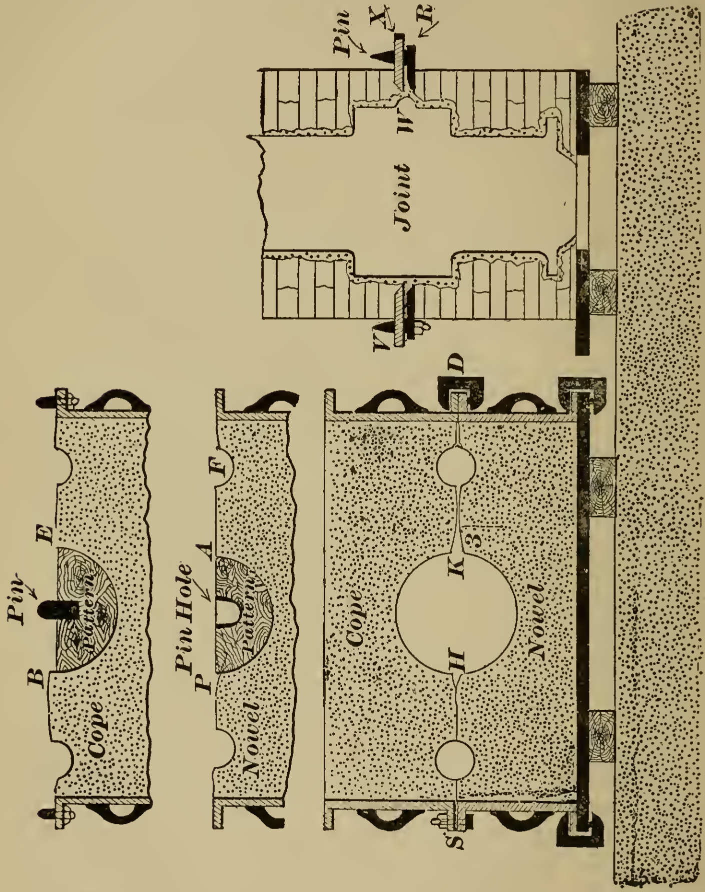

Pin
X
R
W
Joint
V
D
Cope
K
3
H
Nowel
S
Pin
E
B
Pattern
Cope
F
A
Pin Hole
P
Pattern
Nowel

Fig. 41.

the cope is lifted, both joints are then sleeked down. The pressure used in sleeking will, of course, to some extent regulate the thickness of the fin; but by this plan it would require very heavy pressure to provide for a fin as thick as by the first method, as by that a portion of the joint surface is cut away before it is sleeked, and the cutting-away of the projection *B* not only lessens the surface, but also softens the sand so that it sleeks down easily. By the second plan, a thicker fin can be made by swabbing the joint before sleeking, than by sleeking at its natural dampness.

Sometimes, with a good flask and a pattern that draws well (and particularly when *the moulder is a careful man*), sleeking down the cope half of the mould will be sufficient. This makes a thinner fin than when both halves are sleeked down, but its safety depends upon the ability of the moulder to get his work down to a fine limit.

For jobbing work I would establish the first plan, as it gives a doubt the preference. In such work, ill-fitting, unhandy flasks must often be used, as well as poor patterns, so that the second plan named would involve too much risk to be adopted by the majority of moulders or shops.

At *H* is pictured the cause of some moulds being crushed, and the introduction of the castings to the scrap-heap. The fin should be largest at the edge of the mould, and taper back to nothing, the width being from 2″ to 4″. As represented at *H*, this is not provided for; instead of an easy slant, as seen at *K*, the trowel is pressed upon the edge of the joint, raising up back portions of the sand higher than the joint. When the cope is closed, and the two joints come together, the raised portions touch first; and, of course, *a crush is the result*. As a rule, it is best not only to be sure of the opening for a fin at the edge of the mould, but also to sleek over the whole of the surface of the joint to make sure it does not touch hard in places, and that the joints of the flask shall come together, as shown on the side at *K*.

It should not be understood, that, because the joint side *K* shows a clearance over its whole body, larger surface-joints should be cut or sleeked down to allow of finning all over. The idea sought to be conveyed is, that sand-joints should not in any way prevent the flask coming together, as represented as doing at *S*.

When there is a large area of joint fin, there is danger that the joint will hold the fin in shrinking, so that a piece will be pulled out of the casting, as shown in the cuts marked "Fin *Y*" and "Fin *T*," Fig. 42. I have often seen this result in cylinder and roll castings, the iron in which is generally hard, causing the fin to chill very quickly after the mould is poured; and, of course, in cooling, it shrinks. When the fin is large in area, or the joint irregular and the casting a thick one, there is the probability, that, when the fin commences to shrink, it will pull away from the casting, taking with it a piece of the frozen surface or edge of the casting, from the inner, more fluid mass.

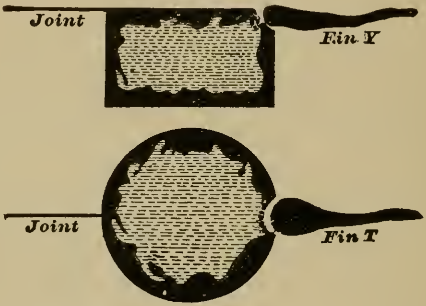


Fig. 42.

Sometimes a moulder may exercise proper care about the mould's fin part of the joint, but be careless where a runner or gate is cut, as shown at *F*, Fig. 41. It is essential that such parts should be finned, as the edges of the joint-gates and runners can be crushed as easily as any other part. If they are crushed, it introduces dirt into the mould, and, perhaps, provides for a run-out.

To guard against crushing, care should be taken that the flask-joints come together properly, and that they are not kept apart by dirt or rust. To this end, before starting to gagger or ram up the cope, it should be firmly bolted or clamped to the nowel, as represented at *D*, Fig. 41. As a further precaution against the loss of a casting by the crushing of dry-sand moulds, it is often advisable to close them together, bolt or clamp them, then hoist off the cope, and examine the mould before casting them. In moulding cylinders in dry sand, this is especially to be commended. In some cases, I have the mould closed before any cores are set: then, with a lamp inside the mould, the joints can be plainly seen, and felt if uneven or overshot; the thickness of fin can also be noted, and, if found too thin, can be cut out when the cope is raised up.

Before leaving the subject of dry-sand joints, there is another point worthy of note. After the mould has been blacked, the joint should be washed over lightly with the same blacking, thinned with beer or molasses-water to a degree that will just blacken the joint-surface. The same treatment should be given the core-prints; as it not only makes a better-looking mould, but by forming a hard skin prevents such parts from crumbling away when being brushed or handled. After blacking the joint, they should be sleeked to level down any lumps that may be on the surface. Often the blacking of the joint is neglected, or it is blacked with thick blacking, thereby increasing the thickness, making it liable to be crushed. Again, the joint will be wet until it is little better than a *bed of mud*, thereby getting it out of all reasonable shape. Either of these last-named operations is likely to bring about bad results.

A consideration of the joints of loam-moulds embraces more than can be covered with a single article. Some of the features connected with this subject have been referred to in previous

L. of C.

articles, and a few points may be mentioned here. The joints of loam-moulds should be finned upon the same general principle as those of dry-sand moulds, but the finning is accomplished differently. Instead of sleeking down the joints, they are generally scraped or shaved off. Two points are here illustrated, which, I believe, are not generally known or practised. At *W*, Fig. 41, in the cylinder loam-mould, is shown a bead swept where the mould is to be jointed. By parting the joint in this way, the fin can generally be chipped off, and the surface smoothed with a file, so as to present scarcely any signs of the joint. This plan also provides for hiding overshotness, which will often occur in loam-castings.

This bead is generally applicable to joints formed by a sweep, and for irregularly formed joints that require hand-work it can sometimes be used. Sometimes sections of loam-moulds are swept independently of each other, and closed together in getting ready to cast. For such moulds, the sweep can often be made so as to form the fin. In this way, the fin will be quite even in size, giving the casting a symmetrical appearance. Fins, at their best, are not an element of beauty, and the refined moulder will study to see that they mar the general appearance of castings as little as possible.

MAKING AND VENTING CORES.

The subject of cores is a very important one in its relation to the production of good castings. Some years back it was customary in many shops for the moulders to make their own cores; but at the present time core-making is coming to be a distinct branch, at least as much so as loam, dry-sand, or green-sand work. To excel in core-making is a credit equal to that of excelling in any other branches of the moulder's trade, as the success of the moulder in producing good castings is often largely dependent upon the skill of the core-maker. Take, for example, the casting of a steam-cylinder. As a rule, there is not much to fear with the outside. The main risk is in the cored parts. Cylinder cores, as a rule, with the exception of the centre core, may be classed as thin and crooked, and are much more difficult to make than larger cores.

The question is often asked, How thin is it practicable to make and use cores? To answer this, it would be necessary to know the general shape of the core, and its position in the mould. A much lighter core can be used if set vertically than if it must be set and cast horizontally. When set vertically, there is a much better chance for the gas to escape; as it is not so suddenly covered with iron in pouring, and there is no great lifting strain on a vertically set core.

The greatest difficulty to be overcome in making thin cores is in rodding and venting them: in fact, here is where the greatest skill in core-making is required. The chief cause of gases in cores is in the materials of which they are made; and the least gas there is in a core to be got rid of, the better, other things being equal.

A large amount of gas results from the use of flour. The gases from strongly-made flour cores, in a small low-roofed shop, often render it untenable. Rosin evolves but little gas; and hence in many cases its use is desirable, particularly as it vents and ignites easily. Rosin is comparatively but little used; one reason being, no doubt, that it requires to be pulverized, and another that it requires more care to use than most material used for the purpose. Rosin cores will rarely admit of handling when hot, and are not so reliable for heavy castings; also they cannot be so firmly and readily pasted together as flour cores. Sometimes, to assist in removing the objections stated, flour is used with rosin.[1]

The chief use of rosin for making cores is in the instance of small cores, in which case it saves labor, because such cores for thin castings need not be blacked, and can be handled more readily when green than flour cores can be, and they assist in producing finer small castings than can be procured with flour.

The blacking of a large number of small cores is not only tedious and costly, but it is often almost impossible to leave the corners as sharp and perfect as when they came from the box. If they can be used without being blacked as by the use of rosin, there is certainly an advantage gained.

In mixing sand for small cores, two things are to be considered: First, fine sand leaves a better surface on the castings; second, the finer the sand, the less opportunity for the vent to get off: hence the question is, how fine sand can be used, and at the same time provide for proper venting.

In making small rosin cores, moulding and bank sands are the best. If the venting will admit, smoother castings may be made by using the moulding-sand alone. If it is particularly desirable to save venting, then bank-sand is best. Sometimes bank and moulding sand can be mixed to good advantage.

The amount of rosin that should be mixed with the sand is dependent upon the nature of the sand used, and the kind of

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[1] For other binders than rosin and flour, see pages 362 and 363, Vol. I.

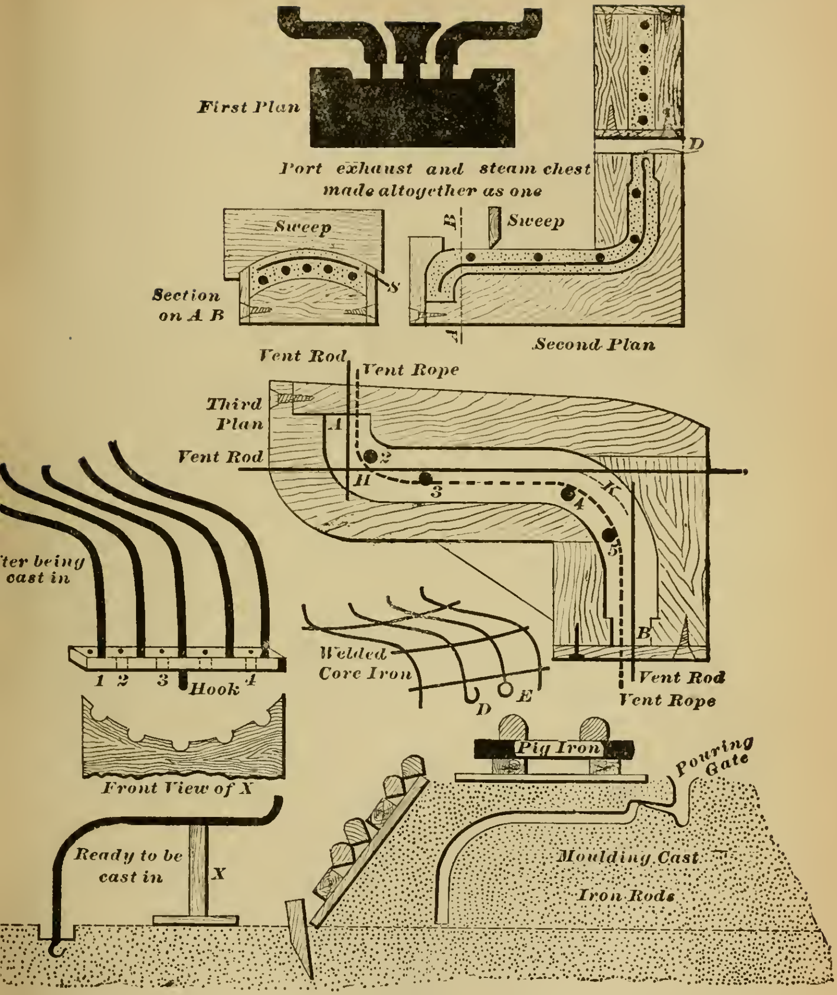

First Plan
Port exhaust and steam chest made altogether as one
D
Sweep
Section on A B
S
B
A
Sweep
Second Plan
Vent Rod
Vent Rope
Third Plan
A
Vent Rod
2
H
3
K
4
5
B
Vent Rod
Vent Rope
ter being cast in
1
2
3
Hook
4
Welded Core Iron
D
E
Front View of X
Pig Iron
Pouring Gate
Moulding Cast
Iron Rods
Ready to be cast in
X

Fig. 43.

cores wanted. With ordinary new moulding-sand, one part rosin to fifteen parts of sand will make good cores for ordinary work; but if very strong cores are required, a larger proportion of rosin may be used, or the sand strengthened with molasses water. In any case, it should be borne in mind, that, the weaker the core, the more freely the gas will escape. In some cases it is advisable to mix a small quantity of flour with the rosin. If too much flour is used, however, it may make it necessary to black the cores. Sometimes it is desirable to have the surface of cores hard and firm, and the interior porous; so that they will bear handling, and provide for a smooth surface on the casting, and at the same time permit the gases to escape freely. In making such cores, the more open the sand, and the less flour or rosin used, the better. To assist in making a firm, hard surface, the cores should be sprinkled with beer or molasses water.

The quicker, after being made, a core is put into the oven, the better. *The air-dried surface of a core is liable to crumble.* Another point that may be noted is, that, the wetter the sand for cores can be worked, the less the flour or rosin required. At the same time, if the sand is too wet, small cores will stick to the boxes, and large cores are liable to sag or crack.

In making flour cores where they must be strong, and where they cannot be thoroughly vented, it is sometimes a good plan to use boiled flour, as a much less quantity will suffice. To use this, the flour should be put in a kettle with enough water to make a thin paste. After boiling, this is mixed with water, and the sand wet with it. If all the water the sand requires can be boiled with the flour, all the better.

A man who can successfully make the class of cores shown in the engraving, Fig. 43, may safely call himself a core-maker.

Some port-cores are comparatively easily made, but as a rule they are amongst the most difficult to make. To properly rod and vent such cores, is often a matter that calls for careful consideration, and a good knowledge of the laws of cause and effect.

It is not the intention to offer instruction as to how any special port-cores should be made, but rather to show different plans that have been and may be practised under different circumstances. When the drawings of a cylinder come into the pattern-shop, the pattern-maker should consult with the moulder as to the best way to make the pattern and the core-boxes, to the end that it may be safely and expeditiously moulded.

In the engravings are shown three plans for making port-cores. The first one can often be used in making small cylinders, to the saving of work by the moulder, and increasing the probability of good castings. The ports, exhaust and steam-chest cores, cannot always be made together, as shown, but very often they can be.

The second plan, in which part of the core is swept up, is very handy for the moulder, as well as simple for the pattern-maker. It gives the moulder an opportunity to see what he is doing, and saves him time and labor.

The third plan, of having a full box, is one often resorted to where the cores are quite crooked and irregular, but should seldom be resorted to where the second plan can be employed.

In the engravings are shown four plans for rodding cylinder cores. The lower right-hand cut represents the making of cast-iron rods. This is done by taking half the core-box, and bedding its face into the sand, which is made solid for the purpose. The box is then withdrawn; and, by using a gate cutter, a frame similar to the welded core-iron shown is made. For a cope or covering, heavy paper is used, laying it over the face of the joint. Sand is then packed on the paper, and boards and pig-iron placed to hold the sand down when the frame is poured, which is done through the pouring gate, as represented. Irons like this are readily made, and are often good for short, thick cores.

On the right are represented wrought-iron rods, ready to have cast on them a narrow plate of cast-iron. This is for the purpose of holding the rods in their proper position at the print end. Single cross-rods are used, when making the cores, for holding the other end together. For getting off the vents, holes are drilled or cast in the plate, as shown at 1, 2, 3, and 4. At *X*, *X*, are shown two views of a wooden support, cut to the circle required, and having notches for the number of rods required. This is used for holding the rods in proper position while the plate is being cast on them. This kind of rod is often good for very large, thick cores. Another plan, which is often better than the one above described, is as seen by Fig. 44. Here, instead of the wrought-iron rods being cast in or held by the print end, they are all held by their centres; which, besides making them stiff, presents a "core-iron" easy and simple to make.

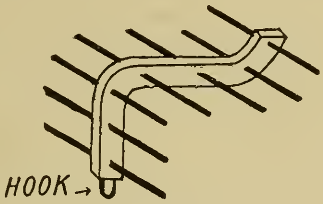


Fig. 44.

The welded core-iron shown is one commonly used. Sometimes, instead of welding the wrought-iron rods, they are riveted together. Frames of either kind make reliable rods for thin cores, large or small. The objections to them are, that they are costly to make, and that removing them from the casting is somewhat troublesome. At *D* and *E* are shown two forms that are used for fastening wire or bolt hooks to them, to securely hold the core in the mould's print. The one at *E* is made by simply flattening the end, and drilling a hole through it.

The fifth and last plan represents the use of single rods, setting them in the core as it is rammed up. The cut shows the proper manner of placing the rods. Were the long rods laid so as to have the cross-rods *S*, seen in section *A B*, on the other side from that represented, when the core was fastened by the hook *D*, in the print, there would be danger of cracking the core. When made as shown, pulling on the hook draws the whole core with it. This plan I have employed for the port cores of large marine-engine cylinders. In one shop, where the custom was to weld the rods together, I started to make a set of large cores in this way, and was told by the foreman that he had never seen large cores so made, and that he did not think the plan a safe one. As I had made larger ones in the same way, I argued him into permitting a trial. From that time on, there were no more welded rods used; and the new plan saved in the neighborhood of five dollars on every cylinder casting.

Regarding the size of rods to be used for such cores, the thickness of the cores and a consideration of getting off the vents, etc., must govern each particular case. The larger the rods, the stiffer will be the core; but they should be no larger than is necessary, for it is more difficult to get large rods out of the casting than it is small ones.

If no vents were needed, the making of port cores would be much simplified. More, generally, depends upon the vent than upon any other feature. The vent-rod and rope shown repre-represent the two plans commonly employed for venting thin, crooked cores. By using the rod, a cleaner vent is usually insured than by using the rope. The rope is reliable, but requires *much more care in its use;* which not always being received, the liability of failure is increased. The use of the rods calls for the most work. When rope is used, nothing more is required after the core is dry; but with rods there are connections to be made, as at *K*, to make the vent continuous. To connect the vent, a crevice should be made with a file, as represented in dotted lines at *K*. This crevice is made deep enough to admit a string to about the centre of the thickness of the core. A string is then passed through either of the holes left by the vent-rods, and made to enter the other. The crevice is then filled up, the surface smoothed, and the string removed. After all the connections have been made, the core is put back in the oven to dry the material used for filling the crevice.

At *H*, is shown how rods can sometimes be made to connect themselves within the body of the core, thereby saving the labor just detailed. The holes at the surface, of course, require filling; and when the rods connect near the surface of the core, care must be used that the filling of the holes does not close the connection. After *H* and *K* have been filled, test the vents by blowing smoke or dust through, as from *A* to *B*. If all the vents are clear, then stop up the openings at *A*.

In using rope or strings, the arrangements of the vents should be well secured; and care must be used, or in pulling them out they will be drawn up to the side of the box. A crooked laid rope or string has a tendency to straighten when pulled; and, although the sand may prevent this, there is always a chance that it will not do so. Sometimes, to all appearances, the operation may have been successfully performed, but in pouring the mould the string may have come so near the surface in some places that the iron will burst through. At 2, 3, 4, and 5, are represented the core-rods placed to prevent the string from being pulled up against the sides of the box.

The making and venting of cores is a broad subject, and calls for the exercise of much thought and judgment. As in moulding, he that uses them *will meet with the most success.*

SECURING CORE–VENTS.

In making a mould for any casting, many of the operations may be described as those common to the art of moulding; while, in some instances, new operations may be required. A good deal of trouble results from neglecting the things that are common, for which there is no reasonable excuse. For bad results, when new points are involved, there is sometimes reason for censuring lightly. The proper securing of core-vents is one of the things too often neglected, and one for which the core-maker is not infrequently unjustly blamed. To show how easily castings may be lost through lack of proper attention, I will return to the subject of cylinder cores.

At *K*, Fig. 44*a*, is represented a core ready to be set in its print, while at *E* it is represented set in place. This is no exaggeration, but an example from actual practice. Paste is often a very useful substance for assisting in securing vents; but it should be used with discretion, or it may defeat the end it was intended to accomplish. Looking at the core *K*, it will be seen that the core-maker has made a good vent, but that the moulder, in setting the core, has stopped up the vent-holes with paste, as shown at 2.

The less paste that can be used, the better, as it is not only liable to clog up the vents, but also to blow, or cold-shut, the casting. My idea of the way to secure such cores is shown at *H* and *F*. Before permanently setting the core, it is set in its print to see if the side *B* will form a close joint along its entire length. Should it be found not to fit properly, it should be made to do so, either by filing or by building up the print with

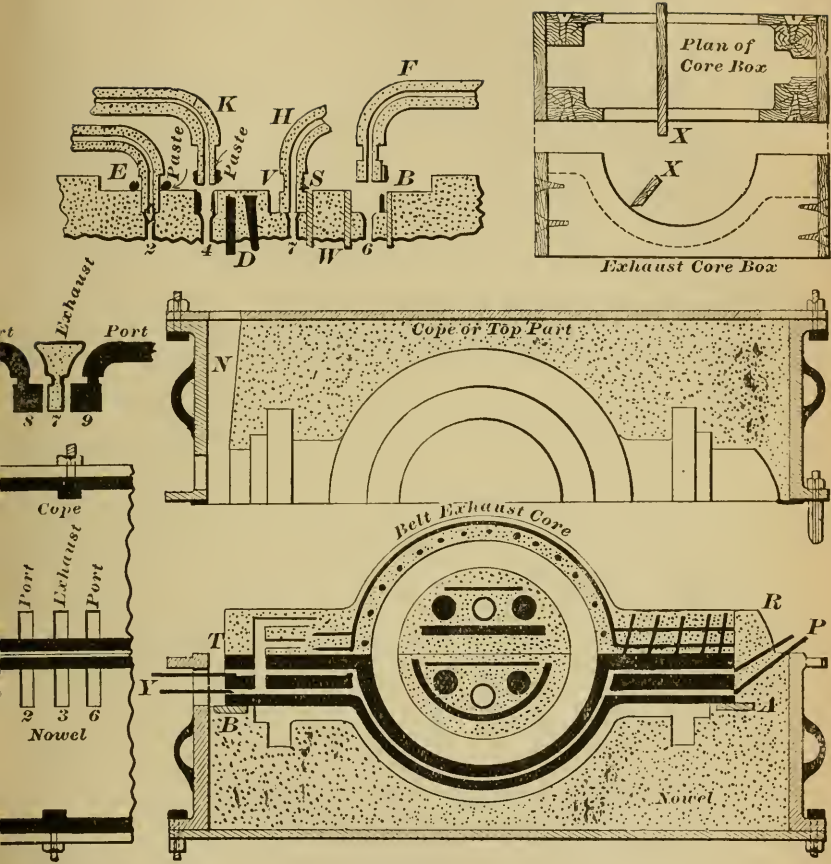

F
K
H
Paste
Paste
E
V
S
B
2
4
D
7
W
6
Plan of Core Box
X
X
Exhaust Core Box
Exhaust
rt
Port
8
7
9
Cope or Top Part
N
Cope
Port
Exhaust
Port
2
3
6
Nowel
Belt Exhaust Core
R
P
T
Y
B
A
Nowel

Fig. 44*a*.

loam or thick blacking. When built up, if the built-up part is more than $\frac{1}{8}''$ thick, if the mould is not hot, it should be dried, either by using a hot iron, or in the oven. When ready, paste may be applied to the side that cannot be readily seen, as *B*. The paste should not be more than $\frac{1}{8}''$ thick, as, if the core is properly fitted, this is ample. Sometimes it may be advisable to put the paste on the mould; and, again, it may be better to put it on both the mould and core. If both mould and core are warm, it is better to apply the paste to only one of them; as by dividing it between both it makes a thinner body, and is likely to become dried before the core gets set, so as not to form a proper joint. Where both mould and core are cold, by dividing the paste between them there is not so large a body from which the print end of the core will absorb moisture, thereby weakening it before it is set in its print. In my practice, I always endeavor to have either the mould or core warm, to dry the paste, when the core is set.

A good mixture for paste is flour wet with black wash, which may be either thick or thin, according as thick or thin paste is wanted. Clay wash may be used instead of the black wash. Both are good to keep the metal from burning away the paste, and finding its way into the vents. Where there is danger of the paste coming to the surface of the mould, in places where it cannot be seen or come at to scrape off, I prefer the black wash, as it is not so liable to blow or cold-shut the casting as the clay wash.

For setting cold cores in green-sand moulds, I prefer to wet the flour with machinery oil, as there is not so much danger of chilling or generating steam as there is when the clay wash or black wash is used. Rye flour is the best for paste, as it is not so sticky or clammy as wheat-flour paste. As regards the thickness or consistency of the paste, it depends somewhat upon circumstances; but, as a rule, it should be so thick that it will not flow.

Another important point in making and using paste is cleanliness. It is a common thing to see a moulder using paste mixed in a dirty pot, and containing foreign matter such as dirt, stones, etc., and hard dried paste from the sides of the pot. In mixing paste, the flour should be finely sifted, and the pot be clean and free from dried paste; also, necessary care should be used to provide against the introduction of any foreign matter whatever.

At H is represented the core F, permanently set in its print. At V a space is left open, which it is often advisable to do at the ends of the cores. The width of this space should not be less than $\frac{3}{16}''$, or more than $\frac{1}{2}''$. In horizontally moulded cylinders, with valve face, it is generally objectionable to make the print ends of the pattern the same size as the print ends of the cores, as at E. In some instances, it is not practicable to leave a space, as shown at V, as there is no chance to get at the prints when the cores are set in. In such cases the pattern prints should be about $\frac{1}{8}''$ larger than the print end of the core-box; and when setting in the cores, use just sufficient paste to make a reliable joint. I prefer, in such instances, to use the paste only on the core, as at K, as there is not the same danger of the paste being forced into the vents as when it is also applied to the mould, as at 4. There is, of course, a possibility of the paste being squeezed to the surface of the mould, as shown at E, by placing the paste on the core's points, as shown; but if care is used, the amount will be very small, if any.

Setting cores in the way just indicated requires the exercise of skill and judgment, and the plan should be avoided when that shown at V can be employed. By the latter plan, there is an opportunity to see what is being done, and *certainty is made to take the place of chance-work.*

When the core is being set in the print for the last time, it should be kept over to the side V, that the paste, shown at B, will not be scraped up, as at *E*, or squeezed down into the vent outlets at 2. When the core is down, it is then pressed tightly against the side *S*. The space *V* should then be rammed up with new moulding-sand, wet with beer; or, if the mould or core is warm enough to dry it, loam or blacking daub may be used, as it will bake so as to hold the core more firmly. The advantage of the beer-sand is that no time is lost in waiting for it to be dried in a cold mould.

To mix the beer-sand, take new, dry moulding-sand, and wet it with the beer, so it will be as damp as sand for making green-sand moulds. The reason for using the moulding-sand dry is that it may absorb sufficient beer to give it strength. When blacking daubing is used, it is made by mixing blacking-dust (same as used for making blacking or for dusting green-sand moulds) with an equal quantity of parting-sand. When thoroughly mixed, the mixture is wet with medium thick clay wash. The clay wash gives body, and the parting-sand makes it open.

This is a good mixture, not only for the purpose named, but also for patching up moulds and the joints of cores. I have used it for daubing up the joints of column cores cold, setting the cores in the moulds without drying. Whatever dampness may have remained was provided for by the porous character given it by the parting-sand. When used for patching the surfaces or corners of moulds, it is better for being dried and blacked over, as this insures a smooth surface on the casting, which might otherwise be rough or scabbed.

To hold the small body of sand between the core prints, some use nails or rods, as represented at *D*. This is a poor plan. At *W* is shown a much better one, as it not only holds the sand firmly, but gives a solid print that will not be broken in setting in or removing the core. It also helps to hold the cores in place. The plates (at *W*) are of iron, about $\frac{1}{8}''$ thick, and long enough to project about 2″ beyond the ends of the print. Their depth is about twice that of the print. The face edge of the plates can be kept $\frac{1}{4}''$ away from the pattern. They are generally placed upon a little sand sifted on it, the plates being wet with clay wash to make the sand stick.

In the large engraving of the section of a belted cylinder mould, two plans of securing cores are shown. At *Y* is represented the plan I prefer. Numerals 2, 3, and 6 show openings made in the flask opposite the exhaust and port-core prints. When the cores are all set, and the outside joints doubled up, the open space *T* is rammed up with sand. After the sand is rammed up to the first row of vent-holes, they are cleaned out, and short vent-rods put in them; then more sand is rammed, and the second row of vent-rods placed, and so on till the joint is reached. (These rods can all be placed before commencing to ram up if we avoid hitting them.) When the cope is on, the vent-rods are placed, and the sand is rammed through the opening provided at *N*.

Sometimes circumstances will not admit of the vents being taken off through the cope. In such cases it is often advisable to connect the upper portion of the core-vents with the lower, as represented in the top and bottom parts of the belt-core. (The bottom half of the belt-core is shown all black, so as to prominently show the line of vents.) Where the cores are not made in halves, this is somewhat difficult to accomplish; but by referring to the article "Making and Venting Cores" (p. 106), the plan of connecting and venting such cores will be understood.

At *P* is shown a plan for taking off vents, which we may be obliged to use when the flask is not adapted to the job, or when the pattern is not properly made.

Whenever the joint of a mould must be raised above the joint of the flask, as shown at *R*, the more room there is to mount a strong body of sand, the more likely it is to keep its form and to support the cores, etc. This plan of moulding is not always objectionable; but unless there is room sufficient for the vents to be cared for within the body of the mould itself, and then all led off through one opening, there should be openings in the flask, as shown at *Y*, 2, 3, and 6.

Taking off vents through the joint of a dry-sand flask, as shown at *P*, is by no means reliable. It would be much better to drill holes through the sides of the flask for the purpose.

When the face of a cylinder is moulded as here shown, it is often advisable to have the cores form their own prints, similar to 7, 8, and 9. This plan saves work in rodding, and labor in setting and securing the cores.

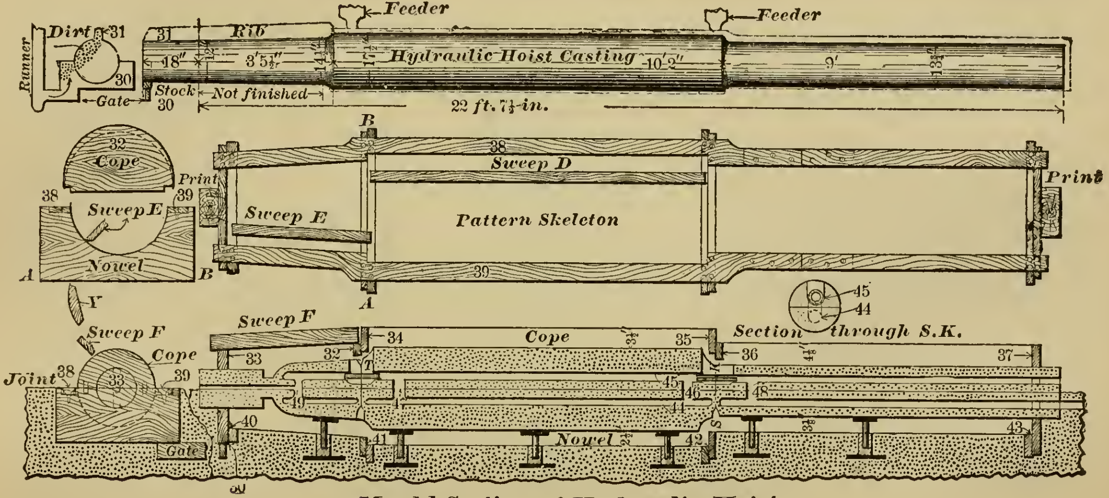
The exhaust core-box shown is a handy one for cores made in halves. *XX* show the sweep being used for striking out the circle portion.

GREEN SAND MOULDING.

CASTING FINISHED WORK HORIZONTALLY.

In a previous article is described the casting of a hydraulic hoist in dry sand. In this the manner of making a longer one in green sand will be described. It may be asked, why, if a casting about twenty-three feet long could be made in green sand, one about fourteen and a half feet long could not be made in the same way. It would be unreasonable to expect that such castings will be as perfect cast horizontally in green sand as if they were cast vertically in dry sand. The longest one would have been cast vertically, had there been a foundry near by that had the facilities for doing it. The casting had to be made; and, as no one would cast it vertically, some one must do it horizontally. The Cuyahoga Works was selected to do the job. The castings, when finished up, presented a very creditable appearance for green-sand work.

The upper cut shows the dimensions of the casting, the dotted lines representing stock allowed for holding dirt and for finishing. The length of casting as taken out of the foundry was twenty-four feet two inches; eighteen inches of which, as shown at the gate end, was added as stock for holding dirt, and was cut off in finishing. The thin rib (31) was cast on as a dirt riser, and was also cut off. No. 30 was a flange used to assist in the moulding; and, as it was a good thing to attach the pouring gate to, it was left and cast as shown. The reason for pouring the casting entirely from the end that was not to be finished was that *such gated castings will be the dirtiest at the gate end;* in fact, such gates, as a general thing, do not distribute dirt only in the section to which they are attached. If one were to


Runner
Dirt
31
30
Gate
Stock
30
31
Rib
18″
12″
3′5½″
14½″
17½″
Not finished
22 ft. 7½-in.
Feeder
Feeder
Hydraulic Hoist Casting
10′2″
9′
13½″
32
Cope
Print
38
39
Sweep E
Nowel
A
B
B
38
Sweep D
Sweep E
Pattern Skeleton
39
A
Print
Y
45
44
Section through S.K.
Sweep F
Sweep F
Cope
Joint
38
33
39
Gate
33
34
32
T
Cope
3½″
35
36
4⅛″
37
40
49
45
46
48
44
K
S
41
Nowel
2½″
42
3⅛″
43

Mould Section of Hydraulic Hoist.

Fig. 45.

cast an open sand block having such an under gate, he would most likely see nearly all the dirt collected in a body directly over the gate. The action of the liquid metal forms a whirlpool, as it were over the gate, thereby preventing the dirt from flowing away with the metal. *As a general thing, the portions farthest from gates will be the cleanest parts of a casting.* Their cleanliness will depend much upon the style of gate used, etc.

To further discuss the important question of properly gating moulds, the small cut, Fig. 46, is given. At *E* is shown an under gate, similar to the one in the large engraving. The arrow represents the flow of metal. The core shown has prevented portions of the dirt from rising to the top of the cope. At *H* is shown a style of gating that will not confine the dirt to the gate portion of the casting; and, in fact, to correctly foretell where the greater portion of the dirt will be collected, is often a difficult task. *Such gates are distributors of dirt*, while such as the one at *E confine it.* This is a point that must be considered in the gating of moulds, as it has much to do with providing that the gated end of a casting shall catch and hold the gate's dirt. The gated end of such castings *should* contain about all of the gate's impurities. But I think the interested reader will plainly see that this will depend greatly upon the style of gate used.

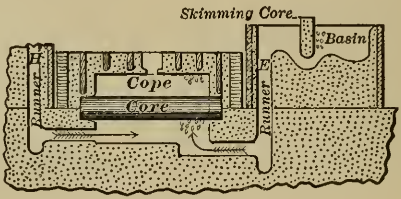


Fig. 46.

Another point that may be here noticed is the destructive qualities of the two styles of gates shown. Under gates, as at

E, are, as a general thing, the easiest upon a mould; as the metal in flowing is not allowed to run over the mould's surface, as it would from gate *H*. Surface scabbing or mould cutting is very liable to occur with the last-named gate, because of the friction of metal upon the mould. Under gates, as at *E*, fill up a mould with very little surface friction, and are often the best to adopt.

When under or side gates are used, so as to be independent of a cope, thus not allowing skimming-gates in the cope, *should they be desired*, the basin with the skimming-core upon the principle set forth in the chapter "Defects in Structural Casting," is advantageous, as it prevents the skimmings from passing into the mould. *In fact, for all clean work, where it is practicable to do it, combining such skimming-basins with direct runners will always be a great assistance.*

As there was only one of these castings to make, the company did not wish to go to expense of a complete pattern, so the skeleton frame shown was used. In making the mould, the frame was bedded in level and true; and after being rammed up, and the joint made, the cope form of pattern was made by setting on circular pieces, as shown at 33, 32, 34, 35, 36, and 37 (Fig. 45). Between these, sand was firmly rammed; the whole being struck off with sweeps, as seen at *F*. Paper being put over the sand to form a joint, the cope was put on and rammed up. After being lifted off, the false sand pattern was then shovelled away, and the nowel part of the mould formed by strikes or sweeps, *E* and *D*. After the sweeping, the long sides of the frame, 38 and 39, were unscrewed and drawn off. The open space thereby left was then filled up with sand; the circle of the mould being followed up by using a piece about two feet long, of the circle of mould, as at *Y*. This made the mould's circle complete up to the joint. The sweep guides, 40, 41, 42, and 43, were then drawn, and their space filled up, after which the mould was finished. The metal around the core was one-half inch thicker in the cope than in the nowel, the half inch being for a riser or space for holding the dirt. The extra stock was turned off in finishing the casting. This extra thickness was allowed for in the making of the circular cope guides, as represented by 32, the outside line being elliptical, while the dotted line represents a true circle of the required finished size.

Another point of some interest is that of coring long moulds, where, through lack of oven or shop facilities, the centre core must be made in three separate lengths. The difficulty attending the splicing of such cores is in getting off the middle core vent. The most reliable way I know of, to carry off such core vents, is the one shown. When making the cores, vent rods, 44 and 45, are rammed up in about the centre of each half. Then, when pasting the cores together, a connection, 46, 47, 48, and 49, is made. (With this job, 48 is not really necessary, as the upper vent is sufficient to take care of what is required to be carried off.) Where the connections are, there must be a reliable close joint; for, if any metal should get in, you might expect a "blow-up." In making the vents in the centre of the halves, as shown, instead of at the joint, as is generally done, there is less risk; for, if iron does find its way to the joint, it can do no harm, the parts where the connections are, of course, being excepted.

When the cores are butted together in the mould, two pieces of ¾″ gas tubes, *T* and *K*, are placed, the cavity for their insertion being cut out in making the cores. An end view of the cavity and tube is shown at section through *S*, *K*. After the tube is inserted about one inch in each vent hole, the rest of the cavity is carefully filled up with new moulding-sand, which, if wet with beer, is all the better, as it will air-dry more solid than if the sand is dampened with water. The tubes are better for having a few ¼″ holes drilled in them, as this will allow any gas in the green sand used to escape. Before smoothing off the green sand, it is well to vent down to the tubes with a fine wire; the holes at the surface being well closed, the green sand is then oiled over. The balance of the work is treated as is commonly done. The cut of pattern, skeleton and mould, is shown wider than its proportion to length. This is done to give a better chance for figures, etc. The cut of the casting is proportionately shown.

HEAVY AND LIGHT WORK SKIMMING-GATES.

As a supplement to the previous chapter, "Casting Finished Work Horizontally," the following will be found an interesting and valuable addition, in which Figs. 47, 48, and 50 are plans for skim-gating heavy work. When one has from ten up to thirty tons of iron to pour into a mould, conditions in gating will seldom permit the use of such skimming-gates as are generally used for ordinary work. In pouring ten tons or more of iron through a gate into a mould, there can be no dribbling process allowed. The iron generally requires to be got into the mould as quickly as practicable.

Figs. 47 and 49 represent plans of gates which I have used on heavy work with much success. While they act as skimmers, there is nothing to prevent their letting in the iron about as fast as if there were one direct gate from the basin to the mould-entrance. In Fig. 47 the metal runs down *A*, passing through *B* to *D*. From *D* it goes through *E* to the mould. Fig. 48 is a plan-view of this gate. It will be seen that the gate *B* is so placed that it sends the metal into *D* upon a whirl. The inlet-gate *E*, being higher than *B*, as shown, admits of a good whirl being generated before the metal rises up to *E*. The inlet-gate *E*, if desirable, could be on a level with or below *B*. The best whirl is created by *B* being below *E;* as, when upon a level with *E*, its opening destroys part of the circle, thereby not permitting of as good a whirl being created as if the circle in front of *B* were complete as shown.

In Fig. 49 the metal passes down *H* to *K*, and from *K* to *F*. ***K*** and *F* are simply one straight gate; the portion between *H* and *R* being as deep again as at *F*, where it runs into the mould. *K* being deeper than *F*, and having the riser *R* at its end, gives a chance for the dirt to be kept up above *F;* thereby allowing,

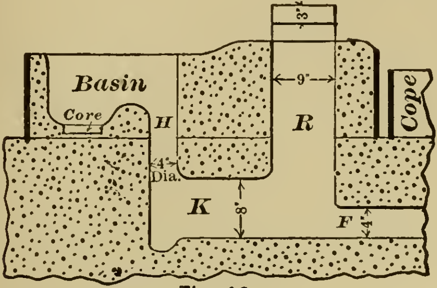

3"
Basin
Core
H
4"
Dia.
9"
R
Cope
K
8"
F
4"

Fig. 49.

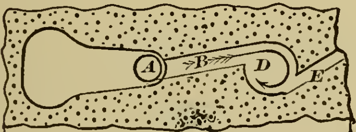


Fig. 48.

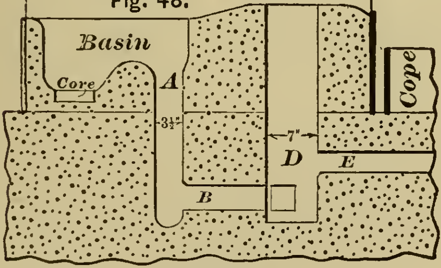

Basin
Core
A
3½"
7"
D
E
B
Cope

Fig. 47.

Heavy Work Skimming Gates.

after the start, clean iron to enter the mould. The farther apart the uprights *H* and *R* are, the deep part *K*, of course, being extended also, the better the chances to catch and hold the dirt. This plan is not recommended as being as good as Fig. 47; for it has no whirl, and some dirt may be admitted into the mould, especially upon the start.

The gate sizes given are only to present some idea as to their relative proportion; for instance, *D* being 7″ diameter, will admit of the $3\frac{1}{2}''$ diameter gate *A*, creating a good whirl, and also gives *D* plenty of room to hold dirt. For practical working the moulder will, of course, have to use his judgment as to the size of the gates in applying them to the conditions to be dealt with. While these gates may be used inside of the flasks, they are more particularly to be used outside; which, for heavy work, is generally the best plan, when practicable, to adopt. Moulders who are accustomed to light work only, are, if given heavy work, likely to adopt the methods to which they are accustomed; that is, they think the same kind of a skimming-gate will answer all purposes. These often fail, because they will not take the metal fast enough.

In heavy work the metal is generally poured duller than in light work; and when we consider the amount that is run through the gates in not much more time than is taken up in pouring far lighter work, we must admit, that, in attempting to pour from ten up to and over thirty tons of iron through a form that would insure a light casting coming clean, some evils will be likely to result.

In light work there is a positiveness which it seems almost impracticable to obtain in heavy work. Skimming-gates, if properly applied to light work, will assist astonishingly in procuring perfect and clean castings. One reason why heavy castings are not generally benefited by skimming-gates is, that the moulds present such a large surface from which dust and dirt can be collected. One thing that should always be remembered is, that a skimming-gate only helps while the metal is passing into the mould, and that it has not the properties of a porous plaster for drawing out impurities (generated in the mould), which many seem to think it has.

Having, in several different parts of this work, referred to various styles of skimming-gates, I will now notice a few other forms adapted for light work. Fig. 50 is an elevation and plan-view of pouring with horn-gates attached to a skimming-gate *H*. This bowl *H* is formed cone-shaped upon its bottom, so as to give impulse to the whirl upon the start. If, at the start, a

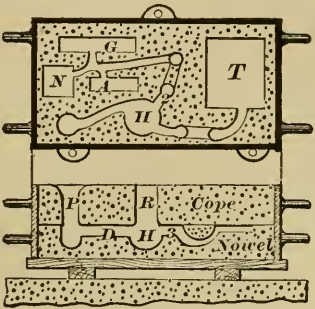

G
N
A
T
H
P
R
Cope
D
H
3
Nowel

Fig. 50.

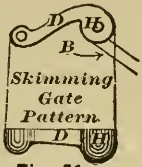

D
H
B
Skimming
Gate
Pattern.
D
H

Fig. 51.

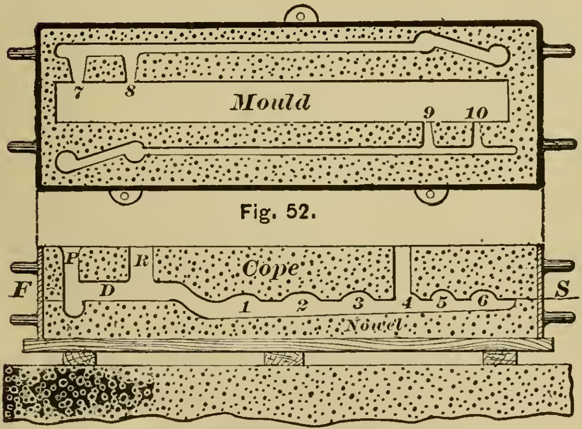

7
8
Mould
9
10
P
R
Cope
F
D
1
2
3
4
5
6
S
Nowel

Fig. 52.

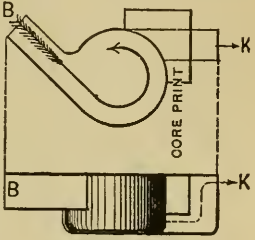
Small Work Skimming Gates.

good whirl is formed, it will drive and hold the dirt in the centre of *H*, thereby preventing it from entering the outlets which connect with the horn-gates. The reason for using the horn-gates is, that by their use there is not such a direct current caused as would be were the gate level from *H* to the mould, which can, of course, be used with this skim-gate if it is so desired. The less current-influences side-gates exert from *H*, the more whirl there will be, which is the main success of such a style of skimming-gate.

A, *N*, and *G* illustrate the pouring of several pieces from one horn- or branch-gate, while *T* shows only one piece being poured. The bowl *H* is best formed by having a pattern rammed up when making the mould. There might be several sizes of such patterns, so that one could use the size best adapted for the piece or pieces to be cast.

Did one wish to further increase the utility of the skimming-gate, the whole thing could be formed by pattern, as per sketch Fig. 51. The holes seen at each end are simply for the purpose of holding and guiding the upright gate-pins, *P* and *R*, while ramming up the cope. Several different sizes of these patterns could be made, either of wood or iron. If of iron, they could be cored out so as to make them light; and not only could they be used for forming the skimming-gate in the nowel, but in copes as well. The branch lines at *B* show where the outlet from *H* should be cut. These outlets could, did one desire, be made as part of the pattern. As there shown, the whirl will be better preserved. While in Fig. 50 two outlets are shown, cut from H, it is not advisable to do so if it can possibly be avoided; for the reason that the whirl in *H* will be greatly lessened thereby. With reference to the proper proportion of such gates, ideas are given (on p. 101, vol. i., and on p. 17 of this book) with which most readers are no doubt familiar. Any shop that has a line of small work which requires to be finished up should in some form or other have skimming-gate patterns, not only for the purpose of saving labor in cutting the gates; but, as every practical foundryman knows, to leave the cutting of skimming-gates to the judgment of most moulders produces a gate which is far from being a cleaner or purifier of metal before it enters the mould.

The author's attention was lately called to a good thing in the line of a light-work skimming-gate, patented by Richard Cross of Cleveland, O. The principles of the gate embody several good features worthy of notice and study. The gate as seen shows a side and a plan view of the pattern. They are made of different sizes, ranging from one suited for pouring a five-pound casting up to one for a casting weighing a thousand pounds. For heavier work two or three gates could be attached to a mould if desirable. The gate pattern is made of cast-iron, the inside being cored out so as to make them light for ease of handling. In using the gate, set it upon the mould-board in such proximity to the pattern as may be desirable. There are right- and left-hand gates, so as to still increase their utility. In ramming up the cope, the pouring-runner gate is set at the end of *B*. The cope being lifted off, and the pattern and skimming-gate drawn, a connection from *K* to the mould is cut; the cutting of which, and the setting of the skimming-core, are all the moulder is required to do to give himself a good skimming-gate.



R. CROSS.
PATENT GATE
Fig. 53.

When pouring the mould, the flow of the metal is illustrated by the arrows shown. The metal going in at *B* causes a whirl which *prevents, in a great measure, at the start, any dirt from passing under the skimming-core*, and thence up into the mould. This is something our ordinarily used skimming-gates accomplish but feebly. In them all, the first flow of iron generally carries more or less dirt with it into the mould. The idea which Mr. Cross has embodied in his skimming-gate is indeed worth noticing.

At Fig. 52 are set forth some more ideas in gating that are useful. The mould shown we will suppose to be a flat plate required to be finished all over. There are two ladles to be used in pouring the mould. The end of the runner nearest the pouring-gate is formed by a skimming-gate cut in the cope. At Nos. 1, 2, 3, 4, 5, and 6, are seen what are generally termed "blind risers." These are formed in the cope, as will be seen by the joint-line *F S*. The lower part of this long runner from which the inlet gates 7, 8, 9, and 10 are cut, is made in the nowel, and is made the deepest at the skimming-gate end, so as to insure its being kept full at the end which admits the metal into the mould. The gates 7, 8, 9, and 10 are supposed to be cut thin, and of an area sufficiently small to insure their taking the metal no faster than the long runner, and gates *P* and *D*, will admit of, keeping them full while pouring. This long runner might often have the blind risers, 1, 2, 3, 4, 5, and 6, omitted. Of course, by their use (if the gates *P R* are kept full) there is very little chance for any dirt that might escape from *D* or *R* finding its way into the mould. In cases where there are many castings to make, did one desire to use such a runner having "blind risers," there often might be a pattern made and rammed up with the mould. Also upon the top of these "blind risers" it might, in some cases, be beneficial to occasionally place risers which would extend up through the cope, as seen at 4, though as a general thing such would be of little practical value. In some cases the air passing up through risers (were it safe to leave them open) may make sufficient air-current to carry or float some dirt to the riser; but, as a general thing, the dirt is more liable to stay between or alongside of a riser, should it be caught there through the upward rising of the metal.

There are, no doubt, many who cannot see the reason why the gates 7, 8, 9, and 10 could not have been cut nearer to the skimming-gate *DRP*, thereby saving the necessity of cutting such a long runner as shown. The reason for cutting such a long runner is simply founded upon the fact, *that, the longer the distance through which iron is made to travel before it can enter the mould, the better the chances for catching and preventing the dirt from getting into the mould.* This long-gate or runner principle applies towards cleanliness, the same as gating a casting, as far as practical, from the parts required to be finished; which is set forth in the previous chapter, "Casting Finished Work Horizontally."

Often, in small work, when a number of small pieces are made in the same flask, should some of them require to be finished they could have no better skimming-gates than to let the metal run through the other pieces into them, thus gating from one piece to another; the piece which receives the first iron from the pouring-gate will naturally contain the most dirt.

In pouring any casting requiring to be finished, the hotter the metal can practically be poured, the cleaner should be the casting. Pieces gated or run from others especially require to be poured with very fluid iron, not only for procuring cleanliness but to insure a good full-run casting.

In the first volume, reference is made in several places to the dirt accumulated in ladles, and pouring-basins or runners, and commonly called "impurities." Treating this subject scientifically, the impurities so rapidly gathered upon the surface of skimmed ladles are *chiefly due to the affinity iron has for the oxygen in the air.* When a ladle is skimmed clean, it is not long before a scum is seen to gather upon the surface of the metal. This scum which occurs from the oxidation of the surface of the metal will, as long as the metal's surface is exposed to the atmosphere, whether in the ladle or on its passage to the inlet-gates, be created. This impurity, coupling with the *dust and washed sand of pouring-basins or runners*, is the reason why we are often surprised at the amount of dirt created in pouring moulds with fresh, clean, skimmed ladles. The function of the skimming-gate is to catch and prevent this dirt from passing into the mould. Of course, good skimming-gates will not counteract the evils of mould-scabbing, etc.; but with intelligence used in gating, in concert with a well-made mould, surprisingly clean castings can be made.

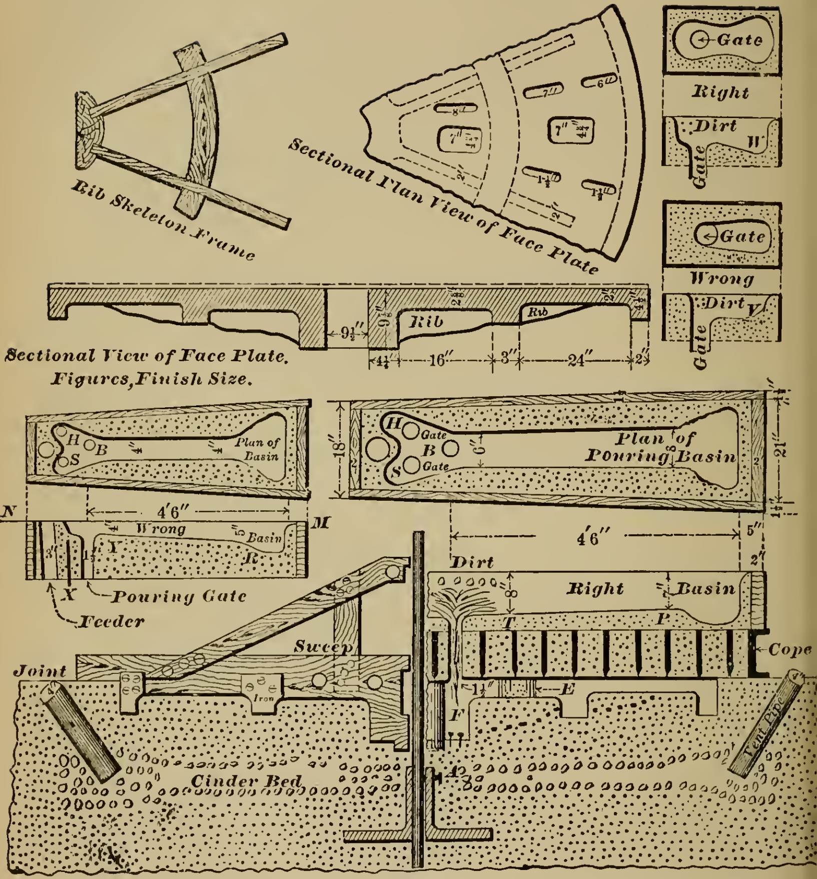

Rib Skeleton Frame
Sectional Plan View of Face Plate
8"
7"
6"
7"
7"
1¼"
1¼"
2"
2"
Gate
Right
Dirt
W
Gate
Gate
Wrong
Dirt
V
Gate
Rib
Rib
Sectional View of Face Plate.
Figures, Finish Size.
9½"
4¼"
16"
3"
24"
2¾"
H
B
S
Plan of Basin
18"
Gate
B
Gate
S
6"
Plan of Pouring Basin
8"
21"
1¼"
N
4'6"
M
Wrong
Basin
Y
R
X
Pouring Gate
Feeder
4'6"
5"
Dirt
2"
8"
Right
Basin
T
P
Cope
Sweep
Joint
Iron
1½"
E
F
A
Cinder Bed
Vent Pipe

Fig. 54.

TOP-POURING GATES, AND SWEEPING A LATHE FACE-PLATE.

A THOROUGH knowledge of the practical working, so far as results are concerned, of the different styles of gates commonly used, will always be a valuable acquisition to the knowledge required to insure clean castings. In previous articles, I have shown the action and adaptation of various forms of gates; in this article, I will try to present a few ideas concerning the so-called top-pouring gates. As a general thing, the merits of this gate as a valuable skimmer in pouring moulds are lost sight of through its use being more a matter of necessity in gating. Many moulders use it simply for its convenience, and not from any knowledge or intention of its usefulness in making a clean casting.

As a general thing, top-pouring gates act as a positive skimmer; for the reason that there is nothing to prevent the flow of dirt to the top of the basins, and the iron that passes into the mould being free from impurities or sulliage; that is, if the gate is properly made. What I mean by positive is, that the principle is positive; and, if the action is not so, the *fault lies with the one who makes the gate.* I have seen some very grave errors committed by men who should have known better; that is, if thirty to forty years' experience are worth any thing.

To show up some of the errors made in the construction of basins and top-pouring gates, the engravings (Fig. 54) illustrate a "Right" and a "Wrong" form. The basin marked "Right" represents the clean iron dropping into the mould, as seen at *F.* Upon the top of the basin iron, is shown the dirt. This condition will exist if every thing is made as it should be; but it is astonishing to note how small a matter will destroy the positive action of the gate.

I will first try to show some of the errors made in this respect. The first one is in the bottom of a long basin, which, instead of having an incline from the pouring-end down to the gate, as seen from *P* to *T*, is made to incline exactly the reverse, as from *R* to *Y* in basin marked "Wrong." This causes the iron to run up-hill, which for long basins is often detrimental to keeping the gates full.

If basins are short, as seen at *W* in the small basin, then I would advise that they be made highest at the entrance of the gates; for, if they were the lowest there, "cutting of the basin" might be caused before the gate could be filled. And, from the fact of their being short, the gate should be easily kept full, which, if accomplished, avoids any use for an incline.

Some differ with me in respect to my making long basins inclining from the basin down to the gates. They claim the incline should be upwards, as seen in the long basin upon the left, in order to keep the dirt out of the gates *at the start*. So far as this point is concerned, the author would say, he advocates the incline in *long* basins as an aid in keeping the gates full, a thing most paramount in making a clean delivering basin. Whether a long basin-runner inclines up or down, will not prevent more or less dirt from entering the gates upon the start. About the only way to aid cleanliness in this respect is, to have the basin with a skimming-core, upon the principle shown in vol. i. p. 93, also p. 17 of current volume. The time necessary to make a skimming-core runner-basin is seldom available. Therefore we must utilize as best we can our hurried basin-making; and in such a case the points to be attained is, to make the basin so that you can keep the *gates full* from the beginning, and, at the start, have no "cutting of basins:" once accomplish this, and I care not whether your runner is inclining up or down. My reason for showing the basin inclining is, simply, because I believe that in the long-run, by this, the best results will be obtained: an extremely steep incline is not advocated. In the basin shown, we have but 1″ of a fall: all that is required is an incline sufficient to insure an easy fall. In some cases, the long part of the basin could have its runner-end *T* made level, the incline being only from the basin down to about one-half the runner's length. While this would, in some cases, be sufficient to insure a good flow, the level part, being near the end of the gates, would present a bottom upon which dirt might lodge, as the runner was emptying itself of its last iron, thus assisting in preventing any dirt that might be inclined to pass down the gates, because of an incline causing a flow towards them.

If a basin the dimensions of the one marked "Wrong" were used in the place of the one marked "Right," in pouring such a casting as is shown, the result would be that the gates *H*, *B*, and *S* could not be kept properly full, and the dirt that should be kept upon the top of the basin-iron would nearly all pass into the mould.

Still another error in making long basins is not having the runner or basin-box *level*. I have often seen bad results from this *blunder*. I remember a case where the moulder, when pouring his mould, could get but little iron to run down the gates. The cause of this was having the bottom of the runner inclined, as seen at *Y* and *R*, and also the basin end *M*, down very nearly level with the gates. Such an error as this could easily occur if the moulder were careless, or did not *think*.

Another error, that is very commonly committed in making small as well as large basins or runners, is seen upon the right in the four cuts showing the side and plan views of short basins. In the upper cut, the basin is shown made larger around the gate than in the lower one. In pouring moulds with top gates, the action of the iron, upon running into the mould, is to suck down any dirt that may be directly over or near to the gates. The more room around gates in a basin, the better are the chances for all the dirt to remain upon the top of the iron. In the large basins, at *S* and *H*, this point is also shown. In the cut marked "Right," the runner or basin is seen to extend beyond the gates. Iron poured into basins flows towards the gates and beyond them, if there is room allowed for its doing so. The flow carries with it the dirt; so that, if a basin or runner is made to extend beyond the gates, the dirt (or impurities) is also, in a large measure, carried beyond the gates, thus aiding in preventing the dirt from passing into the mould. I don't care what shop that uses top-gates may be visited, one will be very apt to see some of the above errors daily committed. To make top-gates positive purifiers, or skimmers, is an easy matter, if a little common-sense is used.

To show the results of proper top-pouring, the sweeping and pouring of a nine-foot lathe face-plate are illustrated. The sectional view of face-plate is that of a casting made and used in the Cuyahoga Works. The dotted line over the face represents ¼″ thickness that was turned off in finishing. The casting was made by the use of the sweep and rib skeleton-frame shown; and to the moulder who made the job, much credit is due, for any one in looking at the casting would hardly imagine that it was cast face up, it was so clean.

In sweeping this mould, the spindle-seat being set, a good cinder-bed was put in; after which, the hole being filled up level with the floor, a plain sweep (not shown) was then attached to the spindle arms (which also are not shown), and a plain hard bed was swept up. The sweep being then removed, the bed was sleeked and sprinkled with parting-sand, and the cope rammed up. The cope being hoisted off, the sweep, as shown, was then attached, and the bottom swept out.

It might be well to state, that before the plain or cope sweep was attached, the bottom sweep was attached, and a rough form of the mould's bottom made about two inches lower than the intended bottom surface. This space was then filled with facing-sand up to the level of the joint; so that in sweeping out the mould, after the cope was hoisted off, the bottom would be all formed in facing-sand. The facing-sand, being taken out of the bottom, could be used for other work.

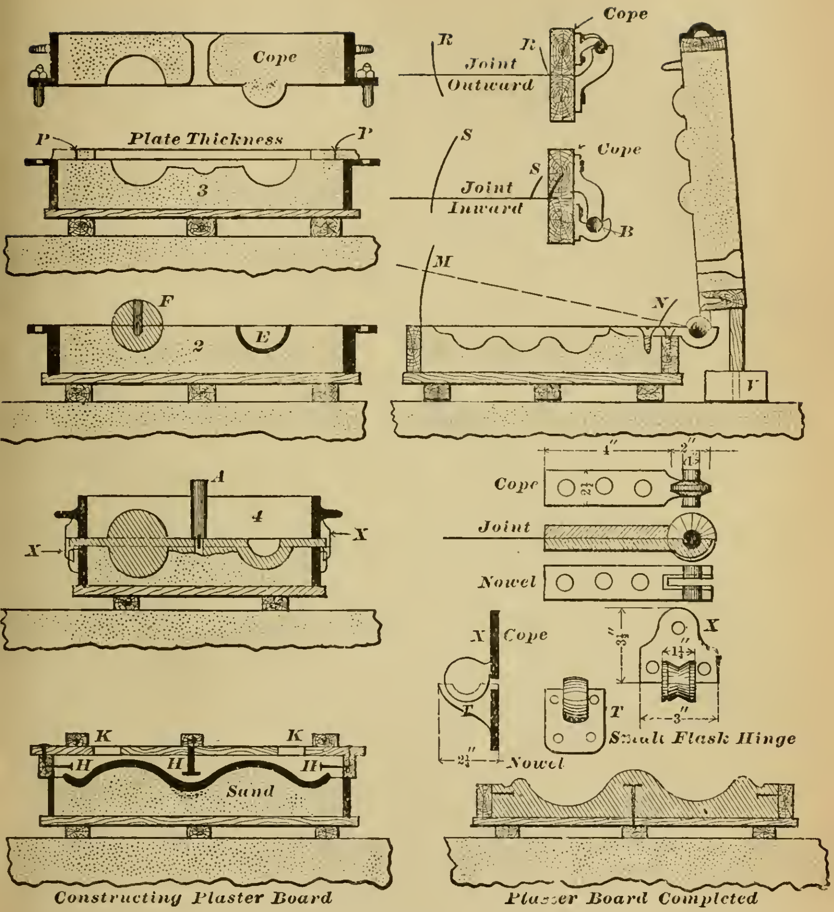
After the sweeping was finished, the rib-skeleton frame was bedded-in, and eight arms formed. The sectional plan view of face-plate shows the number and sizes of cores set between each of the arms. The cores were made just the thickness of the mould, and were set upon the surface without the use of prints, as seen at *E* in the mould. It was, of course, seen that they all touched the cope in a firm manner, in order to prevent their moving when the mould was poured.

By this plan, far larger face-plates than the one shown could be made without a pattern; and not only castings of this form, but many other classes of castings, can be made to have their cope face clean by an intelligent use of top-pouring gates.

SMALL CASTINGS.—THE MOULD-BOARD AND FLASK-HINGE.

For turning out small castings fast and neat, there is nothing more essential than having mould-boards that will save hand joint-making. There are used as common property four kinds of boards; the first being the wooden, the second the sand, the third the plaster-Paris, and the fourth the match board or plate. Making these is with some shops a common affair, while with others it is the reverse. There are many moulders, who, were they told to make a match plate, or plaster-of-Paris board, could not do so without instruction.

At the left, in cut, Fig. 55, is illustrated the making of plaster board. At the right is a section of the board as completed. In making this board, the pattern is rammed up, and the joint made the same as if a cope were to be rammed upon it. Instead of the cope, a sectional view of a wooden frame is seen, the inside of which is even with the inside of the nowel. The joint should be made tight, so as to prevent leakage. The plaster is poured in through holes, *K*, *K;* and when set, or hard, the board is lifted off, and the sand washed off the face of the plaster with water and a brush. After the face is dry, it is given a coat of lamp-black shellac varnish; and, when it is dry, the board is ready for use. In making plaster boards, there are a few details which it may be well to notice. Plaster-of-Paris is made by boiling or burning gypsum, a mineral consisting essentially of sulphate of lime and water, the proportions being: lime, 32.56; sulphuric acid, 46.51; water, 20.93. Gypsum deprived of its water by burning leaves a powder, that, when mixed with its


Cope
P
Plate Thickness
P
3
F
2
E
A
4
X
X
K
K
H
H
H
Sand
R
R
Joint
Outward
Cope
S
S
Cope
Joint
Inward
B
M
N
V
4"
2"
1"
Cope
2¼
Joint
Nowel
X
Cope
3¼"
1¼"
X
T
T
Small Flask Hinge
2¼"
Nowel
3"

Constructing Plaster Board

Plaster Board Completed

Fig. 55.

own bulk of water, formes a creamy paste which almost immediately becomes solid. In using plaster-of-Paris, the liquidity of the mixture should be regulated by the thickness of body required. For thin bodies, two parts of water to one of plaster may be satisfactory; but for general work one of plaster to one of water will be nearly right.

In preparing to pour a plaster mould, the outside of joints should be either carefully stopped up with clay, or firmly banked up with sand, to prevent leakage. If nothing but the water comes out, it is, of course, all right; for much of that is disposed of, and if it does not leak through the joints it is absorbed by the sand in the flask. The holes for pouring in the plaster should be as large as practicable; for, the quicker a mould is filled, the better for filling thin places or corners. If a mould has any body at all, it will shrink so as to require being filled up after it is poured. Before starting to pour a mould, one should have plenty of water and plaster; for it does not work very well to have to run away from the job to procure either after a mould has been poured. With practice one can guess very nearly the amount of mixture required to fill a mould; and it should, especially for light-body moulds, be all mixed before starting to pour. For thick bodies we may partially fill a mould, and then complete the job by a second pouring; but for general work plaster-of-Paris requires prompt and active work.

The patterns used should be oiled, in order to prevent the plaster from sticking to them. In forming the joints, special care should be taken to insure that the mould-board will form a joint that will not only lift clean, but one that will leave a finless and true jointed casting.

At *H*, *H*, *H*, are seen nails driven in for the purpose of assisting in holding the plaster in place. In some cases, nails are driven all over the bottom boards, as well as at the sides of the frame. Again, some will, where there are heavy bodies of plaster to hold, put in bars nailed to the frame, or secure to it strips or blocks driven full of nails.

Plaster boards are ordinarily used only where, from the crookedness of the pattern, other boards cannot be as cheaply made, as perfectly fitted, or kept as true when being used. Wooden boards, when for irregular joints and finely fitted, are preferred by moulders; as they are generally light, will retain good edges, and can be moved with little risk of being broken.

For irregular shaped patterns, there is probably at the present time none more popular than what is called the "sand board." The common way of making sand boards is simply to ram up the nowel hard and solid, and then, after making a good firm joint, ram up a false cope or frame. The kind of sand used for the boards has much to do with their life. Some take all new moulding-sand, mixed with about one to ten of flour; others will use no flour, but will wet their sand with thick clay wash. Samuel L. Robertson, a man of much experience as manager and journeyman upon light work, informed me of a receipt for the mixture of sand for mould-boards which he had used for making irregularly shaped patterns for Taylor & Boggis, Cleveland, O. The mixture is composed of fine sand, boiled linseed oil, and litharge. The sand should be very dry. To about twenty parts sand add one of litharge, mix them thoroughly, and then sift the whole through a fine sieve. Wet with the oil to a temper of moulding-sand, such as would be used for moulding. This mixture is rammed the same as one would ram all moulding-sand. The board is left to dry for about twelve hours, and is then ready for use. The oil gives the sand firmness. The litharge is used as a dryer for the oil. It is not essential that all moulding-sand should be used: almost any sand of fine grain will do as well. Parting-sand, for instance, may sometimes be mixed with one-half moulding-sand to good advantage. Should there at any time be corners or edges broken, they can be mended by patching on beeswax.

In light work, the keeping of the joint edges of sand-mould boards sharp and unbroken, is of the utmost importance. A great many, to help preserve them, will nail all the joint edges: even then they will become ragged, and cause bad joint-work. The objection to plaster-board for fine work is about the same; much working in and out of the pattern soon breaks the edges. The boards made with the oil and litharge keep their edges good and true surprisingly long, and it is on account of this that they are thought so well of; and any who will give them a trial will, no doubt, be greatly pleased with the results.

Alex. L. Faulkner, one of our Cleveland moulders, holds letters-patent upon an elastic follow-board composition, which I lately understand is being much used, and spoken very highly of. To some extent the above composition is like his; but, from what I can learn, his manner of mixing and manipulating his composition makes a much superior "follow-board" to that which the above will give. Any one doing a large business in light work will no doubt find it will pay them to investigate this matter.

As an auxiliary to the fast production of small work, the match-plate is often used to good advantage; the making of which, although a simple affair, is in the minds of some thought to be work requiring fine manipulations and measurements, the same as is required in the making of wooden match-boards. In Nos. 2, 3, and 4 (Fig. 55), is illustrated the manner of constructing match-plates; two patterns being selected, in one of which the indentation comes below the joint line, and in the other above it.

At No. 2 the nowel is rammed up and joint made, *F* and *E* being the patterns. The cope, having been rammed up, looks as seen at top cut shown. The process so far is simply what one would do, were he making a casting from each of the respective patterns. As, instead of doing this, we intend to construct a match-plate, extended manipulations are required. As the pattern portion is moulded, what is now wanted is to mould the plate portion. This is done by building up the joint as seen at *PP*, thereby giving whatever plate thickness is necessary for strength. The gates are cut the same as if the castings were to be poured by them. The cope is then closed, and the mould poured. The match-plate, as seen at No. 4, illustrates its use in the moulding of castings from it. The cut shows the nowel rammed up, cope set on, and gate-pin *A*, in place ready for being rammed up. At *XX* are the cope-pins. This match-plate when made had projections extending out beyond the plain edges so as to fit or make grooves for the pins to fit in, and make a true joint when the mould was closed.

Should there be any overlapping of joints in the castings produced, the fault cannot be laid to the principle of making the match-plate: it will be the fault of shaky or untrue pins. This point, in making the match-plate as well as in using it, must be carefully watched, if true jointed castings are desired. In making wooden match-boards, of course different manipulations are required. The thickness of board is first made; then, by measurement, which requires care and exactness, top indentations or projections are fastened over their corresponding parts.

The match-board, or plate, is only practical for such work as is, in outline, plain and without acute corners, cores, or projections. In fact, of late years, since the art of making mould-boards, patterns, and gates has reached such perfection, the match-board or plate is seldom seen in use.

Another device which is often found very useful in the fast production of small work is the "hinge." There are many different styles used. The hinge is something that might be often employed to excellent advantage in the making of difficult lifts, or in coping hanging indentations. The principles below set forth, I simply give thinking the ideas may prove of value in some classes of work. When the centre of the hinge is on a line with the centre or joint of flask, the lift, at the moment of starting, tends towards the hinge side, thereby clearing any indentations the soonest upon side opposite hinge. To more clearly illustrate this, the cuts "inward" and "outward" are given. At inward, the centre of hinge *B* is considerably below the joint. The moment this cope is started, the lift will be inward, as shown by the arcs *SS*. In the upper cut, on account of the centre of hinge being above the joint, the reverse would be true, as shown by arcs *RR*. The distance of the hinges being so far below and above the joint, the arcs drawn from the centre of hinges show a true inward or outward movement, as the cope is raised or lowered. It is evident from this illustration, that the matter of having a cope go from or towards the hinge side can be controlled, thereby assisting in getting good lifts when a movement in either direction is desirable. Of course, the farther from the joint-centre the hinge is, the more rapid the outward or inward movement. The intersection of the line *MN*, with arcs cutting same, shows in what ratio the given radius or outside of flask rises compared with the inside. This ratio increases proportionately as the radius, or width of flask, increases.

The cut of flask hinges shows two styles that are handy for light work. The upper style is to be secured to the joints of flask; the lower one, to the sides. Either could be constructed so as to bring the centre of hinge below or above the joint, to cause inward or outward motion when first starting the cope, should it be desired.

PIPES, GREEN-SAND CORES, AND HOLLOW PIPE PATTERNS.

There are few foundries that do not, in some form, make more or less pipes; and it is astonishing to note how much faster the same class of pipe-work will be made in some shops than in others. This is mainly due to the difference in the facilities and rigging. In some shops, a man may have to work harder to make one pipe than he would in others to make four; and, as a general thing, the shop that could turn out the four would require the least skill. Shops that produce such castings the slowest are, as a general thing, the ones that have the fewest to make, and therefore cannot afford the expense of getting up labor-saving rigging. There are times when a little outlay in some shops would be the cause of procuring much work, that, in the end, might result in the manufacture of a good paying specialty.

The general jobbing-shop way is to make solid, dried-sand pipe-cores. The extra expense made thereby is the requiring of flour, and sometimes beer or molasses, to mix with the sand. It also requires much labor to make them, fuel to dry them, and the loss of sand; and after all the time, labor, and expense, we can seldom produce a perfect, round, even core.

A plan practised in some shops that make a specialty of green-sand pipe-castings is as illustrated in cut, Fig. 56, showing the sweeping of a green-sand core. This style of core is sure to produce a round hole; and, with rigging properly gotten up, one man can make a large number of cores in a day. The sizes of pipe generally made by this plan range from 3″ up to 12″.

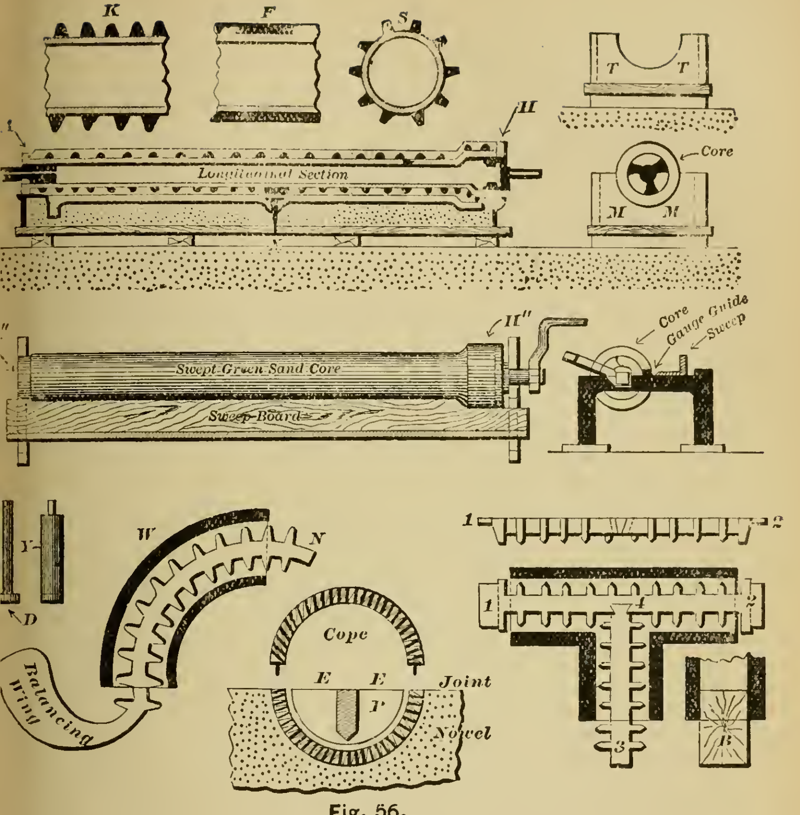

K
F
S
H
Longitudinal Section
T
T
Core
M
M
H''
Swept Green Sand Core
Sweep Board
Core
Gauge Guide
Sweep
Y
D
W
N
Balancing Wing
Cope
E
E
Joint
P
Nowel
1
2
1
2
4
3
B

Fig. 56.

In making the core-arbors, there are two plans usually adopted. One is, to cast arbors having prickers, and the other, ribs, upon their surface, to assist in holding on the sand. To show what is meant by ribs, the sections *F* and *S* are given. At *K*, and in longitudinal section of core, prickers are illustrated. As a general thing, the ribs are used for the smaller sizes of arbors, on account of their making the arbors stiff, thereby preventing the core from springing up and shutting off the thickness of metal when the mould is poured.

The larger arbors are in diameter, the more resistance to springing they generally have when moulds are being poured; so that arbors over five inches in diameter can generally be made stout enough without the ribs. For holding the sand, prickers are to be preferred. The ribs separate, as it were, the sand into sections; whereas the prickers keep it together more in one body. The larger in diameter, the longer can pipes be made. A foot pipe could be some nine feet long; a 3″ pipe, four feet long; and sizes between, in proportion. Of course, the stiffer arbors are made, the longer can the pipes be made. Were chaplets used with this class of cores, as with dry-sand cores, they could be made much longer. There is a way whereby chaplets can be used with some green-sand cores: that is, to have a knob about one inch in area cast or riveted to the arbor, as above the chaplet *X*. This spot, being even with the surface of core, rests upon the chaplet, thereby causing iron and iron to come together. For the cope, a small body of sand is taken out of the core, and some small plates or washers inserted, the top surfaces of which had better be kept $\frac{1}{8}$″ or so below the core surface. The space around these washers or nuts is then filled in, and the core then made as smooth as the rest of its surface. Upon the top of the inserted pieces the cope chaplet rests. In so chapleting cores, care is required; for, should the chaplets come otherwhere than intended, the core would be burst, and the casting, as well as the arbor, most likely lost. With such work, exact measurement and fittings are required. With large-diameter pipes, there might be danger, by thus chapleting, of bursting the casting, on account of the knob *X*, and the pieces above it, making a brace that would prevent contraction. Sometimes there is no danger of the core springing downwards, but there is a tendency to rise. When the lifting-strain of the fluid iron comes upon it in such cases as this, the bottom requiring no chaplet, the knob *X* could be upon the cope side, and the cores thereon be chapleted down, casting the pipe by having a chaplet only on the cope side.

The reason for using the washers or loose plates instead of a solid body being secured to the arbors, as above *X*, is to allow the arbor to free itself. Were the top the same as bottom, there would be immovable iron to iron. By having loose washers or plates, the jarring of arbor soon causes it to be free, thereby letting it come out.

Core arbors should be well perforated with small holes, to allow the gases to escape. The thickness of sand upon arbors ranges from $\frac{3}{8}''$ to $1''$. The more dry the sand can be practically used, the better. In sweeping up a core, the process generally is to wet the arbor with clay wash or water, and after being set upon the horses the sweep board is set, sand is packed by hand upon the arbor, after which, with a man turning slowly, the sweep board is lightly pressed forward until it strikes the gauge guide which gives the diameter wanted. The arbor ends, *A H*, can be used to give the diameter; but having the core gauged independently of the arbor is to be preferred, as the friction of the turning will wear away the guide, and also more or less vibrate the arbor, thereby often causing the sand to drop.

A point that here might be mentioned is, that the less sleeking done to pipe cores, the better. In fact, it is best not to sleek them at all, leaving the surface as it is swept, as thereby the metal lies more kindly to the core.

In casting the larger-sized pipes, it is essential that the arbors should have reliable bearings. 3″ up to 4″ pipes could be cast by having sand print bearings; but above this last size the arbor ends, *A H*, would be better if turned up true, so as to exactly fit the flask iron ends, as shown at *M M*. The cut *T T* shows the end without the core in. The arbors being true, the flask ends would of course require to be the same. By having arbors set in such bearings, it is evident that the core will be kept central, and that its weight cannot sink it down, or the liquid iron raise it up; that is, as far as the prints are concerned. It might be well to mention that the pattern prints must fit into the flask ends when moulding the pipes, in order to have the mould central with the flask ends. In making arbors having such iron-end bearings, one, if not both, should be made smaller than the inside of intended pipe, so they may be readily got out of the castings.

The longitudinal section of mould shows a flange on one end and a socket on the other. This is only to illustrate the idea that either kind can be made. In the smaller sizes of pipe, it is not necessary that the arbors should be larger at socket end, as shown at *H*. If the arbors are straight their entire length, and the sand reasonably tough, the little extra thickness required to form the socket will hang.

The plug seen at *R* is inserted for the purpose of lifting the core. Where arbors are large enough to admit a trunnion being riveted on, as seen opposite *R*, it is advisable to do so, as they can be revolved easier. Revolving arbors, by having their whole diameter turn in a bearing, as seen at *A*, cause much friction.

