American Pattern Shop Practice

By

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PUBLISHERS' NOTE

The sections of this volume have been arranged as separate parts, each paged separately, the object in this being to enable the publishers to make revisions in future editions without having to destroy a large number of plates, as it is the belief of The Frontier Company that any book should be kept up to date by frequent revision.

In order to make the index applicable to a book of this style, it has been necessary to combine with the page numbers a series of Roman numerals indicating the sections; for instance, if one desires to look in the index for the Involute Odontograph Table, they will find a reference to 7-IV. This means that you must run through the book until the IV is found in conjunction with the page numbers, or in other words, turn to section IV and then to the 7th page.

Both the author and the publishers will be very glad indeed to have anyone point out any errors or omissions in this work, or to suggest any additions or corrections which would improve future editions.

THE FRONTIER COMPANY.

PREFACE

The literature pertaining to patternmaking not being as extensive as the importance of the business warrants, it has occurred to the writer that it would be well to offer some of the results of his own experience in the form of short articles and suggestions.

Considerable writing has been done along this line and a number of books published, but nevertheless the writer believes that the field is large enough for one more which treats the subject in a somewhat different manner, as the molding and core making as well as the patternmaking has been treated in each case.

Patterns, rigs and methods for producing steel castings form a special feature, and the examples given are thoroughly explained as is also the subject of core molding and multiple molding for steel casting work.

Core box work is regarded as the most intricate and important part of patternmaking, and among the subjects selected as illustrations will be found excellent examples of this part of the work.

While the art of patternmaking cannot be acquired alone through the study of books, a general and broader knowledge can be obtained, as no one individual can have the experience of many.

The variety of designs in castings and the conditions to be met make it impossible to apply any conventionary or set method to patternmaking at large, each particular object determining the method of molding and the construction of the pattern. In this connection it is desired that the succeeding articles be accepted as suggestions or examples, which have given practical results in the cases under consideration. Many, if not the greater portion of the subjects illustrated and described in this volume have previously appeared as articles in the *American Machinist, Patternmaker, Wood Craft* and the *Foundry*, under the writer's signature. In re-arranging the work under book form, many additions, alterations and corrections have been made in the original articles, and it is hoped that the volume will be useful to many patternmakers.

The author wishes to acknowledge his indebtedness to many friends who have furnished valuable suggestions for the work.

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SECTION I

ENGINE PATTERNS

CHAPTER I

A SLIDE VALVE CYLINDER

Slide valve cylinders are made in a great variety of ways. I have chosen and illustrated a well known type with one head and a guide barrel cast with the cylinders, the guide portion being what is known as a bored guide. A plan of the cylinder is shown in Fig. 1, the plan being taken in such a position as to show the interior of the steam chest. At the right and left of the central figure there are two end views. In Fig. 2 the longitudinal section as taken on the line A A, Fig. 1, is shown in the center and at the right and left cross sections as taken on the lines B B and C C. These views show the arrangement of the steam ports, exhaust chambers, oblong openings in the guide barrel, etc.

In beginning operations in making the pattern for this it is first necessary to make a full sized layout of the work, together with the necessary cross sections. The mode of molding which decides the parting of the patterns must next be determined. In this case the pattern has been parted longitudinally through the cylinder and steam chest. Along the line A A, Fig. 1, this manner of molding places the slide valve seat in the vertical plane which facilitates the setting of the cores.

The construction of cylinder patterns of this class depends largely upon the size of the cylinder being made. If the diameter is to be less than 12 inches the body of the cylinder may be glued up practically solid, but if the diameter is greater than 12 inches it is usually best to stave the body up, as shown in Fig. 3. The body having been roughed to form with the depressions to receive the flanges M N, Fig. 4, it is removed from the lathe and the flanges fitted in place. These flanges are first built up of segments, the inside sawed out, fitted in place and secured. The work is then returned to the lathe and the flanges and body turned to its proper dimensions, as shown in Fig. 4.

The body is next taken apart and one-half carefully placed upon the layout and temporarily secured there. The blocks and pieces forming the various core prints and other projections are then fitted in place, as shown by the two views and section of the completed pattern, Fig. 5. The layout of the work gives the proper location for the different parts as they are assembled.

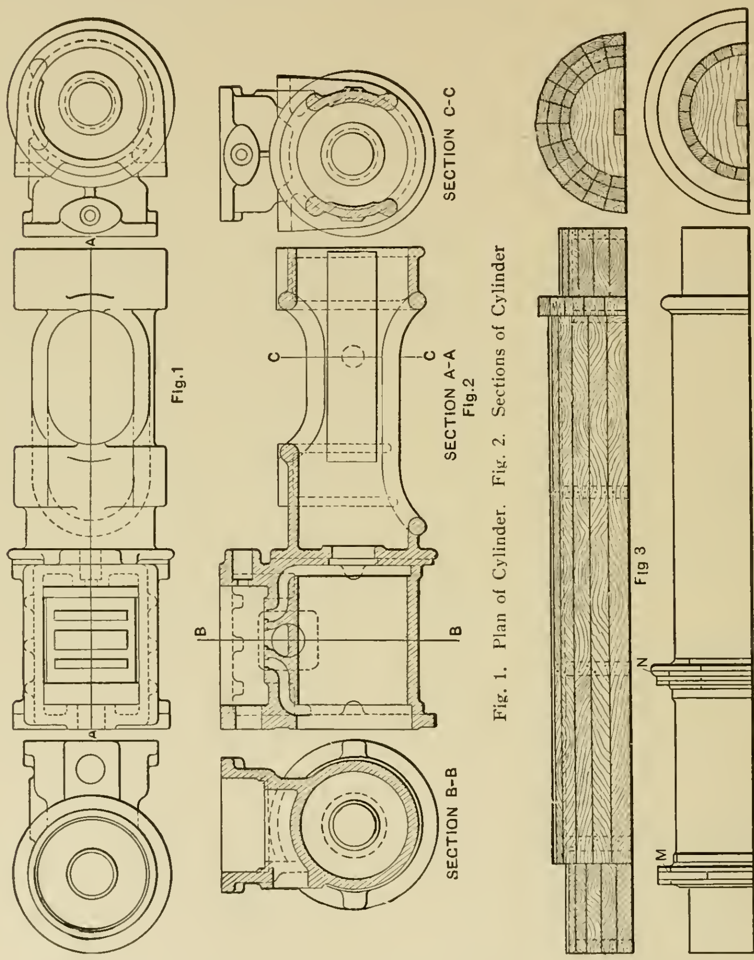


Fig. 1. Plan of Cylinder. Fig. 2. Sections of Cylinder

Fig. 3. Staving of Cylinder Pattern. Fig. 4. Pattern after Turning

A box or block forming a half of the body of the steam chest, O, is gotten out and fitted in place with a core print P attached. The flange Q with stud bosses and stuffing box R with its core prints attached are secured in place. The steam intake core print S with its facing is prepared and attached, as are also the drain cock bosses T T.

The core prints U and V, for forming the oblong openings in the guide, are made, fitted on and secured. It will be noticed that the core print U extends each way beyond the openings and forms the core print W for the feet.

The half pattern is next taken from the layout and turned over,

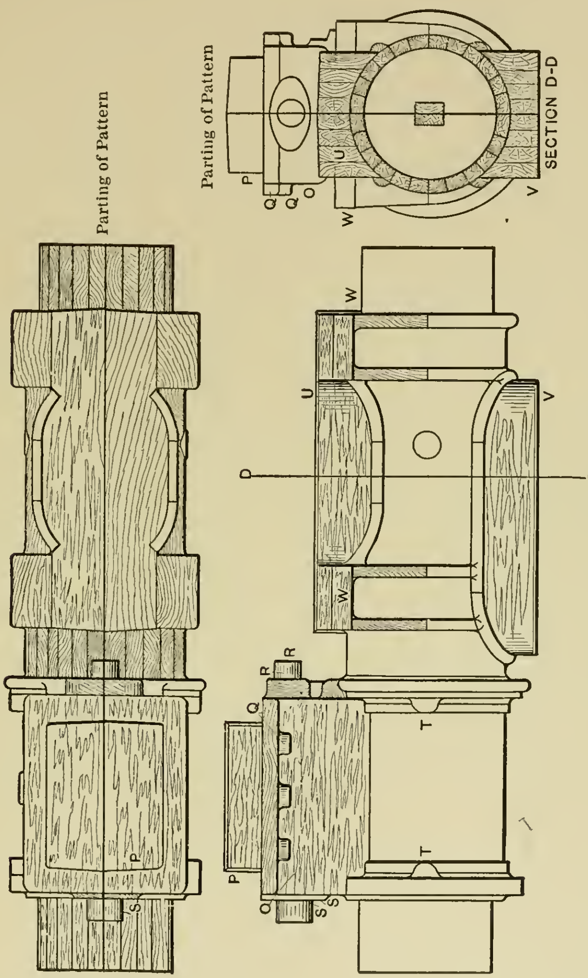


Fig. 5. Completed Pattern

the other half of the body placed on it and the fitting of the parts for this half proceeded with, the finished half serving as a guide. When completed the pattern is fitted with leather fillets and finished.

Two views and a section of the steam chest core boxes are shown in Fig. 6. This illustrates the general construction and arrangement of the parts. The loose pieces J in each end of the box form the stuffing and steam intake portions of the core. When the core has been rammed up in the box these loose pieces are withdrawn and the space occupied by them filled in with sand, so as to support the projecting parts of the core when the box is rolled over and also during the drying of the core.

For receiving the ends of the steam ports and exhaust chamber

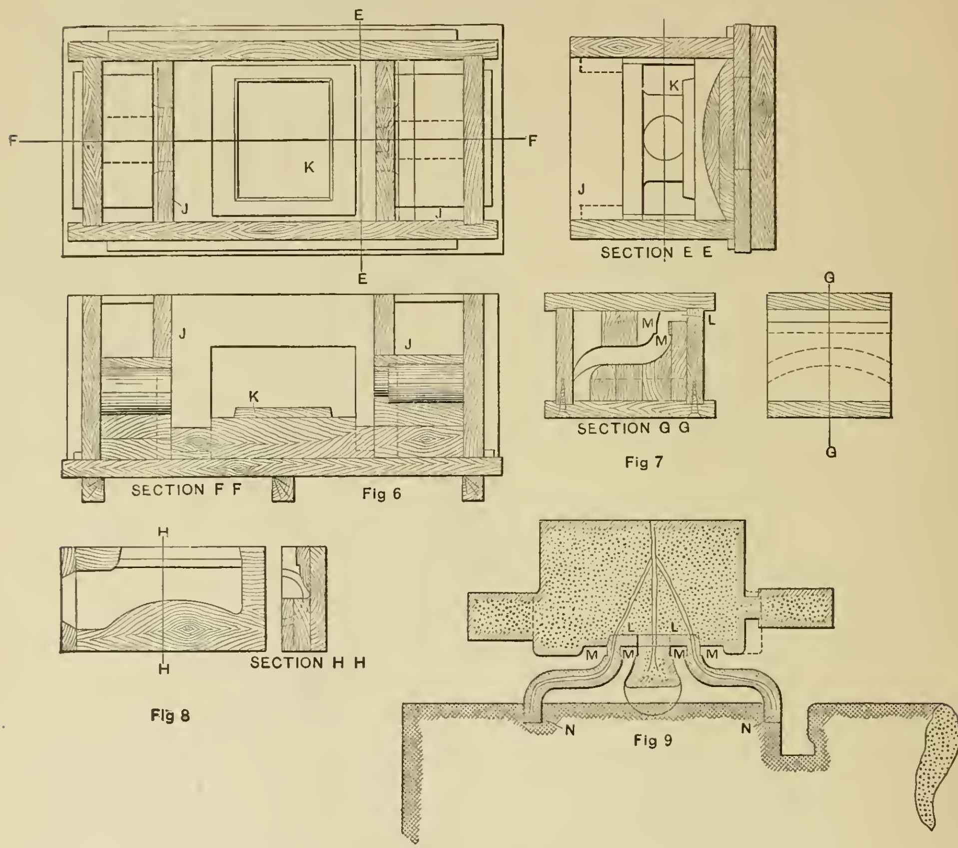


Fig. 6. Steam Chest Core Box. Fig. 7. Steam Port Core Box. Fig. 8. Exhaust Chamber Core Box. Fig. 9. Assembled Cores

cores one large print K is made of such a size that it will receive the ends of all three cores. This is better practice than the old method of using three separate prints, as it simplifies the setting of the cores and insures accurate measurement without greatly increasing the work of making the port cores. It is necessary to provide a projecting lip on the steam port cores to close the intervening space at L, Figs. 7 and 9. This lip also gives a greater bearing surface to the core.

A section and end view of the steam port core box are shown in Fig. 7. It will be observed that a lip M M is allowed around the port and exhaust core openings, as shown in Figs. 7 and 9. This provides metal in the ports, so that the ports may be chipped to the correct dimensions, so as to give exactly the desired area and perfect cut-off.

A core box for half of the exhaust chamber core is shown in Fig. 8. It is necessary to make two of these, one right hand, the other left hand. The core can be entire, or in halves and then fastened together. If it is made in halves it can be dried on a flat plate, which has some advantages.

A longitudinal section of the assembled steam chest, steam port and exhaust chamber cores is shown in Fig. 9. This illustrates the manner in which the cores are secured together. The openings N N

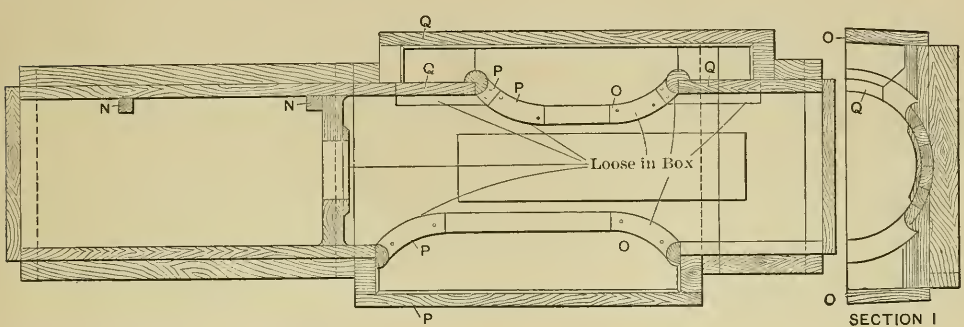


Fig. 10. Core Box for Bore of Cylinder and Guide Barrel

are provided in the bore core to allow the steam port cores to pass down into the bore core, thus holding them in position in the mold. These openings are made by the blocks N N in the core box, shown in Fig. 10.

A plan and cross section of the core box for the core ror the bore of the cylinder and also for the guide barrel are shown in Fig. 10. The body of this box is staved up in the usual manner and planed out to size. The material for forming the oblong openings O O is gotten out and fitted to the sides of the box and secured in place. The sides of the box are then cut out to conform to the pieces attached. The beading P P is fitted around the opening and worked into proper shape, being secured in place with loose dowels. The side of the box at Q Q must be made with loose pieces. In making the core the first section of the loose beading P P on the side of the box is drawn before the box is rolled over. This allows the loose pieces Q Q to be drawn back.

The manner of assembling the cores being shown in Fig. 9, it is unnecessary to show an illustration of the entire mold, as any molder would have no trouble or difficulty in coring up a mold made from the pattern. In Fig. 9 the manner of taking off the vent from the port cores is also indicated.

CHAPTER II

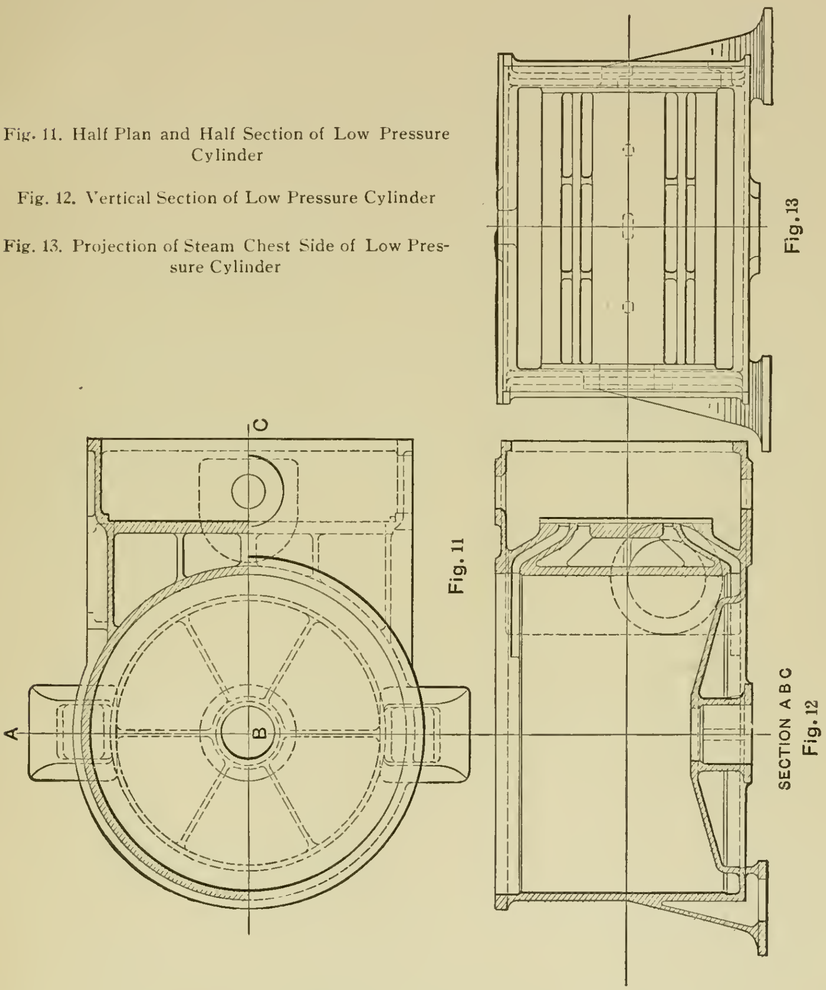
PATTERN FOR A LOW PRESSURE CYLINDER

Several views of a low pressure cylinder for a marine engine fitted with a slide valve are shown in Figs. 11, 12 and 13. Fig. 11 shows a half section and half plan. Fig. 12 shows a section on the

Fig. 11. Half Plan and Half Section of Low Pressure Cylinder

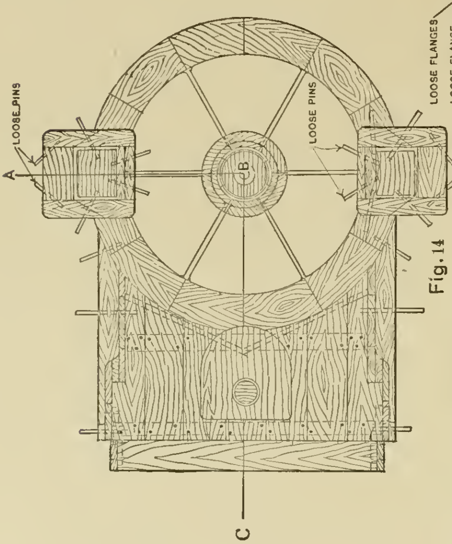
Fig. 12. Vertical Section of Low Pressure Cylinder

Fig. 13. Projection of Steam Chest Side of Low Pressure Cylinder



line A B C of Fig. 11, while Fig. 13 shows an elevation of the steam chest face of the cylinder. This type of cylinder is quite commonly used in compound marine engines.

There are two ways in which the cylinder may be molded, that is, the feet may be up or they may be down. A difference of opinion exists among foundrymen as to which is the more practical. Some claim that better results can be obtained by molding with the feet down on account of the fact that a large riser can be swept up around



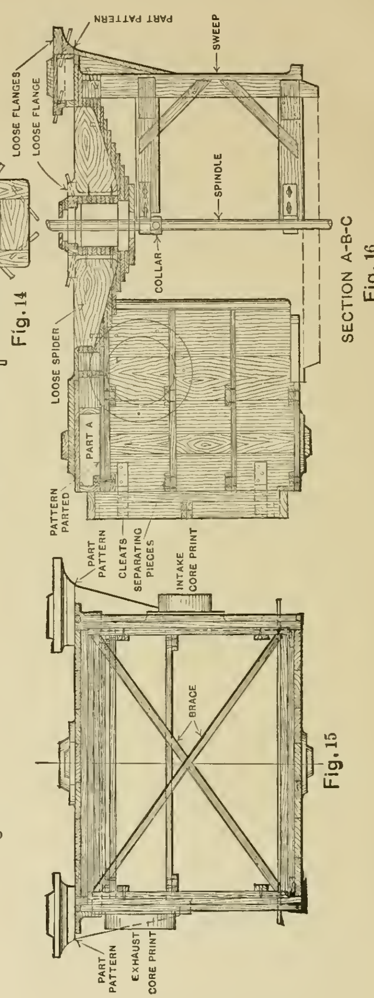


Fig. 14. Plan of Pattern Ready for Molding

Fig. 15. Steam Chest Face of Pattern

Fig. 16. Side of Pattern with Spindle and Sweep in Place

the top of the cylinder to receive any impurities in the metal, and that this will insure a better and sounder barrel for the cylinder. On the other hand, the objection is raised to this method, that it is very difficult to secure or hold down the barrel core on account of the fact that if the feet are down the core must rest upon chaplets and has a considerable tendency to rise, thus necessitating special rigging for bolting it down.

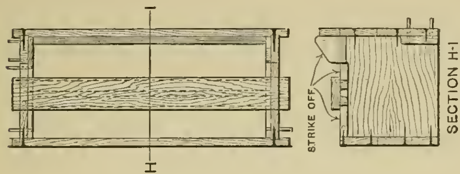


Fig. 17. Steam Chest Core Box

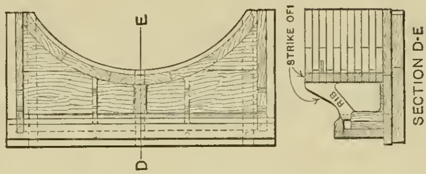


Fig. 18. Core Box for Exhaust Chamber Core

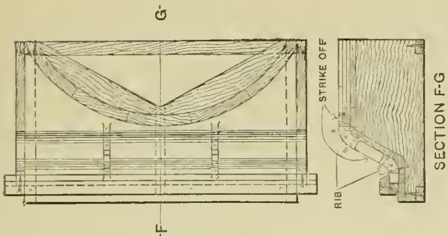
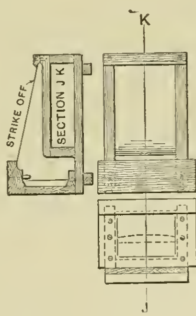


Fig. 19. Box for making Port Cores



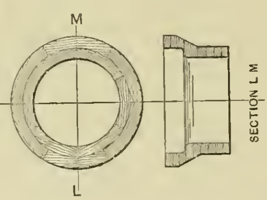


Fig. 20. Core Box for Foot Fig. 21. Core Box for Exhaust Opening

As most foundries make these cylinders in loam with their feet up when large enough to be swept, that method will be described first.

Molding with the Feet Up

In beginning this work it is customary to lay out a full sized plan and a vertical section through the barrel and steam chest, the allowance for contraction varying from 1-16 inch to 1-12 inch per foot, depending upon the size of the cylinder. The details of the pattern and sweeps are shown in Figs. 14, 15 and 16. Fig. 14 shows a plan of the pattern in place. Fig. 15 a view of the steam chest face of the pattern, and Fig. 16 a view of the side of the pattern with the spindle and sweep in place. The view shown in Fig. 16 is a section taken on the line A B C, Fig. 14.

The conical head with its flange is built up in segments and turned to the proper form. The upper portion of the steam chest is then built on to the side of the conical head, as shown in Fig. 16. The upper portion of the steam chest, together with the conical head, is separate from the lower portion of the steam chest with a parting as shown.

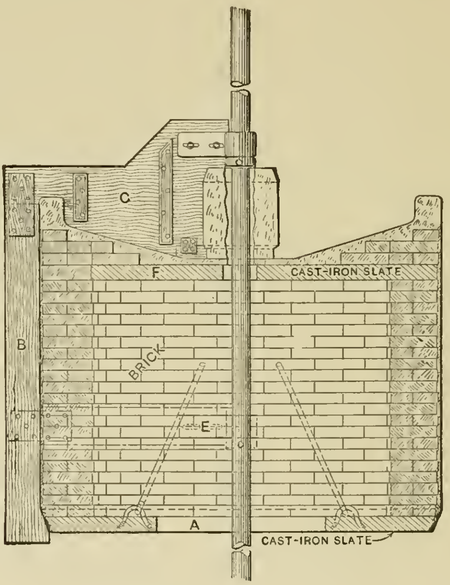


Fig. 22. Rig for Sweeping Barrel Core

The stuffing box is turned up with a loose flange which is cut into sections and held with loose pins so that these sections can be drawn in. The ribs are usually attached to the stuffing box, forming a loose spider which is doweled in place upon the pattern for the conical head.

The patterns for the feet are made in two sections and doweled together, the parting being in line with the top face of the cylinder flange. The central portion of the foot is drawn first and the projecting portions or flanges drawn in. The portion of the foot pattern which forms the rib or connection with the barrel of the cylinder is secured to the pattern for the head by means of pins and screws and, after the sweeping of the barrel has been completed, these are removed and this portion of the foot pattern drawn into the barrel.

The face of the steam chest pattern is built to conform to the diameter of the barrel, 3-16 to ¼-inch clearance being allowed for the sweep to pass.

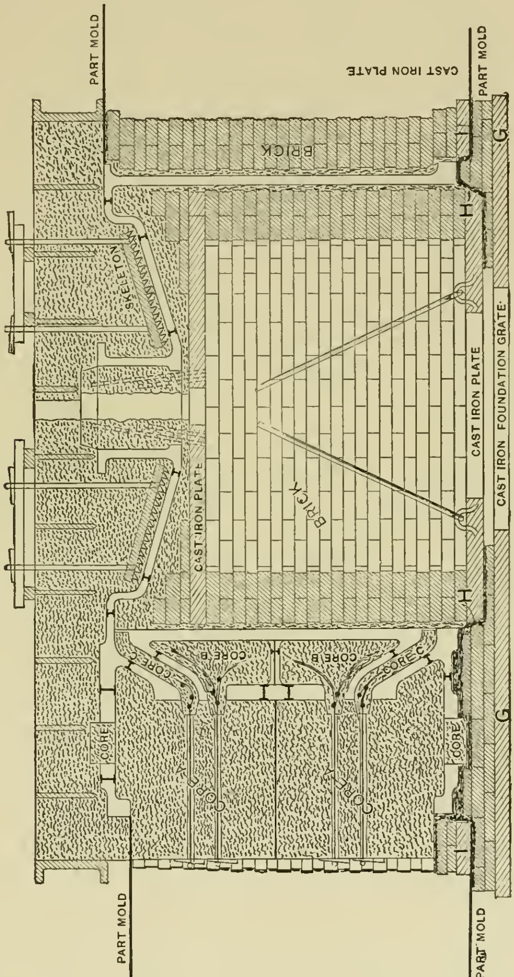


Fig. 23. Section of Completed Mold

The interior of this pattern is so constructed and secured together with pins and screws that the middle section of each end can be removed from the inside, after which the pattern collapses, and allows all parts to be drawn in and removed separately.

The core print for the steam chest is made as an open frame and secured to the chest with cleats, as shown in Fig. 16, braces being used across the face of the core print to keep it square.

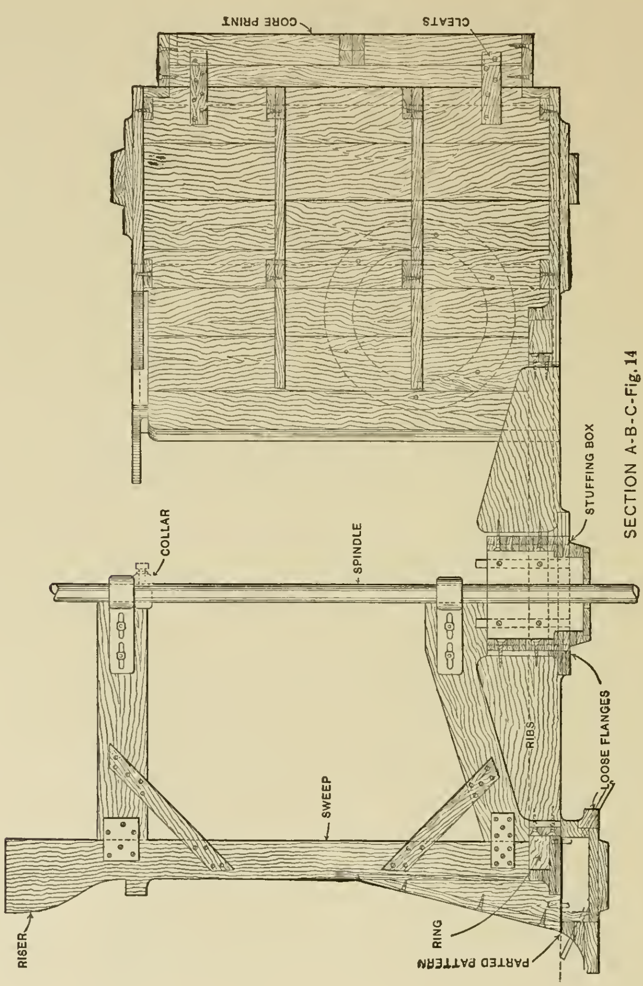


Fig. 24, Rig for Molding Cylinder

The core box used for making one-half of the steam chest core A, Fig. 23, is shown in Fig. 17. The prints for securing the steam and exhaust cores B and C are shown in place.

The core box for making one-half of the exhaust chamber core is shown in Fig. 18. The top of this core being struck off.

The port core box in which the two port cores are made, is shown in Fig. 19. The top of this core is also struck off. The core boxes for the foot and for the exhaust connection are shown in Figs. 20 and 21.

The rig for sweeping the barrel core is shown in Fig. 22. A cast iron base plate A is first placed in position, a few courses of brick work built upon it and loam swept on to the outside of them by means of the sweep B, which during this operation is supported

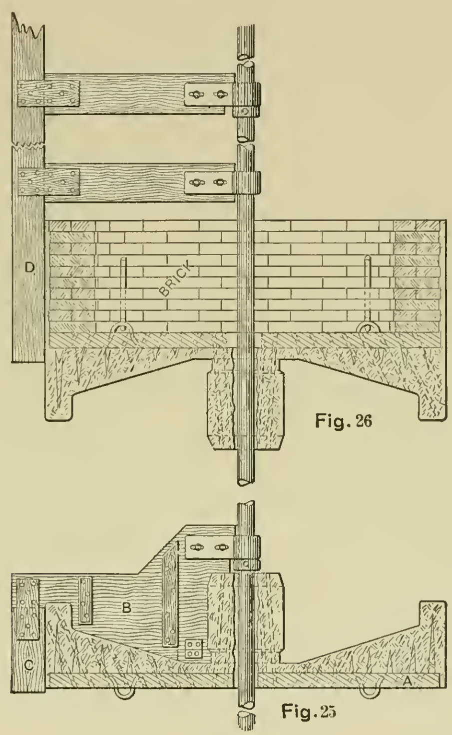


Fig. 25. First Operation in Sweeping Barrel Core
Fig. 26. Second Operation in Sweeping Barrel Core

by the upper sweep C and the temporary arm shown by dotted lines at E. The temporary arm E is then removed, the brick work built up and the plate F placed in position, after which loam is swept on by means of the sweep B which is carried by the sweep C and guided at the bottom by the loam already swept into place. The building and sweeping is continued until the entire outer surface has been finished, when the sweep B can be removed and the upper portion of the work finished with the aid of the sweep C, the stuffing box core being swept up at the same time that the portion of the mold on top of the plate F is swept up. When the stuffing box core is too small to be swept up in this way, a separate core is made and the print swept out to receive it.

The low pressure cylinder described above is a good example of casting in loam. This method of casting is one used for producing intricate castings of large dimensions, in which it is not likely that the pieces will have to be duplicated many times. Frequently a large amount of work is required in designing the rigs and sweeps for loam castings, but on the other hand, the patterns themselves are usually inexpensive, consisting as they do of sweeps and forms.

A section of the completed mold is shown in Fig. 23, showing the manner in which the different cores and parts are assembled. In beginning the mold, the cast iron foundation plate G, which is provided with suitable handling lugs, is first leveled up and a socket provided for the spindle. The pattern is then placed above the plate and blocked in position. The overhanging portion which contains the cope surface of the head is supported with temporary braces placed outside of where the bricking up is to be done. The space below the steam chest is then filled in with brick and a thickness of loam placed against the pattern. A seat or print H is swept up to receive the barrel core and a built up parting made around the outer edge, upon which the cast iron lifting plate I is placed to carry the middle section of the mold. This section is also built up of brick and loam. The sweep shown in Fig. 16 forms the outer diameter of the barrel.

The steam chest face of the mold is left open, the brick work butting against the core print on each side, and the opening being closed later when the cores are in position.

The top or cope part is formed by placing an ordinary flask on top of the brick work and ramming up a dry sand cope, care being taken to provide the necessary bars and skeletons for lifting out the deep pockets.

The cope is lifted off, the pattern drawn, and the sections of the mold and barrel core placed in the core oven and dried.

A pit is prepared and the foundation plate, or lower part of the mold, lowered into it and leveled up properly. The middle section is next placed in position, the offset parting guiding it into the proper relationship to the base. The core for forming the opening on the lower side of the steam chest is next set, the cores B and C having been secured to the cores A before they are placed in position. The upper cores are then secured together and placed in position. The cores for forming the intake and exhaust connections on the steam chest are usually inserted from the outside through openings left in the brick work. The barrel core is next carefully lowered into position and chaplets are then placed on top of the barrel core and the cope placed on.

The space between the walls of the pit and the mold is filled up by ramming in sand and provision made for the necessary gates. The mold is then weighted down, after which it is ready for pouring.

Molding with the Feet Down

The manner in which the pattern is fitted up for molding when the feet are to be cast down is shown in Fig. 24. The barrel is formed by a sweep in both instances. A ring is built up and turned, containing the lower flange of the cylinder, to which the feet and the ribs supporting the stuffing box are secured. The upper part of the sweep is so arranged as to form a riser around the top of the cylinder.

When this method is employed, the sweeping of the barrel core is somewhat more intricate, and it is shown in Figs. 25 and 26. It is first necessary to place the Prickard plate A with its face up as shown in Fig. 25 and sweep on the necessary thickness of loam with the sweeps B and C. The plate A is then dried and turned over, after which the brick work is built up and the main body swept by means of the sweep D as shown in Fig. 26.

CHAPTER III

A PISTON VALVE CYLINDER PATTERN

Piston valve cylinders, as the name implies, are cylinders in which the steam is controlled by a piston or cylindrical valve, moving in a barrel or chamber parallel to the bore of the cylinder. The example chosen to illustrate this type is a pattern for a 32 x 36 cylinder of the above mentioned design. This cylinder is for use in connection with a heavy duty reversible engine. Fig. 27 shows a half plan of the cylinder and a half section through the axes of the cylinder and the

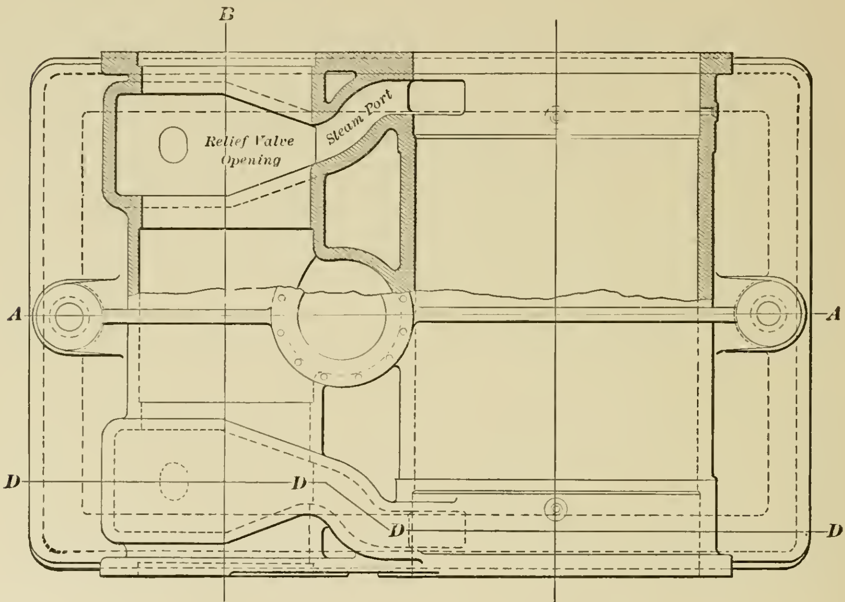


Fig. 27. Half Plan and Half Section of Cylinder

steam chest, showing the plan of one port, relief valve opening, etc. By examining the plan view it will be observed that the cylinder is symmetrical about the center line A-A.

A half elevation of the cylinder as seen from the steam chest side is shown in Fig. 28 together with a half cross section on the line B-B of Fig. 27. This section shows the metal thickness, etc. A cross section of the cylinder and steam chest on the center line A-A of Fig. 27 is shown in Fig. 29. This section serves to show the exhaust chamber, relief valve connection and bolting down lugs. The end view of the cylinder is shown in Fig. 30.

Before commencing the construction of any part of the pattern its position and method of molding must be determined. Having chosen a horizontal position for the pattern under discussion, it must be parted through the axes of the cylinder and steam chest on the lines C-C, Figs. 29 and 30.

Pattern Construction

In beginning the work a full size lay-out or a partial lay-out is essential. As the cylinder and steam chest are symmetrical about the center line A-A, Fig. 27, it is only necessary to draw a one-half lay-out

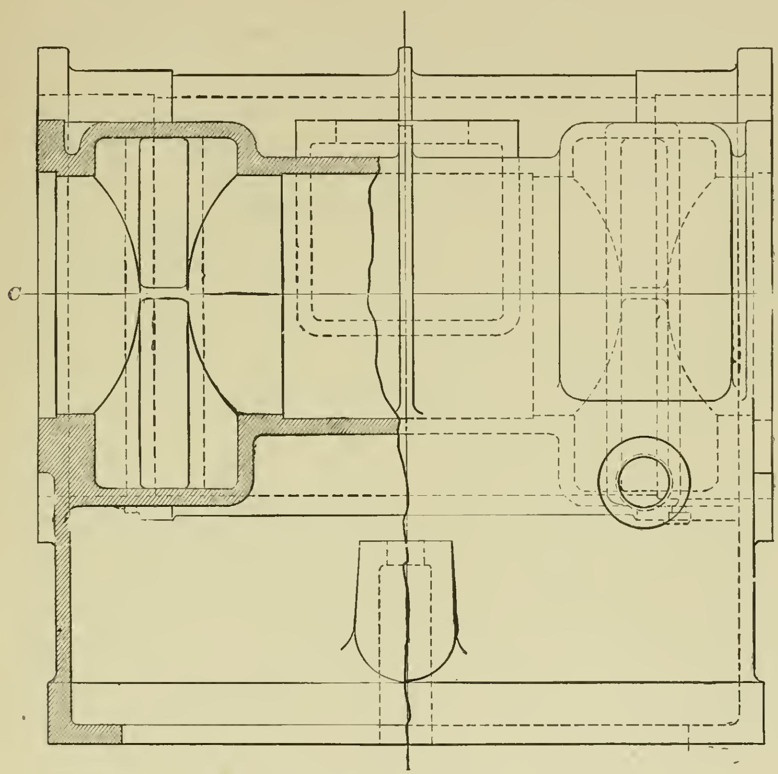


Fig. 28. Half Elevation and Half Section of Cylinder

of the plan, with the outline of the steam ports, etc., also a cross section as shown in Fig. 29, these two lay-outs being sufficient.

The assembled and completed pattern is illustrated in plan in Fig. 31 and elevation in Fig. 32, being shown in a reverse position to that in which it is molded, this being the position the pattern occupied during assembling.

For convenience in referring to the separate parts of the pattern during its description let us designate them as A, B C, D, etc., as shown in the completed pattern Figs. 31 and 32.

Part A of the pattern is shown in plan and cross section in Fig. 33 and consists of the lower part of the base of the cylinder. This can be constructed somewhat after the manner shown. It will be observed by examining Figs. 28 and 29 that one-half of the cylinder and steam chest is contained in this part of the casting, being of course formed by the core.

In commencing part A, three frames are gotten out, being nailed and glued together in a manner similar to that employed in the construction of segment work, that is, each frame is composed of three

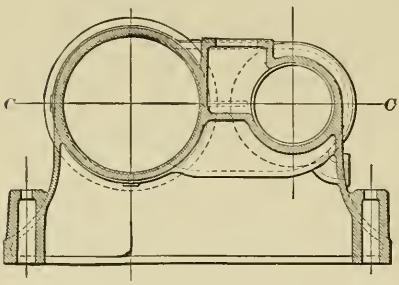


Fig. 29. Section on the Line A A, Fig. 27

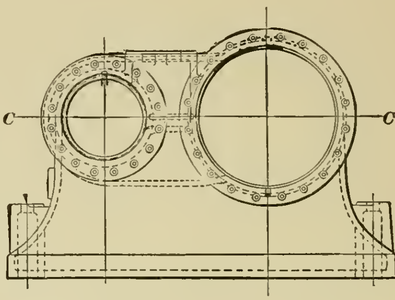


Fig 30. End View of Cylinder

thicknesses of material. The two frames which form the ends of the base are covered or closed in with the proper thickness of material. After this is done one frame is laid out and sawed to the proper form of the base, less the thickness or lagging with which they are inclosed. This frame is then used as a templet to mark off the other two which are sawed to correspond. The three frames are then placed upon a level surface, lined and squared up and secured together in a good substantial manner with bars or braces. The lagging of the sides of the frames is then proceeded with.

If the frames are laid off and sawed out accurately the lagging can be gotten out to the exact thickness and in narrow strips. It is then nailed and glued in place, when it will require but a small amount of dressing with a round sole plane, followed by the usual application of sandpaper.

Next the center lines of the cylinder and steam chest and of the bolting down lugs are carefully and accurately laid off across the parting of the pattern and down the ends and sides.

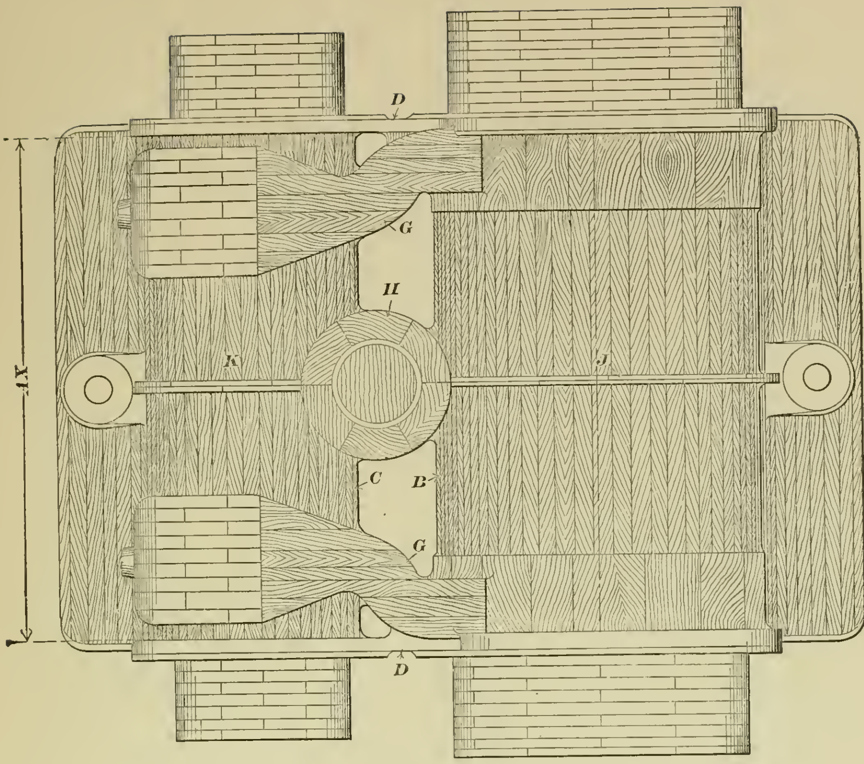


Fig. 31

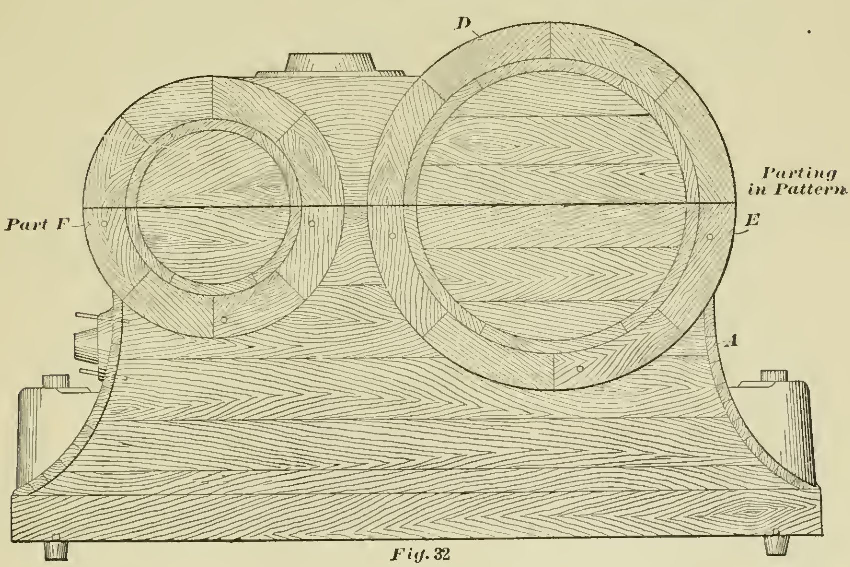


Fig. 32

Fig. 31. Plan of Finished Pattern
Fig. 32. End Elevation of Finished Pattern

Material is gotten out for the bolting down lugs and they are worked out and sawed to conform to the sides of the base, when they are fitted and secured in place. The two relief valve bosses, with their core prints, are also gotten out and secured in place.

It will be found convenient in molding if these latter mentioned parts are attached with screws and loose dowels inserted from the interior of the pattern, as this manner of securing these loose pieces permits of their withdrawal from the sand during the finishing of the mold.

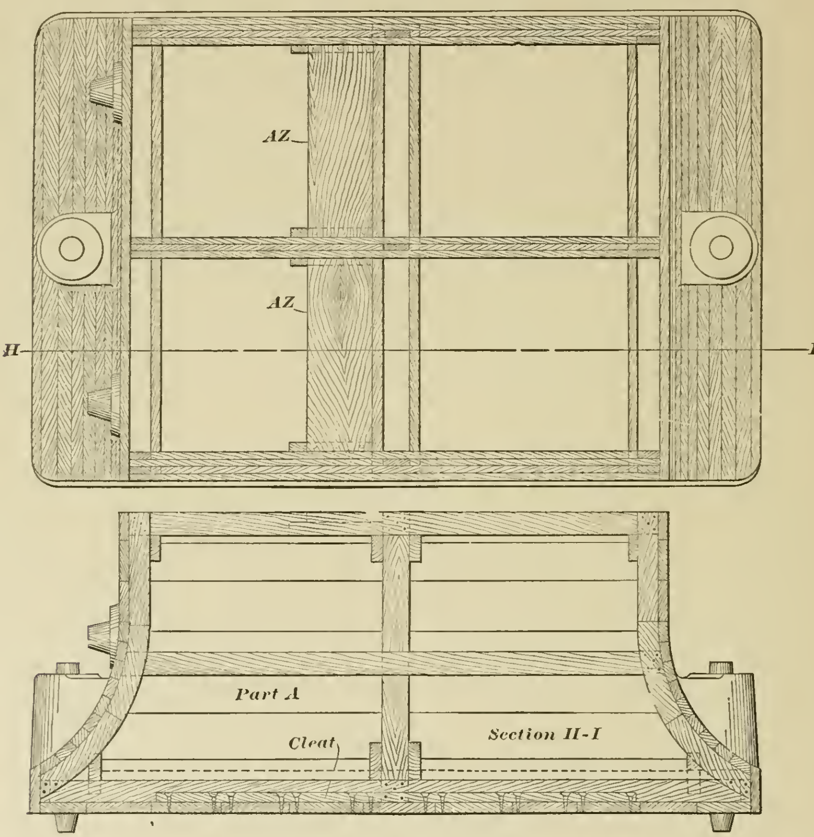


Fig. 33. Base Portion of Pattern

It will be observed by examining Fig. 29 that the combined diameters of the cylinders and steam chest do not inclose the entire parting or top of the base, so that there is a space left between these two parts. For this reason the material A-Z is inserted and secured between the frames as shown in Fig. 33.

The pattern is next turned over and the bottom inclosed. It will be observed, however, that a portion of the material used in closing in the bottom is cleated together, this being done to allow of its removal to give access to the interior of the pattern for the removal

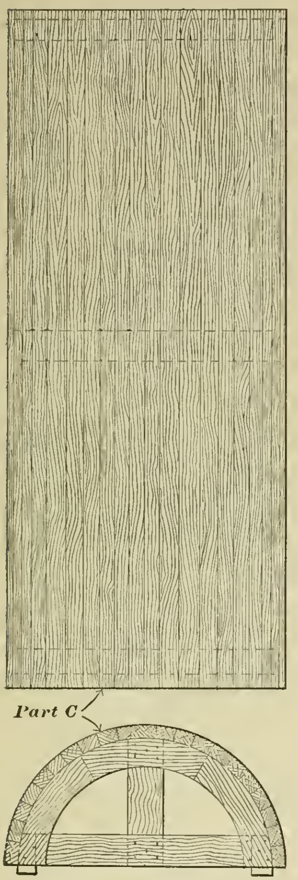


Fig. 35. Half Steam Chest Pattern

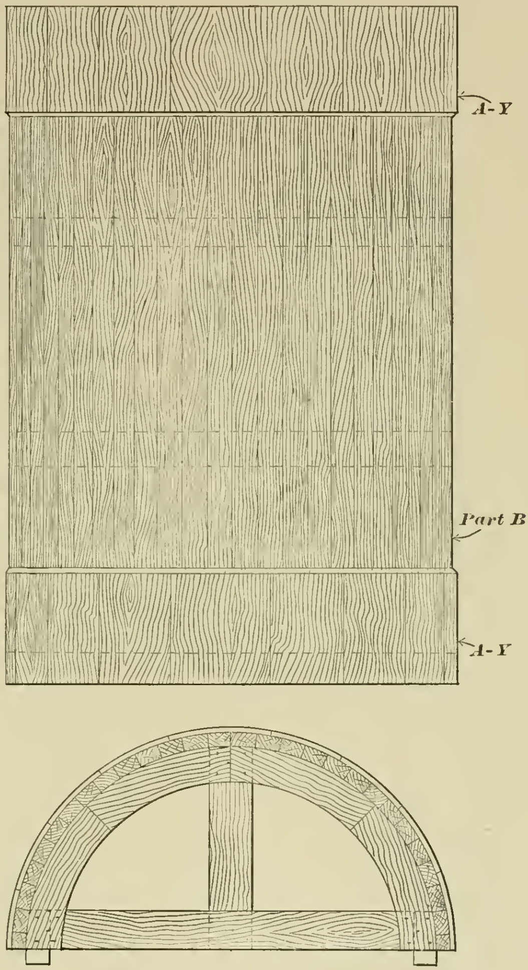


Fig. 34. Half Cylinder Pattern

of screws, loose dowels, etc., during molding. This loose bottom also facilitates the drawing of the pattern, as it affords the molder a good opportunity for rapping the inside of the pattern.

The bottom having been dressed off and sandpapered, the core outline should be carefully laid out and dotted or painted in. This is often considered unnecessary by patternmakers, but the writer believes the time spent in doing this is invested to good advantage, as it shows the molder the metal distribution, which often determines the point of gating. Another good reason for drawing in a core outline when no cope core print is used, as in the case under discussion, is that the molder can see at a glance where he must make provision for taking off the vent from cores which must be vented up through the cope.

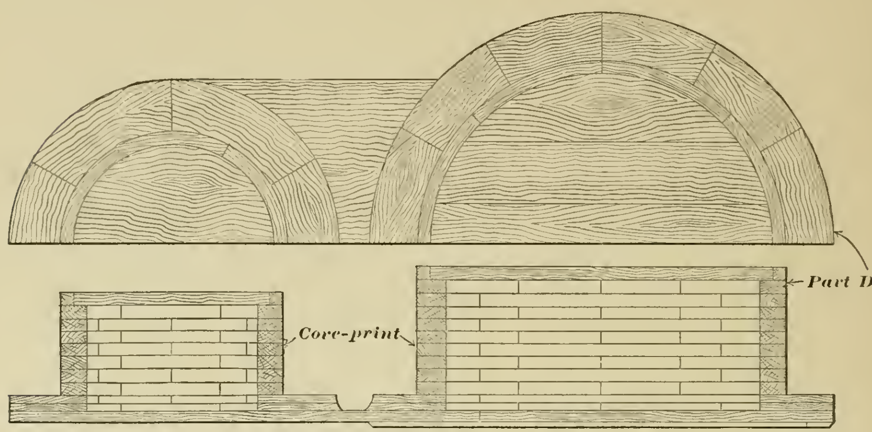


Fig. 36

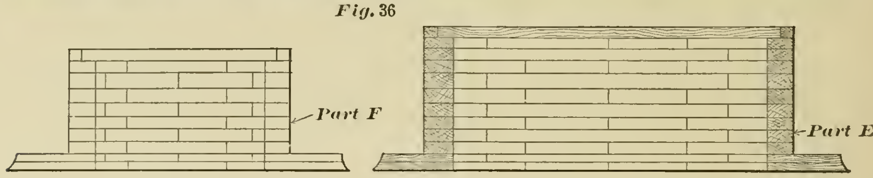


Fig. 37

Fig. 36. Half Flanges and Prints   Fig. 37. Half Prints and Facings

With the locating and placing of the conical core prints for the bolting down lugs, this part of the pattern is practically completed.

Next one-half of the cylinder B and of the steam chest C, as shown in Figs. 34 and 35, are barreled or lagged up over built up frames as shown. These frames are built up and sawed out to the required outside diameter less the thickness of the lagging. As previously stated, if the lagging is applied in narrow widths, very little dressing will be required to bring it to form.

After the cylindrical part B has been worked up in this manner and dressed off, the material A-Y is applied to the ends to reinforce the counterbore at each end of the cylinder. This material is dressed up and attached as shown. The stock can be gotten out in any convenient width and owing to its being rather thin it will conform to the curve of the cylinder without any difficulty.

In length these two half barrels or half cylinders B and C are equivalent to the length of the line A-X in Fig. 31, or the distance between the end flanges D of the cylinder and steam chest.

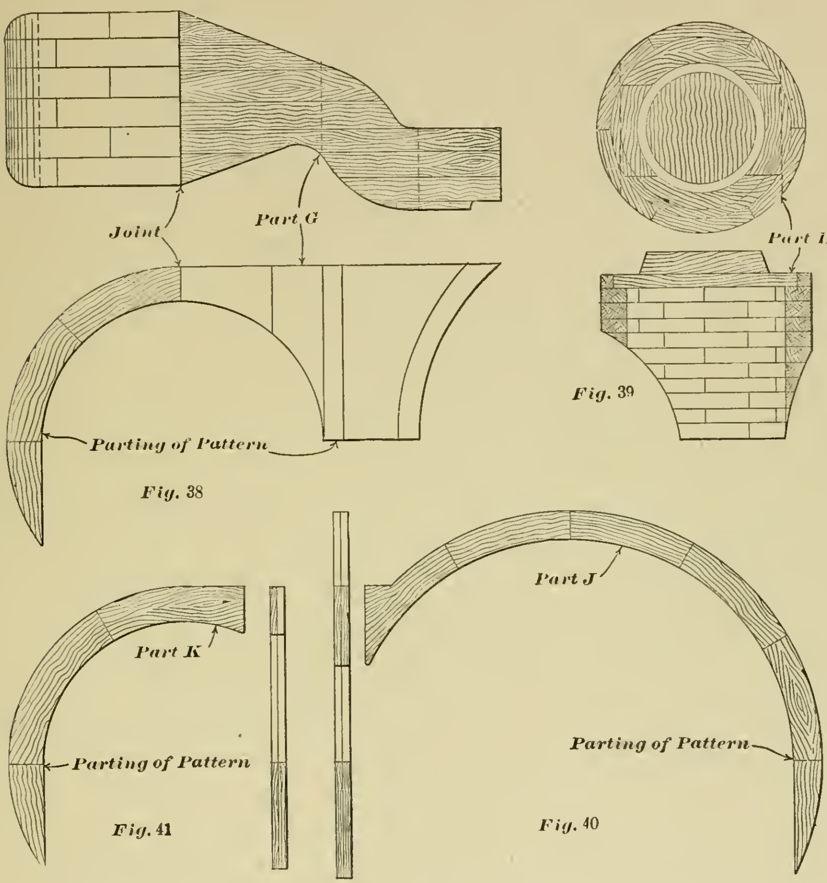


Fig. 38. Steam Port Pattern
Fig. 41. Stiffening Rib for Steam Chest

Fig. 39. Exhaust Cylinder Pattern
Fig. 40. Stiffening Rib for Cylinder

After completing these two parts and locating them on the base portion A, we proceed with the part D, as shown in two views, Fig. 36. This portion of the pattern forms the two half flanges on the cylinder and steam chest and also serves to secure the two half cylinders B and C together at their ends, as shown in Fig. 32. It will readily be seen that two of these flanges will be required, one right hand and the other left hand, together with their respective core prints. These core prints are built up, turned and attached to the flange D, as shown in Fig. 36.

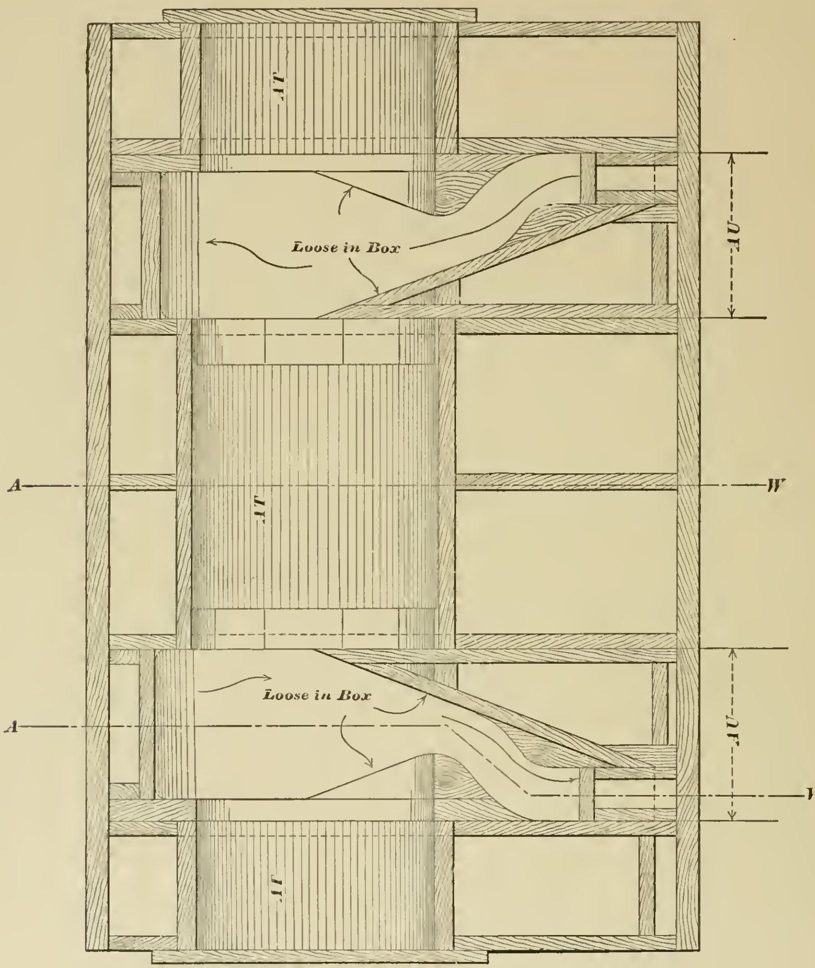


Fig. 42. Plan of Core Box for the Steam Chest

The parts E and F are shown in Fig. 37 and simply consist of the half facings and core prints which are attached to the base of the pattern A for completing the flanges and core prints. Two of each of these will be required, one for each end of the cylinder and one for each end of the steam chest.

After having secured parts B and C in their correct position upon the base A and fastened them together with the flanges D, our attention is next turned to the getting out of the steam ports. One of these steam ports is shown in Fig. 38, and it is designated as part G of the assembled pattern, Fig. 31. Two of these parts are required, one right and the other left hand. Each one of these patterns is constructed in three pieces as shown.

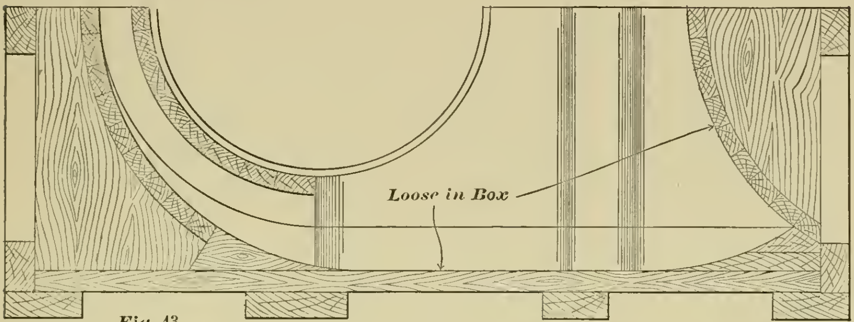


Fig. 43

Section A-V

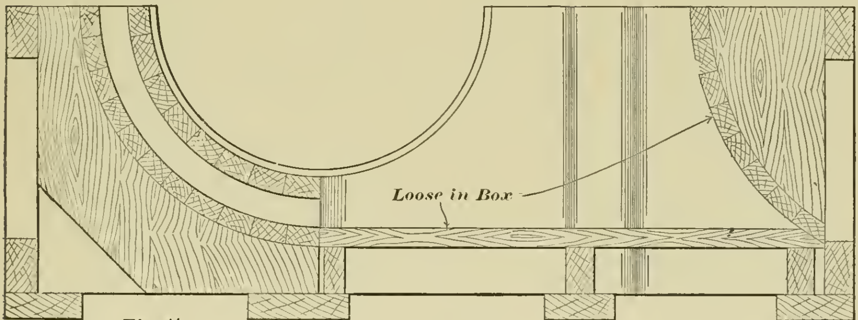


Fig. 44

Section A-V

Fig. 43. Section of Core Box Fitted for Top Half of Core
Fig. 44. Section of Core Box Fitted for Bottom Half of Core

On account of the irregular form of these steam ports, the largest portion of which extends from the center steam chest over to the cylinder, it will be found convenient to glue up a solid block and then saw it to form, rather than to attempt any form of built up construction to save material.

Having glued up two rectangular blocks of the required dimensions they are laid out and sawed to conform to the diameters of the cylinder and steam chest and fitted down into their correct position.

Next, the two separate parts shown at the left of the figure are built up of segments fitted around and secured to the steam chest with loose dowels. After the above parts have been gotten out in this manner their outline is carefully laid off, the parts removed and sawed and dressed to size, when they are returned to their position.

The exhaust chamber or part H of the pattern is shown in Fig. 39. This is built and turned up and then sawed so as to fit down in place as shown in Figs. 31 and 39.

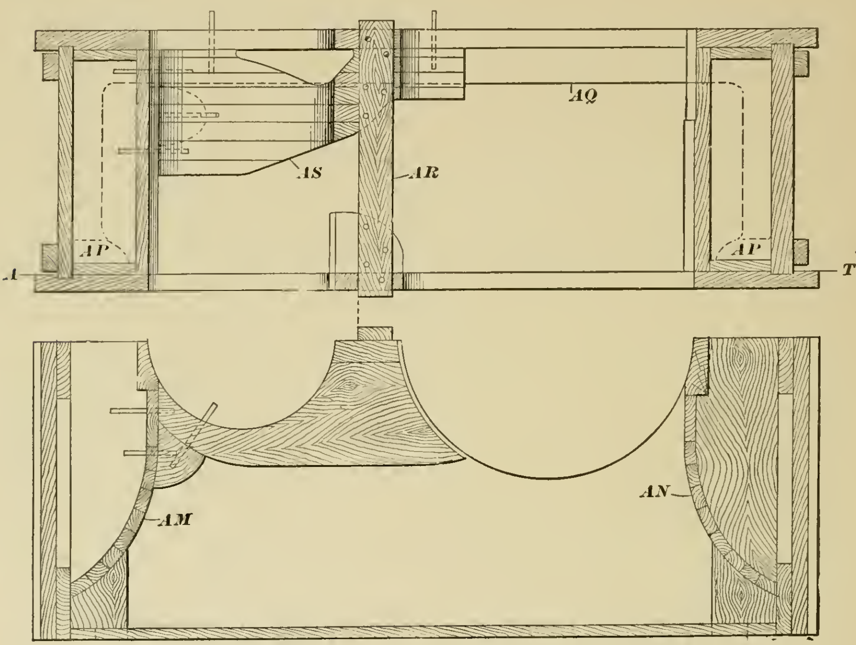


Fig. 45. Core Box for One-Half of Base

With the getting out of the two stiffening ribs as shown in Figs. 40 and 41 the pattern is practically completed.

Core Box Construction

The core box for the steam chest is illustrated in Figs. 42, 43 and 44, it being so constructed that it forms one-half of the entire steam chest core, together with the port openings. The core being symmetrical about the center line A-W permits of its being reversed. This core box will form the two half cores required with the use of the change in outline of the bottom of the port openings, the provision for which will be described later.

By examining the cross section of the cylinder as shown in Fig. 29 it will be observed that the top and bottom outlines of the port do not correspond. This necessitates a slight change in the core box at these two points. In Figs. 43 and 44 are shown two cross sections of the core box on the line A-V, with its two sections showing the two different outlines of the port and the loose filling pieces required for altering their form. The upper section A-V shows the core box set up for the upper half of the core as shown in the completed mold, Fig. 49. The lower section A-V is arranged for the lower core as shown in the mold, Fig. 49.

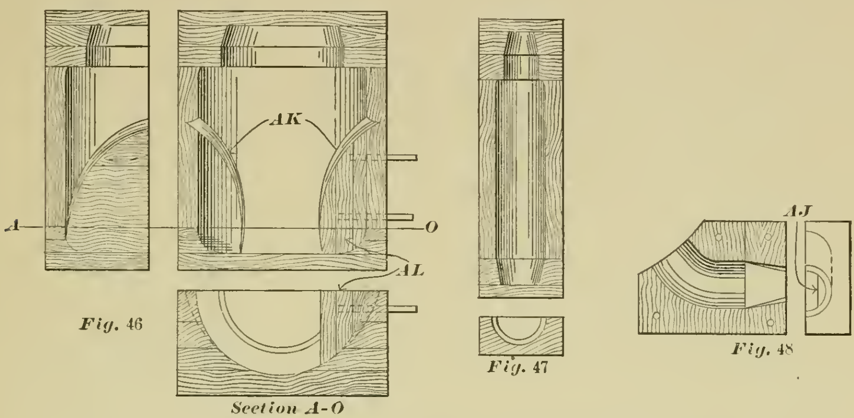


Fig. 46. Core Box for Exhaust Chamber Fig. 47. Core Box for Holding Down Bolt Lugs
Fig. 48. Core Box for Opening for Relief Valve

In constructing this core box the cross stringers are first gotten out, laid off and sawed to form to receive the lagging A-T. The stringers are next lined up and rigidly secured together by bottom and end cleats or by braces as shown. The lagging is applied and dressed out in the usual manner. The box is then completed by filling in the two spaces A-U with the required loose material somewhat after the manner illustrated. This loose material or series of loose pieces is intended to form the outline of the port openings.

A plan and cross section of the core box used in forming one-half of the core for the base, which also forms the outside of the cylinder and steam chest, is shown in Fig. 45. It will be observed that by having two pieces, A-S, of opposite hands, that is, right and left, and also two pieces, A-R, right and left, together with right and left pieces A-Q and A-P, it is possible to set up our box for either one of the two cores required. The box or frame is constructed rectangular in form, the two sides being cut out to conform to the outer dimensions of the cylinder and steam chest. To provide for the flaring sides of the base the material A-N and A-M is placed in the two ends of the box as shown. The box is rammed up in the position shown and the top struck off with the straightedge to conform to the sides of the box. The parts are then withdrawn from about the core and the latter dried upon the plate upon which it was rammed up.

The core box for forming the exhaust chamber core is shown in Fig. 46, two half cores being made from this box. By examining Fig. 29 and the cross section of the completed mold, Fig. 49, the manner in which this core cuts through into the steam chest will be seen. Some special provision is required at this point to take care of the

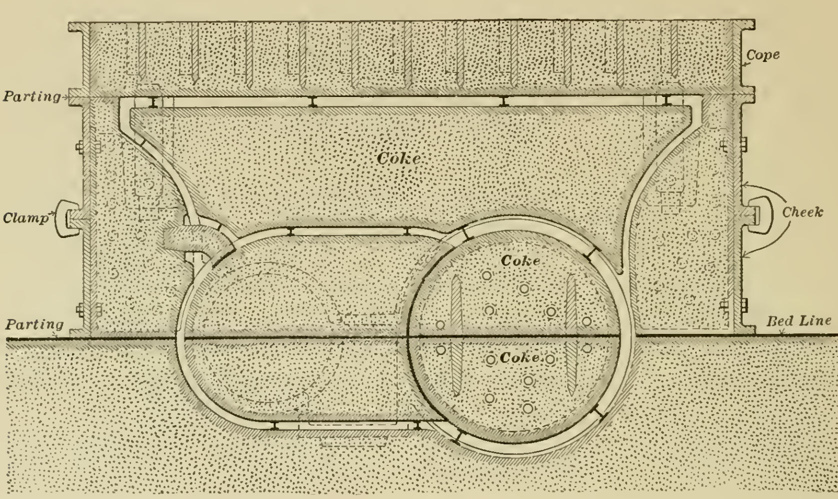


Fig. 49. Cross Section of Mold

irregular form of the core, and the material A-L is dressed up equivalent to the inner diameter of the steam chest at the point at which the exhaust core cuts through into the steam chest. This material is dropped through into the core box and secured with loose dowels as shown. Provision for the rounded corner A-K is made by cutting down into the box as shown. The depression not in use is stopped off or filled up before ramming the core.

The half core box for forming one-half of the holding down bolt core is shown in Fig. 47, while one-half of the core box used for forming the relief valve opening is shown in Fig. 48. To assist in the setting of this latter core in its proper position the core print and core box are flattened off as shown at A-J.

The bore or barrel core for the cylinder is usually made in halves, with the aid of a core frame, or is struck up by the aid of heads secured to the core bar, the parts being subsequently bolted together through the core bar, as is shown in the center core, Fig. 49.

Molding the Pattern

A cross section of the completed mold on the line D-D-D-D, Fig. 27, is shown in Fig. 49. This shows the method of parting the mold very plainly and also the method of setting the cores and the arrangement of the parts of the flask. The mold employed is what is known as a skin dried mold, that is, it is rammed up with green sand, the surface of the mold blackened as would be the case in a dry sand mold, and then the surface dried previous to pouring.

CHAPTER IV

PATTERN FOR A DOUBLE PISTON VALVE CYLINDER

In Chapter II the author discussed the pattern work and two methods usually adopted in molding a low pressure slide valve cylinder of the marine type, together with the necessary sweeps required in forming the barrel of the cylinder and the bore or barrel core. In this article he will describe the general construction of the complete pattern for a double piston valve intermediate cylinder, with core boxes and the arrangement of the sweep for forming the bore or barrel core.

Pattern Construction

The position of this pattern during the operation of molding is with its feet up. Cylinders of this type are frequently used on quadruple expansion engines, and quite often reach such proportions that the sweeping of the barrel becomes an object, on account of the saving of material and floor space in pattern storing, and in such cases they are usually dealt with after the manner of the low pressure cylinder described in the former article.

Three views of a cylinder of this design are shown in Figs. 50, 51 and 52. Fig. 50 shows a half vertical section through the center of the cylinder and steam chest. Fig. 51 shows a half section and half plan of the cylinder, while Fig. 52 shows a half end elevation and half section through the valve openings.

In beginning the work, it is essential to lay out a full sized plan and vertical section through the barrel and steam chest. The usual allowance for contraction is 1-12 inch per foot. Considerable board space can be saved if these views are laid out over each other and their outlines traced with different colored crayon or shellac so that they may be readily distinguished from one another.

The manner of building up the first section of the pattern containing the inclosed head of the cylinder, the stuffing box, feet, and a portion of the steam chest, is shown in Figs. 53 and 54. The web A is gotten out with a form coinciding with a section of the barrel and steam chest at this point. The ring B, containing the lower cylinder flange, is built up, turned, and placed upon the web. The portion of the steam chest containing the lower steam chamber with the nozzle is now built on and up to the ring. The material used in closing the top of this portion of the pattern being of the required thickness, is allowed to project outward so as to form the flange of the steam chest.

The stuffing box is turned up with a loose flange, which is cut in sections and held with loose pins, so that these sections can be drawn in. The ribs are usually attached to the stuffing box, forming a loose spider, which is doweled in place, allowing it to be lifted off with the web.

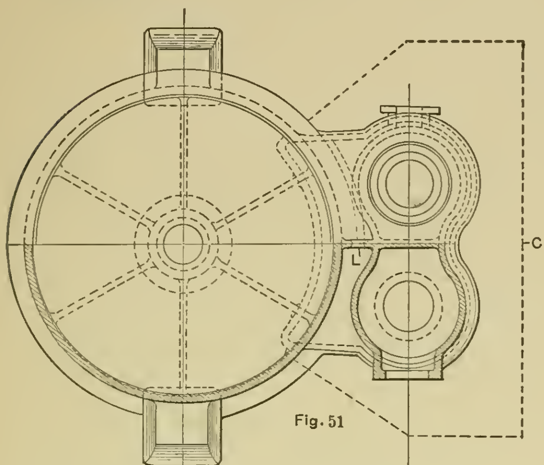


Fig. 51

Fig. 50. Half Vertical Section and Half Elevation of Cylinder

Fig 51 Half Section and Half Plan of Cylinder

Fig. 52. Half End Elevation and Half Section Through Valve Openings

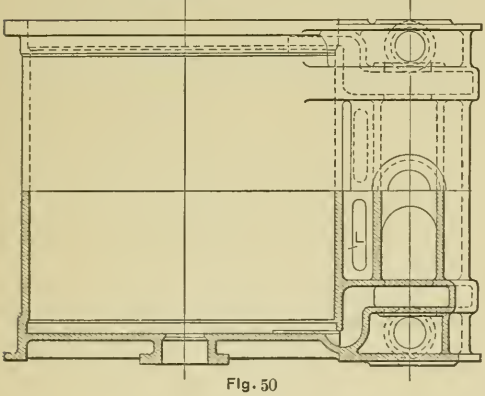


Fig. 50

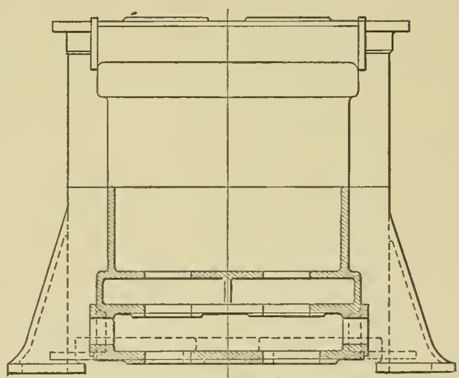


Fig. 52

The patterns for the feet are made in two sections and doweled together, the parting being in line with the top face of the cylinder flange. The cope portion is provided with a loose flange which allows the central portion to be drawn first and the projecting portions of the flange to be picked in afterwards. The part of the feet extending down the barrel is secured to this portion of the pattern from the inside with loose pins and screws. A partial section of the barrel is shown in connection with the first section of the pattern in Fig. 55, the barrel being broken away in two places in order to shorten it up.

It will be noted that there is a parting along the line C F F. The barrel of the cylinder is made up by building up rings, turning them and lagging these over. If the lagging is sawed quite narrow, it will require very little fitting and can be gotten out to the required thickness and then dressed off with a very small amount of work after it is in position.

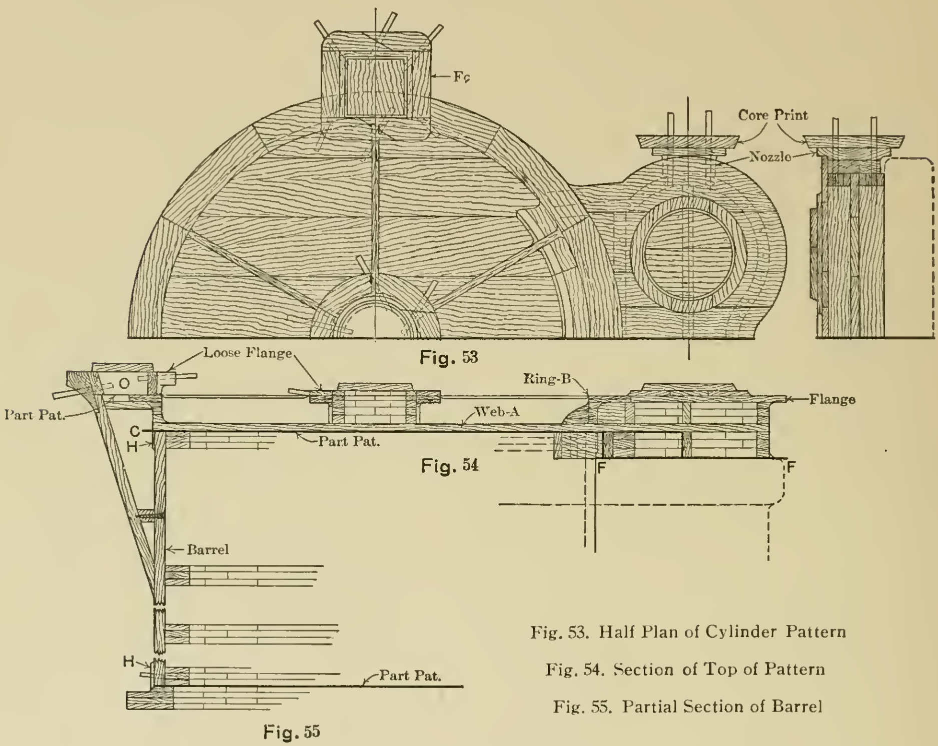


Fig. 53. Half Plan of Cylinder Pattern

Fig. 54. Section of Top of Pattern

Fig. 55. Partial Section of Barrel

At the bottom of the pattern there is a flange which is parted from the lagged up portion as shown, the flange being built up, turned and doweled in place. In order to reinforce the portion of the cylinder opposite the counter bore at each end, it is necessary to introduce the lagging shown at H, at the top and bottom of the barrel. That at the top is secured to the barrel so that it will draw with it, but that at the bottom must be attached with loose dowels so that it may be picked in after the pattern is drawn.

Two views of the steam port section of the steam chest are shown in Fig. 56, two of these parts being required. They are generally gotten out as shown, the sides being made up of segments and the top and bottom closed in.

The exhaust chamber section of the steam chest is shown in plan and section in Fig. 57, the manner of construction being clearly shown. As will be noted the sides are lagged up over ribs built up of segments and cut out to the form of the outline of the pattern.

The exhaust nozzle I, with its core print, is also shown attached by screws and loose pins from the inside. Three views of the upper steam chamber section of the steam chest are shown in Fig. 58, together with the steam nozzle J, which is attached with loose dowels. This part of the pattern is built up of segments and the side forming the top closed with material corresponding in thickness to the required thickness of the flange, the material being allowed to project over and form the flange as shown. On account of the fact that the steam

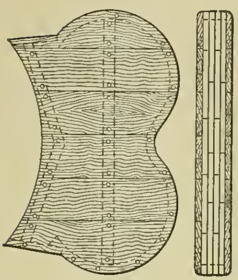


Fig. 56

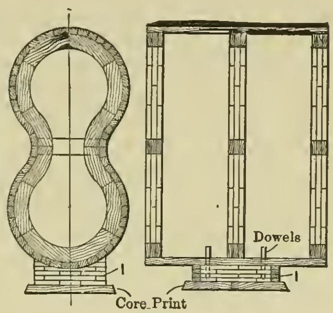


Fig. 57

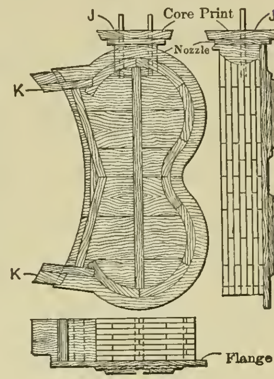


Fig. 58

Fig. 56. Plan of Steam Port Section of Steam Chest Fig. 57. Exhaust Chamber Section of Steam Chest
Fig. 58. Upper Steam Chamber Pattern

ports are of a greater width and that they pass partially through the steam chamber, it is necessary to extend this portion of the pattern as shown at K.

The assembled pattern is shown in Fig. 59, in the reverse position to that which it occupies in molding, but in the position which it occupied during the building. After the different parts are complete, the first section containing the inclosed cylinder head, etc., is blocked up upon the floor as shown. The barrel is placed in position upon it and secured with dowels. The various sections of the steam chest are then placed one upon another, each being located in its proper relationship to the others, by means of suitably placed dowels.

The rib L, which connects the exhaust chamber with the barrel, and which is also shown in Figs. 50 and 51, is made with a joint lengthwise through its center, so that one-half of the rib can be drawn each way, that is, one-half into the barrel and the other half into the exhaust chamber. This is necessary on account of the openings in the rib, as shown in Fig. 50.

Core Box Construction

The core box used in forming the steam chamber, is shown in Fig. 60, the sides being built up of segments, worked out to the proper form, doweled to the bottom board and parted as shown. This allows the bottom to be lifted off when the box is rolled over the sides to be drawn back, and the loose piece drawn out.

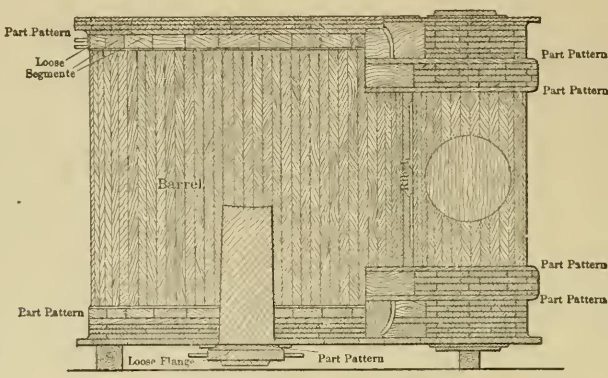


Fig. 59. Assembled Pattern

The cores forming the steam chest must of necessity be placed one upon another when coring the mold, as shown in Fig. 63, and the vent taken off from one core to another and out through the cope. To facilitate the location of these cores in their proper relationship one to another, and to assist in carrying the vent from one core to another, a projection is made on the bottom of each core and a corresponding depression in the top of the one below to receive it, thus forming a male and female joint between the cores. The arrangement of the core box to form the projection is shown at R, Fig. 60, while the print forming the depression is shown in dotted lines at S, Fig. 61. These projections and depressions must be reversed from the bottom to the top of the boxes, as the case requires.

The plan and section of the port core box, with the arrangement of sweeps for forming the outer surface of the circular portion of the core, are shown in Fig. 61. This box is constructed as shown, with the projecting arm or bracket, to which the sweep is secured with the center pin. In the course of ramming up the flat portion of this box, a board with an opening to form the projection or print is secured to the box as shown by the dotted lines at X. After the flat portion of the core has been completed, this board is removed, the sweep set in place, and sand rammed in against the circular portion of the box and struck off with the sweep. By referring to Fig. 63, it will be noticed that the two cores made in this box meet the barrel core in a different manner, that at the top having a projection which laps

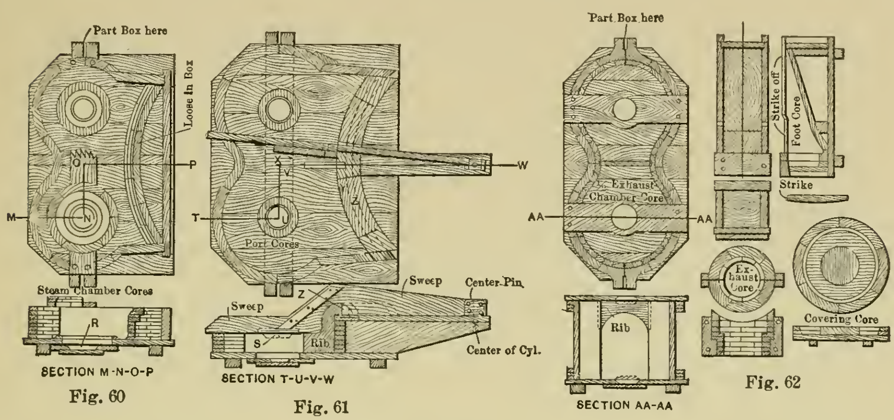


Fig. 60. Core Box for Steam Chamber. Fig. 61. Port Core Box
Fig. 62. Core Boxes for Exhaust Chamber, Feet and Exhaust Opening

over the end of the bore, while the lower core abuts squarely against the barrel core. To provide for the making of the lower core, it is necessary to furnish a stop-off piece to stop off the core on the dotted line Z.

A plan and cross section of the core box used in forming one-half of the exhaust chamber are shown at the left of Fig. 62. The drawing gives the general method of construction and shows the manner in which the rib is drawn out before the box is rolled over and taken apart.

The foot core box is shown by three views in the upper right hand corner at Fig. 62, and it will be noticed that the top is struck off, the strike being shown below the core box.

The core boxes for making the exhaust opening and the covering core used in connection with it are shown in the lower right hand corner of Fig. 62, and the construction and use will be evident from the drawing.

Method of Molding

The molding is carried on as follows. The foundation plate F, Figs. 63 and 64, is placed in position and leveled up. The pattern is then blocked up upon the same and the space below the pattern filled with brick, with a thickness of loam against the surface of the pattern. An off set parting is prepared parallel with the edge of the flange, and at a short distance from it, as shown at P. A lifting plate of proper form is provided and placed upon this parting as shown at K, and the brick and loam work continued up to the lower port chamber, as shown at G, Fig. 63.

By referring to Fig. 50, it will be noticed that the form of the port chambers and the way they fit into the side of the barrel makes it necessary to form this portion of the mold upon cheek plates, as in-

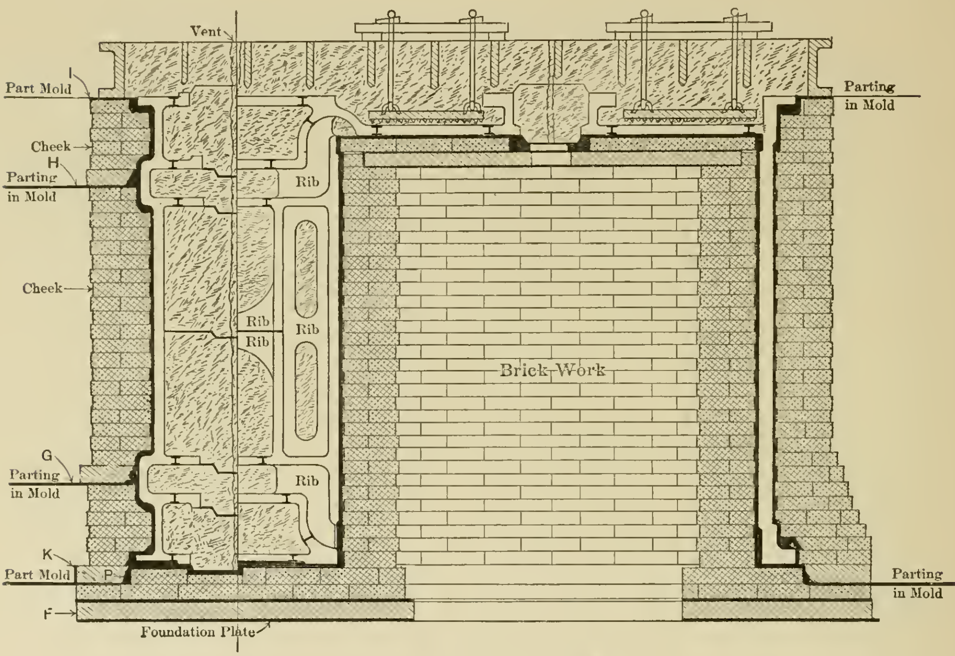


Fig. 63. Section of Completed Mold

dicated by the dotted lines C, Fig. 51. An offset parting for this plate is made upon the surface G, Fig. 63. From the ends of this cheek plate it will be necessary to carry up a vertical parting clear to the top of the mold, this vertical parting extending on a radial line from the barrel of the cylinder. The brick work is then continued until the upper port chamber is reached, where it is necessary to make another parting, as shown at H, and place another cheek plate, similar to that placed upon the parting G. The brick work is then continued to the top of the mold at I, and a parting prepared for the cope which is rammed up in dry sand in an ordinary iron flask.

After the mold is completed, the cope is lifted off and the first section of the pattern containing the inclosed cylinder head is drawn. This gives access to the interior of the barrel and allows the pins and screws securing different parts of the pattern to the barrel to be removed. The barrel is then drawn. The cheeks are then lifted away, and the different sections of the steam chest pattern behind them drawn as they are exposed. The plate K, which supports the outer wall of the cylinder and the lower section of the steam chest and cylinder flange, is then lifted off and while suspended the lower portion of the pattern is drawn down from it.