The cuts of elbow and branch pipes illustrate the making of pipes with hollow patterns, they being the same as the castings wanted. At *E E* is shown a sectional view of the pattern. The nowel having been rammed up, the core arbor *P* is then set in and rammed up. The cope part of pattern is then set on, and sand tucked in. The joint having been made, the cope is rammed up, and, after being lifted off, the top pattern is drawn. By taking hold of the arbor handles, Nos. 1, 2, and 3, the core is lifted out; the bottom pattern is then drawn, and the mould finished. The core is then set back, and cope closed. The end of arbor at No. 3 is of a style different from Nos. 1 and 2. Arbor ends as at Nos. 1 and 2 are handy for small pipe. The arbor is set on the mould board, and the nowel half of the pattern over it; then the nowel is rammed up and turned over, the arbor forming its own print. This style is not recommended for heavy cores, as it does not give print enough to hold up very much weight.

The arbor as at No. 3 is of the same form outside the pattern as it is inside. To form prints for such arbors, with hollow patterns, there could be half-round blocks, as shown in plan at *B*, rammed up with the nowel half of pattern, and then, when the nowel is rolled over, draw out the blocks. This would leave prints formed ready to set in the arbors.

The quarter-turn pipe shows the plan of an arbor made so as to balance the core; the balancing wing projecting beyond the mould prevents the back *W* from sinking down as it would were both ends of arbor the same as at *N*, and the back not chapleted. This style of an arbor can, of course, be operated as regards rolling-over and print-making, the same as the *T* arbor described.

At *Y* is shown a core rod, and core made upon it. The head *D* admits of the core being lifted vertically, and also is a support to the core if rested upon its end. This class of green-sand cores can be used vertically or horizontally, and for pipes about one foot long, 2″ or 3″ in diameter, where their manufacture is to be made a specialty, they are worthy of consideration. The cores are rammed in a box endwise, and require to be vented, for which, in some cases, it might be well to have two or three vent holes drilled through the head *D*.

Green-sand cores, as a general thing, require more or less rigging, which is one reason why more shops do not use them. The holes formed by green-sand cores, as a general thing, for *smoothness* and being *true*, surpass those made by dry-sand cores; and generally thinner castings can be made with green-sand than with dry-sand cores. The making of green-sand cores often requires much skill. There are many cores being made of dry sand that could be made of green sand; but, like many other things in moulding, it often requires practical experience and good judgment to decide the feasibility of making them.

BEDDING-IN AND ROLLING-OVER.

Bedding-in and rolling-over patterns in moulding have each their special advantage. As a general thing, rolled-over moulds are the simplest to construct; the reverse being the case with bedded-in castings. *A moulder that cannot successfully turn out a good general run of castings by rolling-over need never attempt it by bedding-in.* The writer is well aware that there are castings that cannot be as reliably made by rolling-over as by bedding-in; but this fact does not change the sense of the statement made. It will be acknowledged by all practical moulders who have had experience in both rolling-over and bedding-in, that to do general bedding-in requires higher skill than rolling-over. Any shop that does most of its moulding by rolling-over can often get along with less-skilled mechanics than where the patterns, as a general thing, are bedded-in.

When a moulder is furnished with nice patterns and flasks, the requirements are often like those of machine labor: the physical, and not the mental powers, are the ones most required. *Were there more bedding-in practised, we should have more and better-skilled tradesmen.* A novice, in travelling through the foundries of the country, would be at a loss to reason why shops, in making similar castings, do not adopt similar methods. He sees one bedding-in almost every thing: another he finds rolling-over every thing. In many cases, this puzzles even practical men to reasonably explain. One can go into many shops, and there see patterns being bedded-in, that, all points considered, could be better rolled-over: then, again, he will find the reverse, there being large, expensive flasks used for moulds that could be made in less time and with far less risk by being bedded-in. There is no doubt that upon this point there are shops that are working in error. Almost every machinery foundry has some jobs, that, in point of economy and safety, would be better were they bedded-in, and some that would be better rolled-over.

Sometimes circumstances may be such as to call for a pattern being bedded-in when, properly, it should be rolled-over. This, however, is no excuse for the wide difference in shop practice.

I have seen practical men, who, when questioned why they did not have certain jobs bedded-in, would say they knew it was the proper way to mould them; but, having so little of that class of work to do, they did not like to have their shop floors all dug up. This is, no doubt, in many cases, a good reason for not bedding-in work. Shops in which most of the work is bedded-in are, as a class, the dirtiest and ugliest to be found. It is practically impossible to keep them as clean and orderly as a shop that does all rolling-over. A foreman that loves order hates to see his shop a jumble of holes, sand-heaps, and foundry tools. He may, to some extent, control and keep order; but to this there is a limit. It can be carried so far as to be a source of expense rather than of profit. My lot has been chiefly to be employed with the dirty class of shops. It has often made me feel envious of my brother tradesmen who work in the clean shops, to think with what comfort they can work; and I would long ago have been one of their number, were it not for the charm that bedded-in and heavy work has for me. There is a fascination about bedding-in, that many moulders enjoy.

The advantage that bedding-in has over rolling-over is, in the first place, the saving of flask-making; second, the rigidness with which sides and bottoms of moulds can be supported against the strains of high and heavy heads of metal; third, the assurance it often presents of making a casting the duplicate of the pattern in shape. The twisting and wrenching that are given large flasks in being turned over, often makes it impossible to make a casting as true as its pattern. This point was ably brought out in an article by "Foundryman," in "The American Machinist" of March 10, 1883, entitled, "Moulding a Bevel Wheel."

For the reader's benefit, I here insert the article as it originally appeared: —

"How far the introduction of machinery may influence the art of moulding in a way to render results surer, and products more perfect, is as yet a matter of speculation. There are castings that in some localities are moulded and cast without much regard to the duty to be performed by them. Take, as an illustration, gearing. It is claimed that gears moulded by machines are nearer perfect than those made from whole patterns rammed up and cast in the usual way.

"The common method of making moulds for gears is to ram up the drag or nowel, turn over, ram up the cope, remove cope, and draw the pattern, etc. This method will do for gears that are 18″ or less in diameter, and for wooden patterns up to 20″ diameter; but I believe that it is a practical impossibility to make a true spur or bevel gear 24″ or more in diameter by 'turning over.'

"There are several reasons why. First, It is impossible, or rather impracticable, to make a soft bed to receive the cleats of pattern-board so that, when rolled over, all parts of the cleats and corners will bear equally on the bed; and where it bears lightest, the mould will settle, and produce a casting out of round, and the teeth at that particular place will be larger than those where the sand has not settled away from the pattern.

"Second, In turning over the drag when rammed up, as in common practice, the lower side of flask (if square and of wood) bears on the floor, and is compressed; and when on the bed it springs out, leaving the sides of flask free from sand. When the casting is poured, the pressure forces the sand out again, leaving the casting out of round. These imperfections may not be so radical in character as to condemn the casting, but the wheel will not run with the same accuracy as one bedded-in and not turned over. In many shops this fact is well known, but the writer has been in others where the above remarks were as pure Greek. As an illustration: A bevel gear about four feet diameter, for a horse-power machine, was given to a new hand in a shop to mould. He put his bottom-board down good and solid, then levelled up drag, and proceeded to bed-in the gear.

"The proprietor came in, and, seeing the moulder's way was a new one to him, told him he had been at considerable expense to make a follow-board for that wheel, so as to get a true casting, and he would like to see it used. The moulder asked him if he ever made an absolutely true wheel. 'Not exactly true,' was the answer; 'but much better than by any other way, excepting your present plan, and that I never saw before.'

"Says the moulder, 'If this gear is not true when cast, it will be because your pattern is not true.' When cast, and put on the boring-mill, it was found to be true, and acknowledged to be the only true wheel ever cast from that pattern.

"Bevel gears of light rim suffer more than spur gears in rolling-over.

"Now, one important reason why machine-moulded gears are nearer true than those made by whole patterns is the fact that they are not turned over, and the contents of flask wrenched and twisted in the process."

It is amusing to see how some moulders who have never done bedding-in go about such jobs. Not very long ago a moulder who thought himself a first-class man started to work under my supervision. I gave him a pattern, with instructions to bed it in. He said, if he had a flask to roll it over, he could make it in half the time. My answer was, that we did not make a practice of making expensive flasks, that could be saved by bedding-in; especially so where there was only one or two of a piece to make. He started at the job; and at the end of about two hours he put on his coat, remarking to a moulder that he was not going to work in a shop where they had to lie upon their bellies to make a mould. The trouble was, he did not know how to bed-in, and would willingly have kept that position all day if it would have given him the knowledge which his conceit prevented others from giving him.

Among moulders who bed-in, there are two plans that are often adopted. *One is to pound down a pattern, and the other to tuck it up.* This pounding-down business I do not approve of. In the first place, it causes a mould to be the reverse of what its condition should be (a point which is fully treated in vol. i. p. 28); in the second place, it abuses a pattern; and in the third place, although it may often be a quick process, it is not by any means a mechanical one.

Any bull-head can sledge down, but it requires skill to tuck up.

There are a large number of patterns that can be either sledged down or tucked up; the one shown in sketch being of that class. In sledging down such patterns, the process with some is generally to first dig out a hole, and fill it up with sand "riddled through the shovel," then sift on about $\frac{1}{2}''$ thickness of facing-sand, on top of which set the pattern, and on top of this the block, without any regard to which way the grain of pattern timber runs, as shown in Fig. 57.

Then sledge down the pattern until about level with the sand-bed; that is, providing the pattern holds together. There is no intention to here convey the idea that a sledge should never be used. There are very few patterns that can be bedded-in without the use of one. What *is* condemned is the uncalled-for abuse so often given.

To properly tuck up such a pattern, the hole is generally dug out about 3″ deeper than the pattern, and the pattern is placed accurately upon four blocks or wedges, as at *B;* or, the four bearings may be sand-mounds; with the hand, sand is tucked

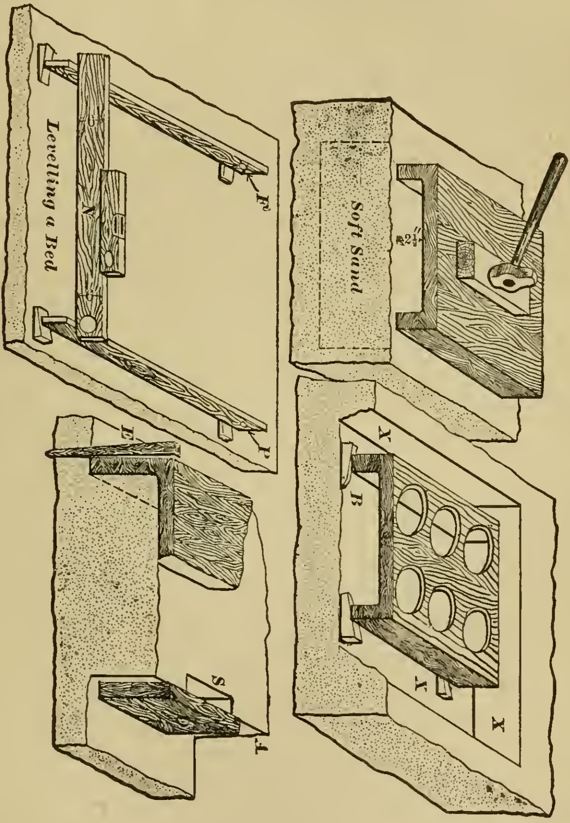


Fig. 57.

under the pattern, facing-sand being used against the flanges, after which the pattern is drawn, and the surface of the mould felt all over, and any soft spots found filled up with facing-sand. A thickness of about $\frac{1}{4}''$ facing-sand is then sifted on the surface, and the pattern returned. A sledge and block are then intelligently used to knock it down about $\frac{1}{4}''$; after which the sides *X X* are rammed up, the joint scraped off, and the pattern sighted to see if it is out of wind. This completes the bedding-in.

While the foregoing, in substance, is one proper way to bed-in, I will dwell upon a few details showing different ways of handling such jobs. Some, in tucking up such jobs, especially if the boss is not looking, will use all facing-sand for the inside. Others will use all common heap-sand, and when the pattern is drawn they will press facing-sand against the sides; and after sifting $\frac{1}{2}''$ thickness, or such a matter, over the surface, the pattern is knocked down to its bed. Some, again, will draw the pattern up to examine if all places are firm and of an even hardness. There is a great difference in the ability of moulders to make a firm bed the first time: some will have to draw out a pattern three or four times before they can get as firm and reliable tuck as others can obtain by once drawing out.

Before going any farther, there are two points which I would call especial attention to. The first is the rapping-down of tucked-up patterns. Before a pattern is first drawn, the guiding-stakes should be driven so as to be a guide in showing how much the pattern is to be knocked down. At *E* the stake is shown driven, having its top even with the top of pattern, there being one of these stakes at each corner. When the pattern is returned, it is readily shown how much it should be pounded down. I doubt if one-fourth of the moulders ever make any calculation upon knocking down a pattern. Some of them pound until the pattern will go no farther, and others won't impress it enough. Every piece that is bedded-in should have a limit to its impression into the bed, and the moulder should use his judgment as to what that limit is. The majority of moulders can tell, by feeling a mould, whether it is too hard or too soft. This is certainly an accomplishment, but it would be a better one to know how and when they were making it hard or soft. The second point I would like to call up is shown at *D*. This represents a plan which a few moulders have, of facing the sides of tucked-up moulds with facing-sand, — a very good plan too. It is simply cutting out a piece of the side of the mould at a time, and then, by means of a board *D*, ramming up the cut-out place, as at *S*, with facing-sand, until the whole side is rammed up. This plan for heavy work, where sides or flanges cannot be gotten at to ram them solidly up with facing while the pattern is in place, is a good one to adopt, as it gives every chance to make a firm surface when the pattern is withdrawn. There are many patterns where portions of level beds can be used to assist in bedding-in, the plain surfaces of the patterns resting upon the beds, and the irregular parts being tucked up. Wherever a levelled bed can be used, it should be, as there is no way that a mould's bottom can be controlled and made so reliable.

Although levelling a bed is a simple affair, it is astonishing what a small per cent of our moulders know how to go about it; yet to accomplish it requires no great skill, as will be seen by the following. In levelling a bed, one side, as *F*, should be first levelled up, after which set the opposite one, *P*. Then upon the top of each and at one end, as seen, set a parallel straight-edge (by parallel, I mean that it must be *exactly* the same width at each end, not 6″ at one end and 5½″ at the other). The straight-edges *F* and *P* do not require to be parallel, but *N* must be if a level bed is wanted. With the parallel straight-edge, level across from *F* to *P*, then try the level on *P;* and if it should not be level, make it so by raising or lowering the end at *P*. Then test the straight-edges by going over them all two or three times if necessary. Another point to be watched is the level, which in a foundry soon gets out of truth. The way to test a level is to turn it end for end If it shows level one way, and not another, it is out of truth. The only way to use such a level is to turn it end for end, and make the bulb stand the same distance from the centre mark each way.

Under the straight-edges shown are four wedges, representing what should be sand-mounds. The middle portion of the straight-edges should be kept clear until they are levelled up, after which tuck under them, and then test them again. Levelling straight-edges having a bearing their entire length, causes a loss of time and extra labor. The holes seen in the straight-edges are to hang them up by, something that is not always done.

The six holes seen in the pattern, being bedded-in, show a provision that ought to be allowed in many patterns to give the moulder a chance to tuck them up. A pattern to be used for rolling-over work, and one for bedding-in, should seldom be made upon the same plan, although they generally are. *A pattern to be bedded-in should be well braced, and made of good strong lumber;* for the reason that bedded-in patterns have to stand more or less *sledge-pounding*, and where they are like a *hollow box* it is often impossible for the moulder to make the bottom of his mould as solid and reliable as it should be.

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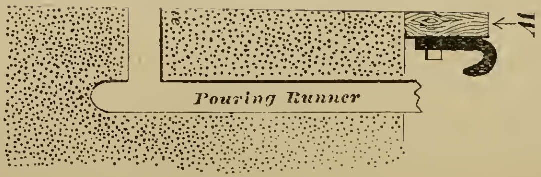
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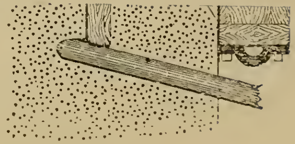

COPING, VENTING, AND JOINTING GREEN-SAND MOULDS.

The proper coping, venting, and jointing of moulds is very essential to the production of good castings. Many castings have their beauty ruined by an *ugly joint.* Irregularly shaped joints in a mould will test a man's ability as a moulder about as sharply as any thing connected with moulding.

Some moulders will make such joints without the use of any *judgment*, while others adopt proper methods. The results can generally be seen, in both instances, in the castings produced.

In the engraving, I have endeavored to show a right and a wrong way of making the joints of irregularly parted moulds. As a rule, the larger the body of sand to be lifted, the better the chances of successfully lifting it. The trouble is with the fine or small bodies. These fine bodies often require considerable manipulation ; and the precaution of not having fine bodies or points of sand to be lifted, whenever they can be avoided, should always be taken.

It is astonishing how many moulders practise jointing irregular patterns as marked "wrong" in the engraving (Fig. 58).

In machinery moulding, irregular surfaces of joints are generally lifted by the aid of "gaggers" and "soldiers," or by rods and nails ; the gaggers and soldiers being used for plain surfaces, and rods and nails for points and corners.

If a joint can be made so that gaggers can be squarely and evenly placed, and so rammed upon it, the chances of obtaining a good lift are improved. It requires but little penetration to see, that, in the engraving, the part marked "right" pre-

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sents a better bottom upon which to set gaggers than the part marked "wrong."

To lift a body of sand, or a joint, the less sand there is under the gaggers, the better. Sometimes joint-gaggers are set with no sand under them; but this is not generally to be approved of, as it does not make a neat joint, and might, in case of straining at the joint, cause the mould to "kick."

When it becomes necessary to patch a joint, from not getting a good lift, it is usually very difficult to get it as perfect as it would otherwise have been. Sometimes the pattern can be set on the cope to assist in getting the required shape; but even then it can seldom be accurately done.

The best-jointed castings are those where no joint-patching was required. The word *patched* should generally be connected with *botched;* although it is easier to botch a job than to patch it, and some moulders who will do a good job of patching are far from being botchers.

At *X*, *V*, and *N* is shown a plan of setting lifting-bars, that I, for two reasons, seldom approve of. The first reason is, that it compels the placing of the flat side of a bar parallel with the surface of the pattern, thereby often necessitating ramming and holding a thin, flat body of sand in its place. In ramming sand in such narrow pockets, the best judgment must be used. If the sand is rammed too hard, the gases will not escape freely, and scabbing or blowing will be likely to result. Another objection is, that when it is necessary to roll the cope over, the thin, flat cake of sand is likely to drop off, unless securely "rodded."

I always try to have bars for lifting out pockets, or carrying hubs or other projections, arranged so that there will be a considerable body of sand around them. This not only lessens the danger of bad results, but gives more room for ramming up and for seeing what is being done.

The second objection to using bars in pockets as above shown is, that setting the gaggers is inconveniently done, and the danger of a "drop-out" is increased.

In this cut, three plans for making deep-pocket joints are shown.

At *A* is represented a plan that will give a free lift, but involves setting many gaggers, and unhandy ramming. At 6 and 9 is shown how this plan of barring causes gaggers to be set, which makes the ramming awkward, marks the joints, and does not securely hold the sand.

At *B* the joint is made more nearly vertical, by which the above objections are to a great extent removed.

In making a joint for such partings, the more nearly vertical it can be made, the better: 4″ slant to a foot in height will generally work satisfactorily.

At *K*, the irregular line, is represented a plan sometimes resorted to on the plea of lack of room, poor tools, etc. The plan shown is a very poor one.

Numerals 1, 6, and 9 upon the left represent lack of *judgment* in trying to lift a body of sand. The gaggers seem to be set on the theory, that, if they are only gaggers, that is all that is required. The sand at 9 would be more likely to be lifted if the gagger were not used, as its length is only about that of the body of sand to be lifted, and iron is heavier than sand.

Nos. 1 and 6 represent conditions not much better. No. 1 shows how easy it is to put one clumsy gagger where it will do the least good, or where there should not be any.

If I could not have bars as at *E*, and it were necessary to set a gagger at 1, I would keep it up about 3″ higher, and turn the toe of 8 the reverse of what it now is, so as to bring the point of the gagger under the bar towards the hub.

The hook shown on 8 is generally made only on wrought-iron gaggers. It is often serviceable for carrying heavy bodies of hanging sand. In some shops, wrought-iron gaggers are used almost exclusively, while in others cast-iron ones have the preference. While I prefer those of cast-iron, for general use, as they will not spring, are cheaper to make, and can be readily broken off to any desired length, I also like to have some wrought gaggers, as they can be bent to set upon slanting surfaces, etc.

I am aware that some will object to breaking gaggers, and that in some shops the rule is that they shall not be broken; but before I would allow them to be left sticking out of a cope, as at 6 (where there are none short enough to be found), I would have them broken so as to come no higher than 5. Gaggers sticking up, as at 6, are liable to be hit, resulting probably in losing the casting. I never allow gaggers to be left standing above the cope, if it can be possibly avoided.

Gaggers 4 and 5, in connection with the bars as at *E*, represent good practice. Gagger 2 shows how gaggers are sometimes badly set by the side of deep hubs and flanges.

No. 3 represents a better plan; and if the cope is to be rolled over, use more gaggers as the height of ramming increases. The points of gaggers against the flat surfaces of hubs, flanges, etc., cannot do the harm flat surfaces can when set as at 2; that is, by producing hard and soft spots in the mould.

The ramming is also an important factor in getting good lifts. The ramming of a body of sand to be lifted should be firmly and evenly done. In the cut, at the point marked "Copes staked," may be seen the marks of the rammer impressed in what should be a level joint. In some cases this would prevent the sand from being lifted, even though well barred and gaggered.

In making irregularly jointed snap-flask moulds, the joint is generally the point of particular importance. Fins on such castings often condemn them. With this class of work, a perfect joint will, in most cases, provide for a perfect casting. A good bench-moulder pays especial attention to his flask-pins: he sees that they are not loose or shaky, and that they fit true.

Floor-moulders have so many other things that claim their attention and time, that the joint seldom gets the attention it deserves. It is apt to be thought, if the casting is all right with the exception of the joint, that a chisel and file will soon fix that. The quicker such ideas are got rid of, the better.

A floor-moulder should take the same pride in the joints of his castings that the bench-moulder does.

In small work, there are two objectionable joint features. One is the fin, and the other "overshotness." In heavy work, the fin can seldom be avoided, but overshotness should always be.

The stake marked "Ring" shows how stakes are often driven, thereby providing for bad lifts and overshot castings. The stake on the opposite side is driven correctly. The ring on the stake is made by cutting off pieces of wrought-iron pipe of the proper diameter. They are good for protecting the stakes from the blows of the sledge-hammer.

In staking flasks for ordinary work, at least two-thirds the length of the stake should be driven in the ground. Sometimes, for greater surety, it is advisable to drive two stakes, one behind the other.

With good sand or plaster-of-Paris mould-boards, the skill and labor of making partings or joints are saved. It is where joints must be made by hand, that the skill of the moulder is tested.

With some irregular light mould joints, it is often advisable to start up the pattern when the joint is nearly completed. This will show if all parts have been made so that the pattern will draw freely. The pattern is then to be lightly rapped into its bed, and the joint completed. Then the cope is rammed and lifted, and the pattern withdrawn.

To still further insure getting a "good lift," it is often a good plan to arrange for rapping the pattern before the cope is lifted off. This is done by having rapping-plates on the pattern, if of wood; or having holes in the pattern, if of iron. Then, when ramming up the cope, ram up gates in the holes; and then, with a pointed bar set in the pattern holes, it can be lightly rapped in all directions. This is a plan adopted by most bench-moulders, the only difference being that their rapping is generally done through the same gate-hole as that by which the mould is poured.

With copes where two or more men are required to lift them, it is often a good plan to raise the cope an inch or two by slightly raising a corner at a time, inserting a wedge to hold it up.

Again, it may be advisable to raise one end or side at a time; but in either case the corner, end, or side should be raised only a small distance, — sometimes not more than $\frac{1}{16}''$ at a time at first, — which distance can usually be increased at each successive lifting.

In order to assist in getting good lifts with a crane, iron starting-bars are sometimes placed as shown. Usually the first starting of the cope is the most important. If it is started so as to jerk one side up before the other, the most careful gaggering, ramming, etc., will have been of but little avail in giving a first-class lift.

There are two more points upon which I will express an opinion, and which may be of interest to those moulding heavy work. At *F*, in the lower cut, is represented a plan of cutting fins, which may be new to many. Of course, fins are objectionable, and should be avoided upon light castings, and upon heavy ones where the joint is on the casting-surface, as in columns and similar castings. But for heavy castings, where the cope surface ends at the joint, or the mould does not project up into the cope, as shown at *P F*, and also for bad or heavy drawing-patterns, cutting fins is often advisable for two reasons. The first is, that in drawing heavy patterns the joint of the mould is to a greater or less degree started. This may be sleeked down, but to get the benefit of any doubt it is often wise to cut for a fin. Of course the idea is, to be sure the cope does not touch the mould at the joint's edge. The fin should run from the surface of the mould back from 2″ to 4″, wedge-shaped, as shown. The thickness of the fin at the mould should be determined by a consideration of the degree to which the mould is started in drawing the pattern, and to some extent by the temperature of the iron to be poured. For dull iron, the fin should be thicker than for hot iron. For safety, and to assist in getting good heavy castings, they are usually poured with dullish iron. In pouring dull iron, the upper edge or surface of the casting is likely to be wavy, presenting the appearance of cold shut. Cutting a fin at the edge of the casting is, to some extent, a remedy for this; as it assists in the escape of confined gases and dust, or permits them to be held in a space, which if the metal does not fill no harm will be done. Observing moulders know that an open sand casting can, by pouring with dull iron, be made from $\frac{1}{8}''$ to $\frac{1}{4}''$ thicker than the mould, for the simple reason that the top edge runs rounding, allowing the surface to run higher than the edge. Coped castings would run rounding in the same way, were it not for the fact that the head pressure forces the metal into filling the top edges; but this head pressure is sometimes insufficient to fill the edges. In the case of a mould in which a fin is cut, the chance of the above occurrence is measurably lessened; and, the thicker the fin, the greater the extent to which it is lessened.

The sides and under portions of moulds are often vented direct from the surface of the joint, as on the side *P*. Venting as at *S* is not always reliable for heavy castings, because there is a chance that the metal will get into the joint; it also makes the management of the joint laborious. On the side *F* is represented a far more reliable way to vent such moulds. When the pattern is rammed up to within from 4″ to 6″ of the joint, the side is then vented, and fine cinders placed as shown.

The remainder of the depth is then rammed up, and vented down into the cinders, no signs of joint vents being visible. At *T* is shown how the vents are carried away from these cinders by a row of vents made from the joint surface to the cinders. In some cases, this plan will work well without the use of joint cinders, by venting down vertically from the joint surface, and stopping up the holes so they will not be seen; the vents *T*, being thickly inserted, will indirectly bring the vertical side vents to the joint surface as shown.

Sometimes, to make joints more secure, and to keep them free from vent-holes, channels of cinders might be connected with the joint cinders shown, and led out as far from the mould as desired, and connected with surface outlets, which could be done by ramming up vent sticks, or by digging down to them after the mould is ready for pouring.

The cinders shown are placed very near to the pattern surface, so they will cover the side vents. Placing cinders so near a surface may sometimes be objectionable, because they weaken the surface of the mould so that the head pressure may strain the casting. In case of apparent danger from this cause, the cinders may be kept back 4″ to 8″ from the pattern surface; and by making a gutter the vertical vents can be connected with it by oblique vents. The wire for these vertical vents may be $\frac{1}{4}''$. It should never be allowed nearer than 2″ from the surface of the pattern, and should be kept parallel with the face of the pattern.

If the moulding-sand is clayey or too fine, it is sometimes advisable to vent vertically, in addition to $\frac{1}{4}''$ wire vents, with $\frac{1}{8}''$ wire; the vents being near together and within about 1″ of the face of pattern. In fact, this last-named plan will always help to assure good results, the only objection to it being that it takes time to do it.

Some sands are so open that the sides need be only vented with the fine wire. When this is the case, the venting is done at each alternate ramming until the top of the joint is reached. If it is not advisable to carry the vents off by cinders, as shown at *T*, they can be taken up direct through and off at the surface of the joint, by reaching them with $\frac{1}{4}''$ oblique joint vents.

Another plan sometimes adopted is, to carry the side vents down to a lower cinder-bed (when one is required under the mould). By this plan, the gases, which would rise naturally, are forced down. A mould will not free itself so easily when vented in this way, as when the gases are permitted to rise.

In venting very deep moulds, that require hard ramming to prevent straining, I recommend that every other course be vented with $\frac{1}{8}''$ wire, and, at about every 18″ of depth, make a gutter about 4″ from the face of the pattern. From this gutter, vent straight down to the lower stratum of cinders with a $\frac{3}{8}''$ vent wire. Small oblique vents can also be made between the vertical vents; care being taken not to touch the pattern, which might permit the iron to find its way into the large vents and fine cinders. This oblique venting, however, will seldom be required if all the space between the large $\frac{3}{8}''$ vents and the pattern is well vented with the $\frac{1}{8}''$ vent wire. Cinders placed near the surface of a pattern, as is often necessary to carry off vents, should be no larger than those that will pass through a $\frac{1}{2}''$ riddle: cinders any coarser than this will permit a mould to strain. Fine cinders, when rammed and surrounded by sand, present an astonishing resistance to pressure; and are not only good for carrying off vents, but they will not admit leakage of iron through vent holes, filling up and destroying their air-passages, as coarse cinders will. Coarse cinders should seldom be used unless making bottom cinder-beds: even then, when they are required to support much strain, they are often better covered with what would be called fine cinders. Coarse cinders are generally so called when they are larger than egg size.

DRAWING AND MAKING PATTERNS.

The complaint of moulders against pattern-makers, for lack of taper to their patterns, is often justifiable. A great many pattern-makers work as if they were house-joiners, or were making tool-chests or children's toys, only occasionally getting an idea that they are working for the foundry by seeing a dirty moulder pass them. Why pattern-makers will not give sufficient taper to patterns, when there is nothing to prevent it, is a question that has often puzzled many a moulder. The attainments of the pattern-maker in the way of draughting, and in working wood into various forms, count as nothing with the moulder if he constructs patterns that will not *draw well.* The moulder's skill is proved by having a "*good cast;*" the pattern-maker's (if he only knew it), by having a "*good draw.*" To have corners, edges, or portions of moulds started or broken through ill-drawing patterns, is not only very aggravating, but is often the cause of defective castings.

Another point is the hammer abuse that patterns receive. Moulders are called destructive because patterns are pounded. If we are destructive, the pattern-makers are greatly to blame for it. Give us patterns properly provided with draw *screws* or *irons* and *rapping-holes*, and of a *good taper*, and our acquired practice of unmercifully hammering every thing that comes along will very soon be lost.

Before patterns can be drawn, they generally require to be loosened. To accomplish this, the moulder must do some hammering. Some one may suggest the use of a pounding-block, to preserve the pattern. As a general thing, this is used when practicable. The pounding-block cannot always be used to loosen a pattern, because it frequently only causes vibration. To *loosen* and to *vibrate* are different things. The loosening is required before starting to draw. The vibration is the second requirement, or that necessary to lessen surface friction or adhesion when drawing the pattern up.

Arrangements for loosening patterns are seldom provided. Let one go through almost any machinery-pattern warehouse in the country, and he will find the patterns scarce having good provisions for preserving them from the effects of the "loosening-bar" and hammer. What rapping-holes are seen were most likely first made by a moulder with an auger or a pointed iron bar. In a short time the holes become so *large*, you can hardly see any pattern. It is proper for pattern makers and owners to take some of the blame for abuses of patterns, and to provide for increasing their durability. The expense of inserting iron rapping-plates in wooden patterns is but little; and, were the custom once established, the benefit derived would soon be seen.

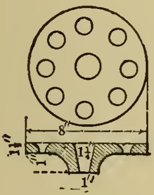

Fig. 59.

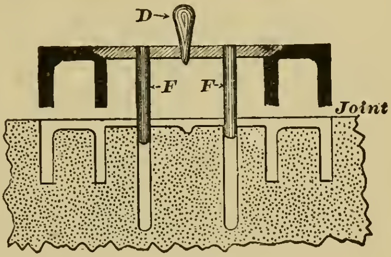

Fig. 60.

Rapping-plates should be placed so as to jar the whole pattern. This will often necessitate the building-in of more lumber than is necessary for making such *shells* as are often turned out and called "patterns." Rapping-plates can be either cast- or wrought-iron, and made in whatever shape the form of pattern may require. For some patterns, the idea given of a cast-iron plate, in Fig. 59, will work well. The size shown is that which would be suitable for large patterns. For small ones, the size could, of course, be decreased. Some pattern-makers go so far as to make a practice of inserting draw irons or plates. This is an excellent plan. But, if the pattern is one to require much rapping, there should also be a rapping-plate. In some cases, the draw and rapping holes may both be in one plate.

For such patterns as small gear-wheels, and others where there is no room except for a small plate on the hub, the draw-plate should be the one. Then the moulder can both rap and draw the pattern with the same draw-screw. Patterns are as likely to be destroyed from the lack of draw-plates, as they are from the lack of rapping-plates.

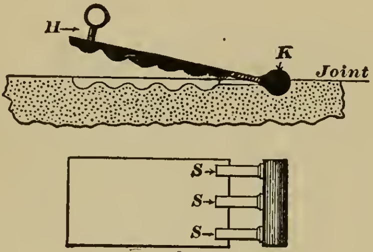

Fig. 61.

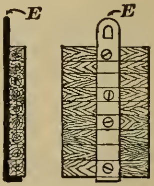

Fig. 62.

It is sometimes said, if the pattern has a weak spot, the moulder is sure to drive his draw-spike or screw there. In some cases this may be true. The moulder generally tries to insert his spike or screw where it will *best balance the pattern:* therefore, should the weakest spot be there, in there, of course, goes the spike. Too many patterns are made without provision for drawing them. I have used patterns that, before they could be got out of the sand, would be — and the mould as well — literally torn to pieces.

I will admit, that sometimes moulders are thoughtless regarding where they drive draw-spikes, or place screws; but what class of tradesmen would not be, under the same circumstances? Our patience is often sorely tried by labor and grief caused by the negligence of pattern-makers. Could we cause them as much extra *labor* and *trouble* as they often cause us, I think they would try to accommodate, and study more to assist the moulder.

In small work, the facilities for expeditiously drawing patterns are much better than for large work. This, in a great measure, is due more to the moulder than to the pattern-maker. Small-work patterns are generally under the moulder's supervision, because of their being chiefly made of iron or brass. All parts are given sufficient taper to insure their drawing well; and, where assistance can be given in steadying the drawing, it is generally done. In Figs. 60 and 61, two ways of doing this are shown. Fig. 60 shows the common way of using steadying-bars; while Fig. 61 will, to many, present a new idea, which, although only adaptable to a narrow range of work, is, nevertheless, worth notice and thought. The principle was first brought to my notice through the kindness of Samuel E. Hilles, of S. C. Tatum & Co., Cincinnati, O. As seen at *K*, the runner part is made round. In the plan-view, at *S S S*, are shown the brazed gates, which unite the runner and pattern. In drawing the pattern, the end, as seen at *H*, is simply lifted until the whole surface is clear of the mould. The runner *K*, being round, acts as a fulcrum for the pattern to roll upon. For such work as sewing-machine legs, etc., this device could often be used to advantage. In heavy or large patterns, the moulder does not have the facilities for conveniently drawing his pattern, the same as in light work, not because it is not possible, but because the foundryman, in heavy work, does not have the management of his pattern-making to so great an extent as in light work.

EE, Fig. 62, shows a simple draw-iron that could and should be used to draw up many deep-sided patterns. Once in a while it is seen upon a pattern, but often where it should be seen it is absent. Numbers of patterns have been pulled apart, moulds broken, and moulders enraged, through the lack of a few simple draw-irons. Missionaries desirous of suppressing evil thoughts and swearing could accomplish much by placarding pattern-shops with the words "Taper" and "Draw-irons."

Now, I do not wish to be understood as thinking moulders are all perfection. I have seen much "smart Aleck" business among moulders, regarding the *design of patterns*. There are many who can show great mouth-wisdom, and find fault with details when patterns are completed, which, in reality, are so far above their conceptions, that they have not the least idea of the difficulties attending, or the thought and skill required in making them. One never hears such men approving any thing. They open their mouths only to find fault.

Instead of finding fault with patterns, we often ought to feel thankful they are as handy as they are. It is no trifling matter for a man to take the general run of drawings, and therefrom conceive, and fully plan in his mind to perfection, all the details of a pattern. The pattern-maker often does well, when we take into consideration what he knows about moulding, and the conditions under which he does his work. If they would only give us "good drawing," and patterns readily "rapped," I would never say a word.

SKIN-DRYING GREEN-SAND MOULDS.

Skin-drying moulds is a term applied to green-sand work, where the surface of the mould is blackened over similar to the process in dry-sand work, and then surface-dried.

Skin-drying is *generally* done for the purpose of giving stability to the surface of the mould, and for assisting in the peeling of solid castings, as anvil blocks, etc. There are a few shops that practise it with lighter work, solely for the purpose of giving their green-sand castings a "dry-sand skin." Then, again, some shops find it necessary to skin-dry much of their work, because of the nature of their sand, which has but little body to withstand the heat and wash of metal, or contains too much clay.

In skin-drying moulds, much judgment is required; for a plan that will answer for one mould will seldom do for another. Not only have ways and means to be devised for drying, but the nature of the sand has to be considered as well. A sand, to work well, should, when dried, present a firm porous crust. Some sands, on account of their weakness, must be mixed with some substance that will give them a body. For such purposes, flour, beer, molasses-water, or clay-wash may be used. When flour is used, it is mixed in the proportion of one to twenty up to one to thirty, according to the quality of the sand. The beer, molasses-water, or clay-wash may be used in connection with the flour in place of water for wetting the sand; or the flour may be often omitted, and the sand be sufficiently strengthened by aid of the above washes.

Sometimes sand, because of its closeness, requires some sharp sand mixed with it in order to make it work well. While some sections possess moulding-sand naturally adapted for skin-drying, others do not; and therefore more or less "doctoring" will be required to make it work properly.

In using the above mixtures, it must be understood, they are used as a facing: all required is to have it face the pattern from 1″ to 2″ in thickness. For a backing, the "heap-sand" is used.

Where copes are skin-dried, they should, as a general thing, be well "gaggered," and sometimes nailed, as the drying of their surface forms a crust that may easily drop off unless held up by the gagger support. Some moulders practise nailing the sides of moulds that are over 6″ deep; and this practice is not one to be condemned, as it will often result in obtaining a good casting. The gates and sections of the mould where the metal first enters are generally the points that should at least be surface nailed; for in skin-dried moulds, if the surface once gets broken, the under crust soon washes away, for it offers but little more resistance than so much dry dust would.

Skin-dried moulds demand that all joints be well finned, for the least touch may readily cause a crush. There is no class of moulds that require more delicacy in handling, for its surface is a crust that has but little union with the body of the mould. Some moulders will not even trust to the nails for holding the portion at the gates: instead, they have cores made the shape of the mould, and ram them up with the pattern. This is the most reliable plan to adopt to prevent the moulds from cutting at the gates when there is a quantity of iron to be run through them. The facing for skin-dried moulds is, as a general thing, worked or used a little damper than facing would be for common green-sand work. After a pattern has been drawn, and the mould finished up by using beer or molasses-water for swabbing purposes, the next process is that of blackening.

In blackening a mould, two plans may be adopted. One is to blacken the mould in a way similar to that used in a dry-sand mould: the other is to rub the blackening on dry, and then after sleeking to go over the surface with molasses-water or beer, the molasses-water being the better of the two. Rubbing on the blacking is of course only necessary upon the sides, etc., of the moulds, where a sufficiently thick amount will not adhere if shaken out of a bag. The blacking can be put on with camel's-hair brushes. The two plans of blackening may often be advantageously used upon the same mould. The plan of rubbing the blacking on dry, and going over it with the molasses-water or beer, does not dampen a mould's surface as much as blackening the mould with all wet blacking, similar to the blackening of a dry-sand mould. The reason why these two plans of blackening will sometimes work together is because, in drying the mould by pan or sheet plates, etc., there are some parts which will naturally receive more heat than others: by using judgment in dampening the facing, in connection with the adoption of the modes of blackening, all parts of the moulds are more apt to become dry at about the same time; while, if the fire acts much upon some one part after all others are dry, there is danger of some places becoming burnt, which is avoided if all the parts become dry at about the same time.

After a mould has been blackened after the plan of a dry-sand mould, some make a practice of sleeking them. This is not the safest plan to adopt in every case. By sleeking the wet blacking, a smoother casting may be produced; but unless very carefully done, there is more or less danger of the sleeking causing scabs. If blacking is used thin enough to not clabber, and the coats are put on with fine camel's-hair brushes so as to show no streaks, castings will result about as smooth as if the moulds were sleeked, and the danger of scabs caused by sleeking is avoided.

In skin-drying moulds, methods must be adopted best suiting the work in hand. For instance, some moulds, such as anvil blocks, etc., may be dried by setting in them a square or round kettle; then, again, some moulds may be dried by means of flat, oblong, or square pans. Often there are moulds where neither of the two plans will answer, because they are so shaped that the kettles or pans cannot be well used. Thin sheet-iron plates perforated with small holes are often used by laying them over the mould. This plan is, as a general thing, seldom used when kettles or pans can be utilized.

The fuel generally used for drying is charcoal. In firing with it, the heat thrown off should be mild and steady, especially upon the start, since too strong a fire is apt to blister or burn the mould. Sometimes the cope and nowel may be dried together, by having the cope propped up clear of the nowel, and the fire between them. Then, again, the mould may be such as to admit of its being closed while being dried, the riser, etc., being left open to let out the steam. Green-sand cores are most advantageously skin-dried by placing them in an oven; and, as in drying the moulds, the heat should be kept mild and uniform.

To ascertain if a mould or core is dried deep enough, either cut a small hole into the surface with some sharp tool, or press the surface with the fingers. The hardest places to dry by pans, etc., are the corners. The sides of some moulds might be burnt to pieces before the corners could be dried. To get the corners dry, it is often necessary, after pan fires have been taken out, to place some hot coals around or in the corners, or to dry them with hot irons.[1]

Before a novice undertakes a difficult job, he should have practised upon minor jobs, which, *if spoiled, entail but small loss.* Experience, coupled with judgment, is necessary, to be successful in drying moulds so as to turn out good castings.

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[1] Advance in founding has led up to natural and artificial gas as well as hot air being used for drying moulds.

SETTING AND CENTRING CORES.

If there is any one thing that a machinist dislikes, it is boring out holes that are not cored centrally. And why a moulder cannot always set cores centrally, is something of a conundrum to him. Moulders can sometimes make excuses, and are generally ready to take a cast-iron oath that the core was set right, which the machinist, of course, cannot dispute. Still it will, I believe, be acknowledged by nearly all moulders, that excuses for cores out of centre are about the worst kind of excuses we have to make. When you get a moulder so that he cannot say any thing, it is a sin to torment him further; but it isn't often that you will get him there.

Why it is that *all* cores cannot be set centrally, is something that cannot be fully explained. To set a core centrally or straight, does not generally call for any great mechanical skill. What is more demanded is *care* and *thought.*

The accompanying engraving may assist in showing why some holes do *not* come central, and perhaps afford some help in setting cores.

The cause of holes being out of the centre is not always on account of the cores not having been set centrally. There are many things, such as uneven closing of flasks, bad-fitting flasks, ill-fitting cores, etc., any of which may result in crooked holes. Some readers of "The American Machinist" will remember about four years back discussions upon core prints.[1] To my mind, the elaborate systems that some writers advocated had but little to do with what prints are practically used for. Prints are for no other purpose than giving bearings and holding cores.

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[1] This refers back to the year 1882.

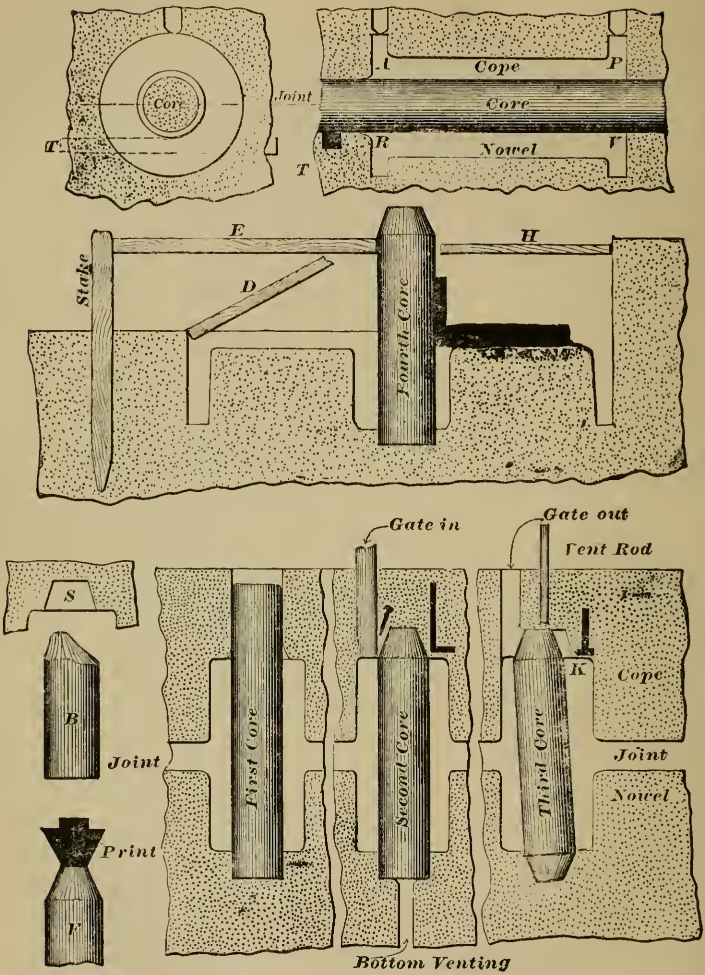

Core
Joint
T
t
Cope
P
Core
R
Nowel
V
T
E
H
Stake
D
Fourth Core
Gate in
Gate out
Vent Rod
S
B
Joint
Print
F
First Core
Second Core
Third Core
K
Cope
Joint
Nowel
Bottom Venting

Fig. 63.

And whether bottom core prints are tapering, as seen in

"Third core," or straight as shown in all the others, has but little to do with the holes being out of the centre, which I think is a vital part of the question. The top prints are the essential ones, and even they often have but very little to do with poor holes. As a general thing, long top taper prints afford a better chance for the cores to accommodate themselves to their centre. For long cores, where there is uncertainty about measuring, such prints as are shown with "First core" are reasonably certain of providing for a true hole. This form of a print is the most reliable one that can be used, as with it the moulder can see whether the core is in its right place or not. In fact, by the use of such a print, it would be a hard matter to get the core out of its centre. Some may think that such prints should always be used; but they are objectionable from the extra labor and time which their use involves. It may be said that there is no gain, if, through the quicker plan, the casting is lost. But all castings are not lost: it is only the ones that are wanted in a *hurry*, that we generally lose.

The cause of many crooked holes where the popular common top-tapering print is used, is as illustrated at "Third core." As a general thing, nearly all pulleys, gear wheels, etc., have either feeders or pouring-gates on the hub. These holes break away, or weaken a portion of what should be a firm, true, sound, tapering print; and the core leans to the weak side, with the result shown.

There are a few moulders who always close such moulds as the above, with the gates in place, as shown at "Second core." By this plan it is evident that much of the risk is lessened.

The gaggering and nailing around the *second core* is another safeguard against the core crowding the print to one side. Another point that will bear looking at is that of the taper ends of cores. A large number of foundries make all their common sizes of round cores, without having the taper end formed. Then, again, a large number of shops make their cores having the taper end on them.

Filing a taper on cores is often very objectionable, especially when done by a careless moulder. A fair illustration of careless work of this kind is shown on core *B*. *If a central hole is got with such a core. it can't be charged to good management.*

A careful moulder, when filing a taper print, will compare his print and core together, as seen at *F*, thereby making a core that is likely to fit and fill the female print *S*.

Cores made with taper prints are often one-sided from being laid down upon plates to dry; although some, by nailing the heads, or packing sand under to hold them up, will get a very fair tapered head.

In some shops, in order to get good round straight cores, they are dried in half-round iron boxes of the same diameter as the cores. This is the only reliable way of making true taper-end round straight cores. The plan is an old one, and the cause of its unpopularity is the expense of making the cast-iron boxes.

At *E*, *D*, *H*, and at the square, are shown the methods generally employed in setting and centring cores. With the exception of *E*, the plans are popular, and call for no comment. *E* is a plan whereby cores in such moulds as green-sand propeller-wheels, and others having no points to measure from satisfactorily, can be centred. The plan is simply the driving of three or four stakes outside or away from the mould, before the pattern is drawn; the stick *E* being placed against the pattern print, and all the stakes driven the length of the stick away from the print. The core, when set by the same stick, will of course occupy the same position in the mould as the print occupied on the pattern, and therefore, as far as centring is concerned, must be right. The plan is applicable in other ways than shown; and, while the idea may be old to some, it will be new to many.

The carrying-off of such core-vents through the cope is often the cause of weakening top-prints, and also the cause of blow-ups, from metal getting into the vent. To avoid this danger, it is often the better plan to carry off the vent through the bottom board, or by running a long vent down into the moulding-floor, as in the case of bedded-in moulds.

Some will say, That is all right, providing you have a cinder-bed under the mould. I have carried off the vent of cores as large as one foot in diameter, and more in length, by simply driving a ½″ vent rod down three or four feet in the sand below the mould. Green sand, where you have a large body, is capable of carrying off and holding more gas than is generally thought; and to such as have never tried this plan, I would say: "Do so," for I know they will find it an easy and good way of carrying off ordinary-sized vertically set core-vents. If the cores are small in diameter, and long, — for instance, say 2″ diameter by 24″ long, — it would then be best to take the vent up through the cope in concert with what would pass downwards. Very long, small-diameter cores cannot be too well connected with outlet vents, as the vents from such, especially if quickly surrounded with metal, require to have a fast delivery.

In the upper part of the cut are represented ideas that to some may be of value. It represents the finning or chamfering of core-prints, in order to prevent the crushing of flanges, etc. At *P* and *V* there is not the chamfer which is seen at *A* and *R*. Many moulders seldom think of chamfering a print, and to the credit of such may be placed many bad castings. Chamfering core-prints should be performed upon the same principles as finning joints; and whenever the print is short, or the core too heavy, there should be bearings to assist the prints, or chaplets, in holding the core, placed as represented at *T T*.

The greatest cause of flange-crushing is probably due to the irregularity and over-size of cores. Should any of my moulders lose a casting through the above cause, I should hold them responsible, although I might reprimand the core-maker for making the core too large. In our shop it is the custom for all pipes or moulds having flanges upon them to be tried off and on in concert with calipering the print and core. This gives the moulder a chance to see if there is any liability of his mould or flanges being crushed; and, if there is, he has time to then remedy any evils that might result in a bad casting. The practice of thus trying off and on all such moulds has been the means of saving many a casting from going to the scrap-pile. I think it is a safe assertion to make, that in not one of fifty shops is this the rule. I know that it takes more time; but will say that in our shop I have yet to see a casting lost through having a crushed flange,—a thing that but few foundrymen can say.

Having all castings good, far more than balances, in dollars and cents, the little extra time taken up in trying off and on all such copes.

IMPROPER SETTING AND WEDGING OF CHAPLETS.

It is not uncommon to see castings lost from improper setting or wedging of chaplets. The work lost may be light or heavy. The little error that will cause the loss of a casting worth one dollar would cause the loss of one worth hundreds of dollars. In selecting this subject, there was no thought of presenting improved plans or ideas; but, if possible, to show how castings may be and are lost through want of *care* or *judgment*, — not practice, for moulders that have worked a lifetime at the trade can be found who are no more expert in this respect than apprentices.

The mould chosen to illustrate this subject is a large piston. The number of cores in it is eight; for each core there are three cope chaplets required; so that, altogether, we have twenty-four chaplets to be set and wedged; and, should any one of this number be wrong, the result would be a bad casting.

Often there are moulds where the vent of some core can only be taken off through the bottom of the mould; and the core may be of such a form as to have only a small bearing on the sand and the rest on chaplets. This core may be the only one in a mould, to lose which would involve hundreds of dollars. When setting this core, the moulder is very careful that the vent portion has a solid air-tight joint; for, if the liquid iron should find its way between the joint of the core and mould, all would be lost. After the core has been carefully set, the next important thing to be done, to insure safety, is, after the cope is on, to wedge down the chaplets, so that the head of iron cannot raise up the core, and allow the metal to get into the vent. At *B*, on the right-hand side of the cut, is an illustra-

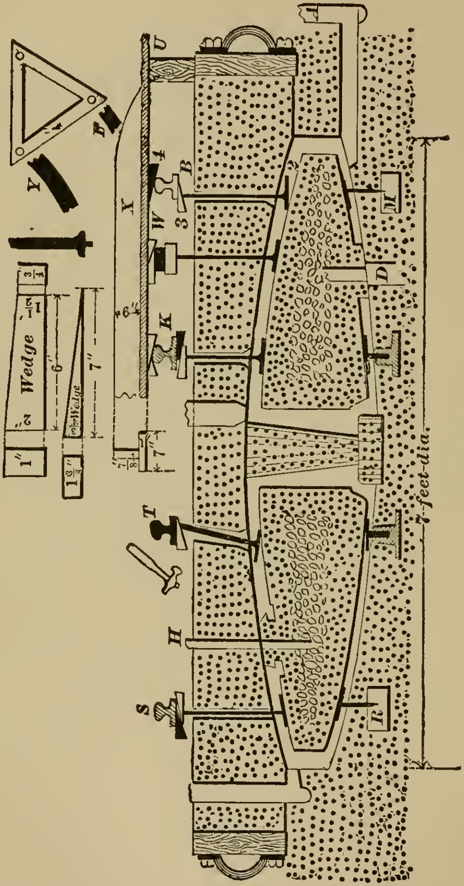

U
4
B
3
W
X
K
6"
Wedge
6"
7"
2"
1"
1 3/4"
7"
D
M
T
H
S
R
Y
7-feet-dia.

Fig. 64.

tion of how a great many cores are dangerously wedged down. As this chaplet is shown, with its wedge and blocking, there are three things that could happen which would allow the core to rise up so that the iron could get into a bottom vent, as shown at *D*. It may be well to remark here, that, whenever it is possible, vents in cores, similar to the one shown, should be arranged to be let off through the cope, as shown on the opposite side at *H*. There is always more or less danger in taking off the vent through the bottom. These remarks are intended more particularly for the draughtsman and pattern-maker, who should always remember that in moulding there is generally more or less risk, and that they can very often greatly lessen this risk by having a little thought for the moulder's interests, as well as for their own.

Going back to the subject: Suppose the mould shown is being poured; the liquid metal is rushing through the runner or gate *A*, and the head soon becomes high enough to exert a pressure up and against the chaplets. Now look at chaplet *B*, and then at chaplet *K*. It will require but little observation to decide which one is liable to let the core rise sufficiently for the iron to run into the vent *D*. (The chaplet *W*, between *B* and *K*, would not in actual practice be used. It is only shown there for the purpose of illustrating the ideas.) Now, the chaplet *B* is by no means an exaggerated illustration, but a true sketch, representing the way a great many chaplets are secured, sometimes on jobs upon which a great deal of money and labor have been expended. The first noticeable weak point is at 2. Here we have only one point touching or resting on the core. This chaplet-head may be stiff enough to stand as it now is, but its chances are very slim indeed: if it does bend when the liquid iron makes it hot, up comes the core sufficiently to let the iron into the vent. Again, suppose the head will not bend: it is plain to see, that, in the way the wedge is placed in relation to the head which rests on the core, it would not require a very great strain to tip up the rail, so as to become loose with the wedge 3, thereby letting the core rise up. There is still another possibility of this core rising up. We will suppose that neither of the above results should occur, and that the chaplet will stay in the position shown. Over the top of this chaplet and wedge is a railroad-bar. This bar is held down by having a wedge, 4, placed between it and the cast-iron beam *X*. Now, the way this chaplet is placed to the outer edge has been known to allow a rail, or similar bar, to partially roll over. Another feature frequently seen in wedging down the bars of a cope as well as chaplets is, that, instead of putting about an equal number of wedges on each side of a bar, they will all be placed on one side, and that most likely the weakest side, as at 4.

At *S* and *T* may be seen some very fair illustrations of the way many unaccountable bad results are accomplished.

A chaplet wedged, as shown at *S*, will often cause bad results. When a heavy pressure comes upon a chaplet thus wedged with cast-iron wedges (which are generally used), they will frequently break, on account of the two faces of the wedges not coming well together, as is shown, and thus allow the core to rise up and make the casting thinner than it should be, or allow the iron to run into bottom vents (should there be any), and cause a blow-up.

The chaplet *K* is wedged in a way to be relied upon. After placing the wedges by hand, they need to be tightened. For this purpose a hammer should seldom be used. The hammering to tighten them should be done by some lighter article than the common run of shop hammers. I once had some words with a moulder about losing a casting through bad chapleting. He was certain he had tightened his chaplets, and went so far as to call upon his helper to testify to his using his hammer. There is no question but what he did tighten his chaplets, and the sketch of the hammer seen no doubt shows how he used it.

Some moulders will say the "blocking" and chaplets cannot always be arranged so as to use two wedges. It is admitted that there are often such cases; but, as a general thing, there is just about as much mechanical skill, or the lack of it, shown in placing the upper blocking, as there is in the general handling of chaplets and wedges. Some moulders are just as liable to place blocking bars six inches above the chaplets as they are to have the bars clear only a quarter of an inch. The first blocks they can lay their hands on will be used to rest the bars on, instead of making a point to study the *proper relation for careful wedging.* About the proper distance to allow for wedging space between bars and chaplets is $\frac{5}{8}''$.

The less blocking and fewer pieces that are used between bars and wedges, the better it is for the wedging and for the safety of a casting. At *W* is shown a chaplet wedged in a reliable manner where the use of blocks is required.

Careless moulders often lose castings by the way in which they set bottom chaplets. *R* and *M* show wooden blocks, having sharp-pointed chaplets driven in them. The block *R* is apt to split, caused by using too long a chaplet. The block *M* shows the other extreme. Both of these blocks are liable to cause a bad casting through settling of the cores. Often, in setting a heavy core upon such chaplets, the weight will force the sharp points deeper into the blocks, thereby causing the core to settle and make the casting too thin. Perhaps, if the core's own weight don't do it, the wedging-down of the chaplets will.

When wooden blocks are used, they are better if made of hard wood set with the grain up; and the moulder will have to use his judgment as regards the proper distance to drive in a point, as the size of the chaplet, the weight of core, and nature of the block must be considered. As a general rule, $\frac{1}{2}''$ is a good distance.

The two inner bottom chaplets shown are placed in cast-iron stands. The chaplet on the right is reliably set. The one on the left illustrates why cores are sometimes broken, or the casting "comes thin," by not having a solid bearing.

The wedges shown, having dimensions given, are of good proportions for cast-iron wedges for general foundry use. Many shops use wrought-iron wedges. Altogether, they are decidedly the best; but, on account of their cost, the cast-iron wedge is used in the majority of shops. It would be better to keep a few wrought wedges, as there are often jobs where the cast wedges are not safe.

More solid wedging can be done by the size shown than by thicker ones. In wedging iron and iron, there is a tendency to slip; and the more tapering the wedge is, the more liable it is to slip. When securing a cope, or a number of chaplets, with iron wedges, they should generally be gone over two or three times; the tightening of one wedge will often loosen others, making it necessary to go over them all once or twice after the first wedging, each time rapping lighter.

The cut shown of a chaplet-stem represents one got up by an acquaintance, A. M. McGee, who is employed in a bolt-works, Cleveland, O. He has devised a machine for putting on the heads, and also claims originating the stem shown. Be that as it may, the plan is a good one.

For slanting cores, similar to those shown in the piston, chaplets with forged heads are not the best, on account of there being no chance for the head to adapt itself to the shape of the core. With a stem having a shoulder and riveting-tip like the one shown, as large a plate head as desired can be readily riveted on in such a manner as to be loose or tight. Castings are often lost on account of chaplet stems not having sufficient shoulders on to hold down the riveted head when the pressure comes upon them. The advantage of having such a shoulder as shown is apparent.

There are often cores used that require the chaplet heads to be bent, to correspond with their irregular surfaces or slanting faces. Such cores call for extra-careful work in placing and holding the chaplets. In some cases it is best, if condition will allow, to file away a portion of the core, so that straight-headed chaplets can be used, or when making the cores provide for this. In some foundries, round-column cores, etc., are often made flat where the chaplets are to rest, so as to allow the use of flat-headed chaplets, and give the chaplets a solid bearing.

The triangle shown illustrates a plan that can often be adopted when a core has three chaplets in order to make the securing of chaplets more easy and reliable; by the use of this, the chaplets are sure to have a good bearing, and also are not jarred by the use of wedges. To show the manner of thus securing a cope and its chaplets, suppose that we are going to get ready such a mould as shown.

After all the cores are set, and clay balls placed where the chaplets are wanted, the cope is lowered down to receive the impression of the balls. The cope is now hoisted up, and the chaplet holes in the cope made; being sure that the holes are all reamed out at the face of the mould, as shown at *K*. Castings are often lost through neglect of this. *W* and *B* are illustrations of how such losses can occur. In *W*, the chaplet is all incased firmly in the sand. In *B*, the hole is ill-made at the stem-end of the chaplet; and the one is nearly as dangerous as the other, as the chances are ten to one that the sand around the chaplets will be found dropped when the casting comes out. This may be caused either by having to push down the chaplet so as to rest on the core, or by the jarring of the chaplet when being wedged. When the chaplets are all placed in the cope as they should be, by having the hole "just easy" enough to permit the stem to work up and down in, and also made larger at the face of the mould, so that there can be no danger of breaking down the face, the cope is then ready to be closed. For uneven or slanting core surfaces, as here shown, it is a good plan to place a little flour on the cores where the chaplets are to come, which is known by the clay marks; then when the cope is lowered down, and all of the chaplets rapped down solid, the cope is again hoisted, when, by the impressions upon the flour, it can be known whether all of the chaplets have a solid bearing. If all are now found to be right, the cope is lowered down to stay.

In the piston mould shown, there are eight cores; and to hold down each core, there are three chaplets used. The top ones are made of $\frac{1}{2}''$ iron, and the bottom ones of $\frac{3}{8}''$ iron. The heads on all the chaplets are 2″ square. The thickness of the metal in the casting is about one inch. There being eight cores, there are also eight triangle plates. These plates are now set, one upon every three chaplets. The round dots represent where they rest upon the chaplets.

After these triangles are all placed, there are then two plate rings placed over them, as seen at *Y* and *F*; these rings being kept up high enough to admit of a wedge being placed between them and the triangle plates. Over the top of these two rings are now placed four railroad-bars, they also being kept high enough to admit of wedging. Set at right angles to and on top of these four bars are placed two heavy cast-iron beams, as shown at *X*. The rings, rail bars, and cast beams are all held up by blocking on the outer edges of the cope, similar to that as shown at *U*. The inner and outer rings *Y* and *F* are connected by three arms, which also extend from the outer ring to reach the outside of the cope. These rings, being made purposely for this job, were made in one casting. On top of the beams are placed all the weights needed to hold down the cope, if there is no chance to bolt it down. After the weights are all on, then carefully wedge the rails, rings, and triangle plates. It is not intended that this article should cover all the ways that castings may be lost through improper wedging or setting of chaplets. The field for *blunders* in this line is too broad to attempt any such task.

MOMENTUM AND RULES FOR WEIGHTING COPES AND CORES.

In the article on weighting down copes (vol. i. p. 113), I wrote that it was absurd, to my view, for one to say he can figure the *exact* weight required to hold down a cope. I think the following examples will fully prove that there is a *momentum*, and that it is absurd for one to say he can figure the *exact* weight that is *just sufficient* to hold down all copes. To say the "statical head" is all the pressure copes are subjected to, is to maintain that there is no momentum, and no difference in moulds or forms of gates in producing a pressure.

Some argue that there are no *conditions* to be considered in the weighting-down of copes; that it is simply a question of hydrostatics. To prove that there are other conditions to be considered, and also that the momentum of the iron at the moment many moulds become full has an influence, I would simply ask any one to take a pattern $12\frac{1}{32}''$ square by about $1\frac{1}{2}''$ thick, common rule measurement, and make four moulds, two of them to be poured as shown at *K*, and two as shown at *H*, Fig. 65. Any one will admit that these modes of pouring cover the common manner of making pouring-runners, as first receivers of the iron, as it is poured out of the ladle.

The mould *K*, if brought up quickly, would require more weight to hold it down than it would were it brought up quickly and poured as shown at *H*. Either one of them, if brought up easily, can be held down by having the cope and the weights weigh two hundred and thirty pounds; but they cannot be brought up as fast as possible, and be held down by that weight. Further, I will allow the use of thirty-five pounds more weight on *K* than the head calls for; and even then the

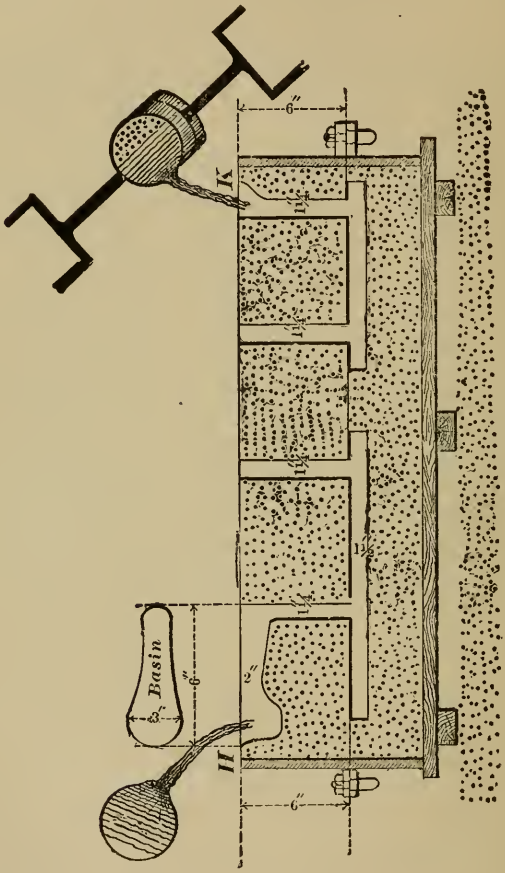


Fig. 65.

cope will lift if the metal is brought up fast. Both of these moulds have the full benefit of a riser. Should each be poured

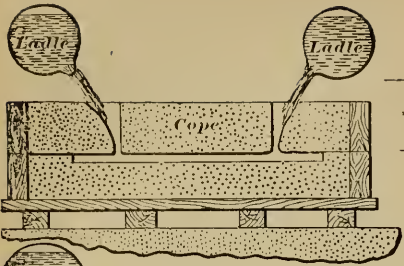

Ladle
Ladle
Cope

Fig. 66.

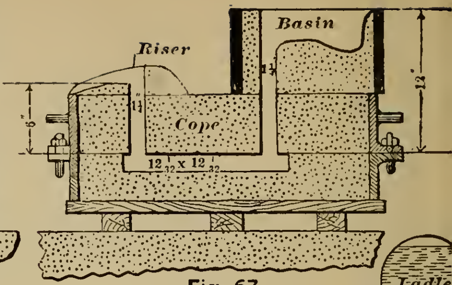

Riser
Basin
1½
1½"
6"
12"
Cope
12 3/32 x 12 3/32

Fig. 67.

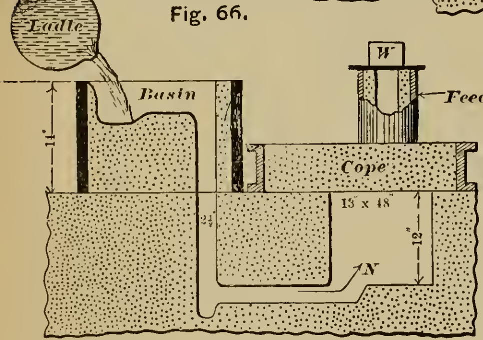

Ladle
W
Basin
Feeders
14"
Cope
2½"
13" x 48"
12"
N

Fig. 68.

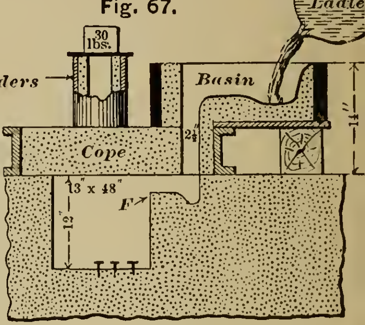

30 lbs.
Ladle
Basin
14"
2½"
Cope
13" x 48"
12"
F

Fig. 69.

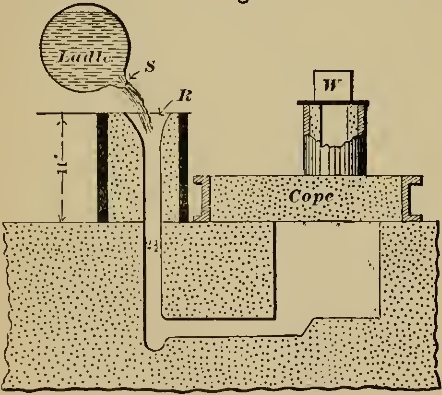

Ladle
S
R
W
11"
Cope
2½"

Fig. 70.

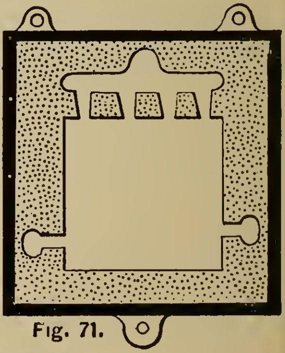


Fig. 71.

Different Styles of Gating Moulds.

fast without a riser, there will be an increased momentum, and more weight will be required to hold them down. Fifty pounds extra, added to the weight the statical head calls for, would not hold down *K* if brought up fast. These moulds, comparatively, present but a very small lifting area to that which some others do. Therefore, if such small lifting areas will give the momentum shown, what must we not expect in large lifting areas?

As supplementary to the two above examples, the engravings, Figs. 66–71, are given opposite, in which is further illustrated how figuring for cope weights is but an approximation, and that for practical safe working one cannot figure the *exact* weight required.

The forms of gates here shown are those also commonly used. In Fig. 67 we have the pouring-gate higher than the riser. The result is, that neither the height of the pouring-basin nor the riser can be figured from to obtain a weight which would be the nearest to the cope's lifting capacity. The mould in Fig. 67 is supposed to have 144 square inches of lifting-surface, and, as shown, has a basin or pouring-head 12″ above the lifting or cope's surface. This mould, were the cope's lifting pressure theoretically figured for the 12″ head, would require a weight, including cope, of 450 pounds. With the style of pouring-basin and gate shown, and having a riser 6″ lower than the pouring-basin, however quickly, at the last, the gates or heads were "brought up," the 450 pounds could not be raised. On the other hand, were one to figure for the weight, taking the height of the riser for the lifting or statical head, he would require half of 450 pounds, as the riser's height is 6″, or half of 12″; therefore, to weight for a 6″ head, we should, theoretically figured, require a weight, including cope, of 225 pounds. With such a weight, even being "brought up slow," the cope would lift. The mean of these two weights — 337½ pounds — is about as near as one could theoretically figure for a *safe* weight. By pouring so as to bring up the pressure slowly, a weight of 250 pounds would hold the lift of the 6″ head. In all these experiments, after the basins and riser were formed, the copes were weighed, and weights added until the copes and all weighed as per figures given. When one has a plain surface, it is simple enough to figure the head pressure; but, when one comes to apply hydrostatics to every thing that comes along, it is different. It may, in some jobs, be safe enough to take the mean of riser and pouring-basin as the lifting-head, or height to figure from. But, unless there is over six inches difference between the height of riser and pouring-heads, I would not advise, in any of the styles of gates shown, to figure the pressure from the mean of the head's heights. He that will make it a practice to figure from the highest point of the pouring-basin as the lifting-head, and then allow extra weight in proportion as the style of mould and gates are productive of momentum, will work the most securely. If it were always practicable to pour with very hot iron, and have enough area of riser to carry off the metal as fast as it could be poured into the mould, and also were one always sure of having as hot iron as he made calculations for, the height of risers or flow-off gates would then, as a general thing, not allow any head pressure much higher than its own to exist.

The duller the iron is, the more apt, in moulds having risers, is the statical pressure to approach that of the pouring-basin's height. Often the metal will freeze at the risers' entrance, and then, again, it will come up the risers so sluggishly as to retard the flow. While the statical head's pressure may be that of the basin's height, it does not always follow that the mould is being strained the full height of the pouring-head; for in some cases, if the metal is dull enough to freeze in the risers, its dulness is very apt to exert less lifting pressure upon the lifting surfaces of the mould. The thinner the metal in lifting portions, the less lift is dull iron liable to exert. Where proportions are thick, then should the risers, through any cause, "flow sluggish," or "freeze up," we are more sure a lifting pressure, the full height of the pouring-basin's head, is being exerted.

There are many moulds, that, were they poured direct, similar to that shown at *K* and in Fig. 66, even were the risers lower than the pouring-gate, would not have their copes held down by the weight obtained from the pouring-gate's height of head. Such styles of direct-poured moulds are productive of more momentum than any style of gated moulds generally made. The amount of weight required over and above what the pouring-head calls for, to hold down the momentum force, depends upon how many ladles are used, how fast the mould is poured, the square inches of area that the metal will *suddenly* rise up against, and the distance of risers below pouring-basins. It might also be added, that these three momentum factors, to an extent, enlarge in ratio as the height of head increases above the lifting surface.

A class of moulds that generally will admit of the closest figuring, or that have the least momentum lifting pressure upon them, are those similar to the one shown in Fig. 68. Here we have the metal entering the mould, as represented by the arrow at *N*. Moulds thus poured or run from the bottom take the metal the fastest upon the start, and the rapidity of filling gradually diminishes till the end, thereby greatly lessening the force of momentum or strain upon the mould.

If it were practicable to pour *like* moulds, having the same sectional area of gates and heads of *like* height, some to be run underneath, similar to Fig. 68; the others to have joint gates, as at Fig. 69; the pouring-basins to be large enough in both cases to admit of keeping them and the gates full, — the joint gated moulds could be filled up the fastest, and would require the most weight to hold the copes. The reason I would assign for this is that the joint gates admit of the greatest velocity in flow.

Metal will more readily flow into air-space than into a body of metal. The higher the heads, and the nearer a level the metal in basin and mould approach each other, the more apparent this becomes. In pouring high, vertically cast moulds entirely from the bottom, we can often see the top portion fill up so slowly as to cause fears of its not running. Some might here say, the reason for the mould's filling so much slower at the last was simply caused by there being less head pressure at the end than at the beginning. While this, of course, is correct, there are two other factors which help to retard the flow. One is the decreased fluidity of the metal, the other its weight. As an example to illustrate how the metal's weight will retard its flowing, the annexed cut is given. The example is simple, and the experiment readily tried. As seen, the metal's highest head is at *Y*, and it escapes through the outlet *W*. By pouring a steady stream into the basin (which, by the way, is far enough from the upright *Y* to prevent any effect such as direct pouring into would cause in adding to head force), and keeping it full, we will, with a head of 12″, as seen, throw up a stream about 8″ high. Now, were it not for the resistance of the air,

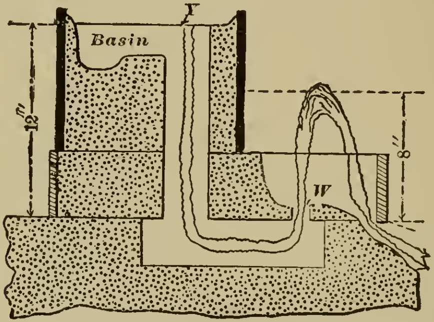


Illustration of Head Weight in Restricting a Flow
Fig. 72.

friction of flow through the gate, and the weight of metal endeavoring to descend, the head *Y* would throw the stream as high as itself.

In about the same ratio as here seen, does this element retard the head's influence in rapidly filling bottom-poured moulds. After the metal has risen to that height in a mould to which the mould's gate or runner head could throw a stream into air-space when first started, then the further filling-up of the mould is more due to that non-momentum element in equilibrium of liquids that is exercised in low heads settling to a dead level. The decreased fluidity of metal mentioned has also much to do in preventing heads suddenly finding their level, and causing momentum. The duller iron is, the more cohesive it is. It can become so cohesive in a mould, while being poured, as to entirely stop the flow before the mould is filled.

As it is true these elements in a greater or lesser degree decrease momentum, it cannot but be seen, that with pouring-basins, and underneath gates similar to that seen attached to Fig. 68, the force of momentum would be greatly decreased. In fact, when it is practicable to use such underneath gates combined with pouring-basins, copes will, as a general thing, have but little momentum force exerted upward against them; and if the weight obtained from figuring the gate's statical head and mould's lifting area (allowing a cubic inch of iron to weigh .26 of a pound) be placed upon any ordinary weight of cope, there will be no danger of its lifting, even were there no risers to indicate when the mould was full.

A point which it may be well to draw further attention to here is the effect of directly pouring into runners, instead of first having the metal enter a basin from which it then flows to the runner, as seen at *H*, Fig. 65, also Figs. 68 and 69. The only difference between these pourers and those of *K*, Fig. 65, also Figs. 66 and 70, is, one has basins, and the other has none except the end of the runner, as at *R*, is enlarged. Pouring direct into runner-gates, to an extent, often gives the momentum head-pressure equal to almost what it would figure taking *S*, Fig. 70, the lip of the ladle, for the height of the head. The momentum that such pouring causes on *forced fast-poured moulds*, such as flat plates, etc., where the metal *suddenly* fills up to a *large lifting surface or area*, may be such as to call for over one-half the weight more than the height of the statical head would figure, in order to overcome the momentum, and safely hold down the cope.

Gates of the style shown at Figs. 69 and 71 are generally termed "joint gates." Moulds poured with such gates are generally subjected to much momentum; and whether their basins are such as in Fig. 68, or in Fig. 70, to a very large degree determines their momentum lifting force. Spray-gates, as seen in plan Fig. 71, it must be remembered, have a lifting force the same as though they formed a part of the lifting area of the mould; and, when figuring such a mould's lifting area, that of the spray-gates should be added to it.

The term *momentum* here used, the reader is to understand, I apply to any pressure over or above the mould's final *statical pressure*, which may be created during the second of time that any head over or above the cope's lifting surface is being filled; also, the height of pouring-basins above any flow-off risers or gates, I consider as factors of momentum. For in strictly practical working, a second or so after the pouring ceases, the height of the lowest flow-off riser is that which should become the statical head, as long as the metal in the gates remains in a fluid state.

Before closing the momentum question, there is another point which it might be well to call up, which is this: We must remember, that, in a degree, whatever pressure we subject the cope's surface to, the same is transmitted to all parts of the mould. Of course, by this it is not meant that the sides and bottom of the mould receive no more pressure than the cope's surface does. In addition to the cope's surface pressure, the bottom and sides of the mould have to support the dead weight of metal in the mould. To find the pressure upon the side or bottom of a mould: For the bottom, *multiply the area covered, by the vertical height to the top of pouring gates or basin;* for side pressure, *multiply the height of the sides measured from the top of the gates to the centre of gravity of the casting:* either when found, and multiplied by .26 (the weight of a cubic inch of iron), will give the pressure in pounds. Taking the momentum head pressure in concert with the metal's weight in the mould, it is surprising, the amount of pressure the bottom of some moulds have to support.

As I think I have proved that momentum enters into the question of pouring moulds, I am now ready to present rules which will, in connection with the above, no doubt, provide a simple and intelligent solution of weighting copes by mathematical calculation. Were there no conditions to be considered, and were all moulds filled without any sudden pressure upon the copes, then it might be true, as one of my critics said ("American Machinist," Aug. 19, 1882): "The science of hydraulics, demonstrated by experience, proves that, given height and surface, and application of multiplication, the result will be, not an approximation, but certainty itself."

In figuring the head pressure for water, etc., experience has no doubt demonstrated there is a certainty or exactness to be obtained by mathematical calculations. When one comes to apply the science of hydraulics, or properly hydrostatics, to foundry practice, my experience would make it read, not a certainty, but an approximation. While the following rules are given for figuring up the pressures upon copes, they can at their best, when practically applied, be but an approximation; and in many cases much more weight than the actual statical head figures up will be required. The momentary pressure almost all copes receive is caused by the sudden attaining of a head, or, commonly speaking, the filling-up of the gates when the mould is full. Did the gates or risers (when a mould was full) fill up as gradually as the mould, then there would be no momentum. As a general thing, it takes from five up to over one hundred seconds to fill the common run of moulds with metal, whereas the gates through which they are poured will generally fill up in about one second, *thereby obtaining a head-pressure in one moment which it often takes the mould in filling over one hundred seconds to create.* The higher the top of pouring-gates above the mould's lifting surface, the greater the increased lifting force of momentum; and as has been fully shown, the various forms of pouring-gates will require different amounts of weight in pouring moulds having exactly the same lifting area, and same height of heads or gates.

There are various formulas for mathematically calculating the theoretical weight required to hold down copes. Mr. Tullis, in the "American Machinist" of Aug. 19, 1882, gave the following concise rule: "Specific gravity of water, 1,000; specific gravity of iron, 7,202. Weight your cope; measure surface and height in feet; multiply by 7,202. The answer will be in ounces."

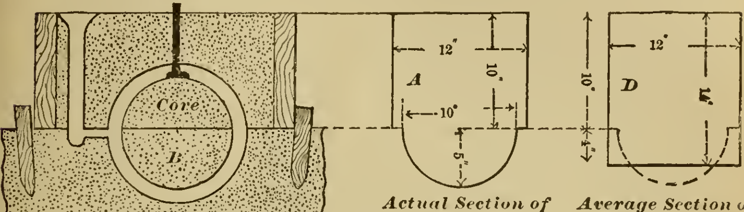
Mr. Jewett, in the "American Machinist" of Sept. 9, 1882, gives a rule in a manner that should be very explicit to those who are ignorant of the subject, of whom, I am sorry to say, there are thousands among moulders. He explains his rule as follows: "I assume a column of water 32 feet in height to equal 16 pounds water-pressure: then 16 feet equals 8 pounds, and 8 feet equals 4 pounds. Iron is $7\frac{8}{10}$ times heavier than water: so, for 8 feet high, or 4 pounds of water, the corresponding pressure of iron would be 4 pounds, which multiplied by $7\frac{8}{10}$ equals $31\frac{2}{10}$ pounds. Four feet head would be one-half as much, or $15\frac{6}{10}$ pounds. Two feet would be one-half this latter quantity, or $7\frac{8}{10}$ pounds. One foot would be one-half this, or $3\frac{9}{10}$ pounds; and six inches head would equal $1\frac{9}{10}$ or say 2 pounds. All displacement of cores must be computed according to depth, etc."