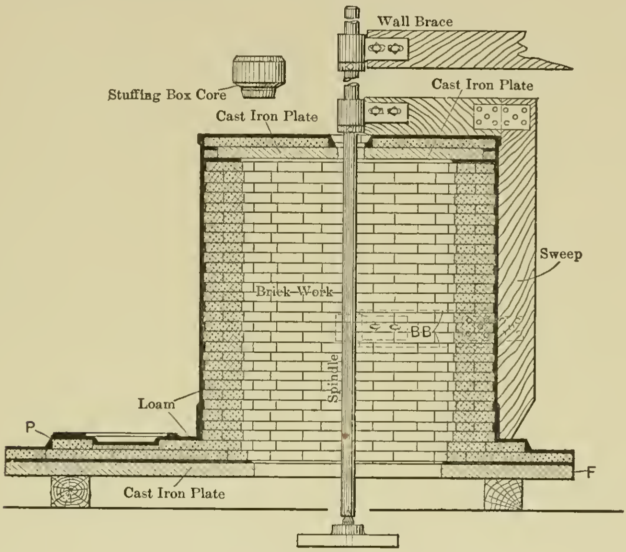


Fig. 64. Sweeping the Core for Cylinder

The parts of the mold which have been removed are then placed in the oven to dry and the spindle is located in the center of the cylinder for sweeping the barrel core, as shown in Fig. 64. The barrel core is swept up with brick and loam in the usual manner. The lower arm B-B (shown by dotted lines) is removed when the brick work reaches this height, and the completed portion of the sweep surface is used as a guide for the lower end of the sweep. A cast iron plate is placed on top of the brick walls, close to the top, and the upper surface finished as shown, with the seat or print swept in the center to receive the stuffing box core.

The stuffing box core is shown in detail to the left of the upper part of the spindle in Fig. 64. The barrel core supported by the plate is now placed in the oven and dried.

The assembling of the mold is as follows: The foundation plate F, with the barrel core and the seat upon it, is lowered into the pit and leveled up. The plate K supporting the outer wall of the barrel is next placed upon it. The cores and cheeks forming the steam chest are now lowered into place in their proper position.

The nozzle cores are inserted from the outside of the brick work through openings left for the purpose, and the openings closed with the covering cores.

The gates and runners are prepared during the building of the mold, the cope placed in position, and the intervening space between the mold and the pit wall firmly packed up by ramming in sand. The cope is then weighted or bolted down, when the mold will be complete and ready for pouring.

CHAPTER V

PATTERNS FOR A HEAVY ENGINE BED

Engine frames or beds assume various forms, being chiefly designed to suit the work and requirements in each particular case. Shown in the accompanying illustration is a familiar form of a heavy duty, or what is sometimes termed the Allis type of bed. This form is especially adapted to heavy mill work, and the engines are frequently made and connected up in pairs, the dimensions assuming large proportions.

The one under discussion is the right hand bed of a pair of reversible, piston valve blooming mill engines. The general practice with concerns building engines of this type is to construct the bed patterns so that they will serve for both right and left beds, and also for engines of different strokes. There are a number of different ways in which a pattern of this nature can be constructed, and it may be difficult to decide which is the most practicable and economical both for the patternmaker and the molder, for in all such work both the patternmaking and the molding should be taken into consideration.

As the duplication of these bed castings is frequent with concerns doing this class of work, the construction of a complete pattern is usually considered the most economical.

Construction of the Patterns

The pattern can be constructed to serve for both the right and left bed somewhat after the manner illustrated and described in this article. Fig. 65 shows the plan and elevation of the bed showing its general outline and the metal distribution. It also shows the points at which the cross sections illustrated in Figs. 67, 68, 69, 71, 72 and 73 were taken. These cross sections should receive close attention from the patternmaker, in order that he may obtain a thorough knowledge of the requirements in making up the core boxes.

Viewing the frames from the front it would appear as illustrated in Fig. 66, while the cross section on the lines AA, BB and CC would appear as shown in Figs. 67, 68 and 69. Fig. 70 shows the outline of the back or cylinder end of the frame, while Figs. 71, 72 and 73 illustrate the cross sections on the lines DD, EE, FF as they would appear from the cylinder end.

Of course, the first thing would be for the patternmakers, foundrymen and others interested, to get together and thresh out the

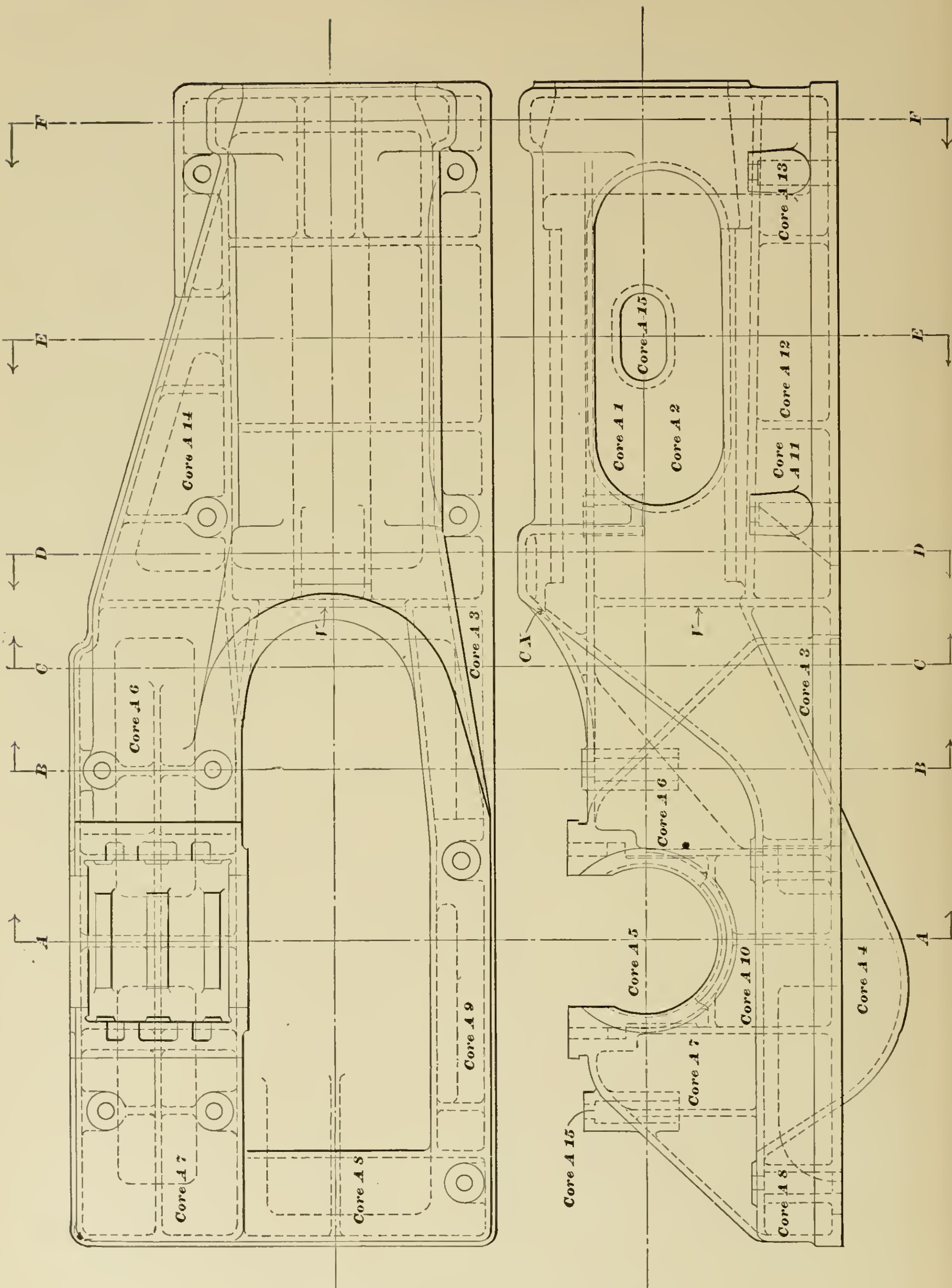


Fig. 65. Plan and Elevation of a Large Engine Bed

general discussion of the molding, shrinkage, arrangement of cores and the construction of the pattern. When this has been done a full sized layout giving both the plan and elevation with core outline or metal distribution is essential. It is also necessary to draw a number

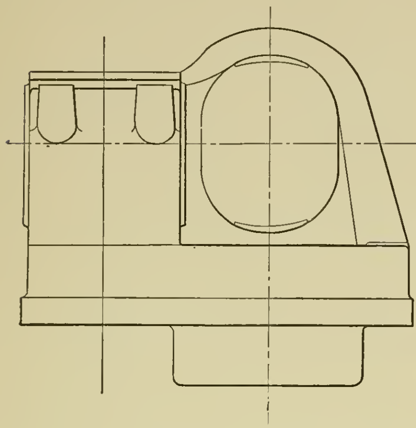


Fig. 66. Front End View

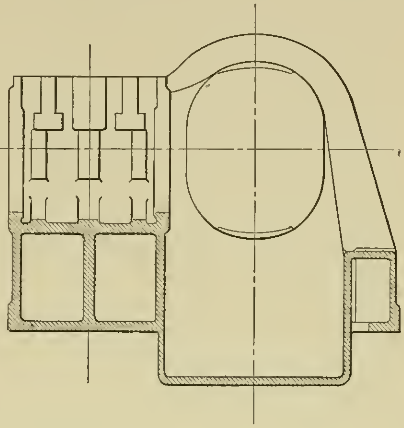


Fig. 67. Section A A

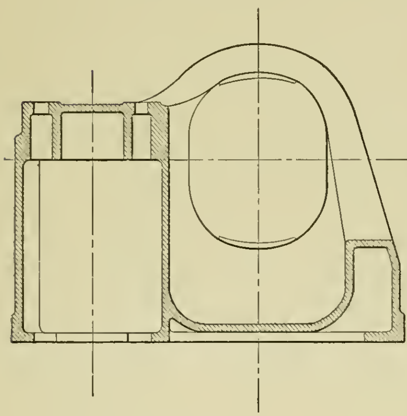


Fig. 68. Section B B

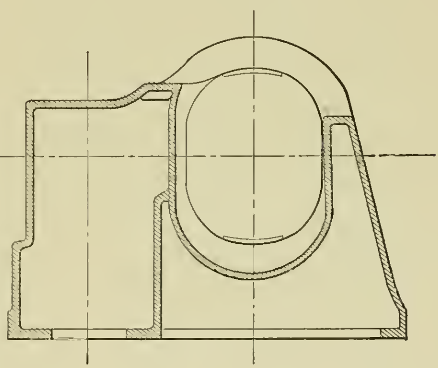


Fig. 69. Section C C

of cross sections, say for instance, AA, DD, EE and FF. To economize the layout board surface, these layouts can be made over one another and dotted in with different colored crayon or shellac, which will enable the workmen to distinguish one section from another without difficulty. The shrinkage usually allowed is 1-12 of an inch per foot, with a liberal allowance for finish upon all machined surfaces.

It might be well to state that in the construction of large patterns the closer the exact dimensions are worked to, the easier will the work be completed. That is, allow scarcely any material for dressing to size. Place what draft is desired upon the frames, and inclose them with the required thickness of material. Then the only work necessary is the cleaning and sandpapering of the pattern.

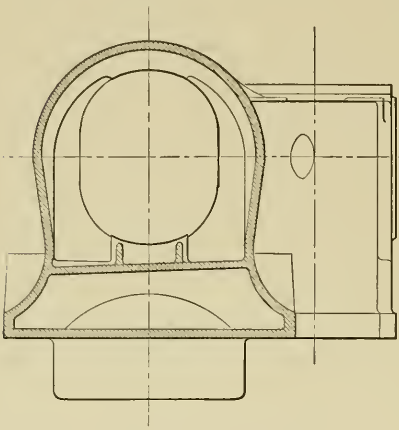


Fig. 71. Section F F

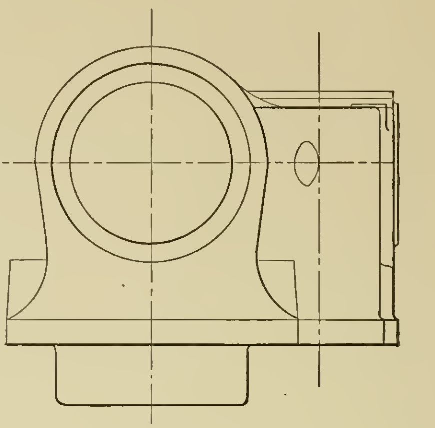


Fig. 70. Back End View

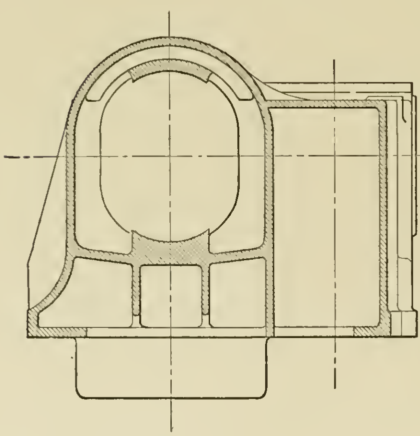


Fig. 73. Section D D

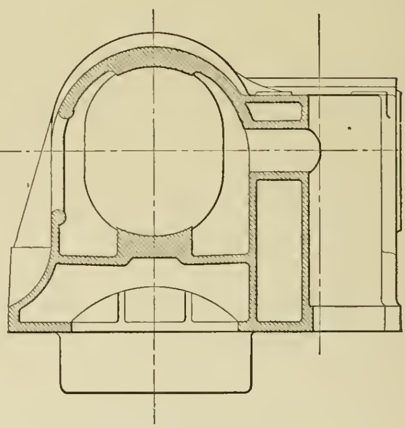


Fig. 72. Section E E

To facilitate the altering of the pattern for different strokes, as well as the handling and storing of the same, it is built in sections and assembled as illustrated in Fig. 74, which shows the general construction, the joints of the various sections or parts, together with their attached core prints, loose pieces, etc.

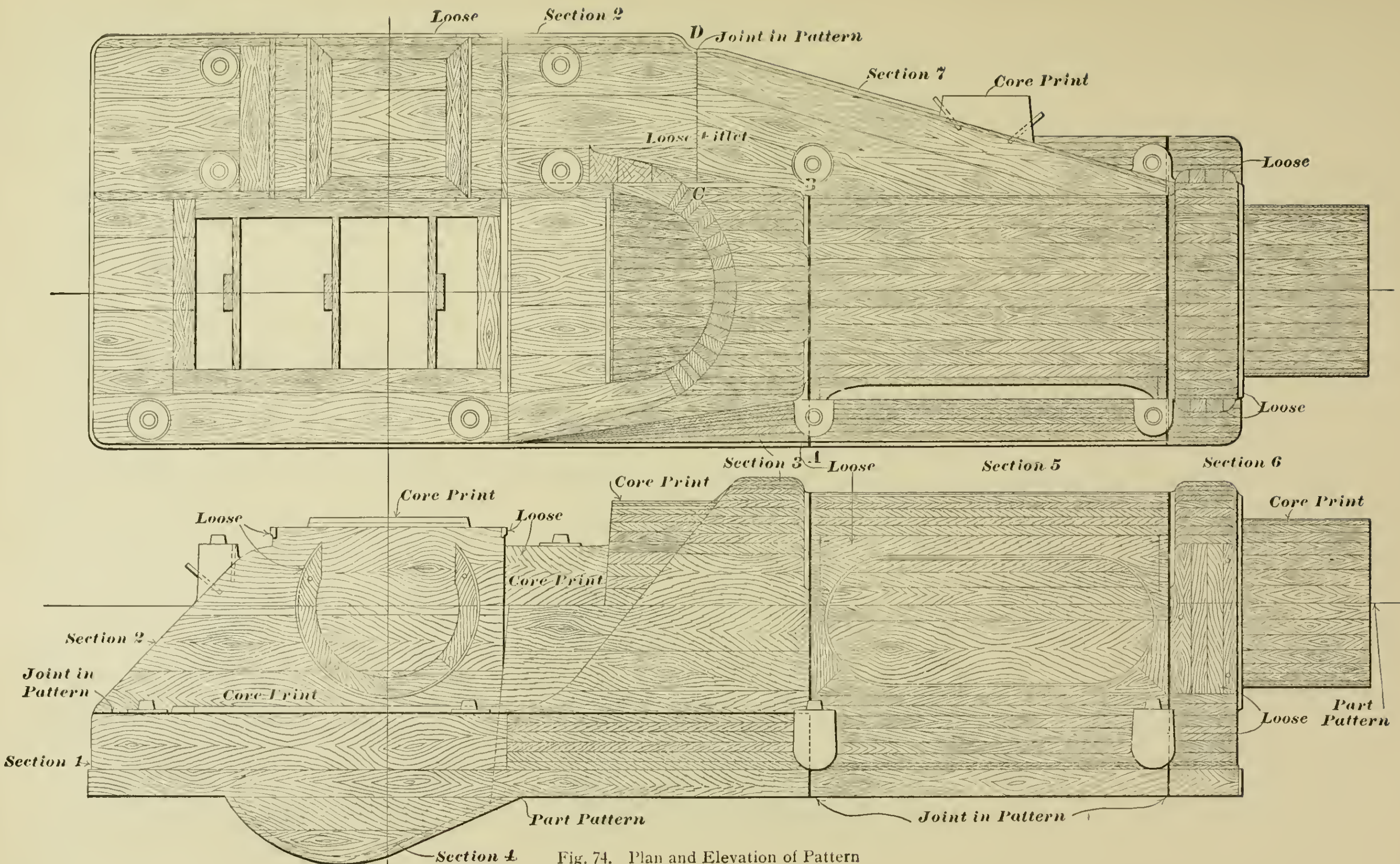


Fig. 74. Plan and Elevation of Pattern

To aid us in referring to the different sections or parts during a discussion of their construction, let us designate them as sections 1, 2, 3, etc. Sections 1, 2, 3 and 4 comprise the forward or bearing portion, while sections 5 and 6 comprise the cross head housing, and part 7 the bracing member.

As section 1 usually receives the initial attention, let us proceed with its construction as shown in Fig. 75. This section, together with sections 2, 4, 5 and 6, are used for both right and left hand beds. It will be observed that in using this section for both right and left hand patterns it is necessary to make right and left hand corner pieces G and H, and also to provide for the reversing of the strips forming outline of the crank-pit core print I, and the covering material J, Fig. 75.

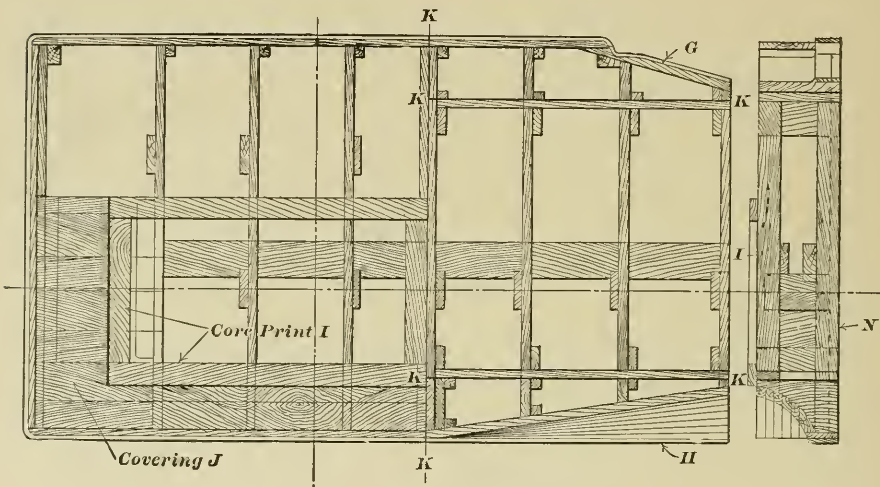


Fig. 75. Section 1 of Pattern

The frames can be gotten out, secured together, and the sides inclosed somewhat after the manner illustrated. Offsets are formed on the line KK to receive the right and left hand corners G and H, which are next built in place and secured with dowel pins and screws. The covering material J is next added, and the strips forming the outline and thickness of the core print I attached. This manner of forming this core print answers the purpose very well, and permits of an opening through the pattern to facilitate the ramming of the mold. In closing the bottom N, the material can be cleated together in two or three sections, which permits of its easy removal giving access to the interior for the withdrawal of the screws and pins, and for the rapping and drawing of the pattern.

Fig. 76 shows a plan, elevation and end view of section 2 of the pattern. The frames O, as shown in the end view, are nailed and screwed together, and covered with stock to form the required outline. As this section is employed for both right and left hand patterns, it is necessary to make an offset on each side along the lines LLL. This space is then filled with a right and left hand piece shown above and to the right of the other views. The right hand piece being shown in place in Fig. 76.

Next the core print M is attached, a section of which is shown in greater detail to the right of the plan. Attention is called to the strip P around the outer edge of this print. The strip being added to assure a perfect setting of the core, for any sand disturbed in the placing of the bearing core in position, will fall down below the seat of the core and into the depression left vacant by the strip P.

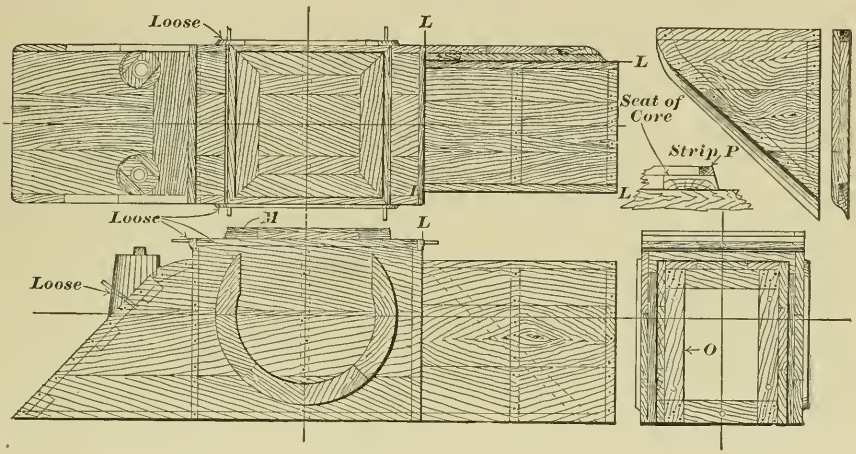


Fig. 76. Section 2 of Pattern

The loose facings and the holding down bolt lugs, having been gotten out are attached with loose dowels, and this section is then ready to be placed in position upon section 1, the two parts being secured together with dowels and screws. These dowels and screws must be so arranged that they are get-at-able when the bottom is removed from section 1.

It is next necessary to construct that part of pattern designated as section 3, as shown in two views and a section on the line QQ in Fig. 77. For this section it is necessary to build a complete right hand and a complete left hand piece. Owing to the irregular form this section is the most difficult to construct, and it is advisable to build it in its correct position upon section 1, with the end fitting against section 2, as shown in Fig. 74. First the lower part of the core print to the center line or height R, and with a width equal to S, is framed up and the top and end closed in. The projection which fills in the offset on the line LL of section 2, built up as shown at Y. The arch frames T and U are now gotten out and placed in their correct position. These frames differ in form, frame T being of an elliptical shape, while U is circular. As the required opening is given through the rib D, section 1, it will be found convenient to locate frame U

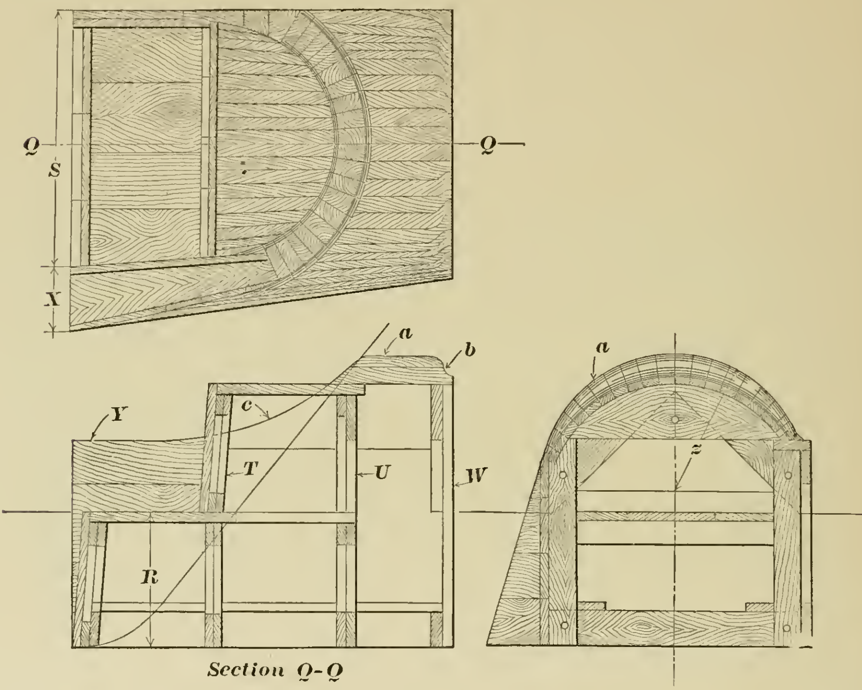


Fig. 77. Section 3 of Pattern

at this point and lay it out accordingly. Of course, allowance must be made for the round corner CX, Fig. 65, which would make the core print that much larger in diameter. The lagging is now placed on and dressed to its proper form. Frame W is then set in position, and the width X built up to the point of tangency with radius *z*. Lagging *a* is now fitted on, dressed to form and the fillet *b* worked out.

Section 5 as shown in plan and cross section in Fig. 78 forms the cross head housing, and is used in both right and left hand patterns. The use of this piece for both right and left hand patterns necessitates the building of oblong openings in each side, the one not in use being closed or stopped off by the bracing member or section 7, Fig. 74. It will be observed that this part of the pattern is built the full height and secured to the end of sections 1 and 3 with pins and bolts. The frames are usually gotten out as shown in the cross section *de*. These frames are lagged over forming the depression *c* on the sides. This depression has a depth equal to the metal thickness which allows the core to cut through when placed in the mold. The oblong openings are now built in with that portion above the center, as shown at *g* secured with pins, so that it may be drawn in after the pattern is removed from mold.

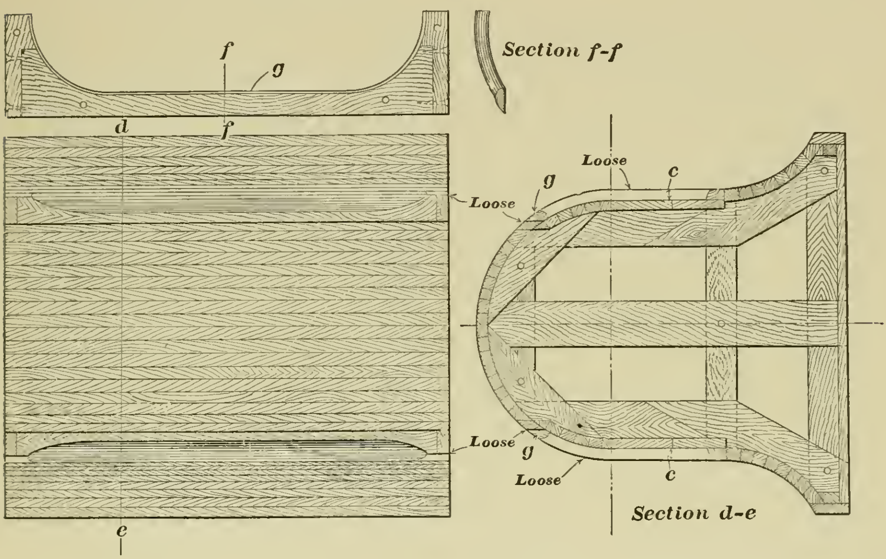


Fig. 78. Section 5 of Pattern

The cylinder end of section 6, is shown in two views in Fig. 79. This portion is used for both right and left hand patterns with practically no change. The frames, two in number, are gotten out and secured together. It will be observed that the outer one, as shown in the end view, is partially closed, leaving a square opening to be covered with the attached core print.

These two frames are lagged over, provision being made to secure the loose pieces HI which are left detached from the pattern to facilitate its drawing from the sand when checking off this portion of the pattern. These loose pieces are next fitted in place and secured, when this portion of the work receives its dressing up, corners rounded, etc.

The core print, one-half of which is shown in two views, Fig. 80, is staved up, the forms being gotten out and covered with lagging and turned in halves, the lower or drag half is secured in its proper position to section 6 with screws and loose dowels, and the upper half placed upon the lower half. Segments forming the loose facings JK are next attached when this section will be ready to secure to section 5, as shown in Fig. 74.

Section 7—or what is sometimes termed the bracing member, is shown in three views, Fig. 81. It is necessary to make both right and left hand patterns for this. The section is built in its proper position to the assembled sections, as shown in Fig. 74, the frames having been

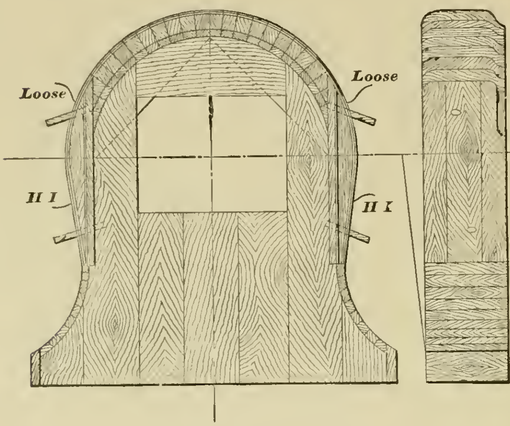


Fig. 79. Section 6 of Pattern

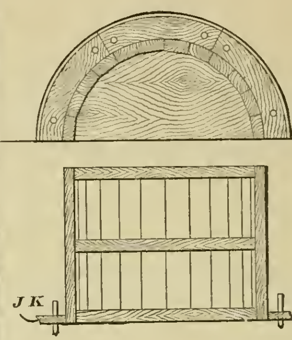


Fig. 80. Core Print for Cylinder End of Pattern

nailed up with ample stock allowed for fitting and sawing to size. They are fitted to the sections 2, 3 and 5 and secured in place with screws and pins.

The proper outline of the section is next laid off upon them; they are then removed and sawed to size and returned to their proper position, where they are secured and well braced together. The material inclosing the top and side is next placed in position and dressed up, and the core print LM attached.

The large fillet shown in two views in the lower right hand corner of Fig. 81 is gotten out, and fitted in place up to section 3 and worked out to shape.

With a dressing up and finishing of the assembled sections of the completed pattern, this part of our work is done, with the exception of the crank pit extension, as shown in two views in Fig. 82. This is constructed by getting out sides and center rib, securing them together with separating pieces and then lagged up. To avoid the end grain of the material used in the lagging, shown on the sides of the pattern, the sides are gotten out of the required form, and the lagging fitted so as to butt against the inside of these pieces, that is, to fit between them. This necessitates a segment, which forms a shoulder to receive the lagging, and is placed in position and secured to the inside of the side pieces. The lagging afterwards is placed in position and dressed off to conform to the sides. This section is used for both right and left hand patterns. The one change necessary is the change of its position on section 1.

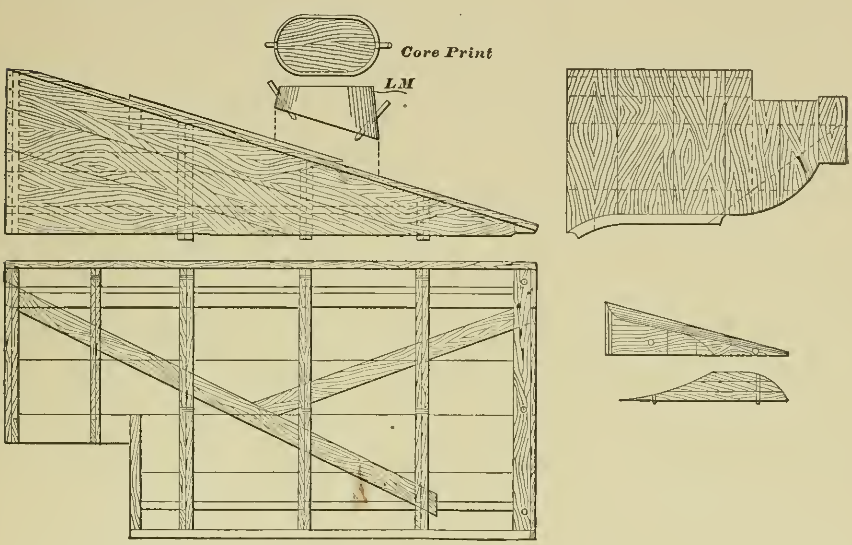


Fig. 81. Section 7 of the Bracing Member

The holding down bolt lugs, etc., are now fitted to the assembled pattern. The various sections given designating marks, so that they can be returned into their proper relationship one to another, after which the pattern is dismantled and set up in a reverse position as required for the left hand pattern, the various left hand sections built in just as the right hand sections were.

Construction of Core Boxes

The core boxes, fifteen in number, next claim our attention. For convenience in referring to the various core boxes employed in forming the interior of the frames they are designated, A1, A2, A3, etc., the location of the cores being shown by the letters placed on Fig. 65.

As the most of these boxes are of simple construction, we will illustrate only those, with the exception of A3, receiving core print settings. The ones illustrated embrace the most intricate boxes in the set. All of the boxes are made of rectangular form, and are all employed for making both right and left hand cores. The form of the cores and changes from right hand to left hand being made by changing the position of the filling in pieces, or by the use of right and left hand sections of the boxes.

We will first consider the construction of the boxes used in forming core A1. This core forms the upper half of the interior of the cross head housing, and is supported in the mold by its projecting core prints, as shown in Fig. 74. This box is, with one exception, the

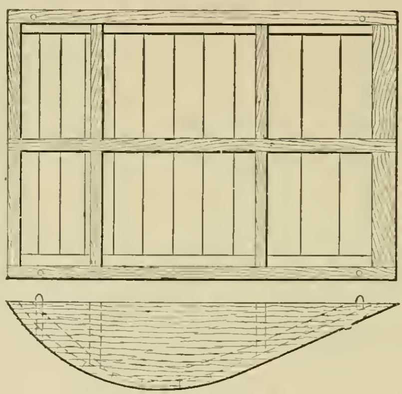


Fig. 82. Crank Pit Extension Pattern

largest and most intricate box to construct. It is shown in plan and longitudinal section through the center, and a cross section on the line LM, in Fig. 83.

Material of about 2½ inches by 6 inches for forming the rectangular frame is first gotten out and secured together in a good substantial manner, about as shown. The cylindrical part forming the projecting print portion at the right of the figure can be staved up and dropped into place. The board forming the taper on the end of the print is fitted in separately. The segments forming the depression O are now nailed up, layed off, sawed out, dressed to the proper form, dropped into place and secured, and the staving up of the barrel proceeded with.

The depression R is also built up of segments, dressed out and fitted in place. It will be observed that a slight change is required at the top of the box at this point, for the right and left beds, and

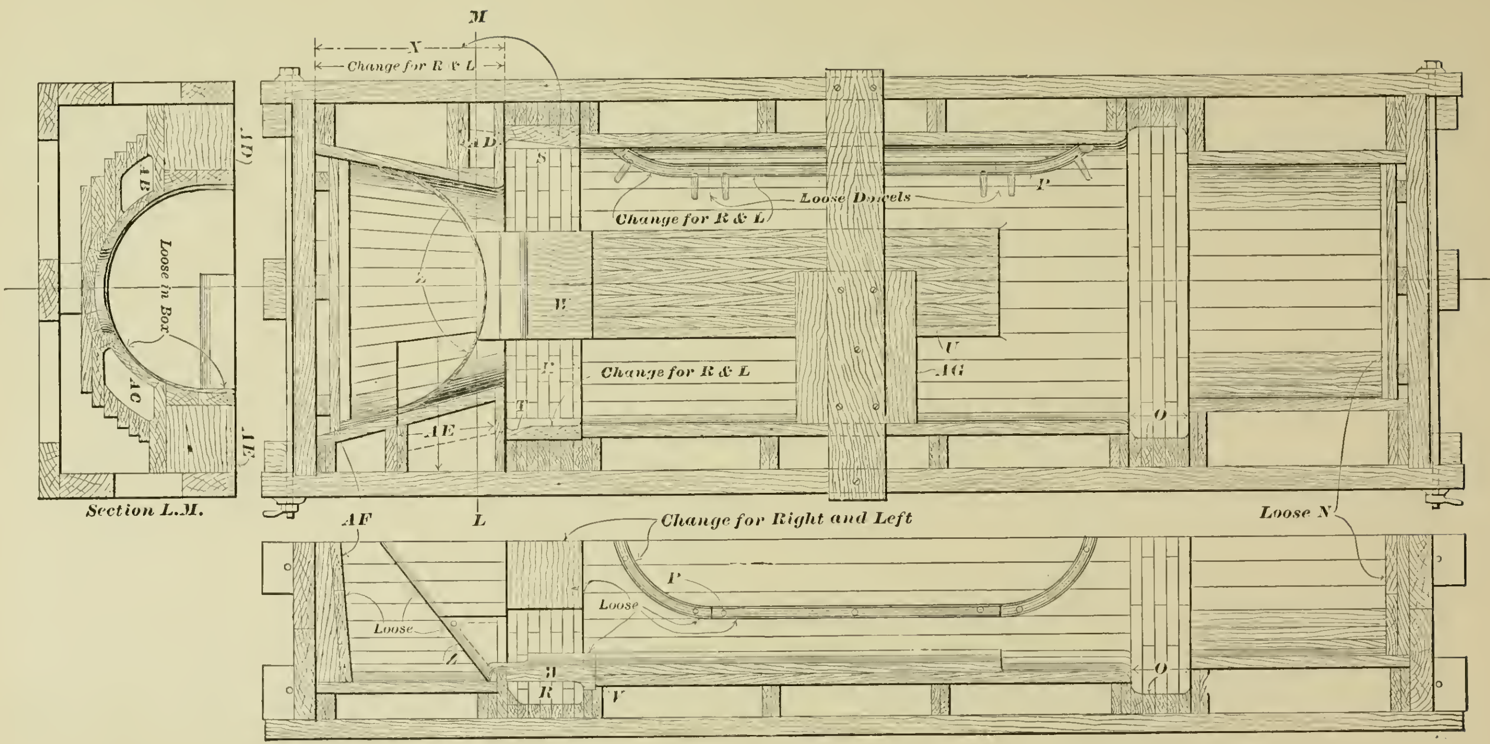


Fig. 83. Core Box A 1

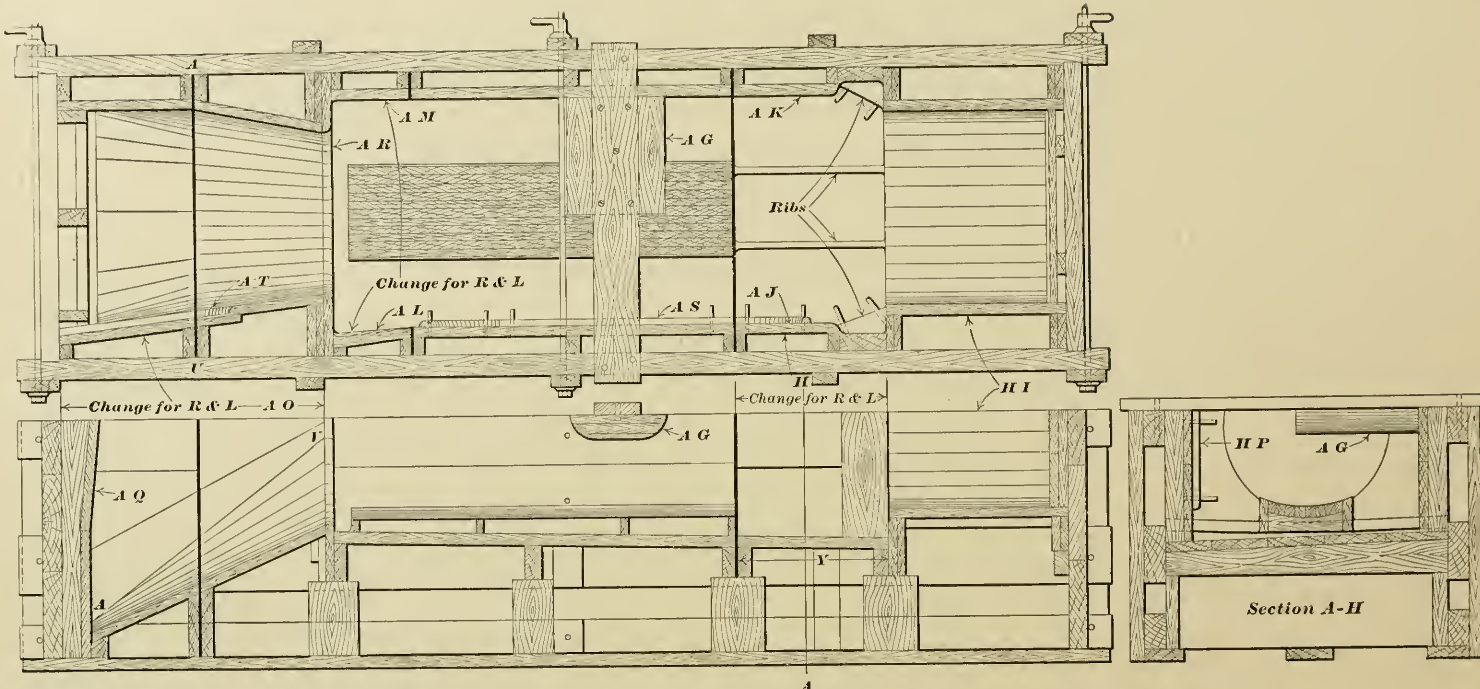


Fig. 84. Core Box A 2

that this necessitates the changing of the blocks S and T. The cross head guide U is now lagged in with the shoulder V arranged as shown to support its projecting end, or loose piece W. This loose piece W must be drawn back out of the core after the removal of the boxes. As the remaining portion of the box cannot be used for

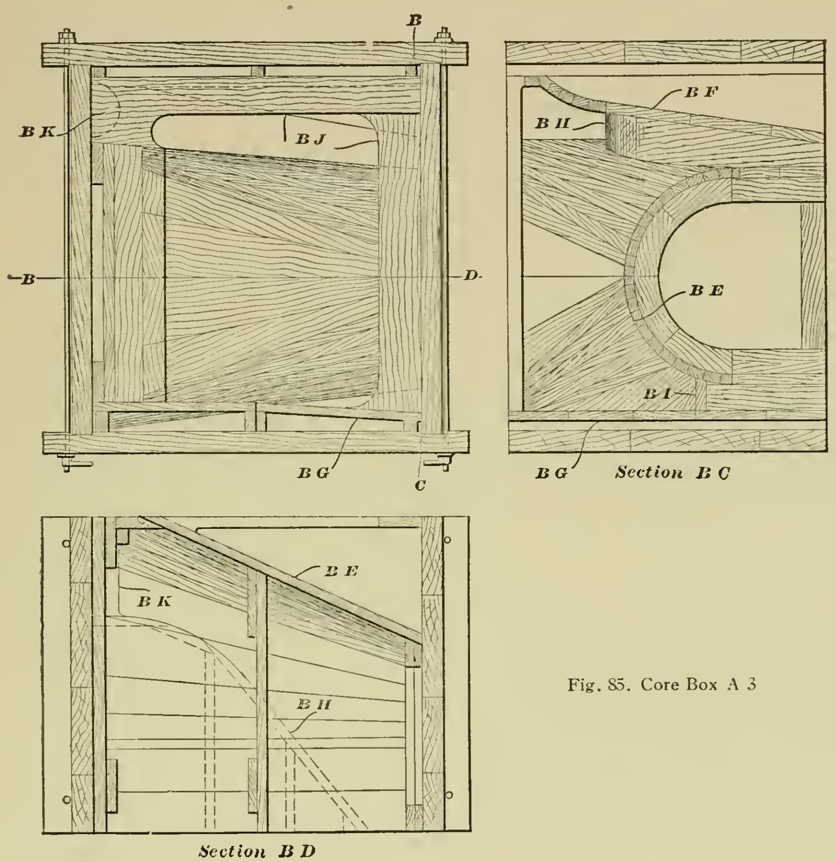


Fig. 85. Core Box A 3

both right and left hand patterns, it becomes necessary to construct a full right and a full left hand section for the portion marked X.

The core print portion having been lagged up and dressed out to conform to the core print of the pattern, the outline of the round corner is next laid off or transferred to the surface. This can be done very nicely and accurately by placing heavy paper over the core print on the pattern and fitting it up against the rounding surface at the intersection of the core print and the pattern. The paper is then placed in the correct position in the core boxes, after which the filling in pieces or lagging, are fitted to its outline as shown by Z.

Material is now added from which the pockets AB and AC, as shown in section LM, are worked out. The blocks or loose parts AD and AE are fitted above the pockets AB and AC.

It will be noticed that these loose pieces AD and AE must be removed and the openings left vacant by them filled in with green sand to support the overhanging projections after the box has been turned over upon the core plate.

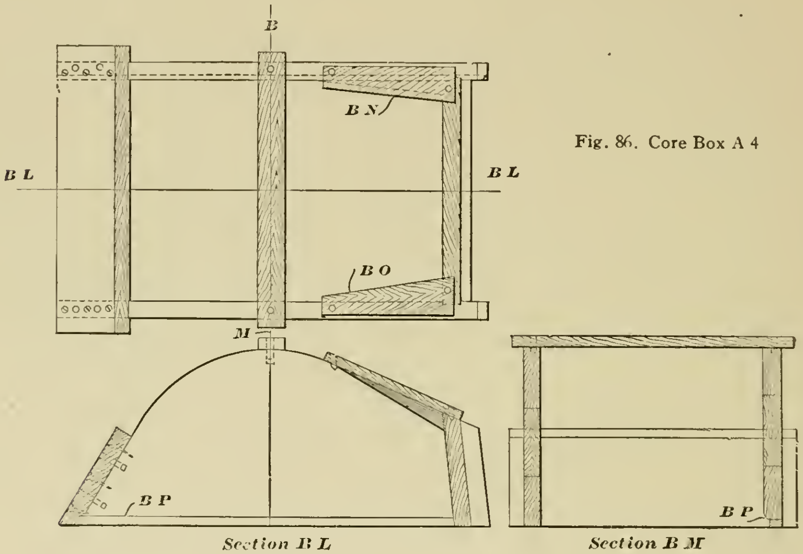


Fig. 86. Core Box A 4

The board AF is now fitted into the end of the box to give the proper taper to the end of the core. The core print AG which is suspended from the top of the box is located and doweled in place. This core print AG forms the interior setting for the oblong core A15, which passes through the core A14 intended to form the interior of the bracing member. This core print is made longer than the setting of the cores requires owing to the fact that the core has to be placed in the depression left vacant by the core print, and then shoved forward through the core A14 and into the impression left by the core print on the pattern. The portion of the core print left vacant after the core A15 has been shoved to its final position may be stopped off with sand.

This completes the core box for the right hand bed. In making the changes for the left hand bed it is necessary to build a left hand section X, and to get out pieces S and T of the opposite hand. It is also necessary to change the beading P around the oblong openings in the side of the cross head housing to the opposite side of the box. The suspended core print AG is also changed from one side of the box to the other.

Fig. 84 shows a plan, a longitudinal section through the center, and a cross section on the line AH of the core box used in forming the core A2. This core when placed in position upon core A1 completes the interior of the cross head housing, and also the exterior part of the bed leading down into the crank-pit. While this illustration is almost self-explanatory a few remarks may not be out of order. The frame is constructed about the same as for the box previously described, and the filling-in sections made, dropped into place and secured to the frame. It will be observed that the only two sections employed for both the right and left hand beds, are the center section or that part which contains a cross head guide, and the round core print H1. With the two parts H1, and the part for the cross head in place, the bottom board Y is fitted in, and the side pieces AJ and AK dropped into place upon it. The side pieces for the center section having been gotten out and secured in place, the change pieces AL and AM are fitted in, as well as board AR, which contains the circular opening at the forward end of the housing. With the suspension of the core print AG, which can be used in both boxes A1 and A2, the getting out of the beading AS around the oblong opening on the side of the housing, which matches the beading of the core box shown in Fig. 83, this portion of our box is completed and the lagging in of the section AO proceeded with. Owing to its irregular form and the provision which has to be made for taking care of the rounding corner AT, it will be found convenient to make the section in four pieces and join them at AU and the sides along the line AV as shown.

Core A3 which forms the metal thickness of that portion of the frame directly forward of the cross head housing is made in the core box shown in plan and two cross sections in Fig. 85. This is a large cumbersome box for making a comparatively light core which is due to the built up form BE, which occupies the greater part of the box interior and conforms to that part of the frame extending down into the crank-pit. Of course, in constructing this part of the box, allowance is to be made for the metal thickness. Practically none of this box can be used for the opposite hand bed except the frame, which is put together as shown. The form BE is lagged up over supports, dropped into place and secured with pins. The material forming the outline of the sides BF and BG is gotten out and fitted in position. Referring to the cross section CC as shown in Fig. 69, which gives the exact outline of the core required, it will be seen that the filling in pieces BH and BI are required to form the desired height and outline of the upright projections as shown in Fig. 85. This box is completed by placing in position the internal flanges BJ and the metal thickness around the holding down, bolt boss BK.

The plan and two cross sections of the core boxes used for forming the core A4 for the crank-pit, are shown in Fig. 86. This box

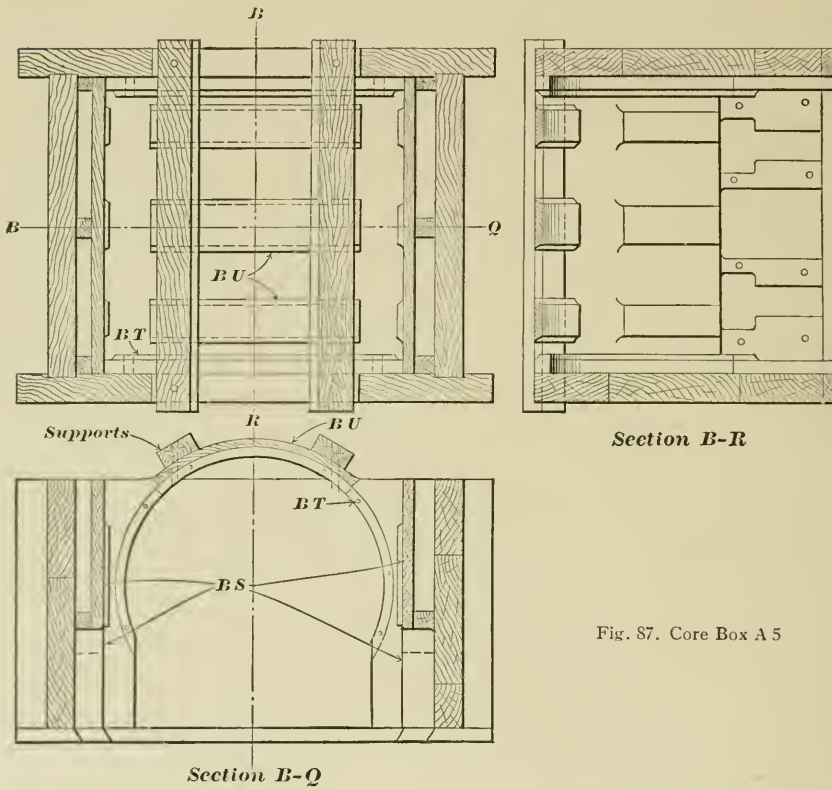


Fig. 87. Core Box A 5

consists of a frame the sides of which conform to the desired height and form of the core, the box being rammed up, struck off and the pieces BN and BO which support the part of the fillet extending into ths core bedded in. It will be observed that this fillet is the continuation of the fillet formed in the core box A2, and which runs out at this point in the crank-pit.

To avoid the sharp corner around the side and end of the pit, an offset as shown at BP is arranged for.

Core A5 which forms the main bearing, is made in the core box shown in Fig. 87, the box being constructed somewhat after the manner illustrated. After the frame is completed the material BS forming the T head facings is made and held in place with loose pins. To form the openings through the metal on each side of the bearing material, the thickness of which is equal to the metal thickness, is dressed up and fitted to the box, and the required openings cut out. The facings BT must also be secured to the openings. The circular pieces on top of the boxes are next attached, and to them are secured the two supports for carrying the circular facings BU.

The seven core boxes or frames used in forming the remaining ten cores are not illustrated, as they are of a comparatively simple nature, so that a description of their general construction and manner of changing from right to left hand will be sufficient. These cores, with one exception, core A15, have no core print setting, being secured in the mold and in their proper relation one to another with chaplets.

Core A10 forming the interior of the bed underneath the main bearing is made in halves, the two halves being joined together with the vertical plane on the center line of the longitudinal rib. As the core is symmetrical about the center of the rib, one-half of the box without any change is all that is required, the two half cores being simply turned over and pasted together. This box consists of a frame and a bottom board, upon which one-half of the thickness of the rib is attached. Next material giving the circular form at the bottom of the bearing, and to form the internal flange at the bottom, together with the cross rib, is placed in the box.

Directly in front and back of the main bearing and extending the entire height of the bed are cores A6 and A7. These cores are also made in halves, being parted in the same plane, that is, along the center rib as was the case in core A10. These four half cores are made from the same frame and upon one bottom board. It will be observed that core A7 is of triangular form, while core A6 is rectangular. As the latter core is the largest the frame and bottom board are made to correspond with its size and filling in pieces used when making the triangular core A7. In ramming up core A7, the bottom of the box forms the joint of the two half cores, while the top of the box forms the joint in core A6. This necessitates the suspension of one-half of the thickness of the rib from the top while making core A6, the change being due to the fact that it is necessary to fill in the bottom board with material to obtain the outline of the metal on the sides, also the internal flange holding down both bosses, etc., which are attached to the side of the box.

That part of the bed between the crank-pit and the extreme front, and which extends part way down the side of the bed, is formed with the core A8. This core is made in a rectangular frame with bottom board, the frame being gotten out the required height and length, and with a width which will allow the placing in of a rectangular stopping off board conforming to the angle of the crank-pit end. It will be seen that this stopping off board does not extend the entire length of the box, but only that portion required in forming the metal thickness across the end, and upon a portion of the side of the crank-pit.

The material forming the internal flange across the end of the bed is now suspended from the top of the boss and the work is completed by placing in upon the bottom board and up to the end of the box, material to form the metal thickness around the holding down bolt. It is also necessary to place a rib on the center line of the bed. This rib separates the core into two parts. The box is rammed up in a reverse position to that shown in the drawing, Fig. 65, that is, upside down.

Core A9 which forms the portion of the space between the side of the bed and the crank-pit and extends from the core A8 to core A3, with the exception of the distance occupied by the thickness of the ribs, is the next one to be constructed. The ribs separating the cores A8 and A9 are on the same angle as the end of the crank-pit. The box is made of rectangular form, and contains a section of the internal flange along the side of the bed, and one-half of the holding down bolt boss, the other half being formed in core A3. With the exception of the piece to form the angle at the end this box is complete.

We next turn our attention to cores A11, A12, and A13. These three cores are all made from the same box. Owing to the fall or pitch of the metal supporting the cross head guide, the bottom of the box requires considerable change for each core. The box consists of a frame with bottom board, and is gotten out in length equal to the width of the bed, plus a convenient allowance for dropping in the lagged up forms, which conforms to the flaring sides at the bottom of the bed, as shown in cross section on the line EE, Fig. 72. The frame is made of sufficient depth to permit the use of filling in pieces upon the bottom board. These pieces give the outline of the cross section of the metal, as well as the proper pitch or fall toward the cylinder end, as shown in the elevation of the bed Fig. 65. The width of the frame is made to correspond to the widest core, which is A12, plus the thickness of the rib, the half thickness of the rib being placed in each side of the box. As cores A11 and A12 do not extend the full width of the bed, but only to the metal thickness separating this part of the bed from the bracing member, it is necessary to use a stop off board to give the core its correct length. The interior flange is placed in at the top of the frame and supported by the lagged up form at the end. The changes required for A11 and A13 can readily be seen by studying the cross sections and Fig. 65.

Core A14 is of triangular shape and forms the interior of the bracing member and a short section of the flaring side of the bed at

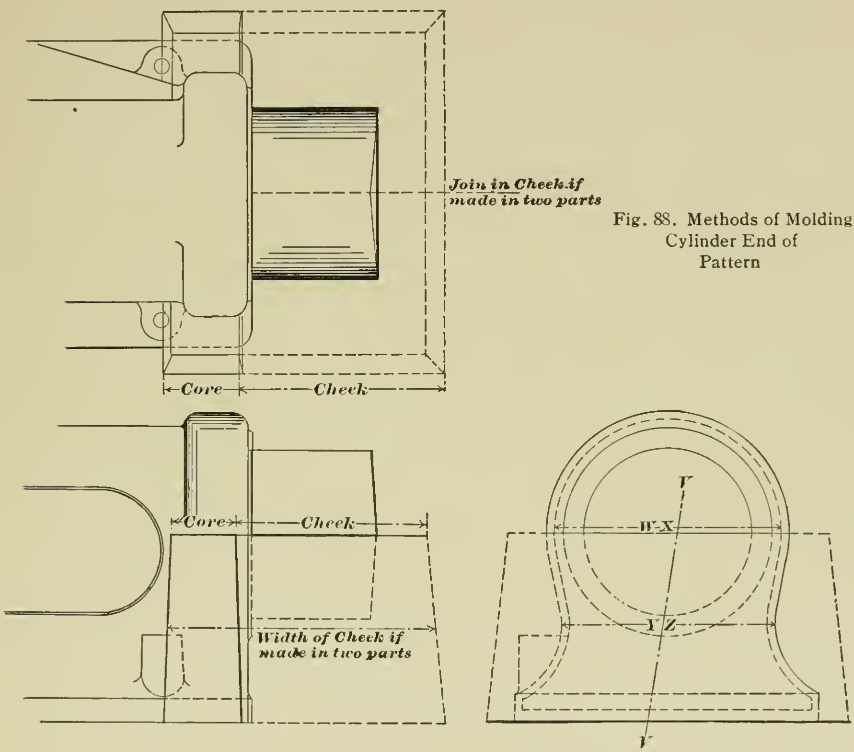


Fig. 88. Methods of Molding Cylinder End of Pattern

the intersection of the two parts, as shown in the plan view of bed Fig. 65. The core is made entire, being rammed up in a frame without a bottom board. The top of the frame corresponds to the angular side of the bracing member. The material forming the internal flange around the bottom of the bed is secured to the side of the box, while the metal thickness around the oblong opening formed by core A15 is provided for by an oval block secured to a support across the top of the frame.

Method of Molding

The method of molding is known as the bedding in process, that is, the pattern is rammed up in the floor and the mold subsequently skin dried. The process may embrace some points of interest, but owing to the limited space, we will discuss only that part shown in the three views in Fig. 88, which, of course, will be molded in the reverse position. This shows two ways of arranging the mold at the top or cylinder end of the pattern. It will be readily seen that the diameter of the cross-head housing core at WX is greater than the width of the mold at YZ, which will not allow the core to be placed in position in the mold without coring or cheeking off the two sides of the mold. There are two ways in which this is usually accomplished. First: Core prints may be attached extending to the rounding of the corner of the pattern, as shown in the full lines, and a dry sand core used. The end of the pattern will be cheeked off, as shown by the dotted lines.

Second: The cheek may be made in two parts joined along the line VV, shown in a view at the right, and letting it extend around the sides of the pattern to the combined width of the core print and cheek shown. Of course, when this latter method is employed the core prints are not attached.

SECTION II

MOLDING IN CORES

CHAPTER I

MULTIPLE CORE MOLDING

As the name implies, this process consists in the grouping or stacking together of a number of cores containing impressions of the object to be cast and so arranged that they can all be poured from one gate. This method of core molding is especially adapted to small steel castings, for in most steel foundries the facilities for pouring light pieces are not of the best. In other words, in steel foundry practice the pouring is usually done from a large bottom pouring ladle and hence it is difficult to pour small molds. The method is also especially applicable in cases where there is not a sufficient number of pieces required to warrant the fitting up of a molding machine.

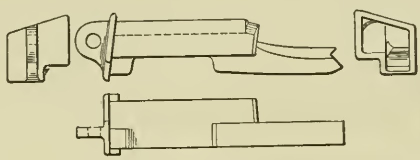


Fig 1. Coupling Pin

This method of core making is remarkably well illustrated by considering the equipment necessary for making the coupling pin shown in Fig. 1. Another advantage of selecting this particular piece is that is affords an excellent example of the making of plaster patterns for the metal core boxes, these plaster patterns being made from the original wood pattern of the pin by a reversing method.

A plan, elevation and cross section of the bottom plate of the metal core box used in forming one-half of the core are shown in Fig. 2, while Fig. 3 shows a plan elevation and end view of the bottom plate used in forming the remaining half.

The metal plates which form the sides and ends of the core and which are secured to the bottom plate by means of pins in the position shown in cross section on the line W in Fig. 2 and in dotted lines Fig. 3 are illustrated in two views in Fig. 4. In the illustration the frame is shown as arranged for the bottom plate illustrated in Fig. 3. The piece for forming the runner in the core is shown at X and in this case must be made of the length shown at Y, Fig. 3. The frame used upon the bottom plate shown in Fig. 2 is of the opposite hand in respect to the runner X only, and this runner has to be of a length equal to Z, Fig. 2. A pair of the half cores which have passed through the operation of ramming and drying are shown ready for pasting together in Fig. 5.

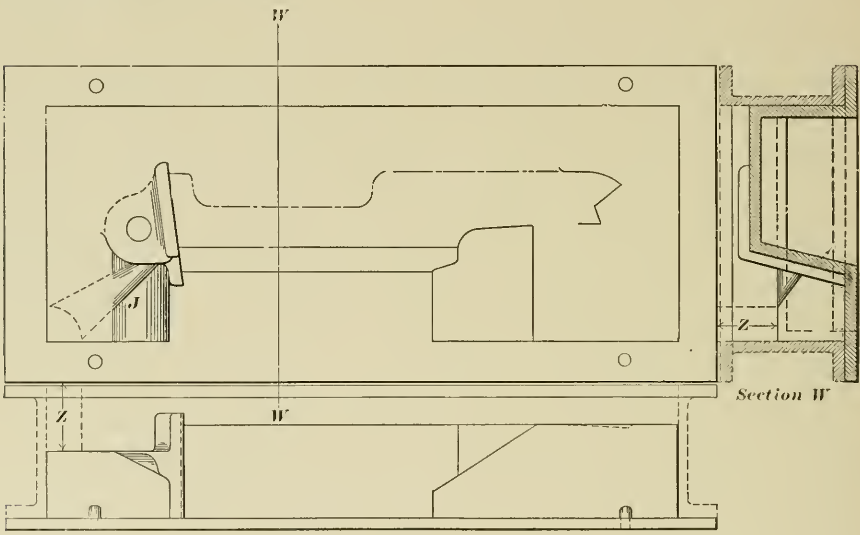


Fig. 2. Bottom Plate for Forming one Core

The arrangement for cores as they would appear when stacked and bolted together ready for casting is shown in Fig. 6. This simply consists of a cast iron bottom plate provided with lugs to receive holding down bolts and of sufficient length and width to receive four complete cores. The cores are stacked up to the desired height, say four feet in the case illustrated. The holding down bolts are set in position, the two top plates applied across the cores and the whole securely bolted together. To prevent the cores from separating lengthwise, two clamps can be dropped over the top plates and wedged up as shown. The runner is next placed in position, when the mold is ready for the metal.

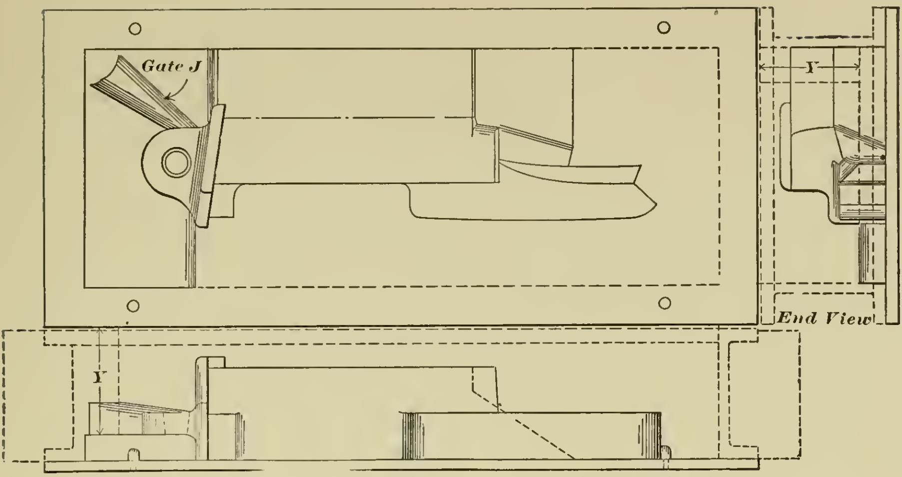


Fig. 3. Bottom Plate for the other Core

One point that is worthy of notice in this connection is that this process works remarkably well for steel, on account of the fact that steel solidifies so quickly that it has very little tendency to work into the joints between the cores and before the upper part of the mold is filled all of the runners in the lower part have chilled so that part of the mold is never subjected to the fluid pressure of a column of molten steel equal to the height of the pile of cores. If this method were used for gray iron castings it might be found necessary to place curbing about the molds and ram in sand between the curbing and the cores.

Making the Core Boxes

As the frame which forms the sides and ends of the cores as shown in Fig. 4 is a very simple casting which is molded from a wooden pattern, its production will not be taken up in detail, but we

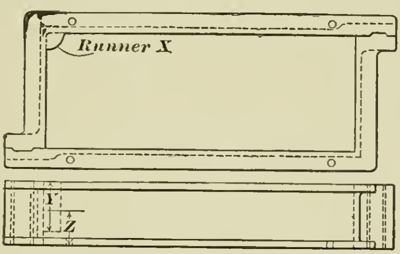


Fig. 4. Side Plates for Core Box

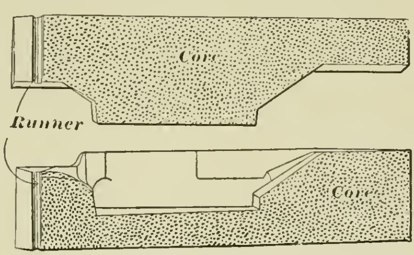


Fig. 5. Section of a Pair of Cores

will discuss only the method required for the production of the plaster of paris bottom plate patterns from the original wood pattern. The wooden pattern is shown at the right of Fig. 7, while to the left is shown the board upon which the pattern is placed for making the first cast. To allow the pattern to lie flat on the board a depression A is cut out to receive the lower shoulder. The pattern is then placed

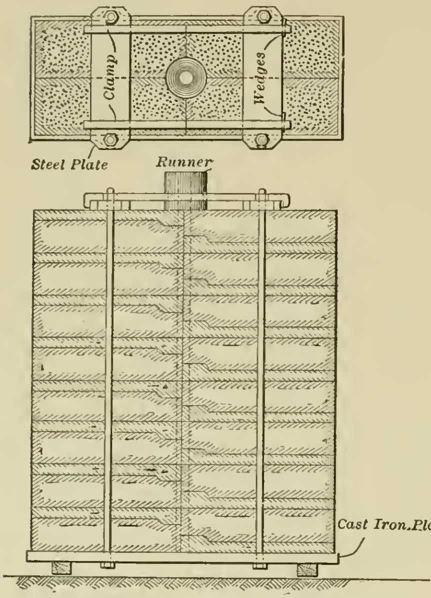


Fig. 6. Stack of Cores ready for Casting

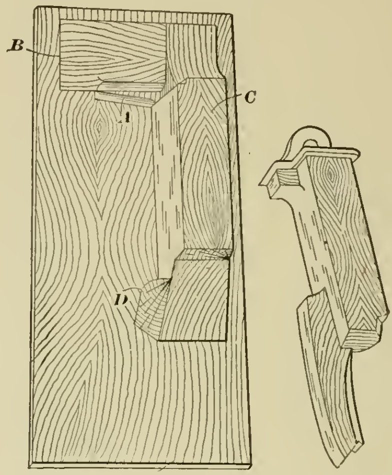


Fig. 7. Wooden Pattern and Pattern Board

in position and the material B, C and D placed about it to bring the parting in the right position and this is secured to the board by screws from the under side, as the pattern is also. The whole is then given

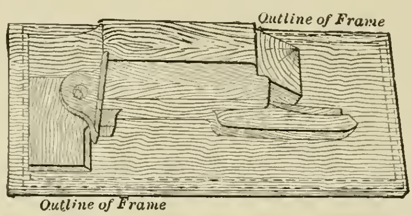


Fig. 8. Board with Pattern in Place

a heavy coat of shellac. Fig. 8 shows the board with the pattern in place ready for making the first plaster cast.

A light wooden frame or box, the inside dimensions of which correspond to the length and width of the desired core as shown in

Fig. 5, and with a depth of about 3½ inches, is nailed together and secured upon the board, as indicated by the dotted lines. The board and pattern are then well oiled or greased, after which attention is given to the mixing of the plaster.

To insure good results, very fine, or as it is sometimes called, dental plaster, should be used. Care should be taken to see that all lumps are broken up, and to accomplish this it is a good plan to run the plaster through an ordinary flour sieve before mixing. The plaster should always be kept inclosed and in a dry place. Two

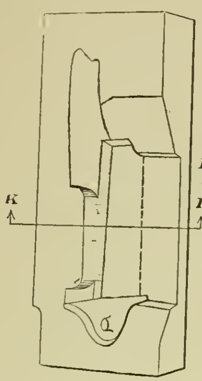


Fig. 10. Second Cast made from the First

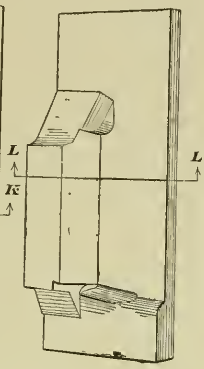


Fig. 9. First Plaster Cast

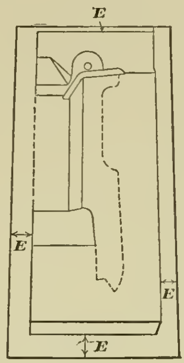


Fig. 12. Plaster Pattern made from Cast Fig. 9

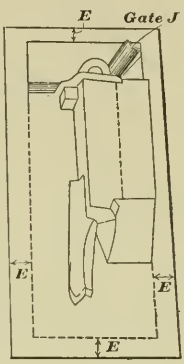


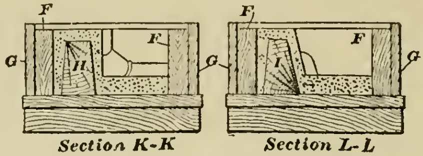
Fig. 11. Plaster Pattern made from Cast Fig. 10

persons should work together when doing the mixing, so that it may be accomplished quickly. First, fill the can in which the plaster is to be mixed with the desired amount of water and introduce a small quantity of plaster. The plaster should be introduced by one person, while the other stirs the mixture. If it thickens too fast, more water should be added. It should be mixed to the consistency of heavy cream.

When pouring care should be taken to see that work sets level and the plaster should be poured as quickly as possible over the entire surface. If the plaster has been mixed properly the screws can be taken out and the frame and bottom board removed in about 30 minutes. Should the pattern or material forming the parting stick in the least, it can generally be loosened by rapping it lightly.

Blow holes are apt to appear in the plaster and when encountered they can be filled up with either plaster or wax.

If this operation has been successfully accomplished the plaster cast will appear as shown in Fig. 9. Fig. 10 shows the second cast which has been obtained from the first cast shown in Fig. 9 with the aid of the wood pattern and a light frame about 4½ inches in depth. In carrying out this work the face of the first cast is shellacked and then covered with a good application of oil or grease. The pattern is then placed upon the first cast in the depression left vacant by it, the cast is placed upon the level board, the frame set over it, and the mixing of plaster and pouring proceeded with, as in the former case.



Figs. 13–14. Sections of Casts ready to receive the Plaster

It is next necessary to cast the two plaster patterns, as shown in Figs. 11 and 12. The plaster pattern shown in Fig. 11 is produced from the plaster cast shown in Fig. 10, while the plaster pattern shown in Fig. 12 is produced from the plaster cast shown in Fig. 9.

As the plaster casts now made are of the same length and width as the desired cores, provision must be made for the additional width or projecting edge E, Figs. 11 and 12. This projecting edge around the four sides is intended to receive the flange of the frame, as shown in Fig. 4. This is accomplished by placing the material F, Figs. 13 and 14, which in thickness is equal to the width of the flange, on the frame shown in Fig. 4, around the four sides of the plaster cast. The entire arrangement is then surrounded with a light frame G, Figs. 13 and 14. Cross sections on the lines KK and LL of the two plaster casts shown in Figs. 9 and 10, as they would appear arranged ready to receive the plaster, are shown in Figs. 13 and 14.

As in the previous case, to prevent the plaster sticking, grease or heavy oil should be used freely over the entire surface.

At the completion of the casting of the plaster patterns, they are removed from their casts or forms and a coat of shellac applied to the face. They are then backed out to give the required metal thickness. A good portion of this surplus plaster can be avoided by placing blocks H and I upon the bottom board as shown in the cross sections, Figs. 13 and 14. The patterns are finished with two coats of shellac. The gate J, Figs. 2 and 3, is next worked out of a piece of wood and attached in the correct position, being secured with shellac. The patterns are then sent to the iron foundry. When the castings come back from the foundry they are cleaned up and finished in the usual manner, the plates being doweled or pinned to the frames shown in Fig. 4.

CHAPTER II

STACKING CORES FOR LARGE WORK

When it is necessary to cast a considerable number of large steel castings from special heat which requires practically all of the metal from one charge of an open-hearth furnace, the question of floor space for the large molds is often an important one and the foundryman frequently finds himself in a quandary as to the best method of getting out of the difficulty. One method of solving this problem is shown in this chapter and consists in simply stacking or piling upon one another a series of cores which form the molds for the rings or pieces to be cast. Of course, it is necessary to provide a proper arrangement of gates so that the rings may be cast from the same runner, and also to provide risers. While this method of molding will not under ordinary circumstances be found the cheapest on account of the expense

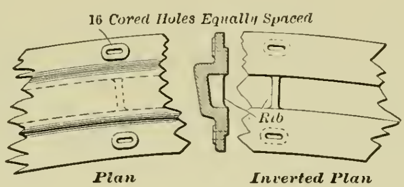


Fig. 15. Section of Ring Casting

of making the cores, etc., it will be found that the extra expense incurred will not condemn the method, owing to the saving in floor space, etc. The rings illustrated are about twelve feet in diameter and have a cross section as shown in Fig. 15.

A cross section of one of the bottom cores, together with the box in which they were formed, is shown in Fig. 16, the core box being shown in the plan and cross section. In like manner in Fig. 17 is shown a cross section of one of the top cores together with the plan and cross section of the core box in which it was formed. It will be observed that a male and female joint is formed upon the two cores, this being necessary to locate them in position one upon the other.

Setting the Cores

In constructing the mold a hole is dug in the floor to the required depth. The spindle with the sweep attached is next located in its proper position and a level bed struck off. The sweep is then raised to the required height and the lower half of the first series of cores placed in position. The proper diameter of the ring is maintained by setting the cores to the gauge A which is attached to the sweep, as shown in Fig. 18.

At the right in Fig. 18 is shown the setting of one of the bottom cores, while at the left of the spindle is illustrated the operation of sweeping off the bed to receive the cores.

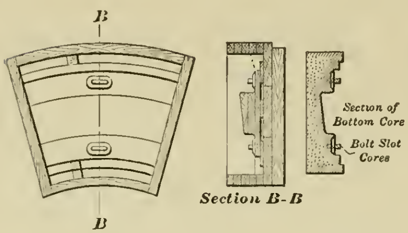


Fig. 16. Section of Bottom Core and Box

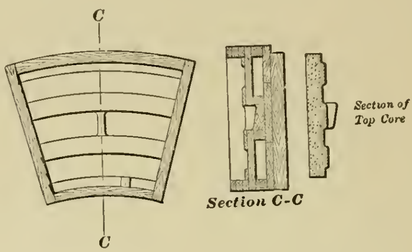


Fig. 17. Section of Top Core and Box

The upper series of cover cores is next placed in position, being guided by the male and female joints. A light thickness of sand is next applied over the upper surface, the sweep is raised up and the sand applied struck off level to receive the bottom cores of the second set. The second set of cores are located with the aid of the gauge A as in the first case. In this way the work is proceeded with until all three of the series of cores forming the complete mold have been placed in the proper position.

The runner is centrally located and each ring receives metal from four gates placed at right angles to one another, as shown in Fig. 19, which illustrates two half sections of the mold. The section at the right being taken through the gates illustrating the manner of gating, while the section at the left is taken through the risers and illustrates the manner of attaching the same. It will be noticed that the risers are placed on the outer diameter of the rings.

After the three series of cores are set in position the molder has to turn his attention to the placing of the runner and gate cores, the arranging of the risers. This work being done during the backing up of the mold with sand, as shown in the cross section of the completed mold.

Sand is first rammed inside and outside of the cores to the height of the gate openings on the inner diameter of the cores and the risers' openings on the outer diameter of the first series of cores.

The runner and gate cores are shown in detail in the upper part of Fig. 19 and also in position in the lower part of the figure. After the first set of cores for the gates are placed in position the first one of the block cores for the runner is placed in the center and the ramming in of the sand backing proceeded with until the openings in the

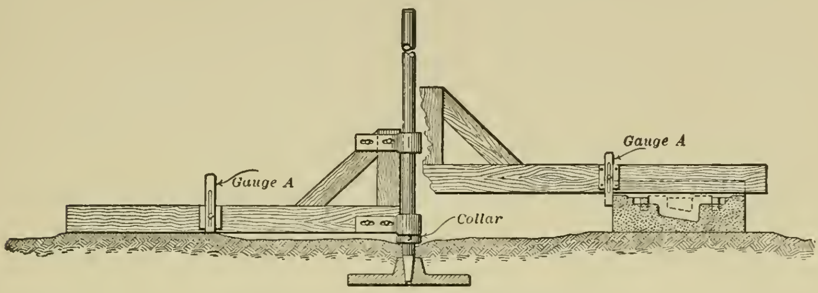


Fig. 18. Spindle Rigged for Setting Cores

second series of cores are reached when the gate cores and next block for the runner core are set as in the first case. When the backing of sand reaches the top of the upper series of cores a level bed is struck off to receive the holding down plates.

The risers are formed by the use of the riser block shown in the upper left hand corner of Fig. 19. The runner and risers are next

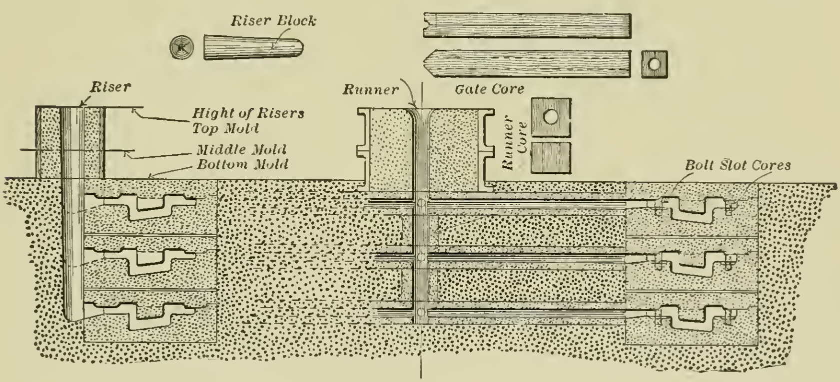


Fig. 19. Section of Mold

carried up to the desired height and the weighting down of the cores attended to. It will be observed that the riser for the lower ring is not carried to the same height as the others on account of the fact that it is not necessary to do so. The riser for the first ring is terminated at the surface of the mold as indicated by the words "bottom mold." The riser for the second ring is terminated at the dotted line designated "middle mold," while the riser for the upper mold is carried up to the same height as the gate. When the metal in the first riser has almost reached the surface of the mold the riser is covered with a plate and weighted down. In like manner when the metal reaches the top of the second riser it is covered and weighted.

CHAPTER III

CASTING ROUND FLASKS IN CORES

The accompanying illustrations show one method of casting round flasks of large diameter in cores which has given very satisfactory results, and a saving in pattern expense, as well as in the floor space required for pattern storage. A plan and cross section of a portion of the required flask is shown in Fig. 20. It will be noted that there are two lines of cored bolt holes about the flask and a sand strip on the inside of the top and bottom. In most cases, four trunnions are cast on each flask, one of these being shown in Fig. 20.

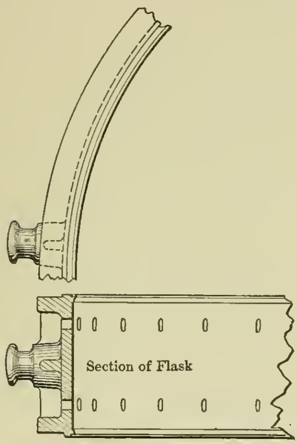


Fig. 20

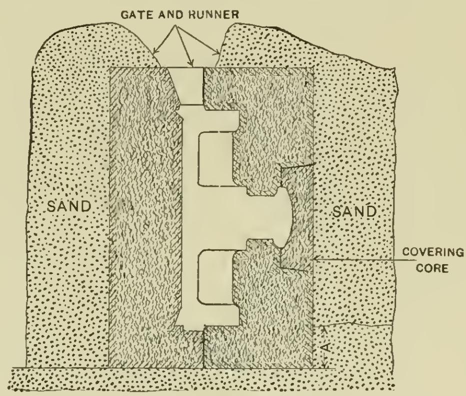


Fig. 21

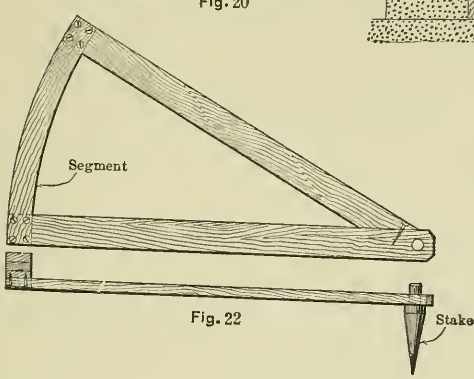


Fig. 22

Fig. 20. Plan and Section of a portion of the Pattern

Fig. 21. Cores in Position

Fig. 22. Segment for Setting Cores

A cross section through one side of the assembled cores is shown in Fig. 21, illustrating the manner in which the cores are placed together. In making up the mold a hole is dug in the floor to a depth equal to the height of the cores and with the aid of straight-edges a level bed is struck off.

With the segment attached to and revolved about the stake as shown in Fig. 22 an offset shown at A, Fig. 21, is rammed up to assist in setting the cores.

The number of separate pieces or cores is governed by the diameter of the flask. The circle formed by the offset is divided by four equidistant lines, and the centers of the four cores containing the trunnions are set to these lines.

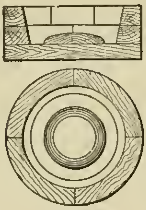


Fig. 24

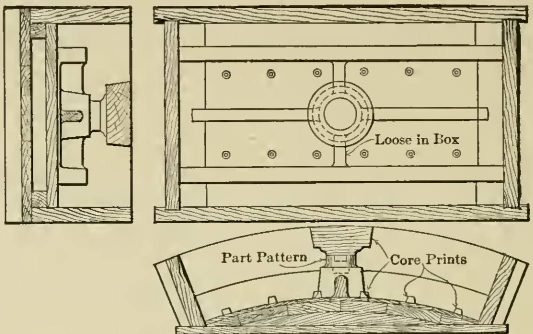


Fig. 23

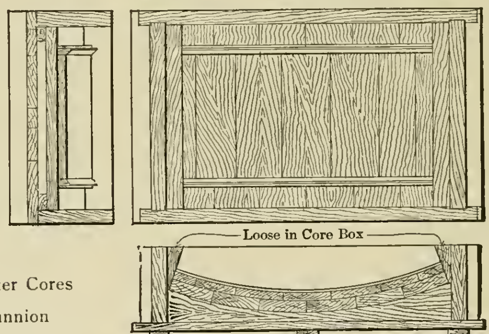


Fig. 25

Fig. 23. Core Box for Outer Cores
Fig. 24. Core Box for Trunnion
Fig. 25. Core Box for Inside Cores

At the completion of the setting of the remaining cores, sand is banked and firmly rammed around the inside cores, as well as in the space between the outside of the cores and the wall of the hole or pit. To avoid filling the entire space inside the cores with sand, a flask of convenient diameter and height can be placed within the inclosure formed by the cores and the space between the flask and the cores rammed firmly with sand.

The core box used in forming the outer cores is shown in Fig. 23. The trunnion and rib portions are loose from the box, allowing these parts to be removed when the plain cores are being made. The bolt holes are spaced off accurately, and taper prints are set to receive the separate cores for these holes. By giving the core prints ample taper, they can be rigidly attached to the box. A covering core is used in connection with this box to form part of the trunnion, this portion of the box being parted as shown with the core print above and extending to the top of the box.

When the print has been withdrawn the core made in the core box shown in Fig. 24 is placed in this impression so as to close the opening and form the flange or outer end of the trunnion.

The core box used in forming cores for the inside of the mold is shown in Fig. 25, and it will be noticed that loose wedge pieces are used to form the radial ends of the cores. To simplify the construction of the box and facilitate the drying of the core, the open side of the box is made flat in place of conforming to the diameter of the mold. Gates are filed in the tops of these cores at different points, and runners built up as shown in Fig. 21.

CHAPTER IV

MOLDING A THREE-WAY COCK

A three-way cock or plug valve of the design shown in Fig. 26 is in many ways a difficult casting to mold. If molded in green sand it would require a three-part flask in addition to the cores.

In most cases this piece can be molded in cores more quickly and cheaper than in any other way.

In Fig. 26 the central view shows a plan of the cock, the left hand figure a side view and the right hand figure a section on the line X, X.

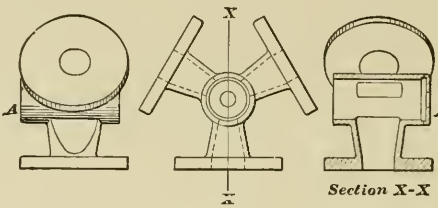


Fig. 26. Three-way Cock

This design of valve is also sometimes made with an open bottom A, which is subsequently covered with a plate secured to the cock.

To a patternmaker or molder the various disadvantages and difficulties in connection with this job will be readily appreciated, but without stopping to discuss these we will proceed to describe one method that has proven very successful in many cases.

The cores for the mold are shown in Fig. 27. The upper view is a horizontal section taken on thé line U, U, while the lower view shows a vertical section taken on the line Y, Y. The outer part consists of three cores B, C and D, which are joined on radial lines at E, F and G.

The center core H and the core for the passage on the line G are made in one piece, while the cores for the passages E and F are made separate as shown at I and J.

When assembling the mold the cores C and D are placed together with the center passage core H in place with its projection for the passage core between the cores C and D. This holds the core H in place and locates it correctly.

Before the core B is set the cores I and J must be set into the center core H and held in place until the core B is located. To assist in holding the cores I and J in place they are made long enough so that their ends project as shown at K. These projected ends may be held or blocked up, while setting the core B.

When the parts have been assembled a flask is placed around the group and a backing of sand rammed in.

The core boxes are made as shown in Figs. 28, 29 and 30. The box for making the large cores B, C and D is shown in Fig. 28, the upper view being a plan and the lower view a section on the lines Z, Z. The checks L, L are made loose in the box as are also the diagonal pieces M, M, which carry the patterns P, P. When making a core the box is rammed full of sand, the blocks L taken out and the depressions left filled in with green sand. The box is then rolled

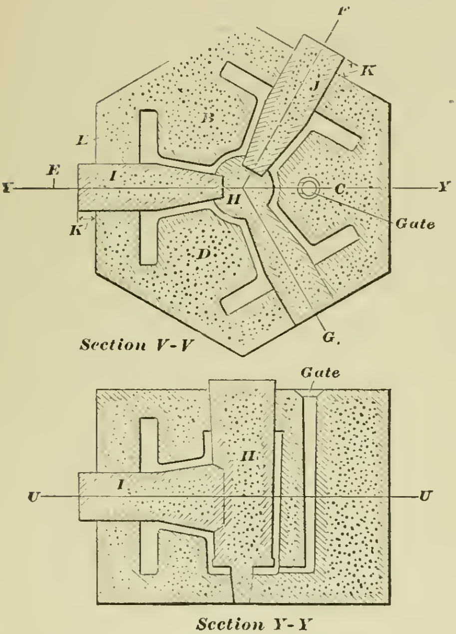


Fig. 27. Cores for the Mold for a Three-way Cock

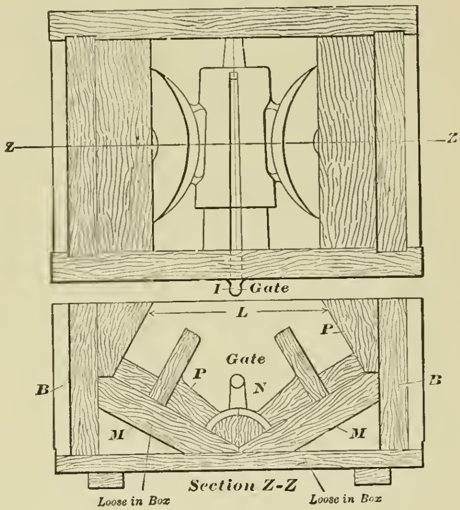


Fig. 28. Core Box for Body

over and the main gate drawn out through the side of the box (of course the gate is only required in one of the three cores). After the gate has been drawn the frame is removed and the blocks M, M carrying the patterns P, P drawn. This leaves the gate N exposed to be drawn.

In order to make the center and passage core H entire as shown in the assembled mold, two half core boxes, one of which is shown in Fig. 29, will be required. The core print in the bottom of the center portion of the box is left loose to be drawn from the core after the latter has been turned over onto the core plate.

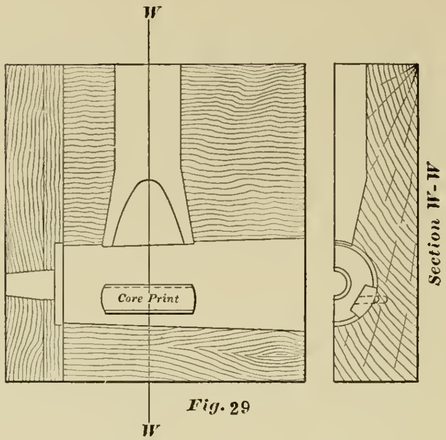


Fig. 29

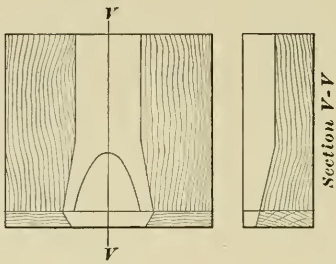


Fig. 30

Fig. 29. Box for Central Core with one Branch

Fig. 30. Box for Branch Cores

Two other half boxes, shown in Fig. 30, are necessary for making the cores I and J shown in Fig. 27. The reason both half boxes are required for this purpose is on account of the taper of the center core H.