This rule of Mr. Jewett's, assuming, as it does, that iron is $7\frac{8}{10}$ heavier than water, leaves a margin upon the side of safety. According to this, a cubic foot of cast-iron would weigh $487\frac{1}{2}$ pounds, while the actual weight of the common run of gray cast-iron is about 450 pounds per cubic foot. However, the extra $37\frac{1}{2}$ pounds in every cubic foot when used for flask weights will only aid in making copes more secure. The outcome of his figures is, that to weight a cope there is $5\frac{1}{3}$ ounces of weight required for every inch in height of head and square inch of lifting surface. To show the practical application of the rule, the following example is given: The section of mould, as seen at Fig. 67, is representative of a plate $12\frac{1}{32}'' \times 12\frac{1}{32}''$, with area of pouring-gate and riser out; this would give us a lifting area of 144″. Now, were we going to pour this with a head that would be 6″ from the joint up to the top of gate, we must multiply the $5\frac{1}{3}$ ounces six times, then with the product, which is 32 ounces, multiply the area of the cope's lifting-surface, which is 144″; the product of this is 4,608 ounces = 288 pounds. Now, did we desire to pour such a mould with a head 12 inches high, we should simply have to double the weight of 288 pounds, making it 576 pounds. Were a plate 12″ × 12″, having a head of 12″, poured slowly at the last so as to bring the head up very easily, a weight of 460 pounds, including the cope, would be just sufficient to hold it down. To do this, the gate and riser (the riser to be as large or larger in diameter than pouring-gate) must be placed on the pattern; for were they to be placed upon the joint, and from them to the mould branch gates be cut, then there would be more than 144″ of lifting surface. Four hundred and fifty pounds being the weight of a cubic foot of cast-iron, it is too near equilibrium to risk the 10 pounds added to the 450 holding down more area than the 144″. When the 460 pounds will hold down the 144″ lifting surface, it is easy to see that the 576 pounds, obtained for same purpose by Mr. Jewett's rule, will give quite a margin for safety. With the cope's weight added to such a margin, we have sufficient weight, as proved by the experiments, to safely hold down such character of copes. In moulds that will create extra momentum, it might, in some cases where the copes are light, be best to add more weight than the rule and weight of cope gives.

A rule the author uses for flask weights is as follows: *Multiply the lifting area by the height of head, the product by the weight of a cubic inch of iron.* To obtain the statical pressure, for instance to the cope of the plate mould, 12″ × 12″ referred to above, the following example is for a twelve-inch head:

Length of lifting surface	12″
Width of lifting surface	12″
Lifting area	144″
Height of gate	12″
Cubic contents	1728″
Weight of a cubic inch of iron	.26
Statical pressure	449.28 lbs.

In figuring up the pressure necessary to resist in holding down copes, there are often certain cores which have to be taken into account. The amount of pressure partly immerged cores will exert upwards depends upon their *depth of lifting area in the liquid iron below the top of pouring-gate or head;* and after a core becomes wholly submerged, its lifting force cannot be increased. The difference in weight it would require to hold down a core two feet below the surface of a body of metal, and that required to hold it down if just 1″ or so below the surface, is practically nothing. Any rise of pressure is only attainable while the core remains partly immerged. To illustrate these points, there is shown a submerged core, as seen in Fig. 73; also a core not submerged, as seen in Fig. 74. Supposing the section (Fig. 74) to be eight feet long, it would require $6289\frac{92}{100}$ pounds weight to hold down its statical head-pressure. Adding the cope's and core's weight to the $6289\frac{92}{100}$ pounds, would allow such a poured mould plenty of margin to overcome any momentum of the lifting force. The following two examples show how the $6289\frac{92}{100}$ pounds was obtained: —



Actual Section of Head Pressure. *Average Section of Head Pressure.*

Fig. 73.

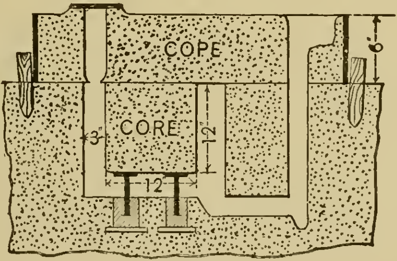


Fig. 74.

Length of lifting surface	96″
Width of lifting surface	12″
Area of lifting surface	1152″
Height from bottom of core to top of basin . .	18″
Cubic contents	20736″
Weight of a cubic inch of iron	.26
Statical pressure	5391.36 lbs.

As this only gives the core's lifting force, the copes must be added to obtain the total lifting power. The metal has a lifting surface of 3″ upon each side of the core; and the depth of the cope being 6″, we have, therefore, the following for the total lifting force of the cope: —

Length of lifting surface	96″
Width of lifting surface	6″
Area of lifting surface	576″
Height from bottom of cope to top of basin . .	6″
Cubic contents	3456″
Weight of a cubic inch of iron	.26
Statical pressure of cope	898 56 lbs.
Statical pressure of core	5391.36 "
Total statical pressure	6289.92 "

The above being illustrative of a core not submerged, we will next notice the conditions of a submerged core, illustrated by Fig. 73, which is a section of a pipe or column which we will suppose to be 12″ outside diameter, the thickness of metal 1″, length of casting 8 feet. In such a mould, it may in a sense be said, that there are two heads to exert a lifting pressure, one being that of the cope, and the other that of the core. From the joint up to the top of the gate, is the lifting pressure of cope. The lifting pressure of the core, as it is submerged, *is the number of pounds of metal its body displaces, minus the weight of the core.*

To make this more clear, suppose we have a pail full of water, into which is pressed a bottle corked air-tight. Now, before this can be pressed down below the water's surface, we will have to displace or allow the water to flow over the pail's edge. The weight of water displaced, less the weight of the bottle, is the pressure required to hold the bottle under the water's surface. Now, this bottle could be immersed as deep as the pail would permit, requiring practically no more pressure than it would take to hold it $\frac{1}{2}''$ below the surface of the water. Returning to the pipe-mould example, the rule for finding its statical pressure will be as follows: —

PRESSURE OF THE COPE.

Length of lifting surface of cope	96″
Width of lifting surface of cope.	12″
Area of lifting surface of cope	1152″
Height from the joint up to the top of the gate.	10″
Cubic contents	11520″
Weight of a cubic inch of iron	.26
Weight of statical pressure	2995.20 lbs.

PRESSURE OF THE CORE.

Length of submerged core	96″
Area of cross section	78½″
Cubic contents	7536″
Weight of a cubic inch of iron	.26
Weight of statical pressure	1959.36 lbs.

Allowing the core to weigh 100 pounds per cubic foot, and having a 6″ print on each end, its weight would be about 520 pounds: this deducted from the statical pressure will leave the buoyancy, or weight required to hold the core down, but $1{,}439\frac{36}{100}$ pounds; which, added to the pressure of the cope, gives us the actual statical pressure such a mould would receive when poured, $4{,}434\frac{56}{100}$ pounds.

A point to be remembered is, that partly immerged cores, similar to that seen in Fig. 74, take their pressure from the pouring-gate or basin height, while with totally submerged cores, as per Fig. 73, the height of a pouring-gate or basin has no effect upon them; for, as above stated, after a core once becomes wholly submerged, its lifting pressure will not practically increase, however high the head or the gate may be carried above it.

With reference to the weight required to hold down cores that stand vertically, similar to the centre core of cylinders, etc., that are cast upon their ends, there is theoretically no lift on a *smooth*, *true*, *vertical-standing* core. The reason that in practice vertical cores require to be weighted down is simply because there is more or less danger of iron getting under them from various causes; or, if the surface of the cores swells, or is rough, the iron may raise it; and, again, cores rarely stand exactly plumb. The lifting-pressure upon vertical-standing, straight cores is one that would not admit of a rule being practically applied, from the fact that the lifting force may, from any of the above causes, be made to vary from practically nothing up to what it would take to hold down the core were its under-surface all immersed in fluid iron. In weighting down vertical cores, one must use judgment as to the chances involved, and weight them accordingly.

A simple plan which could be often used to obtain the lifting-pressure of pipe, etc., cast horizontal, is illustrated by the small cuts *A* and *D* seen at right of Fig. 73. By this plan, lighter pressures are obtained than by the principles set forth in examples on p. 201; and in cases of larger cores than the size shown, it might often be well to add about ten per cent more weight than that calculated by the foregoing for the statical head. It must be understood that the weight obtained by either of these rules is intended to simply give the statical head pressure. To safely hold down the flasks, the weight of the cope is added; and, should the style of pouring adopted be productive of extra pressure, then weight should be added in proportion to the lifting-force thus created. To figure the pressure by this latter plan, as at *A*, we first obtain the sectional area of the half-circle of the core *B*, which is $39\frac{1}{4}''$; then the sectional area of the width of the mould from the joint to the top of the pouring-gate, which is $120''$; the two combined giving a sectional area of $159\frac{1}{4}''$, as at *A* upon the right of

Fig. 73. This, multiplied by the length, 96″, gives us 15,288″; which, multiplied by the weight of a cubic inch of iron, gives us $3{,}974\frac{88}{100}$ pounds, the weight to be placed upon the cope. In practice, to figure the pressure by this plan upon such a cope, I would not take the trouble to find the sectional area of the lifting-heads, but would simply average the half-circle by taking in even numbers fully two-thirds its vertical height, and add it to the vertical height of head above the joint. This would throw the sectional half-circle area into a plain horizontal measurement, thereby giving a horizontal surface to be multiplied by the average inches added to the gate's height, as shown at *D*. The curved dotted lines seen show where the horizontal plane was drawn in averaging the half-circle. To figure the pressure in this way, the example would be as follows: —

Length of lifting surface	96″
Width of lifting surface	12″
Area of lifting surface	1152″
Height of head pressure	14″
Cubic contents	16128″
Weight of a cubic inch of iron	.26
Statical pressure	4193.28 lbs.

Figuring the pressure according to the exact size of the lifting area, as seen above, we obtain $3974\frac{88}{100}$ pounds as the statical pressure. In guessing at the average, as in the last example, the statical pressure obtained, as seen, is $4193\frac{28}{100}$ pounds. This gives a weight of $218\frac{40}{100}$ pounds more than the exact area calls for.

The rule I have here given is one that can, to an extent, be worked mentally, and therefore will be of much assistance in aiding to determine (where time will not admit of figuring) the weight necessary to hold down a cope. To find the weight mentally: *Form in the mind, by mental calculation, a weight equal to the size of the horizontal lifting surface up to the top of the gate.*

While this will no doubt appear very crude, it will, with practice, enable one to become very proficient in the art of guessing, especially if he will occasionally figure to learn how near he guessed. Of course, in guessing there should be a large margin upon the side of safety, as it is not possible that all can guess as closely as it can be figured. The term *statical* here used means acting by mere weight, and is applied to the pressure on copes after the momentum impulse has ceased. To overcome the momentum, *good judgment* must be exercised in determining its lifting force, and in adding weight sufficient to overcome it. If the mode of gating and pouring does not create much momentum, then the statical weight, combined with the copes' weight, will generally be sufficient to hold the copes down.

The decimal .26, here used as the weight of a cubic inch of cast-iron, is not as near as we could figure; but as its use involves the least figures, and it is not far from the most exact weight of a cubic inch of cast-iron, it is adopted.

While upon this subject of "head pressure," it seems a fitting place to present a few notes upon bolting down binders. As will be seen, working plans are shown of top binders. The two sizes shown, I sketched from those in actual use in "our foundry." The design is one which I think is very handy for practical use. Wishing to know how much the bars would spring with a given weight, I had them supported at the ends and loaded in the middle, as shown in the engravings. The end view at Fig. 77 shows the plan adopted in order to load with the shop's weights. Two binders were rested upon solid end bearings, the distance between the binders being 18″. As seen in side view, two flat bars were set 12″ apart, after which the weights, which weighed upon the scales 12,840 pounds, were hoisted on. After being loaded, a template was fitted between the bottoms of binders and iron block *T*, as seen at *X*. The

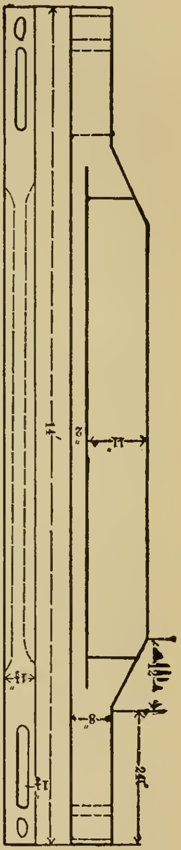


Fig. 75. Plan and Side Elevation of Large Binder.

14′
2″
11″
1½″
8″
24″
1½″

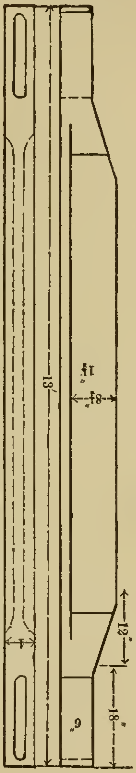


Fig. 76. Plan and Side Elevation of Small Binder.

13′
1½″
8″
12″
18″
6″

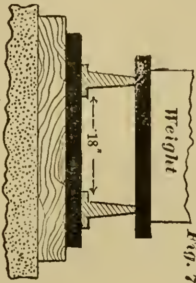


Fig. 77.

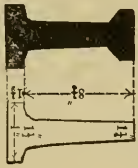
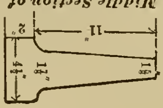
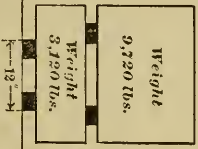


Fig. 78.



Middle Section of Bolting Down Binders.



Weight
9,720 lbs.
Weight
3,120 lbs.
12″

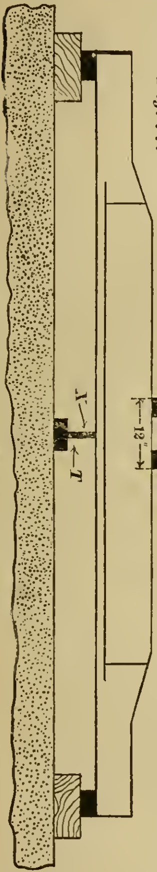


Fig. 79. Deflection of Bolting Down Binders.

weights were now hoisted off. With the top weights of 9,720 pounds off, the binders (Fig. 76) rose up $\frac{6}{32}''$. When the total weight of 12,840 pounds was off, the space between the template and binders showed that this weight had deflected them $\frac{9}{32}''$. The large binders (Fig. 75) were next tested, the same weights being used. With the 9,720 pounds off, they rose up $\frac{7}{64}''$; with the total 12,840 pounds off, the space showed, the two binders had deflected $\frac{1}{8}''$. These experiments are interesting, as it may by them be seen that it is wrong to suppose that a cope cannot rise because it is bolted down. When well bolted down, I am fully aware, it will not rise so as to allow iron to run out, but this is not the rise I refer to. The rise that is likely to occur is where, for instance, there is a heavy lift at about the middle of the binders, such as would be caused by the binders holding down deep cores. It is, as a general thing, when cores have their vents taken off through the bottom of the mould, that we are likely to have trouble through liability of the binders to spring when the head pressure comes upon them. This springing of binders has also often caused castings to be thicker through their centre than the pattern called for, and has been the cause of getting iron into the joint vents.

Taking core vents off through the bottom of mould, is in some cases very risky; for, should they rise $\frac{1}{32}''$, it is sufficient to let the metal strain itself into the vents, and thereby send the casting to the "scrap-heap." Many moulders, to their sorrow, know this to be a fact. All binders will spring more or less. When there is danger of iron getting into under-vents, we should weight down the centre portion of the binders to the best of our judgment, so as to resist the tendency of any spring. While the design of binders here shown is very good, I think were a bottom flange cast on them, as seen in Fig. 78, the stiffness, by the addition of a few pounds of iron, would be greatly increased.

As nearly all copes at the present day are weighted by guess-work, and some by no thought whatever, the rules and fundamental principle herein set forth may be of use. While the rules will be of value in aiding to determine cope weights, it must be remembered that there are a hundred and one things that no rule can cover, which has been practically stated in article on "Weighting Down Copes," vol. i. *Good judgment*, backed by *experience*, must be our guide in successfully providing for copes standing that often-dreaded test, — "head pressure."

MISCELLANEOUS CHAPTERS.

ELEMENTS AND MANUFACTURE OF FOUNDRY FACINGS.

Foundry blackings have always been more or less a bone of contention between the user and manufacturer; the former complaining of inferior goods, and the latter of ignorance in their use. There is no question but both are often right. Blacking can be of an inferior quality, and can also be ignorantly used. There are two things that stand in the way of investigating the qualities of blacking said to be poor. The first is, not knowing of what material it is made; the second, the moulder's readiness to find any excuse for rough-skinned or scabbed castings.

The manufacturer of blacking is very frequently censured for that used on heavy work. One reason for this is in the high quality required for such work, and the fact that the moulder is called upon to make mixtures or washes of blackings before he can apply it to the mould. In this class of work, more than in any other, the manufacturer receives much unjust censure. In vol. i. p. 208, it is fully shown wherein much lies with the moulder in properly mixing blacking, and in putting it on his mould, in order to produce smooth-skinned castings.

Blackings are often condemned that in reality are too good. Almost any blacking will cause trouble if not understandingly used. One complaint, often heard with light work, is that of blacking sticking when being printed or sleeked. Another is that of its washing or rolling up when pouring the mould. This last complaint is in reality a serious one, and one which the moulder is justified in making. A blacking which will wash lacks cohesion, caused either by too coarse grinding or the want of a bond. The materials chiefly used for binding, or preventing blackings from washing, are leads and other minerals, and clays. Our heavy blackings are principally composed of carbon, coke, and anthracite, with the above-named bonds. The finer ground blackings are, the more cohesion and body they will possess, which makes them a better wash and dust for moulds. For a dust, fine-ground blackings are generally more or less sticky. In fact, it is generally an evidence of good quality and mixture, to have blacking sticky. A blacking that will stick while being sleeked or printed can generally be relied upon to "peel" well. I know moulders dislike to work with sticky blackings, and condemn them. Of course, what we moulders want is a blacking that will "peel" well, and that will not stick. To thoroughly combine these two qualities in rich or heavy blackings, is one of the things facing-makers seldom accomplish. To assist the sleeking and printing of sticky blackings, charcoal is extensively used. In stove-foundries the moulders generally have two bags; one containing the peeling or heavy blacking, the other the charcoal. The heavy is first shaken on, then the charcoal. To make a nice "print," the pattern should be well brushed and dry; and in shaking on the blackings, let the dust of the heavy blacking settle before the charcoal is shaken on, for shaking one bag immediately after the other causes the contents of each to become more or less mixed, and thus the full benefit from the charcoal is not obtained. To the objection of the loss of time, it might be said, after shaking on the heavy blacking as soon as the pattern is drawn, then, while waiting for the heavy blacking's dust to settle, the time might often be employed in drying and brushing off the patterns; then, when every thing is ready, they can shake on the charcoal, and work as fast as possible until the pattern is drawn. If the speed is such as to get out the pattern before the charcoal becomes damp and incorporated with the heavy blacking, the "print" should be perfect; and in many cases there would be no time lost. Of course brushing off the pattern first allows it more time to dry. Nevertheless, if a good print is desired, by having a dry pattern, and following the above rule, it will not be the moulder's fault if it is not obtained. A blacking that will not print well can often be sleeked; and, in many cases, charcoal is as beneficial in helping to finish a mould which is sleeked as one which is printed. Charcoal is valuable in either case as long as the mould can be finished before the charcoal becomes damp, but after that more or less trouble may be experienced.

When blacking sticks, not only does it cause vexation and loss of time, but is often the cause of rough or scabbed skinned castings.

In the author's experience he often has had large green-sand moulds, which took a man half a day to sleek the blacking on them: were the blacking sticky, much trouble would be experienced, no matter how much we might try to "doctor" it with charcoal. Where it takes a long time to sleek a blacked green-sand mould, and the blacking becomes sticky, we find the dust of silver lead an excellent thing to use, and we often use it over ordinary blackings whether it is sticky or not.

With a few foundries it is becoming quite a practice to coat their moulds entirely with silver lead; and these moulds, when done, will shine like a mirror. The lead is chiefly used on account of its peeling qualities. In putting it on a mould, many use camel's-hair brushes; and, again, others will shake it out of a bag, or throw it on by hand. Of course lead is expensive, nevertheless it has become very popular to be greatly used.

Not only is charcoal good to assist bag-dust sleeking, but it also is an excellent article to have on hand for mixing with wet blacking. It frequently happens that blacking contains substances of a very close or non-porous nature. These will often cause "blacking scabs." The introduction of a small proportion of charcoal will often remedy this; as the particles, being very light and porous, open up the pores of the mixture so as to cause the metal to lie more kindly to it.

The use of blacking is simply to coat the surfaces of the mould with graphite or carbon, to prevent the heat of liquid iron from fusing or eating into the sand. Moulding-sands are composed more or less of silica, together with smaller quantities of potassa, lime, magnesia, oxide of iron, etc. The potassa, lime, magnesia, and oxide of iron, are the parts that fuse. They combine with the silica to form silicates, or a kind of glass, which, upon heavy castings, may form a scale from $\frac{1}{32}''$ to $\frac{1}{2}''$ thick, where the sand is not thoroughly protected with a coat of carbon, or, commonly speaking, blacking. All black leads consist chiefly of carbon; the other ingredients being alumina, silica, lime, iron, etc. The freer leads are of these latter ingredients, the more intense heat will they stand before they will fuse. There are some leads, it is said, that no heat will fuse. As all good blackings are composed more or less of graphite, or, commonly speaking, leads, the reader will readily perceive the cause of their preventing liquid iron from eating into the surface sand of moulds, and why they provide for smooth-skinned castings. Of course, it is to be understood most blackings are but partly composed of leads. The more lead blackings contain, the better they are for peeling. This applies to loam as well as to green-sand moulds. Consequently the larger per cent of graphite or lead blackings contain, the better. But as these blackings are expensive in proportion to the amount of graphite they contain, and as many foundrymen overlook quality to buy cheaply, it offers a premium to the manufacturer to use cheap materials in order to make cheap prices. The cheaper blackings are composed principally of Lehigh, coke, or gas-house carbons, with additions of various minerals, and contain little or no leads. Lehigh, coke, and carbons are seldom ground pure. The particles, as generally powdered, will lack cohesion, and therefore would be apt to float or wash when pouring green-sand moulds; therefore the necessity of their mixing in the various kinds of minerals or clays to obtain the required cohesion. The finer pure Lehigh, coke, or carbons are ground, the more cohesion will they possess. When ground *very fine* (which is something seldom accomplished), their cohesion may be sufficient to hold them without the use of any bond.

The author, having for about two years been employed almost next door to the Cleveland Facing Mills, obtained from the mill's former manager, R. J. Hayes, an excellent insight into the manufacture of blackings. It is not a little surprising, the amount of machinery and care required to turn out modern blacking. It would be a tedious job, and tiresome to the reader, to go into a minute description of the different crushers, pulverizing machinery, etc , required to reduce the carbons, coke, Lehigh, leads, etc., which go to make up to a great extent our foundry blackings. The machinery is to some extent similar to that of flouring-mills. The materials being hard, they are required to pass through several reduction machines before they are fed to the mills, after which they pass into the bolting-reels, where they are sifted through silk cloth, containing, it is said, about twenty-nine thousand holes to the square inch. All particles too coarse to pass through the cloth are let out at the end of the reels, and returned to the grinders. A facing-mill, so far as dust is concerned, is probably the dirtiest shop to be found. When in full operation, one can hardly breathe, or see any thing but dust. The least generator of dust is that commonly called sea-coal facing. The making of this blacking requires the least labor and manipulation of any with which mills deal; as it is simply the product of a bituminous, or, as it is sometimes called, stone coal A great many take it for granted, that, because this blacking is called sea-coal, it is in some way a sea-product. Sea-coal is not what its name implies. It acquired this name many years ago, when introduced as a fuel in England, being carried by sea to London; and this misnomer still clings to it.

In this country, the sea-coal used in our foundries is principally derived from the mining regions of the Youghiogheny River and the Cumberland districts, and is selected for its freedom from slate and sulphur, and its gas-bearing qualities. The quality of sea-coal blacking is less variable than that of any other blacking made, simply from the fact of its not being mixed with any other substances. Sea-coal, being mixed in with the sand, divides the particles, or fusible element of sand; and what it don't divide it emits its gas among. The hydrogen and carbon sea-coal contains prevent, to a degree, sand fusing. There is a limit to the percentage of sea-coal that should be mixed with sand. When more than one of sea-coal to six of sand is used, unless the surface of the mould be well coated with *good blacking*, and the metal *poured dull*, there is in the heavy body of metal moulds much danger of the surface of the casting being more or less streaked or veined. *Thorough mixing of facing-sand will, to a large degree, prevent this defect.* When iron is poured into a mould faced with sand containing sea-coal, there is much gas generated. This gas, if not driven off by pressure, forms more or less of a cushion between the surface of the mould and metal. This cushion often prevents the iron from running into the corners and edges of moulds, and also often causes cold-shuts and smooth concave indentations in castings. Moulds having been poured with dull iron, although the casting may be heavily proportioned, will often present some of the above defects. In faced moulds, more or less of a gas cushion is raised; and according to the amount of pressure, and the fluidity of the metal, the faster this cushion is destroyed. When strong facings are used upon thin castings, or those poured dull, the metal often becomes set before this cushion is all destroyed. Sometimes sea-coal causes the surface of castings to be covered with a coat of what might be termed coal soot. This, to occur to any great extent, requires certain conditions that seldom happen to combine.

In mixing facing to assist in obtaining a full run and smooth-skinned casting, the moulder has often many points to consider. Many moulds are made that require two or three different grades of facing, such as one part to six, eight, or ten; and not only is the proportion and position of the different parts of castings to be considered, but time of pouring, and intended fluidity of metal as well. The amount of sea-coal to use, according to conditions, and suggestions upon the subject, will be found in vol. i. p. 363.

As Lehigh, coke, graphites, and gas-house carbons form so great a factor in assisting the peeling of castings, a short history concerning them may be interesting. Lehigh is simply a fine quality of Lehigh coal, chiefly obtained from the anthracite districts of Pennsylvania. It is essential that only the best quality should be used, as poor Lehigh containing slate and what is known as "nigger-head" would not contain the amount of carbon required to make good blacking.

Coke blackings are principally made from "Connellsville coke;" it being selected on account of its fixed carbon, said to be as high as ninety per cent.

Carbon, or gas-house retort slag, being a pure carbon, would, were it not for its hard, refractory nature, be more extensively used. Its hardness makes it difficult to be ground and bolted as fine as is necessary to make good blacking: therefore, when used, it is mixed with minerals that will overcome, to a degree, its refractory nature, and give it cohesion, which it lacks in a much greater degree than either Lehigh or coke. To give these refractory substances — Lehigh, coke, and carbon — cohesion, the class of material used has much to do with the peeling quality of the blacking. The more carbon the ingredient used to give cohesion contains, the richer and better the blacking to withstand heat. As leads contain the highest cohesive heat element, and are such an important factor in facings and blackings, a few lines upon their nature may not be out of place. A very fine grade of close-grained graphite or lead, and one extensively used, comes from Bohemia, Austria. *Not only is this lead used in blackings, but also enters to some extent into the manufacture of stove-polish.* Probably the most expensive lead used is that which is mined in the island of Ceylon. In its crude state, it looks like bright chips of burnished silver, from which fact it is commonly called silver lead. This is a very useful article, not only for mixing with blacking for green and dry sand, and loam work, but is also a splendid article to dust, in a dry state, over the surface of blacked moulds ; as it greatly assists the sleeking of the mould, and peeling of the casting. This lead is also ground for electrotyping purposes, and is extensively used as a lubricator for cylinders, etc. While mentioning the leads produced abroad, America has also some mines of note : one especially, near Ticonderoga, N.Y., produces an excellent article, which is extensively used in making lead-pencils. North Carolina produces quantities of lead ; but as it is largely mixed with clays, hornblende, and other foreign substances, it is not of much value. Eastern Pennsylvania has several mines ; but as the lead requires so much treatment in cleaning, it is not very profitable to the producer. Tennessee has also vast beds of leads, more or less mixed with clays. Nova Scotia produces a lead which on account of its hard, flinty nature has so far been but little used. The leads of Ceylon and Europe, surpassing the home product, are therefore the ones chiefly used.

Charcoal, to make a good dust, requires to be made from hard maple wood, and burned with great care. Soft or any stringy-grained wood is not adapted for making charcoal facings. Stringy-grained wood preserves its stringy nature when charred, and makes a harsh powder when bolted. Soft-wood charcoal is even worse ; as it lacks the body necessary, being so light it will float or wash.

A product not yet mentioned, and one sometimes used in foundries and mixtures of blackings, is soapstone.[1] This is found in many of the States, and is by some foundries used quite extensively, while others condemn its use on account of the light color or skin it gives to castings.

It is a well-known fact, that, although moulders use blacking every day, but very few have the least idea of its manufacture, or properties which cause it to peel castings.

This article may be effective in drawing attention and study to a material which, before it can be intelligently purchased or used, requires some knowledge of its constituents and manufacture.

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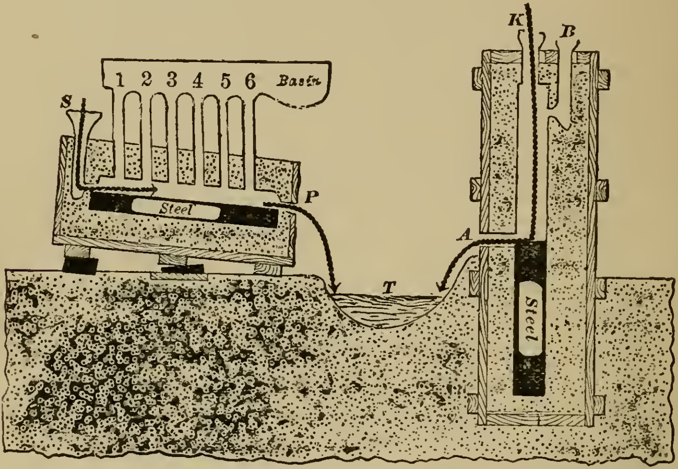
[1] A substance similar to soapstone called talc is now being much used and can often be mixed with or be made to take the place of lead in dry as well as wet blackings, to be effective in turning out a good smooth skin on castings.

WELDING STEEL TO CAST-IRON, AND MENDING CRACKED CASTINGS.

Can wrought-iron or steel be united to cast-iron? is a question that is sometimes asked. Either can be so united, but in the case of wrought-iron the union is so weak that for any purpose requiring strength it is useless. With steel, the point of union will be stronger than the cast-iron: at least, I obtained such results in experiments upon different brands of steel. Uniting steel or wrought-iron to cast-iron, by the process here set forth, is, as far as I know, original. I have made many inquiries from well-informed parties, and all say they never heard of its being done before.

The principle here involved, of uniting steel to cast-iron, is similar to that which foundrymen call "burning;" and therefore the strength of the union will depend greatly upon the shape to be united, and on the plan adopted for uniting the pieces. In the "American Machinist" of Jan. 15, 1881, is the writer's first attempt at mechanical literature, in the shape of an article upon "Burning Heavy Castings." This article, also seen vol. i. p. 267, sets forth the proper principles to adopt in mending, or burning, when its adoption is practicable.

In the cuts shown with this, Fig. 82 illustrates the old-fashioned style of burning, and the one which, even at the present day, is quite generally employed. This, in some cases, is excusable; but it is a poor plan to use it for every job that comes along. In the first place, there is much more metal required to burn or make a union; and, in the second place, the burning or union is seldom so thorough as by the plan illustrated in Fig. 80. At *K* the ragged line represents the dropping metal falling directly upon the materials to be united: the fluid metal, by its striking force, soon eating into the solid. By the old-fashioned plan (Fig. 82), this eating process is lost, from the fact that the falling metal can strike but a very small portion of that to be burned. If a union is made, it has to be caused entirely by the metal's heat and flow; as its falling force counts for but little. *E* represents the metal flowing into the cavity *F*, and *H* its flowing out. The inlet-gate being higher than the outlet, there of course is a current, upon which mainly depends the success of the operation.



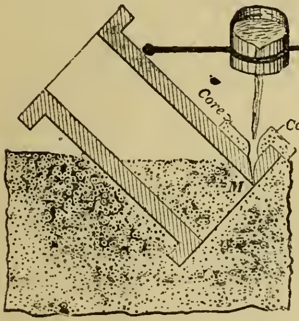
Uniting Steel to Cast Iron

Fig. 80.

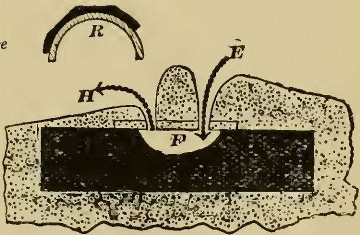
In jobs of this kind, the heat of the metal, length of flow, and nature of the work, must be carefully considered in deciding as to the strength of the union. Sometimes, by testing with a hammer the solidity of the parts may be determined; but, as a general thing, observance of the points named is relied upon.

In the burning of castings, *invention* and *judgment are called for, as the exact operations suitable for one job will seldom do for another.*

In the engravings are represented four plans suggestive of ideas in the art of burning. Having noticed two figures, Figs. 80 and 81 will be referred to. The left of Fig. 80 represents the burning of large flat surfaces. The reason the mould is inclined is to insure keeping bare the material to be burned or united to the cast-iron. In this cut are embodied two plans of gating. At *S* is an inlet-gate, placed so as to be opposite the outlet *P*, thereby causing a flow over the entire surface. Were the surface broader than 2″, there should be branch runners cut from the main gate *S*, to assist the spreading of the metal over the entire surface. The basin and gates, Nos. 1, 2, 3, 4, 5, and 6, give ideas to show how the metal may be made to drop directly on the surface. The inclination given the mould should not be more than enough to insure an easy flow. In the burning or uniting of large surfaces, it is best, when practicable, to have the plate or body which is to be united to the cast-iron made as hot as possible; for, the



Mending a Cracked Flange.
Fig. 81.



Old Fashioned Style of Burning.
Fig. 82.

hotter the plate, the less fluid metal will be required to make a weld.

In some cases the steel or wrought-iron might be heated in a forge or furnace until the face to be united was about at a fusing-point; then by quickly placing the body in a ready-formed mould (which would, of course, require to be made of some such a material as loam or dry sand), and covering it with the cope, the liquid cast-iron would require little if any "flowing through" in order to make a weld. Such a process would also be commendable in view of its diminishing the contraction strains. The strains that must exist in large surface bodies that are welded with such a difference in temperature as the "cold-burning" process demands, cannot but be serious, and often the cause of fractures or cracks in the welded body.

The cut of the "mending a cracked flange" shows a plan that may be applied in various forms. The section represents the actual burning of a cracked flange by Robert Watson, in Todds & Co.'s foundry, Leithwalk, Scotland. The casting was a cylinder, one flange of which was cracked half way around. The casting being placed in about the position shown, the parts around the crack were covered with cores, to prevent the metal from striking or burning other than the portion intended. The cores were made in short sections, and, of course, expressly for the job. In mending the cracks, it was done in sections of from 6″ to 8″ in circumference at a burning. The stream of metal would fall directly into the crack, until it was seen to have cut about ⅜″ of an opening. After each burning became solid, the cylinder, having a chain around it hitched to the crane, would be rotated into place for the next operation. The arrangement at one end of the portions to be burned was such as to allow the metal to run off, thereby preventing the gathering of a head that would prevent the falling stream from forcibly entering the crack. The point of "run-off" would be about on a level with the highest point of the circumference As iron runs level, the surface of the mended portion would present something like the section *R*. This unevenness could, to some extent, be chipped off, so as to leave a circle as near as could be without doing injury by jarring. As soundness, not symmetry, was the point sought, a little roughness was not objectionable. In burning such a crack, there is a liability that the hot iron will eat its way through, and leave the inside, at *M*, rough. To prevent this, cores could be made to the proper circle, and firmly rammed up against it, or a loamy facing could be used at this place. As to the success of the operation, Mr. Watson says that the cylinder, about two months after the operation, was returned to have the balance of the flange mended; it having cracked, while the mended portion remained as sound as any portion of the cylinder. Some may argue that the first burning was the cause of the second crack: it may have been so. And this is a point that should be often considered; for, no doubt, such burning will often cause more or less strains elsewhere. To assist in preventing this, the casting to be burned should be made as hot as practicable, either by placing it in an oven, or by surrounding it with fire or hot irons. In this case the casting was not only heated in the oven, but hot scraps of iron were placed upon it. The crack was mended during the time of one heat; and, as Mr. Watson puts it, he never worked more lively nor sweat so much in his life.

As already stated, steel and cast-iron can be united. I will further explain the cut at right of Fig. 80, as it may present ideas in arranging for the union of many differently shaped articles.

This mould represents the uniting of a piece of steel 1″ square by 12″ long to the same-sized piece of cast-iron. The process was as follows: A pattern 1″ square by 24″ long is rammed up in a flask. In the bottom board, as shown, is a hole about 2″ in diameter. This admits of ½″ thickness of sand to prevent the hot iron which runs through the 1″ hole from burning the board, and also causes more surety in plugging-up; for, were the hole surrounded with wood, the hot iron would burn itself through, and make the plugging-up a blundering job. It would be better in all cases if iron plates were used instead of the wooden bottom boards. In fact, if all the flask were iron, it would be best. The mould having been made, the piece of steel is laid in, and the mould closed. Then, after being firmly clamped together, it is up-ended in a pit, as shown; and then, with about a hundred pounds of hot iron, start pouring a steady small stream. When within about twenty-five pounds of the end, slacken the pouring, so as to have but a small stream, at which time let the outlet *A* be *quickly* and *reliably* stopped. After this, quicken the pouring until the mould is filled up. *Properly stopping the outlet is very essential; for, if not done successfully the first time*, it is as injurious to the burning as is slow, blundering welding at the blacksmith-forge. A good plan for stopping is to securely place a pointed ball of clay on the butt end of a rammer or iron stopper, make sure aim, and firmly hold the hole closed until the metal is set. The gate *B* illustrates the use of side inlets, should it be desirable to burn more than one piece in the same flask.

The burning of steel is by no means restricted to straight bars. A variety of forms might be united by simply making the moulds the shape of the article wanted, and then placing the steel in its proper place. The gates could be often formed, and the mould so placed as to have the hot cast-iron flow over most of the exposed surface, to an outlet. In some cases, there might be a necessity for more than one outlet, as well as inlet, to which there would be no objection. The point to be aimed at is, to *have a dead fall upon all possible exposed parts, and an outlet from same if practicable.* With many moulds, it would be better were they of dry sand, or loam; as the dropping and washing of much running iron would often cause a green-sand mould to produce a rough-skinned job, and cause dirt in the mould, which would of course be injurious to the work.

Cast-iron used for burning purposes should be very soft, and the temperature of the melted iron as high as possible. The reason for giving soft iron the preference is simply because soft iron does not chill as quickly as hard iron, and will retain its life or fluidity longer, and also will form a stronger union. The amount of iron to use for burning purposes will *be regulated by the class of burning to be done, and condition of the iron used, etc.* For direct falling upon plain square or round surfaces, the following table might in *some* cases be used. The table at its best is but a rough approximation; for in some cases it might be in excess, and in others it might prove deficient. In burning any work that needs a steady stream, we should have plenty of iron; then, in the methods which have been described, and by the use of good judgment, we should be able to decide when sufficient metal has been poured in; then the pouring can be stopped, and the remaining metal used for pouring other work. The amount of iron that may successfully burn a like piece of work to-day may to-morrow be insufficient. There are many things which cannot always be controlled in giving to any calculation a certainty of assured success for burning or mending castings.

For a surface of 2″, square or round, use 250 pounds; 3″, 400 pounds; 4″, 550 pounds; 5″, 700 pounds; 6″, 850 pounds; 7″, 1,000 pounds. Above 7″, for every additional inch added to the square or diameter, add 200 pounds. This, if continued up to a surface of 20″ square of round, would call for 3,600 pounds of hot iron to accomplish the burning (for the square surfaces, it might be well to add about ten per cent to the given weights). A point that might be well to mention is that the parts to be burned should be chipped, or the scale removed, so as to give the fluid iron the best possible chance to eat into its surface. Any who are interested in this subject will find additional information in the article "Burning Heavy Castings," vol. i. p. 267. Before closing it might be well to state that the softer the metal is in the *cast-iron casting* to be burnt, the better the chances are for making a successful weld, and also the less is the risk of cracking the casting during the operation or afterward. After the burning, the slower the cooling, the less the danger of checks or cracking. In many cases it is well to keep the casting warm as long as practical, by surrounding it with hot scraps of the iron used for the burning.

The subject of mending or burning is one well worth studying, and one that generally calls for good judgment and experience. *Before a novice undertakes a difficult job of this kind, it would be better for him to experiment with unimportant pieces.* Burning is a job that seldom can be done twice, on account of the surface losing much of its life or texture. Should the second burning be required, the fractured surface should be cut down until good metal is again seen; but in all cases use all *precaution towards making the first burning a success.*

FOUNDRY ADDITION.—OVENS AND PITS.

THERE having been built a large addition to a foundry in which the author has averaged ten hours per day as foreman for about six years (the Cuyahoga Works, Cleveland, O.)[1] it has occurred to him that a description of the laying-out of the ovens, moulding-pits, and cranes might interest others, and give ideas which would be applicable in other instances. The black border represents the outline of the foundry. The new shop, as shown, is partly divided from the old shop by the partition-walls *A B*. In the old shop, there are four cranes, two cupolas, brass furnaces, moulding-pits, etc. As there is nothing except their antique history that could be set forth to interest the reader, I have omitted showing a plan of the old shops, cranes, pits, etc., and devoted the space to showing section-views of the loam-pit, ovens, etc., of the new shop. Credit is due the president of the works, J. F. Holloway, for providing for comfort, and furnishing handy facilities for the new shop; no expense being spared to provide every thing requisite in that direction. We have abundance of light and ventilation, steam-cranes that rapidly do the moving of heavy loads, excellent moulding-pits, and ovens that surpass any I know of for *properly* drying moulds or cores. Although we use slack or soft coal for the fires, a mould or core will, when dry, be almost as clean as when first put into the oven. Another important feature is, that the ovens will dry rapidly, and still not burn, a mould or core.

The three ovens, as will be seen, are fired from one pit. The draught flues being at extreme ends of the oven, and the channel for heat to travel being diverted from side to side, there is but a small chance for heat to escape entering through the joints and thickness of the boiler-plates up into the oven before it can enter the flue at *F*, *H*, and *K*. The arrow-like lines represent the heat passing from the fires to the flue. The partitions, ×, divert the direction of the heat, and also support the covering plates and carriage-track. A clearer idea of partitions, etc., may be had from the elevation of the oven at *K*. The covering plates, 2, 3, 4, 5, 6, and 7, are boiler iron $\frac{1}{4}''$ thick, cut into sections the width of the flue's partitions. As neither of the ovens is partitioned like another, the sizes of plates all differ. The core-oven plan is shown having the plates and track laid. As will be seen, the plates upon the outside of the track, which are shown black, are free at any time to be lifted, in order to clean out the soot. Were the plates in one continuous piece, the width of oven, then to clean out the ovens under flues would necessitate the lifting-up of the carriage-track. Where the fire enters the first flue or partition, the boiler-plates are left out, and in their place a cast-iron plate $\frac{1}{2}''$ thick, having prickers 2″ long, and daubed up with fire-clay, is used. This is to prevent the direct flame from buckling and burning out the plates.

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[1] The Cuyahoga Works was sold Jan. 1, 1887, and is now known as the Cleveland Ship-Building Company. The author has resigned his position with this firm, and is now a member of the Thomas D. West Foundry Company, of Sharpsville, Pa.

There are no holes whatever in any of the plates; the heat passing through them and their joints, which, of course, are not air-tight, heats up the oven. Were there holes in the plates, they would seriously injure the draught of the under flues, and also let much smoke into the ovens, thereby destroying essential points to be overcome in using slack for firing. To be able to fire with slack or soft coal, and still keep moulds and cores free from soot, is something that will be appreciated by all moulders and core-makers that work around ovens. Not only does soot make every thing look dirty, but it is more or less productive of rough castings.

Another arrangement which I doubt being found in any other foundry oven is that for preventing smoke. Upon each side of

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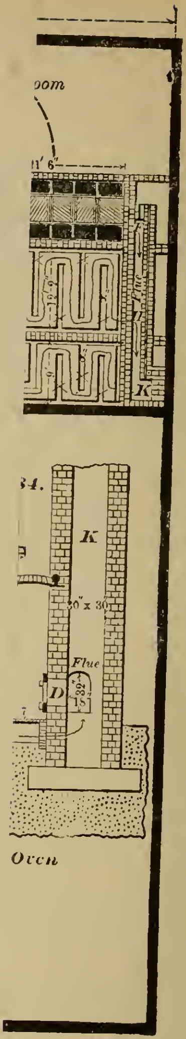

oom
1' 6"
Flue
H
K
34.
K
30" x 30
Flue
D
32
18
Oven

the fireplaces, about on a level with the fire, are ⅜″ openings, seen at *E* in elevation. To admit air to these openings, there are channels leading from the outer fronts. In the rear of these openings, the brick is left open about 4″ x 6″, running the entire length of fireplace. This opening gives a reservoir in which the air becomes heated before being drawn into the fire. This is, I believe, claimed to be beneficial in assisting "smoke-burning" or combustion.

The grate surface for the fires contains an area equal to about 32″x 38″. The fireplaces are all faced with one thickness of fire-bricks, and the tops of fireplaces are arched over with fire-bricks. Under the large oven are two fireplaces. The one nearest core-oven is used for heating the same, and is so constructed, with damper arrangement, that, should an extra heat be required in the large oven, both of the fires can be turned on to it. As shown at *D*, in "elevation of oven," each oven has a small man-hole door whereby the flue leading to the chimney *K* can readily be cleaned.

The tops of the ovens are covered with a series of arches. Fig. 83 shows how the wrought-iron girders, Fig. 84, are held together. For the two small ovens, two rows of bolts are used; for large oven, three rows. Upon the tops of these ovens we store and keep shop-tools, etc. The way the tops are formed, tons of weight can be laid upon them, and do no harm; and the combined area of the tops makes a splendid storeroom for systematically keeping foundry tools. Altogether the ovens are a success, and a credit to their designer, the late Mr. Holloway.

A very novel and no doubt good plan for heating up ovens is that to be seen in Mackintosh & Hemphill's (Fort Pitt Works) Foundry, Pittsburgh, Penn. The foreman, William H. Conner, informed me that they dried their moulds and cores by the use of "natural gas." The old fireplace, which had been used for firing with coal, was simply filled up with bricks thrown in loosely: then, a small shaving fire being started, a very light

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jet of the gas was delivered among the bricks. The gas, when ignited, raised the bricks to a white heat; and the heat which they would throw off heated up the oven.

The loam-pit shown is made up of four cast-iron rings, the thickness cf rim being 1⅜″. The castings were made from a segment about 24″ long. The rings have a taper of 1½″ to the foot, and when together form steps, as shown. These steps are very handy for building staging upon, or standing on, and in getting in and out of the pit. When moulds are so small as not to sufficiently fill the pit, we ram them up in curbing; the mould, of course, being in the pit. When such moulds are cast and ready to be taken out, they can be hoisted out altogether; or a few of the bolts are loosened, and the curbing hoisted up. This leaves the sand free to be shovelled up, and castings taken out. Were the mould sufficiently large to fill the pit, the sand rammed between the mould and cast-rings would then, of course, require to be shovelled or dug out. In such a case, the benefit of the taper of the pit is seen. The taper allows the shovel to free the sand much easier than were the pit straight. When the pit has been dug down to about half its depth, if the mould and casting are not exceptionally heavy, the two cranes can be hitched on, and the whole hoisted out without further digging.

Making the pits with cast-iron rings provides something solid and reliable; which is as cheap as, if not cheaper than, any of the other styles commonly used.

Many will wonder at, and not comprehend, the use of the "entrance-pit" shown. For many shops, there is no call for such an under entrance; and, again, there are many shops where it would be found very useful. An under entrance, such as shown, is an excellent vent channel for safely venting moulds similar to cylinders, etc., having heads cast on as shown on p. 56. Not only with us is this channel handy for carrying off vents; but it is a necessity on account of the shop's old established custom of making cylinders, the plan of which is shown in the chapters "Casting Whole or in Parts" (p. 54), and "Moulding a Jacket Cylinder" (p. 60).

As will be noticed, the pit is entirely under the swing of one crane: the other crane reaches to about its centre. The location of the pit gives us all the advantages possible: in fact, the plan of every thing we well studied in order to utilize every part of the shop, and make it as handy as practicable. The pit is out of the way of the green-sand moulders; and the loam-moulds can, without any changing of cranes, be taken off the oven-carriages, and lowered into any portion of the pit; and when needed the mould can be poured with two crane ladles.

The plan of the core-maker's portion of shop is one which would be hard to equal for heavy work, being handy and out of everybody's way. The oven is right at the core-maker's hand, and he has a crane he can use at any moment.

The loam-moulders work under the same crane that loads the oven-carriages, and in a portion of the shop where they are not interfered with by any other class of work.

The green-sand bolting-down floors are, I think, shown plainly enough not to require description.

Fig. 85 gives the dimension of the binders laid in the bottom of bolting-down floors. The dots shown, and numbered 1, 2, 3, 4, etc., locate the distances of the bolting-hooks shown at Fig. 86. The square end fits the binders, and the round eye is the end into which screw-hooks are hitched when bolting down a cope. The tops of the hooks, Fig. 86, come up within three or four inches of the top of moulding-floor. From the top of floor down to top of planks upon bottom binders, will average eight feet The half of longest bolting-down floor, towards the ovens, is over nine feet deep. This gives us a good chance to sink bottom parts of moulds made of loam, upon which green sand is made to form the upper portion of "deep moulds." This is a much-practised custom with us in making deep green-sand moulds, as it prevents bottom straining. This long bolting-down floor is set slanting with the square of the shop, so as to admit of its being reached at any portion by a crane, and also in order to bring the end nearest the oven under the loam end crane so far as practicable in order that the bottom parts of moulds in the loam may be taken direct from the oven-carriages, and lowered down into the moulding-floor. The reason we did not make the shortest bolting-down floor longer than shown was because we expected to be obliged to sink a small loam-pit between it and the large loam-pit shown.

The "delivery track" shown conveys the iron from cupolas up to the cranes, and takes the casting out to the yard crane. One car answers both purposes; and, as the subject is of interest, it is shown on p. 232.

It is to be understood that this plant is not given as a model to construct from, but simply as illustrative of ideas that in many ways may be of value in helping to locate shop tools, etc., to the best advantage, and also aid in getting foundry builders to learn that the day has passed for them to think "any thing is good enough for a foundry."

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LADLE AND CASTING CARRIAGE COMBINED

The engravings seen are perspective and plan views of a carriage used in "our foundry." Wishing to "kill two birds with one stone," I devised it so as to be safe for conveying large ladles of metal as well as heavy castings.

With the ladle set in the car, should any thing break, it could not fall more than two inches, nor is there any danger of the ladle sliding or falling off the car. To see a heavy ladle full of fluid iron away up off the ground, does not inspire one with feelings of *security* or *confidence*, although it may be perfectly safe. Many shops that are obliged to truck their metal and castings have two cars, one for ladles, and the other for castings. I think many of them would prefer to have one, could it be made to answer the purpose of both.

The construction of the car is very simple, and it costs but little labor to make. The car was cast "open sand;" the ladle-box was formed with a dry-sand core. The holes as *B*, *E*, *K*, and *F*, made a good bearing for the box-core to rest upon. These holes were cast in for the purpose of lightening the casting.

The pockets, as at *H H* (Fig. 88), are simply for the purpose of placing in arms, should a wider carriage be desired. The carriage-wheels are 16″ diameter, and are cast solid. The axles are wrought iron, 3″ diameter, and were cast in the wheels. Before the axles were cast in the wheels, they were used as chills to form the carriage's axle bearings. The axles at this time were $3\frac{3}{16}$″ diameter. After being cast in the wheels, they were turned down to 3″ diameter, in order to make them ex-

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actly central with the wheel rims, and at the same time to leave a little play in the bearings.

The cap, as seen at *R*, is made hollow, so as to form an oil-box in which waste saturated with oil can be kept. The leathers over the axles, shown in view (Fig. 87), are for the purpose of keeping out dirt.

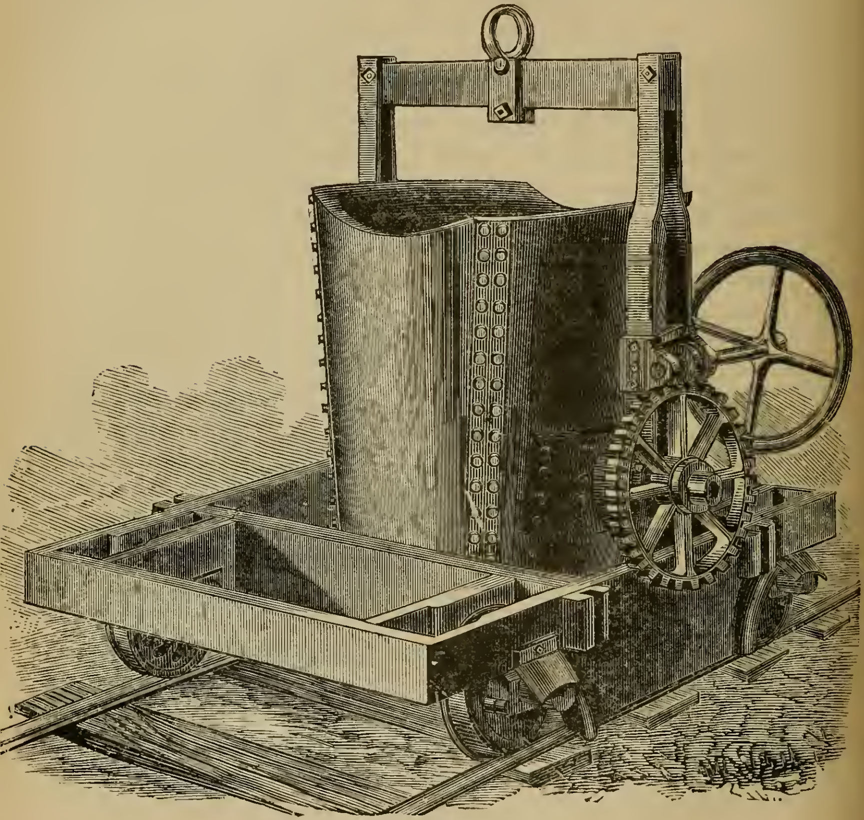


Fig. 87.

I think the practical man will see that the plan described is one which should cause a heavy carriage to run easily. Although this carriage weighs about forty-five hundred pounds, two men can readily move it. For pulling heavy loads, we have a wire cable arrangement which is operated by power. The carriage-wheels might by special arrangement be made with their axles run in "anti-friction" bearings similar to the method set forth in "Travelling Crane" (p. 414), if one wished to improve upon the car shown. In making such anti-friction bearings, it must be remembered, very "fine fits" are necessary to make the bearings a success.

The perspective view of car shows it loaded with one of our crane screw-ladles, which for simplicity in design and good working is worthy of notice. The hand-wheel is detachable, and the rim of same is made of wood. This prevents it from becoming hot from the ladle's heat, thereby leaving it free to handle.

While the carriage shown is applicable to but few shops, it may give ideas that some time will come in play in others. To state the most weight such a car should carry, is at its best but guess-work: however, I would say, that, if squarely loaded over the axles, the car should carry thirty tons.

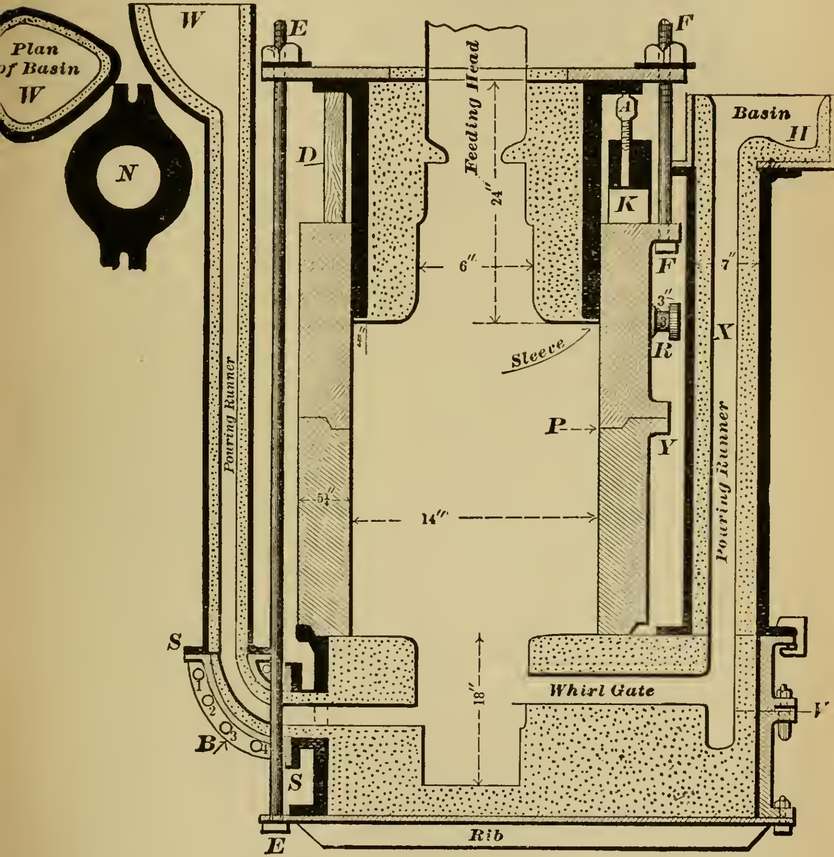
MAKING CHILLED ROLLS, AND ROLL FLASKS, RUNNERS, AND GATES.

In the engraving will be found illustrated different ways of constructing flasks, runners, etc., for making chilled rolls. For a very valuable feature of this article, I am indebted to John E. Parker of Beloit, Wis., who very kindly sent me a sketch and description of a simple and novel plan, and one that may be valuable for other purposes than roll-making.

Mr. Parker was led to devise the rigging shown, to overcome the difficulty of the upper neck cracking, caused by the vertical contraction of the body of the roll in cooling. For this purpose he makes what he terms a sleeve, as shown in the engraving (Fig. 89). It is made of cast-iron, and is about $\frac{3}{4}''$ thick when finished. It is turned on the outside so as to fit easily in the chill. The distance this sleeve sits into the roll varies from 6″ to 20″, according to the length of roll. The upper neck of this roll is moulded the same as in an ordinary flask. In closing, or getting the mould ready to cast, the height of the neck is regulated by placing three scantling, or screw nuts and blocks, as represented at *D*, *A*, and *K*. The blocks *K* can be either iron or wood, and different sizes and numbers of pieces can be used as required.

The rolls thus made are used for paper machinery, and vary in sizes from 6″ up to 14″ in diameter, and from 40″ to 80″ in length. The chills are made in lengths of 20″ to 30″, and set one upon the other, as shown at *P*. To handle these chills, the trunnions shown at *R* are used.

Different thicknesses of chills are required for different diameters of rolls. As a rule, about $\frac{3}{8}''$ of chill for every 1″ diameter of roll is about right. In the instance of a roll 14″ diameter, the chill will be $5\frac{1}{4}''$; for one 30″, $11\frac{1}{4}''$. This thick body of iron is not for the purpose of resisting the pressure


Plan of Basin W
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E
F
D
Feeding Head
24″
6″
A
K
F
7″
3″
R
X
Basin
H
Sleeve
P
Y
Pouring Runner
Pouring Runner
5¼″
14″
S
1
2
3
4
B
18″
Whirl Gate
V
S
E
Rib

Fig. 89.

due to the head, but to effect a deep chill from the surface of the casting, and to prevent the chill from cracking, resulting from the surface being suddenly heated.

The following is a table giving the thickness of chill for rolls ranging from 4″ diameter to 30″, and varying in length from one foot up to that required for the common lengths of rolls made.

Diameter of Roll.	Thickness of Chill.	Diameter of Roll.	Thickness of Chill.	Diameter of Roll.	Thickness of Chill.
4″	2″	13″	4⅞″	22″	8¼″
5″	2½″	14″	5¼″	23″	8⅝″
6″	3″	15″	5⅝″	24″	9″
7″	3⅛″	16″	6″	25″	9⅜″
8″	3¼″	17″	6⅜″	26″	9¾″
9″	3⅜″	18″	6¾″	27″	10⅛″
10″	3¾″	19″	7⅛″	28″	10½″
11″	4⅛″	20″	7½″	29″	10⅞″
12″	4½″	21″	7⅞″	30″	11¼″

The diameters 4″, 5″, 6″, 7″, and 8″ are not, as will be seen. figured upon the basis of ⅜″ per 1″ given, for the reason the body of the chill would then be a little too light for safety; or, as stated above, it is the sudden heating-up of the chill's surface, and not the pressure of the metal, that we have, in great measure, to contend with. The smaller rolls have nearly the same influence in suddenly heating the surface of the chills as the larger rolls. Suddenly heating the surface of course expands it: therefore more or less strain must be exerted upon the cold iron back of the surface. From this cause I have seen car-wheel chills fly in two pieces before the mould was half full of metal. I think the moulder will now see why the author did not adhere to his basis of ⅜″ to the 1″ for the small sizes of chills mentioned, and the advisability of making the smaller-sized chills thicker in proportion than those above the 9″ in diameter shown.

In making chills, the best of iron should be used, or they will not last long enough to pay for the making. The surface of a chill becomes rough from use, then checks, and eventually is useless. Often, in breaking them up, from the surface to an inch in depth the iron is found to be burned.

When chills are made in sections, to make different lengths, or for convenience in handling, the joints must be made true and tight. For clamping together, flanges can be cast on, as shown at *Y*.

Mr. Parker, for securing his flask, uses two long bolts and a top ring binder, shown at *N*. This binder, being placed on top of the sleeve, is bolted to the bottom plate by bolts *E E*. Should it be desirable to use such sleeves independently of the lower part of the flask, lugs or handles could be cast on the chills, and the sleeve held down and operated by means of the bolts shown at *F F*. The lower portion, or neck of the rolls, is moulded as shown at the right-hand side of the cut. The flask parts at *V* to allow for making a whirl-gate, as shown in the plan of "joint *E E*" of the small flask (Fig. 90).

For ramming-up the pouring-runner *X*, Mr. Parker uses a cast-iron pipe, the arrangement of the nowel being similar to that shown in the details of the small roll flask. Black-lead is rubbed on the chills to prevent the iron from sticking, and the rolls are poured with hot iron.

Some men, after the chills have been taken out of the oven, where they were placed to be heated for casting in, wash the face of the chill over with a thin coat of blacking, composed of ordinary blacking wet with molasses-water.

In order to economize space, I have shown, attached to the cut of Parker's flask, another device sometimes used in pouring such jobs.

W W are plan and section of a basin which can be connected to or cast on the end of either a square or round runner-pipe. *B* represents a quarter-turn pipe or box, jointed to the runner-pipe and flask at *S S*. This arrangement saves the work of parting the flask to gate the mould.

At 1, 2, 3, and 4, is shown the manner of constructing the elbow in halves and bolting together. This permits of its being taken apart, should there be any trouble in getting out the casting, or from the breaking of gates.

It would be safer to have the lower joint *S* secured by bolts; the upper joint *S* can be secured with clamps if desired.

The small chill flask represented in Fig. 90 is a very convenient one, and its construction embodies ideas that are applicable to other jobs.

At *K K* is shown a sectional view of the guide-rings made in chills. These are all turned out exactly the same diameter.

R R represent grooves turned in a cast-iron "mould-board." This is used to ram up the cope and nowel on. There is also turned in it a recess to centre and hold the neck pattern. By the use of this rigging, there is no possibility of the neck getting out of the centre in closing.

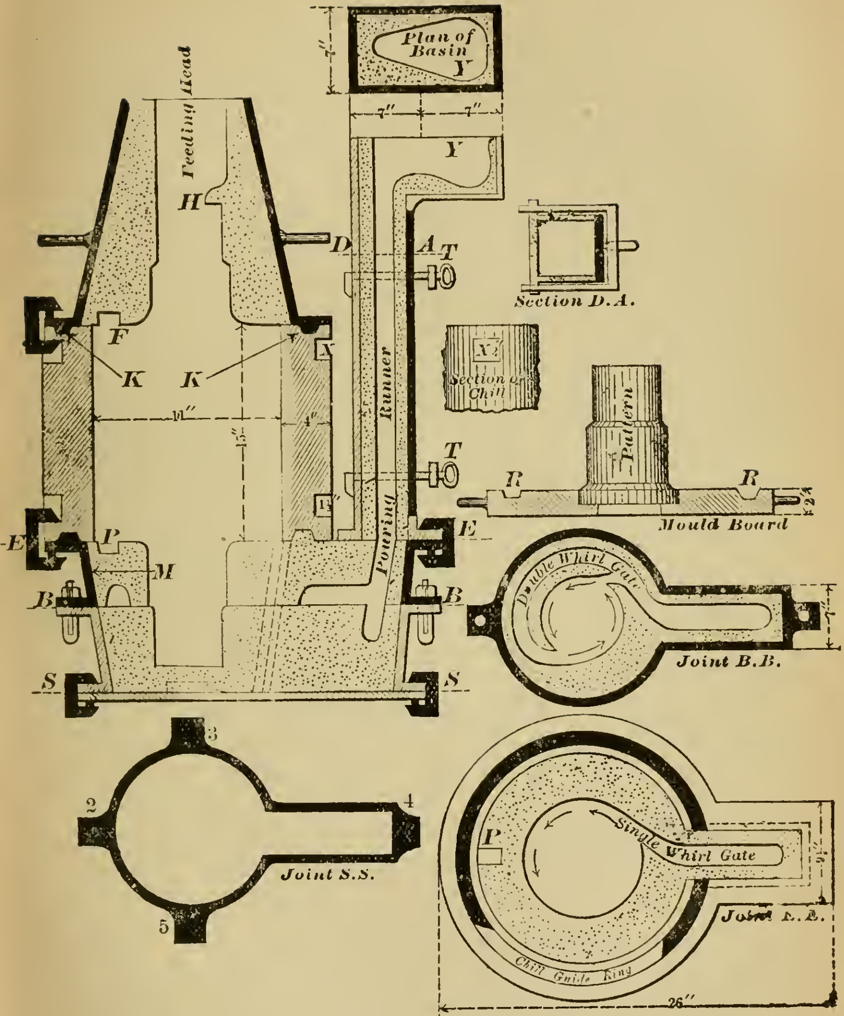
With the exception of the single-whirl gate, "joint *E E*" shows the plan or top view of the nowel section *M*. "Joint *B B*" shows the bottom view of section *M*.

Numerals 2, 3, 4, and 5, on the plan view of "joint *S S*," represent lugs by which to clamp the bottom-plate.

At joint *B B*, the guide-pins are made to serve the purpose of bolts or clamps. Holes *X X* are for clamping and lifting the chills. The runner-box has a loose plate made in halves. To hold this plate, two straps, *T T*, with threads, are used.

Gating chilled rolls is always a point of prominent consideration.

As a rule, the *hotter*, the *faster*, and with the more *whirl*, the iron fills the mould, the cleaner the chilled face. The temperature of the iron must, however, be regulated by a


Plan of Basin
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7"
7"
Y
Feeding Head
H
D
A
T
Section D.A.
F
K
K
11"
15"
4"
X
Section of Chill
Runner
Pattern
T
R
R
2"
Mould Board
Pouring
E
E
P
M
B
B
Double Whirl Gate
Joint B.B.
7"
S
S
3
2
4
5
Joint S.S.
P
Single Whirl Gate
9"
Joint E.E.
Chill Guide Ring
26"

Fig. 90.

consideration of preserving the chilled roll from checking or cracking.

I prefer getting the gate as near as practicable to the body of the roll, as by so doing the whirl of the iron is increased. The iron should be poured as rapidly as is possible, without any stopping.

In the cut (Fig. 89), as shown, one basin is represented higher than the other. Some prefer the lower one, — so as to make sure of not filling the feeding-head too full, thereby leaving room for hot feeding-iron. Others prefer the higher basin *W*, as giving more force to the metal entering the mould.

By careful watching of the moulds, large basins of iron, which are not conveniently melted in the absence of an air-furnace, are avoided. It is only the chilled portion of the roll that requires rapid pouring or filling; so, with long-necked rolls, the pouring can be slower toward the last, giving a better opportunity to "watch up" the rise of the iron.

By using the double whirl-gate, shown at "joint *BB*," nearly double the amount of whirl is given the iron. With this double gate, I have seen dirt gathered to the centre in a ball nearly 3″ in diameter. This would rise up through the neck into the feeding-head in a solid body so as to admit of being taken out, leaving nothing but clean metal in the head and casting. Had the mould been poured without the whirl-gate, this dirt would have been greatly scattered, and lodged against the surface of the roll or under the upper neck.

This whirl-gate is useful not only in making rolls, but often for other classes of castings, especially those cylindrical in form.

MOULDING-MACHINES.

With some classes of work the use of a machine for assisting the moulder in making castings with accuracy and success is often very admissible; but never in moulding have machines produced the excess of product over hand-labor, that machines generally accomplish in the other trades. Many have the idea that because moulding-shops are not strung overhead with lines of shafting, pulleys, belts, etc., they are away "behind the age." In one sense it may be true; but they are behind more on account of their failure to possess a general understanding of the true principles of moulding, than in their lack of machines in shops.

There certainly is work that can and will be done in time by machines, which has not yet been attempted; but I think it a safe assertion, that skill and experience will be surely required, in a greater or less degree, to assist the machinery. I do not know of a machine in the market, that does not require *about* the same skill to make moulds with it, that is required to make them by hand.

There are plenty of small castings made by machines, that most any beginner can make by hand. To say these machines are displacing the requirements of skill and experience, is, I think, a great over-statement. No one must think that moulding has not progressed, because our foundries are not full of machines. In one sense, our shops are full of machines. They do not resemble, I know, what are generally termed machines; nor are they manufactured by others for foundry use. Our machines chiefly consist of well-designed flasks, patterns, mould-boards, and riggings, by which the moulder can often treble the production that a rigging, apparently the same in appearance to a non-experienced person, would do.

If one desires to know whether or not there has been any progress made in expediting work produced in foundries, let them have a talk with any old moulder who has travelled much; and I think they will have their eyes opened a little by his recital of the day's work that was thought large when he was young, compared to that which some moulders turn out at the present time. In many cases, the rigging should have the main credit for this extra production. I can now call to mind a foundry, not one mile from where the author is penning these remarks, in which, comparatively but a few years back, ten or twelve sewing-machine legs were a day's work: now, in the same shop, one man makes from fifty to sixty legs per day, and upon his floor no sign of a moulding-machine is to be seen.

By the above the author is not throwing cold water upon moulding-machines: he simply desires to allay wrong impressions many have regarding our trade. There is one thing certain · machines cannot cause us to work any harder than is now generally done. They may often lighten our labor, and assist us in procuring accurate and successful results.

Accompanying this chapter is shown a recent and very novel invention, which will no doubt interest many readers. The machine is for moulding gear-wheels without the use of a pattern. Mr. P. L. Simpson of Minneapolis, Minn., is the inventor; and, as he is a practical moulder of long experience, he should be competent to give the trade a good practical machine.

The advantages of such a machine as here shown for moulding all classes of gears — spur, bevel, and mitre, mortised, or worm — without the use of a pattern are too well known to need comment. The use of such a machine, especially when but few castings are desired, must save a large outlay in patterns, also enable the use of a gear best suited to the purpose, instead of making a compromise, which is often done to save the price of patterns.

In using this machine, the moulder simply adjusts the index pin to a series of holes on index cylinder, corresponding to the number of teeth required. The diameter is easily adjusted by turning the handle on end of spindle arm, which moves the tooth-block carriage to any desired radius; stops are then adjusted so as to preserve the radius while the wheel is being made. By a quadrant-slot on tooth-block, the latter may be turned so as to describe any angle required on the face of the

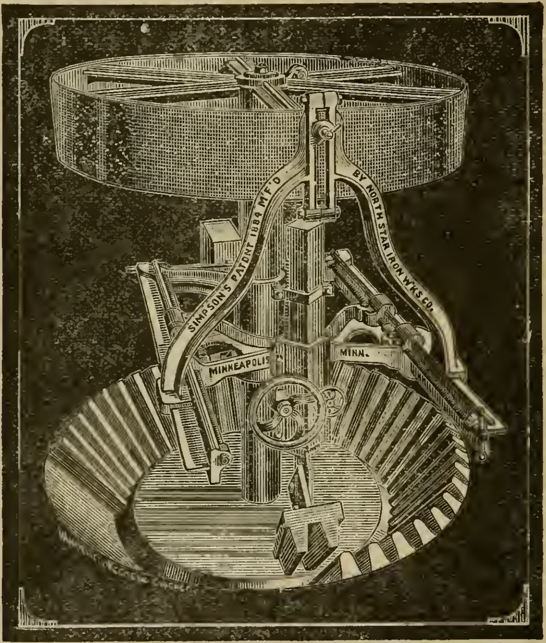
SIMPSON'S PATENT 1884 MF'D
BY NORTH STAR IRON WKS. CO.
MINNEAPOLIS
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Fig. 91.—Simpson's Gear-Moulding Machine.

wheel,—bevel, or mitre, as the case may be. When teeth on the tooth-block are rammed up, the moulder moves the spindle-arm around until the pin enters the next hole, when the tooth-block is again lowered until the stop on the square shaft brings it to its proper place. The same operation is repeated until the gear is completed.

Every thing about the machine looks plain, simple, and straightforward; no worm wheel or compound gearing about it to bewilder with their complexity. It is said that any mechanic with only limited mechanical ability can easily understand the machine, and learn how to work it almost at the first glance.

The holes on index cylinder are accurately spaced and drilled on machines specially made for that purpose. Through this agency the gear to be made must leave the sand with special accuracy.

EQUIVALENT AREAS FOR ROUND, SQUARE, AND RECTANGULAR POURING-GATES.

THE moulder is often required to connect gates of different forms, for the conveyance of metal from the pouring-basin into the mould. One part may be formed from a round and another from a square or rectangular "gate-stick;" and, again, two or more round gates may be desired to convey into a mould about same amount of metal per second that one round gate would.

To have the different forms *when desired* contain like areas, is something that heretofore has been done by guess-work. The efficiency and value of the following tables cannot be better told than by guessing as of old, and then comparing the resulting figures with those of the following tables.

The author would state, that in compiling these tables the round gate is taken as the "base;" and the sizes of the square and rectangular gates seen upon same line in second table contain nearly the same area as that contained in the round gate. Where more than one rectangular gate is required, and it is desired that they shall contain about an equal area to a round gate, all required is to select the size of round gate, and subdivide the rectangular gate found to have same area into the number of gates desired.

The first table given has for its base the same diameters in round gates as appear in the second table: so that, should one desire *two*, *three*, or *four* round gates to have a combined area nearly equal to one round gate, he has but to decide upon the proper area for the large gate, and then upon the same line he will find the number of smaller gates equivalent in area to it; or, should it be desired to have one rectangular or square gate have an area equivalent to *two*, *three*, or *four* round gates, he has but to consult the lines upon which the same size of round gate is found in the "base" or first column of both tables.

TABLE FOR EQUIVALENT AREAS IN ROUND GATES.[1]

One $1\frac{1}{2}''$ gate is equal in area to two $1\frac{1}{16}''$, or three $\frac{7}{8}''$, or four $\frac{3}{4}''$ gates.

One $1\frac{3}{4}''$ gate is equal in area to two $1\frac{1}{4}''$, or three $1''$, or four $\frac{7}{8}''$ gates.

One $2''$ gate is equal in area to two $1\frac{7}{16}''$, or three $1\frac{3}{16}''$, or four $1''$ gates.

One $2\frac{1}{4}''$ gate is equal in area to two $1\frac{5}{8}''$, or three $1\frac{5}{16}''$, or four $1\frac{1}{8}''$ gates.

One $2\frac{1}{2}''$ gate is equal in area to two $1\frac{3}{4}''$, or three $1\frac{7}{16}''$, or four $1\frac{1}{4}''$ gates.

One $2\frac{3}{4}''$ gate is equal in area to two $1\frac{15}{16}''$, or three $1\frac{5}{8}''$, or four $1\frac{3}{8}''$ gates.

One $3''$ gate is equal in area to two $2\frac{1}{8}''$, or three $1\frac{3}{4}''$, or four $1\frac{1}{2}''$ gates.

One $3\frac{1}{4}''$ gate is equal in area to two $2\frac{5}{16}''$, or three $1\frac{7}{8}''$, or four $1\frac{5}{8}''$ gates.

One $3\frac{1}{2}''$ gate is equal in area to two $2\frac{1}{2}''$, or three $2''$, or four $1\frac{3}{4}''$ gates.

One $3\frac{3}{4}''$ gate is equal in area to two $2\frac{11}{16}''$, or three $2\frac{3}{16}''$, or four $1\frac{7}{8}''$ gates.

One $4''$ gate is equal in area to two $2\frac{13}{16}''$, or three $2\frac{5}{16}''$, or four $2''$ gates.

One $4\frac{1}{4}''$ gate is equal in area to two $3''$, or three $2\frac{7}{16}''$, or four $2\frac{1}{8}''$ gates.

One $4\frac{1}{2}''$ gate is equal in area to two $3\frac{3}{16}''$, or three $2\frac{5}{8}''$, or four $2\frac{1}{4}''$ gates.

One $4\frac{3}{4}''$ gate is equal in area to two $3\frac{3}{8}''$, or three $2\frac{3}{4}''$, or four $2\frac{3}{8}''$ gates.

One $5''$ gate is equal in area to two $3\frac{9}{16}''$, or three $2\frac{7}{8}''$, or four $2\frac{1}{2}''$ gates.

---

[1] The fractional parts of an inch, as seen by tables, are not carried out any further than $.0\frac{1}{16}$, for the reason that the subject does not call for any closer figures. Therefore, the figures given will be understood as being "nearly" equal in area. As given, the sizes can be readily discerned, and are also applicable to measurement by the shop pocket-rules commonly used.

TABLE FOR EQUIVALENT AREAS IN SQUARE AND RECTANGULAR GATES TO THAT OF ROUND GATES (see note on p. 245).

ROUND GATES.	SQUARE GATES.	RECTANGULAR GATES 1″ THICK.	RECTANGULAR GATES $1\frac{1}{2}''$ THICK.	RECTANGULAR GATES 2″ THICK.	RECTANGULAR GATES $2\frac{1}{2}''$ THICK.
$1'' =$	$\frac{7}{8}''$				
$1\frac{1}{4}'' =$	$1\frac{1}{8}''$				
$1\frac{1}{2}'' =$	$1\frac{5}{16}''$				
$1\frac{3}{4}'' =$	$1\frac{9}{16}'' =$	$1'' \times 2\frac{3}{8}''$			
$2'' =$	$1\frac{3}{4}'' =$	$1'' \times 3\frac{1}{8}'' =$	$1\frac{1}{2}'' \times 2\frac{1}{16}''$		
$2\frac{1}{4}'' =$	$2'' =$	$1'' \times 4'' =$	$1\frac{1}{2}'' \times 2\frac{11}{16}''$		
$2\frac{1}{2}'' =$	$2\frac{3}{16}'' =$	$1'' \times 5'' =$	$1\frac{1}{2}'' \times 3\frac{5}{16}''$		
$2\frac{3}{4}'' =$	$2\frac{7}{16}'' =$	$1'' \times 6'' =$	$1\frac{1}{2}'' \times 4'' =$	$2'' \times 3''$	
$3'' =$	$2\frac{11}{16}'' =$	$1'' \times 7\frac{1}{16}'' =$	$1\frac{1}{2}'' \times 4\frac{3}{4}'' =$	$2'' \times 3\frac{9}{16}''$	
$3\frac{1}{4}'' =$	$2\frac{7}{8}'' =$	$1'' \times 8\frac{5}{16}'' =$	$1\frac{1}{2}'' \times 5\frac{1}{2}'' =$	$2'' \times 4\frac{3}{16}'' =$	$2\frac{1}{2}'' \times 3\frac{5}{16}''$
$3\frac{1}{2}'' =$	$3\frac{1}{8}'' =$	$1'' \times 9\frac{5}{8}'' =$	$1\frac{1}{2}'' \times 6\frac{7}{16}'' =$	$2'' \times 4\frac{5}{8}'' =$	$2\frac{1}{2}'' \times 3\frac{7}{8}''$
$3\frac{3}{4}'' =$	$3\frac{5}{16}'' =$	$1'' \times 11\frac{1}{16}'' =$	$1\frac{1}{2}'' \times 7\frac{3}{8}'' =$	$2'' \times 5\frac{1}{2}'' =$	$2\frac{1}{2}'' \times 4\frac{7}{16}''$
$4'' =$	$3\frac{9}{16}'' =$	$1'' \times 12\frac{9}{16}'' =$	$1\frac{1}{2}'' \times 8\frac{3}{8}'' =$	$2'' \times 6\frac{1}{4}'' =$	$2\frac{1}{2}'' \times 5''$
$4\frac{1}{4}'' =$	$3\frac{3}{4}'' =$	$1'' \times 14\frac{3}{16}'' =$	$1\frac{1}{2}'' \times 9\frac{1}{2}'' =$	$2'' \times 7\frac{1}{8}'' =$	$2\frac{1}{2}'' \times 5\frac{5}{8}''$
$4\frac{1}{2}'' =$	$4'' =$	$1'' \times 15\frac{15}{16}'' =$	$1\frac{1}{2}'' \times 10\frac{5}{8}'' =$	$2'' \times 8'' =$	$2\frac{1}{2}'' \times 6\frac{3}{8}''$
$4\frac{3}{4}'' =$	$4\frac{3}{16}'' =$	$1'' \times 17\frac{3}{4}'' =$	$1\frac{1}{2}'' \times 11\frac{13}{16}'' =$	$2'' \times 8\frac{7}{8}'' =$	$2\frac{1}{2}'' \times 7\frac{1}{8}''$
$5'' =$	$4\frac{7}{16}'' =$	$1'' \times 19\frac{5}{8}'' =$	$1\frac{1}{3}'' \times 13\frac{1}{16}'' =$	$2'' \times 9\frac{13}{16}'' =$	$2\frac{1}{2}'' \times 7\frac{7}{8}''$

The term "equivalent" used in this chapter does not imply that two or more small gates having a combined area equal to one large gate, all having like "head pressure," will deliver the same amount of metal per second. The flow of metal is retarded by friction, in ratio to the surface area it comes in contact with. Now, although four $2\frac{1}{2}''$ round gates are of equal area to one 5″ round gate, we find the frictional resistance to the flow of a like "head pressure" through four $2\frac{1}{2}''$ round gates to be double that generated in one 5″ round gate, simply because the combined circumferences of four $2\frac{1}{2}''$ round gates are 31.4160 inches, whereas the circumference of one 5″ round gate is 15.7080 inches. As gates are generally combined under varying complicated conditions, the tables as given can be better practically used than where they are lumbered with the question of frictional resistance.

ERRORS IN FIGURING WEIGHTS OF CASTINGS.

Some of our industrial papers having once given much prominence to the rule of *dividing the cubic inches contained in a casting by* 4 in order to find its weight, the author thought it proper to state in this volume his reason for not having given this old rule among the tables contained in vol. i. The reason for not adopting this rule is simply because its use will give a result which is too light for practice.

Before adopting the factors laid down in vol. i., the author had given the subject numerous tests, not only in carefully noting the weight of specially made castings and different grades of iron, but also in having pieces planed up to "fine measurements," and carefully weighed.

To show the "shortage" of the product obtained by *dividing the cubic inches contained in a casting by* 4, we will take for an example a block measuring one cubic foot. In such a block there are 1,728 cubic inches: this, divided by 4, gives a weight of 432 pounds. Now, the actual weight of such a block (when fed solid, of course), made from ordinary gray iron, is about 450 pounds. So we find, by figuring with the divisor 4, a shortage in weight of 18 pounds for every 450 pounds; or, for every 100 pounds, a shortage of 4 pounds.