CHAPTER V

THE USE OF COVERING CORES

There are a very great number of ways in which covering cores can be used, but the accompanying illustrations cover the principal uses of this class of cores.

Covering cores are also frequently called slab cores, and can often be set without the aid of a core print.

The use of the covering core frequently saves a three-part flask, or the adoption of a more intricate cored mold and expensive patterns.

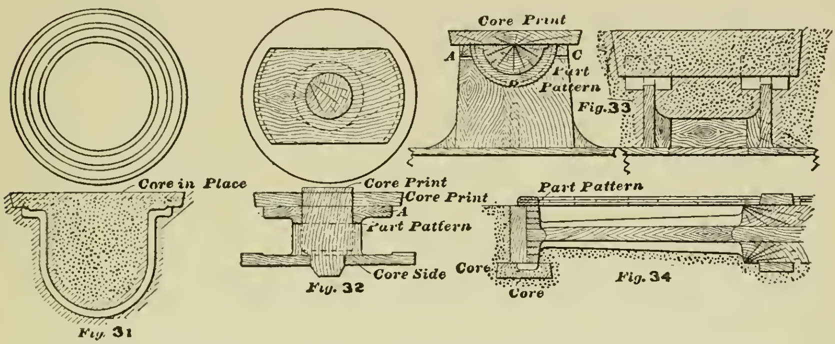


Fig. 31. Covering Core for Casing

Fig. 32. Stuffing Box Pattern

Fig. 33. Pattern and Mold for a Double Bearing

Fig. 34. Mold for a Shrouded Gear

In some cases, especially in a deep setting, the covering core may be objected to by some foundrymen, on account of the difficulty of removing any sand which may fall into the mold during the drawing of the pattern. When the covering core is used in the cope, this objectionable feature is done away with, as the core may be placed in the depression left by the core print previous to or after the closing of the mold. When the core is used in this way, of course it is inserted through the cope and weighted or wedged down.

The application of a covering core to a mold for a casing or hood is shown in Fig. 31. In this casting there is a very light metal thickness and the advantage of the suspended core in regard to venting and also setting, in the production of a sound casting will be readily seen.

The molding of such a piece as this with the ordinary dry sand core would usually make it necessary to cast or mold the piece in a reverse position and this would not, as a rule, give good results. When a metal pattern is used which leaves its own core it is possible to mold the bowl in a reverse position successfully.

A cylinder head and stuffing box pattern are shown in Fig. 32, together with a core print for the covering core attached. This arrangement gives a very simple pattern and mold. The core print is drawn, together with a part of the pattern A, during the ramming up of the mold, and the slab core interposed in place of the core print. The

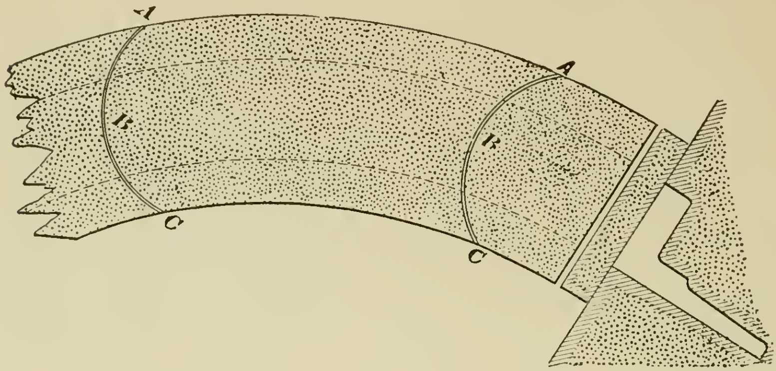


Fig. 35. Covering Cores with Curved Ends

ramming of the mold is then completed by the ordinary method. This operation is described and illustrated more fully in the next example.

The covering core method as applied to a double bearing is illustrated in Fig. 33. At the left is shown the end view of the bracket portion of the pattern, illustrating the general construction of the bracket and showing the parting line A B C. At the right is shown a longitudinal section of the partially completed mold with the covering core in place.

In making the mold the pattern is placed upon the board and rammed up to the top of the core print in the ordinary manner. The core print, with a portion of the bearing above the line A B C, is next withdrawn from the sand and the covering core placed in the depression left by the core print. The balance of the flask is now rammed up, struck off and rolled over in the ordinary manner. The cope is then placed in position, the ramming completed, and the balance of pattern drawn as usual.

The covering core as applied to a shrouded gear is shown in Fig. 34. The illustrations show the pattern rammed up with the core in place and the flask rolled over ready for placing the cope in position.

Many circular pieces of work in the foundry can be covered with slab cores to save the ramming up of the cope. This method is shown in Fig. 35. Usually the ends of the cores radiate to the center. When this is the case unless they are made to the proper diameter the ends will not fit together without filing and fitting of the cores. As these cores are frequently kept in stock, they are a source of much trouble to the molder. This trouble can be readily done away with by making the end of one core convex and the corresponding one concave, as shown in Fig. 35, where the curved line A B C represents the junction between the adjacent cores. By this arrangement the ends of the cores can be kept together while they are adjusted for almost any radius of mold.

CHAPTER VI

T SLOT AND NAME PLATE CORES

The use of chaplets for holding down the cores in floor plates, etc., is generally a source of considerable trouble, but this difficulty may be done away with by constructing the cores as shown in Fig. 36. At the left is shown the pattern with a core print attached and the outline of the core shown by dotted lines. To the right is shown a cross section of the mold, with the core in place.

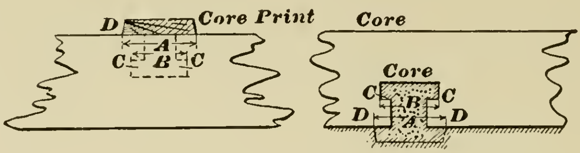


Fig. 36. T Slot Cores

It will be noticed that the core print is wider than the head of the T slot and hence when a core of this section is set into the depression made by the core print and the metal flows into the mold, there will be more area exposed to the metal along the width A than along the width B, in other words, the surfaces D are wider than the surfaces C,

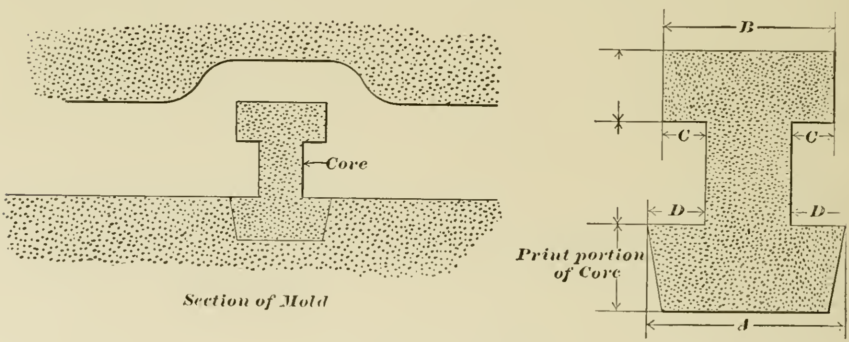


Fig. 37. T Slot Core

hence the metal which exerts a lifting force along the overhanging portions C will be more than balanced by the metal bearing down on the portion D. With cores made and set in this manner, no chaplets are necessary.

These cores are even better illustrated in Fig. 37. This illustration shows a form of core which is used by the author with good results. At the left of the figure is shown a section of the mold with a core in place, while at the right there is a detailed drawing of the cross section of the core.

The lettering is the same as that in Fig. 36. Some persons have claimed that cores of this kind would not stay down if no nails were used. The author has watched every step of making and pouring the

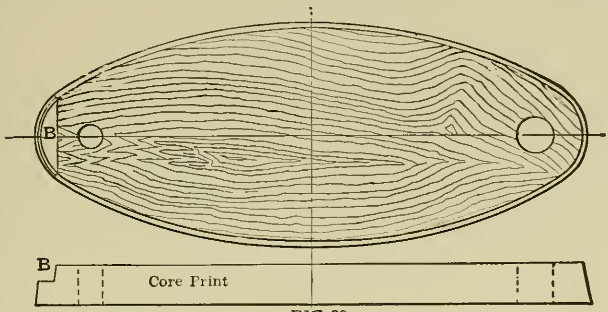


FIG. 38

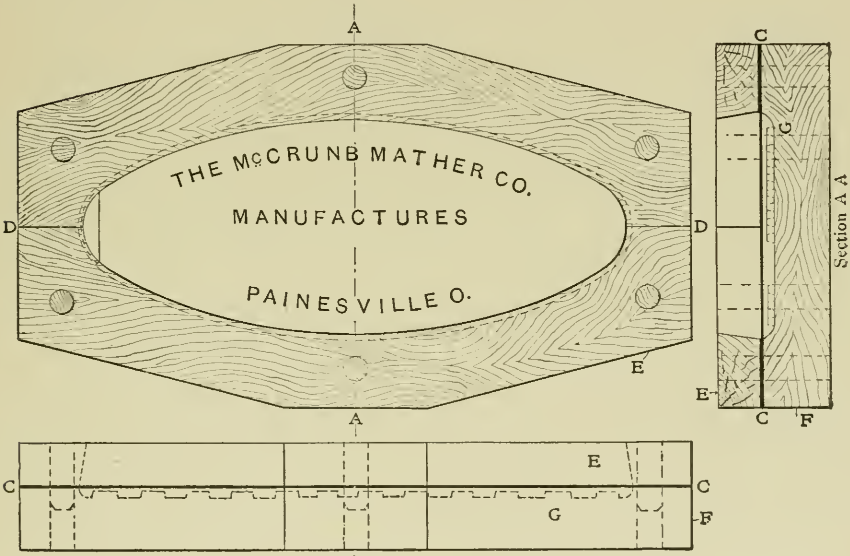


FIG. 39

Fig. 38. Core Print for Name Plate

Fig. 39. Core Print Box for Name Plate

mold many times and knows that they will work if there is no opening under the base of the core into which the metal can flow. If metal flowed under the base of the core it would be lifted. But any good molder will see that the sand is slicked up to each side of the base of the core.

Figs. 38 and 39 show a method employed in placing name plates upon engine beds, etc., and one which insures their non-removal except by chipping. The method consists in the use of a slab core of any form made from a core box upon the bottom of which is placed the desired lettering.

Fig. 38 shows the core print, in this case of an elliptical form, and secured to the pattern by two loose dowels of different diameter as shown, in order to avoid placing the core print in the reverse position. A marker "B" is also required upon the print and in the core box, to insure placing the core in its correct position in the depression left vacant by the core print.

Fig. 39 shows the general arrangement of core box which is parted on the lines "C C" and "D D."

The frame or print portion "E" having been gotten out to conform to the core print shown in Fig. 38, it is placed upon the bottom board "F" and secured with dowels, and its elliptical outline is scribed thereon. The surface inclosed by this outline is now backed out or depressed to the required depth "G" (which is usually the thickness of metal letter used) and the metal lettering is attached in the ordinary manner.

CHAPTER VII

MOLDING IN CORES

In many cases, and especially in the case of steel castings usually, better results can be obtained from a dry sand mold, and frequently this can be obtained more easily and economically by making suitable core boxes and forming the mold of cores.

A Small Steel Casting

Fig. 40 shows a required casting 10 inches in length which would be rather difficult to mold from an ordinary pattern without an exceedingly complicated mold. Fig. 41 shows a plan of the core box and a section of the pattern on the line A-B, Fig. 40.

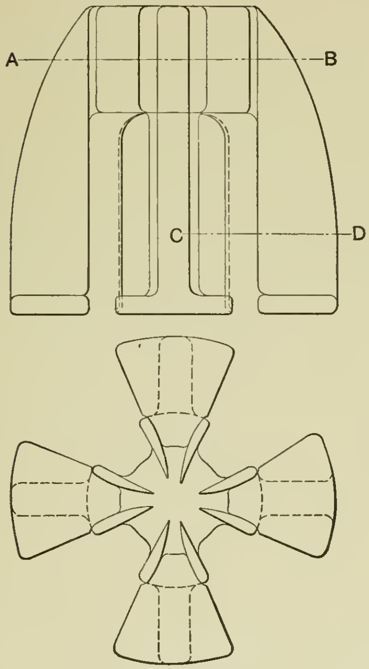


Fig. 40. Casting to be made in Cores

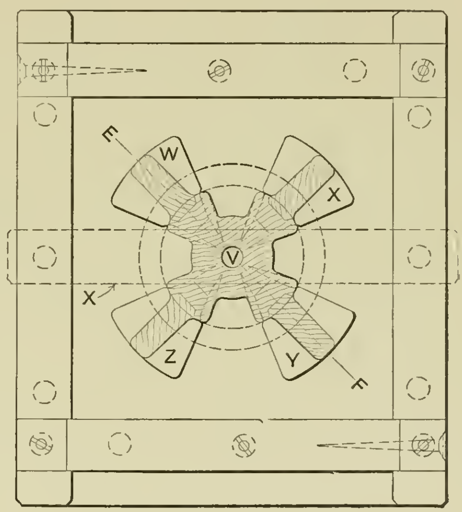


Fig. 41. Plan of Core Box

Fig. 42 shows the manner in which different parts of the pattern are set together. The pattern is made in five parts, as indicated by the letters V, W, X, Y and Z. In Fig. 42 the pattern is shown half in section and half in elevation, so as to show the manner of parting the different pieces of the pattern. The half section is taken on the line

E-F, Fig. 41. It will be noticed that the pattern is set in to the bottom board holding the parts in position.

The core box is made deep enough to allow a sufficient amount of sand above the pattern, and the core print U is placed upon the pattern as shown in Fig. 42. The height of the core print is equal to the amount of sand allowed above the pattern and the diameter of the small end should be large enough to allow the part V of the pattern to be drawn with the print.

In making a core the pattern is placed in the core box, rammed up and struck off. The core print U and portion of the pattern V are then drawn, after which the core box is rolled over and the parts W, X, Y and Z drawn from the other side.

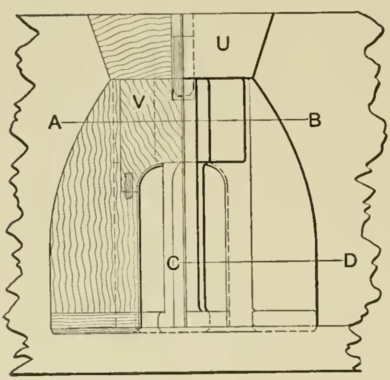


Fig. 42. Arrangement of Pattern

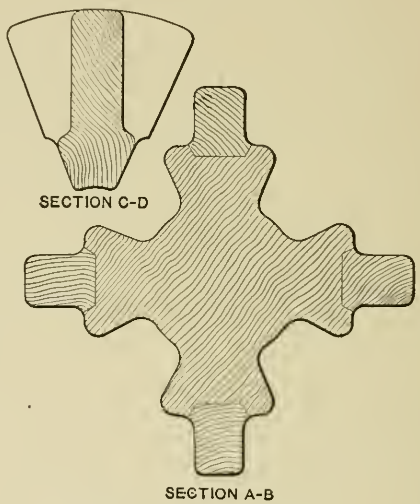


Fig. 43. Section of Pattern

Fig. 43 shows sections of the pattern on the lines A-B and C-D.

A block the form of the core with a depression corresponding to the core print U, not shown, is used as a pattern to make a mold to receive the core, the mold being gated through the portion of the cope fitting the space U.

When a great number of castings are required a box can be made large enough to receive a number of these cores, and rammed up with depressions in the drag. A runner can be rammed up in the center one in place of one of the patterns and the surrounding ones gated from this. This manner of coring will be found very convenient in small steel castings where a dry sand mold is desired.

A Small Propeller Wheel

Small propeller wheels may also be molded in cores, either dry sand or green sand, by using a core box of the form shown in Figs. 44 and 45.

One advantage of this method is that it assures the fact that the blades are as nearly alike as it is possible to make them, which is important. Usually in molding a pattern of this description a follow board is used, while that part of the core box containing the back of the blade is rammed up. The face of the follow board can be developed and built as a propeller blade. As a blade contains but a small portion of the area of the surface of the box, it is not necessary to make a follow board the full dimensions of the size of the box, but just wide enough to form a joint all around the blade. The remaining portion of the surface can be cut away to any convenient angle, as shown in Fig. 45.

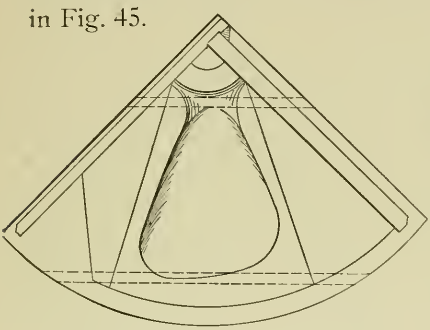


Fig. 44. Plan of Core Box for Propeller

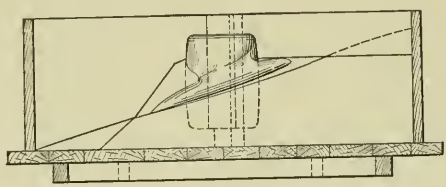


Fig. 45. Section of Core Box for Propeller Wheel

By building the follow board first, so that its face represents a portion of the face of the blade it can be used in building and laying off the pattern, the pattern being built by gluing strips together, and working off back to the proper form.

If the pattern is made first, the follow board can be made of plaster of paris, the pattern being used to give it the proper shape. Plaster being used for very small wheels only.

In molding patterns of this description by this method, iron skeletons or core irons with suitable lifters must be provided for both parts of the mold for lifting out the core.

When making a mold, the top part of the core box containing the back of the blade is rammed up first with a core iron or skeleton properly placed, the core box is then rolled over, the follow board removed, the parting prepared and the balance of the core box rammed up with the core iron or skeleton in place. After the ramming is completed, the core box is removed, the cope part of the mold lifted off and held suspended while the pattern is withdrawn and the mold finished. A level bed is then prepared and the drag part of the core is placed upon it and the cope part on top of the drag portion. These operations are repeated for each of the succeeding blades thus forming a complete circle.

Of course in the case of dry sand cores they must be baked before they are placed upon the bed.

After the cores are placed in position upon the bed an open flask or box or a metal curbing is placed around them and the space between the cores and the box or curbing rammed with sand to form a backing. The cores must also be weighted down.

A Large and Crooked Steel Casting

A large steel casting weighing 8,000 pounds is shown in Fig. 46. This is a cutter head used on a large centrifugal dredge.

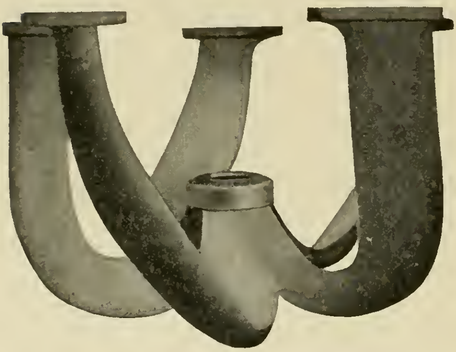


Fig. 46. Forge Steel Casting

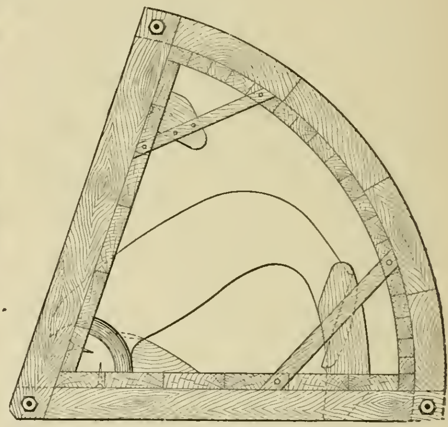


Fig. 47. Plan of Core Box

From the form it will be seen that this would be a rather difficult piece to produce in an ordinary green sand or dry sand mold. But by molding in cores in a manner similar to that used for small propeller wheels, the work was accomplished with ease.

Fig. 47 shows a top view of the core box, with the pattern for one of the five arms in place. Fig. 48 shows the core box with the front removed and shown at the left. The pattern is shown in place in the portion of box on the right.

In making one section of this mold in the core box, that portion of the core which contained the back of the blade was rammed first, the core iron or lifting plate being placed near the bottom of the box.

A parting was made along the edge of the blade as the ramming progressed. This parting was then covered with parting sand, a lifting iron introduced for the upper portion of the core and the upper portion rammed. The front of the box was then removed and the sides drawn back, leaving the core free. The top or cope part was then lifted off and held suspended while the pattern was drawn and the mold finished. It was then placed back in position and the whole

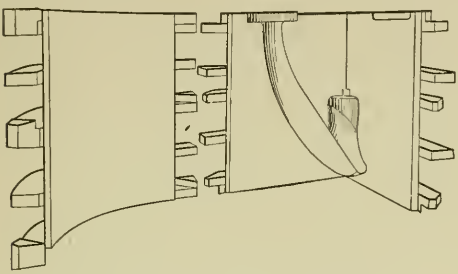


Fig. 48. Elevation of Core Box with Front removed

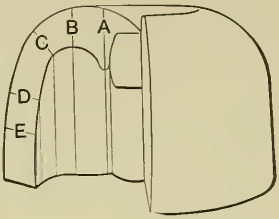


Fig. 49. Block or Model of Pattern

core shoved into the oven to be dried. For convenience the core was made upon a car so that it did not have to be removed from the car to introduce it into the oven.

After the five sections were completed, a pit was dug, a level bed swept up, the sections placed together, provision made for suitable gating and for sinking heads. The whole was then backed up with sand thoroughly rammed.

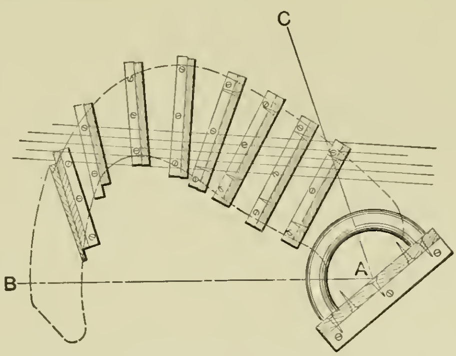


Fig. 50. Plan of Supports on Building Board

The pattern for this job was made as follows: Owing to the angular form of the blade it was impossible to lay it out from the drawing in a reliable manner and hence a block or model was turned to scale, as shown in Fig. 49. The diameter and form of this block corresponded with that of the cutting edge except that it was made to a smaller scale. The outline of the cutting edge was then laid off on this block and the material cut away so as to give the sections A, B, C, D and E. The whole surface between these sections was cut away to represent the under side of the blade. The width of these sections was laid off and these points connected with a flexible rule or strip and this line was sawed perpendicular to the base, giving the inner outline of the blade. This outline was then transferred full size to the building board and perpendicular supports erected as shown in Fig. 50, these supports conforming with the angle of the blade at the points A, B, C, D and E, Fig. 49. A half hub was made and secured in its correct position. The portions of the hub outside of the lines A-B and A-C Fig. 50, were afterwards cut away to fit the core box. The pattern was built by fitting pieces over the supports as shown by the parallel lines in Fig. 50. These being glued together and to the hub, and the back worked off. The pattern was subsequently parted on the lines A-B and A-C and the portions of the pattern which fell outside of these lines were secured to opposite sides of the core box, as shown in Figs. 47 and 48.

Molding Rope Sheaves

A method of molding rope sheaves having wrought iron arms which are staggered in the hub is illustrated in Fig. 51, the left hand portion of the figure showing a section of the wheel and the right hand portion the method of making the mold.

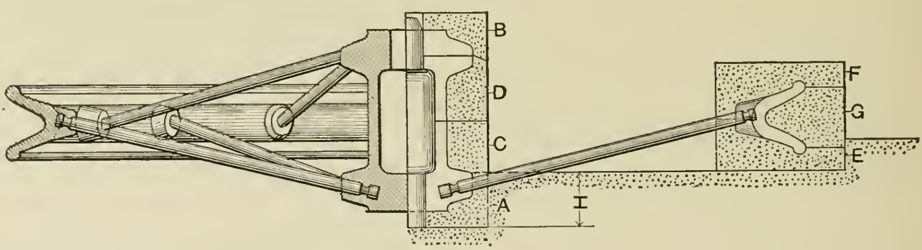


Fig. 51. Half Section of Rope Sheave and Half Section of Mold

The core boxes for making the cores A and B for the upper and lower portions of the hub and the middle portions C and D are shown in Figs. 52 and 53 the boxes being shown in plan in the lower portion of the figures, and in section in the upper portion. These cores form the mold for the outside of the hub. An ordinary circular core formed in a regular core box is used for the bore of the hub.

In Figs. 54 and 55 are shown the core boxes for forming top and bottom rim cores E and F and the groove core C.

At A-B, Fig. 54, are shown two core prints used in the rim core box as shown in the section on the line Y-Z for forming the openings for the introduction of the wrought iron rods. It is necessary to change these prints for the top and bottom cores E and F, owing to the fact that the rods enter the rim at an angle and that this angle alternates with each succeeding spoke.

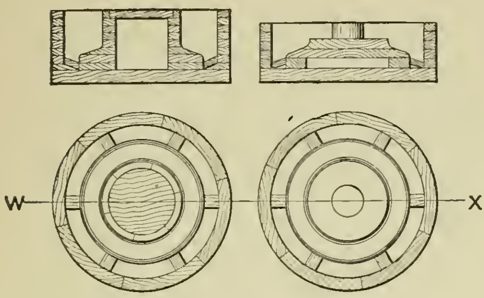


Fig. 53 Fig. 52

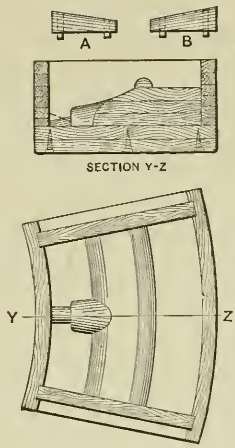


Fig. 54

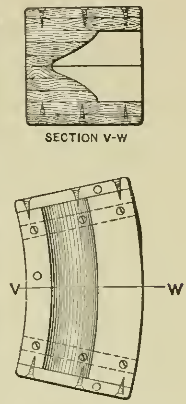


Fig. 55

Fig. 52. Core Box for outside Section of Hub
Fig. 53. Core Box for inside Section of Hub
Fig. 54. Rim Core Box
Fig. 55. Groove Core Box

In making this kind of a mold, a level bed is struck up and the block or print bedded in to receive and set the hub core. The height of this is equal to H, as shown in Fig. 51. To a pin or spindle in the center a sweep is attached as shown in Fig. 56.

This sweep is used for forming the bed which is to receive the rim cores E and the groove cores G. After this has been accomplished the lower section of the hub core A and the rim cores E are set, then

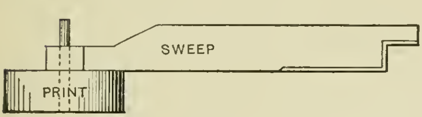


Fig. 56. Sweep in place for Sweeping Bearings

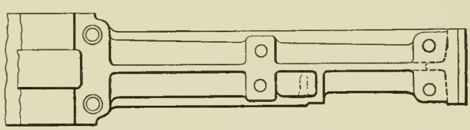


Fig. 58. Elevation of Forge Gear Bolting Face

the rods which enter the core A are placed in position, the groove core G is set and the middle section hub cores C and D.

Then the rods which enter the upper portion of the core are placed in position and the upper portion of the hub core B and the rim cores F placed in position.

The hub cores C and D should be carefully pasted together, so that the upper and lower prints to receive the rods will come exactly between each other. The bore core is set before the top core B is placed in position.

After all the cores are in position, the mold is rammed up with green sand and weighted. In pouring a wheel of this description the rim is usually poured and allowed to cool before the hub is poured, as this lessens the strain caused by contraction and produces a sounder and better wheel.

Molding Large Gear Wheels

One method of molding a large gear in cores is shown in Figs. 57 and 58. This method was applied to a cast steel split gear 15 feet, 6 inches in diameter, 4 inch circular pitch, 144 teeth, and 16½ inch face, with a T section flange cast on one side and joined to arms about midway between the hub and the rim. The entire gear weighed 26,000 pounds. A drawing of a portion of the gear is shown in Fig. 57 a section of the rim, of the T flange and the arm being shown. The

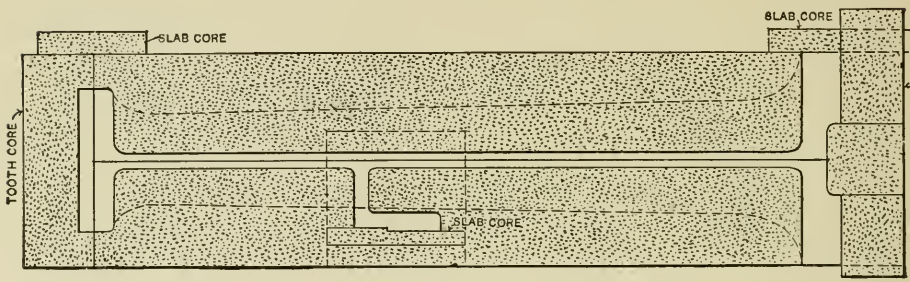


Fig. 59. Section of Mold

dotted lines in Fig. 57 show the arrangement of the different cores which were used in forming the mold. In Fig. 58 a half elevation of the bolting face of the gear is given, showing the location of the bolt holes, which were cored, the construction of the hub, etc.

A section of the mold through the center of one of the arms is shown in Fig. 59. It will be noticed that a slab core is used for covering the joint at the hub, and also under the portion of the T flange opposite the arm.

In making the core for the arm it was rammed level with the T flange, the face portion then drawn and the slab core placed over it, after which the box was rammed full.

The arm core box was used for the upper and lower halves of the arm cores, the flange portion of the pattern being removed for the upper half of the core. The same box was also used for the half arm cores on the bolting line, a half arm with pads and core prints being used in the box as shown in Fig. 60. In this case part of the box was stopped off longitudinally by dropping in a board.

The manner in which the cores for the portion of the T section flange between the arms were joined together is shown in Fig. 61.

In beginning the mold a pit was dug as deep as the cores were

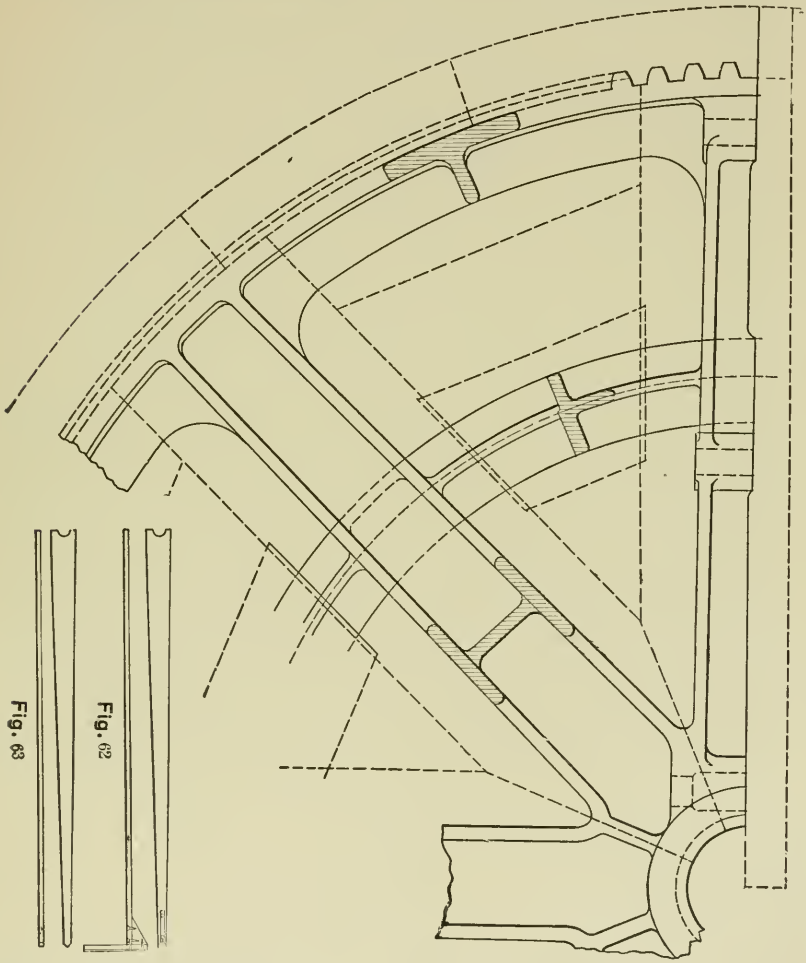


Fig. 62. Spindle and Gauge Stick
Fig. 63. Gauge Stick for Teeth

Fig. 57. Plan of Large Gear

high, and a level bed struck off. With the aid of a spindle and the gauge sticks shown in Fig. 62 the arm and rim cores were set.

The gauge stick shown in Fig. 63 and the templet of teeth shown in Fig. 64 were used for setting the teeth cores. The templet being used at the joints to see that the cores matched properly. This method

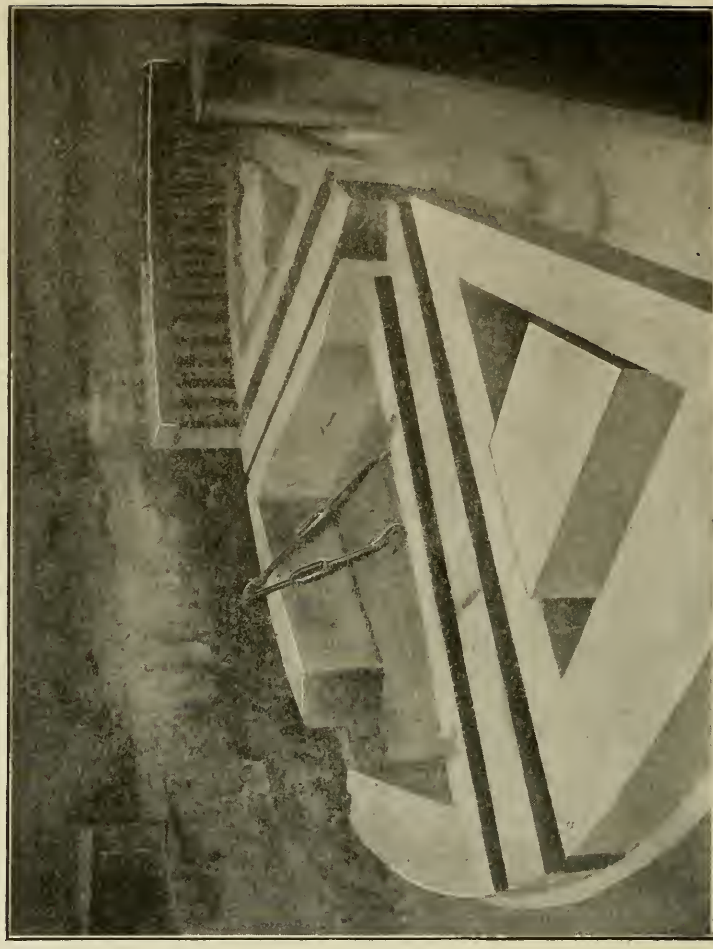


Fig. 66

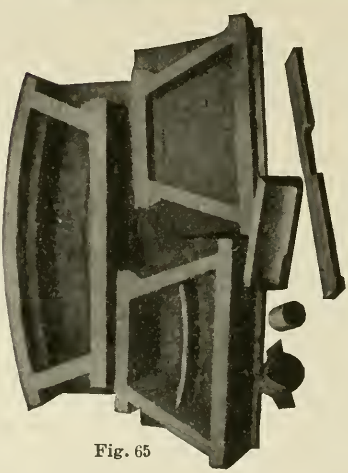


Fig. 65

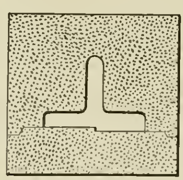


Fig. 61

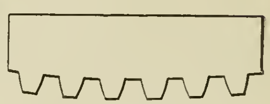


Fig. 64

Fig. 61. Core for T Section Frame

Fig. 64. Templet for Teeth

Fig. 65. Special Core Boxes

Fig. 66. Mold with some Cores set

of forming the teeth should be used only in cases where the teeth are to be finished by cutting. For cast teeth a segment containing a number of teeth should be revolved about a spindle and the teeth rammed up in sections.

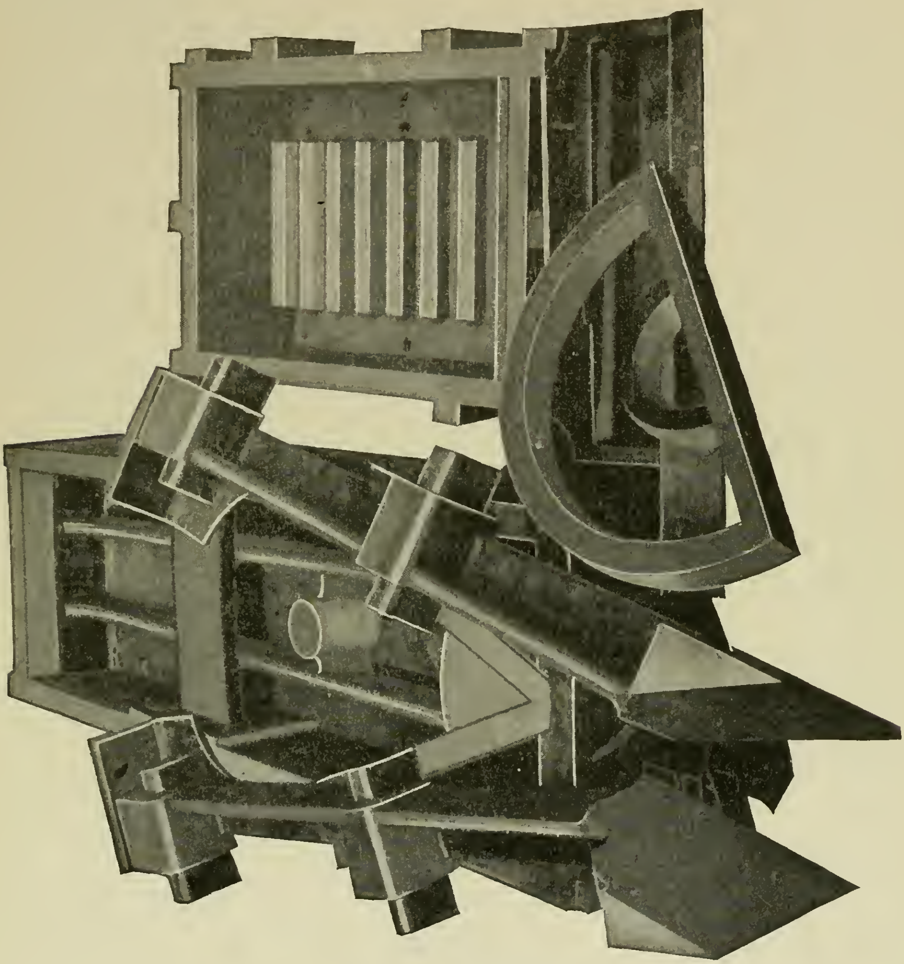


Fig. 60. Arm Core Boxes

A photograph of the mold taken during the setting of the cores is shown in Fig. 66. After the cores were all in place the space between as well as that between the walls of the pit and the tooth cores was rammed with sand.

In Fig. 65 is shown a photograph of some of the special core boxes used, which, together with the core boxes shown in Fig. 60, made all of the cores necessary for the different parts of the mold.

CHAPTER VIII

THE USE OF NAIL CORES

The use of nail cores in perforated cast iron strainers for the intake or suction end of pipes for pumps will be found a very simple and economical method of executing work of this character. While the manner of coring the holes is shown as applied to a strainer of cylin-

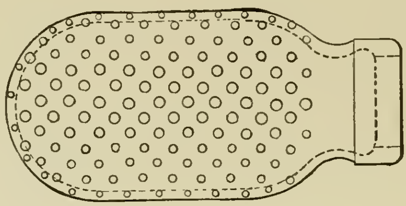


Fig. 67. A Strainer Head

drical form as shown in Fig. 67, it can be applied to almost any form. It is particularly well adapted to flat work, such as strainer plates, furnace door baffle plates, etc. The pattern is parted longitudinally and

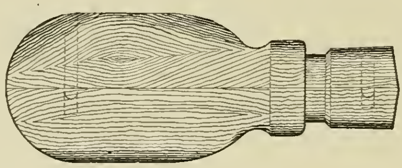


Fig. 68. Pattern for Strainer Head

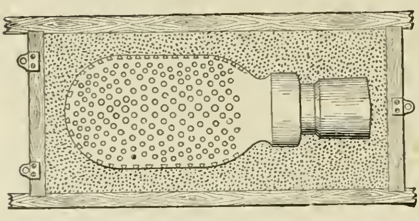


Fig. 70. Mold for Strainer Head

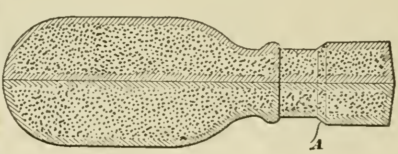


Fig. 71. Body Core for Strainer Head

turned up as shown in Fig. 68. It will be observed that the core print is turned with a shoulder A, this being done to insure its proper setting into the mold. The mold having been rammed up in the ordinary manner and the pattern drawn, the nail cores, as shown in greater detail in Fig. 69, are set at proper intervals around the mold as shown in Fig. 70. The body core shown in Fig. 71 is then placed in position and supported by the nail cores. These cores are similar to those com-

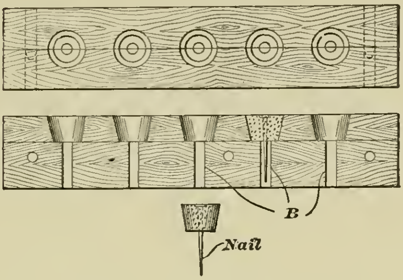


Fig. 69. Core Box for Nail Cores

monly used in coring babbitt anchorage in bearings. They are formed in a multiple core box as shown in Fig. 69, the hole B permitting the nail to be inserted through the core before the box is turned over upon the plate.

SECTION III

SWEEP WORK

CHAPTER I

SWEEPING A PLAIN CYLINDER

Cylindrical castings, such as that shown in Fig. 1, are frequently molded in loam by using sweeps which contain a radial section of the cylindrical portion of the casting. These sweeps are revolved around spindles and used to shape the material for the mold. Where castings are to withstand high pressure it is claimed that stronger and better castings having closer grain and denser metal can be made in loam than in green sand.

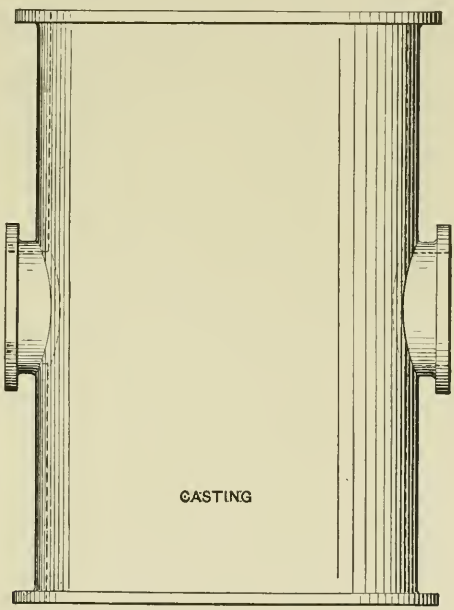


Fig. 1. Cylinder Casting

In this chapter we will treat both the rigs made in the foundry and those furnished by the patternmaker, as the exact method of handling the work cannot be understood in any other way. It is first necessary to make a foundation plate and a parting ring for supporting the inside and outside portions of the mold. The foundation plate is shown in section in Fig. 2, and both the foundation plate and the parting ring in section in Fig. 4. These plates or rings are usually made in open sand molds by using segment patterns.

After the rings or plates are completed, the foundation plate is leveled up with the spindle spider, or socket firmly imbedded below, as shown in Fig. 2. The upper end of the spindle is held in place by a bearing connected with braces which extend to the walls or to suitable supports built up outside of the mold.

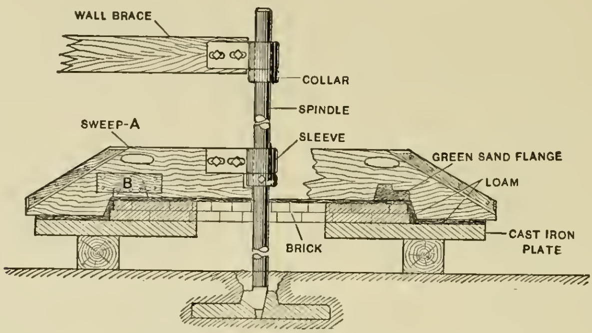


Fig. 2. First Sweeping Operations

The first sweep used in constructing the mold is shown at A, Fig. 2. In using any sweep it is always secured to the spindle in such a way that it is free to revolve about it. The sweep A is used to form the seat or offset parting, which is built up of brick with a loam facing sweep over it as shown.

After the loam has been swept in place, the cleat B, together with the piece connected to it, is removed. This leaves an opening in the sweep having a form like a cross section of the lower flange of the desired casting. A green sand flange is then swept up on top of the loam, as shown in the right of Fig. 2. This is skin dried and is subsequently covered over with loam and brick to form the lower flange of the casting. The green sand can be easily removed when the mold is taken apart. Some molders prefer a pattern made for this flange, as shown in Fig. 3.