The above shortage is certainly quite a serious item in figuring for heavy castings. For example, take a casting weighing 10 tons: we find the divisor 4 would give a shortage of 800 pounds.

The author's main reason for here referring to this old rule is simply to show its error, and prevent any one from being deceived thereby. The factors, as laid down for figuring the weights of castings in vol. i., will, if followed, be found to give answers as near accurate as it is practical to obtain.

CONTRIBUTED CHAPTERS.

The following five chapters all originally appeared in "The American Machinist;" with the exception of Mr. Mallett's, which appeared in "Iron Trade Review and Western Machinist" of Cleveland, O. The author's attention was attracted to these articles by their novelty and practical ideas, and, thinking they would be of much value to the readers of this book, he decided to insert them; and would here tender his thanks to the respective writers, especially to Messrs. Masters and Harrison for their kind dedication to him.

MELTING SMALL QUANTITIES OF IRON.

By Robert E. Masters, Columbus, Ga.

The following plan for melting one hundred to three hundred pounds of iron in a common ladle, I respectfully dedicate to Thomas D. West (as one of the odd methods of melting iron) for his second volume of "American Foundry Practice." I imagine I can see a smile illuminating the features of the moulders in some of the finely equipped foundries where they melt from twenty to fifty tons of iron per day, at the idea of melting a couple of hundred pounds; still there are hundreds of small shops where the knowledge of a method for doing so would be a source of considerable profit, besides sometimes retaining a customer. For instance, Mr. E has a small shop, and only casts once or twice a week: a short distance from him (perhaps in the same town), D & Co. have a large shop, and cast every day. E has just taken off a heat, and will not cast again for several days, when in walks a customer with a broken-down job that will require from a hundred to two hundred and fifty pounds of iron to pour off, and he *must have it immediately.* E doesn't want to lose the job, or run the risk

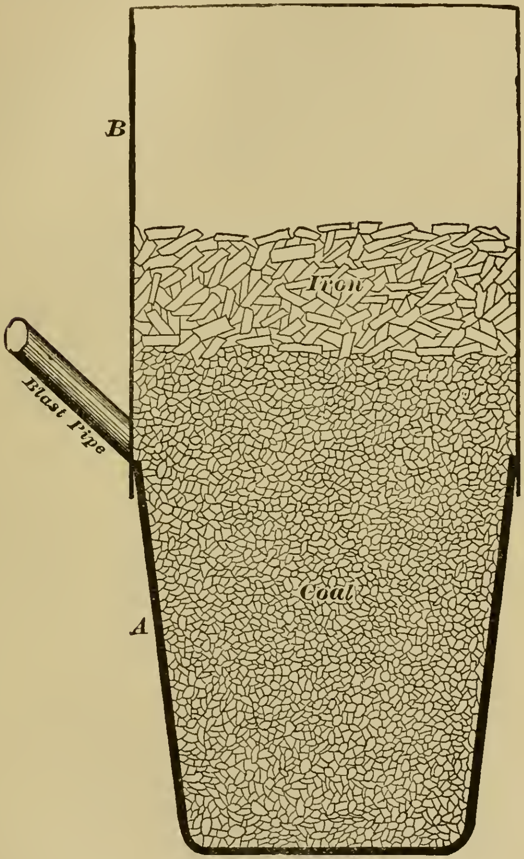


Fig. 92.

of losing a customer. Now for the plan for doing the job, and retaining the customer: Take a common three-hundred pound ladle *A*, Fig. 92, daubed in the ordinary way, and "fire it up" until you have a solid coke or coal fire. Then take a plain cylinder *B*, made of light boiler-iron, 36″ long, and of the right diameter to fit the top of ladle. This cylinder should have a 2″ hole at one end for tuyere pipe, and should be daubed up same as a ladle, and dried ready for use. Place the cylinder top of ladle, daub up around the joint, and add fuel until you have a good bed 6″ or 7″ above tuyeres. Put on such iron as you wish to use, and as much as you need to pour off the piece. Nearly all small foundries have tuyere pipes that can be detached from cupola without much trouble, and used for blast by adding a small piece of pipe to fit tuyere hole in cylinder. After the iron is down, lift off stack, and pour as usual. By this method a ladle holding three hundred pounds can be melted full of good hot iron in a short time.

MAKING A CURVED PIPE FROM A STRAIGHT PATTERN.

By Olin Scott, Bennington, Vt.

A short time since, a customer called on me for a piece of cast-iron pipe to make a curve of about thirty degrees in a pipe about three feet in diameter. He wanted it forthwith for a repair job. Having no such pattern, nor forms for sweeping such a mould, I made the piece in a creditable manner by the means shown in the accompanying sketch. First I got a pattern for a draw-pulley rim, which was about $\frac{1}{2}$″ thick, 6″ wide, and 36″ diameter, having but little draught. Around this pulley-rim I fitted a set of cores, a section of which is shown at ***e***. In the under side of these cores was a recess, to form the bottom flanges of the pipe. I also had a piece of a circular flange pattern fitted to the outside of the rim pattern, which piece of flange pattern was about one-sixth of a circle, and was like the required pipe flange. I was then ready to make the mould, which was done by excavating in the ground floor deep enough for the casting, — say about four feet, — and then ramming and grading a true surface at an angle as shown by the line *a b*. This surface was made true in a manner similar to that often employed for making true beds in pits, by bedding a turned iron pulley-rim in the sand, and using a straight-edge over the edge of the pulley rim, and, after the surface was finished, drawing out the pulley pattern, and filling the hole left by it.

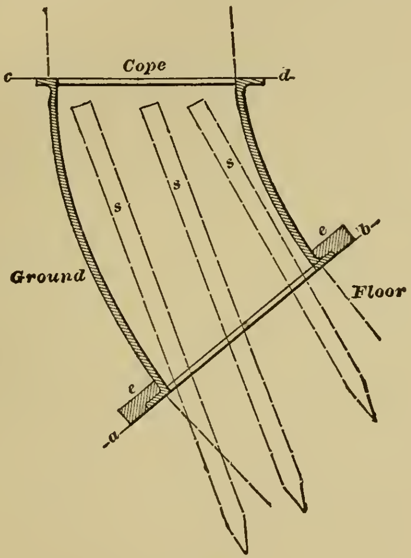


Fig. 93.

After truing the surface *ab*, the 36″ pulley pattern was laid down, and the cores *e*, *e*, set around it, and sand then rammed hard, both outside and inside the pulley-rim, nearly level with the top. Then several holes were made with a bar, and some strong stakes *s*, *s*, *s*, driven into them. A computation showed the pipe would be about 33″ long on the short side, and about 50″ on the long side. The pulley-rim pattern was then drawn up $1\frac{1}{2}''$ on the side *ac*, and 1″ on the side *db*, when more sand was rammed inside and outside, and the pattern again drawn up in the same way as before, i.e., $1\frac{1}{2}''$ on the long side, and 1″ on the short side. This operation was repeated until the pattern was raised to the line *cd*, when the surface *d* was levelled off to the top edge of the pattern, and the cope staked in position and rammed up. The cope was then taken off, and the sand cut out around the outside of pattern so as to bed the section of flange pattern, and ram it level with top of pattern: then the flange section was moved along and rammed again until the flange mould was carried entirely around the pulley pattern. The pulley pattern was then drawn, the cope put on, and runner built, and it was ready for the iron. A thorough venting of the cores *e*, *e*, was secured by a vent rod rammed in the sand over each core, and a vent wire was thoroughly used in every direction from the starting place of the lower end of the mould toward the joint.

Although the pattern was nearly a straight cylinder, the marks of the pattern when it was drawn were scarcely perceptible upon the casting.

MOULDING PIPES ON END IN GREEN SAND.

By James Mallett, Cleveland, O.

A few years ago, a firm in this city received an order for several hundred feet of cast-iron pipe to be used for ventilating purposes. The pipe was to be 20″ in diameter, $\frac{3}{8}$″ thick, and made in sections varying from three feet six inches to seven feet. Mr. P. L. Simpson, who had charge of the shop, conceived the idea of moulding the pipe on end; for this purpose an ordinary pulley-ring, of the size and thickness required, was selected for a pattern. A hole was dug in the floor large enough to enable the moulder to work on the outside of the pattern when ramming-up; a substantial wood stake was driven

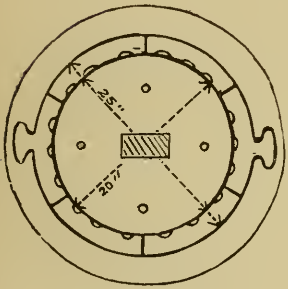


Fig. 94.

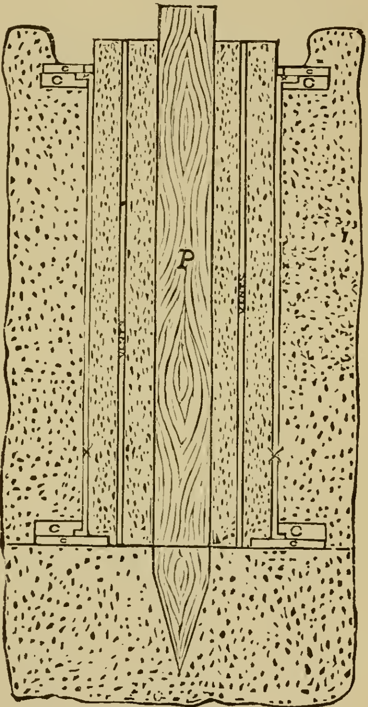


Fig. 95.

firmly into the centre of the hole; a level bed formed around it, upon which were placed the cores that formed the flange or socket, as the case might be, at the bottom end of the pipe. The length of the pipe was then marked on the stake above, the pattern placed upon the cores, four round sticks placed around the stake to help bring off the vent of the core, and sand rammed firmly inside and outside of the ring to the top; then a vent-wire was used freely, the ring and the sticks were drawn up about five inches, and the ramming continued to the top as before; the vent-wire was again used inside and outside of the ring, after which it and the four vent-sticks were drawn another five inches.

This process was continued until the mould was as long as required; the pattern was levelled each time it was drawn; the sticks were also drawn each time so as not to extend below the pattern and so endanger the core. Some rods were placed at intervals in the core when ramming, in order to strengthen and secure it. When the pattern had been drawn to the required height, a joint was made around it on which to set the covering cores: the pattern was then drawn about six or seven inches higher, and the core rammed up so much higher than the outside; the pattern and vent sticks were then drawn out, and the covering cores, with gates filed in them, were placed on the joint against the body-core; the pouring-gate on top was then made up, and the mould was ready to cast.

When there was a flange on the top end, we formed it sometimes by means of a segment worked around the top of the pattern before drawing it out; but, in most cases, we used cores like those shown in Fig. 95, and marked *c* and *c* respectively, as they could be adapted to either end by simply reversing their position. They were made in segments one-sixth of the total circumference required, that size being found the most convenient. When sockets were cast on any of the pipes, the cores to form them were made on the same general principle, and, for obvious reasons, placed at the bottom of the mould.

The advantages attending this method of moulding thin pipes are too apparent to any one acquainted with the trade to require more than a passing notice. Ordinarily, by the old method, considerable expense and delay would be incurred in making a pattern and core-box, not to mention the provision of large and substantial flasks in which to do the moulding subsequently. By careful ramming, a mould made in this way is safer than by the horizontal plan, as there is no danger of a run-out, of having the core rise or sink, or of "cold-shut" if the iron be a little dull.

By this plan, also, two lengths of pipe can be made in the time taken to mould one by the old method, and the moulds take up less room. Of course, the moulds cannot be blacked and sleeked; but by using fine sand, and ramming regularly, a good surface may be obtained, if desired. In this case, the castings were not required to be smooth: so long as they were light and solid, they answered the purpose.

A good plan to form the pouring-gate is to take a pulley-ring about five inches larger than the ring used for the pattern, and when the covering cores, with the gates filed in them, are in place, to put the larger ring on them, and make up the sand all around the outside as high as required; then cut away two places in which to pour the iron from the bull ladles, draw out the ring, and the mould is ready to pour. This kind of gate has the advantage of being quickly made, besides being cleaner and more easily choked than a gate cut out with a trowel as ordinarily. This plan of moulding thin pipes has been adopted by other firms; but to many, the idea will be perfectly new. Of course, the deeper the pattern is, the better, as there is less danger of ramming the mould in or the core out than with a shallow pattern; besides, the pattern can be drawn more each time than the other, and leave a more even surface both inside and out.

Fig. 94 represents a plan of the mould when ready to cast;

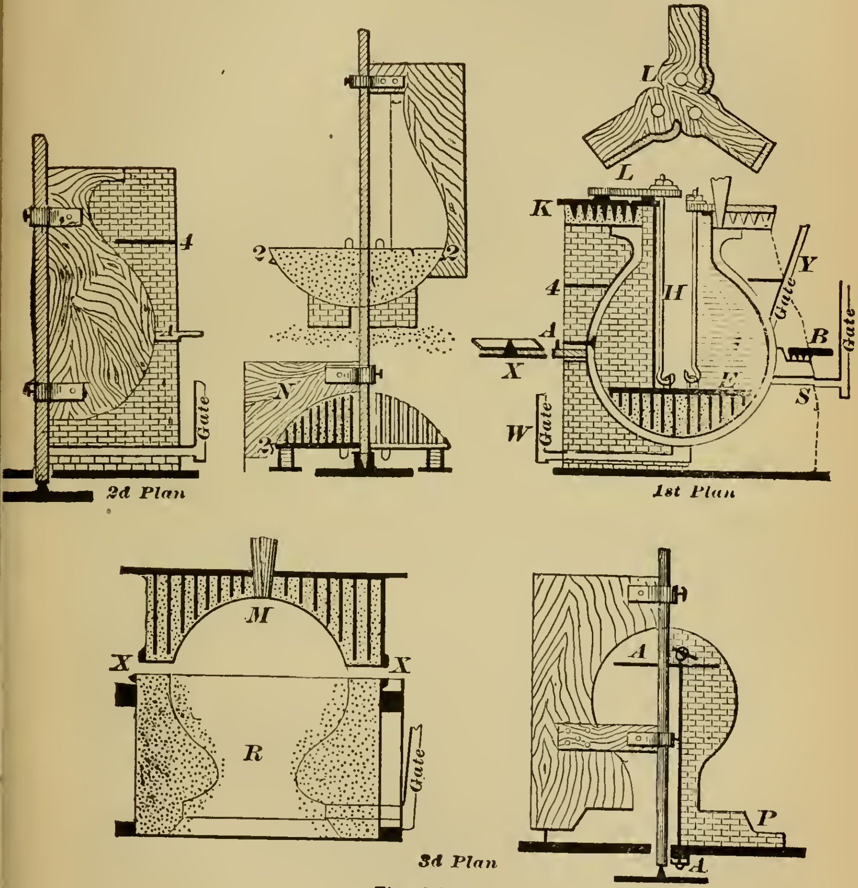
Fig. 95 a central vertical section of the same. When the pipes are to be long, it is best to use some round iron flasks or rings in which to ram up the lower end of the mould, as the strain is very great, and will cause the casting to be much heavier than required unless properly secured.

THREE WAYS OF MAKING AN AIR-VESSEL.

By Robert Watson, Cleveland, O.

In making a casting like the one shown in the engraving, three things suggest themselves to the moulder: First, to *make* it; second, to make it well; and, third, to make it at the least expense, and at the same time have a good job of it. There are three plans represented in the engraving for making this air-chamber; which, it may be remarked, is of a size not often required, the dimensions being 60″ × 48″ and 2″ thick. The moulder who made this particular casting made it in loam, by the first plan represented. This is a plan considered by some old-fashioned, out of date; while others maintain it is the safest plan, although a rather slow one. I will explain the three plans, and leave it for the reader to judge which is the best.

In making this casting by the "first plan," we build up to *A* and *B*, and after loaming and sweeping smooth it is necessary to wait till the loam is stiff enough to bear the weight of the core. By drying it with a fire-basket, a little time can be saved. Then it is blacked with a mixture of charcoal-blacking and water, for the purpose of making it part clean. The sweep is then changed so as to sweep the required thickness, which, in smaller castings, is often done with green sand dampened with clay water; but I doubt if this material would be strong enough to sustain a core of this size. To be on the safe side, it is better in this case to use loam and brick splinters, and to thoroughly dry with the fire-basket. Then a coat of


L
L
K
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X
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Gate
B
Gate
E
S
W
Gate
N
2
Gate
2d Plan
1st Plan
M
X
X
R
Gate
A
P
A
3d Plan

Fig. 96.

parting blacking is put on, and it will part cleaner if a coat of parting-sand is sprinkled on top of it.

To build the core, a plate with prickers on it is used to form the bottom, as shown at *E*. There are different ways of bedding this plate. I have seen them bedded cold in a body of loam, but this requires a long time to dry hard enough to lift clean when the core is taken out of its bed. A better plan is to heat the plate, and have holes in it in which to pack pieces of bricks and loam up level with the plate. I think a better way still would be to turn the plate bottom upwards, and loosely pack in bricks with building-loam, freely using fine coke, up to within 1″ or 1½″ of the points of the prickers, then fill up with loam in a rough state. When dry and ready for use, it is necessary to scratch the surface of the loam with a wire-brush, and rub on a little soft loam; then lower it on a loam bed, say from ½″ to ¾″ thick. The remainder of the core can then be built with confidence in the final result. A sweep has to be put on the spindle, and used to form the upper portion of the core, from the joint *A* and *B*; space must be allowed in the centre for the lifting and blocking gear, as shown at *H*. After loaming and sweeping this part of the core, the sweep must be changed for another to make the proper thickness.

I have seen the same operations gone through with as were with the bottom, — drying the core, putting on parting-blacking, loam, brick splinters, etc.; but all this in the case of the core is quite unnecessary. Instead of loam for the thickness, use green sand dampened slightly with clay water. Press this on firmly with the hands, and sleek a little with the trowel after the sweep has properly shaped it; no parting-blacking is required. Before sleeking it, if parting-sand is sprinkled on, it will assist in getting a clean parting.

You can now start without delay to build up against it to form the outside, after putting on the parting-ring. When at the top, if you have no sweep, it is necessary to have a ring to form the flange: the job is then so far complete. After marking in several places, great care is required to part this off, as the mould is green and easily damaged. This part should be dressed and blackened first, as it must be dried: when this is drying, the upper half of the core can be dressed and blackened, then put the cope part back in place.

The loamed top-plate *K* is placed on the top for the purpose of lifting the core out of its bed. I have seen two bolts used for lifting the core, the bolts being screwed tight on the top of the plate. The position of these bolts is shown at the right of *H*. This plan was not satisfactory, and far from being safe, as it is impossible to screw the bolts so as to have equal strain on them: therefore the core is liable to move, when free from its bed, by the effort to come to an equilibrium. If it does move, there is a poor chance of adjusting it with two bolts. A better way would be to use three bolts, then it can readily be adjusted. By having a strong piece of iron alongside each bolt, extending from the core-plate and tightly wedged, the bolts could be tightened to suit, with confidence that the core will not move from its proper place. This is shown to the left of *H*.

If the top-plate is not strong enough, it would be a good plan to use a three-legged cross, as represented at *L*. This, by bearing on the points of the legs as well as at the centre, would strengthen the plate.

Two ways of making joints are shown at *A* and *B*. Some make a bevelled joint, as at *B*, the bevelled part serving as a guide in lowering. This is generally satisfactory when there is a good foundation. There is at *B* a chance of getting a poor flat joint from the prickers not lifting the loam; also, when closing, there is danger of crushing the bevel part, if not closed entirely fair, which will spoil or disfigure the casting. The level joint at *A* is far better. This is made with two plates, which makes the joint iron and iron. It can be guided together by outside marks. A better way of guiding would be to have pins, as shown at X. To make these plates, have a bed with the size and form marked on it, and high enough to cast two plates. Before casting the first plate, set the guide-pins so the plate will have a good hold of them: the upper portions of these pins should be oiled, and a good coat of parting-sand put on them. After the first plate is cast, put on a good coat of parting-sand to prevent the plates uniting. There can be three or four lugs cast on the upper plate, as shown at *A*, for the purpose of wedging chaplets.

In this plan, there are shown three ways of running the casting, as at *S*, *Y*, and *W*. The runner at *S* is almost sure to cut and scab the core and mould. The runner at *Y* is not so bad, but is open in a less degree to the same objection. I can with confidence recommend the runner *W*.

Looking at the "second plan" in the engraving, the core and the mould are made separate. The bottom of the core is formed with a sweep *N*. When this is dry and turned over, it is laid on a bed prepared for it; care being taken to have the plate level, and placed centrally with the sweep. To insure its proper location, a nick may be made in the sweep that forms the bottom, to correspond with the top sweep, as shown at 2, 2, 2.

For supporting the mould, a plate should be built in its upper portion to bolt to the bottom plate, as shown at 4. In the "third plan," the mould is made in three parts; the bottom when finished is divided into two sections, one of which is shown at *R*. The four lugs are to clamp the sections together by. The top part can be made by having a plate with prickers on it, as shown at *M*. For closing by, the sweep should be made to make an outside mark to correspond with the under part, as shown at *XX*.

Although the third plan seems to be the easiest and simplest, it is seldom adopted, for the reason that the bottom being the weakest part, or the part most likely to give way from over-pressure, it is essential to provide for its being sound and solid;

and the only way to do this is by casting the bottom down as shown in the first and second plans.

A METHOD OF MOULDING GEAR WHEELS.

By William H. Harrison, Braintree, Mass.

As a sort of supplement to the most excellent series of articles which Mr. West has been writing on the subjects of Moulding and Casting, I venture to present the following method of moulding heavy gear wheels, which I believe was original with myself, and which I have found exceedingly useful in a great many instances. It is really a rough substitute for a moulding-machine, and like a moulding-machine possesses the merit of making wheels which are tolerable approximations to truth. The method of making wheels by using short cores on which the teeth are moulded, and spacing them around in a pit, is one not to be tolerated; for, although a thing may be made tolerably satisfactory to the moulder, the application of the machinist's calipers will show that the teeth and spaces vary in thickness from the difficulty in setting the cores, while the cores themselves change their shape from the shape of the core-box in handling and drying.

There are mill-owners who imagine they have accomplished a good work when they insist upon having the gears turned, thus truing the points of the teeth; forgetting that the points of the teeth, even in the most perfect work, are not intended to touch any thing. It is, however, a somewhat melancholy sight to the man who bears the expense, to observe one of the old-fashioned boring-mills, or lathes of light weight, nibbling off a little cut, and the machine jumping from tooth to tooth, as though trying to make time between the cuts.

Fig. 97 represents a section through the sand of the foundry floor. *A A* is a vertical spindle, tapered at the lower end, and fitted to a tapered hole in the base plate. *C* is a casting, having bored holes carefully fitted, so as to slide freely upon the spindle. A board is bolted to *C*, which levels the floor on the line *a b*, and leaves the mound *c*, if required, to form the boss. The cope is then placed, and rammed up as usual with a piece of tubing or gas-pipe slipped over the spindle to allow the cope to be lifted without disturbing the sand. The cope being lifted and swung to one side, another board is used,

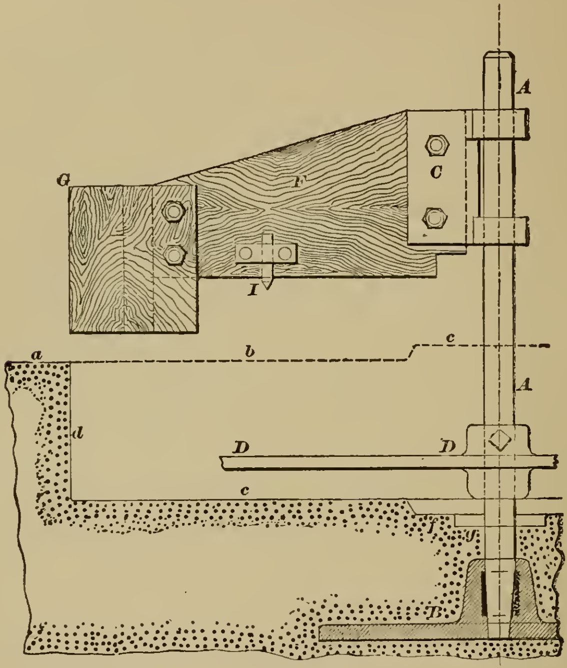

Fig. 97.

which sweeps a pit in the green sand of the floor to the shape *d c f g*. The part *f* is for the boss at the lower side, and *g* is the core print. The casting *C* is now lifted from the spindle, and the index plate *D D* placed and secured by the set screw. This index plate is smoothly turned, and while in the lathe a number of circles are struck with a fine-pointed tool. These circles should be graduated, and the holes drilled on a gear-cutter, or, as the English say, a "dividing-engine;" but in my case the dividing engine was a sharp-eyed apprentice, armed with a pair of compasses, a hammer, and a centre punch, in preference to the pattern-maker with his glasses and lead-pencil.

The board *F*, having the pattern *G* attached, is now bolted to the casting *C*, and slipped down upon the spindle, and the point *I* adjusted so as to drop into the centre punch marks *i*, *i*, *i*, etc., and allow the lower end of the pattern to come down upon the bottom of the pit on the level *c*. The green sand forming the space between two teeth is then rammed, and the board *H*, Fig. 98, laid on with a ten-pound weight on top of the teeth to hold the sand down, when the pattern is being drawn, after which the arm is shifted to the next hole in the index plate. It is well to give this pattern some draught; not to make it lift easier, but because the straining of the lower part of the casting, particularly when the face of the gear is wide, tends to make that part larger.

It is also well not to allow too much for contraction; in case of these heavy wheels, $\frac{1}{16}''$ per foot I have found ample.

After the teeth are formed, the spindle and attachments may be removed, of course leaving the plate *B* in the sand until after the casting is made. The arm cores and centre core may be placed in the ordinary manner, being made of dry sand; or in some cases where the gear is large, and the arms plain, the core box may be laid in the mould, and rammed up with green sand, in the exact location where it is required to be.

The cope may now be put in place, and weighted as usual in work of this character. It will be observed that in Fig. 98 the teeth are shown of the involute form, which I adopted some years ago as the best form for rough wheels. They certainly are the strongest as to form, theoretically; and for smooth running, some of these wheels made with this rough apparatus as coarse as 7¼″ pitch on the pitch circle, I have never seen equalled by any gears moulded from a pattern.

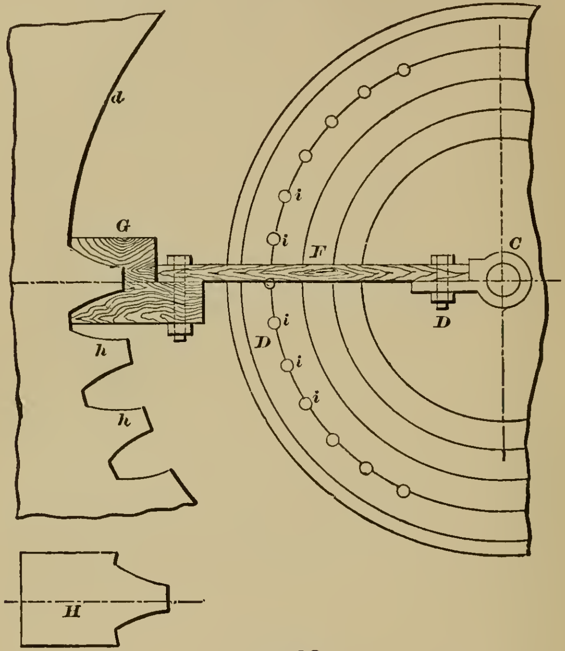

Fig. 98.

CUPOLAS AND MELTING IRON.

SMALL CUPOLAS.

WHEN trade is brisk, nearly all machinery shops cast every day; when dull, many are more likely to cast once a week. Whether trade is dull or brisk, castings are wanted in a hurry; often, the duller the trade, the greater the hurry. Some want them even before they are ordered: they think a casting should be had the same as a piece of forging or carpenter-work.

Waiting for a small casting in dull times, is often caused through waiting for a decreased force to get up enough work to pay for running off a heat. The expense of running off light heats in some shops is very heavy, the cost being regulated by the size of cupola: the smaller the cupola, the less the expense.

Small cupolas are not only good for running light heats, but are valuable for testing our modern brands of pig-iron. Pig-iron is something of a mystery, and to find its qualities it generally requires to be worked. To melt a sample of pig-iron in a large cupola, is not always practicable, from the fact that castings are made of mixtures; and, even would circumstances allow the first charge to be all of one brand of pig, there is little assurance of its being entirely free of upper mixtures. With a small cupola, and thirty to fifty cents' worth of fuel, three or four hundred-weight of pig can be melted, *with an assurance of the casting being all the product of that special pig.*

Small cupolas are often as useful in large shops as in small ones. In the whole country, there might be found a dozen large shops having small cupolas, and out of the dozen there might be four that have been used over a dozen times. It is very easy to build small cupolas, but something of a job to successfully run them. Notwithstanding, the principle of melting is the same in a small cupola as in a large one.

For manipulation in handling, there is not the room in small cupolas that there is in large ones; and on this account the small cupola has not been very successfully used.

There are two styles of small cupolas in use. The first is upon the same plan as the common round, straight cupola; and the second is made so as to be turned upside down, for convenience in cleansing and dumping. Knowing the disadvantages attending the successful running of small cupolas, ranging from 12″ to 18″, I have designed, as shown, an original plan that I think will fully meet the requirements.

The cupola here shown will occupy a space about four feet square. The working portion is hung by two cast-iron trunnions, having a wrought-iron 1¼″ pin cast in each. The trunnions work in a sliding rest, one of which, a face view, is seen at *B A*, in back view of cupola (Fig. 99).

An end view of the slides is shown in the side view. The plan of the slides is seen in small cut at the top. Shown in back and side views, under the sliding rests, are friction wheels. These slides are held in place by the standards *S S*, shown bolted to the columns. By a slight push, the working-portion of cupola can be brought out from below the upper portion or stack. A pin inserted through *P* to *K* prevents any further sliding of the rests. After this the steadying bars *H H*, shown in the plan as well as in back view, are removed. The cupola can now be turned to a horizontal position. To prevent the slides from running out of their roller bearings when moving the cupola, the slides *A B* should have a projection on each end, as seen below the end at *K*. As the working-portion of the cupola is only four feet long, by the means of the drop bottom, a man can reach and see all parts of the inside, there-

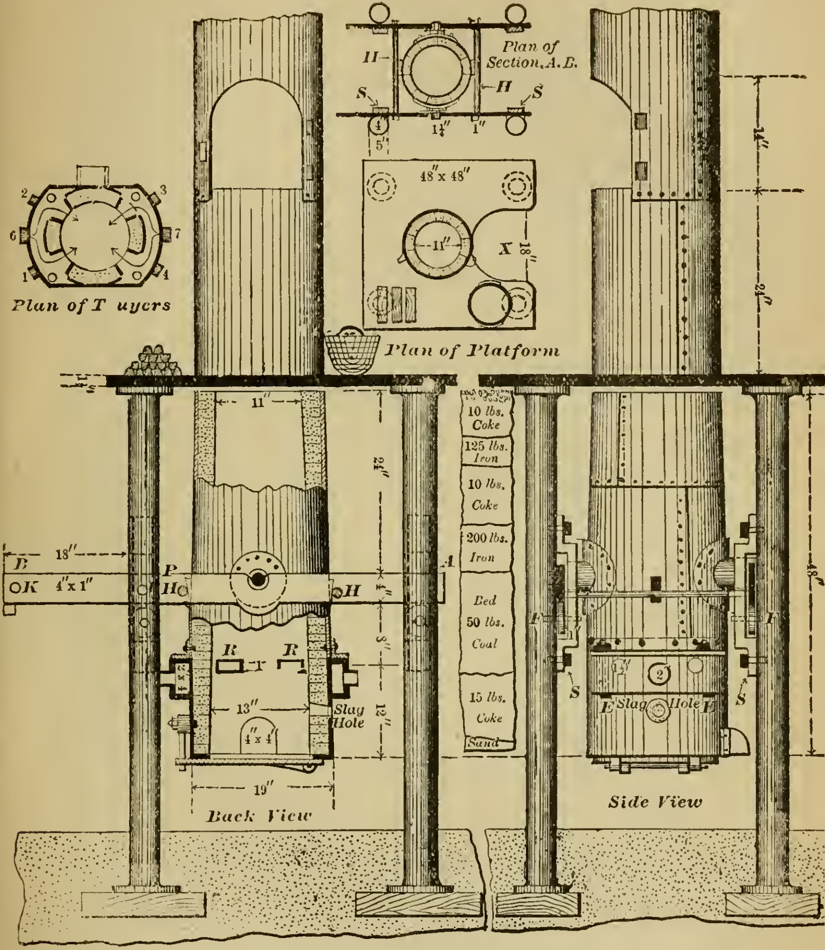
Plan of Tuyers
1
2
3
4
6
7
Plan of Section A.B.
H
H
S
S
4
5"
1¼"
1"
48" x 48"
11"
X
18"
Plan of Platform
14"
24"
11"
24"
B
18"
OK
4"x1"
P
H
H
A
4"
8"
R
R
2x4
13"
Slag Hole
4"x4"
12"
19"
Back View
10 lbs. Coke
125 lbs. Iron
10 lbs. Coke
200 lbs. Iron
Bed 50 lbs. Coal
15 lbs. Coke
Sand
F
F
1"
S
S
1½"
2"
E Slag Hole E
48"
Side View

Fig. 99.

by giving him a good opportunity to thoroughly pick out and cleanly daub it up. This is almost an impossibility in the instance of many small cupolas. With *this part of the work, rightly and handily performed, lies the main secret of successful melting in small cupolas.*

In picking out and daubing up small cupolas, *care and cleanliness must be exercised.* The lining should be kept as smooth and even as possible: any roughness has a tendency to make the charges hang up. It is an easy matter for iron to become wedged in such small cupolas. The daubing would better stand a *long heat* if it were dried, all cracks filled, and then given a coat of good blacking, thereby making it as smooth and clean as the linings of ladles; but for *ordinary heats* this extra work is not necessary.

Not only is it essential that the cupola should be clean, but the iron and fuel should be clean as well. Dirt creates slag, and slag could soon bung up any cupola. The slag-hole, if properly managed, greatly mitigates the disastrous effect of slag. *Dirt in any form is detrimental to successful melting.* With large cupolas one may be somewhat careless and unclean, but with small ones attention to these points must be given.

The thickness of lining for small cupola can range from 1½″ up to 4½″. The 1½″ lining is obtained by daubing the shell with three-fourths of good fire-clay mixed with one-fourth of sharp sand. To mix them well, they should be boiled together in a kettle. Common clay could be used, but in the end the fire-clay would be cheapest. A 2½″ or 4½″ lining is made with fire-brick. For small cupolas, intended for frequent use, the 2½″ thickness of lining is about as thin as should be put in. For daily use the 4½″ lining would be preferable, as this thickness would last longer than a thinner one. To use a 4½″ lining to make the 12″ cupola, the shell of cupola would, of course, require to be larger than shown.

The working-portion of cupola shown has, in the length of four feet, a taper of 2″. This is a point I am aware is not much practised, which is another reason for ill workings. *Small cupolas are better for having a taper, as it assists in preventing the stock from becoming wedged or hung up.*

In constructing the shell for small cupolas, there are several ways in which it may be done. One is to make it out of all boiler-iron; and another, by placing cast-iron rings on top of each other, tying them together with bolts. A third plan is to bind vertically placed cast-iron slabs or staves with wrought-iron rings; and a fourth, to make a square shell by bolting together cast-iron plates. The fifth, a "crank's" plan, is to line up a flour-barrel.

In the cupola shown, the bottom is made of cast-iron $\frac{5}{8}''$ thick. From the tuyeres up, boiler-iron is used. The slides *A B* are of wrought-iron, and the platform plate of cast-iron. The plan of tuyeres shown is one that will evenly distribute the blast. At 1, 2, 3, and 4, are peep barring-holes, which may be plugged, as shown, with wooden stoppers, or they can be closed with swinging slides. Numbers 6 and 7 are nozzles to attach leather, rubber, or sheet-iron blast-pipe to. The pipes must be made adjustable, so as to allow the cupola to be removed. The tuyere boxes, seen at *R R* in back view of cupola, are independent of the outer shell, and are set in when lining up. These tuyeres, to work well in the three sizes mentioned, should have an area of from twenty to twenty-five per cent of that contained in the cupola. For the cupola shown, use four tuyeres $1\frac{3}{4}'' \times 4''$. The milder, with proper volume, the blast can be admitted into small cupolas, the longer can they be made to run; and this is especially so where all coke is the fuel used.

The construction of the tuyeres as shown is, of course, more expensive than were nothing but two round tuyeres used. Some small cupolas have the blast thus directly admitted. It is a cheap and ready plan; but I think the plan given is the best, as admitting the air as shown breaks its direct force, and admits it in a much more even and a milder manner, so that it does not have such a bunging effect as it does when passing directly from the blast-pipe into the cupola. The blast pressure for cupolas ranging from 12″ up to 18″, using all coke for fuel, should be from two up to four ounces; with coal and coke, four to six ounces; using all coal, from five to seven ounces.

The stacks for small cupolas need not be continuous, as for large ones. After a foot or two above the top of charging door, they may be led into the stack of a larger cupola, or into a chimney.

Between the cupola cuts, is shown the manner of charging. In charging the working-portion of the cupola, it would be better to have it slide out to come in under the platform hole *X*. This would give a good chance to properly and conveniently charge. After charging, it can be pushed back, locked, and the portion of cupola above platform charged. The half-inch of space between the platform and underneath portion of the cupola could be stopped up with clay, to prevent the blaze from coming out. The platform as seen is but a plain plate. As shown it would be too weak to carry much of a load, and also there is nothing to stop stock from rolling off. To meet both these requirements, it would be a good plan to have a rib say $1\frac{1}{2}'' \times 6''$ cast all around the plate; and where it crosses the hole *X* it could be given an arch shape, so as to allow the cupola to turn over. Still more to strengthen it at *X*, there might be a complete ring cast on the plate, just large enough for the cupola to fill. If this were not thought sufficient, still another rib could be cast on the plate on its under side, below the place where the pig pile is seen; and to add support, which might be needed should a very heavy stack be used, the plate could be cast thicker than shown, and brackets carried from the columns up to it.

The bed's weight of fuel, given in cut, is intended to place the bed about 13″ above the top of tuyere. With trials made of coal and coke in the shop, the given weights would bring it about as shown. As but few cupolas are exactly alike in measurement, or fuels of the same specific gravity, instead of giving the bed weight, it would be more reliable to state the height which the top of bed should be above the tuyere. For a heat of 900 pounds, having all coal in bed, it should be 12″ above tuyere. Above 900 pounds, add from 1″ to 3″ to height of bed. If all coke is used, have bed 18″ above tuyeres; and for a heat of 1,000 pounds or over, add from 2″ to 6″ to height. Using all coke between charges, continue as shown. Should all coal be used, double the weight of fuel and iron in charging, which would be 20 pounds of fuel instead of 10, and 250 pounds instead of 125 of iron. The fuel should be small size, and the pigs broken into four or five pieces, and scrap in like proportion.

The charges for a 15″ cupola could be made as follows: On a coal bed charge 350 pounds of iron, after which, with coke for fuel, have charges, 17 pounds of coke and 200 pounds of iron. With all coal, double the charges.

The charges for 18″ cupola: on coal bed, 500 pounds of iron; coke between charges of 300 pounds of iron, 25 pounds. For coal charges, double those above. If, in any of the three sizes, coke is used in place of coal for the bed, then make the first charge of iron no heavier than those given for the upper charges. Should the iron come too dull for very light castings, add to height of bed from 2″ to 6″, and between charges two, four, to six pounds of fuel. By using coal for the bed, the cupola will melt more iron than if coke is used, as the coal will stand the effects of the blast better than coke. By slagging the cupola, it can often be made to melt near as much again iron as where no attention is paid to slagging out. The capacity of a 12″ cupola, when slagged out, is about 1,500 pounds; that of a 15″ cupola, 2,000; and an 18″ cupola, 2,500 pounds. With excellent management the above figures might be exceeded. I would here state, that, although I have shown the cut of a 12″ cupola, for daily practical working I would not recommend the use of one less than 15″.

The reason for placing the few pounds of coke below the coal shown in the bed is more for the purpose of assisting in kindling the coal, than for saving expense. Coal is harder to kindle than coke, and in small cupolas the difficulty is greater than in larger ones.

The construction shown is in principle applicable to any of the three sizes mentioned. For a 15″ cupola, the tuyeres should be increased from 4″ × 1¾″, to 3¼″ × 3¼″, and for an 18″ cupola 4″ × 4″. Also for a 15″ or 18″ cupola, the slide bars and platform should be stronger than shown for the 12″ cupola. The tuyeres could be 4″ lower, were all coal used; but for coke the height given is required. A cheaper cupola could be constructed, but for cheapness in the end I think the one here represented would be satisfactory.

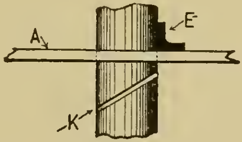

Fig. 100.

An idea which it might be well to express for one who was willing to forego the convenience allowed by having the cupola slide out under X to be charged up, is simply to dispense with this arrangement, and, in order to turn the cupola over and back, to let a part of the body — which is here shown to be above the platform — project below sufficiently to be cut so as to form a slanting joint, instead of being parallel as now shown.

If this were done, the two parts would form a joint something similar to that seen at *K*, Fig. 100. In thus allowing the upper body to project through the platform *A*, it would require to be held up by means of brackets *E*, and by this plan the hole *X* would not be required.

While upon this subject, it might be well to suggest an idea with reference to running large cupolas for constant light heats. In many cases, were the cupola lined up so as to make it smaller, much expense in fuel would be saved. For example, a 48″ cupola could, at a small outlay, be lined up to 30″; then when business warranted it, the false lining could be taken out, and most of the fire-brick saved for periodical American business depressions.

COKE AND COAL IN MELTING IRON.

There often having been some encomiums upon the merits of coke for melting iron, and none for coal, it seems to me that some, through short acquaintance with coke, were a little too enthusiastic to show up one good fuel at the expense of another. I do not deny that coke is a good fuel to melt with: nevertheless, coal is also good, and in some ways superior, for which I would not like to see its use abandoned. I hope to here show wherein the merits of each fuel lie, and to present a few ideas that may assist those wishing to change from coal to coke.

The merits claimed for coke are as follows: First, *that it will melt faster than coal;* second, *that it requires less blast pressure;* third, *that it is a cheaper fuel than coal;* and, fourth, *that it contains less impurities, and will make softer castings.*

The first three are certainly true; but regarding the fourth, it chiefly depends upon the amount of sulphur in the respective fuels.

Either through design, or lack of observation, there seem to be three important points in the use of coke and coal that were not rightly brought out. One is regarding the life and heat of the metal; another, the length of heats; the third, qualities required in melting heavy iron. The foundrymen in my section of the country have had experience with coke for a long time; and I have yet to hear any of them say that coke, on an average, is better than coal for making hot metal, for length of heats, or for soft castings. To run long heats, and have metal keep its life, is a very important factor with many foundries; such, for instance, as those doing heavy work, where the first five or ten tons melted have to stand in a ladle from one to two hours, waiting for more iron to be melted or another ladle to be filled. There is a notable feature — that of the life of liquid iron — that many shops may not notice, as with them the metal may be said to be no sooner out of the cupola than it is poured into the moulds. I am a firm believer in melting iron "hot," as I know it to be a fact that better castings can be made by so doing.

The length of heats has in my practice been increased by using coal with coke; and in this section many foundries mix coal with coke, in order to do clean cupola work, and produce hot iron. That a cupola will run longer with a mixture of Lehigh coal and coke, is admitted by many foundrymen to be a fact.

In order to make my subject plain, and to show ways of charging, the accompanying cuts (Figs. 101, 102) are inserted. The cupolas, as shown, are charged for ordinary heats. To run at their full capacity, about ten pounds more fuel should be added to each charge.

To commence with, I will state that the description of the various modes of melting here given are not of test heats got up to show how fast melting can be done, or to present the two-sided question of economy in fuel. The heats described are the average *practical* workings of a few common, plain, round cupolas in Cleveland. The Cuyahoga, Viaduct, Eclipse, and Globe Works have kindly allowed me to publish their ways of melting.[1]

The Cuyahoga and Globe Works make heavy steam-engine and machinery castings; the Eclipse does a large business in house work and general jobbing castings; while the Viaduct Foundry makes a specialty of vapor oil stoves and light jobbing castings. These four specialties cover about all ordinary foundry castings, so that nearly all can apply one or the other to their own class of castings made.

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[1] The Cuyahoga and Viaduct foundries went out of business about 1888.

The Cuyahoga and Globe Works each has two cupolas; and, their smallest ones being of about the same size, I have chosen them to show their practice of using coke and coal. The Globe Works' cupola is charged with all coke; the Cuyahoga with coke and coal. The charges of iron, as shown, are continued to the end of the cupola's capacity. The Globe Works' blast pressure is five ounces, obtained from a Sturtevant No. 8 fan. Time of melting, when using all coke, three and a half tons per hour.

The Cuyahoga's blast pressure is seven ounces, obtained from a Root rotary-blower No. 5. Time of melting, with coal and coke, three tons per hour.

The Eclipse Works' mode of charging, with all coke, for a heat of seven tons, is, 700 pounds of coke for the bed and 1,200 pounds of iron for the first charge, the balance of iron charges being all 800 pounds. Between the charges, 95 pounds of coke. The cupola is 35″ inside diameter, having four round 5″ tuyeres, about 18″ from the sand-bed to the centre. The height of charging doors, bottom to foundation plate, is nine feet; blast pressure, seven ounces, obtained from a No. 7 Sturtevant fan. Time of melting, 6,500 pounds per hour.

The Viaduct Foundry's mode of charging, with coal and coke, for a heat of six tons, is, 738 pounds of coke and 400 pounds of coal for the bed; first charge of iron, 1,800 pounds. The balance of iron charges, 1,200 pounds; fuel between them, 123 pounds of coke and 25 pounds of coal. The cupola is 38″ inside diameter, and has four oblong tuyeres of the dimensions shown at right of cupola (Fig. 102), their height from sand-bottom being about 16″. The height of charging-door from plate is eleven feet; blast pressure, ten ounces, No. 5 Sturtevant fan. Time of melting, 6,500 pounds per hour. As a general thing, in the charging of this cupola, there is not any fuel used between the last charges.

For a flux, the Cuyahoga Works use fluor spar. In using this flux, we shovel about twelve pounds on the top of each charge, with the exception of the first two or three charges.

In melting with coke, the fire does not require to be started as early, simply because coke does not require as long a time to kindle as coal. The idea of time for kindling should be to allow sufficient to have the fuel all on fire before iron is charged. Any longer than this is only a waste of fuel, and a detriment to successful melting. The draught, and kinds of kindling used, often govern the time of starting fires. The bed, when all coke, should be from 6″ to 10″ higher than where coal is used. The charges of iron should not average much over one-half the weight of the charges when coal is used; or. in plainer language, where a charge consists of 2,400 pounds of iron with all coal, with all coke it should be about 1,400 pounds. As successful melting with coke cannot be done with low tuyeres as with coal. As a general thing, coke melting requires tuyeres to be from 14″ up to 30″ above the bottom plate, or about one-third higher than for coal. I do not mean by this that coke melting cannot be done with low tuyeres, but that with high tuyeres *longer heats will be obtained.*

I recall here a case, where all coke being the fuel, the tuyeres had to be raised in order to successfully melt the required amount of iron. The shop in which this occurred was the Cleveland Rolling Mill Company's foundry, Newburgh, O. Working there at that time, I carefully noted the results of the change. The size of cupola was 44″ inside diameter; charging-door eight feet six inches from the bottom plate. The tuyeres were originally about 20″ high; and by the time fourteen tons of iron were melted, the bottom had generally to be dropped This became a nuisance, as the shop would often be left with moulds unpoured. The tuyeres were finally raised to 30″ high, and altered from flat tuyeres similar to one shown in cupola, Fig. 102, to six 5″ round tuyeres. About 7″ below the tuyeres a slag-hole was inserted. With these changes the cupola would successfully melt twenty tons and upwards.

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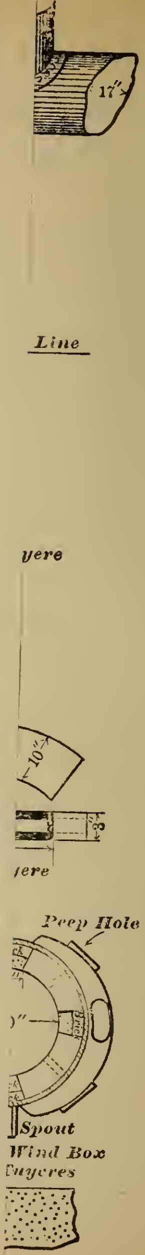
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In melting for machine or heavy castings, the iron is generally allowed to accumulate before tapping-out. This accumulation may cause raising and lowering of fuel (that is, if tuyeres are high enough to permit such action), thereby not leaving any *inside* body of fuel long at a time exposed to the cooling effects of the cold blast. The benefit of this cannot but be seen if connected with the reason for slackening the blast and barring a cupola, as noted in the following. A Lehigh-coal fire has more of a body than a coke fire. The blast, as it goes into a cupola, will more readily cool off coke than coal; and the cooled body of fuel, which more or less *sticks* to the front of tuyeres, if not attended to, gradually increases until it reaches nearly to the cupola's centre, which results in scaffolding or bunging up the cupola. To assist in preventing such results, the blast may occasionally be slackened, the tuyere peep-holes opened, and then, with a bar, the *cooled body of fuel, and frozen droppings of metal, should be driven in towards the centre of the fire.* This may greatly cause the cooled body to be burned up, the frozen droppings re-melted, and give a clean hot body of fuel for the cold blast to play upon.[1]

A point that has much to do with ill success in changing from coke to coal is using too strong a blast. As a general thing, about one-third less pressure should be used for coke than for coal. I know it is nice to see a cupola melt fast; but not so enchanting to have to re-line it about every month, which will often result from too strong a blast.

It is impossible to obtain good clean iron, or have a cupola run very long heats, where a cupola is being cut to pieces with the blast. The cupola on the right (Fig. 102) ran for about one year, almost daily, without being re-lined; which will, I think, be acknowledged as a good showing. I do not credit all to the merits of a mild blast. There is another feature that undoubtedly had much to do with it: that is, the daubing-up of the cupola with fire-clay.

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[1] Large cupolas will largely take care of themselves, and too much poking of tuyeres in small cupolas may prove more harmful than none, showing there is a limit to such practices.

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In both of the Cuyahoga cupolas, we constantly used coal and Connellsville coke, as shown, and, by proper attention to slagging (which I am sorry to say had to be done through the tapping-hole, because of not having a good chance to place a regular slag-hole), the cupolas will run for hours, and then drop as clean as if they had only been in blast for one hour.

The smallest cupola which is here shown has been kept in blast from 1 P.M. until 7.30 P.M., and then dropped clean. In fact, I have never seen such a thing as scaffolding or cupola bunging in these cupolas.

In melting with coke and coal, there is great benefit derived from their mixture; for while it is true coke has some advantages, it is also true coal has others. As we have noticed some of the qualities in which coal is superior, there is one more that can be added; viz., its ability to melt heavy blocks of scrap iron. The benefit of coal in this respect could not be better shown than by melting a three-ton block accomplished by the Pratt & Whitney Company, Hartford, Conn. Having read, in a back number of the "American Machinist," of this firm melting a six-thousand pound block of iron, I thought at the time there had been a mistake made by adding a cipher. As the article did not describe how it was done, or any of the details, there was nothing to figure from: so, to insure that it was correct, I made it my business during one of my tours to pay this firm a visit. In talking with Mr. Gardner, the foundry foreman, upon the subject, he said it was a fact, and took me out to the yard where there was a duplicate of the six-thousand-pound piece he had melted. I told him I thought he had melted the heaviest block that had ever been charged in a cupola of this size, and asked his permission to describe the melting at length, as it was a creditable job, and would interest many foundrymen.

The cupola used was a Mackenzie, the size being as shown in the engraving. The process of melting was as follows:

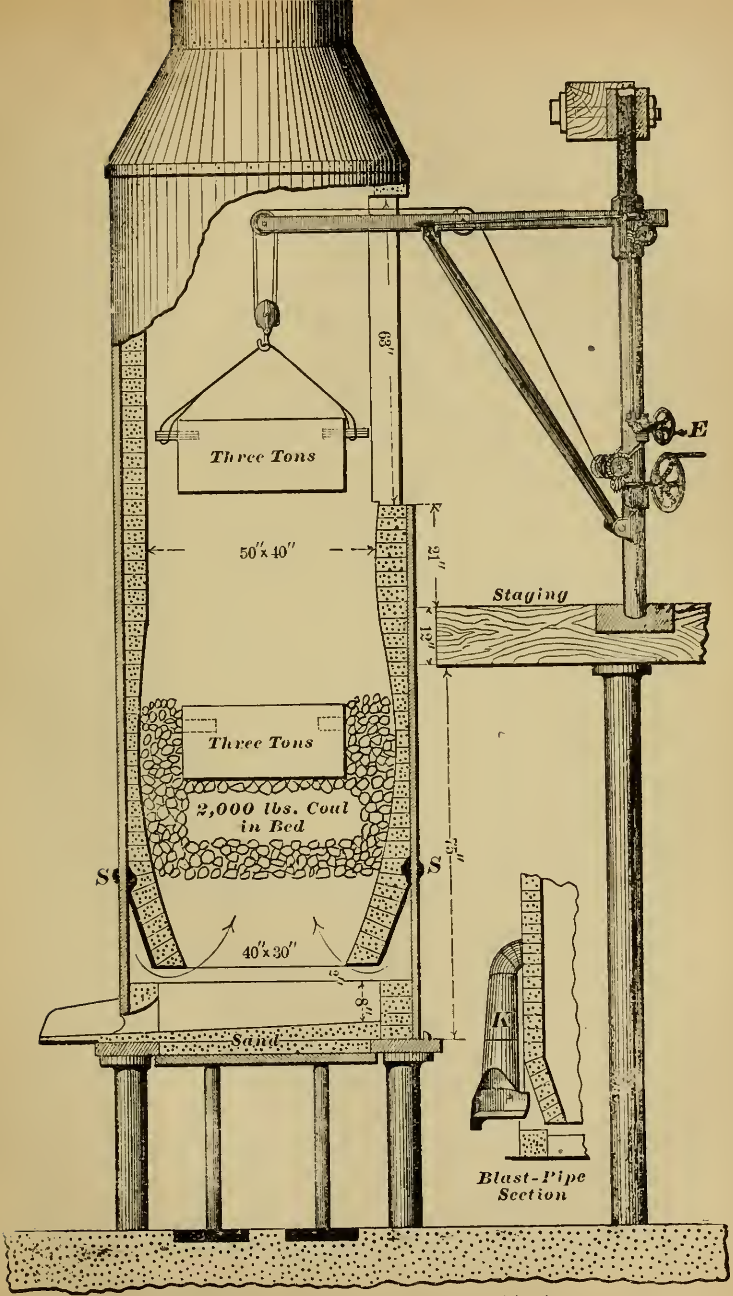

Three Tons
63"
E
50"x40"
21"
Staging
12"
Three Tons
2,000 lbs. Coal in Bed
S
S
75"
40"x30"
8"
Sand
K
Blast-Pipe Section

Fig. 103.—Charging a three-ton block.

For bed, 2,000 pounds of coal, on which was placed the three-ton block. Around this was placed 400 pounds of coal, and the fire started. After it was well going, the cupola was charged, to complete a heat of 22,000 pounds, by having four charges of 500 pounds of coal and 4,000 pounds scrap and pig in each charge. The first 500 pounds of coal was placed upon the 6,000-pound block, thereby burying the block in 2,900 pounds of coal. The metal was used to pour a similar block, and a class of work which, had the metal been somewhat dull, the castings would run full. Although this class of work was selected, Mr. Gardner said the metal would have run lighter work.

The fuel used for the above heat was one to five, this percentage being necessary by the requirement of an extra weight of fuel for the bed. For ordinary heats the bed is 1,500 pounds of coal, with the charges same as used with the block; so that, for an ordinary heat of 22,000 pounds, the fuel would be 1 to 6.28. When this block was charged, the cupola was well burnt out. Had it not been, Mr. Gardner said he could not have melted the block, as there would not have been room to properly bed it. For the purpose of admitting this block, the charging-door was removed and enlarged so as to make it about the height shown. The crane's jib is racked out by the handle *E*, and the load let down by means of the handle below *E*. The cut shows the block suspended, ready to be lowered down on its bed; also, when it is bedded in place.

The charging of heavy scrap by hand and backbone jibs is not only a laborious job, but it is injurious to the lining and bed, and iron can seldom be placed as one might wish. The way it is generally done is to let it drop from the charging-door to the bed, which, in some cupolas, means a fall of seven or eight feet.

In most all trades, more or less consideration is given the comfort of workmen, such as facilities for properly handling material, but for us foundrymen any thing was generally looked upon as good enough: therefore any device which enures to our comfort, such as this cupola crane which Mr. Pratt has designed, is looked upon with favor by all foundrymen. In the early part of this chapter it should have been mentioned, that in the cupola at the Cuyahoga Works, as shown by the cut, much heavy scrap was melted; and on account of this we used the coal as described.

Mr. Gardner could not have accomplished the successful melting of such a heavy block as his with all coke. Outside the Cuyahoga Works' cupola scrap-house could be seen piles of heavy pieces of old machinery-scrap ranging from three hundred up to eight hundred pounds in weight. To keep this pile from increasing, we are obliged to melt as many of these pieces as possible every heat. In charging them, we omitted putting any in with the first twelve hundred pounds, as to do so the height of bed would require to be increased. The first heavy block would generally be placed upon the top of the fuel which covers the twenty-four hundred pounds of iron, which is the weight of the first charge placed upon the bed; then, when the first block comes down, the cupola is hotter, and there is less risk of the heavy blocks sinking down below the melting-point.

There are few foundries but have some heavy pieces of scrap they would like to get rid of, and would do so were they not afraid of bunging-up their cupolas. I would advise such to follow Mr. Gardner's plan, or, if the pieces are lighter, to save fuel they could place them in the second charge; and if they thought it would damage their cupola, or make bad work before it would get all melted, the bottom could be dropped, and what was left of the block could be charged in another heat. Such heavy pieces are best melted when one can arrange to have work that does not require the hottest of iron. Heavy scrap when it is melted is superior to light for making clean mixtures; and, although it takes more fuel to melt it, it may often pay in the end to do so.

There is an adage that "it is a poor foundry that cannot make its own scrap." The way some lose heavy castings, one would think they were trying to supply their neighbors. The loss of heavy castings makes heavy scrap; and for some shops the above may suggest ideas to help them get it out of sight, and rid themselves of unpleasant memories.

INTELLIGENCE AND ECONOMY IN MELTING.

There has at no time been the scientific thought given the subject of melting that is given it at the present time. A few years back, there were more superstitious melters than intelligent ones. In fact, there can at the present day be found men who look upon the cupola as something more supernatural than mechanical. If any thing goes wrong, they give an inquirer a look as much as to say, Question the gods. Dull iron one day, hot iron the next, and a bunged cupola the following day, may be excusable in some shops; but, to the intelligent founder of to-day, such workings are connected with cause and effect, and a want of knowledge.

The cupola can easily be the master if one does not strive to master it. To master the cupola, is simply to have it do as one may wish. Hot iron one day, dull another, three or four different grades got out without being mixed, heavy scrap run down, and fast or slow melting, are points that can be and are mastered by intelligence. It may be a broad assertion, but nevertheless the writer would say, that in no part of foundry practice is there a better chance to control results than in melting. The chances are far more in favor of a first-class moulder having bad results with his work than he would were he a first-class melter. Any mechanic well versed in both branches, I think, will verify this statement.

Having, just before completing this second volume, made a tour through many States, I was much pleased to see with what interest many foundrymen — who, by the way, were readers of "foundry literature" — had taken up the subject of melting. Right here I would like to say, that, although there are those who sneer at foundry literature, a travel through the country will prove that the most intelligent and *progressive moulders* are those who read it. It is not always the information we get from reading, that measures its value, but the thinking it often induces us to do.

Among the most intelligent cupola managers, the question of economy in fuel is the all-important one; so important with some, that it reminds one of the man who tried to teach his mule to live without eating. They keep striving until they find themselves sadly the losers.

This question of economy in fuel is a misleading one. With intelligent management, and conditions alike, two distinct foundries may melt with a like low percentage of fuel, but what may be economy for one shop may be quite the reverse for another.

One shop may have a class of work which will admit of being poured when the iron is in a less fluid condition than another. Then, again, work may be of the same class, but one has arrangements for taking care of the iron which will not admit of carrying it to the moulds as quickly as the other, such as the distance it may have to be carried by hand or power, etc. I have worked in shops, where, on account of their poor arrangement and that of their cranes, the hottest kind of iron would often be too dull to properly pour into the mould by the time the ladle reached it. Such a shop, if arranged so that the metal could be poured into the mould before it began to lose its life to any extent, might often with safety melt with much less fuel, from the simple fact that they would not require the iron to be in as fluid a state.

There are many things to be considered with reference to what is *true economy* in melting; and it is not right for one to insist that because some other shop may be melting one to eight, nine or ten, every other shop should do likewise. The size of cupola, height of tuyeres, weight of heats, and the question of running the heats uniformly in weights and mixtures as in a specialty foundry, or no two alike as in a jobbing foundry, also the class of iron to be melted, and the work to be poured, —all these are things which greatly regulate the per cent with which the iron may be melted in the successful running of all the shop's work. *It is no true economy in melting, when, by melting with a low per cent, the iron comes down so dull that castings are lost, and ladles "bunged up."* It don't require the loss of many castings to balance the cost of the few extra pounds of fuel it would have taken to make the iron fluid enough to fully insure the running of the castings lost because the metal was dull.

Some shops can admit, in practice, melting done with a less per cent than others that do the same class of work, from the simple fact that they have excellent facilities for handling the metal quickly. In cases where work is such as not to require very fluid metal, the low percentage that some may with success use certainly would not be advisable for others to practise. It may be thought that the iron is very hot; but if it had to be carried as far as it must be in some shops, and then poured into thin stones plate castings, it would be found that there was a difference in "hot iron."

Of course the writer has no intention to disparage economy in the use of fuel; *but the only way to rightly judge of true economy is to see the facilities of the shop, and class of work to be made.* For my part, I would not question one to five as being extravagant until I knew all the conditions.

As a matter of fact, when all the circumstances are considered, iron is being economically melted from one to five up to one to eleven. To melt lower than one to eight, is no doubt creditable, and a saving in the cost of melting; that is, if by so doing the *welfare of the cupola, ladles, and castings is not sacrificed;* but were the facts known, more cupolas would be found melting one to five than to seven, eight, or nine. I am well aware that melting one to eight, nine, or ten, sounds very economical when classed against one to five, six, or seven. To concisely give his experience and observation on this point, the author would assert that in any cupola, running to its medium capacity, iron cannot be melted as hot or in as fluid a condition with fuel one to nine, ten, or eleven, as with one to five, six, or seven. Where intelligence is coupled with experience in melting, a good judge of fluid iron can easily detect the decrease in the metal's fluidity caused by melting with less than one to eight. With the best possible management and conditions, I think almost all experts will agree with the author in saying that any less fuel than one to eight in medium-sized heats will show its results by giving a fluid iron with less life. Of course there are many cases where much hotter iron with one to eight can be obtained than others would give with one to five; but what the author wishes understood by the foregoing is, that where one can "melt hot" with one to eight, he will notice a decrease in the metal's life and fluidity, should melting be done with less fuel.

To properly charge and take care of a cupola, involves a knowledge many are not willing to concede. It is often surprising, how hot some melters can bring down their iron with comparatively less fuel than others use. The management of a cupola is every thing: some study to make it a science, while others act as if the cupola were only a hole into which the iron and fuel are to be thrown, and, if it does not come down right, lay the blame to *a poor blast or cupola*, etc. Some in melting do not even weigh their stock. In such case, there cannot be a uniformity in melting. If one wishes to master melting, he must at least weigh the fuel and iron, so as to have data from which to work. He can then regulate his heats, and have a *uniformity that it is impossible to obtain by guess-work.* When cupolas are charged at random, one may see the first of the heat bring down hot iron; the middle, dull iron; and the end, again, hot iron. There may be a half-dozen changes in the fluidity of the iron, every charge seeming to make an alteration in this respect. Uniformity in melting requires the employment of *intelligence* and system. With this, one can have as hot or as dull iron as he may desire. With system, we know how high to have a bed, pressure of blast, and the percentage of fuel to use, etc., to assist the obtaining whatever fluidity of iron we require; and the cupola is as easily regulated as a clock.

ODDITY AND SCIENCE IN THE CONSTRUCTION OF CUPOLAS.

Economy in the use of fuel, and fast melting, are points sought for in constructing cupolas. To this end, many odd features have been introduced. The noticeable oddity of some cupolas is in their outline, while with others it is all in the tuyeres; then, again, we see the two combined. *I have often thought that oddity was devised to bewilder and blind, more than to attain improvements in practical results.* At least, the attainment of oddity is sometimes the only success. By oddity in cupola construction, is meant a departure or break from the plain round cupola having one row of either round or flat tuyeres. The different oddities, if shown, might fill a fair-sized book. Out of them all, but very few have any advantage over the common tuyere straight cupola. Europe, no doubt, is far ahead of our country in the origination of new designs for cupolas; but whether she has accomplished any thing more than America in *true economy* and *speed*, is a question. Should any foreigners wish to compare notes with us, I would be pleased to have them mainly confine their tests to the two following points: first, the fluidity of the iron; second, the greatest amount of iron the cupola can cleanly and successfully melt. These two points are generally ignored in all newspaper accounts of cupola working. What is one to know of any benefit accruing by the footings showing one to eight or ten, if he is not informed of the fluidity of the iron melted? *Any cupola can be made to melt one to eight or ten; but whether the metal is only good for pouring or running solid blocks, or can run thin stove-*

plate castings, is the point we should know of to judge as to the merits of the economy in fuel.

Regarding the length of time a cupola may be run without bunging-up, is another point of importance. If one can daily melt ten tons in a 30″ cupola, where others can hardly do it in a 40″ cupola, there surely is some advantage gained.

The running of cupolas is somewhat like foot-racing. *Some can do excellent work in a short run, but give them a long one, and they soon become "played out."*

With reference to where there is a failure in the length of time a cupola will melt satisfactorily, I will venture the assertion that the fault is more often due to *mismanagment*, than to the design of the cupola.

One great fault with cupolas is that of having so much heat escape up and out of the stack. Could the heat from two cupolas thus lost be concentrated into a third cupola, a person would not be far off in saying iron could be melted. Some, to derive benefit from this escaping flame, make their charging-door as high as they practically can. Others try to construct the cupola so as not to generate this flame. To this end, some cupolas are made with two rows of tuyeres. The principle involved is simply the admitting of an upper volume of air or oxygen to unite with the carbon gas liberated from the fuel by the bottom tuyeres. The flame one sees at common cupolas' charging-door or stack is greatly caused by the escaping gas meeting with the oxygen of the air. If, instead of allowing this gas to reach the charging-door to receive oxygen, we admit oxygen about at the height above the first row of tuyeres, where the melting-point commences, we there generate the flame, or burn some of the gases that otherwise pass up the stack. This point is further treated upon p. 305. If we can confine the heat thus produced to the melting-point, instead of letting it pass up the stack, there should be some benefit derived.

The amount of air admitted through the upper tuyeres, to combine with the gas produced by the air passed through the lower tuyeres, should only be sufficient to consume the gas generated. If more than this is admitted, the solid carbon, or, commonly speaking, the fuel, will be attached, and converted into gas, which will escape, thereby causing imperfect combustion. *If, by two rows of tuyeres, more gas is made than there is oxygen furnished to consume, the fact can readily be known by the amount of flame seen at charging-door.* The greater the distance in a cupola between the bottom and the charging-door, and the fuller it is charged, the less escape of flame or heat.

In order to conduct some experiments upon this subject of two rows of tuyeres, I had in the cupola (shown in chapter upon "Melting with Coke and Coal," p. 273) four 2¼″ tuyeres placed about 14″ above the top of the lower tuyere. In making these tuyeres, we simply cut four round holes in the top of the wind-box over the peep-holes; then, after four round holes were cut in the cupola's shell, 2¼″ gas-pipe was used to make the connection; and to make the turn, there was a T used having three openings. One opening was used as a peep-hole, which was closed by a plug screwed into it. In the centre of this screw-plug, there was a hole bored, $\frac{17}{32}$″, through which was worked a ½″ rod having a cast-iron conical round plug on its end sufficiently large to *just* admit of its sliding easily, and thus regulating the blast. My experience with these tuyeres was an observed *improvement in the speed of melting; and by them at least as hot iron was obtained.*

Another advantage which might be well to notice is, that in running long heats the upper tuyeres are of much assistance in *prolonging the life of a heat.* Should the lower tuyeres become to any serious degree bunged up, the top tuyeres will admit much of their blast, thus letting air into the cupola which otherwise would be excluded.

After running a month or so with the two rows of tuyeres, I had two of the upper tuyeres raised up so as to be 26″ above the bottom tuyeres. This, then, gave us what might be termed three partial rows of tuyeres. The highest row I had put in for the purpose of trying what effect there would be from blowing a blast in among the first charge of iron. Many are under the impression that when there are two rows of tuyeres, the bed of fuel must be well above the upper row, or dull iron will be the result. All I can say regarding this is, that we noticed no difference in the fluidity of the metal by having the two tuyeres above mentioned blow right into the first charge of iron.

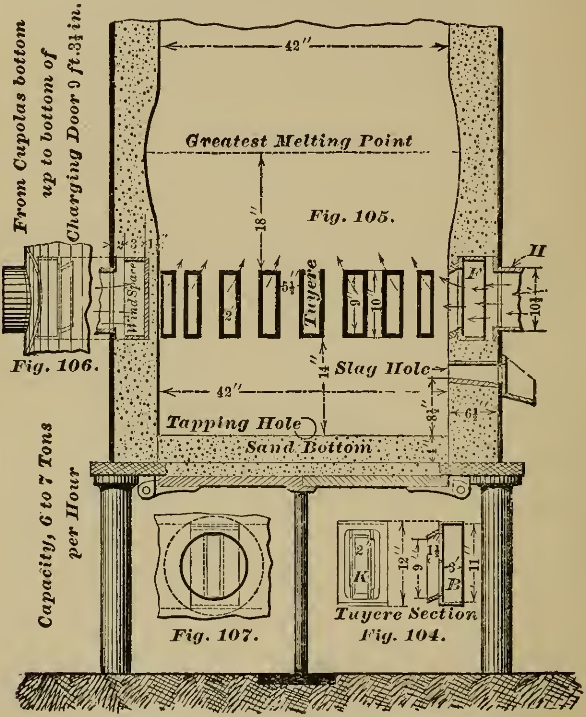
To ascertain if we were making any advancement in combustion, we opened and closed the top rows by means of the above-mentioned valve. When the top rows were open, the flame at the charging-door would be so light that one could stand close to it, and experience very little discomfort; but the minute the top rows of tuyeres were closed, a strong flame would puff up sufficient to make it almost too hot for one to stand there any length of time, thus fully demonstrating the benefit of top tuyeres in assisting perfect combustion. In experimenting with these upper tuyeres, the two rows would alternately be opened and closed for the purpose of learning which two of the four tuyeres, when open, would most diminish the flame at the charging-door. We found that when the two highest tuyeres were open, the flame was the least, and they were the quickest to act: notwithstanding they seemed to diminish the flame the most, I don't think they forwarded the speed in melting as much as the two lower tuyeres. We also experimented with closing and enlarging the tuyere openings. From 2¼″ diameter we closed them up to 1½″ diameter. The 2¼″ gas-pipes gave the best result, both in speed and in reducing the flame at the charging-door. Also it might be well to state, that the 2¼″ pipes cut out the lining much more than the 1½″ ones did. The writer's experiments with these upper tuyeres would lead him to give the following rule for any who might wish to give upper tuyeres a trial. Insert them from 12″ to 16″ above the top of the bottom tuyeres, and have them of such a diameter as to admit from two to three tenths as many square inches of blast as are admitted by the lower tuyeres. Some, in setting upper tuyeres, have them inclining down, so as to have them lowest at the inside of the cupola for the purpose of throwing the blast down so as to meet that which enters from the lower tuyeres, which they claim is essential to the success of combustion. In one way, at least, it does good; and that is in keeping any droppings from running down the tuyeres. The number of upper tuyeres to use for sizes above 36″ cupolas would be six; from 36″ down to 26″, four; or one between every lower tuyere which the cupola is intended to have, or has already. The upper tuyeres should have some kind of a valve arrangement, so that the blast admitted can be regulated or shut off at pleasure.

When upper tuyeres are used, it is better not to open them until the melting is fairly under way; and, further, they should be closed before all the iron is down; allowing them to blow at the end will tend to badly "cut out the lining."

As any improvement rarely is favorable to every thing, the "back-lash" to upper tuyeres tends, more or less, to cause burning-out of the lining, and thus often increasing the amount of slag, which may sometimes cause trouble.

As there are oddities in cupola designs that show no gain over the common cupola, it may interest the reader to learn of some that are doing good work. The cupolas shown are said to be melting economically, and with speed. Two of them embody the principle of admitting oxygen through "upper tuyeres" for the purpose above described. The oddity in Messrs. Callahan & Dearmon's cupola is all confined to the tuyeres. The blast enters an inner wind-belt *F*, which extends entirely around the cupola. From this belt the blast enters the cupola through seventeen tuyeres, a section of which is seen in

Fig. 104. At *K* the front view is seen; and at *B*, a section through the centre. The manner of setting the tuyeres will be better understood by noticing *F*, in the elevation of the cupola, Fig. 105. Fig. 106 shows the outside view of the cupola where


From Cupolas bottom up to bottom of Charging Door 9 ft. 3¼ in.
42″
Greatest Melting Point
18″
Fig. 105.
3
1¼
Wind Space
2″
5½″
Tuyere
9″
10″
F
H
10½″
Fig. 106.
14″
Slag Hole
42″
Tapping Hole
8½″
6½
Sand Bottom
4
Capacity, 6 to 7 Tons per Hour
Fig. 107.
2
K
12″
9″
1½
3″
B
11
Tuyere Section
Fig. 104.

Callahan and Dearmon's Works Cupola, Dayton, Ohio.

the blast enters. Fig. 107 shows the back view of the tuyeres as would be seen by looking in through the branch blast pipes at *F*. The two 10″ branch pipes connect to a main pipe 12″ diameter. The length of this pipe from fan to cupola is eighty-five feet. The blower used is a No. 7 Sturtevant; revolutions, two thousand one hundred per minute.

The cupola heat was as follows: For the bed, 648 pounds of coke, upon which was charged 1,200 pounds of iron. The after charges, of which there were nine, were made each of 60 pounds coke and 1,200 pounds of iron.

The totals for the heat were:

Amount of iron melted	12,000 lbs.
Amount of fuel consumed	1,188 "
Ratio of fuel to iron used	1 to $10\frac{1}{10}$

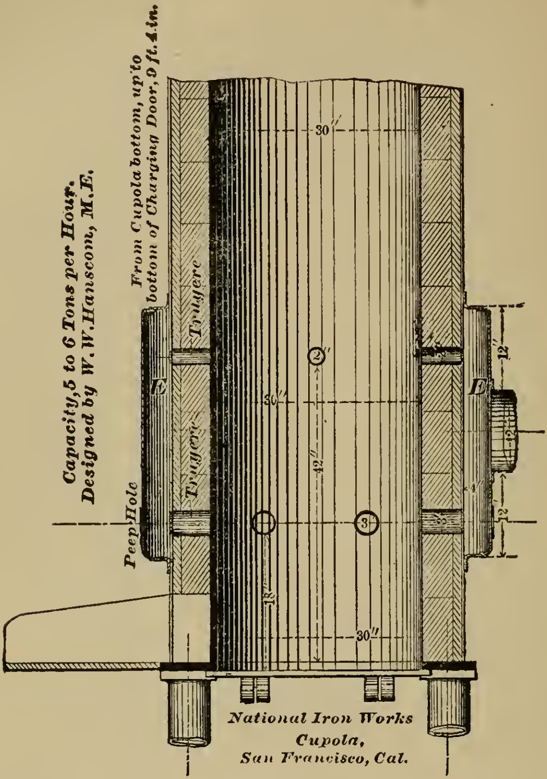
The fluidity of the iron melted was described "hot." As the iron is for castings used in the manufacture of hydraulic oil machinery, the iron would necessarily require to be of fair quality. The fire was started at 1.15 o'clock; first iron charged, 2.30; blast put on, 3.12; iron down, 3.18; bottom dropped, 4.42. This shows the length of heat to be one hour and thirty minutes. J. B. Francis, the foundry foreman, writes that the scrap used was light, and that the blast had to be occasionally slackened in order to allow the iron to be taken care of. For a flux, fluor spar was used. The iron used was half scrap and pig; the fuel, Connellsville coke.

The next cupola is that of the National Iron Works, San Francisco, Cal. W. W. Hanscom, M. E., the designer, gives the following record of heat taken March 24, 1884: —

Time of starting fire	1.30 P.M.
Charging first iron	3.00 "
Blast put on	4.37 "
Iron down	4.45 "
Bottom dropped	6.20 "

CHARGES.

Bed, Lehigh coal	650 lbs.,	iron, 3,000 lbs.
English coke	125 "	" 2,000 "
" "	100 "	" 1,500 "
" "	100 "	" 1,300 "
" "	100 "	" 1,300 "


Capacity, 5 to 6 Tons per Hour.
Designed by W. W. Hanscom, M.E.

From Cupola bottom, up to bottom of Charging Door, 9 ft. 4 in.

National Iron Works Cupola, San Francisco, Cal.

30″
Truyere
Truyere
E
E
Peep Hole
2
3
30″
42″
13″
30″
12″
12″
12″
4″

Fig. 108.

BLAST PRESSURE.

4.52 P.M.	14.2	inches water.
4.55 "	14.8	" "
5.05 "	15.2	" "
5.20 "	15.6	" "
5.32 "	16.4	" "
5.45 "	13.4	" "
5.51 "	11	" "
6.00 "	8.2	" "
6.13 "	5.6	" "

TOTALS.

Iron melted	9,100 lbs.
Fuel consumed	1,075 "
Ratio of fuel to iron	1 to 8.46

Length of heat, 1 hour and 43 minutes.

"The iron was hot enough for stove-plate. Had the work been heavier, so that crane ladles could have been used, faster melting would have been done. Were coke instead of coal used for bed, five hundred and twenty-five pounds would be the weight used, thereby making the ratio 1 to 9.57. The iron charged was scrap and pig in equal proportions. A No. 5 Sturtevant fan was used; blast pipe, twelve inches diameter and fifteen feet long. The size of cupola given is when first lined up. At the time this heat was taken, it would be about three inches larger diameter." The foregoing is not thought to present the lowest ratio this cupola can be made to melt with. The author has a report from Mr. Hanscom of a heat taken later than the above, which shows the ratio to be 1 to 11.64. This only goes to *substantiate* what is set forth in the chapter on "Economy in Melting," which states that any cupola can be made to melt with a low percentage of fuel; but whether the metal is good for solid blocks, or stove-plate castings, is the point which decides the *economical* part of the question.

The record of workings for the Niles Tool Works cupola is given as follows: —

Time of starting fire	2.10 P.M.
Charging first iron	3.30 "
Blast put on	4.30 "
Iron down	4.42 "
Bottom dropped	6.05 "

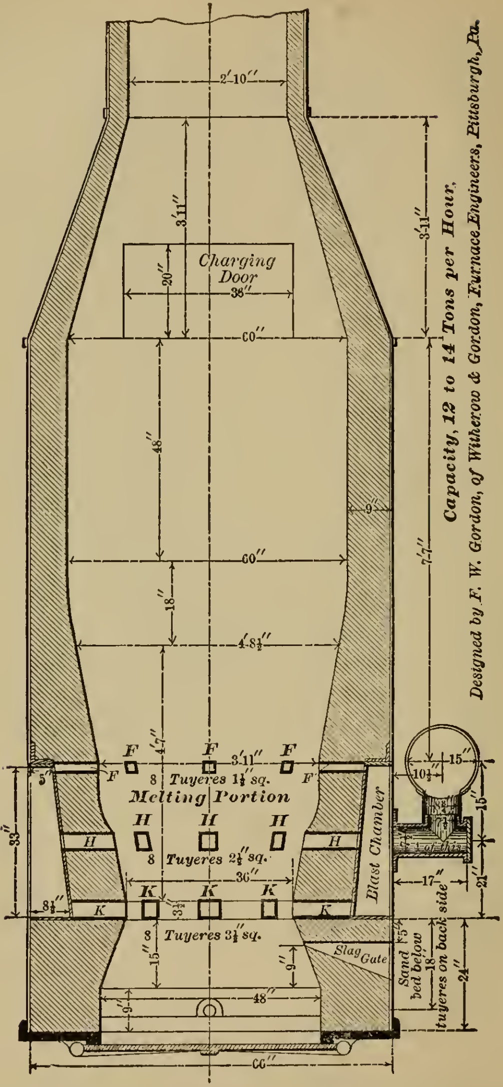

2′-10″
3′-11″
3′-11″
Charging Door
20″
38″
60″
48″
9″
60″
7′-7″
18″
4′-8½″
4′-7″
F
F
F
F
F
3′-11″
8 Tuyeres 1½″ sq.
Melting Portion
5″
15″
10½″
15″
H
H
H
H
H
8 Tuyeres 2½″ sq.
33″
36″
Blast Chamber
17″
21″
8½″
K
K
K
K
K
3½″
8 Tuyeres 3½″ sq.
15″
9″
Slag Gate
5″
Sand bed below
18″
tuyeres on back side
24″
48″
9″
66″
Capacity, 12 to 14 Tons per Hour,
Designed by F. W. Gordon, of Witherow & Gordon, Furnace Engineers, Pittsburgh, Pa.

Fig. 109.—Niles Tool Works Cupola, Hamilton, Ohio.

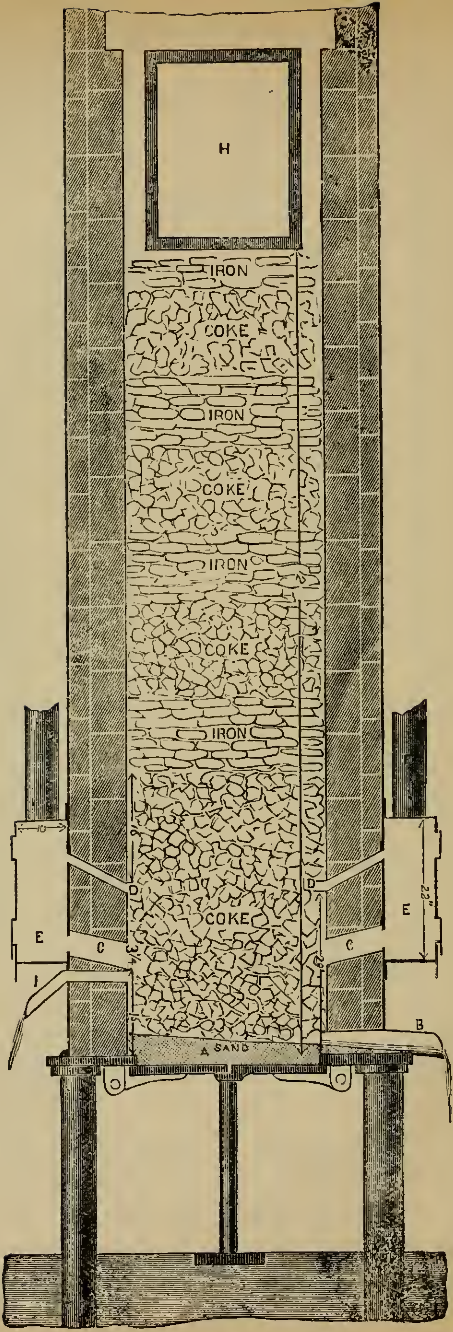

H
IRON
COKE
IRON
COKE
IRON
COKE
IRON
10
D
D
22"
COKE
E
E
C
C
3/4
I
B
A
SAND

Fig. 110.—Cheney Cupola.