After the flange has been placed or swept upon the seat, the parting ring for supporting the outer wall of the mold is placed upon the parting, as shown in Fig. 4. The sweep C is then secured to the spindle, as shown, and brick work built up upon the cast iron ring and loam placed upon it and swept off with the sweep C, as shown. The loam, of course, is given the proper form by revolving the sweep C about the spindle.

Patterns are made for the branches, or nozzles, upon the side of the castings shown in Fig. 1. This pattern is shown in detail in Fig. 5 and its setting in Fig. 4. These patterns are set by lines or are secured in their proper position by temporary supports and braces during the building of the outer portion of the mold. The core print A on the nozzle patterns is to form a seat for the covering core which forms the outer face of the flange and through which pass the cores for the inside of the nozzles.

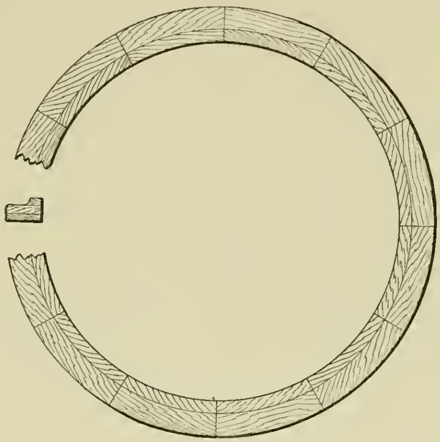


Fig. 3. Pattern for Lower Flange

After the outer wall is completed and the flange and parting swept at the top, the sweep is taken out and this portion of the mold removed and dried in an oven.

The main or central core is next swept up by using the sweep E, shown in Fig. 6. The lower arm F of the sweep is removed when the brick work has reached this height. The completed portion of the surface will act as a guide for the lower end of the sweep, while the remainder of the brick work is being built up and the loam swept on to it. When the core has been built to the required height, it is left in the position in which it was swept and the plate with the seat and core placed in an oven and dried.

A vertical section of the completed mold is shown in Fig. 7. In order to arrange the parts as shown, the foundation plate with the seat and core upon it is taken from the oven and carefully leveled up in the casting pit. The cast iron ring, with the outer portion of the mold, is next lowered in place. The circular covering cores for the nozzles are then placed in position and the central nozzle cores introduced through them as shown.

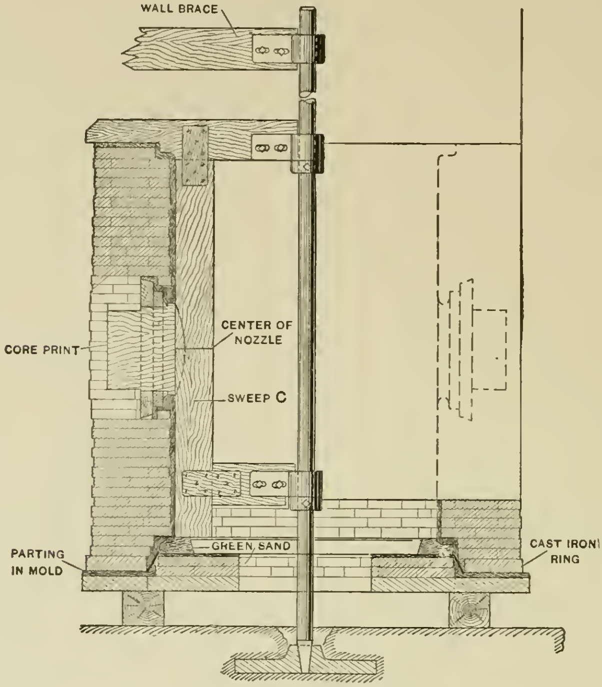


Fig. 4. Sweeping the Body of the Cylinder

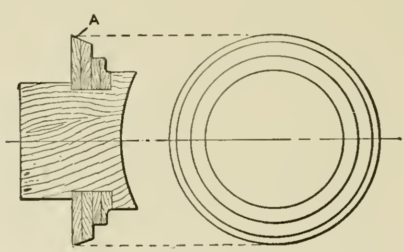


Fig. 5. Nozzle Pattern

After the nozzle cores have been set, the space between the brick work and the mold is rammed up with sand to form a backing for the mold.

Slab cores are used to cover the top of the mold and suitable gates are cut through these slab cores and a pouring basin formed. Of course it is necessary to use weights for holding down the slab cores and the different parts of the mold.

In the case of deep molds in which the iron would have to fall several feet from the gates, there is danger of cutting the mold by the first iron introduced and in such cases auxiliary gates are frequently formed by making a suitable gate into the lower flange and then ram-

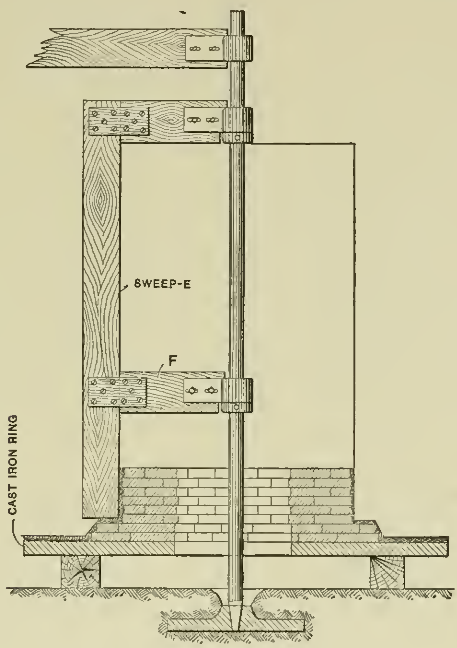


Fig. 6. Sweeping the Body Core

ming up gate sticks in the sand backing, or by introducing a gate made in cores while ramming up the sand.

The pouring basin is so arranged that the first iron will pass down through the bottom of this gate and into the bottom of the mold. After the bottom of the mold is thoroughly covered with molten iron, the ladle may be tipped faster and the metal introduced both from the bottom and from the top through suitable gates in the covering cores.

For such a mold as this the patternmaker has to furnish the sweeps shown, together with the patterns and core boxes for the nozzles and in some cases the segment pattern for the foundation plate and the lifting ring. He also has to furnish a core box for the slab covering cores. In such work as this, care should be taken to see that the nozzle patterns are so formed that there is a small amount of clearance between the edge of the sweep and these parts.

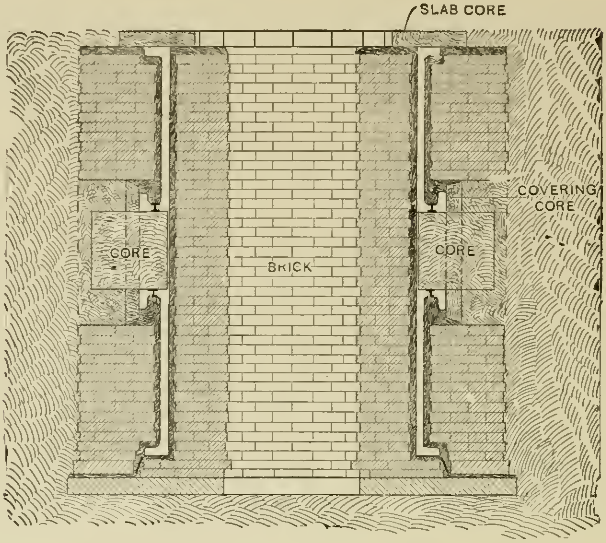


Fig. 7. Section of Finished Mold

As the lower parts of deep molds of this nature are apt to strain or swell, from the pressure of metal forcing the walls out and causing increased thickness of metal, it is often found practical to reduce the section of the lower part of the mold by setting the sweeps in a slightly inclined position.

CHAPTER II

SWEEPING THE MOLD FOR A SUCTION CHAMBER

In the previous chapter there was described the sweeping of a comparatively simple mold in loam, together with the rigs necessary for the job. In this article will be described the molding of a suction chamber which differs from that shown in Chapter I on account of the fact that it is necessary to build up and sweep a temporary seat or cradle to assist in forming and drying the main core and also on account of the method employed for supporting and setting the core by means of a cope ring. This casting also serves to show how irregular partings can be made at any desired point in a mold.

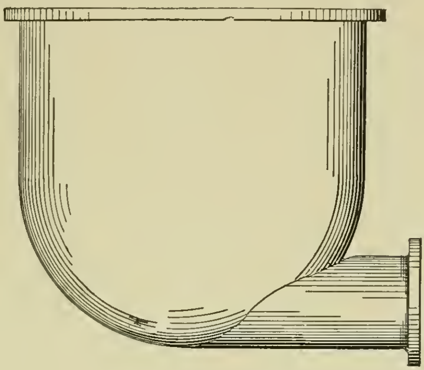


Fig. 8. Suction Chamber

In preparing the rigging for a job of this kind, the patternmaker has to lay out a full sized radial section of the piece to be molded and then to make the necessary sweeps and part patterns, together with the core boxes for the latter. It is also necessary to make any strips, sweeps, or segmental patterns which may be required for making open sand molds for lifting plates, cope rings, etc.

In the mold under discussion, which is shown in cross section in Fig. 14, it is necessary to provide some support for the cope. For this purpose a plate, similar to the one shown in Fig. 9, must be gotten out, but it is not necessary to have the projection at the right, the plate being circular with four bolting lugs.

In carrying on the work it is first necessary to get out a foundation plate F, shown in Fig. 10, level it up and place the spindle S, taking care to see that it is plumb. The sweep A is then secured to the spindle and the lower half of the nozzle pattern held in position by suitable supports as shown. The nozzle pattern must be set in such a position that the sweep just clears it. For setting this pattern the straight edge shown in the upper right hand corner of Fig. 10 will be found very handy. This is arranged with a notch A in the straight

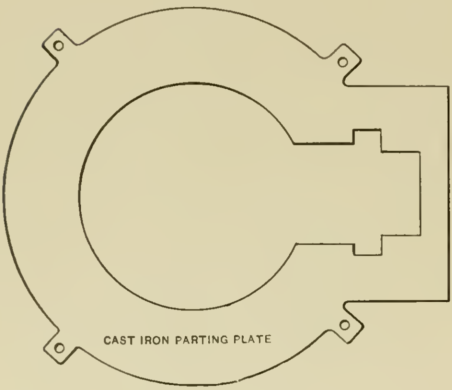


Fig. 9. Parting Plate

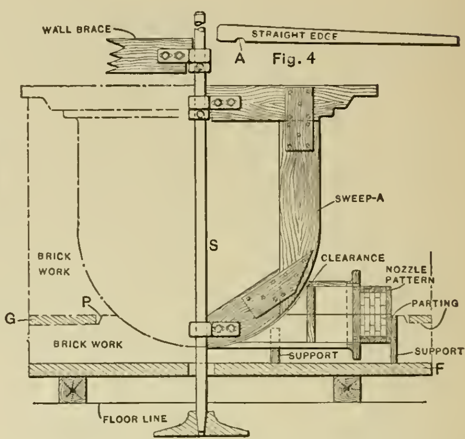


Fig. 10. Setting of Sweep and Port Pattern

edge cut to such a depth that when it is placed in contact with the spindle the straight edge is in line with the center of the spindle,—in other words, lies in a radial section.

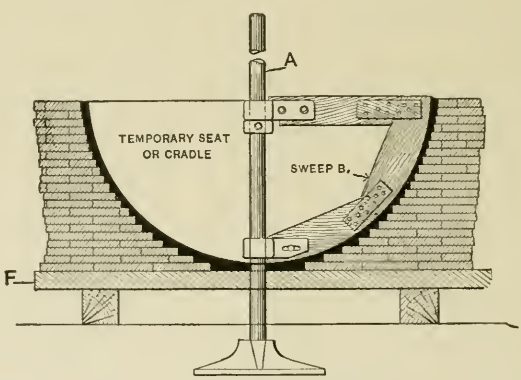


Fig. 11. Sweeping the Seat or Cradle

The lower half of the nozzle pattern should be placed first and held in position by a weight, while the lower portion of the mold is being built.

The circular portion of the mold below the cope ring G, Fig. 10, is built up of brick work covered with loam and swept off with the sweep A. When the brick work with its loam facing is complete to the joint, an offset parting is formed as shown at P, Fig. 10.

The cast iron plate G, shown in detail in Fig. 9, is then placed upon this parting, the cope half of the nozzle pattern set in place, and

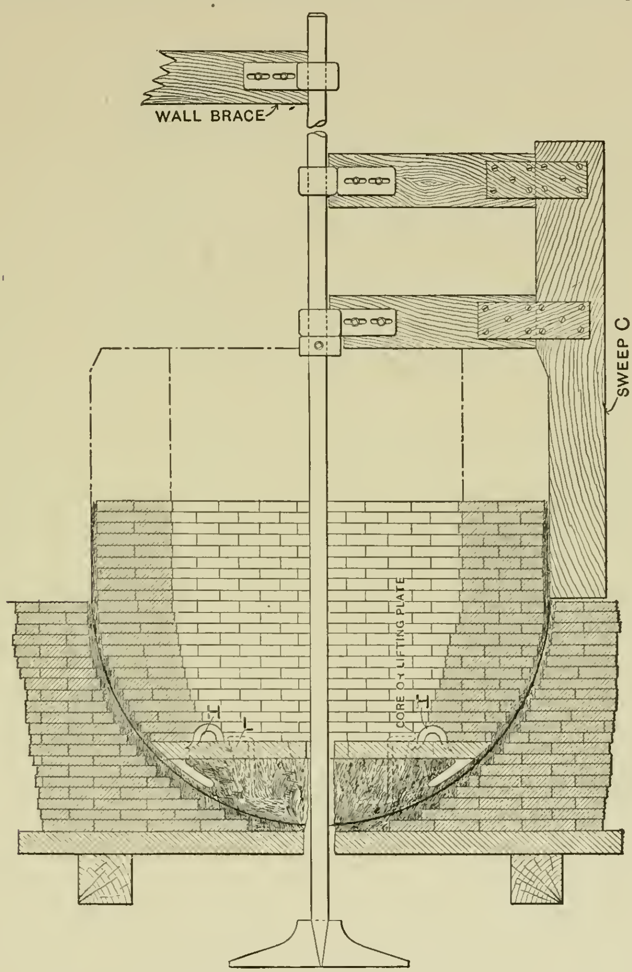


Fig. 12. Building the Core

the brick work and sweeping continued until the top of the mold is finished by sweeping it to the proper form for the flange and also sweeping the seat to receive the covering plate.

The sweep and spindle are then removed and the portion of the mold above the parting lifted off. The pattern is then drawn, the opening at the bottom of the mold through which the spindle passed is patched up, and the opening left for the support of the nozzle pattern are also patched. The mold is then blacked and placed in the oven to dry.

If this were a small casting it would be possible to sweep up the core in a reverse position and then roll it over, but in the case under consideration the casting is too large for this method and hence it will be necessary to sweep up a seat or cradle in which the lower portion of the core can be built. To do this a plate F, Fig. 11, is leveled up and the spindle A set perpendicularly and supported at the top.

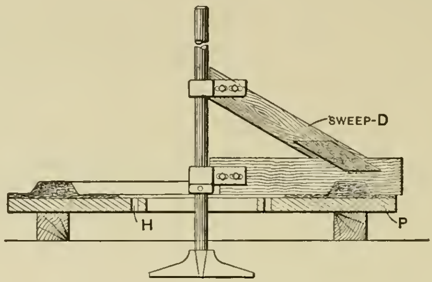


Fig. 13. Sweeping the Covering Plate

The sweep B is then secured to the spindle, brick work built up, loam applied and swept off, so as to form the seat or cradle as shown in Fig. 11. Care must be taken to see that the interior of the seat conforms exactly with the desired interior surface of the casting.

The cradle is then slightly dried, after which the core is built up in the manner shown in Fig. 12.

First, a core plate or lifting plate L is placed in position at the lower portion of the mold. Loam is placed between this and the surface of the cradle, and the space below, between and below the prickers which extend from the plate, is filled with molding sand which is thoroughly rammed and supported with rods or gaggers. Of course a loam facing is used next to the cradle after the space below the plate L has been thoroughly filled brick work is built upon it with a loam facing in contact with the cradle until the upper edge of the cradle is reached.

The upper or parallel portion of the core is then built up and swept off with the sweep C, as in the case of any plain cylindrical piece. The outline of the upper portion of the core is shown by the dotted line.

It is next necessary to make the covering plate, which serves both to cover the mold and to locate the core centrally. The manner of constructing this is shown in Fig. 13. The plate P is first leveled up wrong side up and loam applied over the prickers and struck off with the sweep D. This plate is provided with holes H, through which bolts can be passed and secured to the lifting lugs H, in Fig. 12. After the loam has been swept on this plate and dried it is turned over upon the core shown in Fig. 12 and the two are bolted together as shown in the assembled mold in Fig. 14. Of course it is necessary to dry the core before applying the cover plate.

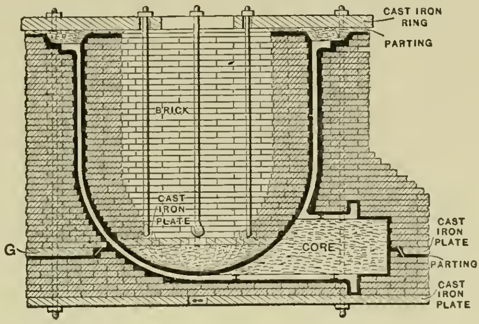


Fig. 14. Section of Mold

The various parts of the mold are now ready to assemble as shown in Fig. 14. First, the core for the nozzle is placed in position and supported upon chaplets. Next, the cast iron plate G carrying the upper portion of the outside of the mold is lowered upon the portion already in position, care being taken to place the necessary chaplets for holding down the nozzle core before the upper portion of the mold is lowered upon it.

Next, the cast iron ring or cover plate, together with the core, are lifted from the cradle and lowered into position. At first they are lowered carefully while strips of clay are interposed at various points to test the metal thickness. The parts are then separated and if the metal thickness is correct, the parts are assembled and bolted together ready for casting.

The cover plate is bolted down to the foundation plate as shown, and the space around the outside of the mold in the pit is firmly rammed with sand. The gating of the mold will vary according to the individual tastes of the molder in charge of the work. In many cases the gating is arranged either by ramming up gate sticks or by placing cores in the sand backing.

CHAPTER III

SWEEPING CAST STEEL SLAG LADLE MOLDS

When slag ladles are of cylindrical form, as shown in the two half elevations, Fig. 15, the mold is usually formed with sweeps, the striking edges of which contain radial sections of the interior and exterior forms of the ladle to be cast. The sweeps are attached to and revolve about a perpendicular spindle with the aid of sleeves and a collar.

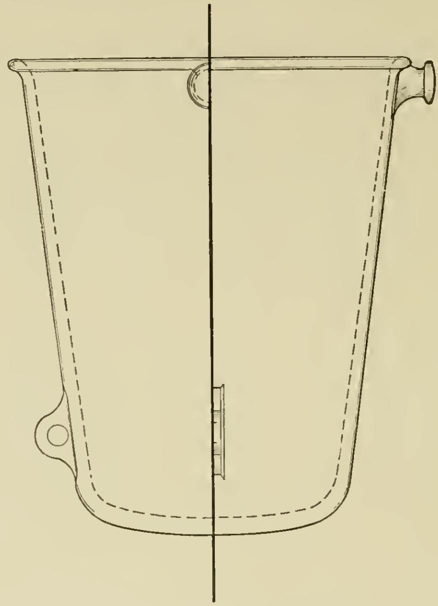


Fig. 15. Cast Steel Slag Ladle

At the right in the illustration is shown the half elevation of the ladle containing one of the trunnions, while at the left is shown a half elevation at right angles to the other, so as to show one of the tipping lugs.

The pattern work for such a job requires the laying out of a full sized radial section of the ladle, and the making of the sweeps and fitting them to the spindle, the making of the core prints for that portion of the trunnion core which extends into the cope, and the necessary core boxes for the trunnions and tipping lugs.

When sweeping up molds for ladles of small diameter, say below four feet, as the one under consideration, a skeleton or built-up bottom as shown in position in Fig. 16, is usually made to form this portion of the mold. The use of such a partial pattern affords a surface for the molder to stand upon while using the sweep and finishing the mold.

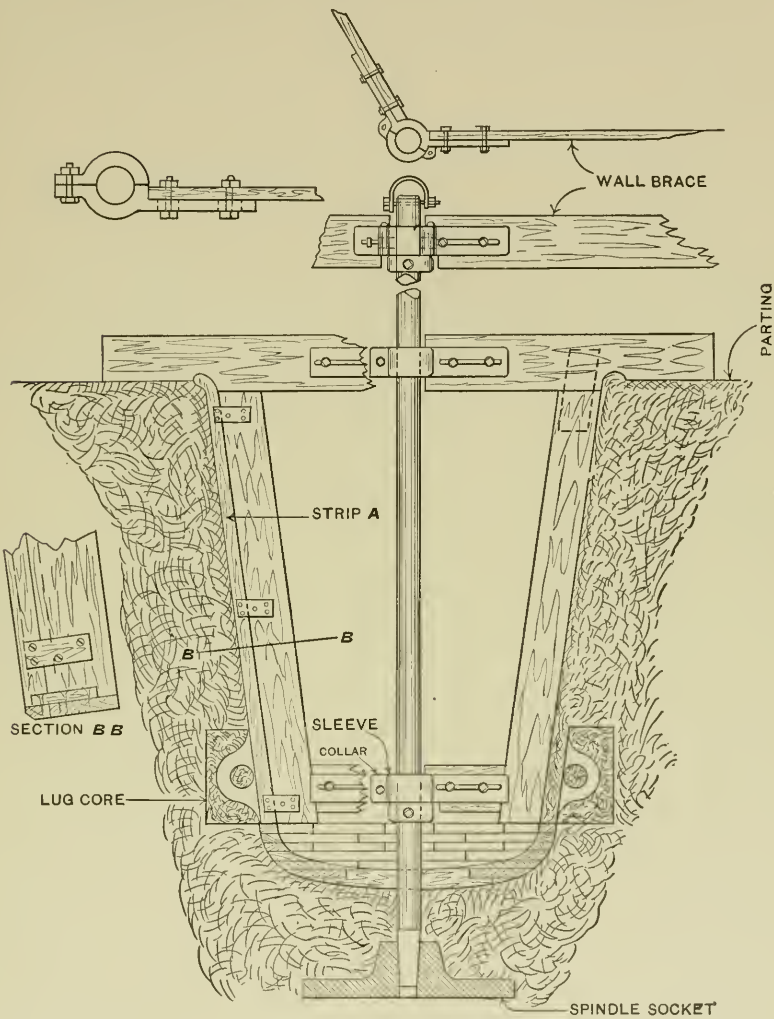


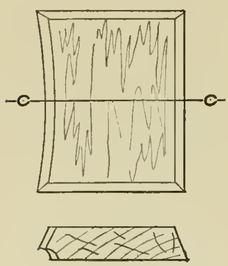
Fig. 16. Sweep in Place

After the completion of the preliminary pattern work, the molder takes the job in hand and begins operations by digging a hole in the floor to the depth of the ladle to be cast and firmly placing the spindle socket in position.

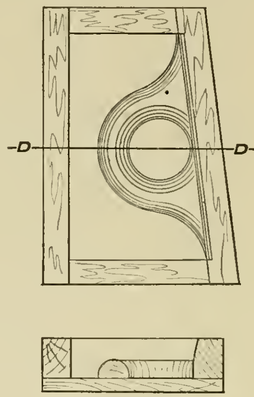
The built up portion of the bottom of the ladle pattern is now placed in the bottom of hole and the spindle passed through the hole in its center and seated in its socket as shown. The spindle is then plumbed and the wall or post braces adjusted. Next, the partial pattern is leveled up and firmly bedded in place.

With the upper edge of the part pattern for a guide two surfaces are struck off diametrically opposite each other to receive the lug cores. These cores are prepared for insertion in the mold by stopping up the openings with waste or some other suitable material.

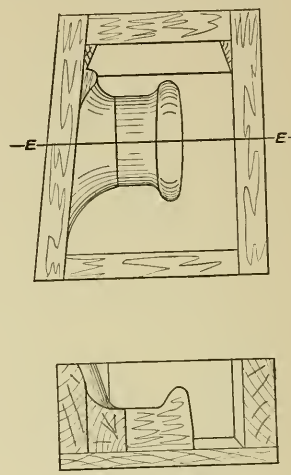
During the sweeping of the inner surface, the lugs are set back from the first sweep a distance equal to the metal thickness by the aid of a strip bradded on to the side of the sweep. The lug cores are



SECTION CC
Fig. 17



SECTION DD
Fig. 19



SECTION EE
Fig. 20

Fig. 17. Core Print for Trunnion — Fig. 19. Half Core Box for Tipping Lug
Fig. 20. Half Core Box for Trunnion.

shown in position in Fig. 16, together with the arrangement of the sweep during the two operations of sweeping. That is, the sweeping up of the inner form upon which the core is rammed and the subsequent sweeping off of the metal thickness.

The sweep is attached to the spindle as shown and as the use of an ordinary solid sleeve causes more or less inconvenience in placing and removing sweeps, a split sleeve as shown in the upper left hand corner of Fig. 16 can be used to very good advantage.

The sweep is constructed as shown in Fig. 16, being provided with a detachable strip A, equal in width to the required metal thickness of the ladle. A cross section of the sweep on the line B B with the attached strip A is shown in detail at the left of Fig. 16.

After the completion of the bedding in of the part pattern and the location of the two lug cores, the sweep without the strip A is attached and the inner form of the ladle swept up, a parting being made for the cope as shown at the right of the spindle in Fig. 16. The sweep and the spindle are then removed and the opening in the part pattern through which the spindle passes stopped up with waste to prevent the sand ramming into it.

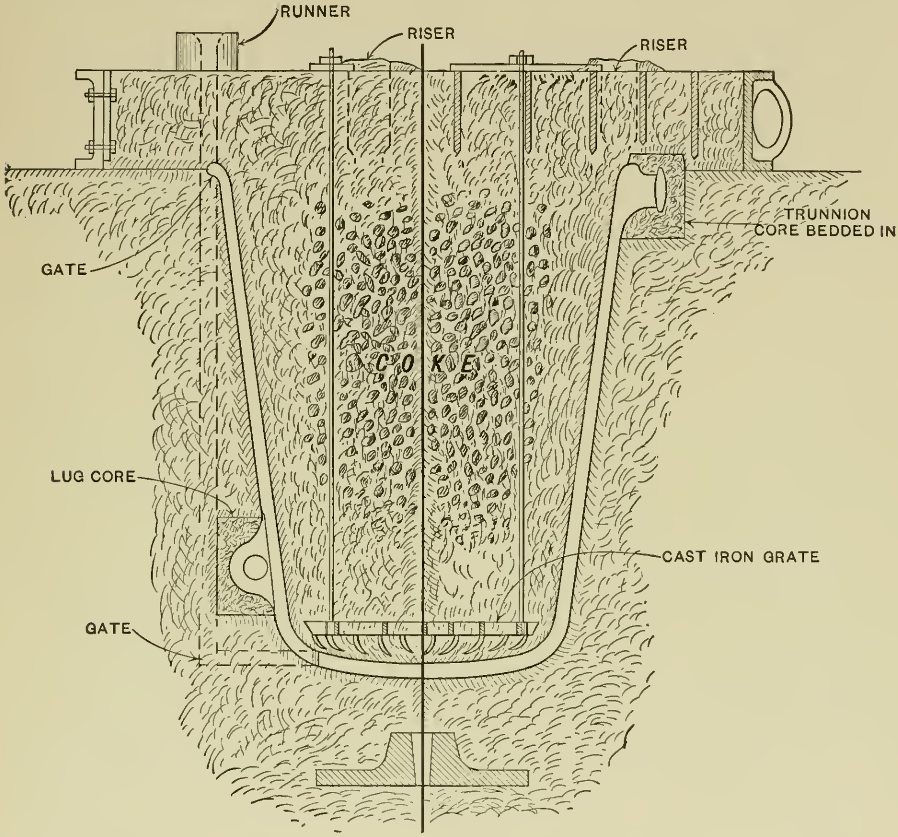


Fig. 18. Section of Mold

With the aid of a straight edge and plumb bob the center line of the trunnions is scribed across the parting of the mold at right angles to the center line of the tipping lugs and the two core prints are placed in position.

One of these core prints is shown in greater detail in Fig. 17. These prints are set diametrically opposite each other and on a line at right angles to the center line passing through the tipping lugs.

Parting sand is next applied to the parting of the mold and the interior cylindrical surface of the ladle covered with paper. A grate or crab iron conforming somewhat to the form of the bottom of the core is next placed in position and provided with bolts of such a length that they will extend up through the cope. This crab iron is shown in Fig. 18. When ramming up the core a thickness of silica sand is placed around the outer surface. Ordinary heap sand is used back of this and the interior of the core filled with coke.

When the ramming of the core, with its filling of coke, has reached the height of the parting line, the cope is placed on and staked in position. The core is now securely bolted to the cope. After the cope has been rammed, the cope, with the attached core, is lifted off, blocked up and finished. The outline of the two trunnion core prints is marked upon the parting by scribing a line around them, after which our attention is turned to the obtaining of the proper metal thickness. The swept surface of the interior of the mold is first roughed off with a shovel to a depth equal to the metal thickness of the ladle plus the thickness of silica facing to be used. The strip A is next attached to the sweep and the spindle returned to its proper position. The outer portion of the mold is then swept up with its silica facing, thus giving the required thickness of metal for the ladle. The depth of the trunnion cores is laid off on the sweep and transferred to the surface, after which the sweep and spindle are removed.

Guided by the outline of the core prints scribed on the parting and the lines scribed on from the sweep, an opening is cut out on each side of the mold and the trunnion cores bedded in in the proper position, as shown at the right in the view of the cross section of the completed mold in Fig. 18. At the left of Fig. 18 is shown a view of the cross section of the completed mold through a tipping lug, together with the arrangement of gates and runners required.

After the setting of the trunnion cores has been completed the inside of the mold is dressed and the part pattern removed. The spindle hole is then filled up and the bottom portion of the mold slicked up and finished. This, as will readily be seen, is a rather awkward operation.

The mold is then given a silica wash and dried. The cope is subsequently placed on and tried for metal thickness and if found correct, is securely weighted down, when the mold awaits the metal.

The core boxes for forming one-half of the lug and trunnion cores are shown in Figs. 19 and 20. Two half boxes are required for each core.

CHAPTER IV

A FURNACE HOPPER AND BELL

A cross section of a blast furnace hopper and bell of familiar design is shown in Fig. 21. These castings are frequently made from steel, and vary in diameter from 6 to 12 feet. When exceeding these proportions, they are usually cast in sections which are bolted together.

While the sweeping or forming of molds of this description is comparatively simple, it may embrace some points of interest. The method frequently adopted is shown in the accompanying illustrations and will serve to familiarize the patternmaker with this character of work, including the laying out and making of the accompanying sweeps, etc.

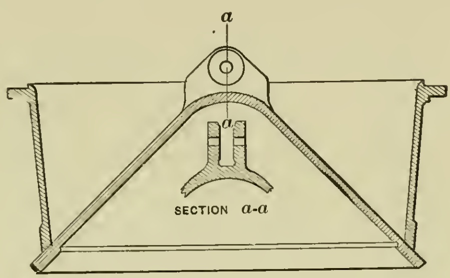


Fig. 21. Section of Bell and Hopper

The bell being of conical form can be cast in either position, but is usually cast with the apex down, as this insures a better casting and allows risers to be placed upon the rim. This position also permits the inside to be lifted out with the aid of a skeleton or lifting plate.

Molding the Bell

In beginning the work, a hole is dug in the floor equal in depth to the height of the bell and the spindle is set and plumbed as shown in Fig. 22, wall braces being used to secure the upper end and to hold the spindle rigidly.

Shown in Fig. 23 is a partial pattern containing the apex of the bell and to which is secured the core print with the lifting lugs or ears attached. This part pattern is provided with a hole through the center to receive the spindle and to locate it in the proper position. It is firmly bedded in, forming the lower portion of the mold, as shown in Fig. 22.

Attention is also called to the manner of supporting the lower end of the spindle upon a center, as shown in Fig. 22. The advantage of this method is that any dirt which may be dropped into the hole will not interfere with the spindle.

The sweep is constructed as shown in Fig. 22 and provided with a detachable strip D, equal in width to the required metal thickness of the bell. A cross section of the sweep on the line C-C, with the

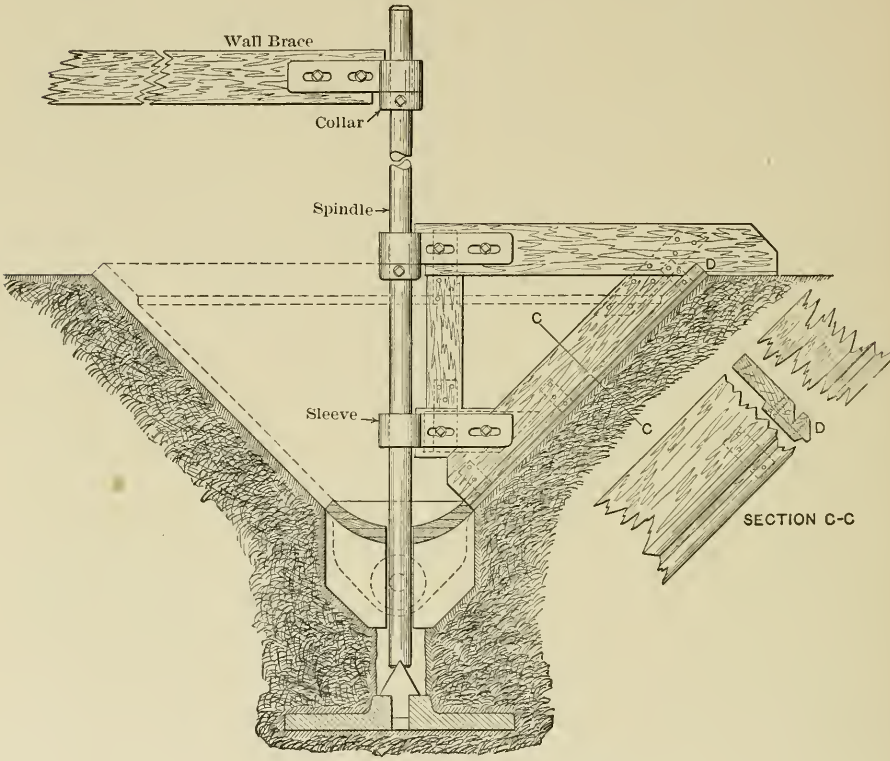


Fig. 22. Spindle Set for Sweeping the Stopper

attached strip D, is shown in greater detail to the right in Fig. 22. The sweep is attached to the spindle as shown. The split sleeve shown in Fig. 16 may be used in this case. This allows the sweep to be attached without disturbing the spindle, the sleeve being provided with a clamp secured with a bolt.

There are two methods which may be used for sweeping up pieces of this description. First, sweeping up of the inner surface or form of the required object, and then the sweeping off of the metal thickness after the central portion or core has been made. Second, the sweeping up of the outer surface or form of the object, applying of parting sand, and then with the strip D removed, the sweeping on of a thickness of sand equal to the thickness of the metal, after which the core is rammed up on this surface. The thickness of sand forming the metal thickness is removed during the finishing of the mold.

The method discussed in this article will be the first mentioned process, which is the one usually adopted in steel foundries. At the completion of the bedding in of the part pattern, the sweep without strip D is attached and the inner surface or form of the mold is swept up and the parting for the cope made, as shown in Fig. 22.

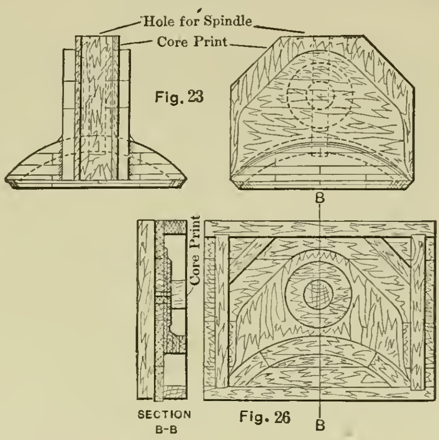


Fig. 23. Pattern for Apex of Bell Fig. 26. Core Box for the Ears or Lugs

The spindle sweeps, etc., are then removed, and the hole for the spindle in the part pattern stopped up. Parting sand is freely applied, and the skeleton shown in Fig. 24, with rods upon it to conform somewhat to the shape of the mold, is placed in position and the ramming of the core begun.

At the completion of the ramming of the core, the cope or flask is placed on and firmly rammed up, being securely bolted together somewhat after the manner shown in the cross section of the complete mold, Fig. 25.

The cope with the core attached is now lifted off, blocked up, finished and dried. The inner surface of the mold is then roughed out, the spindle and sweep replaced, and with the strip D attached, the outer surface or form swept up, giving the required metal thickness. The spindle and sweep are then removed, the part pattern drawn, the mold finished, and the core forming the inside of the lugs, or ears, placed in position. The gate is arranged and the mold is dried.

The cope is now placed on, and if the metal thickness is found correct, the whole is weighted or bolted down, and prepared for casting.

Two views of the core box used for forming the ears or lugs are shown in Fig. 26.

Molding the Hopper

In this particular case, the molding of the hopper differs from that of the bell, inasmuch as only the outer surface is formed with a

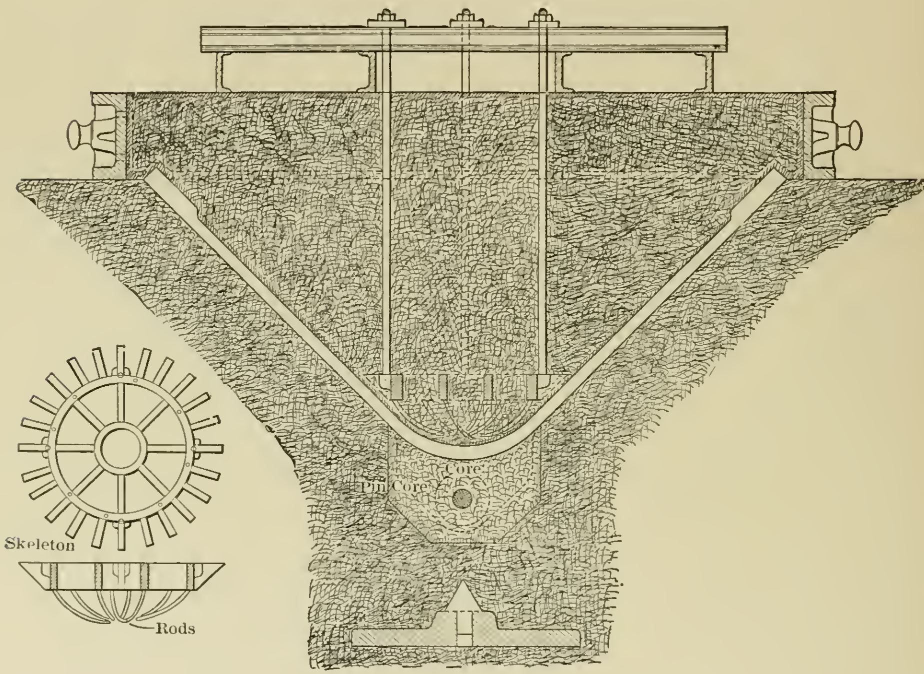


Fig. 24. Skeleton for Core

Fig. 25. Section of Mold

sweep, the inner surface being obtained with the aid of lagging and strips in thickness equivalent to the metal thickness of the hopper. These lagging pieces being used as shown, the strips are placed at intervals around the mold, forming a guide by which the required depth can be struck off from the core, to give the proper metal thickness.

A cross section through the center of the mold for the hopper is shown in Fig. 27. To the right of the spindle is shown the construction and arrangement of the sweep, as it appears during the operation of sweeping the outer surface or form of the mold with the flange and parting at the top, also the seat for locating the core.

At the left of the illustration, the form of the mold after sweeping is completed, is shown, with the lagging and strips for giving the metal thickness, in place.

The outline and position of the covering core is also shown in dotted lines.

The operation of sweeping being complete the spindle and sweep are removed and parting sand or paper applied to the swept surface. Paper is generally applied to the walls of the mold.

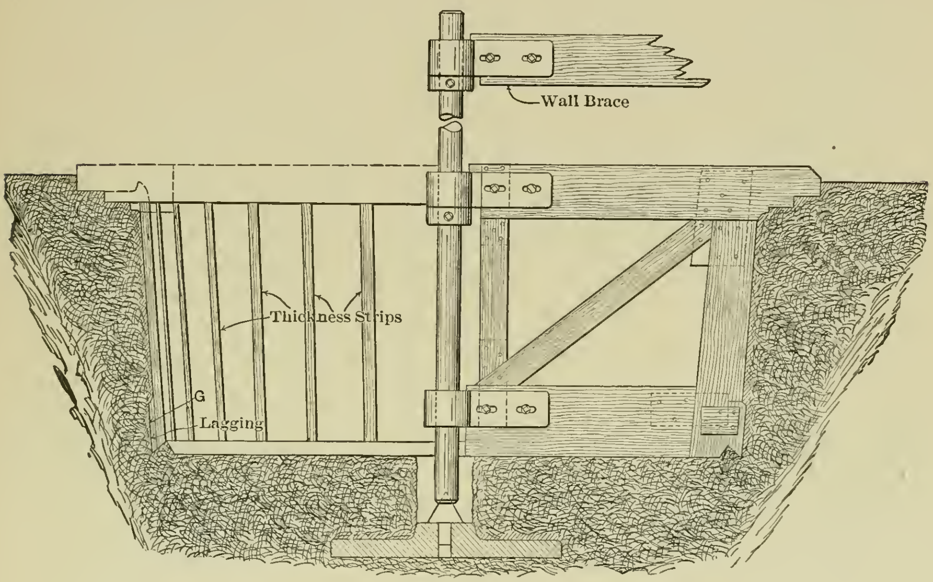


Fig. 27. Section of Hopper Mold with Sweep in Place

The undersweep surface G is now filled in with lagging, so as to close off this depression, and the metal thickness strips are placed in position. A core bar, consisting of a series of round flasks of convenient diameter and depth, which have been firmly clamped and bolted together, and provided with wing bars bolted to their outer diameter, is now lowered into the mold and centrally located upon the seat. Sand is firmly rammed and rodded into the inclosure formed by the outer diameter of the flasks and the swept surface of the mold, the top being furnished with a seat or surface to receive the covering core. This is accomplished with the aid of a segment conforming to the swept core seat and flange and applied in the manner shown in Fig. 29.

The core bar, made up of flasks, is now lifted out with the sand core intact and blocked up. The thickness strips are removed and with these depressions acting as guides for the depth, the metal thickness is struck off and the core finished and dried.

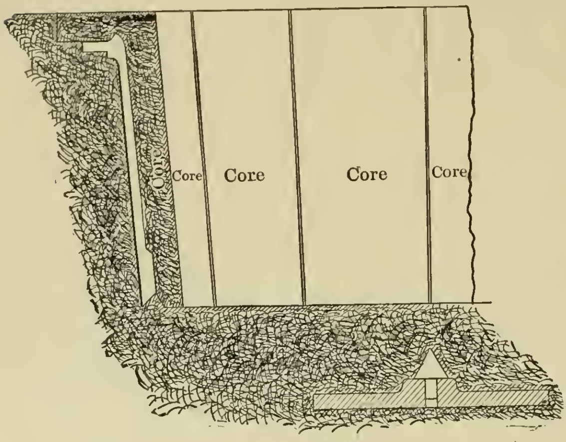


Fig. 31

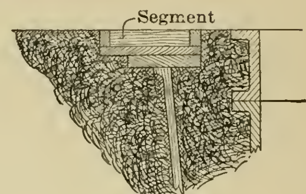


Fig. 28

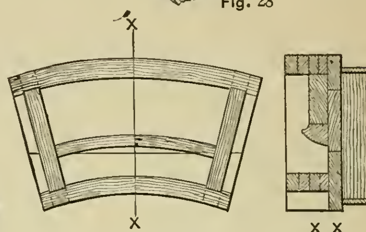


Fig. 30

Fig. 28. Segment to Form Seat for Covering Core Fig. 30. Core Box for Covering Cores
Fig. 31. Use of Cores to Form Inside of Mold

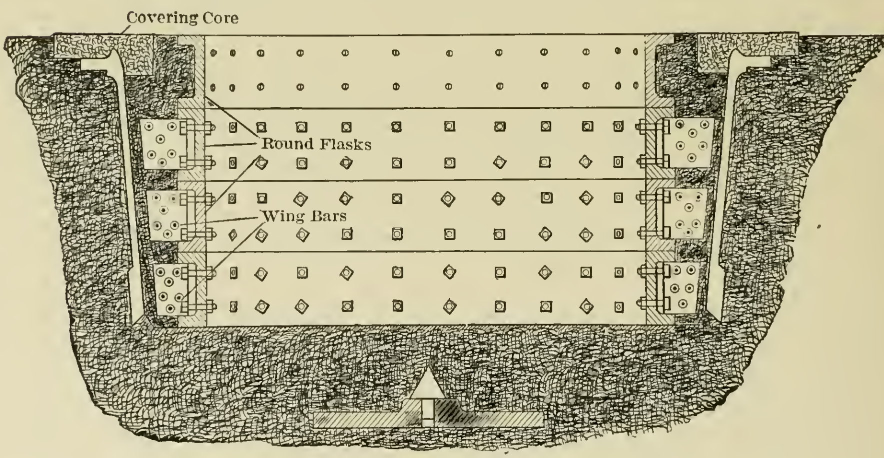


Fig. 29. Completed Mold

The lagging in the portion of the mold G, Fig. 27, being removed the mold is treated in the usual manner. The parts are then assembled, as shown in the cross section of the complete mold, Fig. 29, the covering cores being formed in the box shown in Fig. 30.