CHARGES

Bed, Connellsville coke . .	1,200 lbs.	iron, 6,000 lbs.
" " . .	572 "	" 6,000 "
" " . .	572 "	" 6,000 "
" " . .	704 "	" 6,000 "
" " . .	660 "	" 6,000 "
" " . .	572 "	" 6,000 "

TOTALS.

Iron melted	36,000 lbs.
Fuel consumed	4,280 "
Ratio of fuel to iron	1 to 8.41

Length of heat, 1 hour and 35 minutes.

The iron is described as being very hot, and the cupola as giving entire satisfaction in both economy and speed. One-third scrap to two-thirds pig iron was melted. The blower is Root's No. 6; revolutions, one hundred and twenty-five per minute; length of blast pipe, twenty-five feet. Fluor spar and limestone used for flux.

The next cupola to be noticed is what is called "The Cheney Cupola." In its design, there are many admirable features which commend themselves to the practical man. The following is Mr. Cheney's description of his cupola, as published by the "Boston Journal of Commerce."

"The cut illustrates the manner of constructing an economical cupola of medium size, to melt four tons of iron per hour. It is thirty-four inches inside diameter, and will melt six or seven tons of iron without slagging. By opening the slag-hole after four tons of iron have been drawn, the melt may be continued to twenty tons. To make the slag fluid, so as to run off freely, use thirty pounds of limestone to one ton of iron.

"In charging this cupola with coke, put 600 pounds on the bed; on that, 2,000 pounds of iron. In the subsequent charges, use 130 pounds of coke and 1,400 pounds of iron. In a melt of eight tons, this cupola will melt ten pounds of iron to one pound of coke, or eight pounds of iron to one pound of coal. If coal is used for fuel, the sand-bed should be made about three or four inches deeper than when coke is used.

"This cupola is designed for ordinary foundry-work where sharp iron is wanted. For heavy foundry-work, such as castings, requiring several tons of iron in one piece, the bed may be made deeper by placing the tuyeres from four to six inches higher in the large-size cupolas.

"Put on blast as soon as the cupola is charged, and give this cupola about six ounces pressure of blast for coke, and nine ounces pressure for coal.

"When the lining burns away, and the dimensions of the cupola are enlarged so that six hundred pounds coke fail to make the bed sixteen inches above the upper tuyeres, the coke in the bed must be increased; also increase the iron on first charge in same proportion as the coke is increased.

"Fig. 110 shows a cupola shell 48″ in diameter, continued same size to the full height; lined with 2″ common brick flatways to top of charging-door, and inside these 4½″ fire-brick. The common brick always remain, so that when the fire-brick gets thin the shell is protected.

"A is the sand bottom.

"B is the iron runner.

"I is the slag runner. Outlet for slag is a 2″ hole opposite the iron runner, ½″ lower than the bottom of the lower tuyeres.

"C, lower tuyeres. They decline inward ½″ in 6″, and are 16″ above bed-plate, 8½″ wide at face of lining, and 3¼″ vertical, made with flange on the upper side to bolt to the shell. The opening through the shell to admit the blast into these tuyeres is 3″ by 5″. Each opening admits fifteen square inches.

"D, upper tuyeres. They are 2″ in diameter, decline inward 2½″ in 6″, and are 29″ above bed-plate at the inside of the lining. The hole through the shell to admit blast is 1¼″ in diameter. Six of these tuyeres are made with a flange on the top side so as to bolt the tuyere to the inside of the shell. These tuyeres each receive 1½ square inch blasts through the shell.

"F is an 8″ blast pipe to connect the wind-chamber with the main pipe, which should not be less than 12″ in diameter. If the blower is more then fifty feet from the cupola, the main pipe should be 14″ diameter. The wind-chambers have openings opposite each tuyere, with peep-holes in the shutters.

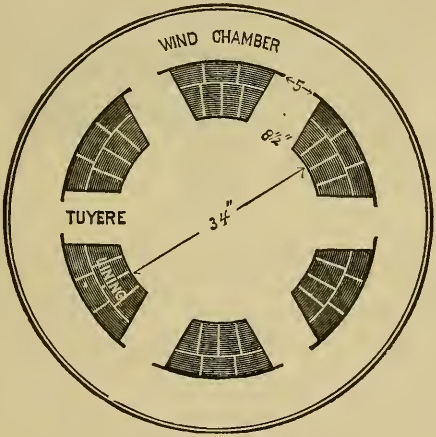


Fig. 111.

"E, wind-chamber, is 10″ deep and 22″ vertical, made in two sections, each section to supply wind to three tuyeres.

"H, charging-door, is twelve feet above bed-plate.

"Fig. 111 shows a sectional view through the tuyeres. They are the same width as the lining between them, and supply an equal force of blast to all the fuel. The tuyere must be twice as large as the opening which admits the blast, and must occupy one-half the space around the inner circumference of the cupola. In larger cupolas, increase the number of the tuyeres.

"Fig. 112 shows a perspective view of the wind-chamber, made in semi-circles, so that when it is bolted to the shell it will extend around it, forming one chamber to supply wind to all the tuyeres, and dropping down 8″ in front of the lower tuyeres. If through carelessness the iron overflows the tuyeres into the wind-chamber, it is more easily removed than if the chamber is even on the bottom, and the chamber is not in the way of the slag-hole."

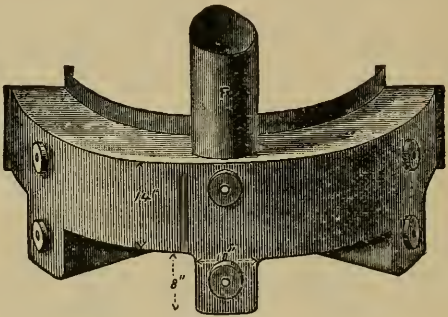


Fig. 112.

COMMENTS ON CUPOLAS.

In closing the preceding chapter, it may be said there are those who, no doubt, would prefer the author's giving a few comments upon the merits of the respective cupolas therein mentioned.

Taking them in the order shown, the first we come to is that at the Callahan and Dearmon's works. The style of tuyere used is one that ought to work well in melting with coke alone in straight cupolas which range from 48″ down. Below 40″ the tuyere area should be decreased in proportion to the decrease in diameter of the cupola. From 40″ to 48″ it would be best to use the tuyere area shown; for, to enlarge them would deter the blast more or less from being forced through the tuyeres to aid combustion in the centre body of the fuel, which in cupolas over 40″ having outside tuyeres only, can never possess the live combustion that is carried on at the outer body of the cupola's circumference.[1]

In melting with coke, it is well that large tuyere areas be used, as they serve to prevent tuyeres from bunging up in running off heavy heats. With coal, it is not as essential to have a large tuyere area, for the reason its life is not so readily chilled and "blown out" by blast pressure as in the case of coke; and also it is often beneficial to have the tuyere area made smaller for coal, as by doing so some fuel can be saved in making the bed.

We require more pressure, or density of blast, in melting with coal, for the simple reason, from its compactness it forms a most dense fuel. It must be understood that this extra pressure is not to be created by a contraction of the tuyeres: whenever pressure must be increased, it must be done by *increasing the power upon the blower;* and the increase there generated should exist in the cupola as well as in the blast pipes or at the tuyeres.

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[1] Information on attaining good centre combustion is found in pages 381 to 411.

Chemically speaking, it is not pressure that fuel demands to produce combustion, but an ample supply of oxygen: we use the pressure simply as a motive power to deliver and feed the oxygen to the carbon in the fuel; and could this oxygen be supplied in sufficient quantities, without the use of this pressure, cupolas could be made to run for months, if dirt and slag were taken care of, and the lining were of such a character as would withstand the constant heat.

The smaller the area of cupola tuyeres, the more pressure the fuel in front of them receives. When the area of tuyeres is such as to cause the blast to have its velocity and density increased as it enters the cupola, the process of "bunging up" at the tuyeres is greatly incited. The less the force of the blast is concentrated upon the fuel in front of tuyeres, the longer will they freely permit the proper volume of air to be blown into the cupola.

The quantity of oxygen necessary to form and incite combustion is regulated according to the *area* of a cupola, and the *kind of fuel used.* The quantity required is obtained by means of the speed given to the "blower," and the tuyeres are only used for the purpose of affording this quantity an entrance to the fuel in the cupola. In small cupolas, there is no fear but that streams of the blast can be made to reach centre of the cupola by the use of large tuyeres. For large cupolas, some decrease the tuyere area, thinking to thereby force the blast more to the centre of the cupola. This is a bad plan, as to obtain the best combustion in the centre body of large cupolas can only be done by the use of a "centre blast" tuyere or to make cupolas of over 60″ inside diameter contracted at the tuyeres similarly to the plan adopted by the "Mackenzie cupola."

In other words, if a cupola needs to be 60″, 70″, 80″, or more in diameter, do not let the diameter at the tuyeres be enlarged over 60″: by this plan we can use a good large tuyere area, and at the same time give the blast more chance to reach the cupola's centre. A rule for the area of tuyere blast-pipes, etc.. will be found in chapter upon "Areas of Tuyeres and Blast-pipe" (p. 315).

Another plan which works well with large cupolas is this: instead of making them round, to have them constructed oblong. By this method any area can be obtained, and at the same time the blast be given good opportunity to reach the central body of the fuel. Some, in making their cupolas oblong, contract them at the tuyeres similarly to the one described in constructing round cupolas. It is, however, seldom best to do this with oblong cupolas, unless in case of a very large one; for it is liable to result in the bunging-up of the cupola.[1] Any cupola had better be made with a straight lining wherever it is practical, or not injurious in other ways. When the shortest diameter of any style cupola measures over 60″, then it becomes advisable to contract the tuyeres so they shall not exceed 60″, or use "centre blast." With our ordinary pressure or density of blast used, this will afford the blast a good opportunity to *penetrate through the fuel,* and thus promote the rapid combustion which should be created in the centre of a cupola.

Where the Callahan and Dearmon style of tuyere is used for large cupolas, say from 60″ up to 72″ or over, the better plan would be, not to enlarge the diameter at the tuyeres to exceed 60″ or to leave the cupola perfectly straight and use a "centre blast" tuyere, the construction and use of which is fully described in pages 381 to 411.

Where all coal is the fuel to be used with such tuyeres, they would be better 4″ instead of 6″ deep as shown, and 4″ or 5″ lower.

The next cupola we come to is that of the *National Iron Works,* as shown, and is practically a coke cupola.

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[1] For further information of oblong cupolas, see pages 376 to 380.

Where all coal is the fuel used, better results would be obtained if the top row of four tuyeres were lowered about 12″, and the bottom iron of six tuyeres lowered 6″, and the diameter of the top tuyeres made ½″ less than now shown.

The Niles Tool Works' cupola is one which should melt very fast if *it had plenty of blast*, on account of its having three rows of tuyeres, or, as it might be put, three melting zones. The principle in this cupola construction is one which would give poor results if it were carried into the building of cupolas under 48″ diameter: the size of this cupola, as seen, is 60″ in diameter. The reason for failure in small sizes is the choking of the cupola which the small area at tuyeres in running long heats would cause. The cupola would of course melt rapidly, but its heat would be short-lived. See pages 376 to 380.

The last cupola to be noticed is the "Cheney." This is a well-arranged cupola for melting with coke. Its area of tuyeres is good and large, the construction of the wind-belt is one well designed, and the peep-holes seen are something most all cupolas should have. The height of the cupola is another admirable feature: this is as shown twelve feet high from bottom to the charging-door, which gives the stock every chance to receive benefit from escaping heat of the fuel. Were this cupola with its diameter shown to be built expressly for coal, the tuyeres would be better if made 4″ or 5″ lower than shown. If in any of the four cupolas as now shown, coal were to be used, their sand bottoms could be made 4″ or 5″ deeper than if they were used in heats where coke is the fuel: this would practically be the same thing as making the tuyeres lower than shown.

For the purpose of aiding any who may be inclined to pattern after any of the cupolas, the measurements are given as shown.

BLAST AND COMBUSTION.

The oxygen of the atmosphere, when combined with the carbon of fuel, generates combustion: without this oxygen, carbon could not be consumed. A piece of coke or coal, if immersed in a ladle of iron so that air could not reach it, would only char; showing us that oxygen, and not heat, is the reducing agent or supporter of combustion.

For every pound of carbon fuel contains (which on an average for coal is placed at seventy-five to eighty per cent), 11.6 pounds, or 152 cubic feet of air at 62°, are required for its perfect combustion. Gases resulting from combustion of the carbon of coal and oxygen of the atmosphere are said to be of same bulk as that of atmospheric air required to furnish the oxygen. Taking this in connection with the amount of oxygen or air that escapes without combining with the carbon of the fuel (which is by some placed at from twenty-five to fifty per cent), the necessity of having to furnish more air than at the rate of 11.6 pounds of air per pound of carbon the fuel contains for its mechanical combustion, is at once seen. Coal being a much more dense fuel than coke, more pressure or volume of air is needed for its combustion in the workings of a cupola. While chemically, as shown by table, p. 308 (compiled from MM. Favre and Silberman, D. K. Clark, and others), nearly the same volume of air is required for the combustion of coke and coal, we find that practically, in the use of coal and coke separately in the same cupola, from one-fourth to one-third more air is used in the creation of a like rapid combustion when melting with all coal, than when all coke is used. If it is a fact that coal and coke chemically require nearly the same volumes of air, then this extra one-fourth or one-third volume of air used in melting with coal is but an addition to the non-combining oxygen, and passes off as the spent product of pressure. To be thus compelled to have the volume increase with pressure, — when with coal, *in one sense*, more pressure than volume is required to accomplish the desired rapidity of melting, — is indeed employing a "necessary evil:" for, since the blast is cold, it must be raised in temperature before it can enter into combustion; and when more air than can be utilized is forced into a cupola, extra heat is absorbed, and therefore it must increase the retarding of melting, for its influence is to reduce temperature. From this fact can be deduced, there is such a thing as delivering too much air into a cupola, a thing which many think cannot be done. Combustion cannot proceed beyond a certain rate; and an excessive supply of air only causes a waste of heat, and an uncalled-for destruction of the cupola's lining. An insufficient supply causes imperfect combustion. The first combination of carbon with oxygen produces carbonic acid, and this, in passing up through the fuel, frequently takes up more carbon, and is converted into carbonic oxide; which, if allowed to pass away in this state, causes considerable loss of heat, as carbonic oxide is a combustible gas, and can be burnt by furnishing it with a supply of air; which, if it only gets as it reaches the charging-door, is then of course too late to be of any service. By having a requisite volume of air properly delivered, this carbonic oxide is much decreased, and therefore more carbonic acid, which is the product of perfect combustion, created. To know when we have the requisite amount of air in our cupolas, can in every-day practice be but approximately told. However, there is much that might be done to help us in intelligently handling the supply of the requisite quantities of blast. When we think how few foundries there are that have any idea of their blast pressure, or the volume of air used, and secondly how few arrange so as to assist the pressure in delivering its volume properly into the cupola, we are not surprised at their excessive cost in running. A great many cupolas are constructed so that the tuyeres cannot be examined to see if they are working freely. The first thing to know is the density of the blast which the blower is creating, and this is easily shown by attaching a blast-gauge to the pipe. The second thing is to know if the right volume of blast is being delivered into the cupola. This can be told to a certain extent by a practical man, by noting the cupola's action; and he may judge very closely as to its working. In fact, it is almost the only way of telling whether or not a cupola is receiving its proper amount of blast; for the pressure of blast in a cupola cannot be known from that generated in the blast-pipes. The pressure in a cupola is generally much less than that in the blast-pipes; and the amount of difference will depend upon how close the iron is charged, and how high and full the cupola is, and also on tuyere area for the passage of air into the cupola. Towards the end of a heat, higher pressure will generally exist in the blast-pipes than in the beginning. This is caused by the tendency of tuyeres to become "bunged up," and the accumulation of slag and dirt in the bed. Chilled iron mixed with fuel and slag is not always the only cause of "choking-up" of tuyeres; often clean fuel will lodge so close in front of tuyeres as to choke them up considerably. This is one of the reasons why large tuyeres are often recommended, for with them the fuel has less chance of preventing the free delivery of the blast; for we must not lose sight of the fact that fuel packed up close to the mouth of a tuyere acts to a degree like a damper. A good thing in practice is, just before the blast is put on, to bar the tuyeres so that whatever pieces of fuel may be "choking" them up, will be pushed back, and thus give the blast a good chance to enter; and then by watching the tuyeres, and keeping them open during the course of the heat, the requisite volumes of air can be more readily admitted.

Combustibles.	Weights of Oxygen consumed per pound of Combustible.	Quantity of Air consumed per pound of Combustibles.		Total heat of combustion of one pound of Combustible.
One pound weight.	Pound.	Pound.	Cubic ft. at 62° F.	Units.
Coke, desiccated . .	2.51	10.9	143	13.550
Coal, average . . .	2.46	10.7	141	14.133

That the pressure or density of the blast as measured in the pipes is more or less regulated by the tuyere openings, and *closeness* and *weight* of the charged iron, is beyond dispute. The conclusion to be drawn from the above would point to the advisability of charging iron closer for coal than for coke; as, the closer the iron is charged, the longer should it take the air and gases to travel upwards, thus affording a better chance for the increasing of pressure or density of blast in among the coal, without being obliged to raise the temperature of the unused *volume* of *escaping* air referred to in fore part of this chapter. The cupola may be said to be only the end of a blower's blast-pipe, and the charges of fuel and iron but a damper, which could be packed so close as to almost shut off the escape of the gases or blast.

It is not intended by the foregoing to say iron and fuel should be charged so close as to form a damper, so that the gases generated by the combustion of the fuel should not freely escape; but simply to show how we can regulate pressure within limits. A cupola will generally melt with more economy of fuel and speed by close charging of the iron than if space is left for a more free escape of the heat or flame.

The pressure of the blast used on cupolas ranges from three up to eighteen ounces. For coal, from one-fourth to one-third more pressure is required than for coke; and for either fuel, the larger the diameter of the cupola, the more pressure is required. A good showing of the average pressure used upon different diameters of cupolas is seen in the following table, which is compiled from Sturtevant's experiments.

As speed in melting is chiefly augmented by the blast, the cupola should be supplied with all the volume it is possible to use *profitably;* for, the more rapid the melting, the better and hotter will be the metal produced.

Diameter in Inches inside of Cupola.	Melting Capacity per hour in Pounds.	Cubic Feet of Air per minute.	Pressure in Ounces of Blast.
22	1200	324	5
26	1900	507	6
30	2880	768	7
35	4130	1102	8
40	6178	1646	10
46	8900	2375	12
53	12500	3353	14
60	16560	4416	14
72	23800	6364	16
84	33300	8880	16

"The number of cubic feet of air per minute given against each size cupola is the result of numerous tests taken on cupolas.

"The melting capacity per hour in pounds of iron is made up from an average of tests on a few of the best cupolas found, and is reliable in cases where the cupolas are well constructed, and driven with the greatest force of blast given in the table." — Sturtevant.

SLAGGING OUT CUPOLAS.

As slagging out cupolas is one of the most important things to be performed in successfully running them *for long heats*, it was thought a special chapter on the subject would attract attention to its importance.

When it is remembered, by slagging out a cupola its melting capacity can be increased so as to make large cupolas run steady for a whole week, the importance of slagging out cupolas at once appears.

Slag is the result of impurities derived from the fuel, the iron, and the burning-out of a cupola-lining. To dispose of it, many let it run out through the tapping-hole; and, again, others more fortunate have in the cupola a slag-hole for "slagging out."

In slagging out by means of the "tapping-hole," it is sometimes let out at almost every tap; but a better way is, if possible, to "keep a head" of iron in the cupola until a sufficient amount of slag has accumulated, and then to make a special tap to let it out. Having made a good-sized hole, then by means of the regular pressure of blast let the cupola blow out until all the accumulated slag is disposed of, and then stop up, repeating the operation as a sufficient body of slag accumulates. As the end of the heat approaches, the slag taps require to be made oftener. It may accumulate toward the end of the heat so that at every tap more or less slag must be let out. As a general thing, however, if ordinarily clean fuel and iron are used, "slagging out" is not commenced until from one-third to one-half of "the heat is down." This refers to what are termed "heavy heats;" for as a general thing, unless burnt iron or bad fuel is used, "light heats" seldom require any "slagging out."

By the above expression "keeping a head," is meant to simply not permit all the iron to run out of the cupola before stopping up. Slag floats upon the top of iron: therefore, by keeping a head of liquid iron in the cupola, the slag cannot run out of the tapping-hole.

In slagging out by means of a regular "slag-hole," the tapping-hole can be kept clean. Slag-holes are simply a hole about 2″ diameter made from 2″ to 15″ below the tuyere's bottom, as illustrated in many of the cupolas shown. You can allow the top of the slag-hole up within about two inches of the bottom of the tuyeres; if any nearer than this, the cold blast entering the cupola has a tendency to chill the slag, and, if your tuyere is a continuous one, blow it back. Should the tuyeres be such as have a space between them, then place the slag-hole about in the middle of the two tuyeres which are the farthest away from the tapping-hole. When the slag commences to accumulate, the slag-hole, having been stopped up with clay, is "tapped," and, in some cases, is left open during the balance of the heat; then the blast blowing out carries slag with it. In others, when slagging out through a slag-hole, opening and closing it is done at intervals, but before opening it the liquid iron is allowed to rise nearly to a level with the hole; which brings the slag upon a level with the slag-hole, so that it can readily run out when the hole is opened. After the slag is nearly all out, if the metal has not risen so as to compel the cupola to be tapped out in order to keep the metal from running out of the slag-hole, the slag-hole is then stopped up, and the cupola tapped out.

The height to place a slag-hole should be chiefly regulated by the class of work to be done.[1] Where the metal must be carried away by small or hand ladles, the slag-hole should be lower than if the metal is carried away by crane ladles.

In using small ladles, it is not desirable to allow much of a head to accumulate; whereas, with crane ladles, a body is often allowed to accumulate in order that taps may yield a large amount each time. In the latter case, this necessity may arise on account of waiting for a ladle to be returned; then, again, it may be best to have large taps for the purpose of assisting in retaining the life of the metal; and, thirdly, it fatigues the melter unnecessarily to be obliged to tap most every minute, when once in fifteen minutes would answer.

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[1] See page 377 for conditions calling for location of slag-holes.

Slag is a substance which will cool off quickly. Therefore, when passing down by the tuyeres, or allowed to remain in a cupola, it becomes easily chilled by the effects of the cold blast. When chilled, the blast cannot penetrate through it, and it soon forms a barrier which can prevent the blast from entering. Also, as slag chills, more or less of the iron and fuel is incased by it, and this makes it more difficult to deal with.

The more fluid slag can be made, the easier it is to remove it from the cupola. For this purpose, fluxes, which will separate the slag from the "stock," and impart fluidity to the slag, are used. Not only are fluxes valuable for the above, but they glaze a cupola's lining, and are thus of great assistance in preventing the heat from cutting it. It is not necessary to mention here the different fluxes in common use, as the reader will have noticed them in other parts of this work.

The amount of slag a cupola will create depends upon the cleanliness of the fuel, the quality of iron used, etc. Burnt iron, in any form, is almost the worst thing that could be put into a cupola, to create slag; and to have the cupola lining "cut out" is almost as bad, since it is composed of nothing but clays. There are two reasons that are the usual causes of cutting linings. The first is blowing with too *strong a blast;* the second, *improper daubing of the cupola*, which greatly consists in putting on too much clay. While the above are some of the causes for the creation of slag, it might be well to add that fuel, although it may be free of dust or dirt, creates more or less slag. Fuel containing a large per cent of dirt, ash.

slate, or stone, is very productive of slag; and the same may be said of iron which is coated with rust or sand.

Another feature which is very essential for the success of long heats is *keeping the tuyeres open.* All cupolas that are expected to run *long heats* should have some arrangement whereby the melter can see the fuel, and get at it with a bar as soon as any chilling shows signs of seriously bridging around or above the tuyeres. Some may inquire how they are to know when chilling is commencing to cause serious effect. It is seen when the fuel commences to look black, and closed up so as to prevent entrance of the blast. The fuel in front of the tuyeres should be so open that more or less of the inner fire can be seen. When the fuel in front of the tuyeres commences to get dark and closed up so that the blast is prevented from entering into the cupola, the blast should be slackened, the tuyeres opened one by one, and the chilled material driven, with a bar, towards the centre of the cupola. This will give a fresh supply of hot fuel for the cold blast to play upon, and the chilled material sent into the hot fire will be partly consumed. By referring to pp. 312 and 329 of vol. i., other points touching upon this subject will be found. It must be remembered that there is a limit to "poking out" the tuyere: too much is injurious, as it causes the body of the fire in front of the tuyeres to be filled with material that will always have a tendency to deaden it. The tuyeres should not be let go too long, nor should they be opened any oftener than is actually necessary to allow the blast a fair chance to get into the cupola. It would be better for a cupola if it could be arranged to run long heats without the necessity of "poking the tuyeres." The smaller the area of tuyeres is, the more liable are they to cause trouble from becoming "bunged up." Having the tuyeres large, or plenty of them, is the best plan to adopt to avoid the necessity of being obliged to "poke the tuyeres" often during long heats. The area of tuyeres, etc., will be found fully treated in the chapter "Areas of Tuyeres and Blast-Pipes," p. 315.

Proper fluxing, slagging out, and keeping the tuyeres open, is "half the battle" in the management of cupolas; and one who can intelligently manipulate slagging out, and keeping the tuyeres open, will get about double the amount of metal out of a cupola, that he would if no attention were paid to the above points. The following table gives an approximate idea of the amount of iron ordinary cupolas should melt without slagging out, and with "slagging out."

INSIDE DIAMETER OF CUPOLA IN INCHES.	MELTING CAPACITY IN TONS WHEN NOT SLAGGING OUT.	MELTING CAPACITY IN TONS WHEN SLAGGING OUT.
20	2	4
25	3	8
30	5	12
35	7	16
40	9	24
45	12	34
50	15	50
55	20	65
60	25	80
65	30	100
70	35	130
75	40	160
80	50	200

NOTE.—The author does not wish it understood that cupolas could not be made to melt any more than shown in "slagging out" column. The weight there given might often be exceeded, especially in the large cupolas. In fact, when properly *fluxed*, *slagged*, and *tuyere-opened*, large cupolas could often be made to run as long as the lining would stand the constant heat.

AREAS OF TUYERES AND BLAST PIPES.

It is evident from an examination of the table upon p. 321, giving the ratio of the area of the tuyere to that of the cupola, that there exists a great variation in the ratio of tuyere to cupola area allowed in the cupola-practice of America, ranging, as is seen, from 4.32 to as high as 30.75 per cent. By this some may be led to think that most any area will do for the admittance of air to a cupola. There is no question but considerable difference in the per cent of tuyere area can be used with but little or no ill results.

While great variation in tuyere area is admissible, some ill effects will undoubtedly result from an indiscriminating *adoption* of tuyere area. The author is far from affirming that there would be no observable difference in the working of two cupolas, both same diameter and run under like conditions, but one having a tuyere area of only four, and the other of thirty, per cent of that contained in the cupola.

Upon general principles, small tuyere areas cause shorter-lived melting than large tuyere areas. This question will be found discussed upon p. 329, vol. i. and p. 302, vol. ii. What tuyere area is the best to adopt, the reader will be better able to understand, after reading the pages above referred to, and a study of the tables and formulas at the end of this chapter.

In taking up the question of blast-pipes, areas, etc., attention is first called to the table of B. F. Sturtevant's for equalizing the diameter of pipes (p. 316); which is very valuable, as by it one can readily learn the number and diameter of branch pipes necessary in conveying of blast from the main pipes to a cupola.

B. F. STURTEVANT'S TABLE FOR EQUALIZING THE DIAMETER OF PIPES.

Parties putting up blast-pipes are very liable to think that because the combined area of four 6″ pipes is the same as one 12″ pipe, the four pipes will convey the same quantity of air with the same ease and freedom that the 12″ will; whereas it actually does take 5.7,—almost six 6″ pipes. Again, sixteen 3″ pipes have the combined area of one 12″ pipe, but in actual practice it takes just thirty-two 3″ pipes to do the work of one 12″.

This is due to the excess of friction for every cubic foot of air in the small pipes over that in the large.

The large figures at the top of each column give the diameters in inches of the branch pipes.

The figures at the intersection of the horizontal line with the vertical give the number of pipes, of the diameter given at the top of the column, that will be equal in capacity for conveying air to one given opposite in the first column.

Diameter of Main Blast-Pipe in inches.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	26	28	30	36	42	48	54
1																													
2	5.7																												
3	16	2.7																											
4	32	5.7	2																										
5	56	9.8	3.6	1.8																									
6	88	16	5.7	2.8	1.6																								
7	129	23	8.3	4.1	2.3	1.5																							
8	180	32	12	5.7	3.2	2.1	1.4																						
9	244	42	16	7.6	4.3	2.8	1.9	1.3																					
10	317	56	20	9.9	5.7	3.6	2.4	1.7	1.3																				
11	402	71	26	12	7.0	4.5	3.1	2.2	1.7	1.3																			
12	501	88	32	16	9.0	5.7	3.8	2.8	2.0	1.6	1.2																		
13	613	107	39.	19	11	6.9	4.7	3.4	2.5	1.9	1.5	1.2																	
14	737	129	47	23	13	8.3	5.7	4.1	3.0	2.3	1.8	1.5	1.2																
15	876	152	56	27	16	9.9	6.7	4.8	3.6	2.8	2.2	1.8	1.4	1.2															
16	1026	180	65	32	18	11	7.9	5.7	4.2	3.2	2.6	2.1	1.7	1.4	1.2														
17	1197	208	76	37	21	13	9.2	6.6	4.9	3.8	2.9	2.4	2.0	1.6	1.4	1.2													
18	1375	239	88	43	24	16	10	7.7	5.7	4.3	3.4	2.8	2.3	1.9	1.6	1.3	1.2												
19	1580	275	100	49	28	18	12	8.8	6.5	5	3.9	3.2	2.6	2.2	1,8	1.5	1.3	1.2											
20	1797	313	114	56	32	20	14	9.9	7.4	5.7	4.5	3.6	2.9	2.5	2.1	1.7	1.5	1.3	1.1										
22	2284	398	145	71	41	26	18	13	9.3	7.2	5.7	4.5	3.7	3.1	2.6	2.2	1.9	1.7	1.4	1.3									
24	2834	493	180	88	50	32	22	16	12	8.9	7.6	5.7	4.6	3.8	3.2	2.9	2.4	2.1	1.8	1.6	1.2								
26	3474	605	219	108	62	39	27	19	14	11	8.6	6.9	5.7	4.7	4.0	3.4	2.9	2.5	2.2	1.9	1.5	1.2							
28	4165	725	265	129	74	48	32	23	17	13	10	8.3	6.8	5.7	4.8	4.1	3.5	3.0	2.6	2.3	1.8	1.5	1.2						
30	4963	864	315	154	88	56	38	28	20	16	12	9.9	8.0	6.7	5.7	4.7	4.1	3.6	3.0	2.6	2.2	1.7	1.4	1.2					
36	7818	1361	497	243	139	88	60	43	32	25	19	16	13	11	8.9	7.6	6.5	5.7	5.0	4.3	3.4	2.7	2.2	1.9	1.6				
42	11488	2000	730	358	205	129	88	63	47	36	29	23	19	16	13	11	9.6	8.5	7.3	6.4	5.0	4.1	3.3	2.8	2.3	1.5			
48	15989	2792	1081	492	282	180	123	88	66	50	39	32	26	22	18	16	13	12	10	8.9	7.0	5.7	4.7	3.8	3.2	2.1	1.4		
54	21560	3753	1368	671	384	244	166	119	88	68	53	43	35	29	24	21	18	16	15	12	9.4	7.6	6.2	5.2	4.3	2.8	1.9	1.3	
60	27913	4879	1781	872	499	314	215	154	115	88	69	56	46	38	32	27	23	20	18	16	12	9.9	8.1	6.7	5.7	3.6	2.4	1.8	1.3

VELOCITY AND QUANTITY OF AIR DELIVERED IN PIPES OF DIFFERENT DIAMETERS, AND 100 FEET LONG, WITH THE SAME LOSS OF PRESSURE PER SQUARE INCH.

Diameter of pipe in inches.	Velocity of air in feet per minute.	Cubic feet of air per minute.	Diameter of pipe in inches.	Velocity of air in feet per minute.	Cubic feet of air per minute.
1	886	4.7	16	3464	4837
2	1224	27	17	3570	5626
3	1500	74	18	3674	6494
4	1732	151	19	3775	7434
5	1936	264	20	3872	8448
6	2121	416	22	4061	10719
7	2291	612	24	4242	13327
8	2449	855	26	4415	16278
9	2598	1148	28	4582	19593
10	2738	1493	30	4743	23284
11	2872	1895	36	5196	36745
12	3000	2356	42	5612	54032
13	3123	2879	48	6000	75386
14	3240	3464	54	6363	101228
15	3354	4115	60	6710	131759

The various quantities of air here given is at the rate of 4352 cubic feet, to be carried a distance of 100 feet per minute, with a loss of 1 horse power, or 1000 feet with 10 horse power.

Sturtevant's table is one which will not only save labor in calculating areas of blast-pipes, but is valuable in other respects; one of which is prominently showing the retarding effect of friction in the delivery of volumes of air through long pipes, and *the advisability of placing blowers near to a cupola in order to save cost in motive power*, for the cost to supply motive power to drive air through *long pipes* is something worthy of consideration. The nearer a blower can practically be placed to a cupola, the better results in every way will be produced.

Blast-pipes should be sufficiently large to convey the required volume of air without undue loss by friction. The longer the distance air is carried, the larger in diameter should the pipes be. Where small conducting-pipes are used, much more power is necessary, as a greater velocity is required to discharge a given amount of air; the friction being increased in the ratio of the square of the velocity with which the air moves.

The table of Baker's (p. 318), giving the diameter of main blast-pipes, will be found a valuable companion to the Sturtevant's table, in determining the areas of main and branch blast-pipes.

"Blast-pipe should, in all cases, be air-tight. A few small holes often cause trouble, the blower having to be run faster to make up for leakage, which is only waste of power, and, as the pressure in the blast-pipe increases, the escape is also in proportion: therefore it will be impossible to force through the furnace the requisite amount of air. Diameter of blast-pipes should be in proportion to the size of cupola, so that the air delivered may not be forced to travel faster through the pipes than sixty feet per second. If the pipes exceed fifty feet in length, their diameter should be increased somewhat (on account of the friction of the air in the pipes). For every additional fifty feet it would be well to add one inch to the diameters given above." — BAKER.

BAKER'S TABLE.

Giving the Diameter of Main Blast-Pipes for all Cupolas ranging from 18″ to 84″ inside diameter. Length of Pipes to be 50 feet.

Diameter of Cupolas.	Diameter of Pipe.	Diameter of Cupolas.	Diameter of Pipe.	Diameter of Cupolas.	Diameter of Pipe.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
18	5	41	11½	63	17¾
19	5½	42	11¾	64	18
20	5¾	43	12	65	18¼
21	6	44	12½	66	18½
22	6¼	45	12¾	67	18¾
23	6½	46	13	68	19
24	6¾	47	13¼	69	19½
25	7	48	13½	70	19¾
26	7½	49	13¾	71	20
27	7¾	50	14	72	20¼
28	8	51	14½	73	20½
29	8¼	52	14¾	74	20¾
30	8½	53	15	75	21
31	8¾	54	15¼	76	21½
32	9	55	15½	77	21¾
33	9¼	56	15¾	78	22
34	9½	57	16	79	22¼
35	9¾	58	16¼	80	22½
36	10	59	16½	81	22¾
37	10½	60	16¾	82	23
38	10¾	61	17	83	23½
39	11	62	17½	84	24
40	11¼				

To complete this chapter, the author will give his original formulas for finding the area of the tuyeres for different diameter cupolas, etc.

The first is the *maximum* area advisable, and is simply to construct tuyeres of such area that their sum shall be twenty-five per cent of the average area of the cupola, calculated on its inside diameter. This would give a $40''$ cupola six $8\frac{3}{16}''$ round, or a $2\frac{1}{2}''$ open flat continuous tuyere.

To find the *medium* area of tuyere: *Divide the area of the cupola by* 9. This gives an area of tuyere of $11\frac{1}{9}$ per cent of that contained in a cupola; and gives a $40''$ cupola six $5\frac{3}{8}''$ round, or a $1\frac{1}{8}''$ open flat continuous tuyere.

To find the *minimum* area of tuyere: *Divide the area of the cupola by* 20. This gives an area of tuyere of 5 per cent of that contained in a cupola; and would give a $40''$ cupola six $3\frac{5}{8}''$ round, or a $\frac{1}{2}''$ open flat continuous tuyere.

To find tuyere areas ranging from medium up to maximum, the ratio would of course increase in per cent by decreasing the divisor. The figure 8, used for a divisor, would give $12\frac{1}{2}$ per cent; 7 would give $14\frac{2}{7}$ per cent; 6 would give $16\frac{2}{3}$ per cent; 5 would give 20 per cent.

To find area of tuyeres ranging from medium down to minimum, the divisors would of course increase from 10 up to 19.

The $40''$ cupola is used as an illustration of the different areas of the tuyeres resulting from these formulas; but if the first formula were employed, and the tuyeres were round, it would be better to increase the number of tuyeres to seven or eight, as this will give a smaller diameter to each, and distribute the blast more evenly around the cupola, — a point worth considering in designing a cupola.

When, by any of the above formulas, the tuyere area is obtained, it will then be divided by whatever number of tuyeres are desired. Then, if the tuyeres are intended to be round, square, or flat, the dimensions of the tuyere can be readily found by referring to page 322, containing the areas and circumferences of circles and squares. Should the tuyere be of other shape, the subdivided areas would then require special figuring to obtain the dimensions of the form of tuyere desired.

With reference to which of the above formulas it is best to adopt, the reader is recommended to consider the conditions referred to in the fore-part of this chapter, and adopt that one best suiting the requirements of the intended cupola. The medium area of tuyere found with the divisor 9 is the formula recommended for general conditions of light or medium heats, and under no conditions is the minimum tuyere area found with the divisor 20 to be used other than in shortest of heats. The maximum area will be found to work best where all coke is used in cupolas running heavy or long heats.

It is to be remarked that the best smaller tuyere area one can use in meeting all conditions, the more fuel should be saved.

The form of tuyeres is often of secondary importance to the question of having them of the *right area, evenly divided,* and of *proper height* above the bottom of the cupola; this last element being regulated by the class of fuel used and castings made (points which are discussed on p. 308, vol. i.).

In the first volume, a few expressions may seem, to some, not to fully harmonize with all that this volume contains upon the inexhaustible subject of melting iron. The trouble, if closely examined, will be found to be that the space there would not permit a full discussion of all the details, and therefore the reader was often left to draw his own conclusions. However, the author hopes that his continued study and experiments since vol. i. was last issued, as shown herein, will prove progressive, and give his readers *data* and *information* that will be of practical value in the construction and managing of cupolas.

TABLE OF CUPOLA AND TUYERE AREAS,

Showing the ratio of the area of tuyeres to that of the cupolas.

Page.	Cupola Area.	Tuyere Area.	Per cent of Tuyere to Cupola Area.	Page.	Cupola Area.	Tuyere Area.	Per cent of Tuyere to Cupola Area.
330	1521	174	11.44	353	661	108	16.34
331	452	96	21.24	354	1018	100	9.82
332	1521	132	8.67	355	2177	234	10.75
333	1964	200	10.18	356	707	84	11.88
334	530	120	22.64	357	1257	152	12.09
335	616	84	13.63	358	962	50	5.19
336	1582	118	7.46	359	491	39	7.94
337	908	60	6.6	360	908	96	10.57
338	2940	328	11.15	361	1963 *	178 *	9.06
339	1810	96	5.3	361	1963 †	225 †	11.46
340	1134	124	10.93	362	855	48	5.61
341	1809	246	13.6	363	1075	63	5.86
342	1662	144	8.66	364	2290	100	4.37
343	1320	110	8.33	365	706	39	5.52
344	4646	261	5.61	366	1257	202	16.07
345	855	73	8.54	367	530	163	30.75
346	2290	120	5.24	368	2463	150	6.09
347	2290	477	20.83	369	531	42	7.9
348	1018	188	18.46	370	661	80	12.1
349	1385	92	6.64	371	707	48	6.79
350	1257	72	5.73	372	380	29	7.63
351	1134	136	12.	373	804	78	9.7
352	1735	75	4.32	374	908	87	9.58
				375	415	50	12.04

Illustrated Cupolas.				
Cuyahoga	274	1256	184	14.65
Globe	274	1256	78	6.21
Pratt & Whitney	278	1572	222	14.12
Callahan & Dearmon	292	1452	306	21.07
National Works	294	707	58	8.2
Niles Tool Works	296	1810	166	9.17
Cheney	298	909	99	10.9

* Car-wheel department.

† Machinery department.

A TABLE

CONTAINING THE CIRCUMFERENCE AND AREAS OF CIRCLES; ALSO, THE AREAS OF SQUARES.

Advancing by ¼″ from 1″ to 100″.

Diameter or root.	Circumference.	Area of Circles.	Area of Squares.	Diameter or root.	Circumference.	Area of Circles.	Area of Squares.
1	3.1416	.7854	1.	7	21.9912	38.4846	49.
1¼	3.9270	1.2272	1.5625	7¼	22.7766	41.2826	52.5625
1½	4.7124	1.7671	2.25	7½	23.5620	44.1787	56.25
1¾	5.4978	2.4053	3.0625	7¾	24.3474	47.1731	60.0625
2	6.2832	3.1416	4.	8	25.1328	50.2656	64.
2¼	7.0686	3.9761	5.0625	8¼	25.9182	53.4563	68.0625
2½	7.8540	4.9087	6.25	8½	26.7036	56.7451	72.25
2¾	8.6394	5.9396	7.5625	8¾	27.4890	60.1322	76.5625
3	9.4248	7.0686	9.	9	28.2744	63.6174	81.
3¼	10.2102	8.2958	10.5625	9¼	29.0598	67.2008	85.5625
3½	10.9956	9.6211	12.25	9½	29.8452	76.8823	90.25
3¾	11.7810	11.0447	14.0625	9¾	30.6306	74.6621	95.0625
4	12.5664	12.5664	16.	10	31.4160	78.54	100.
4¼	13.3518	14.1863	18.0625	10¼	32.2014	82.5161	105.0625
4½	14.1372	15.9043	20.25	10½	32.9868	86.5903	110.25
4¾	14.9226	17.7206	22.5625	10¾	33.7722	90.7628	115.5625
5	15.7080	19.635	25.	11	34.5576	95.0334	121.
5¼	16.4934	21.6476	27.5625	11¼	35.3430	99.4022	126.5625
5½	17.2788	23.7583	30.25	11½	36.1284	103.8691	132.25
5¾	18.0642	25.9673	33.0625	11¾	36.9138	108.4343	138.0625
6	18.8496	28.2744	36.	12	37.6992	113.098	144.
6¼	19.6350	30.6797	39.0625	12¼	38.4846	117.859	150.0625
6½	20.4204	33.1831	42.25	12½	39.2700	122.719	156.25
6¾	21.2058	35.7848	45.5625	12¾	40.0554	127.677	162.5625

CIRCUMFERENCE AND AREAS OF CIRCLES; ALSO, THE AREAS OF SQUARES,—*Continued.*

Diameter or root.	Circumference.	Area of Circles.	Area of Squares.	Diameter or root.	Circumference.	Area of Circles.	Area of Squares.
13	40.8408	132.733	169.	21	65.7936	346.361	441.
13¼	41.6262	137.887	175.5625	21¼	66.7590	354.657	451.5625
13½	42.4116	143.139	182.25	21½	67.5444	363.051	462.25
13¾	43.1970	148.49	189.0625	21¾	68.3298	371.543	473.0625
14	43.9824	153.938	196.	22	69.1152	380.134	484.
14¼	44.7676	159.485	203.0625	22¼	69.9006	388.822	495.0625
14½	45.5532	165.13	210.25	22½	70.6860	397.609	506.25
14¾	46.3386	170.874	217.5625	22¾	71.4714	406.494	517.5625
15	47.1240	176.715	225.	23	72.2568	415.477	529.
15¼	47.9094	182.655	232.5625	23¼	73.0422	424.558	540.5625
15½	48.6948	188.692	240.25	23½	73.8276	433.737	552.25
15¾	49.4802	194.828	248.0625	23¾	74.6130	443.015	564.0625
16	50.2656	201.062	256.	24	75.3984	452.39	576.
16¼	51.0510	207.395	264.0625	24¼	76.1838	461.864	588.0625
16½	51.8364	213.825	272.25	24½	76.9692	471.436	600.25
16¾	52.6218	220.354	280.5625	24¾	77.7546	481.107	612.5625
17	53.4072	226.981	289.	25	78.5400	490.875	625.
17¼	54.1926	233.706	297.5625	25¼	79.3254	500.742	637.5625
17½	54.9780	240.529	306.25	25½	80.1108	510.706	650.25
17¾	55.7634	247.45	315.0625	25¾	80.8962	520.769	663.0625
18	56.5488	254.47	324.	26	81.6816	530.93	676.
18¼	57.3342	261.587	333.0625	26¼	82.4670	541.19	689.0625
18½	58.1196	268.803	342.25	26½	83.2524	551.547	702.25
18¾	58.9056	276.117	351.5625	26¾	84.0378	562.003	715.5625
19	59.6904	283.529	361.	27	84.8232	572.557	729.
19¼	60.4758	291.04	370.5625	27¼	85.6086	583.209	742.5625
19½	61.2612	298.648	380.25	27½	86.3940	593.959	756.25
19¾	62.0466	306.355	390.0625	27¾	87.1794	604.807	770.0625
20	62.8320	314.16	400.	28	87.9648	615.754	784.
20¼	63.6174	322.063	410.0625	28¼	88.7502	626.798	798.0625
20½	64.4028	330.064	420.25	28½	89.5356	637.941	812.25
20¾	65.1882	338.164	430.5625	28¾	90.3210	649.182	826.5625

CIRCUMFERENCE AND AREAS OF CIRCLES; ALSO, THE AREAS OF SQUARES, — *Continued.*

Diameter or root.	Circumference.	Area of Circles.	Area of Squares.	Diameter or root.	Circumference.	Area of Circles.	Area of Squares.
29	91.1064	660.521	841.	37	116.2392	1075.213	1369.
29¼	91.8918	671.959	855.562	37¼	117.0246	1089.792	1387.562
29½	92.6772	683.494	870.25	37½	117.8100	1104.469	1406.25
29¾	93.4626	695.128	885.062	37¾	118.5954	1119.244	1425.062
30	94.2480	706.86	900.	38	119.3808	1134.118	1444.
30¼	95.0334	718.69	915.062	38¼	120.1662	1149.089	1463.062
30½	95.8188	730.618	930.25	38½	120.9516	1164.159	1482.25
30¾	96.6042	742.645	945.562	38¾	121.7370	1179.327	1501.562
31	97.3896	754.769	961.	39	122.5224	1194.593	1521.
31¼	98.1750	766.992	976.562	39¼	123.3078	1209.958	1540.562
31½	98.9684	779.313	992.25	39½	124.0932	1225.42	1560.25
31¾	99.7458	791.732	1008.062	39¾	124.8786	1240.981	1580.062
32	100.5312	804.25	1024.	40	125.6640	1256.64	1600.
32¼	101.3166	816.865	1040.062	40¼	126.4494	1272.397	1620.062
32½	102.1020	829.579	1056.25	40½	127.2348	1288.252	1640.25
32¾	102.8874	842.391	1072.562	40¾	128.0202	1304.206	1660.562
33	103.6728	855.301	1089.	41	128.8056	1320.257	1681.
33¼	104.4582	868.309	1105.562	41¼	129.5910	1336.407	1701.562
33½	105.2436	881.415	1122.25	41½	130.3764	1352.655	1722.25
33¾	106.0290	894.62	1139.062	41¾	131.1618	1369.001	1743.062
34	106.8144	907.922	1156.	42	131.9472	1385.45	1764.
34¼	107.5998	921.323	1173.062	42¼	132.7326	1401.99	1785.062
34½	108.3852	934.822	1190.25	42½	133.5180	1418.63	1806.25
34¾	109.1706	948.42	1207.562	42¾	134.3034	1435.37	1827.562
35	109.9560	962.115	1225.	43	135.0888	1452.2	1849.
35¼	110.7414	975.909	1242.562	43¼	135.8742	1469.14	1870.562
35½	111.5268	989.8	1260.25	43½	136.6596	1486.17	1892.25
35¾	112.3122	1003.79	1278.062	43¾	137.4450	1503.3	1914.062
36	113.0976	1017.878	1296.	44	138.2308	1520.53	1936.
36¼	113.8830	1032.065	1314.062	44¼	139.0158	1537.86	1958.062
36½	114.6684	1046.349	1332.25	44½	139.8012	1555.29	1980.25
36¾	115.4538	1060.732	1350.562	44¾	140.5866	1572.81	2002.562

CIRCUMFERENCE AND AREAS OF CIRCLES; ALSO, THE AREAS OF SQUARES, — *Continued.*

Diameter or root.	Circumference.	Area of Circles.	Area of Squares.	Diameter or root.	Circumference.	Area of Circles.	Area of Squares.
45	141.3720	1590.43	2025.	53	166.5048	2206.19	2809.
45¼	142.1574	1608.16	2047.562	53¼	167.2902	2227.05	2835.562
45½	142.9428	1625.97	2070.25	53½	168.0756	2248.01	2862.25
45¾	143.7282	1643.89	2093.062	53¾	168.8610	2269.07	2889.062
46	144.5136	1661.91	2116.	54	169.6464	2290.23	2916.
46¼	145.2990	1680.02	2139.062	54¼	170.4318	2311.48	2943.062
46½	146.0844	1698.23	2162.25	54½	171.2172	2332.83	2970.25
46¾	146.8698	1716.54	2185.562	54¾	172.0026	2354.29	2997.562
47	147.6552	1734.95	2209.	55	172.7880	2375.83	3025.
47¼	148.4406	1753.45	2232.562	55¼	173.5734	2397.48	3052.562
47½	149.2260	1772.06	2256.25	55½	174.3588	2419.23	3080.25
47¾	150.0114	1790.76	2280.062	55¾	175.1442	2441.07	3108.062
48	150.7968	1809.56	2304.	56	175.9296	2463.01	3136.
48¼	151.5822	1828.46	2328.062	56¼	176.7150	2485.05	3164.062
48½	152.3676	1847.46	2352.25	56½	177.5004	2507.19	3192.25
48¾	153.1530	1866.55	2376.562	56¾	178.2858	2529.43	3220.562
49	153.9384	1885.75	2401.	57	179.0712	2551.76	3249.
49¼	154.7238	1905.04	2425.562	57¼	179.8566	2574.2	3277.562
49½	155.5092	1924.43	2450.25	57½	180.6420	2596.73	3306.25
49¾	156.2946	1943.91	2475.062	57¾	181.4274	2619.36	3335.062
50	157.0800	1963.5	2500.	58	182.2128	2642.09	3364.
50¼	157.8654	1983.18	2525.062	58¼	182.9982	2664.91	3393.062
50½	158.6508	2002.97	2550.25	58½	183.7836	2687.84	3422.25
50¾	159.4362	2022.85	2575.562	58¾	184.5690	2710.86	3451.562
51	160.2216	2042.83	2601.	59	185.3544	2733.98	3481.
51¼	161.0070	2062.9	2626.562	59¼	186.1398	2757.2	3510.562
51½	161.7924	2083.08	2652.25	59½	186.9252	2780.51	3540.25
51¾	162.5778	2103.35	2678.062	59¾	187.7106	2803.93	3570.062
52	163.3632	2123.72	2704.	60	188.4960	2827.44	3600.
52¼	164.1486	2144.19	2730.062	60¼	189.2814	2851.05	3630.062
52½	164.9340	2164.76	2756.25	60½	189.0668	2874.76	3660.25
52¾	165.7194	2185.42	2782.562	60¾	190.8522	2898.57	3690.562

CIRCUMFERENCE AND AREAS OF CIRCLES; ALSO, THE AREAS OF SQUARES, — *Continued.*

Diameter or root.	Circumference.	Area of Circles.	Area of Squares.	Diameter or root.	Circumference.	Area of Circles.	Area of Squares.
61	191.6376	2922.47	3721.	69	216.7704	3739.29	4761.
61¼	192.4230	2946.48	3751.562	69¼	217.5558	3766.43	4795.562
61½	193.2084	2970.58	3782.25	69½	218.3412	3793.68	4830.25
61¾	193.9938	2994.78	3813.062	69¾	219.1266	3821.02	4865.062
62	194.7792	3019.08	3844.	70	219.9120	3848.46	4900.
62¼	195.5646	3043.47	3875.062	70¼	220.6974	3876	4935.062
62½	196.3500	3067.97	3906.25	70½	221.4828	3903.63	4970.25
62¾	197.1354	3092.56	3937.562	70¾	222.2682	3931.37	5005.562
63	197.9208	3117.25	3969.	71	223.0536	3959.2	5041.
63¼	198.7062	3142.04	4000.562	71¼	223.8390	3987.13	5076.562
63½	199.4916	3166.93	4032.25	71½	224.6244	4015.16	5112.25
63¾	200.2770	3191.91	4064.062	71¾	225.4098	4043.29	5148.062
64	201.0624	3217	4096.	72	226.1952	4071.51	5184.
64¼	201.8478	3242.18	4128.062	72¼	226.9806	4099.84	5220.062
64½	202.6332	3267.46	4160.25	72½	227.7660	4128.26	5256.25
64¾	203.4186	3292.84	4192.562	72¾	228.5514	4156.78	5292.562
65	204.2040	3318.31	4225.	73	229.3368	4185.4	5329.
65¼	204.9894	3343.89	4257.562	73¼	230.1222	4214.11	5365.562
65½	205.7748	3369.56	4290.25	73½	230.9076	4242.93	5402.25
65¾	206.5602	3395.33	4323.062	73¾	231.6930	4271.84	5439.062
66	207.3456	3421.2	4356.	74	232.4784	4300.85	5476.
66¼	208.1310	3447.17	4389.062	74¼	233.2638	4329.96	5513.062
66½	208.9164	3473.24	4422.25	74½	234.0492	4359.17	5550.25
66¾	209.7018	3499.4	4455.562	74¾	234.8346	4388.47	5587.562
67	210.4872	3525.66	4489.	75	235.6200	4417.87	5625.
67¼	211.2726	3552.02	4522.562	75¼	236.4054	4447.38	5662.562
67½	212.0580	3578.48	4556.25	75½	237.1908	4476.98	5700.25
67¾	212.8434	3605.04	4590.062	75¾	237.9762	4506.67	5738.062
68	213.6288	3631.69	4624.	76	238.7616	4536.47	5776.
68¼	214.4142	3658.44	4658.062	76¼	239.5470	4566.36	5814.062
68½	215.1996	3685.29	4692.25	76½	240.3324	4596.36	5852.25
68¾	215.9850	3712.24	4726.562	76¾	241.1178	4626.45	5890.562

CIRCUMFERENCE AND AREAS OF CIRCLES; ALSO, THE AREAS OF SQUARES, — *Continued.*

Diameter or root.	Circumference.	Area of Circles.	Area of Squares.	Diameter or root.	Circumference.	Area of Circles.	Area of Squares.
77	241.9032	4656.64	5929.	85	267.0360	5674.51	7225.
77¼	242.6886	4686.92	5967.562	85¼	267.8214	5707.94	7267.562
77½	243.4740	4717.31	6006.25	85½	268.6068	5741.47	7310.25
77¾	244.2594	4747.79	6045.062	85¾	269.3922	5775.1	7353.062
78	245.0448	4778.37	6084.	86	270.1776	5808.82	7396.
78¼	245.8302	4809.05	6123.062	86¼	270.9630	5842.64	7439.062
78½	246.6156	4839.83	6162.25	86½	271.7484	5876.56	7482.25
78¾	247.4010	4870.71	6201.562	86¾	272.5338	5910.58	7525.562
79	248.1864	4901.68	6241.	87	273.3192	5944.69	7569.
79¼	248.9718	4932.75	6280.562	87¼	274.1046	5978.91	7612.562
79½	249.7572	4963.92	6320.25	87½	274.8900	6013.22	7656.25
79¾	250.5426	4995.19	6360.062	87¾	275.6754	6047.63	7700.062
80	251.3280	5026.56	6400.	88	276.4608	6082.14	7744.
80¼	252.1134	5058.03	6440.062	88¼	277.2462	6116.74	7788.062
80½	252.8988	5089.59	6480.25	88½	278.0316	6151.45	7832.25
80¾	253.6842	5121.25	6520.562	88¾	278.8170	6186.25	7876.562
81	254.4696	5153.01	6561.	89	279.6024	6221.15	7921.
81¼	255.2550	5184.87	6601.562	89¼	280.3878	6256.15	7965.562
81½	256.0404	5216.82	6642.25	89½	281.1732	6291.25	8010.25
81¾	256.8258	5248.88	6683.062	89¾	281.9586	6326.45	8055.062
82	257.6112	5281.03	6724.	90	282.7440	6361.74	8100.
82¼	258.3966	5313.28	6765.062	90¼	283.5294	6397.13	8145.062
82½	259.1820	5345.63	6806.25	90½	284.3148	6432.62	8190.25
82¾	259.9674	5378.08	6847.562	90¾	285.1002	6468.21	8235.562
83	260.7528	5410.62	6889.	91	285.8856	6503.9	8281.
83¼	261.5382	5443.26	6930.562	91¼	286.6710	6539.68	8326.562
83½	262.3236	5476.01	6972.25	91½	287.4564	6575.56	8372.25
83¾	263.1090	5508.84	7014.062	91¾	288.2418	6611.55	8418.062
84	263.8944	5541.78	7056.	92	289.0272	6647.63	8464.
84¼	264.6798	5574.82	7098.062	92¼	289.8125	6683.8	8510.062
84½	265.4652	5607.95	7140.25	92½	290.5980	6720.08	8556.25
84¾	266.2506	5641.18	7182.562	92¾	291.3834	6756.45	8602.562

CIRCUMFERENCE AND AREAS OF CIRCLES; ALSO, THE AREAS OF SQUARES, — *Concluded.*

Diameter or root.	Circumference.	Area of Circles.	Area of Squares.	Diameter or root.	Circumference.	Area of Circles.	Area of Squares.
93	292.1688	6792.92	8649.	96¾	303.9498	7351.79	9360.562
93¼	292.9542	6829.49	8695.562	97	304.7352	7389.83	9409.
93½	293.7396	6866.16	8742.25	97¼	305.5206	7427.97	9457.562
93¾	294.5350	6902.93	8789.062	97½	306.3060	7466.21	9506.25
94	295.3104	6939.79	8836.	97¾	307.0914	7504.55	9555.062
94¼	296.0958	6976.76	8883.062	98	307.8768	7542.98	9604.
94½	296.8812	7013.82	8930.25	98¼	308.6622	7581.52	9653.062
94¾	297.6666	7050.98	8977.562	98½	309.4476	7620.15	9702.25
95	298.4520	7088.23	9025.	98¾	310.2330	7658.88	9751.562
95¼	299.2374	7125.59	9072.562	99	311.0184	7697.71	9801.
95½	300.0228	7163.04	9120.25	99¼	311.8038	7736.63	9850.562
95¾	300.8082	7200.6	9168.062	99½	312.5892	7775.66	9900.25
96	301.5936	7238.25	9216.	99¾	313.3746	7814.78	9950.062
96¼	302.3790	7275.99	9264.062	100	314.1600	7854.	10000.
96½	303.1644	7313.84	9312.25				

Not only are the above tables of areas for circles and squares useful for the purpose referred to on p. 319, but also in figuring weights of castings; *for in the case of desired weights for square or round plates not to be found in* vol. i., referring to the above table will save the necessity of first figuring to obtain their areas before they can be multiplied by the weight of a cubic inch of iron as seen in vol. i. pp. 370, 376.

AMERICAN CUPOLA PRACTICE.

The following forty-six reports of cupola-workings have been carefully collected by the author from thirty States, reaching from *Maine to Oregon.* The reports will not only be found interesting, but very valuable to consult; giving, as they do, so many different men's ideas and practice in *mixing* and *melting iron.* In selecting the firms shown, those were chosen that the author thought used *intelligence* and *system* in their practice. These reports the author believes to be a practical account of the cupola-workings of the respective firms.

Each firm's name, and the line of castings made, are given solely for the purpose of attaching authority to the reports, and to enable foundrymen to classify the workings with their own or intended class of work or castings.

In collecting the reports shown, the author would state that considerable stress was laid upon obtaining some knowledge of the fluidity of the iron melted. I believe the questions were conscientiously answered as far as such a thing could practically be done. The *XXX* shown stands for what shops generally term "good hot fluid iron;" the *XX* stands for a medium fluid iron, such as is often suitable for pouring ordinary thicknesses of machinery castings.

When collecting the reports, the length, etc., of blast-pipes was also obtained. Only such portions are mentioned as were thought to be of service in giving ideas, etc.; since, to publish all the bends and different crooks, etc., would only be adding confusion to the reports.

The reports as shown argue well for the kind and liberal spirit of American foundrymen, in letting their experience and practice be known; and, no doubt, many will feel that they should be credited for their liberality shown. In this the author heartily coincides.

PORTLAND, ME.

COMMON 44″ CUPOLA.

Outside diameter	54″
Thickness of lining	5″
Inside diameter at tuyeres	37″
Largest inside or melting-point diameter	46″
Inside diameter at charging-door	44″
Height from bottom plate up to bottom of charging-door	10′

Style of tuyeres: flat, 1½″ opening, continuous tuyere.

Height from bottom plate to bottom of tuyere	14″
Height of tuyere above sand bottom on back side	8″

A wind-belt, 10″ × 10″, from which the blast is delivered to the tuyeres, encircles the cupola about one-third its circumference.

Fuel used for bed: coal	1,300 lbs.	Second charge of coal	300 lbs.
First charge of pig	2,000 "	Third charge of pig	1,500 "
" " scrap	2,500 "	" " scrap	2,000 "
" " coal	400 "	" " coal	250 "
Second charge of pig	1,500 "	Fourth charge of pig	1,000 "
" " scrap	2,000 "	" " scrap	1,500 "

No. 6 Sturtevant fan: diameter main blast-pipe, 16″. Three cupolas are connected to this main pipe.

Time of starting fire	12.00 A.M.	First appearance of fluid iron	3.55 P.M.
" charging first iron,	1.00 P.M.	Bottom dropped	5.45 "
Blast put on	3.45 "		

Revolutions of blower, 2,200. Kind of fuel used, bed-lump hard coal.

TOTALS.

Amount of iron melted,	14,000 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	2,250 "	Length of heat, 2 hours.
Ratio of fuel to iron used, 1 to $6\frac{22}{100}$.		

Remarks. — The above heat presents an average working of the cupola described. We have two other cupolas, one of which is of same diameter as the above; the other is 34″ inside diameter, having four tuyeres 8″ × 3″; distance from bottom plate to bottom of tuyere, 14″. This cupola will melt three tons per hour. The three cupolas are all fed by the same 16″ blast-pipe.

Our iron is melted for making locomotives, marine, architectural, and jobbing castings.

CHARLES H. CARRUTHERS,
Foreman Portland Locomotive Co.'s Works Foundry

Oct. 23, 1883.

PORTSMOUTH, N.H.

COMMON 24″ CUPOLA.

Outside diameter	36″
Thickness of lining	7½″
Inside diameter at tuyeres	24″
Largest inside or melting-point diameter	24″
Inside diameter at charging-door	21″
Height from bottom plate up to bottom of charging-door	8′ 3″
Style of tuyeres: four 8″ × 3″ rectangular tuyeres.	
Height from bottom plate to bottom of tuyere	16″
Height of tuyere above sand bottom on back side	12″

Fuel used for bed: coal	400 lbs.	Second charge of coal	40 lbs.
First charge of pig	500 "	Third charge of scrap	500 "
" " coal	40 "	" " coal	20 "
Second charge of pig	1,000 "	Fourth charge of scrap	1,150 "

No. 4 Sturtevant; diameter main blast-pipe, 10″. Cupola to blower, 130′; six elbows before it enters cupola.

Time of starting fire	12.00 A.M.	First appearance of fluid iron	2.42 P.M.
" charging first iron,	1.30 P.M.		
Blast put on	2.35 "	Bottom dropped	3.40 "

Revolutions of blower, 2,700. Kind of fuel used, Lehigh coal.

TOTALS.

Amount of iron melted,	3,150 lbs.	Ratio of fuel to iron used, 1 to 6$\frac{3}{10}$.
Amount of fuel consumed,	500 "	Length of heat, 1h. 5m.

Remarks. — The work made is general jobbing castings.

JOSEPH W. HUSE,
Foreman Portsmouth Machine Co.'s Works Foundry

Dec. 12, 1883.

BOSTON, MASS.

COLLIAU 44″ CUPOLA.

Outside diameter	61″
Thickness of lining	8½″
Inside diameter at tuyeres	44″
Largest inside or melting-point diameter	46″
Inside diameter at charging-door	44″
Height from bottom plate up to bottom of charging-door	12′
Style of tuyeres: two rows of tuyeres, six above and six below; bottom row, 5″ × 3″; top row, 3″ diameter.	
Height from bottom plate to bottom of lower tuyere, 20″; to upper tuyere	39″
Height of lower tuyere above sand bottom on back side	14″
Height from bottom plate to bottom of slag-hole	18″

Fuel used for bed: coke	1,400 lbs.	Fourth charge of coke	260 lbs.
First charge of iron	4,000 "	Fifth charge of iron	2,500 "
" " coke	260 "	" " coke	260 "
Second charge of iron	2,500 "	Sixth charge of iron	2,500 "
" " coke	260 "	" " coke	260 "
Third charge of iron	2,500 "	Seventh charge of iron	2,500 "
" " coke	260 "	" " coke	260 "
Fourth charge of iron	2,500 "	Eighth charge of iron	2,500 "

Eight more charges, continued per order shown.

No. 7 Sturtevant fan; diameter main blast-pipe, 12″. Cupola 22′ from blower.

Time of starting fire	12.00 A.M.	First appearance of fluid iron	2.55 P.M.
" charging first iron,	1.00 P.M.		
Blast put on	2.40 "	Bottom dropped	7.05 "

Revolutions of blower, 2,500. Pressure of blast, 6½ ounces. Kind of fuel used, Connellsville coke. Kind of flux used, limestone.

TOTALS.

Amount of iron melted . 41,500 lbs.
Amount of fuel consumed, 5,300 "
Ratio of fuel to iron used, 1 to $7\frac{83}{100}$.

Fluidity of melted iron, XXX.
Length of heat, 4h. 25m.

REMARKS. — Our iron is poured into architectural and light house-work moulds. The last of the iron was just as hot as the first of the heat. We use limestone on every charge. After casting five tons, we let out the slag, and very seldom close the slag-hole after it is opened.

JOHN FARRER,
Foreman G. W. & F. Smith's Iron Works Foundry.

MARCH 20, 1884.

HOLYOKE, MASS.

COMMON 50″ CUPOLA.

Outside diameter	65″
Thickness of lining	7½″
Inside diameter at tuyeres	50″
Largest inside or melting-point diameter	50″
Inside diameter at charging-door	50″
Height from bottom plate up to bottom of charging-door	12′ 3″
Style of tuyeres: five tuyeres, 10″ × 5″, at inside; 7″ × 5″ where it joins the blast-pipes.	
Height from bottom plate to bottom of tuyere	15″
Height of tuyere above sand bottom on back side	10″

Fuel used for bed: coal	1,800 lbs.	Fourth charge of scrap	1,500 lbs.
First charge of pig	3,000 "	" " coal	400 "
" " scrap	2,500 "	Fifth charge of pig	2,200 "
" " coal	400 "	" " scrap	1,800 "
Second charge of pig	2,500 "	" " coal	400 "
" " scrap	1,500 "	Sixth charge of pig	500 "
" " coal	400 "	" " scrap	4,000 "
Third charge of pig	4,500 "	" " coal	400 "
" " coal	400 "	Seventh charge of scrap	4,000 "
Fourth charge of pig	3,000 "		

No. 5½ Baker blower; diameter main blast-pipe, 16″.

Time of starting fire	12.30 P.M.	First appearance of fluid iron	3.30 P.M.
" charging first iron,	2.00 "	Bottom dropped	6.00 "
Blast put on	3.15 "		

TOTALS.

Amount of iron melted, 31,000 lbs.	Fluidity of melted iron, XX.
Amount of fuel consumed, 4,200 "	Length of heat, 2h. 45m.
Ratio of fuel to iron used, 1 to $7\frac{38}{100}$.	

REMARKS. — Our iron is used for turbine-wheels and mill-machinery castings.

W. S. BEECHING,
Foreman Holyoke Machine Co.'s Works Foundry.

OCT. 23, 1883.

WORCESTER, MASS.

COLLIAU 26″ CUPOLA.

Outside diameter	42″
Thickness of lining	8″
Inside diameter at tuyeres	26″
Largest inside or melting-point diameter	26″
Inside diameter at charging-door	26″
Height from bottom plate up to bottom of charging-door	9′ 2″

Style of tuyeres: two rows of tuyeres, six above and six below. Lower row, 4″ square; upper row, 1¾″ diameter.

Height from bottom plate to bottom of lower tuyere	22″
Height of lower tuyere above sand bottom on back side	18″
Height from bottom plate to bottom of slag-hole	18″

Fuel used for bed: coke	500 lbs.	Third charge of coke	60 lbs.
First charge of pig	1,100 “	Fourth charge of pig	600 “
“ “ scrap	400 “	“ “ scrap	600 “
“ “ coke	60 “	“ “ coke	60 “
Second charge of pig	600 “	Fifth charge of pig	600 “
“ “ scrap	600 “	“ “ scrap	600 “
“ “ coke	60 “	“ “ coke	60 “
Third charge of pig	600 “	Sixth charge of pig	900 “
“ “ scrap	600 “	“ “ scrap	800 “

No. 6 Sturtevant fan; diameter main blast-pipe, 10″.

Time of starting fire	2.30 P.M.	First appearance of fluid iron	4.15 P.M.
“ charging first iron,	3.30 “	Bottom dropped	5.30 “
Blast put on	4.00 “		

Revolutions of blower, 2,000 to 2,100. Pressure of blast, 5 ounces. Kind of fuel used, Connellsville coke. Kind of flux used, limestone, one shovelful to a charge; but air-slacked lime, or chips from marble-works, are just as good as lime to make the slag fluid and easily discharged.

TOTALS.

Amount of iron melted,	8,000 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	800 “	Length of heat, 1h. 30m.
Ratio of fuel to iron used, 1 to 10.		

REMARKS. — This is a heat taken out of our small cupola. Considering the smallness of heat, the showing is not as good as were the heat larger. The cupola can be kept in blast as long as one might desire. Our iron is hot enough for stove-plate, although we use it for machinery castings.

J. B. COLVIN, *Supt.*,
J. A. Colvin Works Foundry.

FEB. 1, 1884.

SPRINGFIELD, MASS.

COLLIAU 28″ CUPOLA.

Outside diameter	42″
Thickness of lining	7″
Inside diameter at tuyeres	28″
Largest inside or melting-point diameter	30″
Inside diameter at charging-door	28″
Height from bottom plate up to bottom of charging-door	9′ 6″

Style of tuyeres: two rows of tuyeres, six above and six below. Lower row, 3½″ square; upper row, 1½″ diameter.

Height from bottom plate to bottom of lower tuyere	22″
Height of tuyere above sand bottom on back side	14″
Height from bottom plate to bottom of slag-hole	15″

Fuel used for bed: coke	500 lbs.	Second charge of scrap	800 lbs.
First charge of pig	1,500 “	“ “ coke	116 “
“ “ scrap	500 “	Third charge of pig	700 “
“ “ coke	116 “	“ “ scrap	1,881 “
Second charge of pig	1,500 “		

No. 5 Sturtevant fan; diameter main blast-pipe, 8″.

Time of starting fire	3.30 P.M.	First appearance of fluid iron	5.15 P.M.
“ charging first iron,	4.40 “	Bottom dropped	6.15 “
Blast put on	5.00 “		

Revolutions of blower, 3,150. Pressure of blast, 6 ounces. Kind of fuel used, Connellsville coke. Kind of flux used, oyster-shells.

TOTALS.

Amount of iron melted, 6,881 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 732 “	Length of heat, 1h. 15m.
Ratio of fuel to iron used, 1 to 9$\frac{4}{10}$.	

REMARKS. — Fifty-five pounds of coke was saved from dropped bottom; therefore the ratio of fuel to iron actually consumed would be 1 to 10$\frac{17}{100}$. This heat was an exceptional one for its size. With a heat of five tons we can melt 1 to 10 or 11 with ease. We use our iron for machinery and light castings.

JAMES SIMPSON,
Foreman Springfield Foundry Co

MAY 1, 1883.

PROVIDENCE, R.I.

MACKENZIE 38″ × 53″ CUPOLA.

Outside dimensions	52″ × 66″
Thickness of lining	6½″
Inside dimensions at tuyeres	30″ × 44″
Largest inside or melting-point	38″ × 53″
Inside dimensions at charging-door	40″ × 54″
Height from bottom plate up to bottom of charging-door	11′ 6″
Style of tuyeres: flat 1″ opening, continuous tuyere.	
Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	7″

Fuel used for bed: coal	1,100 lbs.	Third charge of coal	200 lbs.
First charge of pig	1,400 “	Fourth charge of pig	1,400 “
“ “ scrap	600 “	“ “ scrap	600 “
“ “ coal	200 “	“ “ coal	200 “
Second charge of pig	1,400 “	Fifth charge of pig	1,400 “
“ “ scrap	600 “	“ “ scrap	600 “
“ “ coal	200 “	“ “ coal	200 “
Third charge of pig	1,400 “	Sixth charge of pig	1,400 “
“ “ scrap	600 “	“ “ scrap	600 “

No. 4½ Baker; diameter main blast-pipe, 12″.

Time of starting fire	1.20 P.M.	First appearance of fluid iron	4.15 P.M.
“ charging first iron,	3.00 “		
Blast put on	4.00 “	Bottom dropped	5.25 “

Revolutions of blower, 140. Pressure of blast, 10 ounces. Kind of fuel used, Lehigh coal. Kind of flux used, oyster-shells.

TOTALS.

Amount of iron melted, 12,000 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 2,100 “	Length of heat, 1h. 25m.
Ratio of fuel to iron used, 1 to 5$\frac{71}{100}$.	

REMARKS. — We make sewing-machines, light machine tools, and castings weighing from one ounce up to one ton. Our iron must be good and very hot.

MATTHEW WIARD,
Foreman Brown & Sharpe Works Foundry

Nov. 15, 1883.

WETHERSFIELD, CONN.

COMMON 33″ CUPOLA.

Outside diameter	40″
Thickness of lining	3½″
Inside diameter at tuyeres	33″
Largest inside or melting-point diameter	35″
Inside diameter at charging-door	33″
Height from bottom plate up to bottom of charging-door	8′

Style of tuyeres: ten ⅝″ × 9½″ flat tuyeres.

Height from bottom plate to bottom of tuyere	8″
Height of tuyere above sand bottom on back side	3″

Fuel used for bed: coke	300 lbs.	Second charge of coke	100 lbs.
coal	400 “	Third charge of pig	500 “
First charge of pig	1,500 “	“ “ scrap	1,000 “
“ “ scrap	1,000 “	“ “ coke	125 “
“ “ coke	100 “	Fourth charge of pig	1,000 “
Second charge of pig	700 “	“ “ scrap	1,900 “
“ “ scrap	800 “		

No. 6 Sturtevant fan; diameter of main blast-pipe, 10″.

Time of starting fire	1.00 P.M.	First appearance of fluid iron	3.36 P.M.
“ charging first iron,	2.30 “	Bottom dropped	4.18 “
Blast put on	3.30 “		

Pressure of blast, 14 ounces. Kind of fuel used, Old Company's Lehigh lump and Connellsville coke.

TOTALS.

Amount of iron melted,	8,400 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	1,025 “	Length of heat, 48 minutes.
Ratio of fuel to iron used, 1 to $8\frac{19}{100}$.		

REMARKS. — Fine light-gray iron castings is the class of work which we make. Our cupola was designed and built by the undersigned in March, 1883. Every heat, from the start, has given the highest possible fluidity We never plug or tap. The second full hand ladle up to the last dribblings must run any of our fine light castings, among which we have a plain plate 13″ × 18″, $\frac{1}{10}$″ thick. Speed in melting from first iron to last, five net tons per hour. Highest speed per minute, 250 pounds; this per hour 7½ net tons.

JOHN HOPSON, JR.,
President and Treasurer Hopson & Chapin Manufacturing Co.

OCT. 18, 1883.

NEW-YORK CITY.

MACKENZIE 78"×48" CUPOLA.

Outside dimensions	88"×66"
Inside dimensions at tuyeres	66"×36"
Largest inside or melting-point dimensions	78"×48"
Inside dimensions at charging-door	78"×48"
Height from bottom plate up to bottom of charging-door	9′

Style of tuyeres: flat, $1\frac{1}{2}''$ opening, continuous tuyere.

Height from bottom plate to bottom of tuyere	14"
Height of tuyere above sand bottom on back side	10"

Fuel used for bed: coke	600 lbs.
coal	2,000 "
First charge of pig	3,600 "
" " scrap	7,500 "
" " coke	500 "
" " coal	400 "
Second charge of pig	2,500 "
" " scrap	5,000 "
" " coke	500 "
" " coal	300 "
Third charge of pig	2,000 "
" " scrap	5,000 "
" " coke	500 "
" " coal	300 "
Fourth charge of pig	1,500 lbs.
" " scrap	4,500 "
" " coke	500 "
" " coal	300 "
Fifth charge of pig	1,500 "
" " scrap	4,000 "
" " coke	500 "
" " coal	300 "
Sixth charge of pig	1,500 "
" " scrap	4,000 "
" " coke	500 "
" " coal	300 "
Seventh charge of pig	1,500 "
" " scrap	4,000 "

No. 6 Mackenzie blower.

Time of starting fire	12.30 P.M.
" charging first iron,	2.00 "
Blast put on	3.00 "
First appearance of fluid iron	3.10 P.M.

Revolutions of blower, 100. Pressure of blast, column of water 20" high.

TOTALS.

Amount of iron melted,	48,100 lbs.
Amount of fuel consumed,	7,500 "

Ratio of fuel to iron used, 1 to $6\frac{4}{10}$.
Fluidity of melted iron, XXX.

REMARKS.—The scrap we use is A No. 1. All things being favorable, and a large crane ladle under the cupola, we can melt eight tons per hour. When small ladles are used, the blast requires to be greatly decreased, in order to have the iron taken care of. This cupola is capable of melting thirty tons. We have another whose capacity is twenty-four tons. We charge so as to have our iron *hot*. Our class of work is all kinds of engines, pumps, and machinery castings.

FREDERICK SIBLEY,
Foreman Delamater's Iron Works Foundry

FEB. 15, 1884.

YONKERS, N.Y.

ODD STYLE OF CUPOLA.

Largest outside diameter	70″
Thickness of lining	5″
Inside diameter at tuyeres	30″
Largest inside or melting-point diameter	48″
Inside diameter at charging-door	60″
Height from bottom plate up to bottom of charging-door	8′
Style of tuyeres: two 4″ × 12″ oblong tuyeres.	
Height from bottom plate to bottom of tuyere	16″
Height of tuyere above sand bottom on back side	12″

Two 10″ diameter by 5′ long branch pipes convey the blast from the main pipe to the tuyeres.

Fuel used for bed: coal	1,100 lbs.
First charge of pig	4,000 "
" " scrap	1,000 "
" " coal	400 "
Second charge of pig	3,000 "
" " scrap	1,000 "
Second charge of coal	400 lbs.
Third charge of pig	3,000 "
" " scrap	1,000 "
" " coal	300 "
Fourth charge of scrap	2,800 "

No. 6 Sturtevant fan; diameter main blast-pipe, 16″; length, 30′.

Time of starting fire	1.00 P.M.
" charging first iron,	3.15 "
Blast put on	3.45 "
First appearance of fluid iron	3.53 P.M.
Bottom dropped	6.35 "

Revolutions of blower, 2,200. Kind of fuel used, Lehigh coal. Kind of flux used, oyster-shell, at the rate of one peck to one ton of iron.

TOTALS.

Amount of iron melted, 15,800 lbs.
Amount of fuel consumed, 2,200 "
Ratio of fuel to iron used, 1 to $7\frac{18}{100}$.
Fluidity of melted iron, XX.
Length of heat, 2h. 50m.

REMARKS. — The class of work made is elevators, gas-engines, and machinery castings. This cupola, in vertical appearance, is somewhat like that of a bulged barrel. 4″ above the tuyeres it starts a taper that, in the height of 36″, increases from 30″ to 60″ inside diameter. This 60″ continues in height for 36″ more; at this point it then commences to decrease, and 36″ higher up it is again the same diameter as at the tuyeres; this point being at stack, the 30″ diameter is continued up to end of same. This style of cupola is not to be recommended as a success for long heats, and I would give a common straight cupola the preference.

L. C. JEWETT,
Foreman Otis Brothers & Co.'s Works Foundry

DEC. 15, 1883.

SYRACUSE, N.Y.

COMMON 40″ CUPOLA.

Outside diameter	53″
Thickness of lining	8½″
Inside diameter at tuyeres	37″
Largest inside or melting-point diameter	42″
Inside diameter at charging-door	36″
Height from bottom plate up to bottom of charging-door	9′
Style of tuyeres: four 6″ × 6″ triangular tuyeres.	
Height from bottom plate to bottom of tuyere	11″
Height of tuyere above sand bottom on back side	8″

Fuel used for bed: coal	1,050 lbs.	Second charge of pig	2,700 lbs.
First charge of pig	3,000 "	" " scrap	900 "
" " scrap	1,000 "	" " coal	200 "
" " coal	400 "	Third charge of scrap	2,300 "

No. 7 Sturtevant fan; diameter main blast-pipe, 12″.

Time of starting fire	1.30 P.M.	First appearance of fluid iron	4.27 P.M.
" charging first iron,	3.30 "	Bottom dropped	5.55 "
Blast put on	4.20 "		

Revolutions of blower, 2,500. Kind of fuel used, Lehigh coal. Kind of flux used, fluor spar.

TOTALS.

Amount of iron melted, 9,900 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 1,650 "	Length of heat, 1h. 35m.
Ratio of fuel to iron used, 1 to 6.	

REMARKS.—The class of work made is for stationary engines. The heat is a small one for the cupola; therefore the percentage is not as high as it would be were the heat a larger one.

PATRICK EGAN,
Foreman The Straight Line Engine Co. Foundry.

NOV. 16, 1883.

ROCHESTER, N.Y.

COLLIAU 48″ CUPOLA.