These are used to form the upper surface of the flange and close the top of mold, openings being filed in a number of these covering cores at different points around the mold, at which points risers are built up.

The runner is arranged through the center of the mold or flasks, and the castings gated from below. The whole structure is then weighted down and prepared for casting.

Another method practiced in some cases is illustrated in Fig. 31. In this case, cores are used to form the inner surface of the mold and the upper face of the flange. The inner surface or form of the mold with the seat for the cores at the top and bottom is swept and dried in the manner already described, after which the series of cores are placed around the inside of the mold, so as to form the metal thickness, provision of course being made for the runner and gating, after which sand is firmly rammed within the inclosure formed by the cores forming a solid core.

CHAPTER V

SWEEPING A CYLINDRICAL AND CONICAL DRUM

The accompanying illustrations show a combined cylindrical and conical hoisting drum with a variable pitch score, and also one method of sweeping the same in loam. These drums, two in number, form a right and left when placed together, and were designed by the Wellman-Seaver-Morgan Co. They were used in the construction of an electric automatic water hoist, in an anthracite coal mine near Scranton, Pa.

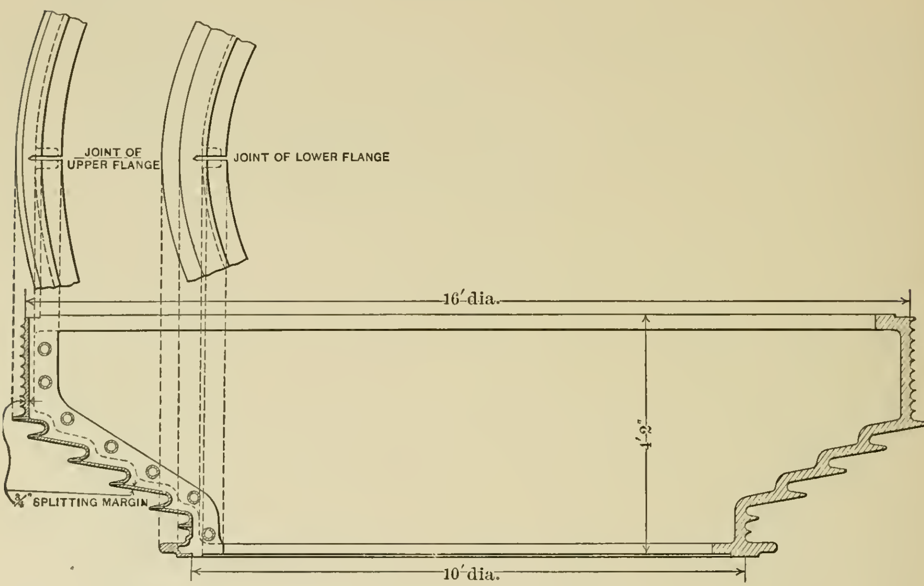


Fig. 32 Cylindrical and Conical Drum.

This design of hoisting drum is employed in winding heavy loads from deep mines. When the skip or load is at the bottom of the mine, ready to be hauled up, the winding of the cable begins at the small cylindrical end. This prevents the load from starting too suddenly, and allows the slack cable in the shaft to be gradually taken up at the beginning of the hoist. The motor or engine also gains a decided advantage when these drums are employed, as the winding starts at a slow speed and gradually increases, thus giving the motive power a better chance to do its work, and reducing the strain to a minimum.

Fig. 32 gives a cross section of the drum; to the right is shown the metal thickness, and to the left the bolting flange with its splitting margin along the joint and around the bolt holes. The drum is cast practically entire, and subsequently split in two.

It will be seen that the drum is 16 feet in diameter at the large end, and 10 feet at the small end. The conical section is very flat,

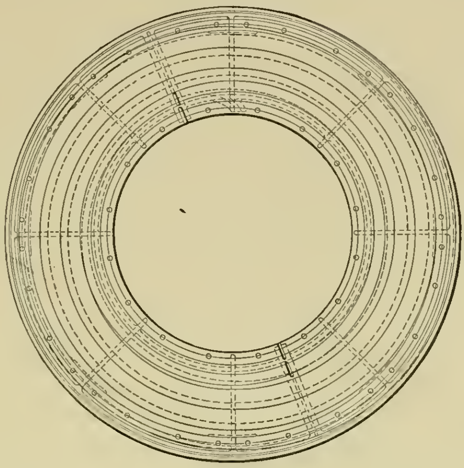


Fig. 33. Plan of Drum

and increases from the small to the large diameter in four revolutions. Fig. 33 gives plan of drum at the small cylindrical end, showing ribs, bolting flanges, etc.

As the rig or device employed in producing conical drums of this description is one of the principal features, upon which the accuracy

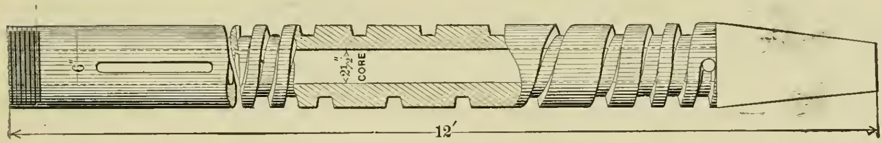


Fig. 34. Spindle Screw

of the work greatly depends, its calculation and construction usually receive the initial attention, therefore we shall proceed in this wise.

Special Sweeping Rig

The variation in the axial pitch of the drum score was produced by a variable pitch thread cut upon the cast iron hollow spindle, as illustrated in Fig. 34. This thread receives the conical roller A, which is provided with a roller bearing bracket B, as shown in plan and section, Fig. 35. The outer diameter of the spindle is turned to the required dimension, six inches, the variable pitch thread is laid off, and holes drilled at the points where the pitch of thread changes. The spindle is then returned to the lathe, and the required pitch of thread between the drilled holes cut, the spindle being finished at the top and bottom as shown.

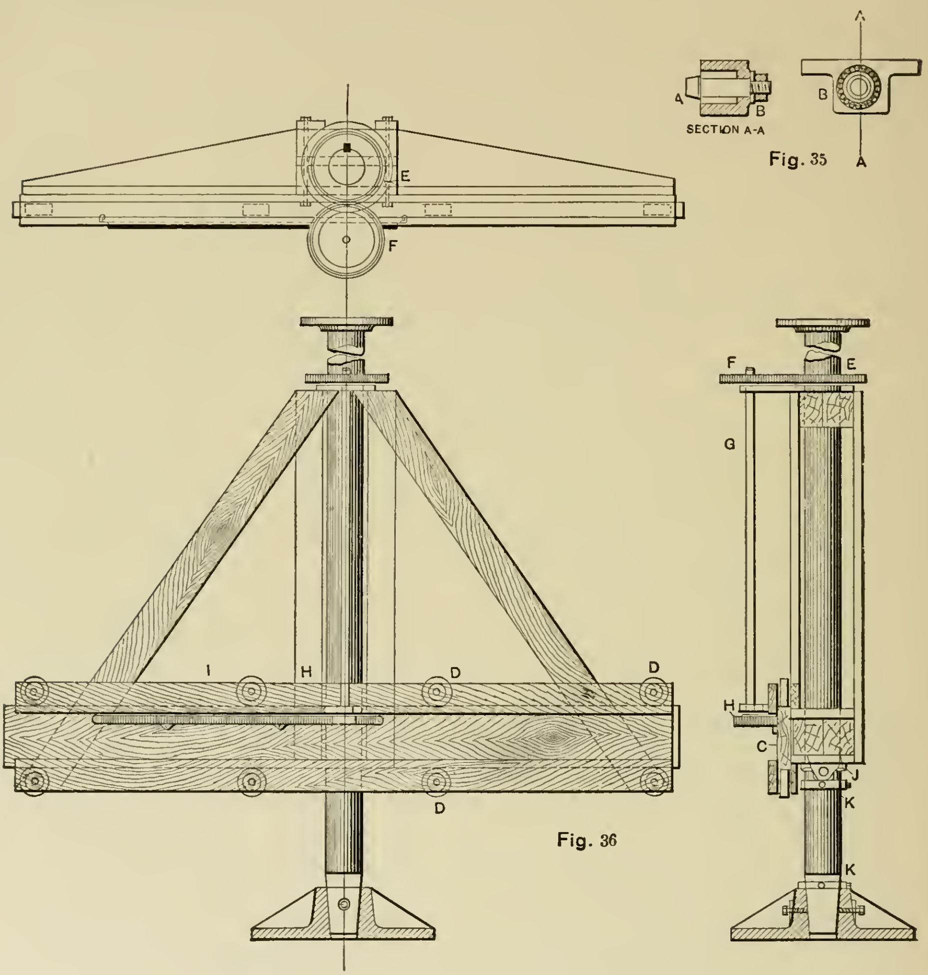


Fig. 35. Roller Bearing Bracket Fig. 36. Sweeping Rig

Three views of the assembled device are shown in Fig. 36, giving the general construction of the frame. The material used is hard wood. The sliding arm C is held in place as shown, and with the aid of rollers D, is allowed to travel or slide freely. Gear E at the top of the frame is attached to the spindle with a feather key, permitting it to travel up and down the spindle as the frame is raised or lowered. As the frame is revolved around the spindle, gear E drives gear F, which, by means of shaft G, pinion H, and rack I, causes the sliding arm C to travel radially backward or forward, as the case requires.

The raising or lowering of the frame is governed by the engagement of the conical roller A, with the thread of the spindle. The bracket B is located and secured to the lower part of the frame at J. The proportion of gears governing the travel of arm C during the sweeping of the conical section of drum is as follows: The angle of the conical section is 120 degrees, giving a 9-inch throw to the 5-inch pitch; that is, the frame would rise 5 inches in one revolution, while the arm C would travel outward 9 inches. The gears are of ½ circular pitch, gears E and F having a pitch diameter of 10.15 inches, and 64 teeth; gear H contains 18 teeth with a pitch diameter of 2.86 inches.

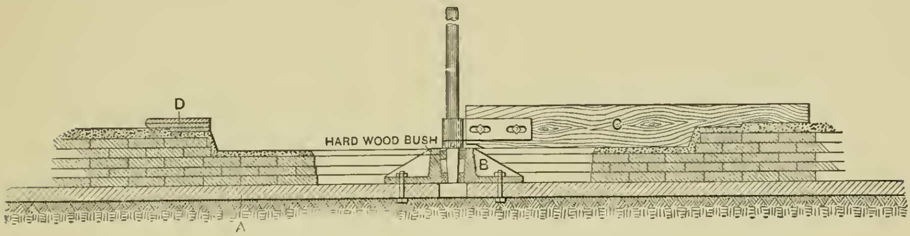


Fig. 37. Foundation Plate and Spindle Setting

These proportions give the gears the same number of revolutions as the frame.

When using the frame with the arm C stationary, as in the sweeping of the cylindrical sections, gear E is thrown out of mesh with gear F by being raised up and a block or support placed underneath it. This also requires the disengaging of the roller from the thread of the spindle. The frame is now held suspended and revolved upon the collar K; the collar being dropped down upon the spindle socket when not in use.

Sweeping the Mold

The pit having been dug to the depth of the drum, a bed is struck off for foundation plate A, which is placed in position and leveled up with the spindle socket attached, as illustrated in Fig. 37. The socket is bushed as shown, to receive an ordinary spindle, to which is attached the sweep C. The brick work is now built up to the required height in the usual manner, and a heavy facing of loam applied and struck off to the form of the sweep. The cutting edge of the sweep forms the seat for the core, and also a surface and guide for placing flange D, which is shown in position to the left.

Fig. 38 illustrates the rig in operation, showing the arm with the various cutters and strikes attached, which are employed at the different

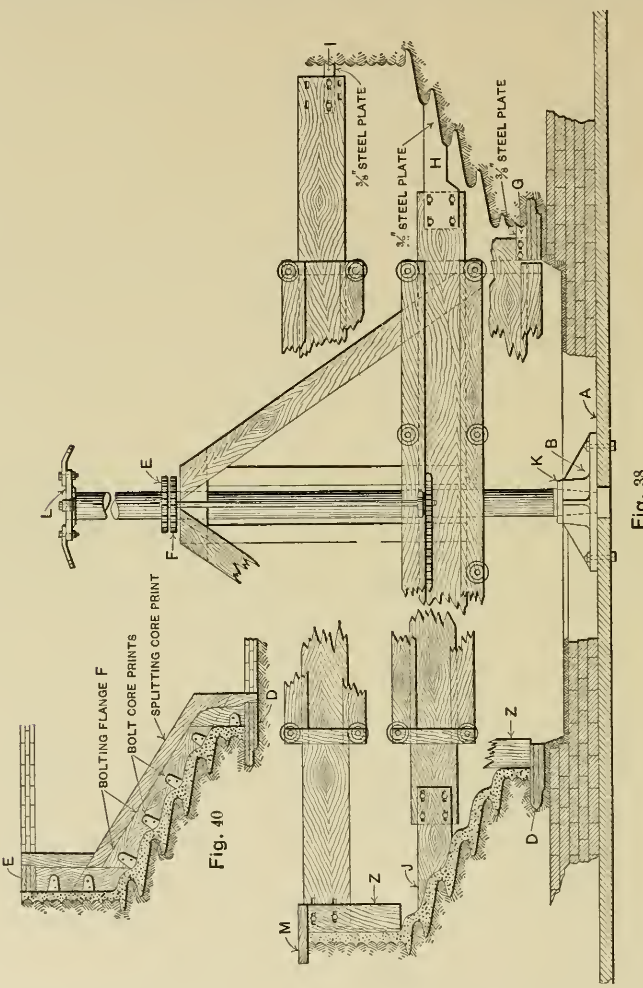


Fig. 40. Bolting Flange

Fig. 38. Sweeping Rig in Use

stages of sweeping the mold. To the right are shown the cutters G, H and I, required in forming the score. They are made of $\frac{3}{8}$-inch. steel plate, dressed to form and the back beveled off, forming a comparatively sharp edge. To the left are shown the strikes J and Z, employed in sweeping on a body of sand the equivalent of the metal thickness.

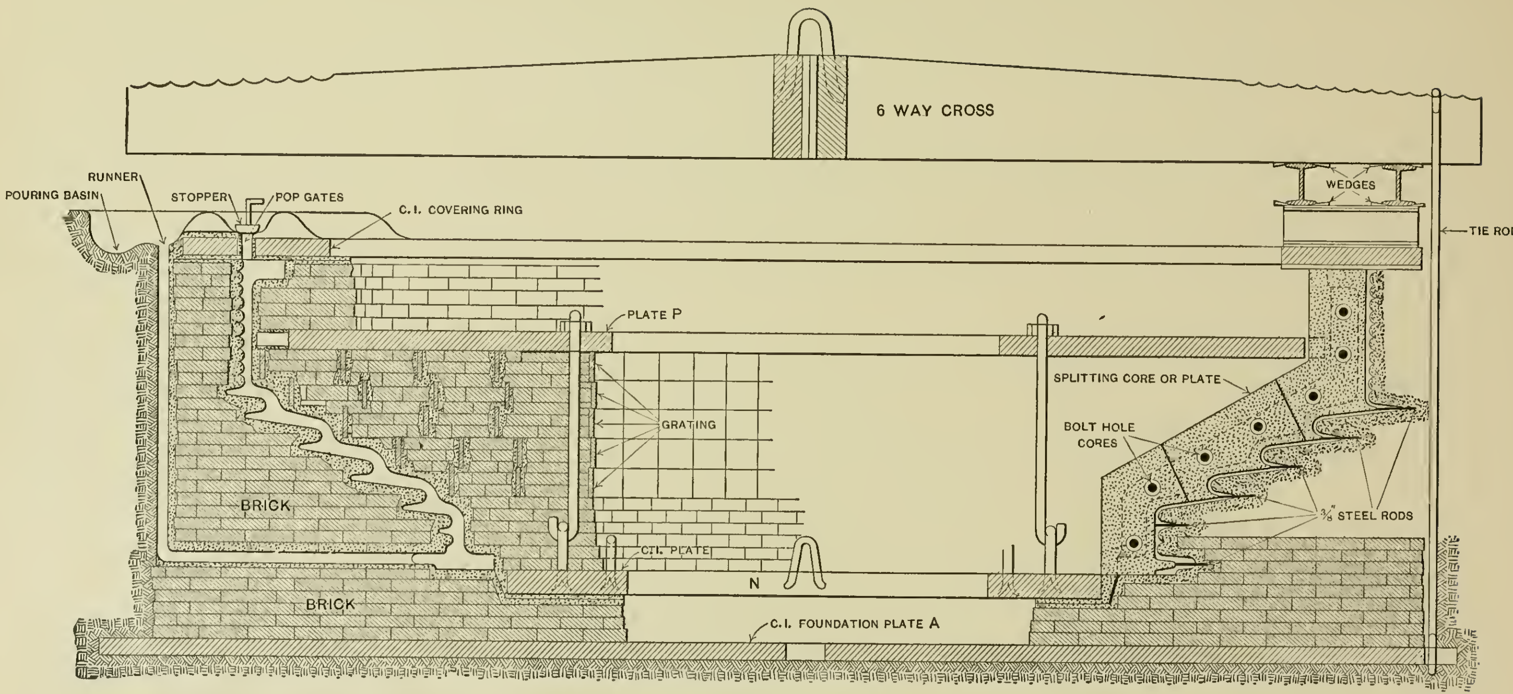


Fig. 39. Section of Mold

With the seat for core prepared and flange D in position, the scoring of the mold is in order. Following the plumbing of the spindle, the frame is lowered down over it, and the upper end secured with guy rods attached to flange L. With the roller engaged with the thread of the spindle, the gear E thrown out of mesh with gear F, the frame is placed in position at the starting point, this being governed by the thread of the spindle. The slide with cutter G attached is next adjusted to the required diameter of score, and the slide locked in position, as shown to the right at the starting point.

The brick work with a heavy loam facing, which is struck off to the form of cutter along its helical path, is now laid until the conical section is reached. Cutter H is now attached to the slide as shown, gear E dropped into mesh with gear F, causing the slide to travel outward as the frame is revolved.

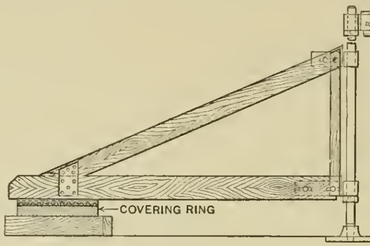


Fig. 42

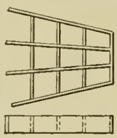


Fig. 41

Fig. 41. Grates for Holding the Core Fig. 42. Sweeping of Covering Ring

As the changing of these cutters and pitch of scoring is rather abrupt, a little doctoring or making up of score becomes necessary at this point, and is accomplished with the aid of a segment representing a section of scoring. The segment is so dressed that it works from one section to the other. This mending up also becomes necessary when the large conical and cylindrical sections meet, at which time cutter I is attached, and the bricking and scoring completed to the top.

At the top a surface to receive the covering ring is struck off with the aid of strike M, attached to the slide, as shown to the left. This necessitates the throwing out of the gears and conical roller, the frame being supported and revolved upon the collar K.

With this portion of the mold completed and air-dried, a body of ordinary sand, equivalent to the metal thickness, is then swept on. The gears and conical roller having been disengaged, the strike Z attached, and the slide locked to the inside diameter, the frame is lowered until the strike clears the flange D, and the collar K adjusted. This thickness of sand is now swept up on the small cylindrical section of the mold, as shown.

The conical section being reached, the strike J is attached, the conical roller engaged with the thread of the spindle, and the gears dropped into mesh and this thickness of sand swept up on the conical section. The large cylindrical section is treated like the small section, strike Z being employed.

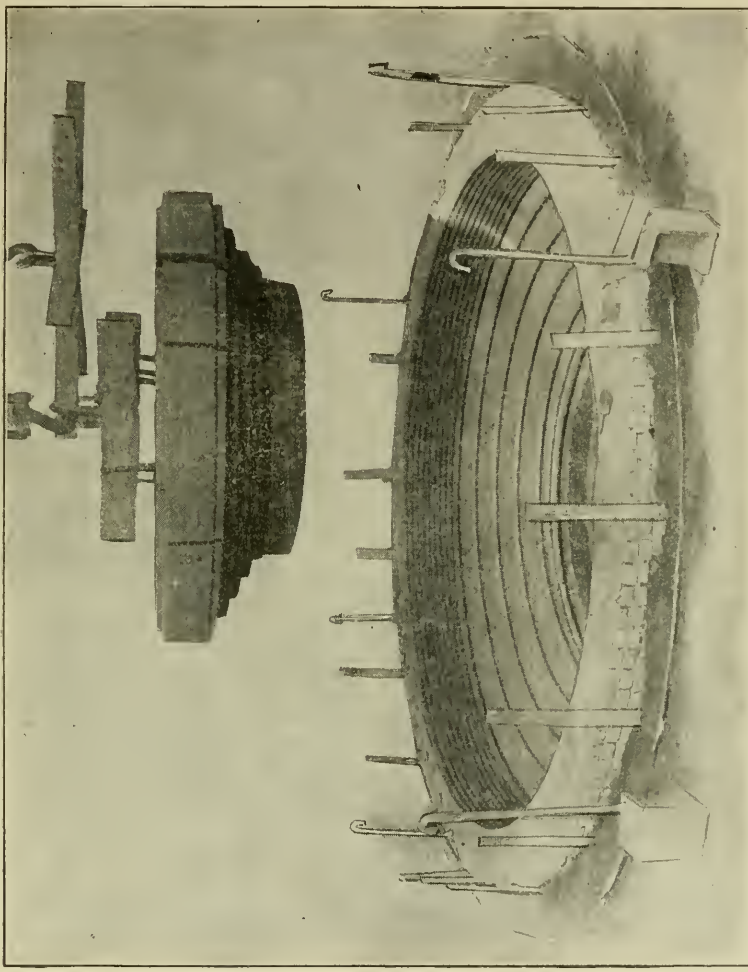


Fig. 43. Core and 6-Way Cross Above Mold

The frame and spindle are now removed, paper applied to the seat for the core, a heavy loam facing spread over it, and the lifting plate N, upon which the core is built, as shown in cross section of mold, Fig. 39, pressed down upon it; to which it adheres, forming a seat and guide for locating the core when returned to the mold. The ribs and bolting flanges, Fig. 40, with splitting and bolt core prints attached, are now placed in position. They support the flange E, as shown in Fig. 40. This flange and flange D are in sections, which allows their being drawn in or back, as the case requires. The arrangement of ribs, etc.,

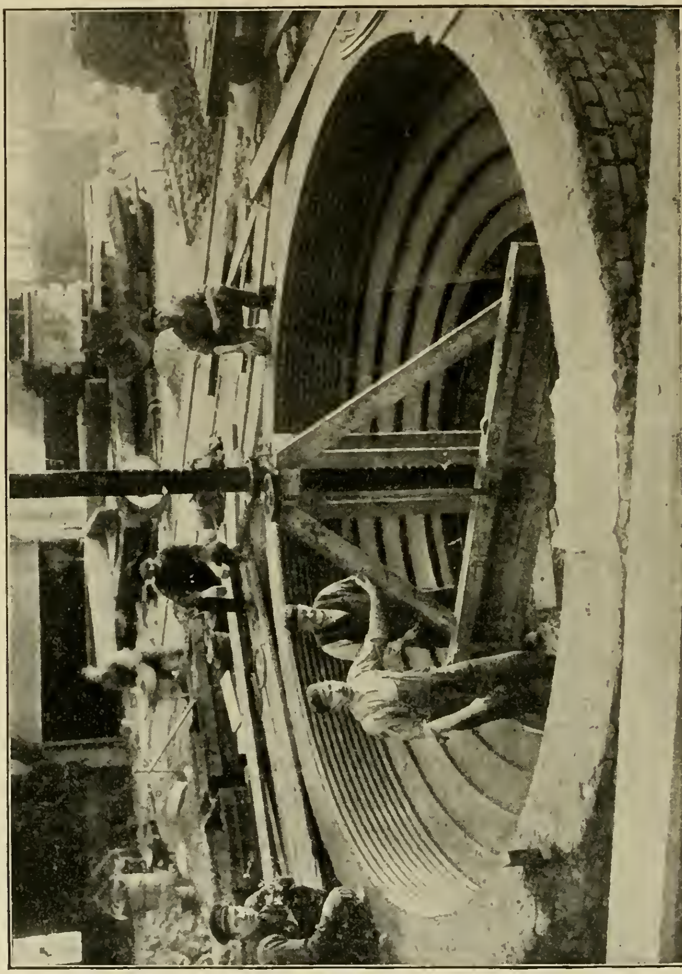


Fig. 44. Mold During Sweeping

is screwed together, the screws being removed as the building of the core progresses.

Building the Core

The bricking, strengthened with rods and plates, having a thickness of loam between it and the molding sand thickness, which represents the metal thickness of the drum, is now placed upon the lifting plate N, Fig. 39, until the conical section is reached. Open sand grates, as shown in Fig. 41, are now employed to secure the overhanging brick and loam, the grates increasing in length as the building of the core progresses. The small end is kept somewhat in line, allowing the sixteen clamping bolts to pass up through them. The height of the conical section is built up in this manner; plate P, Fig. 39, is placed upon the grating with its filling of brick and loam, and this portion of the core securely clamped together. Brick and loam are now applied to the top of the plate, and the remaining portion of the core completed and the top finished, as shown.

A center line for the splitting core is now laid off across the top of the core and outer wall of the mold.

The lifting plate is provided with four staples, as shown. The core is lifted from its seat with the aid of a four-way cross, as shown in Fig. 43, and placed upon a car, the ribs and flanges drawn, the core dressed and placed in the oven and dried.

The lower flange is drawn and the sand forming the metal thickness is removed from the mold, it is then treated in the usual manner, and thoroughly dried by the aid of coke fires placed in it.

Owing to the deep scoring of the conical section of the drum, the splitting of the projecting metal between the score is an object to be considered. This can be overcome to a nicety with ⅜-inch steel rods in the following manner: By the aid of a plumb-bob and straight-edge across the top of the mold, the center line of the drum at the splitting core is projected down the side of the mold, and ⅜-inch machine steel rods driven in opposite these projections, as shown to the right in Fig. 39. This same figure also shows the splitting and bolt cores in position. The bolt cores are placed through the splitting core, but independent of it, being secured by the tail prints, leaving a ½-inch metal thickness around the bolt holes.

The splitting core consists of a perforated ¼-inch cast iron plate, covered with loam, forming a core of about ⅝-inch in thickness. To facilitate the handling and setting of these cores, and to lessen the danger of the cast iron plate warping or expanding when heated from the metal, thus causing the loam to crack and chip from the plate, the cores are made in three sections. A complete core box is used, the cores being separated by the introduction of pieces of tin at the desired lengths. The splitting preparations being completed, the mold is ready to be assembled.

The core is lowered into place, and the cope ring placed on. This ring consists of a cast iron prickered semi-ring, or plate, provided with lifting lugs and openings for gating. To the prickered surface a heavy facing of loam is applied, and struck off with the aid of a spindle and sweep, as shown in Fig. 42.

The clamping of the mold is accomplished with the assistance of a six-way cross in a very positive manner. Foundation plate A is provided with lugs corresponding with the arms of the cross, and the tie rods are attached to it, as shown. The crane is now hooked on to the cross, and given a heavy lift, and while being subjected to this strain, the blocking between the covering ring and cross is placed in position and securely wedged up.

The intervening space between the wall of the mold and the side of the pit is firmly rammed in with sand. The runners, two in number, are located opposite each other, and are prepared during this ramming or backing up.

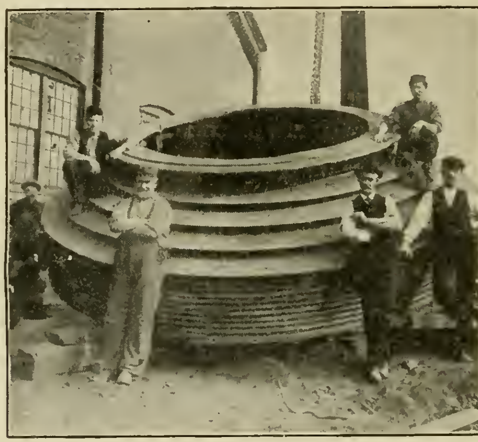


Fig. 45. Finished Casting

The gating to the lower flange is not on a radial line, as shown to the left, Fig. 39 (this being simply for illustration), but is carried farther around the flange so as to cause the metal to whirl or circulate as it rises in the mold; this provision being necessary to offset the tendency of the metal to become sluggish or chilled as it nears the top.

The pouring of the mold does not depend entirely upon the gating from below, as the mold is provided with a series of pop gates closed with cast iron stoppers and connected with the pouring basin, as shown in Fig. 39. During the pouring, and when the metal has reached the top of the conical section, the ladles are tipped, choking the runners, and causing the metal to back up over the pop gates to the depth of three or four inches. The stoppers are now lifted out, causing the metal to drop into the mold.

A photograph of the mold during the operation of sweeping is shown in Fig. 44.

A view of the mold with the core suspended from one crane immediately behind it and the six-way cross for tying down the cope suspended from the other crane near it, is shown in Fig. 43. The finished casting is shown in Fig. 45.

CHAPTER VI

SWEEPING RIGS

A Double Sweeping Frame

The accompanying illustrations show a convenient sweeping rig, to which may be attached various strike boards, the striking edge of which contain radial sections of the pieces to be swept up. As the strike boards are rigidly and permanently secured together with cleats

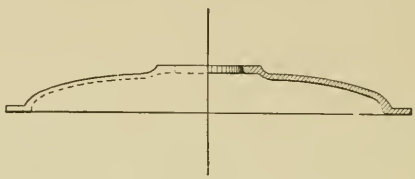


Fig. 46. Section of Dome Casting

they can be attached to or removed from the rig very quickly as the case may require, no special adjusting being necessary. The advantages of the rig can readily be seen, for if a casting is to be duplicated all that is necessary is to go to the pattern storage, get the strike boards, and attach them to the rig.

The blocks B-B, Fig. 47, upon the cleats which secure the boards together guide the parts into their correct position upon the rig.

The rig is shown as applied to the sweeping up of a green sand mold for producing a dome casting, as shown in half section and half elevation in Fig. 46.

The assembled arrangement of the rig with the strike boards attached is shown in Fig. 47. At the right of the spindle the operation of sweeping the exterior form of the dome is shown in progress. Upon this sweep surface the cope is subsequently rammed up. At the left of the spindle the rig is shown in the reverse position or upside down, as when set for sweeping off the metal thickness or striking up the interior form of the dome. Of course, the striking up of the interior form takes place after the ramming up and lifting off of the cope.

The separate parts of the arrangement are shown in Fig. 48. The rig itself is shown at the left, and consists of a rigid frame made from 3½ x 1½-inch material, the frame being strengthened by cross braces, as shown. The spindle sleeves are of the hinge design, as this form of sleeve allows the rig to be attached to or detached from the spindle without disturbing the latter; that is, the spindle can be set up and adjusted and the rig attached afterward. The sleeve is shown in greater detail above the frame.

At the right of Fig. 48 are shown the strike boards as they would appear when removed from the rig. Care should be taken in attaching boards together to see that they are rigidly secured to the cleats with screws and a spot of glue at the extreme ends of the cleats. There are two advantages in this manner of gluing. First, any shrinking or

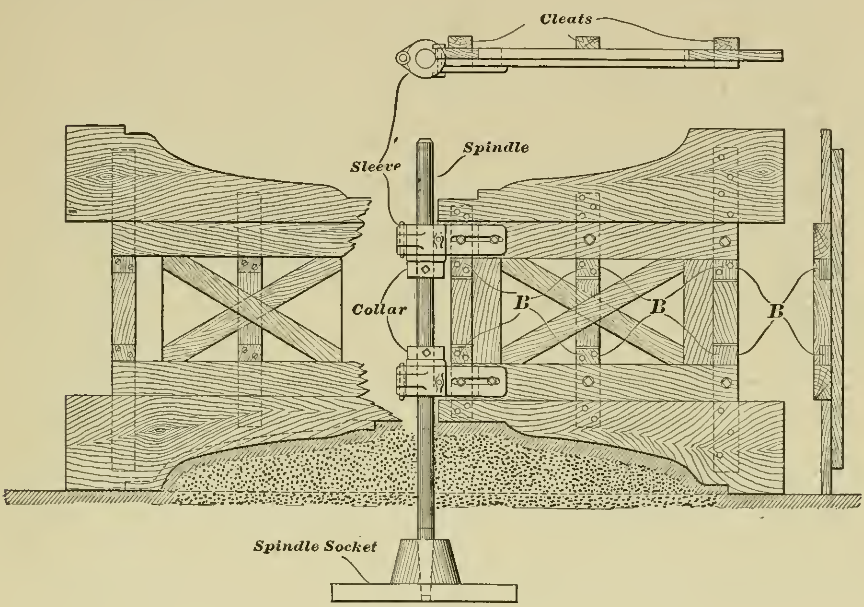


Fig. 47, Assembled Rig

swelling that may take place in the boards will be toward or from the glue spots at the ends of the cleats and will prevent the striking edge of the boards being distorted. Second, if glue was applied to the portion of the cleats extending across the boards, warping of the boards would be the result. In fitting the boards to the frame the latter is laid down and the boards with the striking edge dressed to form, placed in about their correct position and the cleats attached.

Next the centering pin shown directly above the striking boards in Fig. 48 is used in locating the blocks B-B, Figs. 47 and 48.

These blocks should be securely fastened in place with glue and screws. The centering pin is usually turned up from well-seasoned hardwood, its diameter being the same as that of the spindle. A portion of the center is cut out to half the diameter and the center line of the pin scribed thereon. By shoving the pin through the sleeves as if it were the spindle and turning the flat side of the pin into the plane of the striking boards, the center line upon the pin becomes immediately available for setting the boards.

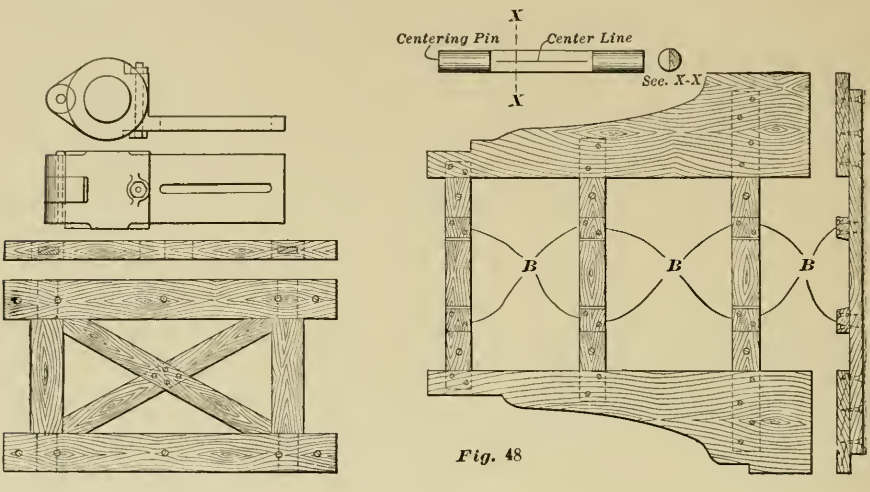


Fig. 48

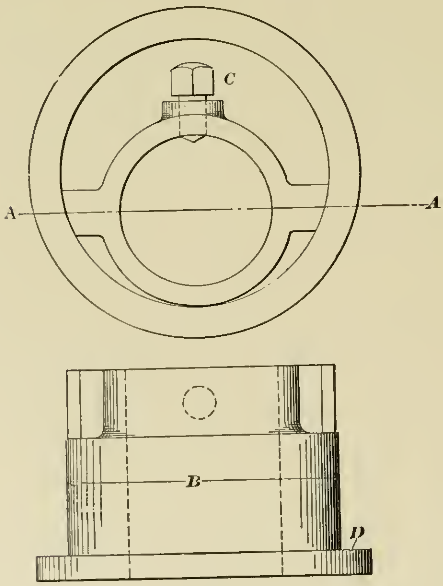


Fig. 49

Fig. 48. Details of Sweeping Rig

Fig. 49. Eccentric Collar

An Eccentric Spindle Collar

The accompanying illustrations show an eccentric collar applied to an ordinary foundry spindle for sweeping up circular molds. This is especially adapted to the sweeping up of circular work that is cast in halves, the mold being divided or separated by what are termed splitting cores.

To split such work usually necessitates the shifting of the spindle a distance equal to the thickness of the splitting core used. This is often an awkward operation owing to the fact that the adjustment must be made below the floor level.

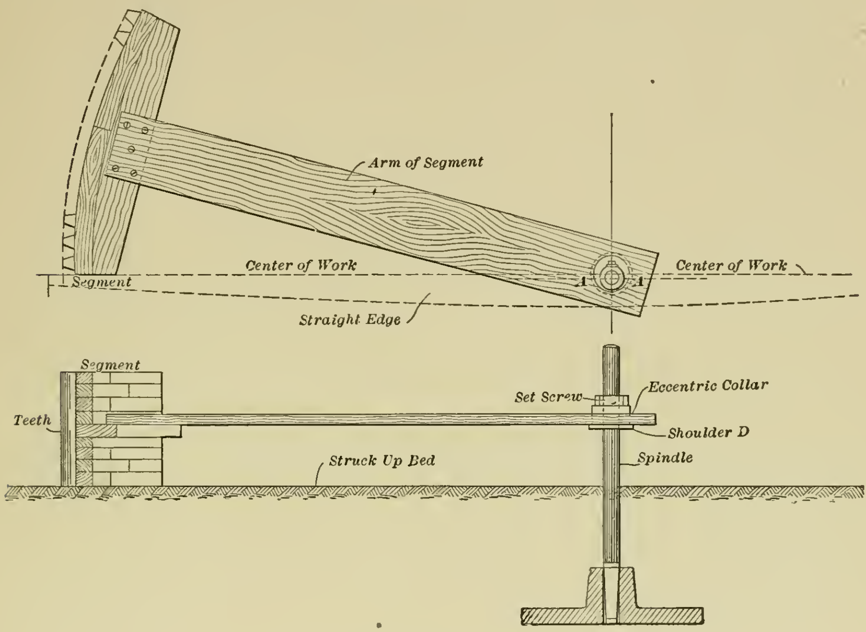


Fig. 50. Eccentric Collar Rig in Use

The collar under description avoids such trouble very nicely, the piece is bored out and turned up as shown in Fig. 49 with any desired throw. The center line AA should be scribed distinctly across the face of the collar.

This device is especially adapted for the molding of sections of gears, etc., where a section of the rim or a segment is used in ramming the outside diameter as shown in Fig. 50. To adjust the collar to the arm of the rim or segment a hole is cut at the exact center of the work, the diameter of the hole being sufficient to receive the portion of the collar marked B, Fig. 49.

The spindle is first set and plumbed in the usual manner. The collar is then slipped over it and secured by the set screw C at about the right height from the bottom. The arm with the segment attached is now let down over the spindle and centered upon the collar which holds it in the proper position and allows it to revolve upon the shoulder D.

As is the general practice, the segment is first set around the entire circumference, using flour to mark the correct position and spacing. When the spacing is found to be correct, a straight edge is placed across the center of the mold, as indicated by the dotted lines in Fig. 50. At the center the straight edge is cut out to receive one-half of the collar at the diameter B as shown. This brings the front edge of the straight edge in line with the center of the gear and locates the stopping point in ramming up this half of the wheel. Care should be taken in laying off this center line to see that it is parallel with the center line AA of the collar.

After one half of the mold has been rammed up the center line AA is marked on the spindle and the collar given a half revolution. The other half of the mold is rammed up just like the first half, care being taken to see that the space allowed for the spacing cores is equal on the two sides of the mold.

SECTION IV

GEARING

CHAPTER I

SPUR GEARING

The theoretically perfect gear wheel is a friction wheel communicating a smooth, uniform rolling motion by means of frictional contact of its surface. It is, in fact, a gear wheel with a great many very small weak and irregular teeth. Such a gear as this is manifestly imperfect, subject to slip, and on the whole not suitable for many purposes. The whole object of the science of gear wheels is to increase the size and strength of the teeth without destroying the uniformity of the motion transmitted. This is accomplished by so forming the outlines of the teeth that they will produce the desired result. Theoretically, there are an infinite number of curves that will meet the requirements, but only two are of any practical importance or have come into use to any extent. These are the epicycloidal and the involute.

Definitions

The *spur gear* is one whose teeth are parallel to its axis. It is used for transmitting motion from one shaft to another whose axes are parallel. There is also a class of spur gears called *herring bone gears* or double helical spur gears in which, while the axes are parallel, the teeth are arranged spirally around the cylindrical surfaces of the gears.

Bevel gears are gears used to transmit motion between shafts at right angles to each other, the shafts being in the same plane. The teeth of the gears must necessarily stand at an angle to the axis.

Miter gears are bevel gears whose teeth stand at an angle of 45 degrees to the axis and are used to transmit motion between shafts at right angles, in which the number of revolutions of the two shafts is the same.

Angle gears are similar to bevel gears, except that while the shafts intersect they are placed at some other angle to each other than 90 degrees. This angle may be either obtuse or acute.

A *hunting tooth gear* is a gear into which an extra tooth has been introduced so as to make the number of teeth in the gear and pinion prime to each other so that any two teeth will not come in contact until each tooth in the small gear has been in contact with every tooth in the large gear. This tends to equalize wear on the gears. A hunting tooth may be introduced either into bevel or spur gears.

An *internal gear* is a spur gear having teeth on the inside of its periphery in place of on the outside and the pinion or smaller gear is situated inside of the large gear. In an internal gear the shapes of the teeth correspond to the spaces in an ordinary spur gear of the same pitch and diameter, with the exception of the fact that the back-lash and clearance are reversed in position.

A *rack* is a straight bar having gear teeth formed upon it. It may be considered as a gear of infinite radius.

When two gears act upon each other, the greater is termed the *gear* and the less the *pinion.*

The word diameter when applied to gears is always understood to mean the *pitch diameter.* The tooth curves are always developed from the circle which represents the pitch diameter.

Circular pitch is the distance between corresponding points of adjacent teeth measured along the pitch circle and is obtained by dividing the length of the circumference of the pitch circle by the number of teeth in the gear.

Diametral pitch is the number of teeth in a gear divided by the number of inches in the diameter of the pitch circle. In other words, it is the number of teeth per inch of the pitch diameter of the gear.

The *thickness* of a gear tooth is its thickness measured on a pitch circle.

The *space* between two gear teeth is the space measured on the pitch circle.

The *addendum* is that part of the tooth outside the pitch circle.

The *dedendum,* or *root,* is that part of the tooth inside the pitch circle.

The *back-lash* is the side clearance between the two teeth in mesh.

The *clearance* is space between the point of a tooth and the bottom of the space into which the tooth meshes.

The *face* of a tooth is the working surface from the pitch circle to the point of the tooth.

The *flank* of a tooth is the surface from the pitch circle to the root of the tooth.

The *length* of a tooth is the distance from the root of the tooth to its point.

The *pitch point* of a tooth curve is the point in which the outline of a tooth intersects the pitch circle.

When two gears are so located that their teeth run together, the gears are said to be *in mesh.*

Rules

When the circular pitch is given to obtain the diametral pitch, divide 3.1416 by the circular pitch.

When the diametral pitch is given to obtain the circular pitch, divide 3.1416 by the diametral pitch.

When the number of teeth and the circular pitch are given to obtain the pitch diameter, multiply the circular pitch by the number of teeth and divide the product by 3.1416.

When the number of teeth and the diametral pitch are given to obtain the pitch diameter, divide the number of teeth by the diametral pitch.

When the pitch diameter and the circular pitch are given to obtain the circular pitch, multiply the pitch diameter by 3.1416 and divide by the circular pitch.

When the pitch diameter and the diametral pitch are given to obtain the number of teeth, multiply the pitch diameter by the diametral pitch.

When the pitch diameter and the number of teeth are given to obtain the circular pitch, multiply the pitch diameter by 3.1416 and divide by the number of teeth.

When the pitch diameter and the number of teeth are given to obtain the diametral pitch, divide the number of teeth by the pitch diameter.

Involute Teeth

The involute curve is the curve which would be drawn by a pencil point at the end of a thin band that will not stretch and is drawn tight while being unwound from a cylinder.

The base circle in the involute system of gearing is the circle from which the involute curve that forms the tooth outline is drawn. The base circle is always inside of the pitch circle. The base circle for the 15 degree involute tooth is inside the pitch circle a distance equal to 1-60 of the pitch diameter, and the base circle for the 20 degree involute tooth is inside of the pitch circle by a distance equal to about 3-100 of the diameter of the pitch circle.

Fig. 1 shows the manner of developing or drawing the 15 degree involute tooth curve. A is the pitch point of the pitch circle. The line B-C is drawn at an angle of 15 degrees to a tangent to the pitch circle at the pitch point. The base circle is then drawn tangent to the line B-C.