Outside diameter	62″
Thickness of lining	7″
Inside diameter at tuyeres	48″
Largest inside or melting-point diameter	48″
Inside diameter at charging-door	48″
Height from bottom plate up to bottom of charging-door	12′
Style of tuyeres: two rows of tuyeres; lower row, oblong; upper row, round; lower, 9″ × 4″; upper, 2½″ diameter.	
Height from bottom plate to bottom of lower tuyeres, 24″; to upper tuyeres	40″
Height of tuyere above sand bottom on back side	21″
Height from bottom plate to bottom of slag-hole	17½″

Fuel used for bed: coke	1,400 lbs.	Second charge of coke	240 lbs.
First charge of pig	1,515 "	Third charge of pig	1,515 "
" " scrap	1,852 "	" " scrap	1,852 "
" " coke	240 "	" " coke	240 "
Second charge of pig	1,515 "	Fourth charge of pig	1,515 "
" " scrap	1,852 "	" " scrap	1,852 "

Seventeen more charges, continued per order shown.

No. 9 Sturtevant fan; diameter main blast-pipe, 14″ at blower, 12″ at cupola.

Time of starting fire	10.10 A.M.	First appearance of fluid iron	12.35 P.M.
" charging first iron,	11.20 "	Bottom dropped	4.45 "
Blast put on	12.30 P.M.		

Revolutions of blower, 1,800. Pressure of blast, 8½ ounces. Kind of flux used, limestone.

TOTALS.

Amount of iron melted,	70,707 lbs.	Ratio of fuel to iron used, 1 to 11$\frac{4}{10}$.
Amount of fuel consumed,	6,200 "	Length of heat, 4h. 15m.

REMARKS. — In this heat the above amount was melted, having a uniform temperature from first to last. The metal was poured into car-wheels.

EDWARD J. CAMPBELL,
Superintendent Rochester Car-Wheel Works.

OCT. 23, 1883.

JERSEY CITY, N.J.

COMMON 45″ CUPOLA.

Outside diameter	$55\frac{3}{4}''$
Thickness of lining	5″
Inside diameter at tuyeres	45″
Largest inside or melting-point diameter	47″
Inside diameter at charging-door	45″
Height from bottom plate up to bottom of charging-door	11′
Style of tuyeres: four 3″ × 12″ oblong tuyeres.	
Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	6″

Fuel used for bed: coke	500 lbs.
First charge of pig	2,000 "
" " coke	300 "
Second charge of pig	2,000 "
" " coke	300 "
Third charge of pig	2,000 "
" " coke	250 "
Fourth charge of pig	2,000 "
" " coke	200 "
Fifth charge of pig	1,500 lbs.
" " scrap	500 "
" " coke	200 "
Sixth charge of pig	1,200 "
" " scrap	1,000 "
" " coke	150 "
Seventh charge of pig	1,400 "
" " scrap	1,200 "

No. 8 Sturtevant fan; diameter main blast-pipe, 10″.

Time of starting fire	3.00 P.M.	First appearance of fluid iron	4.30 P.M.
" charging first iron,	3.45 "	Bottom dropped	5.50 "
Blast put on	4.15 "		

Revolutions of blower, 1,800. Kind of fuel used, Connellsville coke.

TOTALS.

Amount of iron melted, 14,800 lbs.
Amount of fuel consumed, 1,900 "
Ratio of fuel to iron used, 1 to $7\frac{78}{100}$.

Fluidity of melted iron, XX.
Length of heat, 1h. 35m.

REMARKS.—The class of work made is general machinery, piano-plates, and pulleys. The iron was hot enough to pour piano-plates and very light pulleys. I supposed it might be called very hot, but I did not care to exaggerate.

DANIEL F. TREACY,
Supt. Davenport & Treacy Co.'s Works.

DEC. 29, 1883.

MT. HOLLY, N.J.

MACKENZIE 41″ CUPOLA.

Outside diameter	51″
Thickness of lining	5″
Inside diameter at tuyeres	28″
Largest inside or melting-point diameter	41″
Inside diameter at charging-door	41″
Height from bottom plate up to bottom of charging-door	8′

Style of tuyeres: flat 1¼″ opening, continuous tuyeres.

Height from bottom plate to bottom of tuyere	13″
Height of tuyere above sand bottom on back side	8″

Fuel used for bed: coke	400 lbs.	Fourth charge of coke	90 lbs.
coal	600 “	Fifth charge of pig	800 “
First charge of pig	1,600 “	“ “ scrap	400 “
“ “ scrap	800 “	“ “ coal	120 “
“ “ coal	120 “	Sixth charge of pig	800 “
Second charge of pig	800 “	“ “ scrap	400 “
“ “ scrap	400 “	“ “ coke	90 “
“ “ coke	90 “	Seventh charge of pig	800 “
Third charge of pig	800 “	“ “ scrap	400 “
“ “ scrap	400 “	“ “ coal	120 “
“ “ coal	120 “	Eighth charge of pig	800 “
Fourth charge of pig	800 “	“ “ scrap	400 “
“ “ scrap	400 “		

Three charges more, continued per order shown.

No. 7 Sturtevant fan; diameter of main blast-pipe, 12″.

Time of starting fire	12.00 M.	First appearance of fluid iron	4.00 P.M.
“ charging first iron,	3.00 P.M.	Bottom dropped	5.30 “
Blast put on	3.30 “		

Revolutions of blower, 2,255. Pressure of blast, 16″ column of water. Kind of fuel used, Lehigh coal, Connellsville coke.

TOTALS.

Amount of iron melted,	14,400 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	2,050 “	Length of heat, 2h.
Ratio of fuel to iron used,	1 to $7\frac{2}{100}$.	

REMARKS. — The above is an average heat. Our iron is used for pouring turbine water-wheels and mill machinery.

T. H. RISDON, *President*,
LUCIUS L. AYERS, *Foreman*,
Risdon & Co.'s Works Foundry

DEC. 3, 1883.

PHILADELPHIA, PENN.

MACKENZIE 116″ × 54″ CUPOLA.

Outside dimensions	133″ × 66½″
Inside dimensions at tuyeres	110″ × 42″
Largest inside or melting-point dimensions	116″ × 54″
Inside dimensions at charging-door	116″ × 54″
Height from bottom plate up to bottom of charging-door	8′ 2″

Style of tuyeres: flat 1″ opening, continuous tuyere.
Height from bottom plate to bottom of tuyere, 12″ front and 8″ back.
Height of tuyere above sand bottom on back side . . . . 4″

Fuel used for bed: coal	3,000 lbs.	Third charge of coal	1,200 lbs.
First charge of iron	14,000 "	Fourth charge of iron	14,000 "
" " coal	1,200 "	" " coal	1,300 "
Second charge of iron	14,000 "	Fifth charge of iron	12,000 "
" " coal	1,300 "	" " coal	1,300 "
Third charge of iron	14,000 "	Sixth charge of iron	12,000 "

I. P. Morris Co.'s 30″ × 24″ blowing engine.

Time of starting fire	11.00 A.M.	First appearance of fluid iron	1.20 P.M.
Blast put on	1.00 P.M.		

Bottom dropped, 5.08 P.M.

Stroke of blower, 70. Pressure of blast, 12 ounces. Kind of fuel used, Lehigh coal.

TOTALS.

Amount of iron melted, 80,000 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 9,300 "	Length of heat, 4h. 8m.
Ratio of fuel to iron used. 1 to $8\frac{6}{10}$.	

REMARKS. — The iron is used for heavy engine and machinery castings.

DAVID J. MATLACK,
Foreman I. P. Morris & Co.'s Works Foundry

OCT. 25, 1883.

ERIE, PENN.

COMMON 32″ CUPOLA.

Outside diameter	40″
Thickness of lining	5″
Inside diameter at tuyeres	31″
Largest inside or melting-point diameter	35″
Inside diameter at charging-door	30″
Height from bottom plate up to bottom of charging-door	9′ 8″

Style of tuyeres: flat, $\frac{3}{4}$″ opening, continuous tuyere.

Height from bottom plate to bottom of tuyere	15½″
Height of tuyere above sand bottom on back side	8½″

Fuel used for bed: coke	120 lbs.	Second charge of coke	80 lbs.
coal	300 "	" " coal	70 "
First charge of pig	900 "	Third charge of pig	900 "
" " scrap	600 "	" " scrap	600 "
" " coke	80 "	" " coke	80 "
" " coal	70 "	" " coal	70 "
Second charge of pig	900 "	Fourth charge of pig	900 "
" " scrap	600 "	" " scrap	600 "

No. 4 Sturtevant fan; diameter main blast-pipe, 7″.

Time of starting fire	2.10 P.M.	First appearance of fluid iron	4.06 P.M.
" charging first iron,	3.10 "	Bottom dropped	5.05 "
Blast put on	4.00 "		

Revolutions of blower, 3,100. Kind of fuel used, Shamokin coal and Connellsville coke. Kind of flux used, Kirk's flux.

TOTALS.

Amount of iron melted,	6,000 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	870 "	Length of heat, 1h. 5m.
Ratio of fuel to iron used, 1 to $6\frac{89}{100}$.		

REMARKS. — The above workings show average results. Our work is chiefly engine-castings.

DAVID SMITH,
Foreman Skinner & Wood's Works Foundry.

OCT. 18, 1883.

PITTSBURGH, PENN.

COMMON 54″ CUPOLA.

Outside diameter	72″
Thickness of lining	9″
Inside diameter at tuyeres	54″
Largest inside or melting-point diameter	56″
Inside diameter at charging-door	54″
Height from bottom plate up to bottom of charging-door	12′
Style of tuyeres : flat 1″ opening, continuous tuyere.	
Height from bottom plate to bottom of tuyere	20″
Height of tuyere above sand bottom on back side	14″
Height from bottom plate to bottom of slag-hole	16″

Fuel used for bed : coke	1,400 lbs.	Second charge of coke	200 lbs.
First charge of iron	4,500 "	Third charge of iron	2,500 "
" " coke	200 "	" " coke	200 "
Second charge of iron	2,500 "	Fourth charge of iron	2,500 "

Six charges more, continued per order shown.

No. 8 Sturtevant fan; diameter main blast-pipe, 12″.

Time of starting fire	12.00 A.M.	First appearance of fluid iron	3.00 P.M.
" charging first iron	1.30 P.M.	Bottom dropped	4.50 "
Blast put on	2.50 "		

Revolutions of blower, 2,200. Pressure of blast, 9 to 11 ounces. Kind of fuel used, Connellsville coke. Kind of flux used, limestone or oyster-shells.

TOTALS.

Amount of iron melted, 27,000 lbs.	Fluidity of melted iron, XX.
Amount of fuel consumed, 3,200 "	Length of heat, 2 hours.
Ratio of fuel to iron used, 1 to $8\frac{43}{100}$.	

REMARKS. — The class of work made is heavy steam and blast engines, and machinery. We have two 54″ and one 36″ cupola; also one air furnace. Our large cupolas can melt 35 tons without trouble.

WM. H. CONNER,
Foreman Mackintosh & Hemphill (Fort Pitt) Works Foundry.

FEB. 25, 1884.

BALTIMORE, MD.

COLLIAU 54″ CUPOLA.

Outside diameter	72″
Thickness of lining	9″
Inside diameter at tuyeres	54″
Largest inside or melting-point diameter	54″
Inside diameter at charging-door	54″
Height from bottom-plate up to bottom of charging-door	14′
Style of tuyeres : two rows of tuyeres, six above and six below; lower row oblong, upper row round, lower 6″ × 12″, upper row 3″ diam.	
Height from bottom plate to bottom of lower tuyeres	26″
" " " " to upper tuyeres	45″
" " " " to bottom of slag-hole	20″

Fuel used for bed : coke .	2,000 lbs.	Fourth charge of coke . .	240 lbs.
First charge of pig and scrap,	4,000 "	Fifth charge of pig and scrap,	4,000 "
First charge of coke . .	240 "	Fifth charge of coke . .	240 "
Second charge of pig and scrap,	4,000 "	Sixth charge of pig and scrap,	4,000 "
Second charge of coke . .	240 "	Sixth charge of coke . .	240 "
Third charge of pig and scrap,	4,000 "	Seventh charge of pig and scrap,	4,000 "
Third charge of coke . .	240 "	Seventh charge of coke .	240 "
Fourth charge of pig and scrap,	4,000 "	Eighth charge of pig and scrap,	4,000 "

Five more charges, continued per order shown.

No. 6 Baker blower; diameter main blast-pipe, 22″.

Time of starting fire . .	11.00 A.M.	First appearance of fluid iron	1.45 P.M.
" charging first iron,	12.00 "	Bottom dropped	4.30 "
Blast put on	1.30 P.M.		

Revolution of blower, 120. Pressure of blast, 9¼ ounces.

TOTALS.

Amount of iron melted,	52,000 lbs.	Ratio of fuel to iron used, 1 to $10\frac{85}{100}$.
Amount of fuel consumed,	4,880 "	Length of heat, 3 hours.

REMARKS. — We use 15 per cent wheel-scrap and 85 per cent charcoal pig metal. Our heats range from 50,000 up to 150,000 pounds. Our iron is good and hot.

WILLIAM HYSAN,
Foreman Baltimore Car Wheel Co.'s Foundry.

FEB. 14, 1884.

WILMINGTON, DEL.

MACKENZIE 36″ CUPOLA.

Outside diameter	50″
Thickness of lining	6″
Inside diameter at tuyeres	30″
Largest inside or melting-point diameter	36″
Inside diameter at charging-door	39″
Height from bottom plate up to bottom of charging-door	10′ 10″
Style of tuyeres: flat 2″ opening, continuous tuyere.	
Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	6″

Fuel used for bed: coal	1,050 lbs.	Third charge of iron	3,000 lbs.
First charge of iron	3,000 "	" " coal	150 "
" " coal	150 "	" " coke	75 "
" " coke	75 "	Fourth charge of iron	3,000 "
Second charge of iron	3,000 "	" " coal	150 "
" " coal	150 "	" " coke	75 "
" " coke	75 "	Fifth charge of iron	3,000 "

Sturtevant fan; diameter of main blast-pipe, 12″.

Time of starting fire	12.00 A.M.	First appearance of fluid iron	3.07 P.M.
" charging first iron	2.00 P.M.	Bottom dropped	5.15 "
Blast put on	3.00 "		

Revolutions of blower, 2,500. Pressure of blast, 8 to 12 ounces. Kind of flux used, oyster-shells.

TOTALS.

Amount of iron melted,	15,000 lbs.	Ratio of fuel to iron used, 1 to 7$\frac{69}{100}$.
Amount of fuel consumed,	1,950 "	Length of heat, 2h. 15m.

REMARKS. — The above is the working of our smallest cupola. Our castings are for marine and heavy machinery work.

WILLIAM STUART,
Foreman Pusey & Jones Co.'s Works Foundry.

Nov. 25, 1883.

CINCINNATI, O.

COMMON 42″ CUPOLA.

Outside diameter	60″
Thickness of lining	9″
Inside diameter at tuyeres	34″
Largest inside or melting-point diameter	42″
Inside diameter at charging-door	42″
Height from bottom plate up to bottom of charging-door	8′
Style of tuyeres : eight round tuyeres, four 2″ and four 5¾″.	
Height from bottom plate to bottom of large tuyere	16″

Fuel used for bed : coke	750 lbs.	Fourth charge of coke	100 lbs.
First charge of pig	1,100 “	Fifth charge of pig	550 “
“ “ scrap	900 “	“ “ scrap	450 “
“ “ coke	100 “	“ “ coke	100 “
Second charge of pig	550 “	Sixth charge of pig	550 “
“ “ scrap	450 “	“ “ scrap	450 “
“ “ coke	100 “	“ “ coke	100 “
Third charge of pig	550 “	Seventh charge of pig	550 “
“ “ scrap	450 “	“ “ scrap	450 “
“ “ coke	100 “	“ “ coke	100 “
Fourth charge of pig	550 “	Eighth charge of pig	550 “
“ “ scrap	450 “	“ “ scrap	450 “

Eleven more charges, continued per order shown.

No. 5 Root's blower; diameter main blast-pipe, 15″.

Time of starting fire	1.00 P.M.	First appearance of fluid iron	3.35 P.M.
“ charging first iron	2.00 “	Bottom dropped	5.25 “
Blast put on	3.30 “		

Revolutions of blower, 150. Kind of fuel used, Connellsville coke.

TOTALS.

Amount of iron melted, 20,000 lbs.	Fluidity of melted iron, **XX**.
Amount of fuel consumed, 2,550 “	Length of heat, 1h. 55m.
Ratio of fuel to iron used, 1 to $7\frac{84}{100}$.	

Remarks. — Our castings would be classed as light, the machine castings being principally for wood-working machinery, and more than half of our total output being of lighter character. We frequently have iron hot enough for stove-plate. Our heats vary from 15,000 to 24,000.

SAMUEL E. HILLES,
Samuel C. Tatum & Co.'s Works.

Nov. 23, 1883.

PORTSMOUTH, O.

TAPER CUPOLA.

Outside diameter	72″
Inside diameter at tuyeres	37½″
Largest inside or melting-point diameter	40″
Inside diameter at charging-door	56″
Height from bottom-plate up to bottom of charging-door	10′
Style of tuyeres : six 3″ × 4″ oblong tuyeres.	
Height from bottom-plate to bottom of tuyere	29″
Height of tuyere above sand bottom on back side	20″

Fuel used for bed: coke	500 lbs.
First charge of pig and scrap	600 "
First charge of coke	30 "
Second charge of pig and scrap	600 "
Second charge of coke	30 "
Third charge of pig and scrap	600 "
Third charge of coke	30 "
Fourth charge of pig and scrap	600 "
Fourth charge of coke	30 lbs.
Fifth charge of pig and scrap	600 "
Fifth charge of coke	30 "
Sixth charge of pig and scrap	600 "
Sixth charge of coke	30 "
Seventh charge of pig and scrap	600 "
Seventh charge of coke	30 "
Eighth charge of pig and scrap	600 "

Four more charges, continued per order shown.

No. 4 Root's blower; diameter main blast-pipe, 12″.

Time of starting fire	2.00 P.M.
" charging first iron,	3.30 "
Blast put on	4.00 "
First appearance of fluid iron	4.10 P.M.
Bottom dropped	5.05 "

Revolutions of blower, 120. Pressure of blast, 10 ounces. Kind of fuel used, Connellsville coke.

TOTALS.

Amount of iron melted, 7,200 lbs.
Amount of fuel consumed, 830 "
Ratio of fuel to iron used, 1 to $8\frac{67}{100}$.
Fluidity of melted iron, XX.
Length of heat, 1h. 5m.

REMARKS.—This cupola is old style, drawn in at the bottom to save fuel. We use very little scrap, as it is scarce. We pour our iron into moulds for heavy machinery and rolling-mill castings.

THOMAS L. WHITE,
Foreman Portsmouth Foundry and Machine-Works Foundry

DEC. 12, 1883.

AKRON, O.

COMMON 38″ CUPOLA.

Outside diameter	50″
Thickness of lining	7″
Inside diameter at tuyeres	38″
Largest inside or melting-point diameter	38″
Inside diameter at charging-door	36″
Height from bottom plate up to bottom of charging-door	9′
Style of tuyeres : seven 5″ round tuyeres.	
Height from bottom plate to bottom of tuyere	13″
Height of tuyere above sand bottom on back side	9″

Fuel used for bed : coke	700 lbs.	Fifth charge of scrap	540 lbs.
First charge of pig	1,625 “	“ “ coke	150 “
“ “ scrap	900 “	Sixth charge of pig	750 “
“ “ coke	150 “	“ “ scrap	500 “
Second charge of pig	915 “	“ “ coke	150 “
“ “ scrap	500 “	Seventh charge of pig	600 “
“ “ coke	150 “	“ “ scrap	500 “
Third charge of pig	875 “	“ “ coke	150 “
“ “ scrap	500 “	Eighth charge of pig	625 “
“ “ coke	150 “	“ “ scrap	540 “
Fourth charge of pig	700 “	“ “ coke	150 “
“ “ scrap	540 “	Ninth charge of pig	650 “
“ “ coke	180 “	“ “ scrap	550 “
Fifth charge of pig	800 “		

No. 5 Sturtevant fan; diameter main blast-pipe, 12″.

Time of starting fire	3.00 P.M.	First appearance of fluid iron	4.30 P.M.
“ charging first iron,	3.45 “	Bottom dropped	6.00 “
Blast put on	4.15 “		

Revolutions of blower, 3,000. Pressure of blast, 13 ounces. Kind of flux used, limestone.

TOTALS.

Amount of iron melted, 12,610 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 1,930 “	Length of heat, 1h. 45m.
Ratio of fuel to iron used, 1 to 6$\frac{53}{100}$.	

REMARKS. — Our iron is used chiefly for making engines and heavy machinery-castings.

ADAM FRANCE,
Foreman Webster, Camp, & Lane Works Foundry

NOV. 6, 1883.

YOUNGSTOWN, O.

COMMON 48″ CUPOLA.

Outside diameter	60″
Thickness of lining	6″
Inside diameter at tuyeres	44″
Largest inside or melting-point diameter	48″
Inside diameter at charging-door	48″
Height from bottom plate up to bottom of charging-door	11′

Style of tuyeres: six 4″ round tuyeres.

Height from bottom plate to bottom of tuyere	21″
Height of tuyere above sand bottom on back side	16″
Height from bottom plate to bottom of slag-hole	18″

The blast-pipe is connected to a wind-belt 10″ × 12″; the belt encircles the cupola, with the exception of about 24″ in front at the spout.

Fuel used for bed: coke	1,500 lbs.	Fifth charge of scrap	2,200 lbs.
First charge of pig	4,500 "	" " coke	300 "
" " scrap	500 "	Sixth charge of pig	2,000 "
" " coke	300 "	" " scrap	2,000 "
Second charge of pig	2,000 "	" " coke	200 "
" " scrap	2,200 "	Seventh charge of pig	2,000 "
" " coke	300 "	" " scrap	2,000 "
Third charge of pig	2,000 "	" " coke	200 "
" " scrap	2,200 "	Eighth charge of pig	2,000 "
" " coke	300 "	" " scrap	2,000 "
Fourth charge of pig	2,000 "	" " coke	200 "
" " scrap	2,200 "	Ninth charge of pig	2,000 "
" " coke	300 "	" " scrap	2,000 "
Fifth charge of pig	2,000 "		

No. 7 Sturtevant fan; diameter of main blast-pipe, 12″.

Time of starting fire	12.00 A.M.	First appearance of fluid iron	3.45 P.M.
" charging first iron,	2.00 P.M.	Bottom dropped	6.50 "
Blast put on	3.30 "		

Revolutions of blower, 3,000. Kind of flux used, limestone.

TOTALS.

Amount of iron melted, 37,800 lbs.	Fluidity of melted iron, XX.
Amount of fuel consumed, 3,600 "	Length of heat, 3h. 20m.
Ratio of fuel to iron used, 1 to 10½.	

REMARKS. — Our work is heavy machinery-castings. When required, we have another cupola, 34″ inside diameter, to help us out in very heavy heats. The small cupola is built upon about the same principle as the above, and both have always worked satisfactorily.

WILLIAM NOLL,
Foreman Hamilton's Works Foundry.

OCT. 24, 1883.

LANSING, MICH.

COMMON 29″ CUPOLA.

Outside diameter	48″
Thickness of lining	$9\frac{1}{2}$″
Inside diameter at tuyeres	29″
Largest inside or melting-point diameter	29″
Inside diameter at charging-door	29″
Height from bottom plate up to bottom of charging-door	8′ 6″

Style of tuyeres: three 4″ × 9″ oblong tuyeres.

Height from bottom plate to bottom of tuyere	18″
Height of tuyere above sand bottom on back side	11″

Three 6″ branch-pipes carry the blast from the main pipe to the cupola's tuyeres.

Fuel used for bed: coke	168 lbs.	Second charge of iron	1,000 lbs.
coal	200 "	" " coke	64 "
First charge of iron	2,000 "	Third charge of iron	1,000 "
" " coke	168 "		

No. 4 Sturtevant fan; diameter main blast-pipe, 8″; cupola 18′ from blower.

Time of starting fire	2.20 P.M.	First appearance of fluid iron	3.35 P.M.
" charging first iron,	2.58 "	Bottom dropped	4.41 "
Blast put on	3.25 "		

Revolutions of blower, 3,000.

TOTALS.

Amount of iron melted, 4,000 lbs.	Fluidity of melted iron, **XXX.**
Amount of fuel consumed, 600 "	Length of heat, 1h. 16m.
Ratio of fuel to iron used, 1 to $6\frac{66}{100}$.	

REMARKS. — Our iron is used for engine, saw-mill, and jobbing castings

JAMES CROWNER,
Foreman Jarvis, Barnes, & Co.'s Works Foundry

FEB. 26, 1884.

INDIANAPOLIS, IND.

COMMON 36″ CUPOLA.

Outside diameter	53″
Thickness of lining	8½″
Inside diameter at tuyeres	36″
Largest inside or melting-point diameter	36″
Inside diameter at charging-door	36″
Height from bottom plate up to bottom of charging-door	9′ 3″

Style of tuyeres: two 8″ round tuyeres.

Height from bottom plate to bottom of tuyere	16″
Height of tuyere above sand bottom on back side	12″

Two 8″ branch pipes lead direct from the main pipe to the tuyeres.

Fuel used for bed: coke	1,050 lbs.	Fourth charge of coke	125 lbs.
First charge of pig	700 “	Fifth charge of pig	700 “
“ “ scrap	300 “	“ “ scrap	300 “
“ “ coke	125 “	“ “ coke	125 “
Second charge of pig	700 “	Sixth charge of pig	700 “
“ “ scrap	300 “	“ “ scrap	300 “
“ “ coke	125 “	“ “ coke	125 “
Third charge of pig	700 “	Seventh charge of pig	700 “
“ “ scrap	300 “	“ “ scrap	300 “
“ “ coke	125 “	“ “ coke	125 “
Fourth charge of pig	700 “	Eighth charge of pig	700 “
“ “ scrap	300 “	“ “ scrap	300 “

Thirteen more charges, continued per order shown.

No. 8 Sturtevant fan; diameter main blast-pipe, 14″; cupola 50′ from blower.

Time of starting fire	2.30 P.M.	First appearance of fluid iron	4.05 P.M.
“ charging first iron,	3.15 “	Bottom dropped	5.30 “
Blast put on	4.00 “		

Revolutions of blower, 2,600. Pressure of blast, strong.

TOTALS.

Amount of iron melted,	21,000 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	3,550 “	Length of heat, 1h. 30m.
Ratio of fuel to iron used,	1 to $5\frac{91}{100}$.	

REMARKS. — The above was an average heat during the busy season. Our castings are for architectural work.

CHRIS. BAKER,
Foreman Haugh, Ketcham, & Co.'s Works Foundry.

APRIL 12, 1884.

CHICAGO, ILL.

MACKENZIE 66″ × 42″ CUPOLA.

Outside dimensions	78″ × 54″
Thickness of lining	6″
Inside diameter at tuyeres	60″ × 36″
Largest inside or melting-point dimensions	66″ × 42″
Inside dimensions at charging-door	66″ × 42″
Height from bottom plate up to bottom of charging-door	9′ 6″
Style of tuyeres : flat 1½″ opening, continuous tuyere.	
Height from bottom plate to bottom of tuyere	10″
Height of tuyere above sand bottom on back side	7″

Fuel used for bed : coke	600 lbs.	Fourth charge of pig	2,500 lbs.
coal	400 "	" " scrap	2,500 "
First charge of pig	2,500 "	" " coal	200 "
" " scrap	2,500 "	" " coke	200 "
" " coal	200 "	Fifth charge of pig	2,500 "
" " coke	200 "	" " scrap	2,500 "
Second charge of pig	2,500 "	" " coal	200 "
" " scrap	2,500 "	" " coke	200 "
" " coal	200 "	Sixth charge of pig	2,500 "
" " coke	200 "	" " scrap	2,500 "
Third charge of pig	2,500 "	" " coal	200 "
" " scrap	2,500 "	" " coke	200 "
" " coal	200 "	Seventh charge of scrap	7,000 "
" " coke	200 "		

No. 6 Root's blower; diameter main blast-pipe, 14″.

Time of starting fire	1.00 P.M.	First appearance of fluid iron	3.45 P.M.
" charging first iron,	1.30 "	Bottom dropped	6.00 "
Blast put on	3.30 "		

Revolutions of blower, 196.

TOTALS.

Amount of iron melted, 37,000 lbs.	Fluidity of melted iron, **XX.**
Amount of fuel consumed, 3,400 "	Length of heat, 2h. 30m.
Ratio of fuel to iron used, 1 to $10\frac{88}{100}$.	

REMARKS. — There can be 20 or 22 tons melted in this cupola; but do not advise any more than 18 tons, as there is no economy in overcrowding a cupola. The last charge of all scrap will make grate-bar, etc. Our general run of castings are steam and hydraulic engine fittings.

JNO. B. ROCKAFELLOW,
Superintendent Crane Brothers Manufacturing Co.

DEC. 3, 1883.

GALESBURG, ILL.

COMMON 30″ CUPOLA.

Outside diameter	40″
Thickness of lining	5″
Inside diameter at tuyeres	30″
Largest inside or melting-point diameter	31″
Inside diameter at charging-door	30″
Height from bottom plate up to bottom of charging-door	9′

Style of tuyeres: three 6″ round tuyeres.

Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	9″

Three 6″ branch pipes lead direct from main pipe to the cupola's tuyeres.

Fuel used for bed: coal	600 lbs.	Fourth charge of coke	100 lbs.
First charge of iron	1,500 "	Fifth charge of iron	500 "
" " coke	200 "	" " coke	100 "
Second charge of iron	1,000 "	Sixth charge of iron	500 "
" " coke	100 "	" " coke	100 "
Third charge of iron	500 "	Seventh charge of iron	500 "
" " coke	100 "	" " coke	100 "
Fourth charge of iron	500 "	Eighth charge of iron	2,000 "

No. 5 Sturtevant fan; diameter of main blast-pipe, 8″; length, 25′.

Time of starting fire	1.30 P.M.	First appearance of fluid iron	3.30 P.M.
" charging first iron,	2.45 "	Bottom dropped	4.30 "
Blast put on	3.25 "		

Revolutions of blower, 2,500. Pressure of blast, 10 ounces. Kind of flux used, limestone.

TOTALS.

Amount of iron melted,	7,000 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	1,400 "	Length of heat, 1h. 5m.
Ratio of fuel to iron used, 1 to 5.		

REMARKS. — Our work is very light, and hence we require very hot iron. Our castings are for agricultural purposes.

DAVID SPENCE,
Foreman G. W. Brown & Co.'s Works Foundry

APRIL 3, 1884.

BELOIT, WIS.

COMMON 40″ CUPOLA.

Outside diameter	55″
Thickness of lining	$7\frac{1}{2}$″
Inside diameter at tuyeres	40″
Largest inside or melting-point diameter	40″
Inside diameter at charging-door	40″
Height from bottom plate up to bottom of charging-door	8′
Style of tuyeres: four 7″ round tuyeres.	
Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	8″

Fuel used for bed: coke	300 lbs.
coal	300 “
First charge of iron	2,400 “
“ “ coke	120 “
Second charge of iron	1,200 “
“ “ coke	120 “
Third charge of iron	1,200 “
“ “ coke	120 “
Fourth charge of iron	1,200 “
Fourth charge of coke	120 lbs.
Fifth charge of iron	1,200 “
“ “ coke	120 “
Sixth charge of iron	1,200 “
“ “ coke	120 “
Seventh charge of iron	1,200 “
“ “ coke	120 “
Eighth charge of iron	1,200 “

No. 7 Sturtevant fan; diameter main blast-pipe, 12″.

Time of starting fire	1.30 P.M.
“ charging first iron,	3.00 “
Blast put on	4.00 “
First appearance of fluid iron	4.10 P.M.
Bottom dropped	5.40 “

Revolutions of blower, 2,400. Kind of flux used, fluor spar.

TOTALS.

Amount of iron melted, 10,800 lbs.
Amount of fuel consumed, 1,440 “
Ratio of fuel to iron used, 1 to $7\frac{5}{10}$.
Fluidity of melted iron, XXX.
Length of heat, 1h. 40m.

REMARKS. — The class of work made is paper machinery and jobbing castings. The blast-pipe connects to a wind-belt 6″ × 12″, which encircles three-quarters of the cupola's circumferences.

J. E. PARKER,
Foreman Merrill & Houstin Works Foundry

OCT. 25, 1883.

MINNEAPOLIS, MINN.

COMMON 35″ CUPOLA.

Outside diameter	43″
Thickness of lining	4″
Inside diameter at tuyeres	35″
Largest inside or melting-point diameter	35″
Inside diameter at charging-door	35″
Height from bottom plate up to bottom of charging-door	7′ 4″
Style of tuyeres: four tuyeres, 3″ diameter at inside of lining, and 6″ diameter at shell.	
Height from bottom plate to bottom of tuyere	16″
Height of tuyere above sand bottom on back side	12″
Height from bottom plate to bottom of slag-hole	9″

Fuel used for bed: coke	450 lbs.	Fifth charge of pig	300 lbs.
First charge of pig	1,200 "	" " scrap	300 "
" " scrap	1,200 "	" " coke	50 "
" " coke	50 "	Sixth charge of pig	300 "
Second charge of pig	300 "	" " scrap	300 "
" " scrap	300 "	" " coke	50 "
" " coke	50 "	Seventh charge of pig	300 "
Third charge of pig	300 "	" " scrap	300 "
" " scrap	300 "	" " coke	50 "
" " coke	50 "	Eighth charge of pig	300 "
Fourth charge of pig	300 "	" " scrap	300 "
" " scrap	300 "	" " coke	50 "
" " coke	50 "	Ninth charge of scrap	1,400 "

No. 5 Sturtevant fan; diameter main blast-pipe, 9″.

Time of starting fire	3.10 P.M.	First appearance of fluid iron	4.47 P.M.
" charging first iron,	4.15 "	Bottom dropped	5.40 "
Blast put on	4.40 "		

Revolution of blower, 2,800. Kind of flux used, fluor spar. After the first charge, then 7 pounds to every charge was used.

TOTALS.

Amount of iron melted, 8,000 lbs.	Fluidity of melted iron, XX.
Amount of fuel consumed, 850 "	Length of heat, 1 hour.
Ratio of fuel to iron used, 1 to $9\frac{4}{10}$.	

REMARKS. — We have made quicker time than the above, but that shown is an average. What scrap we use, aside from our gates, etc., is of the best quality. The last charge of 1,400 lbs. is mostly all scrap for sash-weights. Our general work is mill-machinery and steam-engines.

P. L. SIMPSON,
Foreman North Star Iron Works Foundry

OCT. 31, 1883.

BURLINGTON, IOWA.

COMMON 25″ CUPOLA.

Outside diameter	40″
Thickness of lining	8″
Inside diameter at tuyeres	25″
Largest inside or melting-point diameter	26″
Inside diameter at charging-door	24″
Height from bottom plate up to bottom of charging-door	10′
Style of tuyeres: two 5″ round tuyeres.	
Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	6″

Fuel used for bed: coke	400 lbs.	Second charge of pig	300 lbs.
First charge of pig	300 "	" " scrap	600 "
" " scrap	300 "	" " coke	100 "
" " coke	100 "	Third charge of scrap	800 "

No. 5 Sturtevant fan; diameter of main blast-pipe, 10″; length, 31′.

Time of starting fire	2.30 P.M.	First appearance of fluid iron	4.45 P.M.
" charging first iron,	4.00 "	Bottom dropped	5.45 "
Blast put on	4.30 "		

Revolutions of blower, 1,400. Kind of fuel used, Connellsville coke.

TOTALS.

Amount of iron melted,	2,300 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	600 "	Length of heat, 1h. 15m.
Ratio of fuel to iron used, 1 to $3\frac{83}{100}$.		

REMARKS. — The class of work made is small castings and general machinery. Most of our work requires metal at white heat. The blast was not put on as strong as it could have been had we been able to take care of the iron. The heat being small does not, of course, show the economy it would were the heat a larger one.

W. L. SCHUCK,
Foreman Heimlen & Schuck Works Foundry

MAY 19, 1884.

GRINNELL, IOWA.

COMMON 34″ CUPOLA.

Outside diameter	48″
Thickness of lining	7″
Inside diameter at tuyeres	34″
Largest inside or melting-point diameter	34″
Inside diameter at charging-door	34″
Height from bottom plate up to bottom of charging-door	9′

Style of tuyeres: eight 2″ × 6″ flat tuyeres.

Height from bottom plate to bottom of tuyere	14″

Two branch-pipes 7″ diameter carry the blast from main pipe to the wind-belt.

Fuel used for bed: coke	300 lbs.	Fourth charge of pig	650 lbs.
coal	200 "	" " scrap	300 "
First charge of pig	700 "	" " coke	55 "
" " scrap	300 "	Fifth charge of pig	650 "
" " coke	60 "	" " scrap	300 "
Second charge of pig	650 "	" " coke	55 "
" " scrap	300 "	Sixth charge of pig	700 "
" " coke	55 "	" " scrap	250 "
Third charge of pig	650 "	" " coke	55 "
" " scrap	300 "	Seventh charge of pig	300 "
" " coke	55 "	" " gates	600 "

No. 5 Sturtevant fan; diameter main blast-pipe, 10″; length, 27′.

Time of starting fire	3.25 P.M.	First appearance of fluid iron	4.37 P.M.
" charging first iron,	4.00 "	Bottom dropped	5.16 "
Blast put on	4.30 "		

Revolutions of blower, 3,200. Kind of fuel used, Lehigh and Connellsville coke.

TOTALS.

Amount of iron melted,	6,650 lbs.	Ratio of fuel to iron used, 1 to $7\frac{96}{100}$.
Amount of fuel consumed,	835 "	Length of heat, 46 m.

REMARKS.—I am running a cupola that we put up six months ago. The most fuel I ever used was 1 to 7, and I am now melting with 1 to 8. I believe in using all the fuel required to melt good iron, but I do not believe in wasting it.

The first fifteen hundred pounds of iron is run into mower wheels. These wheels have wrought iron spokes in them, and the rims have to be poured first, to give them a chance to shrink before the hub is poured. We have a light seat, and also a light gear cover, and several other pieces that take hot iron, and we have no trouble in running them.

The tuyeres in my cupola are 14″ from base. I have used them as low as 12″, but for coke I prefer to have them higher.

In some foundries they use fire-clay, weakened with sand. I use common clay mixed with the burned sand that comes from the castings. It is hard to mix, but makes a good lining. The sand prevents the clay from cracking, and it stands fire equal to fire-clay.

JACOB OTT,

Foreman Craver, Steele, & Austin's Agricultural Works Foundry

JUNE 3, 1884.

OMAHA, NEB.

CAR-WHEEL DEPARTMENT: COMMON 50″ CUPOLA.

Outside diameter	62⅓″
Thickness of lining	6″
Inside diameter at tuyeres	50″
Largest inside or melting-point diameter	52″
Inside diameter at charging-door	50″
Height from bottom plate up to bottom of charging-door	10′ 2″

This cupola has six 3½″ × 8½″ oblong tuyeres. Height from bottom plate to bottom of tuyeres, 15½″. The hottest melting-point is about 18″ above the top of the tuyeres. Main blast-pipe to branches is 206′ long. There are two branch-pipes, 16″ diameter, 18′ long.

MACHINERY DEPARTMENT: COMMON 50″ CUPOLA.

The cupola in this department is the same size as the cupola in the wheel department, with the exception of the tuyeres. This cupola has three rows of tuyeres, all of which are 4″ in diameter; there are six in each row. The respective distance of each row from the bottom plate is 15″, 24″, and 34″. The two upper rows of tuyeres are at an angle of 40°, so as to throw the blast downwards. The hottest melting-point is about 14″ above the top row. The lining between the two lower rows is also burned out a little from the effects of the blast.

From the fan to the branch-pipes, the main pipe is 68′. The length of the two 18″ branch-pipes leading to the cupola is 22′. The diameter of main pipe is 24″. It has a No. 8 double Sturtevant blower, making 1,700 revolutions. The wind-belt surrounding the cupola is 30″ deep by 9½″ wide.

Car-Wheel Cupola.	lbs.
Fuel used for bed: coke	1,200
First charge of pig	2,000
" " wheel-scrap	2,480
" " coke	215
Second charge of pig	1,000
" " wheel-scrap	1,240
" " coke	215
Third charge of pig	1,000
" " wheel-scrap	1,240

Fourteen more charges, continued in the order shown.

TIME.	
Time of starting fire	11.00 A.M.
" charging first iron	11.55 "
Blast put on	12.15 P.M.
First appearance of fluid iron	12.22 "
Bottom dropped	2.50 "

TOTALS.	
Amount of iron melted	40,320 lbs.
Amount of fuel consumed	4,640 "

Ratio of fuel to iron used, 1 to 8.69.
Length of heat, 2h. 35m.

Machinery Cupola.	lbs.
Fuel used for bed: coke	1,200
First charge of scrap	5,000
" " coke	210
Second charge of scrap	2,000
" " coke	210
Third charge of scrap	2,000
" " coke	210
Fourth charge of scrap	2,000

Fifteen more charges, continued in the order shown.

TIME.	
Time of starting fire	2.00 P.M.
" charging first iron	3.00 "
Blast put on	3.20 "
First appearance of fluid iron	3.27 "
Bottom dropped	5.40 "

TOTALS.	
Amount of iron melted	41,000 lbs.
Amount of fuel consumed	4,980 "

Ratio of fuel to iron used, 1 to 8.23.
Length of heat, 2h. 20m.

Remarks. — We have melted as high as 1 to 9¼ (with Connellsville coke for fuel) in the wheel furnace. Our iron is when melted very hot and fluid. I find very little difference in the two cupolas, with the heats we are running, except the machinery cupola melts the fastest at the end of heat. Were the two cupolas run above the general capacity of such sized furnaces, then the cupola with the three rows of tuyeres would produce the hottest iron, and perform the fastest melting, if they were both charged exactly alike.

EDWARD RICHELIEU,
Foreman Union Pacific Railway Foundry.

April 4, 1884.

DENVER, COL.

COMMON 32″ CUPOLA.

Outside diameter	48″
Thickness of lining	8″
Inside diameter at tuyeres	32″
Largest inside or melting-point diameter	36″
Inside diameter at charging-door	32″
Height from bottom plate up to bottom of charging-door	8′ 9″

Style of tuyeres : six 3$\frac{1}{4}$″ round tuyeres.

Height from bottom plate to bottom of tuyere	24″
Height of tuyere above sand bottom on back side	18″

Fuel used for bed : coke	600 lbs.
First charge of pig	800 "
" " scrap	500 "
" " coke	80 "
Second charge of pig	700 "
" " scrap	500 "
" " coke	90 "
Third charge of pig	400 "
" " scrap	600 "
" " coke	100 "
Fourth charge of pig	400 "
" " scrap	600 "
Fourth charge of coke	100 lbs.
Fifth charge of pig	400 "
" " scrap	600 "
" " coke	100 "
Sixth charge of pig	400 "
" " scrap	600 "
" " coke	100 "
Seventh charge of pig	400 "
" " scrap	600 "
" " coke	100 "
Eighth charge of pig	250 "
" " scrap	750 "

Four more charges, same as last charge shown.

No. 6 Sturtevant fan; diameter main blast-pipe, 10″.

Time of starting fire	1.00 P.M.
" charging first iron,	3.00 "
Blast put on	3.45 "
First appearance of fluid iron	4.00 P.M.
Bottom dropped	6.10 "

Pressure of blast, 7$\frac{1}{2}$ ounces. Kind of fuel used, Connellsville coke.

TOTALS.

Amount of iron melted, 12,500 lbs.
Amount of fuel consumed, 1,670 "
Ratio of fuel to iron used, 1 to 7$\frac{48}{100}$.
Fluidity of melted iron, XXX.
Length of heat, 2h. 25m.

REMARKS. — We used in this heat 4,000 pounds old car-wheel; the balance of scrap was ordinary railroad castings. We have melted in same cupola 15,000 pounds in three hours, with about same conditions. Our general castings are for mining machinery.

F. M. DAVIS, *Proprietor*,
A. CORDINGLY, *Foreman*,
Denver Foundry and Machine Co

SEPT. 20, 1884.

FORT SCOTT, KAN.

COMMON 36″ CUPOLA.

Outside diameter	52″
Thickness of lining	8″
Inside diameter at tuyeres	37″
Largest inside or melting-point diameter	37″
Inside diameter at charging-door	36″
Height from bottom plate up to bottom of charging-door	9′
Style of tuyeres: four 3½″ × 4½″ oval tuyeres.	
Height from bottom plate to bottom of tuyere	19″
Height of tuyere above sand bottom on back side	9″

Fuel used for bed: coke	425 lbs.	Third charge of pig	400 lbs.
First charge of pig	700 "	" " scrap	1,700 "
" " scrap	100 "	" " coke	150 "
" " coke	200 "	Fourth charge of pig	400 "
Second charge of pig	200 "	" " scrap	1,700 "
" " scrap	1,100 "	" " coke	100 "
" " coke	150 "	Fifth charge of pig	100 "

No. 4 Sturtevant fan; diameter main blast-pipe, 14″, 60′ long, having three round curved elbows.

Time of starting fire	4.30 P.M.	First appearance of fluid iron	6.16 P.M.
" charging first iron,	5.35 "	Bottom dropped	7.16 "
Blast put on	6.05 "		

TOTALS.

Amount of iron melted, 6,400 lbs.	Fluidity of iron melted, XXX.
Amount of fuel consumed, 1,025 "	Length of heat, 1h. 11m.
Ratio of fuel to iron used, 1 to 6$\frac{24}{100}$.	

Remarks. — The above is the working of an ordinary heat. The last charge of scrap was omitted; as, after the pig was in, we found we had enough charged necessary to pour all off. Had there been more wanted, 800 pounds more iron could have been melted without the adding of more fuel. Our castings are for engines, mining and mill machinery.

F. J. NUTZ, *Superintendent,*
NELSON ANDERSON, *Foreman,*
Fort Scott Foundry and Machine Works.

Oct. 19, 1883.

ST. LOUIS, MO.

COMMON 54″ CUPOLA.

Outside diameter	64″
Thickness of lining.	5″
Inside diameter at tuyeres	54″
Largest inside or melting-point diameter	54″
Inside diameter at charging-door	54″
Height from bottom plate up to bottom of charging-door	12′
Style of tuyeres: eight flat 1¼″ × 10″ tuyeres.	
Height from bottom plate to bottom of tuyere	22″
Height of tuyere above sand bottom on back side	13″
Height from bottom plate to bottom of slag-hole.	18″

Fuel used for bed: coke .	1,500 lbs	Fourth charge of coke . .	200 lbs.
First charge of		Fifth charge of	
pig and scrap .	7,000 "	pig and scrap .	3,000 "
" " coke	200 "	" " coke	200 "
Second charge of		Sixth charge of	
pig and scrap .	3,000 "	pig and scrap .	3,000 "
" " coke	200 "	" " coke	200 "
Third charge of		Seventh charge of	
pig and scrap .	3,000 "	pig and scrap	3,000 "
" " coke	200 "	" " coke	200 "
Fourth charge of		Eighth charge of	
pig and scrap .	3,000 "	pig and scrap .	3,000 "

Five more charges, continued per order shown.

No. 5½ Baker blower; diameter main blast-pipe, 18″.

Time of starting fire . .	11.00 A.M.	First appearance of fluid iron	2.15 P.M.
" charging first iron,	1.00 P.M.	Bottom dropped	4.30 "
Blast put on	2.00 "		

Revolutions of blower, 130. Pressure of blast, 10 ounces. Kind of fuel used, Connellsville coke. Kind of flux used, limestone.

TOTALS

Amount of iron melted, 43,000 lbs.	Fluidity of melted iron, XX.
Amount of fuel consumed, 3,900 "	Length of heat, 2h. 30m.
Ratio of fuel to iron used, 1 to $11\frac{2}{100}$.	

REMARKS. — Our charges are, as a general thing, mixed two-thirds pig to one-third scrap. Have melted a 54,000 pounds heat with the charges the same as above, thereby making the ratio 1 to 12. Our castings are for all kinds of machinery.

WILLIAM G. LOCKHART.
Foreman Fulton Iron Works Foundry

OCT. 18, 1883.

ASHLAND, KY.

COMMON 30″ CUPOLA.

Outside diameter	44″
Thickness of lining	7″
Inside diameter at tuyeres	30″
Largest inside or melting-point diameter	30″
Inside diameter at charging-door	24″
Height from bottom plate up to bottom of charging-door	10′

Style of tuyeres · two 5″ round tuyeres.

Height from bottom plate to bottom of tuyere	18″
Height of tuyere above sand bottom on back side	12″

Fuel used for bed : coke	300 lbs.	Fourth charge of scrap	200 lbs.
First charge of pig	100 "	" " coke	30 "
" " scrap	200 "	Fifth charge of pig	100 "
" " coke	40 "	" " scrap	200 "
Second charge of pig	100 "	" " coke	30 "
" " scrap	200 "	Sixth charge of pig	100 "
" " coke	40 "	" " scrap	200 "
Third charge of pig	100 "	" " coke	30 "
" " scrap	200 "	Seventh charge of pig	100 "
" " coke	30 "	" " scrap	200 "
Fourth charge of pig	100 "		

No. 4 Sturtevant fan.

Time of starting fire	1.30 P.M.	First appearance of fluid iron	3.15 P.M.
" charging first iron,	2.30 "	Bottom dropped	4.00 "
Blast put on	3 00 "		

Revolutions of blower, 3,200.

TOTALS.

Amount of iron melted, 2,100 lbs.	Fluidity of melted iron, **XXX.**
Amount of fuel consumed, 500 "	Length of heat, 1h.
Ratio of fuel to iron used, 1 to $4\frac{2}{10}$.	

REMARKS — Railroad and mine castings is the general run of work made.

WILLIAM LEWIS,
Foreman Ashland Coal and Iron Railway Works Foundry

NOV. 15, 1883.

RICHMOND, VA.

COLLIAU 40″ CUPOLA.

Outside diameter	54″
Thickness of lining	7″
Inside diameter at tuyeres	40″
Largest inside or melting-point diameter	40″
Inside diameter at charging-door	40″
Height from bottom plate up to bottom of charging-door	12′ 6″
Style of tuyeres: two rows of tuyeres, six above and six below; bottom row 4″ × 8″, top row 1½″ diameter.	
Height from bottom plate to bottom of lower tuyere, 22″; to top	38″
Height of lower tuyere above sand bottom on back side	18″
Height from bottom plate to bottom of slag-hole	14″

Fuel used for bed: coke	800 lbs.
First charge of pig	2,500 “
“ “ scrap	1,500 “
“ “ coke	170 “
Second charge of pig	1,000 “
“ “ scrap	1,500 “
“ “ coke	170 “
Third charge of pig	1,500 “
Third charge of scrap	1,000 lbs.
“ “ coke	170 “
Fourth charge of pig	500 “
“ “ scrap	2,000 “
“ “ coke	170 “
Fifth charge of pig	500 “
“ “ scrap	3,000 “

No. 5½ Baker blower; diameter main blast-pipe, 12″.

Time of starting fire	12.00 A.M.
“ charging first iron,	2.00 P.M.
Blast put on	3.15 “
First appearance of fluid iron	3.35 P.M.
Bottom dropped	4.45 “

Revolution of blower, 96 to 100. Pressure of blast, 7 ounces. Kind of fuel used, West Virginia coke. Kind of flux used, scraps of marble, 40 pounds to each charge.

TOTALS

Amount of iron melted, 15,000 lbs.
Amount of fuel consumed, 1,480 “
Ratio of fuel to iron used, 1 to $10\frac{13}{100}$.
Fluidity of iron melted, XX.
Length of heat, 1h. 30m.

REMARKS. — Our last iron is hotter than the first. The coke used was rather soft and mashy. The castings made are for engines and saw-mills.

L. FOX,
Foreman Tanner and Delaney Engine Co.'s Works Foundry

Nov. 3, 1883.

SALEM, N.C.

COMMON 26″ CUPOLA.

Outside diameter	42″
Thickness of lining	8″
Inside diameter at tuyeres	26″
Largest inside or melting-point diameter	26″
Inside diameter at charging-door	22″
Height from bottom plate up to bottom of charging-door	7′ 6″
Style of tuyeres : flat, 2″ opening, continuous tuyere.	
Height from bottom plate to bottom of tuyere	$12\frac{1}{2}$″
Height of tuyere above sand bottom on back side	4″

Fuel used for bed : coal	400 lbs.	Second charge of coal	50 lbs.
First charge of iron	500 "	Third charge of iron	500 "
" " coal	50 "	" " coal	50 "
Second charge of iron	500 "	Fourth charge of iron	500 "

Ten more charges, continued per order shown.

No. 4 Sturtevant fan; diameter main blast-pipe, 8″. Fan within 8′ of cupola.

Time of starting fire	1.00 P.M.	First appearance of fluid iron	2.20 P.M.
" charging first iron,	2.00 "	Bottom dropped	3.50 "
Blast put on	2.15 "		

Revolutions of blower, 3,000. Kind of fuel used, Lehigh anthracite (egg).

TOTALS.

Amount of iron melted,	7,000 lbs.	Fluidity of melted iron, **XXX**.
Amount of fuel consumed,	1,050 "	Length of heat, 1h. 35m.
Ratio of fuel to iron used, 1 to $6\frac{66}{100}$.		

Remarks. — We use Low Moor and Longdale, Va., iron. The Low Moor is very refractory to melt. Our work is saw-mill and general machinery castings.

E. BABINGTON,
Foreman Salem Iron Works Foundry

Oct. 12, 1883.

NASHVILLE, TENN.

COMMON 56″ CUPOLA.

Outside diameter	72″
Thickness of lining	8″
Inside diameter at tuyeres	56″
Diameter 12″ above the centre of the tuyeres	50″
Largest inside or melting-point diameter	56″
Inside diameter at charging-door	56″
Height from bottom plate up to bottom of charging door	13′
Style of tuyeres : twelve 4″ round tuyeres.	
Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	8″

The tuyeres take their blast from a wind-belt 12″ × 20″ with which two 13″ branch-pipes connect.

Fuel used for bed: coke	1,300 lbs.	Fourth charge of coke	252 lbs.
First charge of pig	2,000 “	Fifth charge of pig	1,400 “
“ “ scrap	1,000 “	“ “ scrap	800 “
“ “ coke	252 “	“ “ coke	252 “
Second charge of pig	1,300 “	Sixth charge of pig	1,400 “
“ “ scrap	700 “	“ “ scrap	800 “
“ “ coke	252 “	“ “ coke	252 “
Third charge of pig	1,400 “	Seventh charge of pig	1,400 “
“ “ scrap	800 “	“ “ scrap	800 “
“ “ coke	252 “	“ “ coke	252 “
Fourth charge of pig	1,400 “	Eighth charge of pig	1,400 “
“ “ scrap	800 “	“ “ scrap	800 “

Eight more charges, continued per order shown.

No. 5 Root's blower; diameter main blast-pipe, 18″.

Time of starting fire	12.00 A.M.	First appearance of fluid iron	3.09 “
“ charging first iron,	1.30 P.M.		
Blast put on	3.00 “	Bottom dropped	5.30 “

Revolutions of blower, 150. Kind of fuel used, Alabama coke.

TOTALS.

Amount of iron melted, 35,800 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 5,080 “	Length of heat, 2h. 30m.
Ratio of fuel to iron used, 1 to $7\frac{4}{100}$.	

REMARKS. — The blower does not run as fast as it should to do its best work. We melt from 7½ to 8 tons per hour. There is about two thousand pounds of metal left in the cupola when the blast is stopped, which stands fifteen to twenty minutes until it can be poured. It has to be poured into moulds that require dull iron, and is handled by few men; hence the delay. The castings we make are stoves, mantels, and hollow-ware, therefore our iron must be very hot.

CHARLES PRESTON,
Foreman Phillips & Buttorff Stove Works Foundry.

FEB. 27, 1884.

CHATTANOOGA, TENN.

COMMON 28″ CUPOLA.

Outside diameter	40″
Thickness of lining	6″
Inside diameter at tuyeres	28″
Largest inside or melting-point diameter	28″
Inside diameter at charging-door	20″
Height from bottom plate up to bottom of charging-door	7′ 6″

Style of tuyeres: two 3½″ × 7″ oval tuyeres.

Height from bottom plate to bottom of tuyere	15″
Height of tuyere above sand bottom on back side	12″

Two 6″ branch pipes carry the blast from main pipe to the cupola tuyeres.

Fuel used for bed: coke	400 lbs.	Fourth charge of coke	50 lbs.
First charge of pig	600 "	Fifth charge of pig	600 "
" " scrap	200 "	" " scrap	200 "
" " coke	50 "	" " coke	50 "
Second charge of pig	600 "	Sixth charge of pig	600 "
" " scrap	200 "	" " scrap	200 "
" " coke	50 "	" " coke	150 "
Third charge of pig	600 "	Seventh charge of pig	600 "
" " scrap	200 "	" " scrap	200 "
" " coke	50 "	" " coke	150 "
Fourth charge of pig	600 "	Eighth charge of pig	600 "
" " scrap	200 "	" " scrap	200 "

No. 1 Root blower; diameter main blast-pipe, 8″.

Time of starting fire	2.00 P.M.	First appearance of fluid iron	4.05 P.M.
" charging first iron,	2.45 "		
Blast put on	4.00 "	Bottom dropped	5.40 "

Revolutions of blower, 600. Kind of flux used, limestone.

TOTALS.

Amount of iron melted,	6,400 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed,	950 "	Length of heat, 1h. 40m.
Ratio of fuel to iron used, 1 to $6\frac{73}{100}$.		

REMARKS. — The blower is too small for our work, and has to run too fast. When our heats are heavier than 4,800 pounds, we make the sixth charge of fuel 150 pounds instead of 50. We find that we cannot make good fluid iron with certainty every heat with much less coke than 1 to 7½. We have melted as high as 1 to 9, and quite frequently melt 6,000 pounds by having 400 pounds coke on bed and 50 pounds for all the charges; but we prefer to use a little more coke, as it makes more certainty of obtaining economy in the end. Our iron is used for making engines, turbine-wheels, and mill-castings.

G. W. WHEELAND, *Proprietor,*
W. S. BURGER, *Foreman,*
Ætna Foundry and Machine Works.

MARCH 18, 1884.

MONTGOMERY, ALA.

COMMON 28″ CUPOLA.

Outside diameter	38″
Thickness of lining	5″
Inside diameter at tuyeres	28″
Largest inside or melting-point diameter	30″
Inside diameter at charging-door	28″
Height from bottom plate up to bottom of charging-door	10′
Style of tuyeres : eight 5″ × 2″ flat tuyeres.	
Height from bottom plate to bottom of tuyere	15″
Height of tuyere above sand bottom on back side	11″

Fuel used for bed : coke	350 lbs.	Third charge of coke	75 lbs.
First charge of pig	400 "	Fourth charge of pig	200 "
" " scrap	300 "	" " scrap	500 "
" " coke	75 "	" " coke	75 "
Second charge of pig	400 "	Fifth charge of pig	200 "
" " scrap	300 "	" " scrap	500 "
" " coke	75 "	" " coke	75 "
Third charge of pig	200 "	Sixth charge of pig	200 "
" " scrap	500 "	" " scrap	500 "

No. 3 Root blower; diameter main blast-pipe, 12″.

Time of starting fire	2.30 P.M.	First appearance of fluid iron	4.45 P.M.
" charging first iron,	4.00 "	Bottom dropped	5.30 "
Blast put on	4.30 "		

TOTALS.

Amount of iron melted,	4,200 lbs.	Fluidity of melted iron, **XXX.**
Amount of fuel consumed,	725 "	Length of heat, 1h.
Ratio of fuel to iron used, 1 to $5\frac{79}{100}$.		

REMARKS.—The above is not as good a showing as we can make. I take it as an average of heats run last spring, of which we kept a record of fifteen heats. Our iron is used for general jobbing castings.

R. I. MEALOR,
Foreman Montgomery Iron Co.'s Works Foundry

Nov. 6, 1883.

COLUMBUS, GA.

COMMON 30″ CUPOLA.

Outside diameter	42″
Thickness of lining	6″
Inside diameter at tuyeres	30″
Largest inside or melting-point diameter	30″
Inside diameter at charging-door	30″
Height from bottom plate up to bottom of charging-door	8′
Style of tuyeres : flat ½″ opening, continuous tuyere.	
Height from bottom plate to bottom of tuyere	11″
Height of tuyere above sand bottom on back side	7″

Connected with the ½″ opening tuyere is an air-chamber, 8″ × 2½″, inside the cupola shell. The blast is carried to this by means of one branch pipe, 4″ × 8″ where it connects with the chamber, and 8″ × 10″ where it joins the main blast-pipe.

Fuel used for bed : coke	175 lbs.	Fifth charge: scrap	300 lbs.
coal	400 “	“ “ coke	75 “
First charge: pig	1,800 “	Sixth charge: pig	300 “
“ “ coke	75 “	“ “ scrap	300 “
Second charge: pig	300 “	“ “ coke	70 “
“ “ scrap	300 “	Seventh charge: pig	300 “
“ “ coke	75 “	“ “ scrap	300 “
Third charge: pig	300 “	“ “ coke	60 “
“ “ scrap	300 “	Eighth charge: pig	300 “
“ “ coke	75 “	“ “ scrap	300 “
Fourth charge: pig	300 “	“ “ coke	60 “
“ “ scrap	300 “	Ninth charge: pig	300 “
“ “ coke	100 “	“ “ scrap	300 “
Fifth charge: pig	300 “		

Six more charges, continued per order shown in last two charges.

48″ shell, four-blade, home-made blower, main blast-pipe 12″ × 12″.

Time of starting fire	1.30 P.M.	First appearance of fluid iron	3.59 P.M.
“ charging first iron,	3.45 “	Bottom dropped	5.51 “
Blast put on	3.50 “		

Revolutions of blower, 1,600.

TOTALS.

Amount of iron melted, 10,200 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 1,525 “	Length of heat, 2h. 1m.
Ratio of fuel to iron used, 1 to $6\frac{68}{100}$.	

REMARKS. — One piece for an ammonia ice machine in this heat weighed 5,800 pounds, and had to be poured with clean, hot iron, in order to stand a test of 275 pounds pressure. We cast every day, but never use our large cupola, 60″ × 36″, unless we have some one piece that takes over 7,000 pounds of metal to pour it. Our chief work is engines, saw-mill and cotton-machinery castings.

ROBT. E. MASTERS,
Foreman Columbus Iron Works Foundry.

APRIL 15, 1884.

PALATKA, FLA.

COMMON 22″ CUPOLA.

Outside diameter	36″
Thickness of lining	7″
Inside diameter at tuyeres	22″
Largest inside or melting-point diameter	22″
Inside diameter at charging-door	22″
Height from bottom plate up to bottom of charging-door	9′ 6″
Style of tuyeres: three 3½″ round tuyeres.	
Height from bottom plate to bottom of tuyere	19″
Height of tuyere above sand bottom on back side	15″

Three 4″ branch-pipes carry the blast from the main pipe to the cupola's tuyeres. Two of the branch-pipes are 8′ long and one 2′ long.

Fuel used for bed: coal	600 lbs.	Third charge of scrap	800 lbs.
First charge of pig	100 "	" " coal	100 "
" " scrap	800 "	Fourth charge of pig	100 "
" " coal	100 "	" " scrap	800 "
Second charge of pig	100 "	" " coal	100 "
" " scrap	800 "	Fifth charge of pig	100 "
" " coal	100 "	" " scrap	800 "
Third charge of pig	100 "		

No. 5 Sturtevant fan; diameter of main blast-pipe, 8″; length 160′.

Time of starting fire	9.00 A.M.	First appearance of fluid iron	1.15 P.M.
" charging first iron,	11.00 "		
Blast put on	1.00 P.M.	Bottom dropped	3.30 "

Revolutions of blower, 2,500. Kind of flux used, oyster-shells.

TOTALS.

Amount of iron melted,	4,500 lbs.	Fluidity of iron melted, XXX.
Amount of fuel consumed,	1,000 "	Length of heat, 2h. 30m.
Ratio of fuel to iron used, 1 to 4½.		

REMARKS. — Our foundry is new, having run only fourteen heats up t date. We use No. 1 Glengarnock Scotch pig.

D. J. JUSTICE,
General Foreman Florida Southern R.R. Works.

APRIL 22, 1884.

MARYSVILLE, CAL.

COMMON 32″ CUPOLA.

Outside diameter	43″
Thickness of lining	$5\frac{1}{2}$″
Inside diameter at tuyeres	32′
Largest inside or melting-point diameter	32″
Inside diameter at charging-door	32″
Height from bottom plate up to bottom of charging-door	10′
Style of tuyeres: four 5″ round tuyeres made tapering at the point.	
Height from bottom plate to bottom of tuyere	15″
Height of tuyere above sand bottom on back side	7″

Fuel used for bed: coke	100 lbs.	Second charge of coke	300 lbs.
coal	400 “	Third charge: scrap	2,000 “
First charge of pig	2,500 “	“ “ coke	300 “
“ “ coke	200 “	Fourth charge: pig	1,000 “
Second charge: pig	1,000 “	“ “ scrap	1,000 “
“ “ scrap	1,000 “		

No. 5 Sturtevant fan; diameter of main blast-pipe, 10″.

Time of starting fire	2.30 P.M.	First appearance of fluid iron	4.00 P.M.
“ charging first iron,	3.15 “	Bottom dropped	6.00 “
Blast put on	3.45 “		

Kind of flux used, oyster-shells.

TOTALS.

Amount of iron melted,	8,500 lbs.	Fluidity of melted iron, XX.
Amount of fuel consumed,	1,300 “	Length of heat, 2h. 15m.
Ratio of fuel to iron used, 1 to $6\frac{53}{100}$.		

REMARKS. — Our work is engines and mining machinery.

O. H. WESCOTT,
Foreman Marysville Machine Works Foundry

NOV. 12, 1883.

THE DALLES, ORE.

COMMON 34″ CUPOLA.

Outside diameter	45″
Thickness of lining	5½″
Inside diameter at tuyeres	34″
Largest inside or melting-point diameter	34″
Inside diameter at charging-door	30″
Height from bottom plate up to bottom of charging-door	10′
Style of tuyeres : seven 4″ round tuyeres.	
Height from bottom plate to bottom of tuyeres	11″
Height of tuyeres above sand bottom on back side	4″

Fuel used for bed: coke	50 lbs.
coal	500 "
First charge of pig and scrap,	2,000 "
" " coke	250 "
Second charge of pig and scrap,	1,800 "
" " coke	150 "
Third charge of pig and scrap,	1,500 "
" " coke	100 "
Fourth charge of pig and scrap,	1,000 "
Fourth charge of coke	100 lbs.
Fifth charge of pig and scrap,	1,000 "
" " coke	100 "
Sixth charge of pig and scrap,	1,000 "
" " coke	100 "
Seventh charge of scrap	1,000 "
" " coke	100 "
Eighth charge of scrap	1,000 "

No. 7 Sturtevant fan; diameter of main blast-pipe, 12″.

Time of starting fire	1.30 P.M.
" charging first iron	3.00 "
Blast put on	3.45 "
First appearance of fluid iron	4.00 P.M.
Bottom dropped	5.40 "

Revolutions of blower, 2,800. Kind of fuel used, English coke and Lehigh coal.

TOTALS.

Amount of iron melted, 10,300 lbs.
Amount of fuel consumed, 1,450 "
Ratio of fuel to iron used, 1 to $7\frac{1}{10}$.
Fluidity of melted iron, XXX.
Length of heat, 1h. 55m.

REMARKS. — The class of work made is machinery and railroad castings. With the first six charges, a small per cent of scrap was used. The blast is admitted to the tuyeres through a wind-belt 11″ × 7″.

JOHN LEWIS,
Foreman Dalles Car Railroad Works Foundry.

FEB. 18, 1884.

PORTLAND, ORE.

COMMON 23″ CUPOLA.

Outside diameter	32″
Thickness of lining	5″
Inside diameter at tuyeres	22″
Largest inside or melting-point diameter	24″
Inside diameter at charging-door	23″
Height from bottom plate up to bottom of charging-door	9′
Style of tuyeres : four 4″ round tuyeres.	
Height from bottom plate to bottom of tuyere	12″
Height of tuyere above sand bottom on back side	6″

Fuel used for bed : coke	250 lbs.	Second charge of coke	75 lbs.
First charge of pig	1,000 "	Third charge: scrap	1,000 "
" " coke	150 "	" " coke	50 "
Second charge: pig	500 "	Fourth charge: scrap	500 "
" " scrap	500 "		

Time of starting fire	2.00 P.M.	First appearance of fluid iron	3.45 P.M.
" charging first iron	2.30 "	Bottom dropped	4.30 "
Blast put on	3.30 "		

Revolutions of blower, 1,500. Kind of fuel used, English coke.

TOTALS.

Amount of iron melted, 3,500 lbs.	Fluidity of melted iron, XXX.
Amount of fuel consumed, 525 "	Length of heat, 1h.
Ratio of fuel to iron used, 1 to $6\frac{66}{100}$.	

Remarks. — The class of work made is stoves, hollow ware, and jobbing. The blower used is an old-fashioned wooden one, made by hand. The iron came down very hot. The pig used is Glengarnock Scotch.

JOHN MONTAG,
Foreman Novelty Iron Works Foundry.

Feb. 18, 1884.

SUPERIORITY OF ROUND OVER CONTRACTED AND OBLONG CUPOLAS.

A PLAIN round cupola, about the same diameter at the tuyeres as above and below them, would melt or run longer, all conditions being equal, than the oblong or contracted cupola of the same average area, where forced blast was used. By "contracted" is meant cupolas that are built so as to be considerably smaller in the lower body, as shown in Fig. 114. Some years ago cupolas were often lined after this plan. Such a cupola would greatly obviate the "cold center" as far as getting the blast to the center body of the fuel was concerned, but its period for melting would be much shorter lived than with a cupola as seen in Fig. 113. Both these cupolas are supposed to be of about 84″ shell. For such large cupolas, having a 9″ lining, not using center blast or the projection *H* and *K* seen in Fig. 115, p. 379, it is sometimes a good plan, instead of lining them strictly straight, to bring them in a little over the tuyeres, about as seen at *B*. Some advocate when lining a cupola, also a blast-furnace, to give it shape about the same as it would be assumed to have after being in use a while, as for cupolas about as seen at *A*, Fig. 113. For cupolas using center blast and having a 12″ lining or so, this plan works very successfully.

In melting large quantities of iron it is essential to have all conditions possible to favor continued running without bunging-up sufficiently to bridge over or stop melting. We have but to look at the design or construction of cupolas used in Bessemer-steel practice to get a pointer on this question.

Here we find that cupolas run a week, night and day, without dropping their bottoms, and if some foundrymen run a cupola for three hours, they would think miracles had been performed, and so there would, in cupolas of some designs. The main secret of running steel-works cupolas for a week at a stretch is in having high tuyeres and a space of 12″ to 15″ between the bottom of the tuyeres and the top of the slag-hole, and good system of slagging out, combined with a following of the design shown in Fig. 113, and if such have upper tuyeres of one or more rows, they often work much better than where they have only one bottom row. Some melters, in running such cupolas, do very little "poking at the tuyeres," and if their fronts should become clogged up they generally let them burn themselves out as the refuse blocking up the front of such tuyeres is chiefly only clean fuel caked together with chilled droppings of iron, their tuyeres being so high above the slag-hole that there is no chance for slag reaching them, which latter element is the greatest source of trouble for the melter in foundry practice where low tuyeres are used. When some steel-works cupola tuyeres are five feet above the bottom, the intelligent founder never having had an opportunity of seeing such work, will be in position to comprehend why they are able to run so long without dropping bottom. Of course, most founders now understand that the lower the tuyeres are in a cupola for foundry practice, the greater the economy in fuel. It is for this reason that cupolas are made having low tuyeres and in some shops are essential for the class of work done, but nevertheless, many cupolas having low tuyeres would prove to give greater all-round economy were their tuyeres placed higher. Improper charging of fuel and material is another reason why we find round cupolas superior. With this class of cupola there is much less likelihood of mismanagement in charging, etc., causing bad results. I admit that the oblong form of cupola is an excellent form to obviate the cold center, but the center blast or projection, Fig. 115, in a large round cupola insures the end sought by making a cupola oblong or contracted in a much more satisfactory manner, and is in keeping with blast-furnace practice using protruding tuyeres combined with forced blast to penetrate the center stock in order to obtain more perfect combustion, uniformly throughout the fuel. As high as 24 ounces pressure has been used in large cupolas, thinking thereby to force the air to the center to answer the ends of center blast. With cold blast such only aggravates the tendency of bunging, to diminish the length of time some cupolas can run, and is destructive to fuel and linings. According to the area of a cupola a certain volume of blast is required, and the milder and more uniformly this can be admitted throughout a cupola, the better all-round economy is attained. So far, no plan has been advanced to achieve this so well as center blast combined with outside tuyeres, for cupolas over 60″ in diameter.

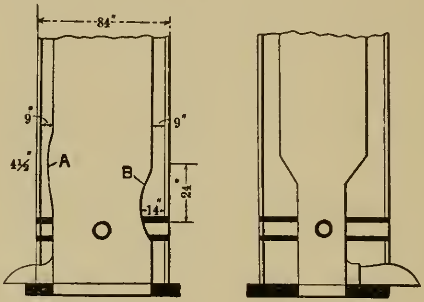

Fig. 113 Fig. 114.

CONTRACTED VS. ROUND CUPOLAS.

Before the author adopted "center blast" proper, for the large cupola seen in Fig. 119, p. 393, he conducted quite a few experiments in carrying forward the body over the tuyeres for 3″ to 6″ all round the cupola and finally the projections protruding from the side as shown in Fig. 115,

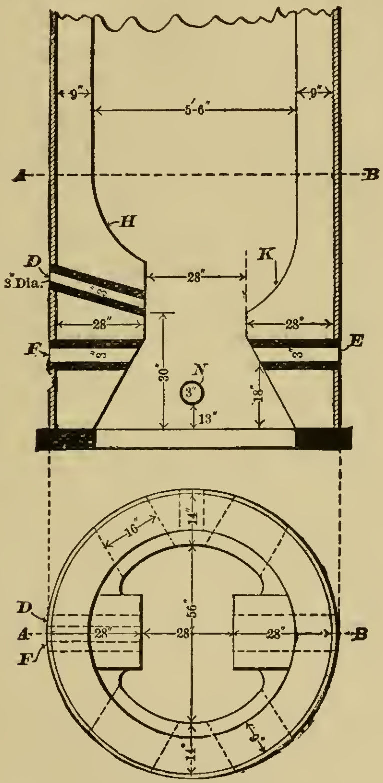
9″
5′-6″
9″
A
B
H
K
D
3″Dia.
3″
28″
28″
28″
F
E
3″
3″
30″
N
3″
13″
18″
16″
14″
D
A
F
28″
28
56″
28″
B
9″
14″

Fig. 115.

this page, feeling that a nearer approach to the center with a forcible blast would be beneficial. The plan seen in Fig. 115 he continued using for about six months, attaining results comparing partially with the economy, etc., found with the bottom center tuyere shown in Fig. 119. By an examination of the plan view in Fig. 115, which shows a section through *A B* of the vertical view, there will be seen two projections extending out 18″ from the inner surface of the lining, the one on the side at *A* or *H* standing higher than on the side *B* or *K*. The projection *H* was carried up higher for the purpose of having an upper tuyere *D* to aid in reaching the center with a blast to blend with that blown in at the tuyeres *E* and *F*, in order to attain the ends sought by "upper tuyeres" as generally used. The objection found to this upper tuyere was the repairs necessary at every "heat" to keep the point below *H* in right form, owing to its being so close to the "melting point." The lower tuyere of the projection *K* called for but little repair, as at the end of six months' running of three heats per week it showed but little wear. Some might think that bringing in such radical projections as illustrated in this case, would have a tendency to "bung-up" a cupola. I would say that we found no difficulty on this score with our weight of heats, 60 to 80 tons, at that time in this large cupola, as long as the cupola was slagged out properly. The idea shown in Fig. 115 is merely given for those that might wish to improve very large cupolas, having straight walls that were timid about trying "center blast," which has excelled this plan in every way.

INTRODUCTION TO "CENTER-BLAST" CUPOLA PRACTICE.

The following treatise on "center-blast" cupolas gives the author's latest experience in their use and recommendations for application by others. It is to be said that for large cupolas, or those over 60″ inside diameter at the tuyeres, running long heats, "center blast" excels any improvement for obtaining economy in fuel, hot iron, fast melting, saving of linings, etc., that has been introduced for the past fifty years.

About the year 1889, the author conceived the idea of a "center blast" for cupolas, but it was not until 1892 that an opportunity presented itself for him to give his ideas a practical test. When he started experimenting with center blast, he thought himself the first to introduce the principle, but it was found later on that Mr. H. B. Hibler had claims to the honor of being father to the idea. Nevertheless, the author has reason to believe that he is credited by all familiar with the past history of this work, with being the first to originate a center blast that is practical for every-day use in general founding, also with being the first to give the public general information of its utility and application to various conditions in founding and advocate its adoption. Shortly after the author first announced his origin of center blast in a paper before the Western Foundrymen's Association, Chicago, October 18, 1893, Mr. Keim brought out an article in *The American Machinist,* which is given on the succeeding page, after which the matter seen on pages 384–387 appeared in *The Foundry,* all of which will serve to show what degree of credit the author is entitled to in originating a practical center blast and what a few who have tested its principles, think of their utility for cupola work.

"*Editor American Machinist:*

"In your Nov. 30th issue, Mr. West's article I appreciate, also article you kindly published entitled 'Remarkable Coincidence,' but take exception to the title of the latter. I take pleasure in sending you Mr. B. H. Hibler's patent papers, which I obtained from Mr. Stewart, patent solicitor here. You will notice from the drawing (Fig. 116) that it is entirely unlike the West central tuyere, as printed in Nov. 3d

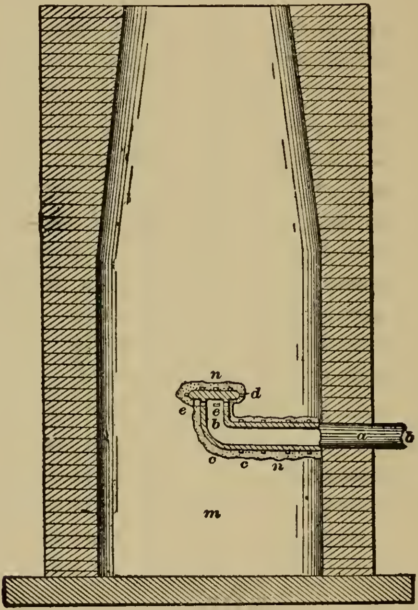

Fig. 116.
HIBLER'S PAT. "CENTER BLAST."

issue. This patent being granted Aug. 13, 1867, it is but fair to admit that Mr. Hibler invented the first central blast tuyere; if it had been a success, would not the enterprising cupola builders have adopted it? Would it have been hidden under a bushel for 26 years? Mr. West's central blast is entirely different in mechanical construction, as you will notice in comparing drawings, and looks to me like a great improvement on Mr. Hibler's. The 'coincidence' of the central-blast question we notice, but compare the drawings and you see nothing 'remarkable' except being so different in design.

"T. BEVERLEY KEIM.

"READING, Pa., Dec. 28, 1893."

STOTT'S CENTER-BLAST CUPOLA.

THE following extract of Stott's Center-Blast Cupola originally appeared in *The Foundry*, July 10, 1894:

"Mr. Stott declares he first tried this plan in Thibodeaux, La., in the year 1888, and has since erected several successfully. His methods incorporating one or two original ideas that he says work successfully.

"*A A A* illustrates the blast-pipe leading below and up into the center of cupola. *J* represents water-pipes which pass into and upwards through center of blast-pipe, the latter being covered with fire-clay or other fire-proof material to protect it from heat of fuel, and melted metals. *B B* are the drop-doors, so arranged and shaped as to admit of the introduction of blast-pipe *A*. *C* the tap-hole, *D D* the apertures for blast, *E* hollow iron cone covered like *A* to protect from heat and filled with running water, and which serves to protect interior of pipe *A* from receiving fuel or melted iron. It rests on three iron sockets which set into pipe *A*.

"There is a joint in pipe *A*, marked *F*, which is secured when pipe is in position by clamps. In the bottom of pipe *A* is a hinged bottom that may be opened and closed at will for purposes of cleaning, and which has a hole filled with lead that will melt out in case pipe gets any melted iron in it. *H* is a stand for bottom of blast-pipe, and has a flange at top which enables the sliding of blast-pipe *A* forward or backward, as may be required before and after casting. *I* is a water-tank for holding water to feed cone *E*. While casting this water passes from tank through pipe *K* down to pipe *J* and up into cone, from which it escapes into the overflow-pipe and goes out by way of *L* and *M*."

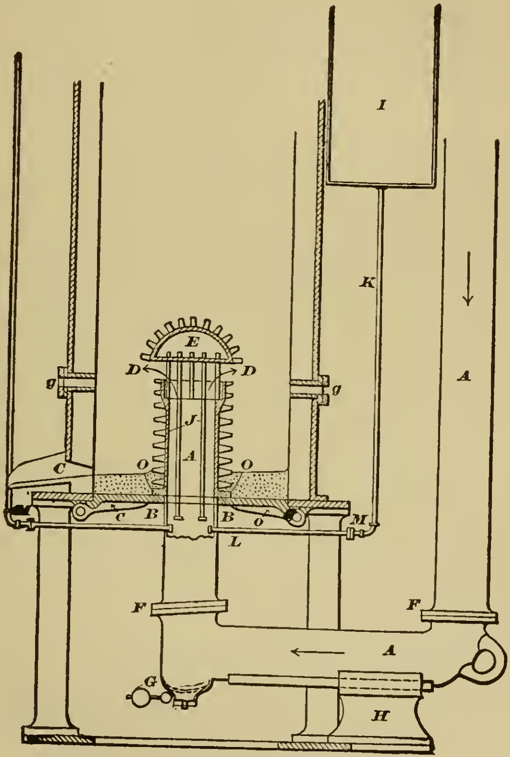

Fig. 117.

STOTT'S CENTER-BLAST CUPOLA.

Mr. Stott's plan of center blast differs from the author's mainly in having water-pipes run through the center tuyere, a principle which, for cupolas running a week at a stretch, as in steel-work practice, might, at times, prove of service. However, for daily heats only, the author's use of center blast causes him to affirm that the water-pipe is not necessary, and would only detract heat from the fuel in the cupola and be troublesome to operate.

CALDWELL'S CENTER-BLAST CUPOLA EXPERIMENTS.

THE following article was printed in *The Foundry*, February, 1894:

" A few years ago I made the experiment precisely in the same way as described by Mr. West in the November number of *The Foundry*, in a small foundry in Brockport, N. Y., in the full belief that I was the first and only person who had ever tried such a plan. It gave entire satisfaction; indeed, it exceeded my expectation, as I found I could melt faster and hotter with less fuel than any way I ever saw tried before, and that is the result all foundrymen are looking for. If some of the leading men in the business would give it a trial, they would see the advantages it has over all other known methods, and its adoption would become common in a short time among the foundries, for it will not only save time and fuel, but will save the lining, which is a large item.

" I have been engaged in connection with the foundry business for many years, and have closely watched the many attempts made to cheapen and facilitate the melting of iron, and I feel quite safe to say that the bottom center tuyere is the correct way of applying the blast to a circular cupola. Besides, a cupola can be built much cheaper, as it need not be so high above the foundry floor, or the stack built up to the skies to keep the coal from blowing out at the top. Iron can be melted in an old hogshead without any stack at all (though not quite so safely, perhaps,) as in a hundred-dollar furnace.

I have been trying to find an opportunity to try my plan in a large cupola, as the larger the better, and hope to do so soon.

"LANCASTER, ERIE CO., N. Y., Feb., 1894."

JOHNSON'S PATENT CENTER-BLAST CUPOLA.—In Fig. 118 is shown a design of center blast patented by Mr. Charles Johnson, of Rutland, Vt., June 25, 1895; number of patent, 541759. The patent was applied for December 1, 1894, a little more than a year after the author gave his design of center blast free to the world. With what success Mr. Johnson met in introducing this center blast, the author has no information.

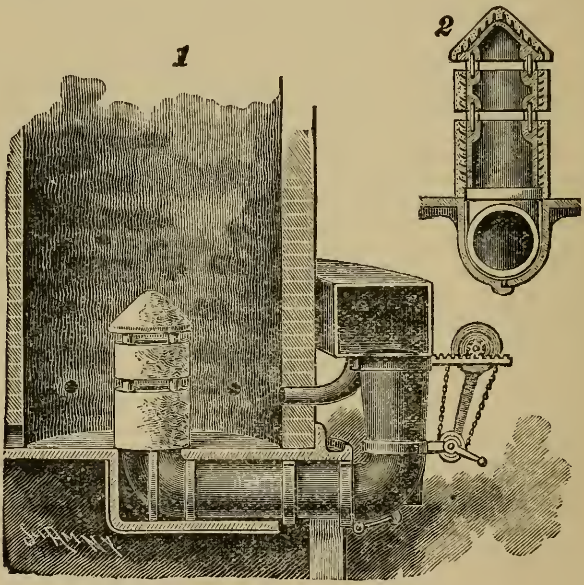

Fig. 118.

JOHNSON'S PATENT CENTER BLAST CUPOLA.

GENERAL UTILITY, ECONOMY AND CONSTRUCTION OF CENTER-BLAST CUPOLAS.*

The advantage of having a tuyere carrying blast up through the center of the cupola will be obvious to any one who closely watches the action of cupolas as the last charge approaches within 4 or 5 feet of the outside tuyeres. He will then see that the greatest heat and flame is obtained right above the tuyeres at the outer circumference of the fuel, the center portion being left less active in live combustion. Moreover, by watching the blast blowing into the bed of fuel before any iron is charged, he will notice a similar action. Again, another test is to stand inside a cupola after the bottom-plate is put up before any fuel is charged in, and allow the blast to enter with all its force against a handkerchief held in the hand a short distance from a tuyere. This last test will be a source of surprise to many, as frequently in large cupolas a handkerchief will not be affected by the blast if held a foot away from the walls of the cupola or a tuyere opening. Of course, the writer does not wish to imply by this that when the cupola is filled with fuel and iron, the blast will not penetrate further toward the center; but nevertheless, it is far from exerting the same pressure or giving the same volume at the center body as it does at the entrance in front of and above the tuyeres.

One advantage of center blast consists in permitting a more uniform distribution of the blast throughout the fuel in the cupola, and also in permitting the use of a greater volume of blast with a decrease of pressure. This with cold blast is less effective in choking the tuyeres or in chilling the fuel around and in front of the tuyeres. The author's experience with central blast clearly shows that, for economizing fuel and for securing clean and fast melting, it is not so much the pressure but a well-distributed volume of blast that is necessary.

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* Revised paper presented by the author to the Iron and Steel Institute, 1897.

This feature is confirmed by the fact that in some blast-furnaces in the United States the output is being increased by a larger number of tuyeres having been put in, so as to give a better distribution of blast. Grace Furnace, at Briar Hill, Ohio, increased its daily output from about 270 to 300 tons, the increase having been brought about by the tuyere space having been divided so as to insert the tuyeres closer together and to increase their number from eight to twelve. Before the number of tuyeres was increased their pressure ranged from 15 to 18 lbs., but with the greater tuyere area it fell about 2 lbs. The speed of the engine was kept the same, so that it is evident that it was a better distribution of blast volume, and not pressure, that was wanted in this case to give the best results.

The theoretical percentage of fuel said to be necessary for melting one ton of iron in a cupola is 59 lbs. Experience shows, however, that if a ton of iron can be melted with an average of 200 lbs. of coke or coal, good work is being done. The uneven distribution of the blast is the greatest drawback to obtaining the best economy of fuel.

Since the author has introduced central blast in cupola practice, others have adopted the principle by using central blast alone, that is to say, independently of outside tuyeres. It is obvious, however, that this plan prevents the even distribution of blast that is desirable, and, moreover, the central tuyere would soon be so choked as to retard or to wholly stop the melting. In all cases where cupolas have an inside diameter of more than 50″, whether they run short or long heats, the central blast should be combined with outside tuyeres. Cupolas that are not expected to run much over an hour, and are of smaller size, may for some certain conditions be economically worked with central blast alone. In no case, however, where heats have to be longer than an hour, is central blast recommended to be used alone. The best results are obtained with center blast in cupolas above 60″ inside diameter connected with outside tuyeres and running long heats.

The sources of economy obtained by the use of the center blast, connected with outside tuyeres, may be enumerated as follows:

1. Greater economy in fuel.
2. Less destruction of lining.
3. Increased speed of melting.
4. Saving in labor in preparing a cupola.
5. Less waste of chilled iron and fine shot.
6. Greater absence of flame escaping from the stack.
7. Greater freedom for the admission of blast, and less labor in keeping the tuyeres open.
8. As hot and clean iron can be obtained at the end of heats as at the beginning.

The first result is brought about by there being less space for fuel in the body of the cupola below the level of the tuyeres, and by there being a more uniform distribution of the blast throughout the fuel, and, again, by the tuyere openings being freer to admit the blast. Moreover, the fact that the central tuyere openings are at a higher level than the outside tuyeres causes the carbonic oxide formed in the lower portion of the cupola to be reduced to a greater quantity of carbonic acid gas. The saving of the linings is due to there being a less force of blast, or, in other words, less volume of carbonic acid gas, playing against the lining, owing to its being distributed more uniformly throughout the body of the fuel in the cupola. The speed of melting is increased owing to the fact that there is greater freedom for the admission and more uniform distribution of the blast throughout the fuel. There is also a smaller quantity of carbonic oxide escaping. Labor is saved because less chilled material is formed round and in front of the tuyeres, owing to a more uniform distribution of the blast. The lessened waste in chilled iron and fine shot is due to the higher and uniform temperature, better preventing the accumulating of chilled stock around the tuyeres during the process. Moreover the milder distribution of blast throughout the fuel does not give rise to the accumulation of excessive bodies of chilled material in front of the tuyeres to lessen the melting area. The greater absence of flame at the charging-door and stack which may be attained, is due to a more thorough combustion in the melting zones, owing to the fact that the carbonic oxide formed in the lower portion of the cupola is more completely converted into carbonic acid before it reaches the charging-door. By proper manipulation of the blast-valves (see *W* and *L*, Fig. 126, p. 406) the combustion can be made so perfect that at the end of a heat but little flame or sparks can be seen escaping at the stack compared to cupolas not using center blast. The greater freedom for the admission of blast and the less labor involved in keeping the tuyeres open, is the result of there being less chilled iron and refuse collected in front of the tuyere openings. The increased fluidity of the iron is due to the more perfect combustion. It is also due to the greater freedom from chilled material collecting around the tuyeres, diminishing the area of a cupola available for live fuel during the progress and ending of a heat.

CONSTRUCTION OF CENTER-BLAST CUPOLAS.

In the latest form of center-blast cupola adopted by the author, the center tuyere is so designed as to form a permanent or stationary structure which remains in its place when bottoms are dropped. Its construction is shown in Figs. 119 to 125. It is obvious that such a design would be unsuitable

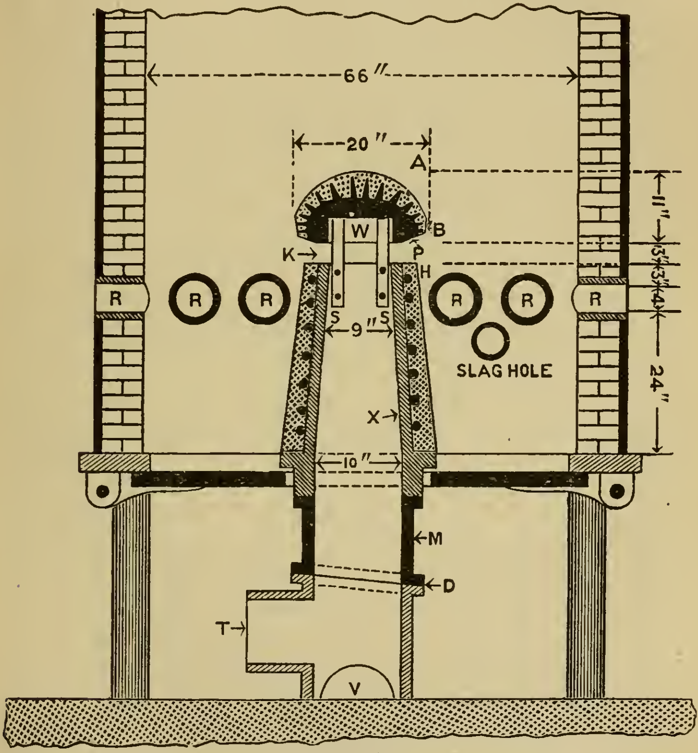
66"
20"
A
W
B
K
P
H
R
R
R
R
R
R
S
S
9"
SLAG HOLE
X
10"
11"
3"
3"
4"
24"
M
D
T
V

Fig. 119.

West's Permanent Center-blast Tuyere Cupola.

for cupolas under 60″ in inside diameter. Illustrations of designs best adapted for smaller cupolas is seen in Figs. 126 to 130, pp. 406, 407. In all cases of cupolas over 50″ inside diameter it is generally best to have outside tuyeres in addition to the central one.

Some difficulty has been experienced by founders, who have adopted center blast something after the author's design, with the burning out of the covering-cap shown at *A* (Fig. 119). The author has no knowledge of the type of cap used in these cases. At his own foundry, however, he has had the same cap-casting in use in the 66″ cupola (Fig. 119), running daily heats ranging from 60 to 100 tons, for one year at a stretch, and have it in as good condition as it was when first put in position.

Many imagine that, on account of its being incased in the center of a cupola surrounded by incandescent fuel and molten iron, the center tuyere would be unable to resist for any length of time the heat surrounding it. A study of the conditions obtained shows, however, that when all is working regularly such a tuyere is not subjected to a temperature high enough to burn or melt the tuyere lining. In fact, the temperature at the lower portion of the center tuyere is not much higher than that to which the lining of the ladle holding molten metal is exposed. It may also be said that as long as the covering-cap is not extended too high above the level of the outside tuyeres, it is not subjected to a much higher temperature than the lower portion. One reason, no doubt, why many have experienced trouble with covering-caps is that they have carried them up too high, so as to bring them up close to the melting zone, or not constructed and cared for rightly. The central tuyere's blast-opening should never be carried more than 3″ to 6″ above the level of the outside tuyeres.

In order to lessen any danger of injury to the cap, with green men, the author has used, with success, a method of charging, which consists in placing the first charge of iron in the form of a circle, with a hole in the center larger than the diameter of the covering-cap. This is then filled with fuel (see Fig. 120), instead of having the center all iron, as well as the outer portion, as is the usual practice.

It is also advisable to protect the edge at *B* (Figs. 119 and 122) by placing, as shown at *F* (Fig. 124), pieces of $\frac{1}{4}''$ round iron and nails, projecting about an inch, placed together as closely as they can be cast in, and then daubing them over with clay. Not only is the edge of the covering-cap protected in this way, but the whole body of the cap-casting is prepared in a similar manner. The iron prickers shown should project 2″ to 3″ from the body of the cap-casting. The casting should not be less than $1\frac{1}{4}''$ in thickness at any part; it should be 3″ to 4″ larger in diameter than the top of center tuyere at *H*, in order to prevent molten metal dropping from the cap and leaking into the tuyere. For the space between the cap and the top of the center tuyere for the admission of blast and other blast-openings or areas, see p. 405. The under side of the covering-cap at *P*, Figs. 119, 122 and 124, may have short projections of about $\frac{1}{2}''$ cast on it, and daubed over with clay. But as the cold blast is constantly playing against this surface, there is little danger of it becoming too hot if cupolas are kept fairly constant in blast. In cases where they are left to stand for an hour or two without the blast being on, it is desirable to prepare the under side of the cap as described. In order to support the cap in place, $1\frac{1}{4}''$ pieces of square wrought-iron bars are bolted to the center tuyere, as shown at *S*, Figs. 119, 122 and 123. A recess *W* of about 3″ in depth is cast in the cap-piece, Figs. 119 and 124. This recess permits the cap to be fitted over the $1\frac{1}{2}''$ support (Figs. 119 and 123), to hold it in position dur-

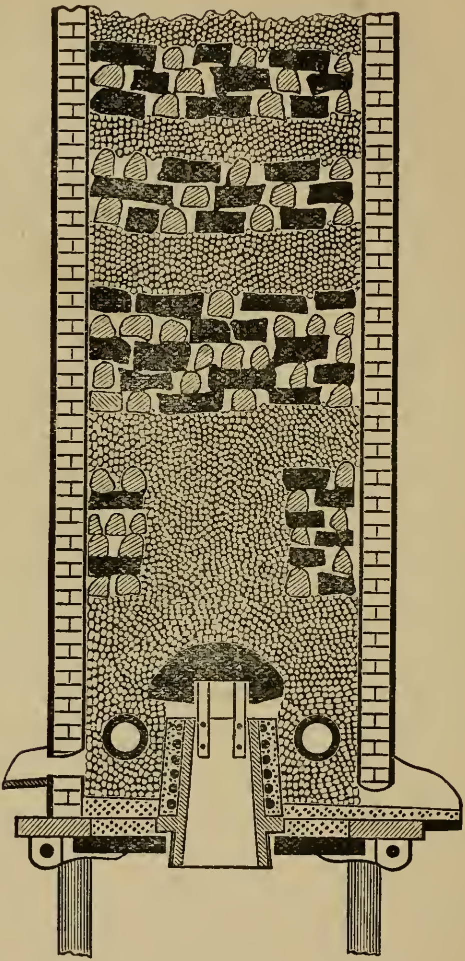

Fig. 120.

Plan for Charging the Bed of Center-blast Cupolas.

ing the heat. It is best to make this recess having a solid, square center as seen at *U*, Fig. 121, which then leaves an opening at *Z* to admit the entrance of the four $1\frac{1}{2}''$ square bars seen at *S*, Figs. 119 and 123. Such a construction in the recess would prevent the bending inward of the bars *S* should they become heated red hot from any cause. The dimensions given with Fig. 121 show that of the pattern from which the covering-cap is moulded, before the prickers for holding the clay are made in the mould. The test applied at the author's foundry, in the cupola seen in Fig. 119, has been a severe one, for the length of heats is not merely of an hour or so duration, but range from four to six hours. It will be noticed that the pipe-connection and wind-belt for bringing the blast to the outside tuyeres are not shown in Fig. 119. It is, however, necessary that dampers or valves be provided, so that the central and outside tuyeres can be worked together or separately, so as to regulate the blast-pressure at will. One plan for such valves is seen at *W* and *L*, Fig. 126, p. 406. Where long heats are run, there is a

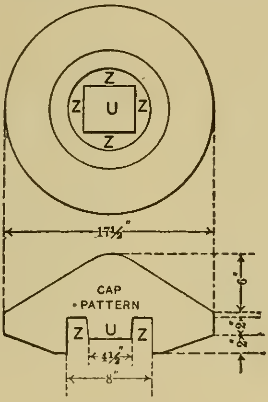

Fig. 121.

liability of the center tuyere chilling the stock at *K*. This difficulty can readily be obviated by shutting off the blast for a short time from the center tuyere, so as to permit the heat of the cupola to melt any chilled material that might be clogging the opening of the center tuyere at *K*. Sometimes a piece of half-melted iron may lodge in front of the opening at *K*, and obstruct the fluid iron in its direct descent to the hearth of the cupola. The escape of sparks, etc., down a center tuyere caused in this manner can be stopped almost instantly by increasing the blast-pressure in the center tuyere. The door *V* is so arranged as to be readily opened or closed, in order to permit the removal of any iron or slag that may have fallen to the bottom of the center tuyere.

The center tuyere itself can be made all of cast iron, or of boiler plate. For a permanent structure a cast-iron tuyere is preferable, as it presents greater rigidity, and is made at less cost. The center tuyere, as at *X* (Figs. 119 and 123), is made about an inch thick, with ribs throughout its length on the periphery (as shown at *C*, Fig. 123), in order to sustain wrought rings of $\frac{3}{4}''$ iron for supporting the clay, which is about 3″ thick. (For methods to daub and dry the clay on center tuyeres and caps, see p. 410.) These rings are shown in position in Fig. 123. Cast-iron projections or prickers have been tried in place of these rings, but the inconvenience of properly casting them on to the body of the tuyere renders them undesirable. Fig. 122 shows the center tuyere, with its covering-cap daubed over with clay ready for a heat, or as it would appear in position on the base in Fig. 119. The base is made in sections, so that the section *M*, Fig. 119, can be removed if anything goes wrong with the center tuyere. The main opening of the tuyere could then be stopped with clay, it being necessary for this purpose to place a large lump on a plank, levered on a horse so as to press it upwards into the interior of the center tuyere's

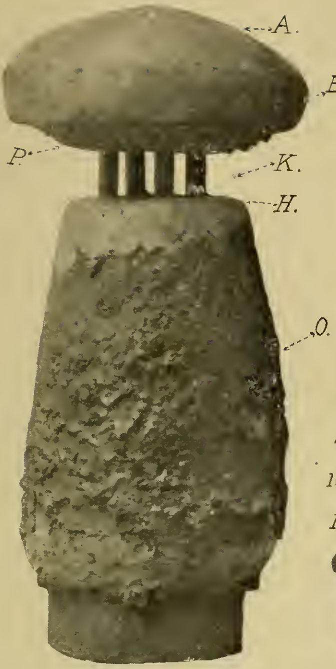

Fig. 122.

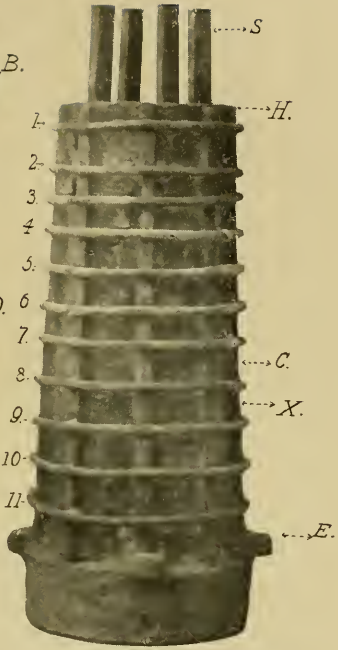
S
H.
1
2
3
4
5
6
7
8
9
10
11
C.
X.
E.

Fig. 123.

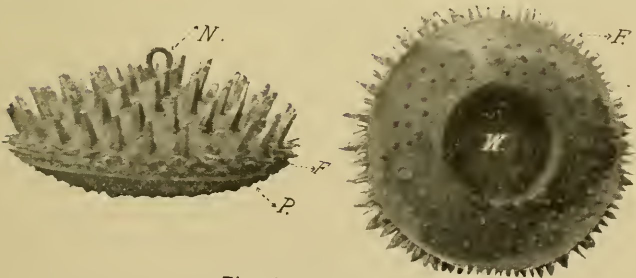

Fig. 124.

opening. It would then be tightly closed against the descent of iron or blast and the heat could be finished by the use of outside tuyeres only. It will, of course, be understood, that this is only a precaution against an accident that might never occur; and further, in the case of such an accident the part of the center tuyere remaining in the cupola would, in some cases, be melted up, requiring a new tuyere to replace the old one. In fact, the author keeps a whole set on hand to have them ready in case of accident, and such a set can now be seen at our foundry (May, 1901), covered with rust awaiting use. It is not to be taken for granted, because the author has called attention to the unexpected that might happen to disable center blast, that any one need be alarmed at its not proving a success. Mishaps can occur to outside tuyeres and in fact to almost any workings in founding. All that the author has done in thus calling attention to the liability of accidents occurring, is what any practical founder would do in providing for the worst and guarding to insure the best—provisions which, as a general thing; cause all to go well.

With the center blast shown in Figs. 119 and 125, pp. 393 and 402, the author has effected at his foundry a saving in fuel of 20 to 30 per cent according to the quality of the fuel, over what could be done if we run our heats with outside tuyeres only. Apart from this economy, the advantages enumerated at the beginning of this paper are sufficient to warrant the adoption of center blast, in large cupolas.

Some time ago we raised the outside tuyeres about 6″, from that shown in Fig. 125 to have them the height seen in Fig. 119. This enabled the cupola to hold a larger mass of metal, and at the same time there was more space between the slag-hole and the outside tuyeres. The change resulted in an increased speed in melting and in still cleaner working of the cupola. Where long heats have to be run or where slagging out is necessary, it is especially important to have a good space between the slag-hole and the outside tuyeres, as when they come close together, as seen in Fig. 125, it brings the slag up too near a level with the outside tuyeres,

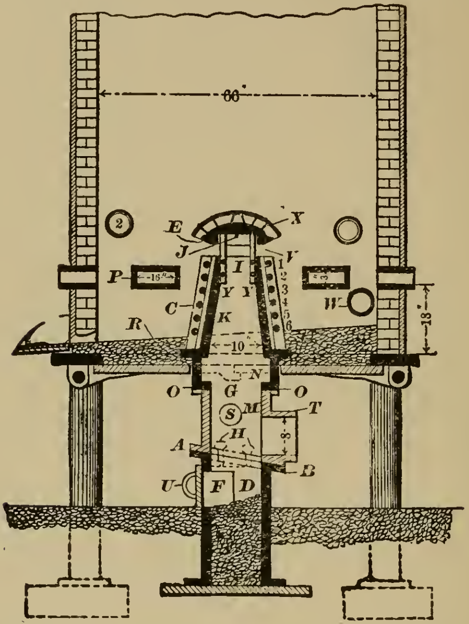

Fig. 125.
West's Permanent Standing Center Blast for Large Cupolas.

where the incoming cold blast can readily chill the slag, lower the temperature and may eventually choke or badly bung the tuyeres. The outside tuyeres in Fig. 119 are shown of round form. A better form is that seen in Fig. 125, and which shows the outside tuyeres to be of an oblong form. This cut also shows a plan whereby the pipe leading the blast to the center tuyeres connection at T, can be attached nearer the bottom doors, if necessary, although that shown in Fig. 119 is the best plan when it can be followed.

In conclusion, the author trusts that the new illustrations and descriptions, with the extended experience he now brings forward, will afford further proof to the public of the general utility and economy of center blast for large cupolas.

CONSTRUCTION AND UTILITY OF CENTER BLAST FOR SMALL CUPOLAS.

It is to be understood that while the author presents here the illustration seen in Figs. 126 and 130, pp. 406, 407, for constructing center blast in small cupolas, they are not advised for general use, but more for isolated cases or localities where material has to be melted that is exceptionally destructive to linings or where good fire-bricks are very costly or cannot be obtained. One great objection to center blast in small cupolas is the extra labor and trouble they cause to remove them out of a cupola's dump at every heat, and set them in position again ready for another heat, as with cupolas less than 55″ inside diameter they cannot be a permanent structure, as seen in Figs. 119 and 125, pp. 393, 402. This is owing to a lack of sufficient room in which to move around while picking out and daubing up a cupola where much cinder, etc., would stick to the sides after a bottom was dropped. In cases of very short heats, where no outside tuyeres were necessary, then it might, in some cases, be practical to use a permanent standing tuyere. However, for cases where the center tuyere would best be dropped with the bottom at the end of a heat, the author has designed the plan seen in Figs. 126 and 130, pp. 406, 407, and which is a plan that will save much labor in getting the bottom up and a center tuyere in place ready for a heat. It will be noticed by Figs. 127 and 128 that the drop-doors are constructed in such a manner that one-half has an opening made in it by which the blast can be carried to the center tuyere direct, without the use of under piping, as seen necessary for Figs. 119 and 125. It will also be noticed that the drop-doors for cupola Fig. 126 calls for a greater height of bottom sand by two to three inches than is usually adopted in the ordinary cupola. This may be objectionable for small cupolas, but the same can be overcome by having the drop-doors extend lower with a flange around the circumference to project upwards to close the bottom-plate of the cupola, as suggested at *B B*, Fig. 128, and cutting a piece out of the bottom-plate at *B*, Fig. 126, and then strengthening the same with a wrought sheet, bolted to the bottom-plate. For holding up the drop-doors, with props, two bars are to be used as represented at *E*, Fig. 126. One to be on each side of the blast inlet circle. *H* is a door so hinged and held up by means of the weight, wire rope, hook and staple seen at *M*, *P* and *F*, that should any occasion call for the door being opened suddenly to release any slag or molten metal that might, from any cause, leak down the center tuyere, it can be quickly operated without causing any stoppage or much loss of blast. *S* is a peep-hole to be closed with isinglass. *A* is a rib to make a backing for clay to tightly close the joint of the drop-doors in its union with the wind-box *K*, and which should be of the same area at *A* for the admission of blast as that for the area at *U*. *D* is a recess to admit a slide-valve to close the end of the drop-doors. *N* is one of the ear-lugs for hinging the drop-doors. *R* is the sand bottom showing the cupola ready for its bed of fuel, *C* the center tuyere and *X* the covering-cap. *W* is the branch blast-pipe for the outside tuyere and *L* for the center tuyere.

In obtaining the blast area of the opening at *U*, Figs. 126 and 127, are to be found by dividing the area of the cupola by 30. If the cupola is 40″ inside diameter, this gives an area of 41.86″, or in rough figures an opening 4″ × 10″, and at *I* a diameter of about 7″. This rule can also be applied to find the mean diameter of the opening at *M* and *I*, Fig. 125, for all center tuyeres, which, for a 30″ cupola, gives an opening of 5½″ diameter, for a 50″ about 9″, for a 60″ about 11″,

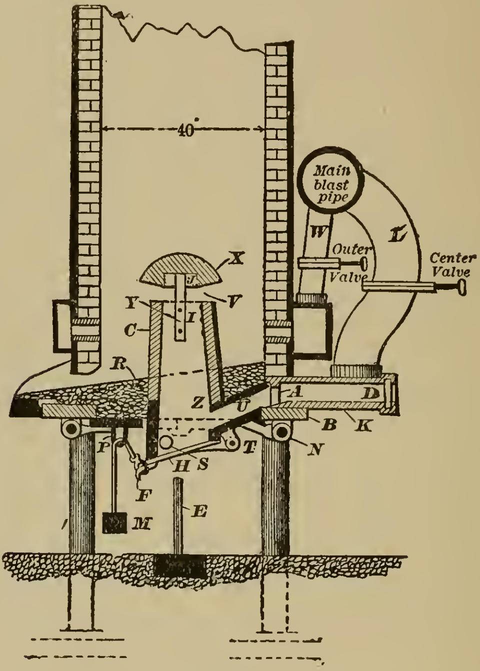
40
Main blast pipe
W
L
Outer Valve
Center Valve
X
J
Y
V
I
C
R
Z
U
A
D
B
K
N
P
T
H
S
F
E
M

Fig. 126.

West's Improved "Center Blast" for Small Cupolas.

and for a 70″ cupola, about 12½″ opening at the points *M* and *I*. This is to be understood as the mean diameter, and as the tuyeres are tapering, the top at *I* is intended to be 2″ less diameter than the bottom at *M*, thus making the opening at *I* about 4½, 6, 8, 10 and 11½″ respectively, for the diameters of cupolas above described. The width of the opening at *K*, Fig. 119, and at *V*, Fig. 126, for the admission of the blast to the cupola, should range from 2½″ to 3½″; the larger the heats, the greater should be this opening.

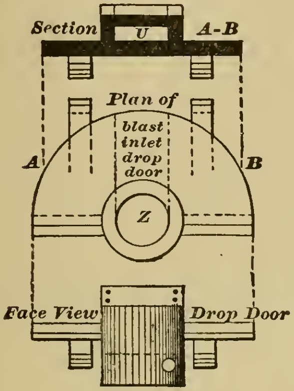
Section
U
A-B
Plan of
blast
inlet
drop
door
A
B
Z
Face View
Drop Door

Fig. 127.

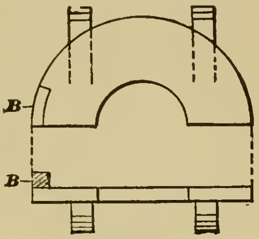

Fig. 128.

PLAN OF PLAIN HALF DROP-DOOR.

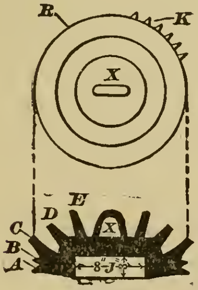
R
K
X
E
D
X
C
B
A
8″ J

Fig. 129.

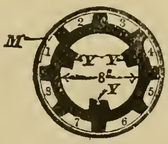
M
1
2
3
4
5
6
7
8
Y Y
8″
Y

Fig. 130.

GENERAL APPLICATION OF AND INSTRUCTIONS FOR UTILIZING CENTER BLAST.

It requires a little experience to utilize "center blast" to the best economy. But when a cupola man learns to utilize center blast in large cupolas running long heats, he will be the first to object to its being taken away, for the reason that it saves him much labor in picking out and repairing his cupola. Then again, when the cupola is in blast he finds little or no labor necessary to keep his tuyeres open, as it is remarkable what a difference exists in having free tuyeres as against the practice of not including center blast in large cupolas. In first adopting center blast one is not expected at the very first heat to charge with a radical change in decreasing the fuel, but gradually trying less every heat until he finds by trial just how low he can get. At the start the foundryman can at least depend upon reducing the "bed" in bulk whatever the bulk of his center tuyere may occupy, and between charges have about 10 per cent less fuel. A poorer grade of fuel can be utilized with center blast than with outside tuyeres alone.

There is nothing in the construction and erection of center blast that should cause any practical founder to hesitate to adopt it. It will be found most economical in the use of fuel and speed of melting to have the outside blast about equal in pressure to the center to whatever degree the blower or fan can drive it through the entire opening of the dampers in both connections. A large cupola will stand harder driving to force fast melting, where the center and outside tuyeres are used in connection, than where either are used alone. The larger the cupola, the more pronounced are the benefits in this line. It must be remembered that whenever the outside and center tuyeres are combined, the opening of the center tuyere admitting the blast to the fuel should be carried up to a height of from three to six inches above the level of the outside tuyeres.

If the center tuyere is used alone, as is practical in small cupolas running heats of not more than one hour's duration, it need not project above the level of that found best for economy of fuel with outside tuyeres, as by this arrangement less fuel can be used for the bed; but it must be remembered that this is not recommended for small cupolas that may be taxed to run heats of more than one hour's duration. Where center tuyeres are dropped with the bottom, as in use with small cupolas, there should be one or more extra tuyeres in reserve to replace any badly fractured ones, and instead of daubing these up when they are erected in a cupola, they should be previously prepared and dried in ovens. By adopting such a plan, a chance is afforded of having a solid, permanent lining and filling up any cracks firmly with soft clay, after which the whole surface could be blacked over to still further protect the new lining until it is hardened and glazed from the effects of its first heat in the cupola.

The thickness of the clay to be used when first lining a center tuyere should be put on the body of the tuyere, so as to project about two inches beyond the rings, Nos. 1, 2, 3, 4, 5 and 6, Fig. 123, p. 399, and have it appear as at *O*, Fig. 122. Accidents have happened by reason of the clay on the center tuyere wearing to such a thinness that it permitted the metal to burn through the casting *C*, and hence start the tuyere leaking. To guard against such, it is a good plan, if judgment cannot be relied upon, to have two standard gauges and occasionally caliper the diameter of the tuyere at its bottom and top, which, if found to be less in size than the gauges called for, can be built up to give the necessary protection by patching on clay over the rough surface of the tuyere's lining.

In using the permanent center tuyere originated by the author, shown in Fig. 119, it can often have the green clay daubed on with the tuyere (Fig. 123) in position and then by building a little fire at the opening of the center pipe at *V*, Fig. 119, supporting the tuyere, the same can be dried, where the time of five to seven hours will permit of such a process. Upon first starting to use center blast the author thought he was going to have difficulty in obtaining material for lining that would stand the heat. Experience has shown that his fears were groundless, and all that is necessary is to use a fair grade of common fire-clay, mixed with sharp sand, and to make the whole of a consistency found good to daub large ladles or cupolas. Where fair fire-clay cannot be obtained, it may often work well to strengthen common clays with plumbago or coke-blacking, wet with a solution of silicate of soda. A center tuyere prepared in the manner above described will, after the first heat, present a hard, glazed body, which may resist high fusing effects of the cupola's heats, for a dozen heats or more before requiring patching with clay, and foundrymen thus using center tuyeres will often be surprised at the small amount of clay necessary to repair the tuyere and cap and keep them in good order. In order to have about as hot iron at the beginning of a heat as will be found at the latter end, where center blast is used, it is well to rob the first charge of fuel to raise the height of the bed. Where this is not done, the first melting can often be found duller than that obtained at the latter part of a heat. Another point by regulating the volume of blast through the center and outside tuyeres, the cupola man will soon find that he is able to greatly retard the escape of flame and sparks at the closing of a heat. Again, if any sparks should emanate from the center tuyere, from any cause, they can generally be stopped by making most of the blast to pass through the center tuyere for a short period.

Since the publication of the author's origin of center blast, p. 393, he is led to believe that many have been trying center blast and doing its introduction more harm than good, mainly through a lack of experience in founding, and not knowing that what may work well in one case may not in another. The instructions herein given on the construction, use, etc., of center blast are the result of over seven years' experience of the author in the perfection of center blast, to make it practical for every-day use, and any one may adopt it upon the lines herein described, with the assurance that if fair judgment is used in first utilizing center blast, success will be assured and the results finally attained demonstrate center blast to be the most scientific and economical method yet advanced for large cupolas.

INTRODUCTION TO NATURAL- AND SUCTION-DRAFT CUPOLAS.

There is no machinery founder or moulder of long experience who has not, to a greater or less degree, imbibed a feeling of dread that something may break down or the unexpected happen just at the worst moment to stop the blast and cause trouble before an important casting is poured or a "heat" is finished. The natural-draft cupola has many qualities to commend its adoption for certain lines of work, one of which is in sections of the country where a foundry is placed out of the reach of quick repairs, or situated where it would be desirable to dispense with an engine, its boiler, etc., and then, again, in localities where boiler fuel is exceptionally expensive. It is also adaptable for a class of work which might call for slow but continuous melting—as, for example, in cases where a founder has but little floor-room or would prefer to avoid carrying a large number of flasks, etc., in order to produce a large day's yield of castings.

The author does not wish to convey the impression that a natural-draft cupola could equal a forced blast in speed of melting. Of course, the larger a natural-draft cupola the greater the quantity of iron it could melt per hour, so that in one way it is only a question of size in order to increase speed in melting; and were it not for the question of economy in fuel, in using large cupolas to melt small bodies of iron, it is plain that we could economically adopt natural-draft cupolas to meet the requirements of many shops for speed in melting.

The great advantage which a natural- or suction-draft cupola offers in some instances to founding has weighed upon the author to such an extent as to cause him to seriously consider the practicability of natural draft, and as a result of his research, study and experience, he offers the design shown in Figs. 132–136, and which are for the free use of any one.

ALLEN'S NATURAL-DRAFT CUPOLA.

In a paper on melting without blast, published in *The Foundry*, April, 1895, Mr. J. McCash says:

"In the November issue of *The Foundry*, I find a very good, practical article by Thos. D. West on the subject of blast for cupolas. He expresses the desire to use a cupola so constructed as to work without blast-fans, etc. In 1854, I was employed in Allen's foundry, Springbank, Glasgow, Scotland, working on hollowware. In the shop where I worked—it kept busy twenty-five or thirty moulders, all of whom worked piece-work, on stove plate and hollowware principally—this cupola was used daily and was oblong in shape, being about four feet the long way across by three feet the narrow way. The tuyeres were flat wedge-shape and were all the way around except the necessary places to support the upper part of shell, the inside opening of tuyeres being about five inches, the height from tuyeres to top being about ten feet, or about equal to the charging-door of ordinary cupola. The top was covered with a revolving cover resting upon trunnions at the ends and lined with fire-brick. The charges of pig iron and fuel were placed on the cover and dumped inside by turning the handle, when the cover was brought back to its original position. Underneath the cover was a large flue, similar to that used in a brass furnace, entering into a tall stack; its exact height I do not remember, but it had sufficient draft to produce hot metal for light work. This cupola had been a long time in use and is seen in Fig. 131.

"It was said that the owner, Mr. Allen, had to pay a royalty for the privilege of erecting it.

"I do not know what the result would be, but it seems to me that a well-built furnace of that description ought to melt iron more economically than the present method."

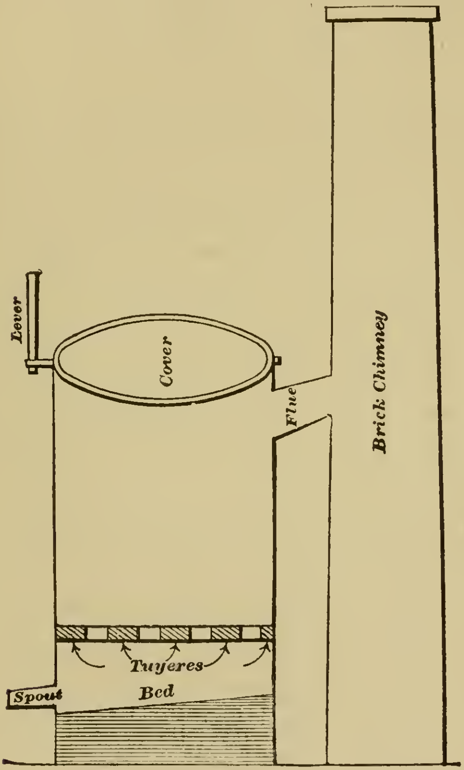
Lever
Cover
Flue
Brick Chimney
Tuyeres
Spout
Bed

Fig. 131.
Allen's Natural-draft Cupola.

CONSTRUCTION OF NATURAL- AND SUCTION-DRAFT CUPOLAS.*

THE natural-draft cupola illustrated on p. 415 probably presents the best success with which natural-blast cupolas have met, and I largely attribute this to the fact of the Allen cupola being of an oblong shape, which admitted of air reaching the center body of its fuel much better than had it been of a round form. In a study of the reason which can be assigned for the failure of some natural-draft cupolas, I first found thát every time a charge of stock was admitted to the cupola, a large area was opened which admitted such a volume of air at the top as to cause a decided check to the draft. All founders know that any temporary lull, no matter of how short duration, with force blast, checks the speed of melting and often results very seriously in causing "bung-ups." The second bad point I found lay in there not being sufficient tuyere area and means for regulating the same according as the atmosphere influenced the draft, which is seldom found two days alike, no matter how high a chimney may be constructed. The third drawback I found was in not providing methods for the proper deliverance of slag, and to prevent its rising to a level of the tuyeres, as it can easily do in a cupola as the length of a heat advances if not properly arranged for.

The author has endeavored in the design shown (pp. 418 to 422) to overcome the evils above described and which to his mind have prevented the success of natural-draft or suction cupolas in the past. How far he may have succeeded will be best decided by a practical test and which could be most economically done by any one having one or two high chimneys conveniently located, to which the draft for such a cupola as here shown could be connected. It is said that two chimneys of a medium height may often work better than one very high one. Fig. 136, p. 422, shows a 40″ cupola, mainly for the reason that this size is about midway between those in general use. To build smaller or larger cupolas than that shown, I would advise following the horizontal proportions, and increasing or decreasing the vertical proportion (see p. 422) by increasing or decreasing the height one-half of the measurement that the diameter proportions are increased or decreased. The total tuyere area for any size of a natural- or suction-draft cupola should range from 60 to 70 per cent of the area of the cupola's largest inside diameter. The area of the continuous tuyere *A* is to be found by dividing the largest area of the cupola by 2 and the first row of tuyeres by 9, the uppermost row *M* by 20, and the center-draft tuyere *N N* by dividing the largest area of the cupola by 35.

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* Revised extract of a paper presented by the author to the Foundrymen's Association, Philadelphia, Pa., June 5, 1895.

It is well to have the bottom or hearth portion of the cupola constructed wholly independent of the bosh and stock body, so that a perfectly continuous tuyere opening can be obtained, as seen at *A*. The upper and lower plates protecting the brickwork at this tuyere are made of cast iron about one and one-half inches thick, the upper plate being best constructed of one continuous circle, whereas the lower plate could be in sections if so desired for convenience in being replaced should it crack or be burnt out in any way from outflowing metal. The upper plates are held in place to support the upper brickwork by having a flange project upward on the outside and bolted to the shell as shown. To aid in supporting the brickwork in the bosh and stack portion, an angle-iron, as seen at *D*, should be placed around the inner portion of the shell about every two feet in height. The same columns used to support the bosh and stack portion of the cupola can, by having projecting flanges, as seen at *E*, Fig. 136, also carry the hearth portion, and this body can be raised or lowered so as to increase or diminish the height of the continuous tuyere by means of "blocking" or jack-screws placed between the flange *E* and the cupola's bottom-plate, as shown at *F*, by making the difference between the flange and bottom-plate greater in distance than shown. "Blocking" is

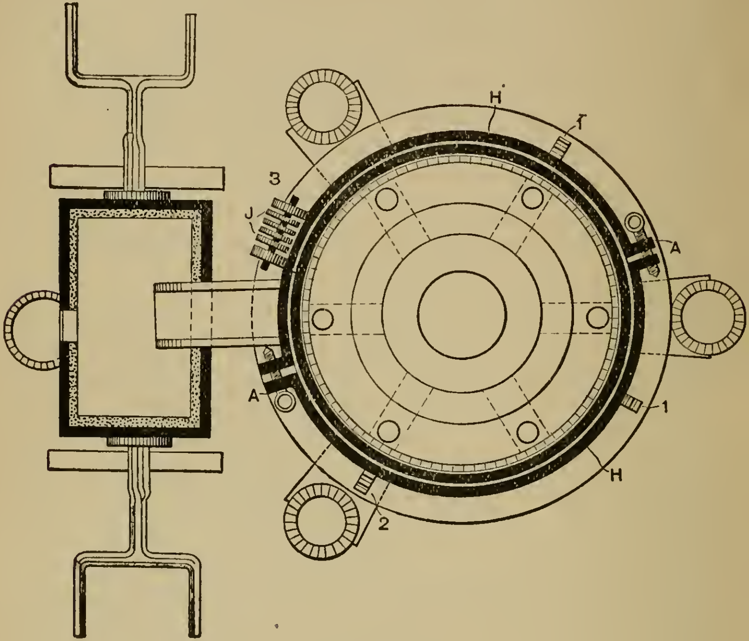

Fig. 132.
SECTION THROUGH X 2.

preferable to jack-screws, etc., as the latter, in many foundries, can be made readily inoperative at such points by

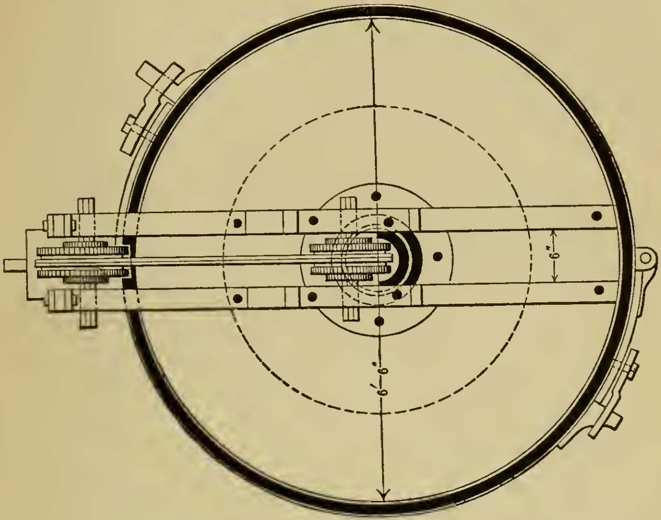

Fig. 133.
Top Plan of Cupola.

means of flying sparks of iron or dirt getting in between the threads of the screw or nut, or joints of levers.

To regulate the draft, a wrought-iron gate-belt about a half inch thick is made to encircle the cupola as seen at *H H*, Fig. 136, and in the plan view, Fig. 132. To raise or lower this belt, a weight *G* is used, having two wire ropes *I* passing over the pulleys *J J*, seen in Fig. 136; the rope after passing over these pulleys, *J J*, is then carried down to come under pulleys or small sheaves, seen at *L* in Fig. 136, passing from these to sheave-wheels at right angles to *L*, secured opposite each other on the cupola's shell. At this point the rope branches off in two directions on each side to connect with the gate-belt at the points 1, 2, 3 and 4, seen in Fig. 132. Should it be desirable to secure this gate-belt *H* closely around the tuyere opening *A*, so as to shut off all possible admission of draft, this can be readily done by adjusting or tightening screws or clamps at the points *A A*, Fig. 132, and packing the taper access at the outer edges *R R* with clay. To stop all draft passing through the center tuyere, a door is hung having the lug *O*, Fig. 136, for support at one side and a latch-catch at the other. When these two openings and the belt *H* are closed, in connection with stopping the breast with clay or sand and closing the chimney-valve flue, we have a condition practically the same as that implied in the "banking of a furnace." To be able to thus bank a cupola, is a feature that may at some time be well utilized.

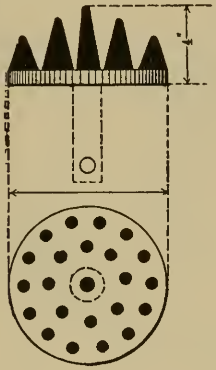

Fig. 134.

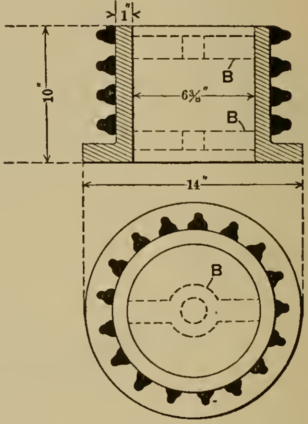

Fig. 135.

After the stock is charged around in the space at *K* as seen on the right at Fig. 136, the charging-doors as at *T* are then closed as seen at *X* on the left, and then by pulling on the weight *W*, the conical cylinder *Y* (made conical to pull out of the stock easily) is raised and the stock slides down to fill the cupola. According to the speed with which the closing cylinder *Y* is raised, so can the locating of stock be largely regulated as to its being chiefly charged to the outer or inner circle, and thus afford facilities to arrange the fuel and iron at any desired portion of the cupola's area. This is a very essential point to insure uniformity in melting and lessening the chances of "bung-ups" and short-lived heats. Even where the charging arrangements as shown are not necessary for preventing an inrush of air at the top every time stock is delivered to the cupola, the point of insuring evenness and any desired distribution of stock in charging in itself recommends the adoption of such a charging device as here illustrated.

As arranged in Fig. 136, the charging cylinder cone *Y* can be raised two feet or more. It will not be out of place to say that when it is necessary to charge massive pieces, this should be done. In charging heavy pieces in the cupola they should be placed in the last one or two charges near the top, and this should be done before the draft-gates are opened to start the process of melting. It will be seen also that the principle involved in the charging arrangements will admit of raising the charging cylinder cone *Y* up out of the way to admit good light to the cupola, or the entrance of a man in making any repairs or lining a cupola, and also permit of the fullest freedom in passing down kindling to form the bed for first firing, or iron for the first charges in the cupola. The cone *Y* cannot drop into a cupola should the rope or chain used break. It would be well where long heats are run to have the cupola made two to three feet higher from the bottom-plate to the charging-ring than that shown in Fig. 136.

This cupola can largely dispense with our present neces-

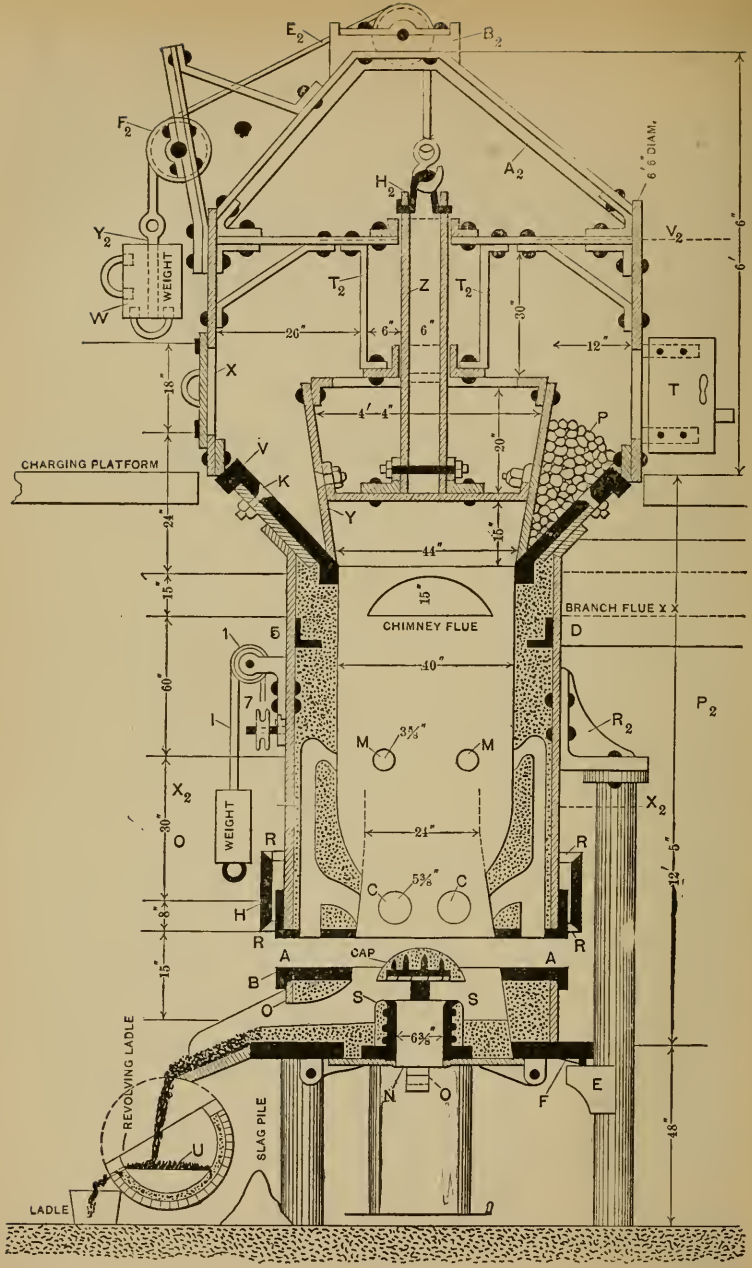
E2
B2
F2
H2
A2
6'6" DIAM.
Y2
V2
6'-6"
WEIGHT
T2
Z
T2
W
30"
26"
6"
6"
12"
X
18"
T
4'-4"
20"
P
V
CHARGING PLATFORM
K
Y
24"
15"
44"
15"
15"
CHIMNEY FLUE
BRANCH FLUE X X
1
5
D
40"
60"
7
I
P2
R2
M
3⅝"
M
X2
X2
24"
WEIGHT
30"
O
R
R
12'-5"
C
5⅜"
C
H
8"
R
R
15"
CAP
A
A
B
S
S
O
6⅜"
REVOLVING LADLE
N
O
F
E
SLAG PILE
U
48"
LADLE

Fig. 136.

West's Natural-draft Cupola.

sary evil of tapping out or stopping up when desirable, and which is another advance over our present practice. In long heats or where much slag is created, it might be necessary to have a blow-pipe or a jet of gas burn at the breast-hole so as to prevent the slag chilling as it flowed out against the draft pressure with the iron. At the first meltings it might be found necessary in some foundries to bank the breast to a height near the top of the center-draft tuyere opening so as to insure a body of metal quickly collecting in the revolving stand-ladle seen at the spout of the cupola, Figs. 132 and 136. After a body of metal of about the height shown is collected in the stand-ladle, the slag which may emanate from the cupola to float on top of the metal in the stand-ladle, or fine coke dust or blacking, can be used to hold the heat of the molten metal so as to possess sufficient fluidity in the metal coming from the stand-ladle to pour light work as well as heavy. For obtaining different degrees of fluidity as the iron comes from the cupola to the stand-ladle, we have recourse to the same methods which we use with force blast, which, with natural or suction draft, would simply mean regulation of draft and fuel and the height of continuous tuyere opening at *A*.

It will be noticed that I have planned a new form of stand-ladle, one which can empty itself of iron on one side or of slag on the other, without having to stop the outflowing stream of iron in its passage from the spout to the stand-ladle. This stand-ladle can be turned by hand or by means of spur or worm gearing. Should any one desire to have such a cupola arranged so as to hold large bodies of iron before tapping, or to dispense with the stand-ladle shown, they can readily do so by raising the height of the continuous outside tuyere and center-blast opening to whatever level desired, and then tap out as in regular practice.

It will be well at this point to discuss how natural or suction draft gives us promise of economy in melting. One advantage is that fuel is not necessary to raise steam to run fans or blowers. One shop may burn nearly as much fuel to raise steam for a fan as is used in the cupola to melt iron. A natural draft moreover is less destructive to linings owing to the fact that we know a mild blast is much less injurious to a lining than a strong forced blast. Again, the expense is saved of keeping up repairs due to break-downs of appliances, in the form of fans, belts, pulleys, shafting, engines, etc., in a shop using forced blast.

While we must acknowledge that there are days when chimneys may have little or no draft, no matter how high they are, still this should not debar us from utilizing natural draft, as such rare occurrence could be often largely overcome by building a small fire in the bottom of a chimney through an opening provided for that purpose. Then, again, there are economical methods by which we could obtain the assistance of suction draft on such occasions. We have not shown any chimney to accompany the cut of Fig. 136, p. 422, but all are to understand that the flue *XX* seen on the right of the cut is extended for any length necessary to connect itself with one or more chimneys, the height of which will depend upon localities.

The cupola, Fig. 136, should not exceed the cost of our present cupolas, especially when we consider the high stacks, boiler, engine, etc., necessary to force-draft cupolas.

It is not a question whether iron will melt by natural draft, for this is demonstrated to be practical in the Allen cupola, p. 415, and is often done even in our present cupolas before the blast is put on; and to stop the iron from melting, tuyere openings are often closed to shut off natural draft. But the question is, can we melt fast enough by natural or suction draft? For some lines of work or conditions the author would say yes. One thing, however, is evident: if we cannot melt fast enough with natural draft, we should often be able to do so with the assistance of suction draft; and inasmuch as suction draft is not incompatible with the use of the cupola herein illustrated, with its several accompanying advantages and improvements, the design is presented as one which, for some peculiar or certain conditions outlined in the introduction (p. 412), may prove of much value.

UTILITY OF HOT-BLAST CUPOLAS.

The question is often asked, why "hot blast" would not work well and be more economical than cold blast for cupola practice. Every now and then some one is trying experiments in this line, believing he has original ideas which would work successfully. The author has thought an article on the subject, to illustrate what has been done and the success attending such experiments, would be of interest to founders and possibly be the means of saving time and money to any one who might think to experiment in this line. For this reason the author presents herewith what information he has been able to obtain on the subject, and also his own experiments, suggestions and ideas on this question.

Large stacks have been built on cupolas containing coils of piping so arranged that the blast would come in at the top and be carried through them to the tuyeres as heated air. The author has tried the plan of having cold blast pass through pipes suspended in the stack about four feet above the top of the charging-door and having the hot air pass down to the tuyeres. Then, again, the plan has been tried of curving the stack and of carrying the escaping gases down to a brick oven on the ground which was filled with coils of piping. All of these plans proved unsuccessful.

A late firm of Allegheny, Pa., is said to have used hot blast in a cupola for the purpose of converting into pig metal old iron and "suggens," that is, large lumps of scrap iron made from "boils," etc., around a blast-furnace. They used an oven filled with pipes somewhat after the plan of blast-furnace "iron-stoves," which they heated wholly by natural gas, independent of the cupola's waste gases. The plan is reported to have assisted the cupola to run freely, and to have advantages over that of cold blast.

Some have tried to draw hot air from the stack of a cupola by means of a pipe leading from the stack to the fan's air entrance and then drive the air to the tuyeres as ordinarily done. This has proved a failure, owing to the hot air heating the fan and burning the belts, etc. Then, again, such a plan, the author would say, would be objectionable on the ground of the air, which was drawn from the cupola, being loaded with injurious gases or a blast less rich in oxygen than that which would come from the atmosphere. There have been what are called "jacket-cupolas," designed with a view to having the blast enter at about the level of the charging-door to a space of about two to four inches wide around the curcumference of the whole body of the cupola before it can descend to the tuyere entrance. There are no records to show that such a plan has proved of any advantage.

One element which is a detriment to utilizing waste gases in making warm or hot blast for cupolas in the majority of foundries at the present time is this: That many cupolas have conditions which permit their being in blast but one or two hours at a heat, thus affording very little opportunity for the waste gases to get pipes, etc., heated to a degree sufficient to raise the temperature of the blast which would pass through them, in order to do much good before it would be time for the "bottom drop." Where a cupola with one row of tuyeres must depend on its own gas to heat its blast, it would have to be running from one-half to one hour before the pipes in it or an oven could get sufficiently heated to raise the temperature of the blast to any effective degree. Many cupolas would have their heats run off by the time blast would be heated to a point to be of much benefit. The expense of keeping pipes and ovens in repair more than counterbalanced any economy which was derived from hot blast in the past, by means of a cupola's own gas or stoves heated by special firing of coal or gas to run off short heats.

Some interesting illustrations of hot-blast cupolas are presented by M. Gouvy, Jr., in a work translated from the French by W. F. Durfee, M.E.* The cupola seeming to the author the most practical of those shown is that seen at Fig. 137, p. 429. The plan of this cupola is to collect the metal in a crucible, *B*, independent of the cupola proper, and have the heat from the metal held in the crucible and gases, which would blow through the outlet *E* to heat up the blast-pipes seen in the upper inclosure *A*. M. Gouvy, in commenting on the utility of hot blast for cupolas, says:

"Finally, we conclude that heated air for blowing cupolas only results in an increase of their melting power in consequence of the elevation of the temperature of the zone of fusion; but we do not find any economy of fuel, which fact is attributable to the zone of fusion extending to a very much greater height than when cold air is used, and therefore the carbonic acid formed at the tuyere encounters a very large surface of incandescent coke, which effects a reduction of gas, and the advantages of heating the blast are annihilated by the loss of heat due to the transformation of this carbonic acid into carbonic oxide."

With regard to M. Gouvy's conclusions, the author would say that if we increase the melting power of a cupola, we should find economy in two ways, one of which is to permit small cupolas running larger heats than they otherwise could, and the second important factor, which seems to have been lost sight of, is that of the benefit to be derived in greatly preventing tuyeres from being bridged over and finally "bunging-up" a cupola to the extent which cold blast effects such action, and which, we must also remember, can often cause quite a loss in "shot iron," etc., being contaminated with the refuse of a cupola's chillings and droppings. Then, again, to use hot blast, cupolas should be made as high as practicable. This would give the elevation of the temperature about which M. Gouvy speaks a better chance to heat up the iron before it comes down to the melting point and cause some saving of fuel.

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* Presented before the Franklin Institute, 1889.

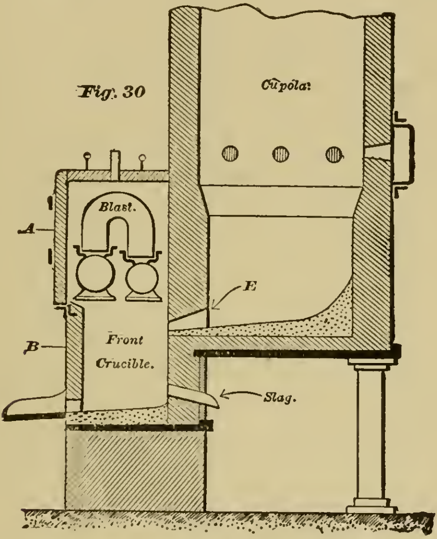

Fig. 137.
THE TITTL AND ERNDT, OR MODIFIED KRIGAR SYSTEM.

Another point is the benefits which might be expected in utilizing hot blast to further advance the utility of "center blast." By having warm or hot blast enter through a center tuyere, we would obtain the same benefits to be derived in the center tuyere being kept open to freely admit the blast, as is stated for outside tuyeres; but if hot blast is used for a center tuyere, it might, with temperatures over 500 degrees, require some cooling arrangement similar to that shown in Fig. 117, p. 385.

Our present state of advancement appears to offer no design that has proved of any special benefit in economically utilizing the waste gases to raise the temperature of cold blast to any beneficial degree for short heats. But for long heats, especially in cases where center blast is used in large cupolas, we have conditions more favorable for utilizing waste gases. However, in cases where warm or hot blast can be cheaply obtained from independent sources, good results and economy in working the cupola should be obtained in short as well as in long heats.

MELTING STEEL IN AN ORDINARY 30″ CUPOLA.

	lbs.		lbs.		lbs.
Fuel for bed : coke . .	250	Fourth charge : pig . .	300	Seventh charge : scrap .	300
coal . .	200	" " scrap .	300	" " coke .	50
First charge : pig . .	1,200	" " coke .	50	Eighth charge : pig . .	300
" " coke . .	50	Fifth charge : pig . .	300	" " scrap .	300
Second charge : pig .	300	" " scrap .	300	" " coke .	100
" " scrap .	300	" " coke . .	100	" " coal .	100
" " coke .	50	Sixth charge : pig . .	300	Ninth charge : steel .	1,200
Third charge : pig . .	300	" " scrap .	300	" " coke . .	100
" " scrap .	300	" " coke . .	50	Tenth charge : steel .	1,000
" " coke .	50	Seventh charge : pig .	300		

Time of starting fire	2.15 P.M.	First appearance of fluid iron .	4.27 P.M.
Time of charging first iron . .	3.15 "	Bottom dropped	5.45 "
Blast put on	4.20 "		

Revolutions of blower when on steel, 1,900. Kind of fuel used, Birmingham coke and Lehigh coal. The cupola in which we melted this heat is the one given on p. 371; as the dimensions of cupola can there be seen, it is not shown with this report.

TOTALS.

Amount of steel melted . . .	2,200 lbs.	Ratio of fuel to iron used	6.66
" iron melted	5,400 "	Length of heat	1h. 25m.
" fuel consumed . .	1,150 "		

REMARKS. — The "American Machinist" of Aug. 23, 1884, contained an account of my "Melting Steel in an Ordinary Cupola." Since then, by experimenting, we have learned something of the nature of it, and not only found the class of work we can use it in to best advantage, but have also made a decided improvement in manner of melting and fluidity of metal. The method of charging is different from the account I gave in the article referred to. We have not melted a heat of steel alone, not having occasion to melt more than 1,000 to 2,000 pounds at a time. We continue to melt it right behind the cast-iron portion of the heat, as above shown. As soon as the last charge of cast-iron begins to settle away from the charging-door, we keep the cupola full of steel up to the charging-doors until the last has been put on : this gives it the benefit of a long heat, and when it reaches the melting-point it comes down (to use the expression of a moulder here) "hot enough to run a needle with the point up." It is very fluid when it first comes from the cupola. While it does not remain fluid as long as cast-iron, I am satisfied a very large piece could be poured with it. I notice, by agitating it in the ladle, it "gums up" around the ladle quicker than cast-iron.

Charging in above manner, the cast-iron all melts down ahead of the steel. Then there is a cessation in the melting for a few minutes before the steel starts : once started, it melts very fast. The appearance of the metal is so different from cast-iron in the fluid state that we can tell it as soon as it starts from the cupola.

The steel scrap used is of a class known as "slab, or agricultural steel;" and we have melted 60,000 out of the 75,000 pounds we had on hand, besides using up all the scrap that has been made since then. By itself, the steel runs porous. By adding one-sixth cast-iron to the charges, we find it runs the castings very close and solid, and harder than the steel alone. For furnace-liners, back-plates, grate-bars, brake-shoes, etc., it is superior and more serviceable than cast-iron. In light castings annealed, I feel sure it would make stronger castings than malleable iron.

Last fall, J. C. Albrecht, master machinist of the railroad shops here, complained about the chilled truck-wheels, shipped him here for section masters' hand-cars, cutting out and getting flat places in them in a short time. We asked him to let us make a set of steel-rim wheels for a trial. He placed an order with us for two sets of wheels, steel rim, 26″ diameter, 3½″ face, ⅝″ thick, 1″ flange, ten ⅝″ round wrought-iron spokes, set zigzag in hub; hub of cast-iron; weight of wheel, 120 pounds. They have had to stand the test through the most severe winter we have had in the South for years. Having filled orders for 150 since then, is evidence of the satisfaction they are giving.

The above heat was melted April 24, 1885.

ROBT. E. MASTERS,
Foreman Columbus Iron Works Foundry, Columbus, Ga.

MELTING AND MIXING STEEL WITH CAST-IRON TO OBTAIN STRONG OR CHILLED CASTINGS.

As a supplement to the previous page, the author offers the following few notes, which the readers will no doubt find interesting and of value.

The union of steel with cast-iron has of late years been much practised for the purpose of either adding strength to or increasing the depth of chill to cast-iron, ideas and notes upon which will also be found in vol. i., pp. 272, 297, 298, and 299. It might be well to here state that wrought-iron has also been used in mixture with cast-iron, sometimes being melted in the cupola and again mixed in with the cast-iron after it was melted. I have heard of its being used as high as 33 per cent in mixture with cast-iron melted in a cupola.

The greatest per cent of either steel or wrought-iron which can be mixed in with liquid cast-iron *after it is melted*, will, of course, depend on how "hot" the fluid cast-iron is, and what it is intended to be poured into. I would not have the reader understand by the above term, "greatest per cent," that the more cast-steel scrap there is mixed in a ladle or cupola with cast-iron, the stronger should the product be. As far as strength is concerned, I would be led to say there is a limit, and that it greatly depends upon what grades of steel and cast-iron are mixed together. The cast-iron, in order to obtain the greatest strength in product of mixture, will be greatly affected by the amount of carbon the steel and cast-iron contain. A soft or low carbon steel should produce a much stronger product than a hard or high carbon steel; and I have no doubt but that, from a careful mixture of *low-carbon steel with low-carbon cast-iron*, proportionately strong castings could be produced. The result obtained from a mixture of high-carbon steel with cast-iron can be such as to impair the original strength of the cast-iron.

Steel, as is well known, *contains less carbon than cast-iron, and more than wrought-iron*, the latter sometimes containing but a trace. Carbon is held in cast-iron in a combined and in an uncombined state. When combined, it is chemically united with iron, as seen in hard or white cast-iron; and when uncombined, the carbon appears in the form of graphite, as seen in No. 1 grades of foundry soft gray iron. Cast-iron containing carbon in the graphite or uncombined state requires a higher temperature to melt it than when it is chemically combined with the iron; and the larger per cent of chemically combined carbon iron contains, the less heat is required to melt it.

The more carbon there is in wrought-iron, steel, and hard cast-iron not only causes it to be melted easier, but also makes it retain its life or fluidity longer.

Carbon can be given and taken away from iron or steel. *Fuel will supply it, and air eliminate it.* When wrought-iron or steel is melted in a cupola, both of the above agencies are at work upon it; and while we can in one sense say they are being weakened through oxidation, we can in another sense say they are also weakened through carbonization; for when steel, etc., is mixed in among fuel, and there melted, it cannot but be affected by it, as the oxygen of the atmosphere combining with fuel in a cupola creates carbonic acid and carbon oxide, which, when liberated in concert with other gases, — such as sulphur, etc. — which fuel contains, all go towards destroying the original strength of scrap-steel or wrought-iron scrap.

When we see, in the manufacture of steel, that the slightest per cent of a component can so materially change its nature, what can we expect in the way of certainty in producing grades out of a cupola, where steel is tumbled in with a conglomeration of cast-iron and fuel, of a chemical analysis radically different and much more impure than steel, etc.

To procure a homogeneous product from the mixture of steel with cast-iron, as a rule, seems to have been poorly accomplished. The steel mixes with the cast-iron in such a manner, that, when castings are turned or bored, hard spots or mottled surface often appear.

In melting steel with cast-iron there are, however, a few things which can often be done in assisting to obtain a uniformity in percentage of the material charged: as, for instance, did one desire castings made of one-fourth steel and three-fourths cast-iron, the material should be carefully weighed and charged; and in charging the cupola, adopt the method set forth in vol. i. p. 304. The method there described will at least insure the production of the mixture as charged. Of course, if there were enough weight of the steel mixture to make a heat by itself, then the mode above referred to would not be necessary.

Another point which might be well to mention in regard to obtaining a uniform mixture is, that the more metal there can be collected in a large ladle, and agitated by stirring with a "mixer" or wrought-iron rod, the better homogeneous castings will be produced. No one should expect, that, by catching and pouring the metal into small work as fast as it melts, the castings produced can contain the uniformity in mixture they would where large bodies of the metal are first collected before the pouring commences. Of course, in the case of large castings the metal would, through necessity, require to be collected in large bodies. For small castings the metal would, in being collected, require covering with dust, etc., in order to "hold its life;" or, where it was to be made a steady business, a closed reservoir could be used; the iron as it melted, running into it, could, after a body was collected, be taken out in "small taps" as required. There are of course many castings which will not be much injured through irregularity in uniformity of mixture. The above points aré simply to *give ideas* to assist thorough and equal mixing in cases where fine work is required.

In charging steel mixed with cast-iron, *or alone*, in a cupola, the steel cannot but be injured through carbonization and oxidation. Were air-furnaces or crucibles used (which I believe could be made practical for the purpose) for melting steel, the above injuries steel receives would be greatly overcome. I simply here suggest "air-furnace" and "crucible" for the purpose of presenting something that may be of value to those inclined to experiment with scrap-steel to the end of obtaining strong castings. The author would state that the above suggestions, written 1885, would seem to have been followed by some to produce what is known since 1896 as "semi-steel," a product gaining a tensile strength of 40,000 to 50,000 pounds per square inch.

Samuel M. Carpenter of Cleveland, O., who holds letters-patent No. 173,159, awarded him Feb. 8, 1876, upon a process for the immersion of steel into liquid cast-iron, claims that the only way in which cast-iron can be strengthened by a mixture with steel is by melting the steel immersed in liquid cast-iron, thereby preventing it from contact with the blast of air which oxidizes the steel and impairs its strength when melted in cupolas. Scrap steel melted with cast-iron in a cupola, for the purpose of hardening or giving a deep chill to castings, *is at least effective.* While in some ways I agree with Mr. Carpenter, I would say that it depends largely upon the character of the mixture. It is generally safe to conclude that soft grades of cast-iron can be strengthened by mixture with low carbon steel, but what to expect from hard grades or pig-iron above No. 2 is rather difficult of conclusion.

Almost all kinds of scrap-steel can be melted (borings, etc., are best melted by being packed in cast-iron pots, etc.), and classes of castings found in which it may often be well utilized. The melting of cast-steel in cupolas, as far as manipulation is concerned, is in principle the same as melting cast-iron. For steel, more fuel and blast-pressure may often be required than for iron.

Scrap-steel when melted in a cupola produces a product somewhat similar in nature to "white iron."

With reference to melting steel or wrought-iron in ladles of liquid cast-iron, previously referred to in this chapter, it should be stated, that, when borings or small nails are used, the latter, if rusty, should be brightened by means of "tumbling;" as immersing rusty scrap is not only dangerous to the eyes, but retards its melting. If, however, heavier scrap, as ¼″ round iron, is used, it can be melted by immersing the scrap twice in a ladle, the first ladle being simply used to heat the scrap as nearly to a fusing-point as possible, and the metal, having the scrap held back with a "skimmer," can, without great loss in temperature, be used to pour some moulds or fill up a larger ladle. The scrap remaining in the ladle is again filled at the cupola with fresh-tapped metal. This scrap twice immersed should, with good hot life-keeping metal, melt from 10 to 15 per cent of short, rustless ⅜″ round wrought rods. Heavier scrap could be melted by first heating it to nearly a fusing-point in forge or floor fires. In respect to which of the two — steel or wrought-iron — most toughens cast-iron, it may be said, that which contains the least carbon. As a general thing, wrought-iron, containing the least carbon, would be most effective in giving strength to cast-iron; and for castings requiring toughness, the more wrought-iron that can be mixed homogeneously with cast-iron, the stronger can some grades be made. Irons ranging from 1.00 to 3.00 in silicon, with sulphur under .05, can be strengthened as a rule.

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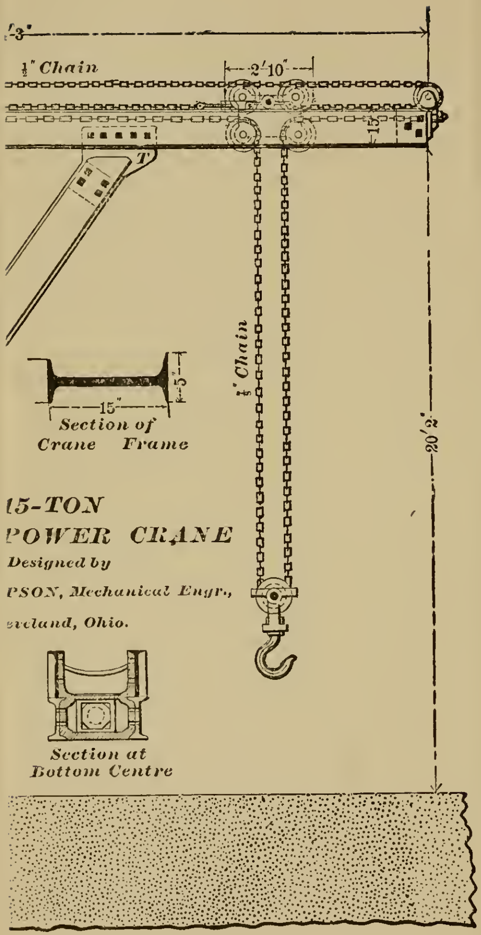
′3"
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Section of
Crane Frame

15-TON
POWER CRANE
Designed by
PSON, Mechanical Engr.,
eveland, Ohio.

Section at
Bottom Centre

FOUNDRY CRANES.

STEAM-POWER CRANES.

As an introduction to the following chapters upon cranes, the author wishes it understood that no patents cover any of the devices shown, and that any one is at liberty to use and profit by any of the ideas set forth. The author's mode of dealing with the construction of cranes is one which is not only original, but also one which he thinks all will agree is practical, and of real value to the mechanical engineer as well as to the foundryman.

There are two classes of cranes in general use in foundries, — the jib and traveller. The traveller is chiefly used for heavy work. The designs of cranes in use are somewhat like those of cupolas, very numerous. The designs of some cranes, so called, are wonderful to behold: all they lack is wings to complete their representation of the bird after which they are named. If some of them were to fly away, their loss would not cause much regret. There is probably no foundry tool formerly so illy constructed as the crane. Many were built by men who probably never had been inside of a foundry until they were called upon to erect a crane.

To build a good working crane requires not only some science, but also demands observation and experience in their use. The user of cranes should be one fitted to know their requirements. The class of crane which is now receiving much attention is the power crane. The hand crane is giving place to it, and it is only a question of time when the power crane will be as common as hand cranes now are. As there are many who have

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no idea of the principle of constructing power cranes, and as those who have like to learn of all the styles, I thought it best to begin the subject by the illustration of the power crane. In this I am greatly indebted to the courtesy of Messrs. Griffith and Wedge, the Niles Tool Works, and W. H. Thompson, M.E.

The advantages of power over hand cranes are readily seen where they are in nearly constant use. In this city we have a pipe-foundry using several steam cranes; under one of them, at present, there are being daily cast one hundred and ten 6″ pipes. In making one hundred and ten pipes, it is safe to say two thousand crane movements are required, hoisting and lowering, racking in and out, or swinging. The flasks in which these pipes are made, I should judge, are about thirteen feet long. The castings are made in a deep pit, which, of course, means the pipes are cast on end. To see how quickly the moulds are taken out of drying-pit, cored, cast, shaken out, and the flasks set, ready to be again rammed up, would make one think lightning was the motive power.

The cranes used in making these pipes were designed by the same person who designed the one shown in Fig. 138. The crane there shown is one adapted for machinery work, and is arranged so as to be sensitive in its operation. The pipe-shop cranes have four cylinders instead of two as here shown. The reason for having four cylinders is so as to make the racking and revolving independent of the hoisting gear, and also to save a complication of clutches, gears, etc. The crane here shown is not revolved by steam-power, the work not requiring it. The crane engineer stands upon the platform, which is about four feet above the floor, or clear of flasks, etc. A thirty-ton crane, which Mr. Thompson lately designed, has the cylinders and platform about six feet above the floor.

The steam crane here shown is operated, in hoisting or lowering, by the lever *A*, and in racking out or in by lever *K*. The

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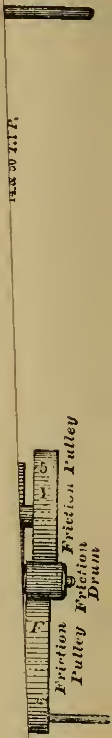
FIG 30 T.I.P.


Friction Pulley
Friction Drum
Friction Pulley

brake-lever is at *B*. The mitre wheels, seen at *E*, transmit power to the rack. The arrangement is such that the racking and hoisting or lowering can be done at the same time. In lowering heavy or light loads, steam is used; and then, by means of the brake *B*, any desired speed in fall can be obtained. The crane can hoist slow, and have no sudden jerking; thereby enabling us to use it in drawing patterns or setting cores, which is about the most sensitive work cranes can be subjected to. Should it be desirable to operate the crane by hand instead of by steam power, all that is required is to place a crank upon the shaft, as seen, and throw the hand-rack chain into the sheave grooves, and loosen the nut at *E*, seen in end elevation.

The cylinders are 7″ × 12″. Steam is carried through about one hundred and fifty feet of 2″ pipe, which is well covered so as to prevent condensation, as well as liability to freezing in winter season. With a pressure at boiler of from forty-five to fifty pounds, the crane will easily hoist fifteen tons. The weakest point of the crane is the hoisting-chain. As this is $\frac{7}{8}''$, and of best proof, twenty tons could be lifted. There is cylinder enough for thirty tons; in fact, the same pattern is to be used for a thirty-ton crane lately designed. For cranes under fifteen tons capacity, cylinders 5″ × 10″ are used.

There are steam cranes having only one cylinder. With such there is too much trouble caused by their getting on a "dead-centre." Having two cylinders, and cranks at right angles to each other, makes such a thing impossible.

The frame of this crane is all iron, a section of which is as shown in the enlarged scale. In the manufacture of these beams, what are called heavy and light beams are made. In the crane shown, the heavy beam is used for the jib, and the light one for the mast and brace.

In drawing the end elevation, I omitted showing a few parts which the close observer will miss. To make the crane clear,

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I thought it best only to show the more important points and to describe the rest.

The gear *R*, and all upon the same shaft, seen in side elevation, were they shown in place in end elevation, would muddle up the view; so, to save confusion, the shaft *N* is again shown at top of end elevation.

In operating the crane, the gear *R* has motion transmitted from the largest wheel, *W*, upon the crank-shaft. The gear *S* is fastened to the gear *R*; and both, like the friction-wheel gear *Y*, are loose upon the shaft. The clutch seen upon this shaft works either way by moving the lever *A*. As it slides upon a key, which is fitted in the shaft, sliding the clutch to either side of course gives motion to the shaft, by which hoisting or lowering can be done. The gears *H* and *F*, upon the racking-shaft, at *E*, are also loose upon the shaft; and it is not until the clutch is engaged with either of the wheels that any racking can be done. The wheel *S*, on shaft *N*, engages with *H* upon rack-shaft *E*, and *Y* engages with *F*. The small pinion *X*, seen on shaft with crank handle on, engages with *R*. The diameter of the drum is $18\frac{1}{2}''$. The pitch-line of all the gears is shown in side elevation; so that, with the above explanation, there should be no trouble in understanding the "motions." A plan of the shop in which the author daily used two of these cranes is described on p. 225. He can recommend power cranes for foundry use, as an appliance worthy of adoption, not only on account of their speed in handling work, but also because they are less fatiguing to employees, as well as because they enable the shops to handle heavy work with the same advantage and ease during dull times, when the shop has but few men, as when working with a full force.

Before closing this chapter, the author would specially call the attention of designers to the importance of constructing power cranes so that they can be advantageously worked by hand-power. Of course, for a line of castings, such as or similar to the requirements of pipe-making described above, hand-power would not be of much use. But for shops that make a line of machinery castings, the ability to operate by hand as well as power will often be found valuable; for then the crane can be operated, when, through accident to the boiler or pipes, or otherwise, steam could not be obtained or used.

FRICTION POWER CRANE.

The Griffith & Wedge (Zanesville, O.) power cranes shown opposite were used in foundry of the Niles Tool Works, Hamilton, O. Several cranes stood in a row, and were worked by one line of overhead shafting, to which power is transmitted by belt. The top gudgeon *A*, being hollow, admits of the shaft *B* passing through it; and being engaged by the mitre wheels at *S*, the shaft R revolves the driving friction pulley *Y*. To throw the crane into power-hoisting gear, the lever *D* is pulled, which presses the friction drum against the friction pulleys *F* and *Y*.

To throw the crane into hand-hoisting gear, the shaft *H* and gear *V* slide out, thereby engaging the clutches at *X*. The pinion *Z*, also gear *M*, is keyed to the sleeve: this sleeve, of course, revolves upon the shaft *H*. When driving the crane by power, the gear *V*, which is keyed to shaft *H*, being, as shown, engaged with gear *G*, drives the pinion *L*, which then transmits power to gear *M*, thereby revolving the sleeve and pinion *Z*. The gears *L* and *G*, being keyed to the brake-shaft, make the brake operative, whether the crane is worked by hand or by power.

These cranes have a platform at the rear, so the operator revolves with the crane. This also places him high enough to handily reach all the levers. The crane's frame is made of pine.

One special feature is that of the carriage. It is not only a handy carriage, but a short one. Many cranes lose nearly half of their working floor area through having a long carriage.

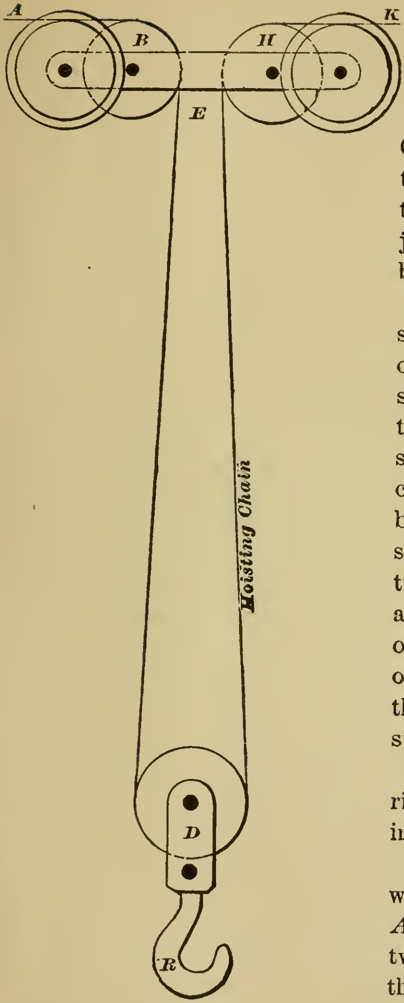

Fig. 140.

There is little sense in building a crane in which the length of jib cannot be more than half utilized. One should remember that the floor room located within the "sweep" of the crane jib should be such as could be used for crane work.

Some may think that the sheaves, shown in the plan of carriage, could be made smaller in diameter, and thereby allow of a still shorter carriage. This could of course, be done: but the 18″ sheaves, as shown, are advantageous in two respects, — first, they are easy upon chains; second, they prevent twisting of the chain when revolving the crane hook with a load suspended from it.

Many use a style of carriage similar to that shown in annexed cut, Fig. 140.

Here the sheaves, *B*, *H*, which the chain or rope, *A K*, passes over, are upon two axles. The carriage of the crane made by Messrs. Griffith & Wedge has sheaves (as shown in Fig. 139), which answer the same purpose as *B*, *H*, Fig. 140, upon one axle. With Fig. 140 style of carriage, one can often see the hoisting-chain hanging out of parallel, as shown. Bringing the chains close together, as at *E*, is often done in this style of carriage, for the purpose of making a short carriage. When the hoisting-chain in two parts, as here seen, is contracted out of parallel, as at *E*, there is more or less trouble caused when turning the hook *R*. I have often been obliged to lower down and take part of the weight off a crane before I could turn the hook without twisting the chains. Such bother as this is very annoying, besides causing loss of time. I think that it is evident that a shorter carriage can be practically worked, made after the style of the Griffith & Wedge carriage, than the one shown in Fig. 140.

Another point which would be well to notice is that of the moving or racking of the carriages. There are many devices for this purpose. With chains there is often much annoyance, caused through their stretching; and, again, the chain will be so situated as not to move the carriage steadily. I see by the Griffith & Wedge design, the carriage is made, as far as practicable, to overcome these evils. It is hardly to be believed that a chain will stretch as much as it does. I have often been obliged to cut out from one to two feet in rack-chains during the first week or so they were used. Many carriages are made with no provisions for taking up any slack. As will be seen at *W*, a simple arrangement for this purpose is provided. Having a slack rack-chain often causes much bother, and, where there is no provision for taking it up, it has to be often taken down and cut off, involving much labor.

As will be seen in the plan of carriage in Fig. 114, the two sheave wheels are carried to one side of the carriage, in order to allow the hooks, *W* and *C*, to which the rack-chain is hitched, to have a pull as near to the centre of the carriage as is practical. Many carriages are moved by a rack-chain upon each of their sides; again, others will have only one at the extreme outside or in the centre. The thing to be sought for, in moving a carriage, is *that it shall move along steadily, and have no more* *friction upon one side of jib than upon the other.* A good way to accomplish this is to pull with one chain as near the centre of carriage as possible. To pull with two chains would be better, were it possible to have them always pull even and alike. This, I think it is safe to say, is seldom done, even with the flat link chain which is the best to adopt for that purpose. Where there are two common link chains pulling a carriage, one will often see first one and then the other pulling, every change causing a jerk. Were the links of chains all of an *exact* length, and if they would not stretch, then with a true pitch-chain sheave they could be depended upon to pull alike.

The blocks of cranes often cause us moulders trouble. They are frequently made so light that it requires the hanging-on of weight to pull them down. Again, they will be made without any guard, as shown at *D*, Fig. 140, p. 443. With such blocks trouble is often caused by their getting out of the sheave grooves. As seen in the blocks of the Griffith & Wedge crane, there is not only a guard, but the blocks are heavy enough to pull the chain down. It is not necessary that a large sheave be used in order to make weight. Should a small sheave be used, the cheeks of the blocks could readily be made heavy enough to aid the weight of sheave in pulling down the chain.

There is not quite the objection to the chains hanging out of parallel, caused through small lower blocks, that is stated with reference to the chains narrowing up at the upper or carriage blocks shown on p. 443. However, when practicable, it looks and works better to have the lower sheaves large enough to cause the chains or ropes to hang parallel.

Driving-power for cranes is not limited to the two modes here shown: some use hydraulic power. The latest means is the employment of electricity and pneumatic power, both of which have proven of such advantage that it is now rare to find steam or hydraulic power being applied to foundry cranes.

HAND-POWER IRON CRANE.

Although power cranes have many advantages over hand cranes, the simple mechanism of the latter is alone a factor which will always command attention. The simplicity of hand cranes is such as to allow their being made by almost any firm, whereas the power crane will often require to be "built outside."

Before 1880 the frames of cranes were almost entirely made of wood; but at the present time most cranes are made of iron, the low price of iron making this construction nearly as cheap as when made of wood. Iron is really the proper material. Iron cranes not only look neat and light, but they are durable, and will keep their original shape. Wooden cranes, through unequal shrinkage, get more or less out of shape, thereby often causing trouble with carriages, gears, and chains.

The iron hand crane (Fig. 141) of Messrs. Webster, Camp, & Lane, Akron, O., which I am enabled to here show, is very simple in construction and readily worked. The end elevation shows the crane as one would see it if viewed from the front. The gears are shown engaged for "fast motion." To engage for "slow motion," the pinion *A* is pushed into contact with the gear *B*. The cranks, or handles, are removable, so that for either speed two handles may be used.

Some cranes are so arranged that the handles always remain upon the one shaft. In such cases they are generally secured by means of a nut or pin upon end of, or through, the shaft. Where handles are not thus secured, they should, as shown at *F*, have plenty of shaft length. In this, as well as other fea-

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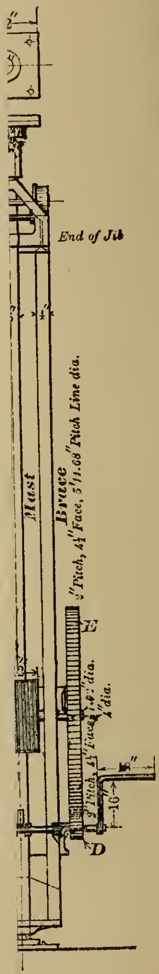
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tures of the crane, the experience of practical men is seen. Some may think this shaft question one of minor importance. I know it's a simple thing, and one to which, by many designers, no attention is paid. A handle that requires to be changed from one shaft to another necessarily requires a very easy fit. Where the square part of shaft is so short as with many cranes, the handles can readily work off without its being noticed. There are many besides the writer who could testify to this often having occurred, and to serious accidents caused thereby that would have been avoided had there been more length of handle shaft. The increased length not only gives a better chance to notice any working-off of handles, but also provides more room to guard against errors upon the part of thoughtless foundry helpers.

The principle involved in the plan of carriage here shown is one which the reader will remember is favorably commented upon, p. 442. A point which much simplifies the crane's frame construction is having but one girder for the mast. This is best seen in end elevation of the crane.

One of the most modern features of this crane is the use of wire rope for the sustaining cord. Wire rope would, no doubt, in years to come be the most popular sustaining cord used, were it not because its durability demands much larger drums and sheaves than chains.

John A. Roebling & Sons, Trenton, N.J., manufacturers of wire ropes, and who are taken as authority upon strength of wire ropes, in one of their tables, call for the drum and sheaves in crane shown in Fig. 116 for steel wire ropes to be over 3′ in diameter ; the drum in crane, as shown, being but 25″ diameter. The use of such large drums and sheaves as table calls for is not very practicable in foundry crane construction.

The Roebling table (p. 393) certainly gives sizes, which, if used, will increase the length of time a rope will last, compared with the use of smaller sizes. What many would, no doubt,

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like is a table that would tell them how small drums or sheaves could be used without serious injury. In our foundry we use a $\frac{1}{2}''$ iron wire rope (hemp centre), on the core-maker crane, the drum of which is $8\frac{1}{2}''$ diameter. Roebling's table calls for a drum for this sized rope to be 18″ diameter. The rope coils around the drum very readily; and, although in use six months, there is no apparent injury done to it yet. Before putting this rope upon the crane, it was passed over a charcoal fire, and heated about as hot as the hand could bear. While hot, it was soaked in a pan of oil; then, after being put up, the rope was kept well coated with a mixture of oil and black lead. Throughout our works, there are several wire-rope cranes; and all of the ropes are kept well coated with oil and lead. There is no question but that wire ropes are much benefited by being kept well lubricated, and that when so attended to small drums or sheaves may with much success be used.

For the area, there is nothing to equal the strength of a steel rope. In the case of the crane shown in Fig. 141, the rope, by Roebling's table, would only have a safe lifting capacity of about five tons. To break the rope, a load of about twenty tons would be required: therefore a load of twelve tons could be occasionally hoisted without breaking the rope.

In using wire ropes for foundry cranes, the lower blocks should be made heavy enough to hold the rope straight, and pull themselves down. This evil overcome, the wire rope makes an excellent sustaining cord, and has points which recommend its use instead of chains or hemp ropes. The use of chains often causes more or less jerking; and they are treacherous, as they break without giving any warning.

Hemp ropes are objectionable on account of their short life and their clumsiness. If daily used, they are not worth much at the end of a year. The heat and dampness of a foundry soon destroy them.

Wire ropes will hoist steadily, are neat and light, and will often give warning before they break. About the only objection to their use is their requiring such large drums and sheaves to insure their longevity. Nevertheless, there is one thing with cranes in their favor: that is the slow speed with which the rope is wound around sheaves and drums, thereby practically permitting the use of smaller sheaves and drums than where the ropes run with a velocity such as is obtained with ropes used for driving machinery, etc.

JOHN A. ROEBLING'S SONS CO.'S STANDARD HOISTING-ROPES, WITH NINETEEN WIRES TO THE STRAND.

Trade No.	Circumference in inches.		Diameter.		Breaking strain in tons of 2000 lbs.		Proper working load in tons of 2000 lbs.		Circumference of Hemp Rope of equal strength.		Minimum size of drum or sheave in feet.	
	Iron.	Cast Steel.	Iron.	Cast Steel.	Iron.	Cast Steel.	Iron.	Cast Steel.	Iron.	Cast Steel.	Iron.	Cast Steel.
1	6¾	6¾	2¼	2¼	74	130	15	26	15½	–	8	9
2	6	6	2	2	65	100	13	21	14½	–	7	8
3	5½	5½	1¾	1¾	54	78	11	17	13	15¾	6½	7½
4	5	5	1⅝	1⅝	44	64	9	13	12	14½	5	6
5	4¾	4¾	1½	1½	39	55	8	11	11½	13½	4¾	5½
5½	4⅜	–	1⅜	–	33	–	6½	–	10¼	–	4½	–
6	4	4	1¼	1¼	27	39	5½	8	9½	11½	4	5
7	3½	3½	1⅛	1⅛	20	30	4	6	8	10	3½	4½
8	3⅛	3⅛	1	1	16	24	3	5	7	9¼	3	4
9	2¾	2¾	⅞	⅞	11½	20	2½	4	6	8	2¾	3¾
10	2¼	2¼	¾	¾	8.64	13	1¾	3	5	6½	2½	3½
10¼	2	2	⅝	⅝	5.13	9	1¼	2	4½	5¼	2	3
10½	1⅝	1⅝	9/16	9/16	4.27	6½	¾	1½	4	4¾	1¾	2¾
10¾	1½	1½	½	½	3.48	5½	½	1	3½	4½	1½	2

ROEBLING S NOTES ON THE USES OF WIRE ROPE.

Two kinds of wire rope are manufactured. The most pliable variety contains nineteen wires in the strand, and is generally used for hoisting and running rope. The ropes with twelve wires, and seven wires in the strand, are stiffer, and are better adapted for standing-rope, guys, and rigging. Ropes are made up to 3″ in diameter, both of iron and steel, upon special application.

For safe working-load allow one-fifth to one-seventh of the ultimate strength, according to speed, so as to get good wear from the rope. When substituting wire rope for hemp rope, it is good economy to allow for the former the same weight per foot which experience has approved for the latter.

Wire rope is as pliable as new hemp rope of the same strength: the former will therefore run over the same sized sheaves and pulleys as the latter. But the greater the diameter of the sheaves, pulleys, or drums, the longer wire rope will last. In the construction of machinery for wire rope, it will be found good economy to make the drums and sheaves as large as possible. The minimum size of drum is given in a column in the table.

Experience has demonstrated that the wear increases with the speed. It is therefore better to increase the load than the speed.

Wire rope is manufactured either with a wire or a hemp centre. The latter is more pliable than the former, and will wear better where there is short bending.

Steel ropes are, to a certain extent, taking the place of iron ropes, where it is a special object to combine lightness with strength.

But in substituting a steel rope for an iron running rope, the object in view should be to gain an increased wear from the rope rather than to reduce the size.

Wire rope must not be coiled or uncoiled like hemp rope. All untwisting or kinking must be avoided.

To preserve wire rope, apply raw linseed oil with a piece of sheepskin, wool inside, or mix the oil with equal parts of Spanish-brown or lampblack.

HAND-POWER WOODEN CRANES.[1]

Although iron is the modern material for crane frames, wood will, no doubt, continue to be used some. The fact that timber is obtainable in almost any section, that it is cheap in first cost, and that local skill is easily available to design and frame it, are points which will command attention, and keep wood from falling into disuse. The timber chiefly used for cranes is pine, maple, and oak. There are probably more pine cranes than all the others combined. The species of pine generally used is the yellow or red pine. The red Canadian pine, found from the Pacific to Canada, is the yellow pine of Nova Scotia and Canada. The timber is much esteemed for its strength and durability, and is used greatly for ship-masts, etc. The pitch pine of Carolina and Georgia is noted for its strength and durability, in which qualities it surpasses others of its class. Maple is chiefly found in North America. For strength, it is superior to pine, and by some authors is placed ahead of oak. Maple being a sweet wood is apt to "doze;" but if in good shape when framed, and given a coat of paint, it will remain sound much longer than were it not thus treated. Oak, like pine and maple, has several species, and for its strength and durability is greatly prized. It is especially adapted for exposure to the weather in a damp climate. Its species are found in almost all parts of the country. Live oak is generally considered the best. It grows on the coasts of the Gulf of Mexico, and as far north as Virginia.

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[1] While from now (1901) on few wooden cranes may be built. the treatment accorded them will in many cases prove as valuable for iron construction as for wood.

The timber used for cranes is generally regulated more by what can be readily procured, and in the best shape, than from choice or preference of kinds. The following table, showing the transverse strength of woods, is deduced from United States Ordnance Department experiments, conducted by Hodgkinsons, Fairbairn, Kirkaldy, and Haswell; power reduced to uniform measure of one inch square, and one foot in length; weight suspended from one end as illustrated by Fig. 142.

	Breaking weight.
Ash	168 lbs.
" English	160 "
" Canada	120 "
Beech	130 "
" white	112 "
Birch	160 " 115 "
Cedar, white . . .	160 "
Elm	125 "
" Canada, red . .	170 "
Maple	202 "
Oak, white	150 lbs.
" live	160 "
" red, black . .	135 "
" African . . .	207 "
" English . . .	105 " 157 "
" Canada . . .	146 "
Pine, white	125 "
" pitch	137 "
" yellow	130 "
" Georgia . . .	200 "

In the construction of foundry cranes, the strains timber is subjected to are chiefly transverse strains. The transverse strength of a timber is that which it would stand were it laid horizontally, being supported at one or both ends, and loaded until it broke, as illustrated by Figs. 142 and 143.

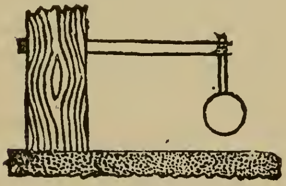
Fig. 142.

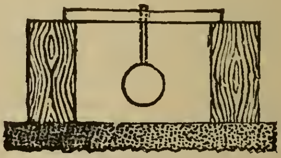
Fig. 143.

It is often remarkable how strength and lightness can be combined by the judicious use of material in the making of tools, whether cranes or any other kind of machinery.

The form given to timber, and the way it is framed, have much to do with its relative strength, as will be seen by the following example for Figs. 144 and 145. To ascertain the relative sectional strength of timber, *multiply the square of the depth by the thickness.*

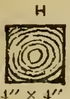

Fig. 144.

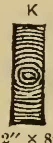

Fig. 145.

EXAMPLE.

Fig. 144.		Fig. 145.	
	4		8
	4		8
Square of depth	16	Square of depth	64
Thickness	4	Thickness	2
Relative strength	64	Relative strength	128

In the sections, Figs. 144 and 145, we have the same area, or number of square inches; but by having the area in the oblong or rectangular shape, as per Fig. 145, we have a timber that will stand double the load that such a one as Fig. 144 would, were both to have the load applied on their respective surfaces, *H* and *K*; the timbers to be either supported at one end, as per Fig. 142, or supported at both ends, as per Fig. 143, and same length between, or from their support. There are many cranes whose frames would have been much stronger had the above principles been more strictly adhered to in construction. The following gives the fundamental principles for finding the transverse strength of beams: —

“ *Transverse strength of a beam is inversely as its length, and directly as its breadth and square of its depth, and, if cylindrical, as the cube of its diameter.* That is, if a beam 6′ long, 2″ broad, and 4″ deep can carry 2,000 lbs., another beam of the same material, 12′ long, 2″ broad, and 4″ deep, will only carry 1,000 lbs., being inversely as its length. Again, if a beam 6′ long, 2″ broad, and 4″ deep can support a weight of 2,000 lbs., another beam of the same material 6′ long, 4″ broad, and 4″ deep will support double that weight, being directly as its breadth; but a beam of that material 6′ long, 2″ broad, and 8″ deep will sustain a weight of 8,000 lbs., being as the square of its depth." — TEMPLETON.

"*When one end is fixed and the other projecting*, strength is inversely as the distance of the weight from the section acted upon; and stress upon any section is directly as the distance of weight from that section.

"*When both ends are supported only*, the strength is four times greater for an equal length, when the weight is applied in middle between supports, then if one end only is fixed.

"*When both ends are fixed*, the strength is six times greater for an equal length, when the weight is applied in the middle, than if only one end is fixed.

"Beams of wood, when laid with their annular layers vertical, are stronger than when they are laid horizontally, in the proportion of eight to seven.

"The lower end of a tree will furnish the best timber." — HASWELL.

Accompanying this chapter, two wooden framed cranes are shown, which will not only give ideas in framing, but present valuable points in constructing jib-cranes for foundry use.

The twenty-five-ton crane (Fig. 146), shown on p. 455, is "triple-geared," *K* being the "first motion," *B* the second, and *P* the third. The shaft of pinion, *K*, is such as will slide out, thereby disengaging the first motion whenever it is desirable to operate the crane by its second or fastest motion. The "third motion" is not operated by crank. For some it might be well to say that the third motion is added for the purpose of increasing the power. Some may think it odd that the pitches were not more proportioned, the first and second motion wheels being both of same pitch. This was, no doubt, caused through the desire to make one pattern answer. One thing in its favor is, that the pitch is larger than the first motion actually requires. Were the first motion $1\frac{1}{4}''$ pitch, it would have been strong enough. When one comes to consider that the pattern

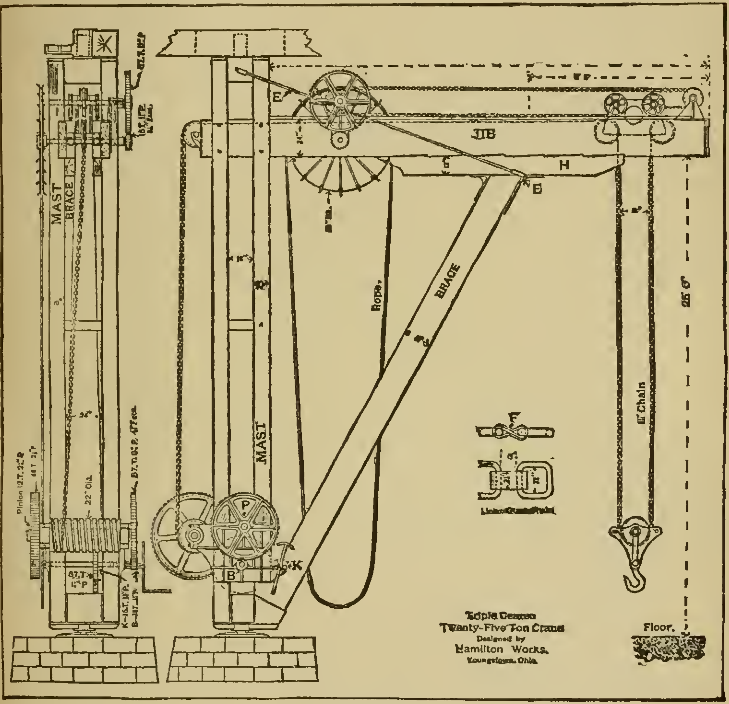
MAST
BRACE
E
JIB
H
E
Rope.
BRACE
25' 6"
Chain
MAST
P
B
K
F
Triple Geared
Twenty-Five Ton Crane
Designed by
Hamilton Works.
Youngstown, Ohio.
Floor.

Fig. 146.

was drawn $1\frac{1}{2}''$, so as to make the "second motion" gears $4\frac{1}{2}''$ face, whereas the first motion is $3''$ face, he will find that the proportion of the second motion is not far out of the way. Did one desire to substitute a $1\frac{3}{4}''$ pitch for the $1\frac{1}{2}''$ pitch, in "second motion," the number of gear teeth would be 74, while the pinion would require 13 teeth. The link of the rack-chain shown with this crane is made of wrought-iron. At *F* is a $\frac{1}{4}''$ flat iron bent around solid links $\frac{5}{8}''$ in diameter; the flat link being held by a rivet through its centre.

One of the valuable and striking features of this crane is the manner in which the jib is braced. It is a good plan, and one worthy of notice. The under piece, *H*, greatly strengthens the jib; and by its use and the tie rods *E E*, one of which is upon each side of the crane, the necessity of braces *D* and *R*, as shown in the ten-ton crane (shown on p. 457), is obviated.

The question of bracing up the jib of a crane is an important one, not merely on account of giving the jib proper support, but to make the height of hoist capable of being operated as far as possible. Crane carriages and braces are two things that are often so blunderingly designed as to shut off much of what should be the crane's working floor area.

The idea that should be prevalent in bracing jibs of cranes is to have, as far as possible, all the area for height of hoist one can. Some cranes are braced in such a way that they destroy fully one-third of what should be good moulding-floor area. simply on account of the braces allowing so little room for height of hoist in towards the crane's centre.

In the ten-ton crane shown on p. 455, the main brace *Y*, where it connects with the jib, is, as seen, $9' \, 4''$ back from the jib's end. The brace *R* coming acutely to it, as shown, allows of the crane's hoisting near the full height up to the jib for fully one-half the jib's length. This crane is one used in the old part of our foundry. As this portion is not very high, we are allowed but about $16'$ from the floor level up to the

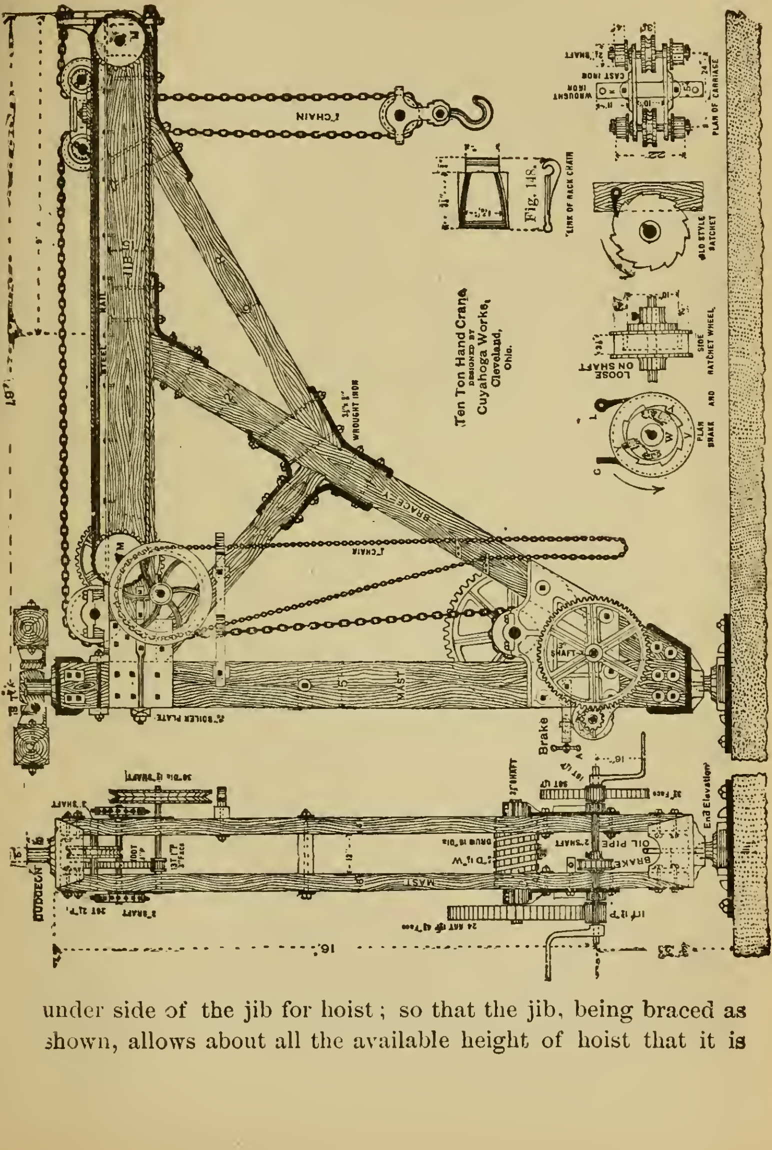
Ten Ton Hand Crane
DESIGNED BY
Cuyahoga Works,
Cleveland,
Ohio.
CHAIN
JIB
STEEL RAIL
BRACE
WROUGHT IRON
MAST
BOILER PLATE
SHAFT
Brake
LINK OF RACK CHAIN
OLD STYLE RATCHET
PLAN OF CARRIAGE
CAST IRON
WROUGHT IRON
LOOSE ON SHAFT
SIDE RATCHET WHEEL
PLAN BRAKE AND
End Elevation
OIL PIPE
BRAKE
DRUM
MAST
GUDGEON
16'

Fig. 147.

Fig. 148.

under side of the jib for hoist; so that the jib, being braced as shown, allows about all the available height of hoist that it is consistent to expect in what is termed a "low crane." Were the crane as high as the twenty-five-ton crane shown on p 455, we would of course, by the style of bracing shown on p. 457, increase the jib's length for height in hoisting.

Another feature of the bracing in the ten-ton crane worthy of notice is the mode by which the joints of the braces are ironed. As a general thing, braces are held in place by means of cast-iron "cheek-pieces," which are not only cumbersome and clumsy-looking, but much more costly to produce than the wrought-iron brackets here used. As regards the durability of this style of fastenings, it can be said that they have stood the lifting of heavy loads over ten years, and at this writing the joints appear as firm as the day they were put together.

During my life's experience with using cranes, I have yet to see the crane that can always be revolved with the same ease in all directions. The powerful leverage effect which weights hung from jibs have upon buildings, more or less causes the masts of cranes to be out of plumb, and is often such as to cause fears of the building's being pulled over. I have worked in shops where it was often a necessity to hold the crane from swinging by means of ropes; and also have worked in shops where almost every move of the crane would cause some of its bricks to fall down. Of course such operations only show that the shop was not strong enough for the leverage of the crane. This is a point too often neglected or not provided for in building foundries intended for crane or heavy work. Such shops cannot be built too strong. I doubt if there is a shop in the country but moves more or less every time a jib crane is rotated. Often by the moving of an unusually heavy weight a shop will be strained so as to receive a "permanent set," and thus cause the crane to be badly out of plumb. One great trouble with almost all cranes is the lack of some arrangement whereby cranes, when they receive an out-of-plumb "permanent set," could be expeditiously adjusted. In some shops they adjust by hanging weights from the crane's jib. This, put into rule form, would read: "To adjust a crane, *move the building.*" A thing all right enough, provided the building can be given a "permanent set" to stay in about the same position.

The manner in which top gudgeons are generally incased in cranes causes them to become more or less bound when cranes get out of plumb. To overcome the evils arising from such effects, we use, as seen at *T*, a round cap which the gudgeon can readily accommodate to any incline to which the out-of plumb crane may oscillate it. The cap *T*, as seen, covers the gudgeon so as to keep it free of the dust which collects upon beam, etc. In this cap are two small oil-holes for the purpose of keeping the gudgeon well lubricated, a thing which must be attended to before one need expect to have a crane revolve easily.

On p. 448 the question of cranes, when loaded, getting the control of the operators, was touched upon. That such things have often happened, most users of cranes can testify. In some cranes a ratchet (shown, old style, p. 457) is used. This is only of service while the hoisting is being done. Should the crane through any cause "get away," it cannot be stopped until all the "mischief is done."

Shown by plan and side views is the sketch of a brake and ratchet wheel which are attached to the crane as shown. This brake is formed of two parts, best seen in plan view. The outer part *V*, which contains the internal ratchet, is loose upon the shaft. The inner part, which contains the springs and the ratchet pawls seen at *YY*, is fastened by set screws or keyed to the shaft. Supposing the crane to be hoisting, the direction *W* would take would be that shown by the arrow. The pawls *YY* turning the reverse way of the ratchet notches are sprung out by the springs in *W*, as they pass them by. Now, should the crane through any cause attempt to "get away," *W* would then, of course, turn the opposite way to the arrow directions, and in doing so the pawls would catch the notches; and as the ratchet part *V* is held by the brake straps *G* and *L*, the crane cannot, of course, run down. Should it be desirous to lower by means of the brake, all that is required is to operate the brake wheel *A*, seen in side elevation of the crane. The mechanism of this little machine rightly entitles it to the designation of a safety ratchet-brake.

The racking device of this crane is one worthy of notice, as it is no doubt the best that could be adopted for carriages that are pulled by two chains. The trouble that pulling carriages with two chains generally causes having on p. 445 been commented upon, the subject will not be here discussed. This carriage is pulled by having a chain composed of malleable-iron links (one of which is seen at Fig. 148) passed over the sheaves *MM*, and bolted to the wrought-iron bar *K*, seen in the plan of carriage. These links being all of the same pitch, and the sheaves *MM*, over which the chain works, being very accurate in pitch also, the carriage must necessarily pull very square, and without causing much friction upon the sides of the track. The track, as will be seen, is formed by railroad-rails. The way tracks are generally made is by simply using flat bars. The using of the rails shown not only makes a rigid track, but also helps to strengthen the jib, and presents very little friction surface for the carriage-wheel rims to work upon. Altogether this original idea is one that works well and is worth noticing.

Shown by the ten-ton crane, the distance of the shaft upon which the crane handles are seen is 3′ above the floor-level; this is about the right height to place shafts for convenient working, or operating of the crane's handles. While the above is the most convenient height for shafts, they can be worked higher or lower; the limit to their convergency from the above height should not exceed 8″ below or above the 3′.

The gears in all of these cranes show the arms and rims strongly constructed. This is something too often neglected. I have yet to see any gear's teeth fractured from "*pure* strains," but many arms and rims have I seen break from the same. Many arms and rims have been known to break in wheels that had their teeth worn half away. A thing that should be kept in mind is, that all wheels have more or less strains that will exist in their rims and arms as long as the wheel remains whole. It is practically impossible to cast wheels that will be entirely free of strains. Wheels may run for years and all at once break under comparatively a light load. Could the shrinkage (or, properly, contraction[1]) strains be annulled in castings, they would then often bear double the working-load. The teeth of a wheel are more free from contraction strains than any other portion of a wheel that can be mentioned. Did the strains exist in the teeth, that is, in the arms and rims of the wheels, it is safe to say the teeth would not stand to be worked down to as thin a body as many can be found so worn.

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[1] The two terms "shrinkage" and "contraction," properly defined for foundry practice, should apply "shrinkage" to action of metal when in a liquid state; "contraction," to the action of metal after becoming solidified.

POST-CRANES.

Posts in a moulding-room will by almost all moulders be conceded as being more or less of a nuisance. If it were only the floor area which posts occupy that was hampered or lost, posts would not be so objectionable. To describe why posts are so undesirable, is not the purpose of this article. As posts are often a necessity, the desire is simply to set forth ideas showing how posts may, in some cases, be utilized for crane purposes, and much moulding-floor area thereby saved.

If it is necessary for a post to be "stuck up" in a moulding-room, and in its locality a crane is desired, there is decidedly a great gain if the post can be made to answer both purposes. There are many places where a crane is erected in close proximity to a post which could as well as not have been arranged so as to answer the purpose of the crane's mast, and thereby have given a "clear swinging crane," and an unbroken radius of moulding-room area. The non-utilizing of posts is something that would not have often occurred, were the designers informed as to ideas such as this article is intended to illustrate and set forth.

About all the difference there need be in construction between post and pivot cranes is the matter of revolving. For cranes under ten tons' capacity, the writer sees no reason why they could not be constructed so as to revolve as easily as pivot-swung cranes. For the construction of post-cranes up to three tons' capacity, there is probably nothing used that presents a more simple and better working design than that illustrated on the revolving principle set forth in the post-crane shown. (The word "capacity," wherever used with reference to cranes, means the amount of weight a crane can safely carry, and not, as many moulders think, that which is about sufficient to break the crane down.)

At first glance, one sees hardly any thing to distinguish the crane from an ordinary jib-crane, the principle of hoisting and racking being practically the same. The difference is mainly confined to the jaws *F* and *B*, they being constructed so as to allow the crane to revolve around a stationary column or post. A plan for top jaws is shown by Figs. 150 and 154. These are made so that most of the crane's weight comes upon anti-friction rollers held by them. As shown at *X* and above *F*, these points being where the greatest friction is generated, the rollers, of course, greatly prevent its being created. In fact, if the rollers are projected sufficiently to have the crane's weight come upon them, the amount of friction there generated would be hardly worth taking notice of. The greatest point of friction in this crane is upon the collar *A*. Some might think the dead surfaces there in contact would be sufficient to require a dozen men to revolve the crane when heavily loaded. As this crane was one designed by the "Cuyahoga Works," and daily seen used by the author in this foundry, he can say that if the collar *A* is kept well lubricated, the crane will swing around about as easily as a pivòt-crane of like capacity. Should one wish to prevent all the friction possible, he could be much aided by making the supporting collar *A* upon the principle set forth in Figs. 152 and 153. The round balls or conical rollers shown are by no means any thing original: they have in other things for years back been used as friction preventives, and there is no reason why the principle cannot be turned to a good account in constructing post-cranes. In fact, for instance in the post-crane shown, were these balls or conical rollers used at the flange *A* in concert with the rollers *X* and *F*, the crane would no doubt far surpass pivot-cranes as far as easy swinging is concerned.

The braces and jib of the crane as shown are constructed of wrought-iron bars, $1\frac{1}{4}'' \times 6''$. If it were desired to construct them of wood, for a crane of about like capacity, it could be

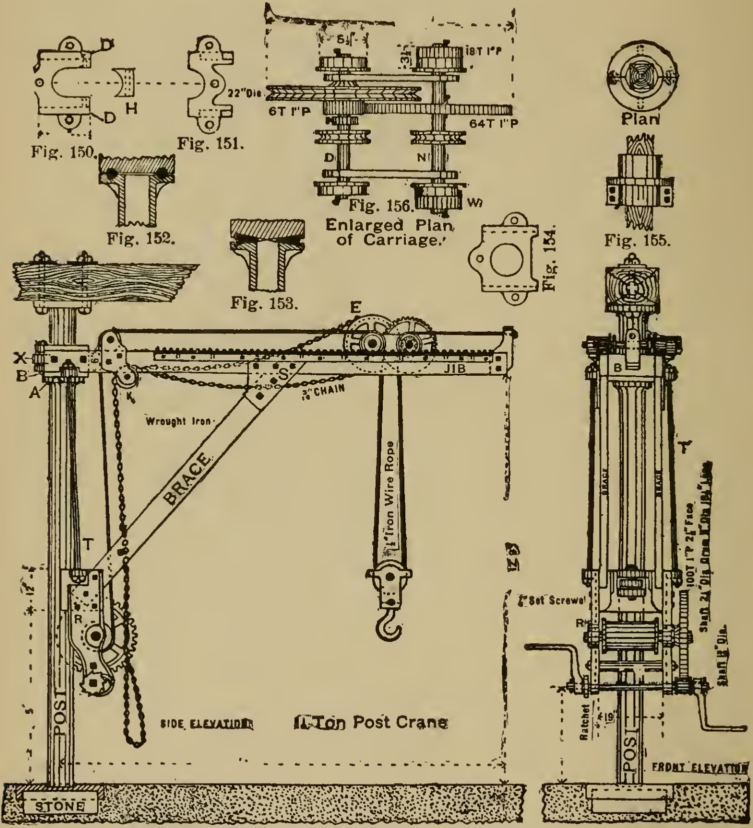
Fig. 150.

Fig. 151.

Fig. 152.

Fig. 153.

Fig. 156. Enlarged Plan of Carriage.

Fig. 154.

Fig. 155.

D
D
H
22" Dia.
5½
3½
18T 1"P
6T 1"P
64T 1"P
D
N
W
Plan
E
X
B
A
K
S
JIB
¾" CHAIN
Wrought Iron
BRACE
¾" Iron Wire Rope
T
R
12"
5'
POST
SIDE ELEVATION
1½-Ton Post Crane
STONE
B
T
BRACE
BRACE
100T 1"P 2½" Face
Shaft 2½" Dia. Drum 1' Dia. 18½" Long
Shaft 1½" Dia.
¾" Set Screws
R
Ratchet
19"
POST
FRONT ELEVATION

Fig. 149.

done by constructing the jaws *B* and *F* wide enough to take a jib $3'' \times 10''$, and braces $3'' \times 8''$, and having the sides of the top jaw *DD* made from 6″ to 8″ longer, so as to give more support to the jib.

It will be noticed that the top jaw (Fig. 150) is made so that it can be placed after a post has been set up. After the jaw is set upon the collar *A*, the piece *H* is placed in, and a bolt put through the two. The jaw then answers the same purpose as if it were one solid casting, as per plan seen in Fig. 154. The plan Fig. 154 is, of course the strongest, and often the best to adopt where circumstances will permit.

The constructing of a post-crane does not always necessitate the erecting of a post especially for that purpose. It may be that one would like to use some post that is standing. With a jaw, as per Fig. 150, it can be utilized without the post being taken down. Should the post require to have a collar to support the top jaw, ideas are illustrated in Fig. 155, showing how a casting made in halves could be bolted on to a square or round wooden or iron column.

The diameter or square of a post or column may not be entirely regulated by the capacity of crane desired. The weight a post will have to support may often call for a much stronger one than the capacity of the crane would require. When posts are erected for crane purposes, it is a good plan to raise the beams by means of jack-screws and timbers; so that when the post is set up the building's load may be let down so as to rest solidly upon it. This not only insures the post supporting its intended load, but it causes the top of the post to be more firmly held when the crane is loaded.

It is, of course, understood that the above does not mean that posts are to be erected for the special purpose of making a crane: it is only where a post is required to support a building, and in the same locality a crane is desired, are they advocated. The building of post-cranes is not advised except under circumstances which will not permit the use of a clear-swinging pivot-crane.

A peculiar feature of this crane, which will no doubt attract the eye of many, is that of the racking arrangement. The movement of the carriage is done by means of an endless "racking-chain" passing over two 6″ loose sheaves at *K*; from thence over the sheave *E*. This sheave, as shown in Fig. 156, is chucked into the pinion *H*, and both the pinion and sheave are loose upon the shaft *D*. As this sheave and pinion is made to revolve by means of the racking-chain, the spur-wheel *S* which is keyed on to the shaft *N* revolves the truck-wheels *W W*, thereby moving the carriage. Cast on to the wheels *W W* are pinions which mash into the rack seen upon the side elevation of the crane. This rack is used for the purpose of insuring the carriage travelling square when heavily loaded. While this form of a racking device is quite a novelty and a success, as far as working is concerned, in point of cheapness it cannot be said to have much advantage over the style used in the twenty-five-ton jib or travelling crane shown (pp. 455, 469). From this it must not be inferred that the style shown in post-crane would work well upon the ten or twenty-five ton cranes shown. For loads over three tons, such a style of carriage should give place to those shown with the heavier cranes.

For holding up the lower jaw *F*, bolts *T T*, as shown, are used. The construction of this lower jaw is simplified by making the cheek-pieces *R* so as to be secured to *F* by means of set screws. A plan view of the lower jaw *F* is seen in Fig. 151. The width between the cheek-pieces *R* in constructing a crane will be regulated by the length of drum required. For the same number of feet in height of hoist, the length of a drum can be much less where wire ropes are used instead of a chain for the sustaining cord. This, of course, means that in both cases the same diameter of barrel is used. For wire rope it is best to use the barrels as large as practicable, and they should be larger in diameter for wire than chain sustaining-cords. As this crane is only intended for loads up to one and a half tons, it is but single-geared. To construct one for loads ranging from two to five tons or upwards, it would require that the crane be double-geared, a thing which can be applied to post-cranes as well as pivot swinging-cranes.

The construction of the lower jaw in the crane shown is such as to bring the lower end of the braces up fully five feet clear of the floor. This will allow one's moulding up within about two feet of the crane's post; and also give good height in hoist when working under the braces. The frame-work of the crane shown is strong enough to carry a load of three tons, and is, as all frames of cranes should be, stronger than the sustaining-cord.

TRAVELLING-CRANES.

The hand travelling-crane shown on p. **469** is one which the author has designed to illustrate principles and ideas which he thinks would work well in hand-travellers for foundry use.[1]

The capacity of the crane is intended to be ten tons. The arrangement of the hoisting and racking of the crane is in principle similar to those used in jib-cranes.

For moving the traveller upon its longitudinal track, a shaft connected to the two wheels *S S* is operated by the bevel-wheel X and the pinion *F*, as shown.

Moving "hand-travellers" lengthwise in a shop, is usually a troublesome performance to arrange; so much so that I doubt if in this particular point a ten-ton "hand-traveller" can be made a success. I do not call a traveller a success that requires an army of men to move it when heavily loaded, nor are they a success when they cannot be made to travel much faster than a snail.

While this crane is presented for ten tons capacity, it should be understood that such loads should be handled only occasionally. If it is desired to handle daily from six to ten tons, I would advise the traveller be operated by other than hand-power. In reality I do not believe "hand-travellers" can be made to move properly for foundry use with much more than five-ton loads.

In designing the gearing for this crane, I thought it best to make it "triple-motioned," in order to save the necessity of employing six or seven men to climb up into the pendant to do the hoisting for heavy loads, which would be the case if the gearing were only "double-motioned." With the gearing as shown, two men should "manage the crane." For heavy loads they would use the tripled or slowest speed shaft *R*. For

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[1] Ideas presented here for hand cranes are also applicable in many cases to power travelling-cranes.

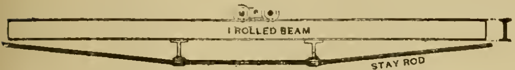

I ROLLED BEAM
I
STAY ROD

Fig. 159.

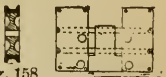
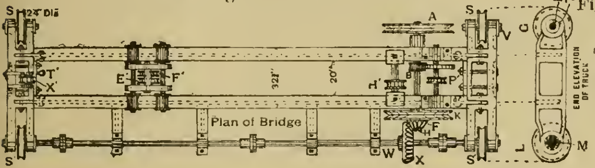

PLAN OF PENDENT PLATFORM

Fig. 158.


S
12" DIA
A
S
T'
X'
E'
F'
32"
20"
H'
B
P'
K
F
H
W
X
S
S
Plan of Bridge
P
T
G
END ELEVATION OF TRUCK
L
M

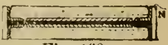


Fig. 160.
Enlarged Section of Built up Bridge through Section A. B.

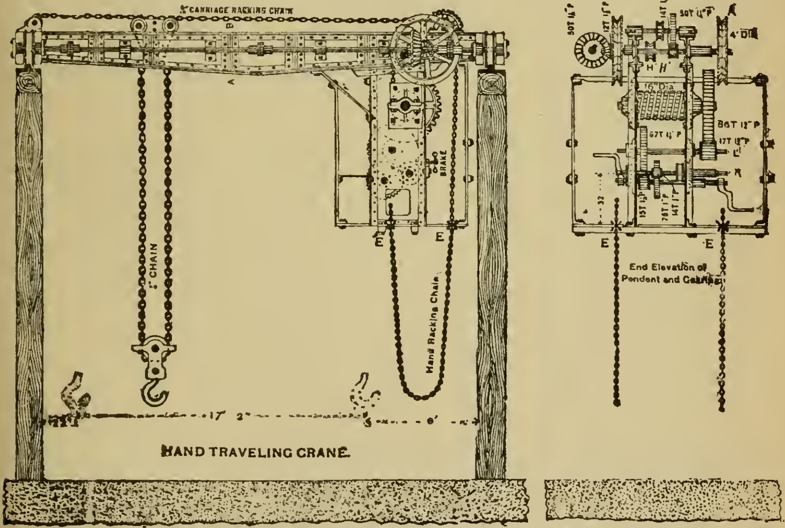

¾" CARRIAGE RACKING CHAIN
D
A
BRAKE
½" CHAIN
E
E
Hand Racking Chain
17' 2"
6'
HAND TRAVELING CRANE.
50T 1¼" P
12T 1¼" P
14T 1¼" P
50T 1¼" P
A
4' DIA
H H'
16" Dia
86T 1¼" P
67T 1¼" P
17T 1¼" P
L'
R
32
15T 1¼" P
76T 1" P
14T 1" P
E
E
End Elevation of Pendent and Gearing

Fig. 157.

lighter loads the handles can be used upon either of the other two shafts shown; and thus they can hoist with increased speed. In lowering loads the crane can be manipulated by the brake shown, if desired. The brake intended for use is that described as a "safety brake," and is shown on p. 457.

The racking of the carriage, and moving of the traveller lengthwise upon its longitudinal track, are so arranged that one shaft *B* answers for both purposes. This is best seen in the "plan of bridge:" the sheave *A* there seen is keyed on the shaft *B*, while the sheave *K* is loose. Into the end of the shaft at *H*, there is screwed a set-screw for the purpose of keeping the sheave *K* in its proper place. Instead of the set-screw, there could be a collar used by having the shaft a little longer. The pinion *F* is a part of the sheave *K*, and thus will revolve whenever the sheave *K* is rotated.

The arrangement of the sheaves *A* and *K* is such that the hand racking-chain passes down each side of the pendant so as to be out of the way of the handles. The chains may be run through the platform to within a few feet of the floor, as seen at *EE* in the end view. The advantage of this will be that the sheaves *A* and *K* can be worked by help below as well as above. The sheave *K*, being the one that operates the moving of the traveller, should be a regular chain-sheave in order to give the chain as good a purchase as possible. Of course there would be no objection to sheave *A*, which operates the carriage, being also a chain-sheave.

For assistance in climbing into the pendant, there could be a ladder arranged so as to slide up and down one side of the pendant, and a counter-balance weight used for holding it up in concert with a rope for pulling it down. Some use a rope-ladder; which will, after the men have climbed up into the pendant, be pulled out of the way. Where a traveller is kept in almost constant use, a poorer arrangement for getting up into the pendant can be more practically used, than where the crane would be but occasionally used; for in the former case the men would only require to climb up three or four times during the day, whereas in the latter case they might have to climb very often.

The wheels of the traveller $S'S'$, SS, have their axles run in anti-friction rollers, as seen at M, in the "end view of the bridge-trucks."

The shaft W, to which the bevel-gear X is keyed, rotates the two wheels $S'S'$. The shaft being coupled, as seen, allows of its being easily attached to the axles of the wheels. Coupling the wheels to one shaft makes their revolutions positively alike, and thereby aids the crane to travel squarely upon its longitudinal track; a very essential element in making a traveller a success.

The wheels $S'S'$, SS, are grooved cast-iron ones. Some in constructing wheels for use in very heavy travelling-cranes shrink on a steel or wrought-iron band for forming the groove part of the wheel, similar to that shown in Fig. 158. The reason for doing this is so as to make the feather or rim of the groove strong enough to resist any side-pressure that may be brought to bear upon the groove's rim through any uneven travelling of the crane. In regard to the expansion and contraction of a traveller, it might be thought it would be too great to permit the use of groove-wheels. It is found, however, that in out-of-door structures such as bridges, etc., the greatest difference winter and summer, the two extremes in the temperature, can cause in the length of one hundred feet, is less than $\frac{3}{4}''$. As fifty feet is near the greatest span yet given "travelling-cranes," we see then from the above that $\frac{3}{8}''$ upon each side is the most we would have to allow for. Now, this is hardly worth noticing, when we consider that grooved wheels are not required to be the exact size of the rails upon which they travel. Single flanged wheels, similar to car-wheels, are seldom used for "travelling-cranes," as they are not so good as grooved wheels for aiding the crane to travel squarely.

As the hoisting-chain, where it is attached to the drum and passes over the sheaves, is not shown, it might be well to state that the chain in leaving the drum passes up over the sheave H, from thence to the sheave F', then down and up through the lower blocks as shown to the sheave E', and from thence to the eye-bolt T, where the chain is held.

The sheaves P' and X' shown are those over which the carriage racking-chains work.

The crank-handles seen in the end elevation of pendant are upon the "second motion" shaft; R being the "first motion," and L' the "third motion."

A question often asked is: Which is the best for foundry use, a "travelling" or "jib" crane? Some think that travelling-cranes are all perfection, and in some cases they may be: but, like most machines, they have their objectionable as well as their commendable points.

The element most commendable in travellers is their leaving the moulding-floor of a shop clear from central-post obstructions; but whether a "traveller" or a "jib" crane is the most expedient to adopt with reference to speed in turning out work, will depend upon the class of work to be done, and the form of a shop. Take a shop, for instance, that is long, and where it is necessary that oven-work metal or castings should be conveyed a distance farther than one jib-crane could reach: the traveller then is decidedly the more advantageous; that is, if it moves with desirable speed. Changing from one jib-crane to another in moving loads lengthwise of a long shop is very slow work. But where work is of such a nature that it may be completed upon the area encircled by jib-cranes, then the jib-crane has the advantage. It does not follow, that because a shop is long, its crane-work can be most expeditiously done with travelling-cranes. A traveller might often be convenient for delivering the metal and castings; but the loss of time that shops experience where the men often require the use of a crane during moulding-hours, caused by having to wait for it to be brought from some other portion of the shop, might often be so serious as to make the little advantage gained by the delivery of the metal or castings to be far from making the traveller a profitable tool in the end.

Many think that because a travelling-crane can go from one end to the other of a shop, it can do all the crane-work capable of being moulded upon the area over which it travels. This is seldom practicable. If a shop is of any size, and has an ordinary number of moulders working upon moulds often requiring the use of a crane, there should be two travelling-cranes: though the work may often be done with one traveller, yet the disadvantage and loss to the firm from the necessity of "waiting for the crane" may often in the end be much more than the saving in expense by purchasing but one; and not only are two travellers necessary to prevent waiting, but are often essential in assisting the handling of moulds that require two crane-ladles to pour them, etc. *

Another false idea many have concerning travelling-cranes is, that they leave the total area of a shop-floor available for crane-work. With many travellers, if the area that is lost on account of the bridge's trucks, as at *L* or *G*, preventing the crane's hook from coming up to the shop's end, were taken into consideration, and also the area lost along the side of the shop through the operations of the pendant, it would be found that not much more of the area could be utilized than if the shop was filled with jib-cranes sufficient to utilize its floor-area; but that portion of the shop's area lost through travellers as above described, is far from being as valuable as that lost through jib-cranes. Having the central portion of the area of a shop all free, is generally of more value than where the sides and ends are free, and the central portion "cut up" with the masts of jib-cranes.

Some travelling-cranes are so constructed that the hoisting and racking gearing are placed so that the operators stand upon

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[1] In many cases "jib-cranes" placed at sides, corners, or end of a shop will make the use of one "traveller" work to excellent advantage, and all sufficient.

the top of the traveller; this is very objectionable for foundry use, one reason being they place the operators out of sight and proper hearing. A traveller for foundry use should have its gearing so as to be manipulated below the crane-bridge; for then the operators are given every chance both to see and to hear, as in the crane here shown.

The bridge of the traveller here shown is a "built-up" one. In order to save that labor in the building of medium travellers, some use I-beams braced with stay-rods, as seen in Fig. 159. Where the span is not too great, and the intended loads are below eight tons, the I-beams may often be used without the bracing shown in Fig. 159.

Travelling-cranes should be braced sideways, as well as in other directions, on account of the tendency of the bridge to spread apart when the crane is moving heavy loads. In bracing sideways, some persons adopt a system of stay-rods similar to that shown for under-bracing in Fig. 159, but others brace by means of wide flanges, etc. For making the crane shown, stiff sideways, the plates *NN*, Fig. 160, are used. If the "span" of crane shown should exceed the length given, then a stronger system of bracing would be necessary: this would consist in using wider flanges than at *NN*, Fig. 160, or else bracing with stay-rods, etc.

The "span" of the travelling-crane, as shown, is about twenty-five feet. So far as the principle of its working is concerned, there is nothing to prevent the span being made any length desired; but the longer the "span," the deeper and stronger in proportion must the bridge be made.

In any length of span, the distance 22″ and 6′, shown between the dotted hooks and the wall of the shop, would remain the same: only the distance between the dotted hooks shown is that which would be changed by any alteration in the length of the span as here shown.

GEARING UP CRANES.

WHILE in the modern designs of cranes shown in this work, plans of gearing are well illustrated, a brief explanation of principles involved will for many be found interesting and useful.

The principle involved in gearing is the same as that found in the lever. *The ratio which the orbit that the crank-handle travels bears to the space through which the block moves in the same time*, is the same relation as that which the two ends of a common lever bear to each other. The following serves to illustrate this: A crank-handle having a radius of 16″, in making one revolution, would travel through a circumference of about 100″. If, in turning this handle one revolution, a crane's block would move through a space of 1″, the leverage of the crane would be about 1 to 100.

The crank-handle is but the long arm of a lever. Its length, and the motive force applied to it, determine its power. In a crane, for instance, having a leverage of 1 to 100, every pound exerted upon the crank will correspondingly increase the number of hundred pounds which can be hoisted.

The power an ordinary man exerts upon a crank, when hoisting a crane, ranges from fifteen to fifty pounds. For a short time he could exceed the fifty pounds; but for general practical use he should not be expected to exert more than twenty pounds, the crank travelling with a velocity of 220′ per minute, which in a crank of 16″ radius is nearly equal to 26½ revolutions per minute.

In designing the gearing for a crane, it must be remembered that *to gain power without a sacrifice in speed* can only be done by increasing the motive power by which the crane is operated.

The "power of a crane" is but the product of *force*, *leverage*, and *time*.

The heavier the weight to be hoisted, the longer time will be necessary in proportion when the same motive force is used. A crane which would require twenty revolutions of its crank to hoist the block one foot high has but half the power of a crane where forty revolutions of a crank are necessary to hoist the block the same height; this of course means where both cranes have the same amount of friction. The loss of power in cranes through friction ranges from twenty to fifty per cent. A crane may be so badly constructed that where a hundred pounds of force are exerted upon its cranks, only fifty pounds are effective in hoisting the load, the balance being used in overcoming friction. To construct a good working crane, much judgment and care should be exercised in the construction of its gearing and shaft-bearings, and when used they should be kept well lubricated.

To increase the power or pull of a crane without increasing its motive force, can be accomplished by any means which will *decrease speed in hoisting*. Plans which are generally adopted to accomplish this end are, first, by means affecting the "gearing-up" of a crane; second, by means of multiplying parts in the sustaining cord, as set forth in chapter on page 481.

Obtaining power or leverage in the crane by gearing is not, as some suppose, confined to the multiplication of "motions." The different number of motions given to cranes are simply for the purpose of increasing or diminishing its speed, and for convenience in procuring power by the use of the limited space allowable in the construction of cranes. A crane, if it were practical to use enough space, could be made as powerful with one motion as if it had two or three motions. To illustrate this idea, we will suppose the ten-ton crane seen upon p. 457 constructed so as to have the same power or leverage with "one motion" as it now has with its "two motions." As the crane is now geared, the crank when upon its first motion travels about 185″ for every 1″ it raises the blocks. To have this same leverage or power of 1 to 185 in the above crane with a single motion or speed, the wheel upon the drum's shaft would require to be made with the $1\frac{3}{4}$″ pitch, having 528 teeth; and the pinion, having eleven teeth, as there shown, would then require the crank to turn the same number of revolutions it now does in raising the blocks one foot high. Now, to show the impracticability of using a wheel having 528 teeth (leaving out the question of utility in having different speeds), it is only necessary to state that a wheel $1\frac{3}{4}$″ pitch, having 528 teeth, would be about 24′ 6″ diameter.

In gearing a crane, the pitch generally used ranges from 1″ to $1\frac{3}{4}$″. The pitch of a gear is the distance from centre to centre of two adjacent teeth measured upon their pitch-line.

The pitch-line of a wheel is the line tangent to the circumference of a circle passing through the point of contact of the teeth of two wheels when engaged, and is about midway between the extremity and root of a tooth.

The extremity of a tooth is the outmost face, and the root that which joins or forms the face of the rim of the wheel.

The class of wheel-gearing most used for cranes is that termed "spur-wheels." There are two other kinds of gearing, — bevel and mitre wheels, which are also sometimes used.

A *spur-wheel* is a wheel having its teeth perpendicular to its axis.

A *mitre-wheel* is a wheel having its teeth at an angle of 45° with its axis.

A *bevel-wheel* is a wheel having its teeth at an angle with its axis.

"*To compute the pitch of a wheel.* — Divide the circumference at the pitch-line by the number of teeth.

"EXAMPLE. — A wheel 40″ in diameter requires 75 teeth: What is its pitch? $3.1416 \times 40 \div 75 = 1.6755''$.

"*To compute the diameter of a wheel.* — Multiply the number of teeth by the pitch, and divide the product by 3.1416.

"EXAMPLE. — Number of teeth in a wheel is 75, and pitch 1.6755″. What is the diameter of it?

$$75 \times 1.6755 \div 3.1416 = 40''."$$

HASWELL.

Where two gear-wheels engage each other and one is smaller than the other, the smaller is called the "pinion," and the larger the "wheel When in contact, the ratio of their revolutions is regulated by the number of teeth each contains.

To find the number of revolutions in a pinion to one of a wheel. — Divide the number of teeth in the wheel by those in the pinion. With a wheel having 96 teeth, and a pinion with 16 teeth ($96 \div 16 = 6$), we see the pinion makes six revolutions to every one of the wheel.

In cranes the smallest pitch is used for the "first motion," those used upon the last motion being larger. This is done because the nearer to the pull of a drum a gear is, the greater strain there is upon the teeth of the wheel.

The strength of teeth, and relative proportion in depth of face to pitch of teeth, are well illustrated by the following formulas, given by the Walker Manufacturing Company, Cleveland, O.

"The durability of the teeth of gears, under the same circumstances, is nearly in a direct proportion to their breadth, and inversely as the pressure. The strength of the teeth of gears is directly in proportion to their breadth, as the square of their thickness, and inversely as their length. For example, if we double the breadth we only double the strength; but if we double the thickness, or in other words double the pitch, keeping the original length and breadth, we increase the strength four times: but as the length of teeth commonly increases with the pitch, this circumstance must be taken into view; for if we double the thickness and length at the same time (as is common in practice), we only double the strength, in which case the strength is directly as the pitch.

"The stress on the teeth of gears is as the pressure and inversely as the velocity. For example, if the pitch lines of one pair of wheels move at the rate of 1,000 feet per minute, and another pair of gears, in every other respect under the same circumstances, moves at the rate of 500 feet per minute, the stress on the latter is double that on the former.

"STANDARD FACES FOR SPUR GEARS.

Pitch.	Face.	Pitch.	Face.	Pitch.	Face.	Pitch.	Face.
½″	1¼″	1¾″	5½″	2⅞″	8½″	4″	12″
⅝″	1½″	1⅞″	5½″	3″	9″	4¼″	13″
¾″	1¾″	2″	6″	3⅛″	9″	4½″	14″
⅞″	2″	2⅛″	6½″	3¼″	9½″	4¾″	15″
1″	2½″	2¼″	7″	3⅜″	10″	5″	16″
1⅛″	3″	2⅜″	7″	3½″	10½″	5¼″	17″
1¼″	3½″	2½″	7½″	3⅝″	10½″	5½″	18″
1⅜″	4″	2⅝″	7½″	3¾″	11″	5¾″	19″
1½″	4½″	2¾″	8″	3⅞″	11″	6″	20″
1⅝″	5″						

"*Gearing.*

"1″ pitch by 2½″ face will transmit 1.40 horse-power at 100′ per minute, on pitch line, with a safety of eight.[1]

"1¼″ pitch by 3½″ face will transmit 2.52 horse-power at 100′ per minute, on pitch line, with a safety of eight.[1]

"1½″ pitch by 4½″ face will transmit 3.84 horse-power at 100′ per minute, on pitch line, with a safety of eight.[1]

"1¾″ pitch by 5½″ face will transmit 5.48 horse-power at 100′ per minute, on pitch line, with a safety of eight.[1]

"2″ pitch by 6″ face will transmit 6.83 horse-power at 100′ per minute, on pitch line, with a safety of eight.[1]" — WALKER.

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[1] Ultimate tensile strength, 30,000 pounds per square inch.

Before closing this chapter, it may be well to state that the reason for not introducing "worm-gearing" in any of the chapters on cranes is, that, for general foundry use, its principle is not so well adapted as "spur-gearing" shown.

The author's opinion of worms *vs.* spur-gears on cranes coincides so closely with that published in "Industrial World," that the following extract is quoted: —

> "A worse objection to the use of a worm combination is the difficulty of providing for a change of speeds without the use of more fixtures, in the form of clutches, and an additional worm, than would need to be provided for doing the entire work if the spur-gearing were used. With this form of multiplying fixtures, the change from fast to slow is made without trouble, by the simplest kind of an end movement of the hand-shaft, the pawl being thrown in for the moment if the change must be made while the load is hanging. In fact, for most kinds of lifting which, in weights to be moved, fall within this friction limit referred to, a single multiplication, from the hand-shaft to the chain-drum, by the use of a very large spur-wheel, can generally be made which shall very closely meet the ratio of any worm likely to be used. In cost of attachment to the crane frame, the preference cannot be against the spur-gearing, when the need of a change of speed, and room for a proper length of chain-drum, are considered."

As a modifier to the above, the author would say, that, for cranes run by other than hand-power, "worm-gearing" may often be made to answer all practical requirements, but for hand-power cranes he could not approve of their adoption for foundry use.

MULTIPLYING PARTS IN CRANE CHAINS.

IN all the cranes shown in this work, the load is to be carried upon "two-part" chains or wire rope. The strength of chains when used in two parts is given in vol. i. p. 123.

When the capacity of a crane is to be over that which a two-part 1″ chain could safely hoist, then it is better to increase the number of parts rather than to use heavier chains.

For large cranes, intended for a load of over twenty tons, the blocks can be constructed having from two to four sheaves or more. For every sheave a block contains, we have double their number in parts of chain by which to carry loads, so that with a block having four sheaves we have eight parts or single chains to carry the weight.

In multiplying the parts of chain or rope in "blocks," we correspondingly increase their lifting capacity. If a *two-part* 1″ chain will carry twenty tons, a four-part 1″ chain will carry forty tons. The single part of the chain or rope, which runs from the upper block in the crane carriage to the crane drum, has the strain upon it due to its ratio to the number of chains used in the blocks: thus, if the blocks have the four 1″ chains carrying forty tons, the one part leading from the drum up to top block has only one-quarter the weight to carry, which is ten tons.

As the number of parts in chains or ropes in "blocks" multiply, so in like proportion does the length to be wound around the drum of the crane increase. As an example, if in any of the cranes shown, their sustaining cord be increased from the two parts up to four, six, or eight parts, then their drums would require to be enlarged sufficiently to receive double the four, six, or eight times the height of the hoist of the crane.

The more parts of chain used on any of the cranes shown, the slower would be the speed in hoisting or lowering the crane. Should the cranes be geared up, so as to increase the speed, then more power would be required to operate them. The multiplying of parts in chains or ropes is in one sense but the "gearing up" of a crane: for it decreases speed, and whatever decreases speed also diminishes the power required to operate it. The relation of speed to power cannot be changed by any manipulation in gearing up: the higher we "gear up," the more proportionally we diminish speed and increase power.

HOOKS.

Where cranes exist, hooks are necessary. While in point of style they may differ, yet in principle they are all alike. There are two modes generally adopted in making hooks; one is to flatten that portion of the iron which forms the hook, while the other is to leave the hook round. Figs. 161 and 162 represent the round and the flat hook. Wishing to learn the relative strength of the two styles, I had several hooks made from one 1¼″ round bar of iron, and tested through the courtesy of the Otis Steel Works, Cleveland, O., by their "Olsen testing-machine."

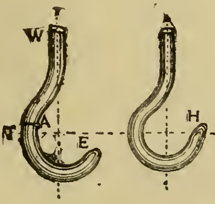


Fig. 161.

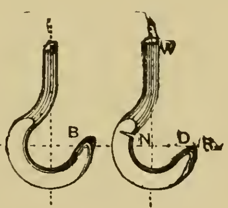


Fig. 162.

The process of testing was not only very interesting, but instructive as well; for, as the load or weight was applied, the stretch, or "opening out," of the hook was measured and was noticeable to the eye. What surprised the writer was the fact that the round hooks required on the average about as much load to break them as the flat hooks did. The average breaking load obtained was about 13,000 lbs. The round hooks would on an average commence to open out when a load of about two tons was applied: whereas it would take about three tons to cause any weakening or opening out of the flat hooks; and when they did commence, the opening out was very slow as compared with that which the round hooks showed.

Some idea of the opening out of the respective styles can be formed from the dotted line *T R*. At Fig. 161 we see the round hooks: *H* shows the form before any load was applied, and *E* shows the hook as it looked when it commenced to break. A few of the round hooks opened out much more than *E* illustrates, before they broke. In Fig. 162, *B* shows the form of the flat hooks before any load was applied, while D represents their form when they commenced to break. The breaks seen at *A* and *N* show about the point of first fracture, and may be rightly said to be the portion of a hook that the greatest strain comes upon.

The flat hooks, Fig. 162, were made or forged from the same $1\frac{1}{4}''$ round bar as that from which the round hooks, Fig. 161, were made. In making hooks, some construct them after the style shown in the crane hook, Fig. 163, which is simply a round iron hook having the portion at *S* the largest in diameter. Whatever size is required for the hook shown at *S*, commercial bar iron of that diameter is taken to make the hook from; and, to give the hook proportion, the other parts are forged down similar to the proportion as shown. To hold such a hook in the crane's blocks, a thread is cut on the shank at *K*. The principle involved in the hook part can be used in almost all classes of hooks. Taking every thing into consideration, this style of hook is a very good one for general work; as it not only gives a strong hook, but it is simple and easy to forge. The point *Y*, as shown, runs well up, so that where two chains

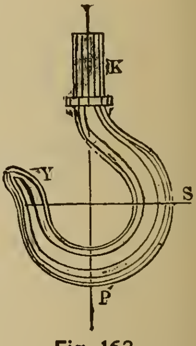


Fig. 163.

are hitched on the hook (a thing often required upon crane hooks in a foundry), there would be no danger of their slipping off from the hook. While this is advantageous in this respect, there is a limit to the height of the point. A point any higher than shown would be much in the way when the hook was used to hitch directly into another hook, — a thing which is also often necessary to do.

Another feature that should not be lost sight of is, that while at *N*, Fig. 162, and *S*, Fig. 163, there is the greatest strain upon the hook: the bottom, as at *P*, Fig. 163, when the hook is loaded with two chains, is also greatly strained, and such strains have been known to break hooks at *P*.

To construct a well-proportioned hook, the sections *N* and *S* should be larger in area than that of any other portion, from the fact that there is the point which has to stand the greatest strain. Theoretically, a really well-proportioned hook would be one so constructed that an expert would be puzzled to rightly *guess the part first to break.*

While the above is true proportion, I do not think it advisable to have hooks so finely constructed. It is well to have the section at *N* or *S* a little the weakest; for then there will be a chance to watch and note any overloading of the hook, which can be told by any opening out of the jaw. It is advisable, in any tool that can endanger life, to have it, if possible, so constructed that its user can be forewarned of any tendency to break.

From the above tests, two things are to be deduced. One is, that the flattened hook is the stiffest; while through this very element it may be said to be the most treacherous, from the fact that they are often apt not to open sufficiently before breaking to attract attention, while the round hook generally affords ample warning of an overloading. The strength of the hook depends greatly upon the mechanic who forges it. There is such a thing as abusing and distorting the fibres of iron so as to leave the hook strained within itself when finished, and no doubt many hooks have been broken that would have stood a much greater load if there had been more skill used in their construction. One may have hooks made from the same bar that, when tested, would give such different results as to cause doubts of the same bar having been used. Hooks should never be loaded to any thing like what may be thought their ultimate strength, and in designing them a large factor of safety should be allowed.

Heretofore there has been, as a general thing, but little thought given to the question of proportioning hooks, as can be readily seen by considering the varieties in use. To Henry R. Towne of Stamford, Conn. (manufacturer of hoisting-machinery) belongs the praise of presenting, in his work upon cranes, a "standard hook;" and through the courtesy of Mr. Towne the hook, accompanied by his formula for its construction, is here shown. It is no doubt a hook which will by practical men be received as one worthy of imitation.

. . . "Fig. 164 represents, to a scale of one-sixth natural size, a 5-ton hook of the dimensions and shape determined by the following formulæ, which give the dimensions of the several parts of hooks of capacities from 250 pounds (or one-eighth of a ton) up to 20,000 pounds (or 10 tons). For hooks of larger sizes the formulæ become slightly different, the general proportions, however, remaining the same.

"For economy of manufacture, each size of hook is made from some regular commercial size of round iron. The basis, or initial point, in each case, is therefore the size of iron of which the hook is to be made, which is indicated by the dimension A in the diagram. The dimension D is arbitrarily assumed. The other dimensions, as given by the formulæ, are those which, while preserving a proper bearing-face on the interior of the hook for the ropes or chains which may be passed through it, give the greatest resistance to spreading and to ultimate rupture which the amount of material in the original bar admits of. The symbol Δ is used in the formulæ to indicate the *nominal capacity* of the hook in tons of 2,000

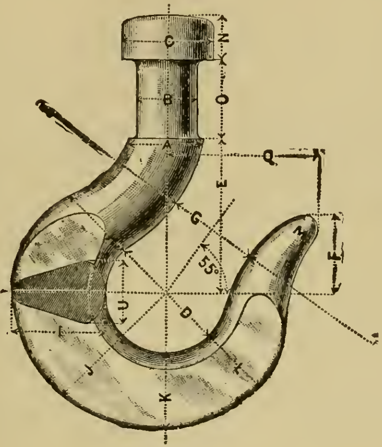


Fig. 164.

pounds. The formulæ which determine the lines of the other parts of the hooks of the several sizes are as follows, the measurements being all expressed in inches: —

$D = 0.5\Delta + 1.25$
$E = 0.64\Delta + 1.60$
$F = 0.33\Delta + 0.85$

$G = 0.75D$
$O = 0.363\Delta + 0.66$
$Q = 0.64\Delta + 1.60$

$H = 1.08A$
$I = 1.33A$
$J = 1.20A$
$K = 1.13A$

$L = 1.05A$
$M = 0.50A$
$N = 0.85B - 0.16$
$U = 0.866A$

" Example. — To find the dimension D for a 2-ton hook. The formula is: —

$$D = 0.5\Delta + 1.25,$$

and as $\Delta = 2$ the dimension D by the formula is found to be $2\frac{1}{4}$ inches.

"The dimensions A are necessarily based upon the ordinary merchant sizes of round iron. The sizes which it has been found best to select are the following: —

Capacity of hook .	$\frac{1}{8}$,	$\frac{1}{4}$,	$\frac{1}{2}$,	1,	$1\frac{1}{2}$,	2,	3,	4,	5,	6,	8,	10	tons.
Dimension A . .	$\frac{5}{8}$,	$\frac{11}{16}$,	$\frac{3}{4}$,	$1\frac{1}{16}$,	$1\frac{1}{4}$,	$1\frac{3}{8}$,	$1\frac{3}{4}$,	2,	$2\frac{1}{4}$,	$2\frac{1}{2}$,	$2\frac{7}{8}$,	$3\frac{1}{4}$	inches.

"The formulæ which give the sections of the hook at the several points are all expressed in terms of A, and can therefore be readily ascertained by reference to the foregoing scale.

"EXAMPLE. — To find the dimension I in a 2-ton hook. The formula is $I = 1.33A$, and for a 2-ton hook $A = 1\frac{3}{8}$ inch. Therefore I, in a 2-ton hook, is found to be $1\frac{13}{16}$ inch.

"Experiment has shown that hooks made according to the above formulæ will give way first by opening of the jaw, which, however, will not occur except with a load much in excess of the nominal capacity of the hook. This yielding of the hook when overloaded becomes a source of safety, as it constitutes a signal of danger which cannot easily be overlooked, and which must proceed to a considerable length before rupture will occur and the load be dropped." . . .

Figs. 165 to 170 are cuts of hooks very useful for foundries. The hooks, Figs. 165–167, may be properly termed crane-hooks, as they are chiefly used with cranes. The cuts of Figs. 165–167 show both ends of their hooks as being parallel to each other: in practice they are generally made so that the lower hooks L will stand at right angles to the upper hooks X. Hook Fig. 165 is one which is handy to hitch to crane-hooks in order to save labor and trouble in handling lighter loads than the capacity of crane-hooks is intended for. In heavy cranes the benefit of such a hook is much felt, as the bending and turning of heavy hooks and blocks in hitching onto light loads is more or less a nuisance. In some cases it is well to have two of these hooks, one to be lighter than the other: the larger of the hooks can often be used to good advantage if made nearly the capacity of the crane's hook.

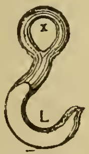


Fig. 165.

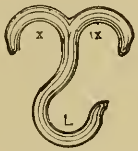


Fig. 166.

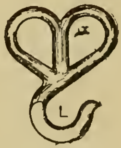


Fig. 167.

Figs. 166 and 167 are what are commonly known as "changing hooks," on account of their being used in changing loads from one crane to another. Fig. 167 may be termed the safest hook from the fact that it is welded to the shank as shown. Fig. 166 is the most popular hook, no doubt because its double hook-end presents the least interference when hitching on. Fig. 168 is well known as the S-hook, and is one found to be very handy in many ways, and can be made from flat iron as well as round. Figs. 169 and 170 are a style of link and hook seldom to be found. They are simply made from flat iron, ranging from ½″ up to 1″ in thickness, and in width from 1″ up to 3″. They make the stiffest kind of a hook, and would, no doubt, be much used were their strength more fully known.

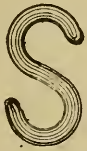


Fig. 168.

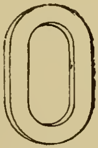


Fig. 169.

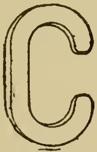


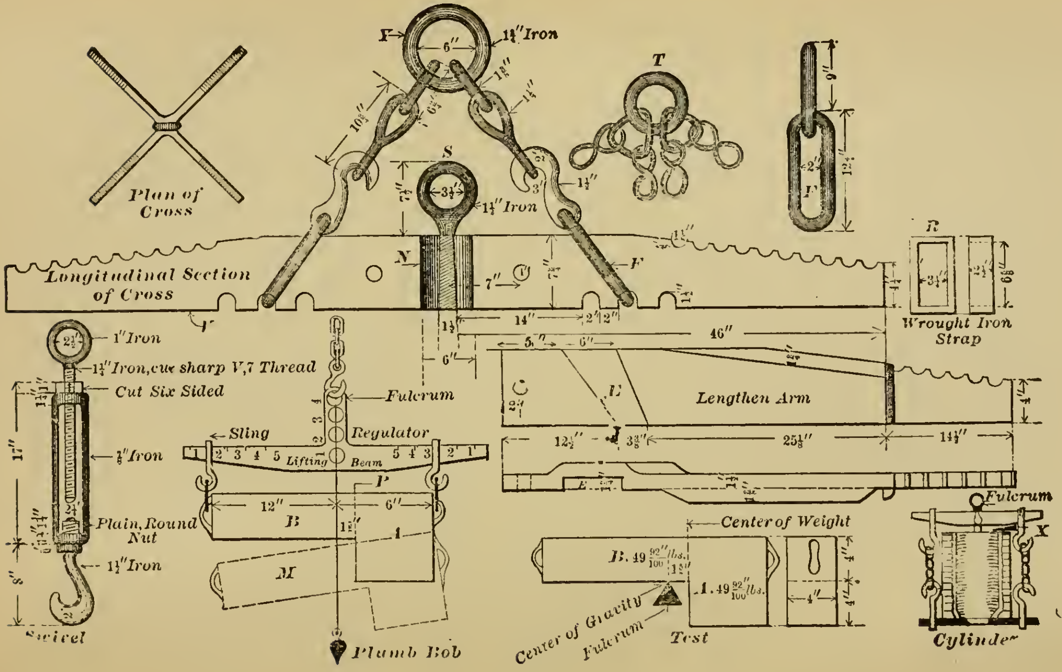
Fig. 170.

BALANCING AND HOISTING MOULDS.

The balancing and hoisting of moulds is an operation that often involves experimenting, and sometimes results in loss of life or limbs. Of course there are a large number of moulds that one can readily hitch to, but again there are a large number that require good mechanical judgment and knowledge in hoisting; for such, the following notes and ideas set forth will be of value.

In hitching to moulds, there is one thing that is very apt to be overlooked. The general impression is, that, if the crane-blocks hang directly over the centre of a mould's weight, it will hang level when hoisted up. This idea is not correct, as will be seen by the simple example illustrated in cut marked "Test," Fig. 171. This block, instead of being suspended by an overhead fulcrum, is let rest upon an underneath fulcrum. The block is divided by a dotted line. Each of the parts *B* and *A* weighs exactly alike. Still you have to deduct 6.76 pounds, or nearly 7 pounds, from *B*, and add it to *A*, in order to make the block balance, as shown. This will be readily understood by those who have studied the principle of the lever, and illustrates that a mould's centre of weight is not always its balancing-point, and that, instead of guessing for the centre of weight, we should guess for its centre of gravity. Some may ask, Is there not a more intelligent way to hitch to a mould than by mere guesswork? There is no practical way. Of course the weight might be figured, and its balancing-point be determined; but the time involved makes such a course generally impracticable.

As shown by the plumb-bob line, the fulcrum or lifting-chain



Plan of Cross
Longitudinal Section of Cross
F
1¼″ Iron
6″
10⅝″
6¾″
1⅝″
1¼″
T
9″
12¼″
2″
F
S
3½″
1¼″ Iron
7½″
N
7″
1½″
F
R
3¼″
2¼″
6⅝″
Wrought Iron Strap
14″
2″
2″
46″
5″
6″
6″
Lengthen Arm
E
12½″
3⅜″
25⅛″
14⅛″
4″
1″ Iron
2½″
1¼″ Iron, cut sharp V, 7 Thread
Cut Six Sided
17″
⅞″ Iron
Plain, Round Nut
1½″ Iron
8″
Swivel
Fulcrum
Sling
Regulator
1 2 3 4 5 Lifting Beam 5 4 3 2 1
P
12″
6″
B
1½″
A
M
Plumb Bob
Center of Weight
B. 49 92/100 lbs.
A. 49 92/100 lbs.
Center of Gravity
Fulcrum
Test
4″
4″
4″
Fulcrum
X
Cylinder

Fig. 171.

is directly over the centre of gravity of the weight. This is obtained through the regulation of the slings shown hitched to the lifting-beam.

The regulation of slings to make a mould balance, although apparently so simple, is an operation that sometimes puzzles a moulder. It often troubles him to tell which way the slings should be moved upon the lifting-beam, when they find a mould hanging similar to the weight that is shown at *M*, in dotted lines below *B*, *A*. The cause of such unlevel balancing would be, that the fulcrum or lifting-block was hung over the point *P*, seen in *B A*, the right-hand sling being set in the beam's notch No. 4, and the left-hand sling set in No. 1. To make the weight hang level, they must be placed as shown ; remembering that moving a sling towards the centre of a beam *lifts up the mould's side or end*, and that moving a sling towards the end of the beam *lowers it*. I have often seen first-class moulders obliged to study for quite a while before they could tell which way the slings should be moved.

About the most dangerous class of moulds with which we have to deal are those similar to the one marked *Cylinder*. In lifting such moulds, extra care must be taken, or the mould will turn over on account of the weight being all above that portion by which the mould is lifted. In hoisting any mould, as long as we can have the largest portion of its weight below the point by which it is lifted, there is generally little danger of its capsizing. Some, in hoisting such a mould, will drive wedges beneath the cross or beam, as seen at *X*. This is, no doubt, a good plan to adopt in hoisting top-heavy moulds. The farther from the beam the point from which the crane-hook is hitched to it, the more weight will it require to pull the lifting-beam out of balance ; that is, if the point by which the beam is suspended is rigid, so that it will always remain in its own relation or angle to the beam. In the beam shown lifting *B* and *A*, the chain-hook is hitched in an upright rigid beam at right angles to the main beam. In this upright beam are four holes. The fourth or upper one is the fulcrum point now used. To illustrate how we can regulate this point, we will suppose that this beam has no weight upon it, thereby allowing us to rock it back and forward. After noticing how much weight it will take to make one end come down to a given point, we will then cut off the top down to hole No. 3. The hook being hitched in this hole, we again try it, and so on down to No. 1. Now, I think it is very evident that with the top three holes cut off, and No. 1 used for the fulcrum, it will not require much force to turn the beam entirely over, did the chain seen not prevent it.

This explanation will, I think, prepare for an understanding of the principle and advantages of the cross shown. The ideas embodied in this cross, and its lifting slings and hooks, are such as can be applied to all classes of beams. The rigging, as shown, was devised by R. B. Swift. It is the first cross of the kind I ever saw; and, as I used it for six years, I know it to be a valuable appliance. The ordinary plan of hoisting with crosses is to hitch to an eye *S*. By this plan the fulcrum is but little above the centre *N* of the beam. Now, as we have seen, that, the higher we raise the fulcrum, the harder it is to tip up a beam, we must acknowledge that by hitching at *Y*, and having the hook slings spread apart as shown, it would be a hard matter to tip over a mould, even in hoisting top-heavy moulds similar to the cylinder shown. In using this lifting-cross, we rarely use any wedges between it and the mould *X*. So, if the latter is not exactly balanced at the point where it is hitched on, there will be little danger of its tipping over if the mould does not lift in a level position.

Another feature of this beam is that its straight face *V* is underneath. This construction is good, as it gives a more reliable surface to wedge against when using the cross for binding a mould together to be cast. Still another good feature is the "lengthening arms," of which there are four. The indenture *E* is for the purpose of allowing the arm to clear the sling *F* when it is attached to the cross. At any time, should a longer beam or cross be wanted, the arms can be readily attached. If a stronger lifting-cross is required than the one shown, the principle set forth will admit of making it of any size or strength.

R is a wrought-iron strap used to bind the outer end of "lengthening arms," while a bolt is inserted in the holes seen near the centre *N*, to hold the inner end. *T* shows the lifting-eye *Y*, as seen before being hitched on to the cross. The sling seen at *F* is another view of *F*, as seen hitched to the cross. The "swivel" shown is a well-devised one, and is very handy for adjusting or binding heavy loam moulds when being hoisted or got ready to be cast.

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