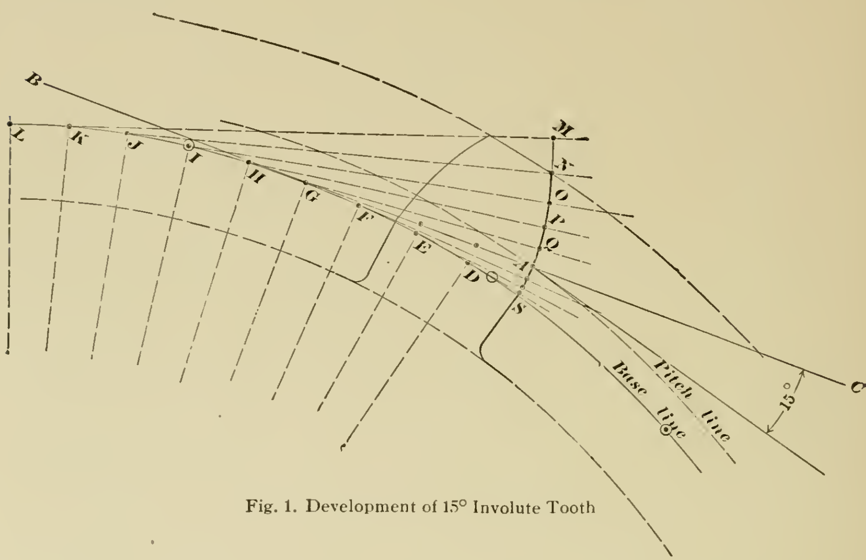


Fig. 1. Development of 15° Involute Tooth

The line B-C is called the *line of action,* as it is along this line that the gear teeth will be in contact. In laying off a gear tooth any convenient number of points may be stepped off between the pitch point A and the point of tangency of the base circle G. With the dividers set at the same distance succeeding points are stepped off along the base circle as shown at L, K, J, I, H, G, F, E, D, and S. Point S is one point in the tooth curve. Tangents to the base circle should then be drawn at the points D, E, F, H, I, J, K, and L and on these tangents distances equal to the arcs which they correspond to should be stepped off. This will give a series of points M, N, O, P, Q, etc., which are points in the desired tooth outline. A smooth curve drawn through these points will represent the outline of the tooth.

An approximate method of drawing a 20 degree involute curve is shown in Fig. 2. This method can, however, be applied to any other degree of involute teeth equally well. The pitch circle should be drawn first and spaced off to correspond with the pitch points. One of the spaces should then be divided, giving the point O, which corresponds to the center of the tooth on the pitch circle. Through this point draw a radial line and at right angles to it a tangent as shown. From this tangent lay off an angle of 20 degrees and draw the line A-B. Tangent to the line A-B draw the base circle. Also draw the radial lines C, D and E through the pitch points of the teeth. At the pitch point on the line C draw a tangent to the pitch circle, lay off 20 degrees and draw the line F-G. In like manner from the pitch point on the line D draw a tangent, lay off 20 degrees and draw the line H-I and also from the pitch point on the line E draw

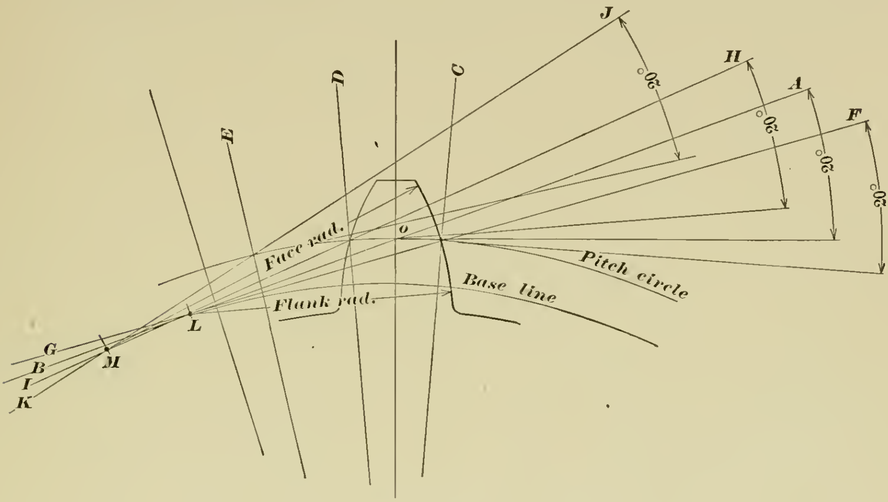


Fig. 2. Approximate Method of Drawing 20° Involute Tooth

a tangent, lay off 20 degrees and draw the line J-K. It will be noted that all of these lines pass through a pitch point on the pitch circle and hence are tangent to the base circle. The point L where the lines F-G and H-I intersect will give a center for the flank radius to use for drawing that portion of the tooth outline between the base circle and the root, and the point M where the lines H-I and J-K intersect will give the center for the face radius which is used in drawing the portion of the tooth curve outside the base circle. The points L and M will fall very close to the base circle, in fact, close enough so that for all the teeth the centers may be taken on the base circle. By this means, it will be noticed that, circular arcs of approximately the same form as the involute curve have been substituted for it.

Drawing the Epicycloidal Curve

An epicycloid is a curve formed by a point on the circumference of the circle as it is being rolled on the outside of another circle, while a hypocycloid is a line generated by the point on the circumference of a circle that is being rolled on the inside of another circle.

In the epicycloidal system of gearing the faces of the teeth are formed of epicycloids and the flanks by hypocycloids, as shown in Fig. 3. The complete circles are not drawn in this case, but only short arcs, though the centers for the circles are shown on the radial lines.

The circle rolled upon the other circle to generate the tooth curve is called the circle of action or the generating circle and is rolled upon the pitch circle. In laying off this tooth, the pitch circle, addendum circle and root circle should be drawn first. The pitch circle is then spaced off to correspond with the number of teeth desired.

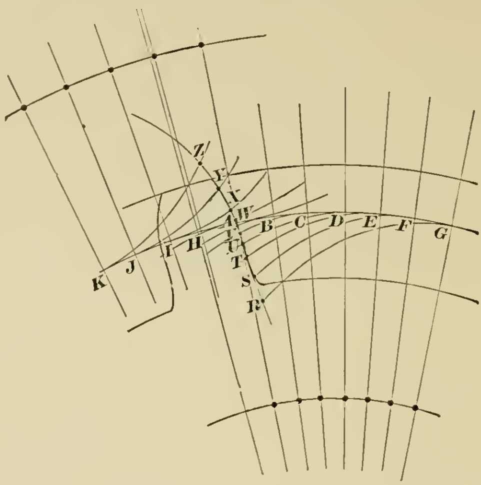


Fig. 3. Drawing Epicycloidal Teeth

In order to lay off the tooth curves from the pitch point A step off equal divisions on the pitch circle right and left as shown. Through these points radial lines are drawn and from centers upon these radial lines arcs of the circle of action are drawn as shown. In order to determine the points of the tooth curves it is necessary to measure off on these arcs of the generating circle distances corresponding to the portion of the pitch circle which has been rolled over between the point A and the point where the radial line intersects the pitch circle. For instance, to find the point Z, step off the distance from A to K upon the pitch circle with a pair of dividers. Then step off corresponding distances along the generating circle from K to Z, thus obtaining the point Z. The point Y is obtained by stepping off the distances from A to J and back along the generating circle to Y. X and W are obtained in like manner and the points V, U, T, S, and

R of the flank curve are in like manner obtained by stepping off distances from the pitch circle to radial lines at B, C, D, E, F, and G and then back along the generating circles to points V, U, T, S and R. After the points are obtained a smooth curve is drawn through them which will represent the desired tooth curve.

Involute Odontograph Table

In practice these theoretical curves are rarely laid out, approximations being used which are obtained by means of circular arcs. The radii for these circular arcs are commonly obtained from odontograph

GRANT'S INVOLUTE ODONTOGRAPH

STANDARD INTERCHANGEABLE TOOTH, CENTERS ON BASE LINE

TEETH	Divide by the Diametrical Pitch		Multiply by the Circular Pitch	
	F. Face Radius	G. Flank Radius	F. Face Radius	G. Flank Radius
10	2.28	.69	.73	.22
11	2.40	.83	.76	.27
12	2.51	.96	.80	.31
13	2.62	1.09	.83	.34
14	2.72	1.22	.87	.39
15	2.82	1.34	.90	.43
16	2.92	1.46	.93	.47
17	3.02	1.58	.96	.50
18	3.12	1.69	.99	.54
19	3.22	1.79	1.03	.57
20	3 32	1.89	1.06	.60
21	3.41	1.98	1.09	.63
22	3 49	2.06	1 11	.66
23	3.57	2.15	1.13	.69
24	3.64	2.24	1.16	.71
25	3.71	2.33	1.18	.74
26	3.78	2.42	1 20	.77
27	3.85	2.50	1.23	.80
28	3 92	2.59	1.25	.82
29	3.99	2 67	1.27	.85
30	4.06	2.76	1.29	.88
31	4.13	2.85	1.31	.91
32	4.20	2.93	1.34	.93
33	4.27	3.01	1.36	.96
34	4.33	3.09	1.38	.99
35	4 39	3.16	1.39	1.01
36	4.45	3 23	1.41	1.03
37—40	4 20		1.34	
41—45	4.63		1.48	
46—51	5.06		1.61	
52—60	5.74		1.83	
61—70	6.52		2.07	
71—90	7.72		2 46	
91—120	9.78		3.11	
121—180	13.38		4.26	
181—360	21.62		6.88	

Draw the rack tooth by the special method.

—[From Grant's Treatise on Gear Wheels.

tables. In Grant's work on Gearing, he gives an involute odontograph table from which radii for various sizes of gears can be obtained. Fig. 4 illustrates a method of laying out an involute tooth by means of this odontograph table.

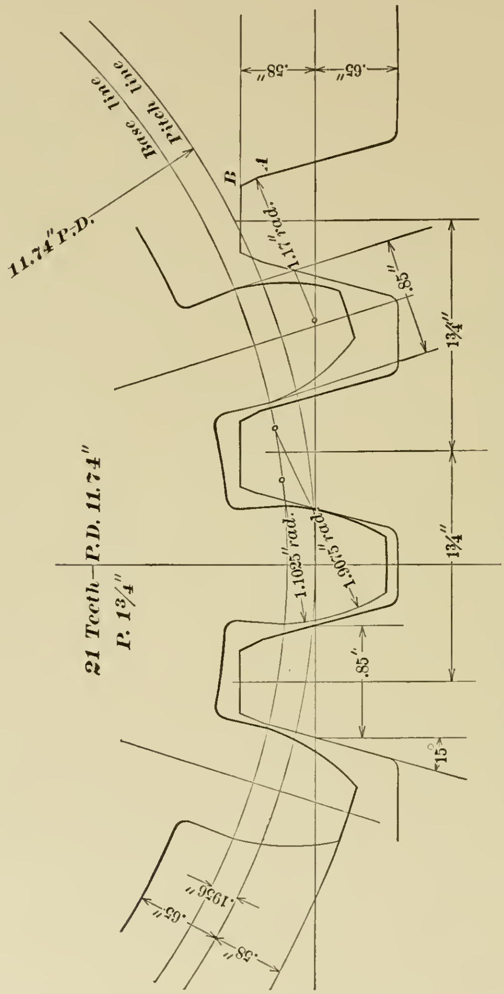


Fig. 4. Laying Out an Involute Tooth from Odontograph Table

The pitch circle or pitch line should be drawn first and the addendum line drawn outside the pitch line at a distance from it equal to one divided by the diametral pitch or to 1-3 of the circular pitch. The dedendum line should be drawn inside the pitch circle the same distance, but in practice this is not used, the root line being inside of the pitch line by a distance equal to 9-8 of the addendum.

The base line is drawn inside the pitch line by a distance of 1-60 of the pitch diameter. To draw a gear proceed as follows: The figure shows several teeth of a gear having 21 teeth 11.74 inches pitch diameter and 1¾ inches circular pitch. The gear is also shown in contact with the rack. After the various circles have been drawn the pitch circle should be spaced for the pitch points by stepping off with a pair of dividers or any other convenient method.

In the Odontograph table opposite the 21 teeth and under the face radius is found the number 1.09. This must be multiplied by the circular pitch of the gear and gives 1.907. With the dividers set to this face radius of 1.907 draw the face of the teeth from the addendum to the pitch circle, keeping one point of the dividers on the base line as a center. If the number of teeth is greater than 36 or if the pitch is small, this face radius should be extended to the base line. In the case under consideration opposite 21 teeth in the table and in the column headed Flank Radius is found the figure .63 and this multiplied by the circular pitch gives 1.102. With the dividers set to this

GRANT'S EPICYCLOIDAL ODONTOGRAPH

STANDARD CYCLOIDAL TEETH — INTERCHANGEABLE SERIES

From a Pinion of Ten Teeth to a Rack

Number of Teeth in the Gear		For one Diametrical Pitch — For any other pitch divide by that pitch				For One Inch Circular Pitch — For any other pitch multiply by that pitch			
		Faces		Flanks		Faces		Flanks	
Exact	Intervals	Rad.	Dis.	Rad.	Dis.	Rad.	Dis.	Rad.	Dis.
10	10	1.99	.02	—8.00	4.00	.62	.01	—2.55	1.27
11	11	2.00	.04	—11.05	6.50	.63	.01	—3.34	2.07
12	12	2.01	.06	∞	∞	·64	.02	∞	∞
13½	13—14	2.04	.07	14.50	9.43	.65	.02	4.60	3.00
15½	15—16	2.10	.09	7.86	3.46	.67	.03	2.50	1.10
17½	17—18	2.14	.11	6.13	2.20	.68	.04	1.95	.70
20	19—21	2.20	.13	5.12	1.57	.70	.04	1.63	.50
23	22—24	2.26	.15	4.50	1.13	.72	.05	1.43	.36
27	25—29	2.33	.16	4.10	.96	.74	.05	1.30	.29
33	30—36	2.40	.19	3.80	.72	.76	.06	1.20	.23
42	37—48	2.48	.22	3.52	.63	.79	.07	1.12	.20
58	49—72	2.60	.25	3.33	.54	.83	.08	1.06	.17
97	73—144	2.83	.28	3.14	.44	.90	.09	1.00	.14
290	145—300	2.92	.31	3.00	.38	.93	.10	.95	.12
∞	Rack	2.96	.34	2.96	.34	.94	.11	.94	.11

The table gives the distances and radii if the pitch is either exactly one diametral or one inch circular and for any other pitch multiply or divide as directed in the table.

—[From Grant's Treatise on Gear Wheels

radius and the center on the base circle, draw the flanks of the teeth from the pitch circle to the base circle. From the base circle continue the flanks of the teeth to the root circle by straight radial lines and round the roots of the teeth with a fillet.

To lay off the rack teeth it is first necessary to draw a straight line for the pitch line and two parallel lines for the addendum and root lines. The sides of the teeth are drawn through the pitch points at an angle of 15 degrees from the perpendicular, as shown in Fig. 4.

The point of the tooth from the point A Fig. 4 to B must be rounded by an arc drawn from a center on the pitch line and with the dividers set to a radius equal to 2.10 inches divided by the diametral pitch or the circular pitch multiplied by .67. In the case under consideration multiplying .67 by the circular pitch we obtain 1.17 as the radius to be used.

Epicycloidal Odontograph Tables

Grant has also gotten up an Odontograph table giving the proportions of epicycloidal teeth. To apply this table in laying out the gear shown in Fig. 5 we will proceed as follows:

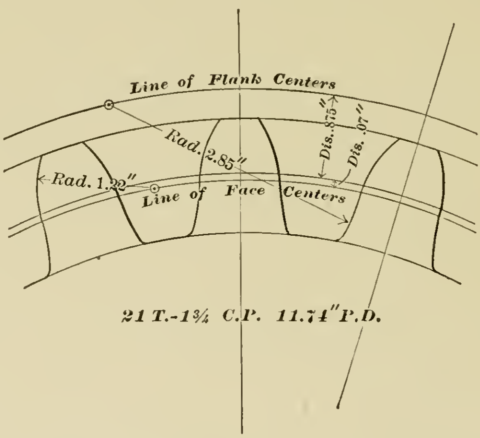
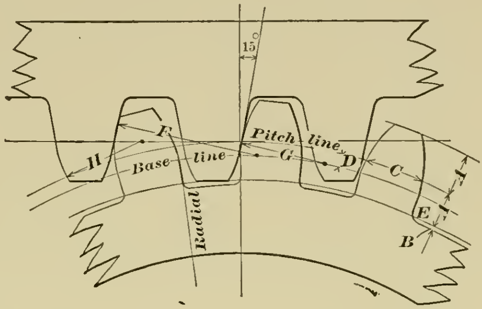


Fig. 5. Laying Out an Epicycloidal Gear by the Odontograph Table

The gear has 21 teeth, 11.74 inches pitch diameter and 1¾ inches circular pitch. The pitch circle, addendum and root circles should be drawn. The pitch points should also be marked on the pitch circle.

In the Odontograph table we find opposite 21 under the head of circular pitch and the faces of the teeth, .04 as the factor for obtaining the distance of the circle of centers from the pitch circle. Multiplying the circular pitch by this we have .07 and hence we must lay off a circle at this distance inside the pitch circle.

The flank center distance for 21 teeth is .5 and multiplying this by the circular pitch we have .875 as the distance between the pitch circle and the line of centers for the flanks. This circle should be drawn as shown in Fig. 5. From the table we find that the factor for the



GRANT'S INVOLUTE GEAR TEETH PROPORTIONS

Circular Pitch.	A	B	C	E	H	C'
1	.33	.04	.49	.08	.67	.475
1⅛	.37	.04	.55	.08	.75	.534
1¼	.41	.05	.61	.10	.83	.594
1⅜	.45	.05	.67	.10	.91	.653
1½	.50	.06	.73	.12	1.00	.712
1¾	.58	.07	.85	.14	1.17	.831
2	.66	.08	.98	.16	1.34	.950
2¼	.75	.09	1.10	.18	1.50	1.07
2½	.83	.10	1.22	.20	1.67	1.19
2¾	.91	.11	1.34	.22	1.84	1.31
3	1.00	.12	1.47	.24	2.01	1.43
3¼	1.08	.13	1.59	.26	2.17	1.54
3½	1.16	.14	1.71	.28	2.34	1.66
3¾	1.25	.15	1.83	.30	2.51	1.78
4	1.33	.16	1.96	.32	2.68	1.90
4¼	1.41	.17	2.08	.34	2.84	2.02
4½	1.50	.18	2.20	.36	3.01	2.14
4¾	1.58	.19	2.32	.38	3.18	2.25
5	1.66	.20	2.45	.40	3.35	2.37
5¼	1.75	.21	2.57	.42	3.51	2.49
5½	1.83	.22	2.69	.44	3.68	2.61
5¾	1.91	.23	2.81	.46	3.85	2.73
6	2.00	.25	2.94	.50	4.02	2.85
6½	2.16	.27	3.18	.54	4.35	3.09
7	2.33	.29	3.43	.58	4.69	3.33
7½	2.50	.31	3.67	.62	5.02	3.56
8	2.66	.33	3.92	.66	5.36	3.80
8½	2.83	.35	4.16	.70	5.69	4.04
9	3.00	.37	4.41	.74	6.03	4.28
9½	3.16	.39	4.65	.78	6.36	4.51
10	3.33	.41	4.90	.82	6.70	4.75

D or distance to the base line equals $\frac{1}{60}$ of pitch diameter.

NOTE.—Column C' is for cast gears.

face radius of the 21 teeth is .70, then multiplying the circular pitch by this factor we have 1.22. With the dividers set to this radius and keeping one point on the circle of face centers the faces of all the teeth should be drawn. From the table we find that the factor for the radius

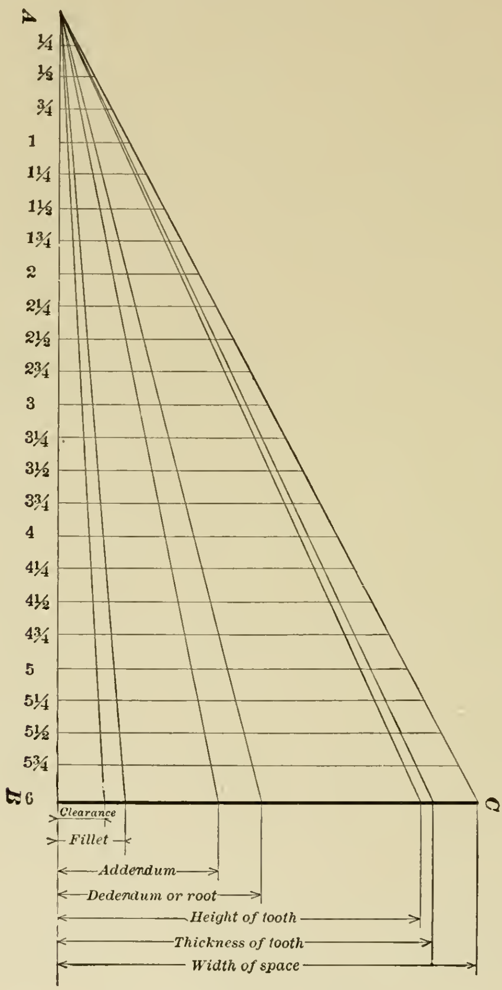


Fig. 6. Diagram for Tooth Parts

of the flanks of the teeth corresponding to 21 teeth is 1.63 and multiplying the circular pitch by this we have 2.85. With the dividers set to this radius and one point on the circle of flank centers, we should draw the flanks of the teeth. Small fillets should then be drawn at the base of each tooth, thus completing the tooth outline.

Proportions of Tooth Parts

Grant has gotten up a table of proportions of tooth parts for use in connection with his involute odontograph. For convenience, however, in obtaining this information quickly for different pitches, a diagram like that shown in Fig. 6 may be used. This diagram is for the extra short involute tooth and gives proportions of teeth from ¼ inch to 6 inches circular pitch. Such a diagram can be made for teeth of

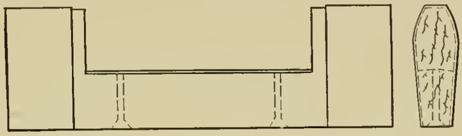
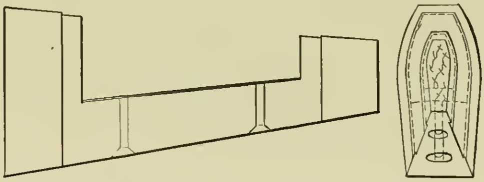


Fig. 7. Jig for Plain Spur Involute Gear

any proportions, and will be found a great time saver on account of the fact that its use reduces the calculations necessary.

In laying out such a diagram A-B represents the greatest pitch required, in this case six inches. The perpendicular B-C is used for laying off the various proportions for six inch circular pitch. After these points are laid off they are connected with the point A by a series of diagonal lines. In order to obtain the proportions for any other tooth it is only necessary to erect a perpendicular at a distance from A corresponding to the circular pitch desired. In the illustration perpendiculars have been drawn corresponding to all circular pitches between ¼ inch and 6 inches, varying by quarters of an inch.



Fig, 8. Jig for Involute Bevel Gear

The proportions of this short involute tooth are as follows: Addendum equals 2-10 circular pitch. Dedendum equals 2-10 circular pitch. Clearance equals 5-100 circular pitch, plus one. The thickness of the tooth equals 47-100 of the circular pitch.

Tooth Jigs

In place of having to lay off the tooth curves or outlines on each individual tooth it is best to make a hard wood jig of the exact outline of the tooth and use it in forming all of the other teeth. Fig. 7 shows such a jig for a plain spur involute gear and Fig. 8 such a jig for an involute bevel gear. It will be noticed that the jig is cut down or relieved for a short distance each side of the space which is to receive the block for the gear tooth. The opening in the jig to receive the block should be the exact length of the teeth across the face of the wheel and the blocks trimmed to fit snugly and then secured with screws as shown.

After the block is secured in the jig, a plane may be clamped in the vise as shown in Figs. 9 and 10. Blocks should be clamped to

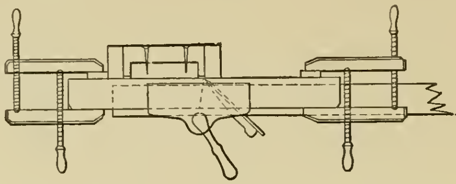


Fig. 9. Side View of Plane Clamped to Cut Teeth

this plane at such points that the blades of the plane cannot cut the face of the jig. It is on this account that the clearance is provided in the face of the jig at each end of the tooth block. Fig. 10 shows an end view of the block and plane with the stops removed so as to show the different positions assumed by the jig in working out an involute tooth. In working out an involute tooth a plane having a

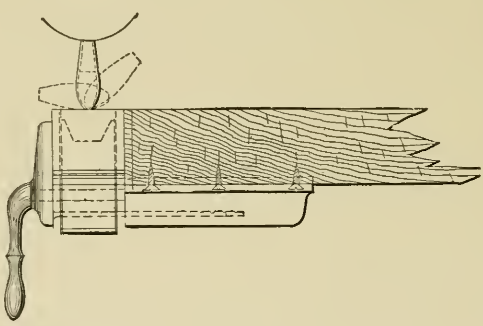


Fig. 10. End View of Plane Clamped to Cut Teeth

flat face may be used and it is well to make a special plane with a long sole so that it will not be necessary to use blocks to piece it out when working long teeth.

When working out epicycloidal teeth it is necessary to use a plane having a curved face as shown in Fig. 11, and also to use a block or stop on the side of the plane as shown. The curve of the face of the plane should be of less radius than the curve of the flanks of the teeth.

In laying out the wooden block for the spur tooth jig the device shown in Fig. 12 will be found very handy for laying off the tooth curves. In the device shown the jig for a 16-tooth pinion is being laid out. A board shown at A is taken and a slot cut in one end that will just fit the jig block. The jig block is placed in position as shown with one end flush with the face of the board. The tooth is then laid off. After this the jig is removed and placed other end to in the slot, when the same centers can be used in laying off the tooth outline. This insures an accurate layout on both ends of the block and brings the layout on the two ends in line.

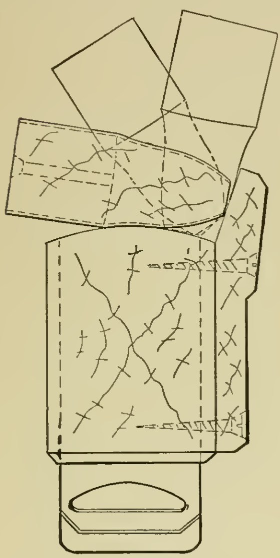


Fig. 11. Plane with Curved Face for Epicycloidal Gear

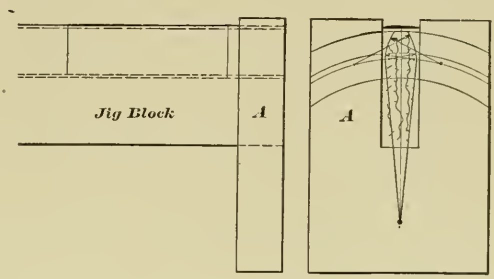


Fig. 12. Rig for Laying Off Tooth Jig

After the teeth for the spur gear have been planed out in jigs, they can be tested by placing two of them end to end and seeing if they coincide, then reversing both teeth and placing the opposite ends in contact. If there is any error in the teeth it will be doubled by this method. Care should be taken to have the bottom of both blocks planed free from wind and to fit accurately on the outside of the cylindrical portion of the pattern.

Construction of Gear Patterns

The general method of constructing or building up a gear pattern is shown in Fig. 13. The rim should be built up and turned in the usual manner with just perceptible draft in the outer diameter. The number of teeth should be spaced off before it is removed from the lathe. If there is a surface plate available the rim should be laid on it and, with the try square, lines drawn across the face corresponding to the spacing done in the lathe. Placing the try square against the rim of the gear is not always a reliable method.

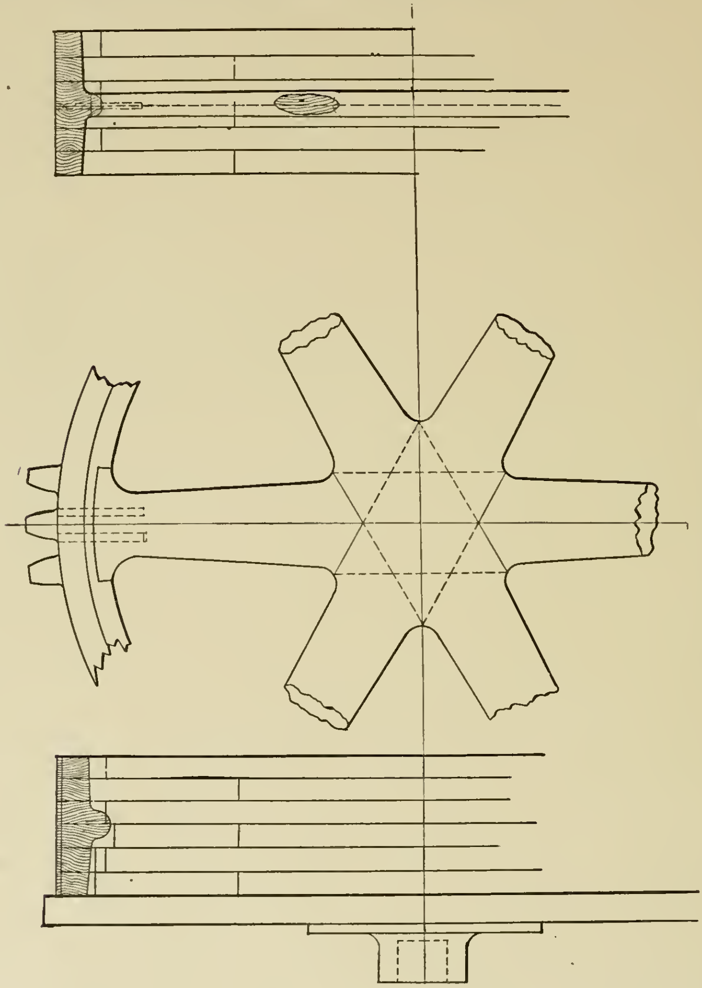


Fig. 13. Construction of Gear Patterns

Fig. 14 shows a common manner of setting the arms together. This work can be done very handily on the ordinary bench saw. After the arms have been put together, they should be let into the rim as shown in Fig. 13 and secured with glue and dowel pins. A more substantial manner of securing the arms in place is to build them into the rim during its construction.

After the teeth have all been jigged out or sanded to form, in the manner to be described later, they should be placed on the rim, the root of each tooth being set with its edge in contact with one of the spacing lines drawn on the face of the rim. This is a very much more accurate method than attempting to space the teeth to a

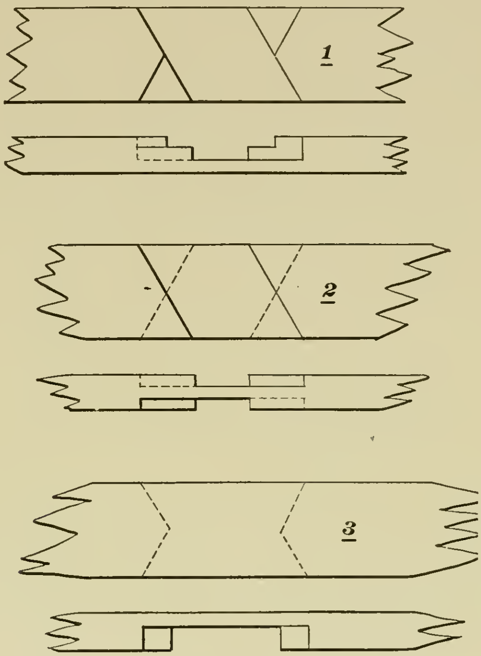


Fig. 14. Method of Setting Gear Arms Together

center line. Each tooth should be glued in place and rubbed down so that it fits the line accurately and then, after the glue has set slightly, nailed in position. As the work proceeds the teeth should be tested with the square and calipers and the work finished by rubbing in a leather fillet.

CHAPTER II

BEVEL AND WORM GEAR PATTERNS

Bevel Gears

In the last chapter the making of spur gear patterns and the method of jigging teeth for spur or bevel gear patterns was described. In this chapter will be described one or two methods of making bevel and worm gear patterns which have proven very satisfactory in practice.

The rim of a bevel gear should be built up of segments in a manner similar to the method used in building the rim of a spur gear, except that, owing to the conical form of the rim no two series of segments are of the same diameter. Fig. 15 shows the iron faceplate

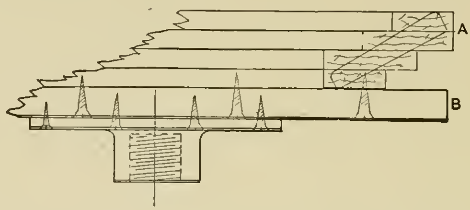


Fig. 15. Segments for Bevel Gear Pattern on Face Plate

of the lathe with a large wooden faceplate B attached to it and the section of the rim of a gear built up of four courses of segments as shown at A.

The outline of the rim is drawn on the segments showing the amount of stock to be turned off in finishing this portion of the pattern. After the rim is built up and attached to the faceplate the inside surface should be turned and a chuck should then be attached to the faceplate B, turned up to fit the inside of the rim, the rim secured to the chuck and the outside or face turned ready to receive the teeth.

It is best to space off the teeth before removing the rim from the lathe. Spaces corresponding to the number of teeth should be stepped off on the face near the outer diameter. Next attach a block to the center of the faceplate, which will project far enough to contain the apex of the cone of which the rim is the frustrum. This block is shown at A, Fig. 16. The point of the block should be turned so that it will form a portion of the surface of the cone, of which the rim is a portion.

Next, take a long lathe rest as shown at D and adjust it so that its upper edge is level and on a line with the point or apex of the cone. If the lathe rest is not long enough a straight edge can be attached to it.

After the rest or straight edge has been adjusted lines can be drawn on the face of the gear through the points stepped off near its

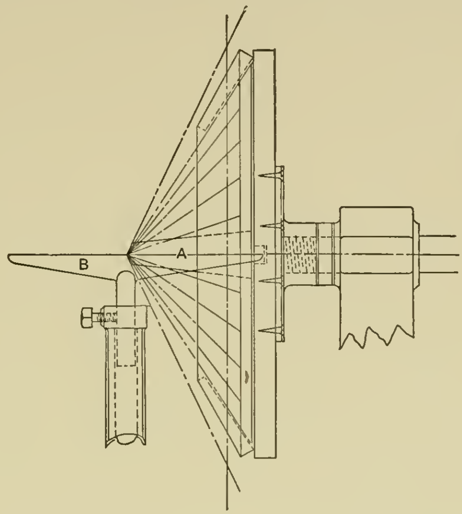


Fig. 16. Face Plate with Blocks at Center of Gear to Form Apex of Cone

outer circumference, as shown in Fig. 16. These lines would all intersect at the apex of the cone.

The teeth can then be formed by jigging, as described in the

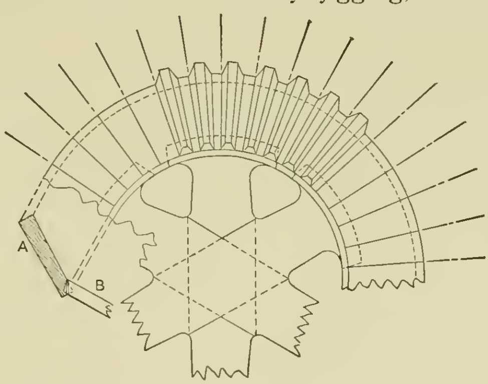


Fig. 17. Gear with Part of the Teeth Attached and Arms Fitted

previous chapter, or by sanding, and attached to the face of the gear as shown in Fig. 17.

While attaching the teeth the work should be removed from the lathe, but the gear should not be removed from the faceplate. The root of each tooth should be set to one of the radial lines and the teeth should be tried with calipers and with the straight edge from the apex of the cone, as located on the post attached to the center of the faceplate. It will be found convenient to drive a small pin or brad into the apex to assist in this work. The arms of the gear should be

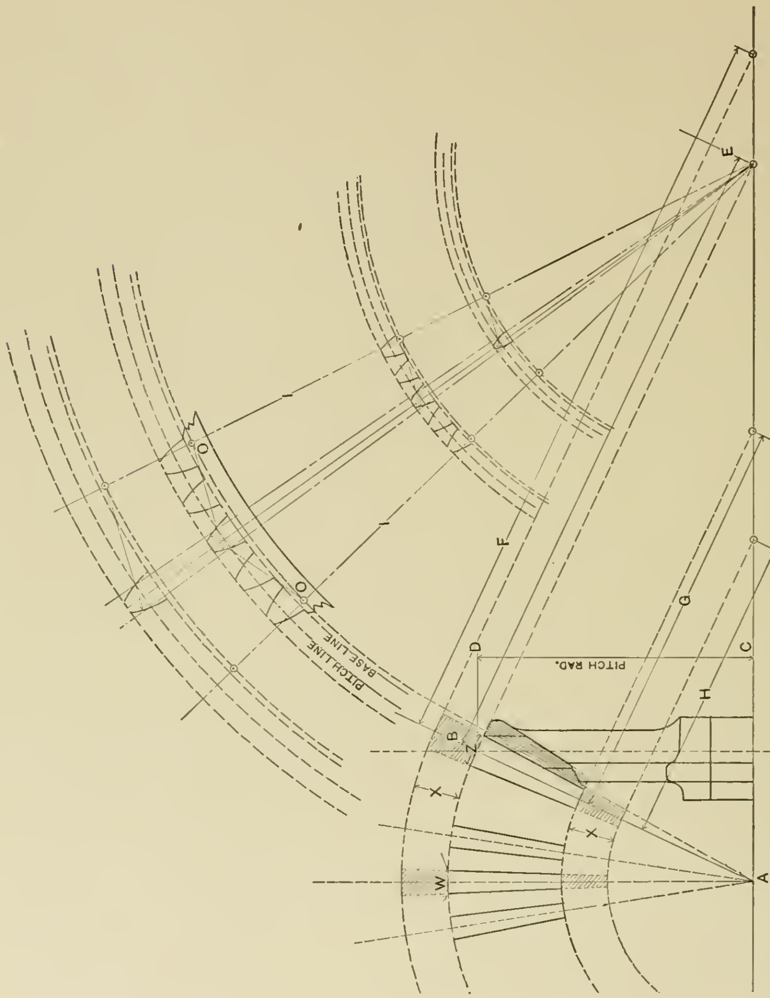


Fig. 18. Development of Tooth Outlines

laid out and set in as shown in Fig. 17. At A is shown a section of the rim and at B the manner in which the end of the arm joins the rim.

The method of developing the outline for the tooth at the outside and inside faces of the gear, also at the outer and inner ends of the jig is shown in Fig. 18. The work is laid out for a gear having a pitch radius of 12 3-32 inches, 38 teeth, 2-inch circular pitch and a 5-inch face.

The number of teeth in a bevel gear is the number upon the working pitch diameter or radius C-D, but this number is not used in laying out the tooth outline. In developing the curves for the tooth, the number of teeth in a gear of corresponding pitch and having a pitch radius equal to the back conical radius or B-E in Fig. 18 is used. In order to lay out the teeth it is first necessary to draw a section of one-half of the gear as shown in Fig. 18, the pitch radius of the gear being C-D and the face conical radius A-B.

Next draw a line perpendicular to A-B from a point on the pitch line of the gear which is on the line passing through D and at a distance from the axis equal to the pitch radius C-D. This line will intersect the center line of the gear at the point E, thus giving the back pitch radius B-E. Lay off the height or length of the tooth Z, and draw radial lines extending beyond the ends of the teeth.

The spaces X-X correspond to the portions of the jig at each end of the tooth and it will be necessary to determine the outline of the tooth for both the outer and inner ends of the jig, as well as for the outer and inner ends of the face of the tooth proper. With A as a center and the radius A-B scribe an arc of a circle and space off several teeth with the given circular pitch, lay off the thickness of the tooth W and draw radial lines through these points. This will give the thickness of the tooth and the circular pitch at the ends of the jig and at the smaller end of the tooth.

It should be noted that all lines on the face of the tooth whether at the top, bottom, or any point on the side, including the base line, all meet in the apex A.

With E as a center and B-E as a pitch radius, draw the pitch line, and set off several teeth with the given circular pitch. Lay off the thickness of the teeth on this pitch line and draw in the addendum, root and base circles, the whole to be calculated as explained in the previous chapter.

As the tooth outline is taken from the back conical radius, it should be calculated as follows: In the case in hand the radius B-E equals 28.61, multiplying this by 2 equals 57.22 inches, as the diameter. Multiplying this diameter by 3.1416 equals 179.76 inches, as the circumference of the pitch circle used in determining the form of the tooth. Dividing this circumference by 2, the circular pitch gives 89.8 teeth. It should be noted that in dividing the circumference of this construction pitch circle, the result will rarely be a whole number, hence the nearest whole number is taken as the number of teeth. In this case 90 should be taken and we would look in the Odontograph table opposite this number of teeth for the factors to be used in drawing the tooth outline. From the Odontograph table the radius to be used in drawing the face of the teeth should be found and the centers O-O determined. With pitch radius equal to the lines F, G, and H, and E as a center, draw pitch circles for the outer end of the jig, inner end of the tooth and inner end of the jig, as shown in Fig. 18. Next draw the radial lines I-I through the points O-O which will determine the centers to be used in drawing the face of the teeth corresponding to each of these different radii. Of course the addendum, root and base circles would be drawn in in each case in their proper relationship to the pitch circle.

When the gear is so large that it is not convenient to determine the length of the back radius by a lay out for the large and small ends of the tooth and jig, these radii can be calculated in the following manner: If it is desired to calculate the back radius B-E corresponding to a gear having the pitch radius C-D, we would first subtract from 90 degrees or the angle formed by the intersection of the back radius B-E with the face radius A-B, the angle formed between A-B and the center line of the gear, which in this case is 65 degrees; 65 degrees taken from 90 degrees will leave an angle of 25 degrees as the angle between the radius B-E and the center line of the gear.

From a table of natural signs take the sign of 25 degrees, which is .42262, divide the working pitch radius C-D by this decimal, which will give the length of the back radius B-E equal to 28.61 inches.

Having obtained this radius, calculations are next made for the outline of the tooth at the large end as already explained. The outline of the tooth at any other point or at the ends of the jig can be calculated in the same way.

In all the calculations for the length of the back radius and the outline of the tooth at the ends of the jig it should be borne in mind that the number of teeth in any given bevel gear remains the same, no matter what radius is used.

Double Helical Gears

For heavy mill work double helical gears of the form shown in Fig. 19 are frequently used. Considerable care is necessary in making the pattern for this class of gear, on account of the fact that the two halves of the pattern must be screwed from the sand and any irregularity in the teeth or body will cause trouble in the molding beside making the gears run poorly on account of the fact that if the teeth are not regular the gears will not mesh correctly. The profile of the teeth remains the same as in an ordinary spur gear and is laid out from the Odontograph tables.

In building such a gear as this the cylinder or body is built up of segments with an off-set parting line as shown by the dotted lines in Fig. 19 (A). This off-set or projection turned on the parting line is for the purpose of centering the two halves of the pattern in relation to each other.

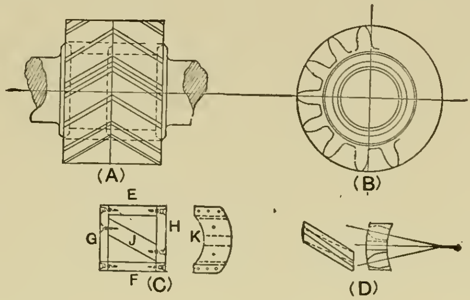


Fig. 19. Double Helical Gear

After the body of the gear is completed, the number of teeth should be laid off on the outer edge and also on the inner edge or parting, taking care to allow the proper pitch or angle of tooth, which is usually 30 degrees. To dress the inner face of the blocks so that they will fit the tooth the device shown in Fig. 19 (C) may be used. This consists of a box composed of sides E and F and ends G and H. The block J for the tooth is secured to the ends G and H by screws as shown and then the inner face of the block is worked off to the curve K. The blocks are left high enough to allow the outer diameter to be trimmed slightly after they are in place.

After the blocks have been fitted to the rim they should be secured with dowel pins and screws and then the gear with the tooth blocks in place should be returned to the lathe and turned to the exact diameter of the points of the teeth.

From the center of the cylinder or body to the outside diameter of the blocks scribe radial lines passing through points stepped off to correspond with the number of teeth and with a metal templet cut from a piece of sheet steel or zinc, scribe the profile of the teeth on the outer and inner end of each block. Remove the blocks from the gear and with a flexible rule draw lines from the points corresponding to the root and top of the teeth as shown in Fig. 19 (D). Next dress the tooth to shape, using the templet to determine the form of the tooth at any point, the templet being guided by the lines corresponding to the point and root of the tooth. The teeth should now be placed back in position and secured to the body with screws and dowel pins, but not with glue. Then rub in leather fillets. When both parts of the pattern are completed they can be placed together and one revolved on the other. If the teeth are perfect, they will match at any point. Fig. 19 (A) shows a front elevation of the gear and (B) an end view.

Worm and Worm Gear Patterns

A right hand single threaded worm and gear are shown in Fig. 20. The worm was laid out for a 6-inch pitch diameter to mesh with a

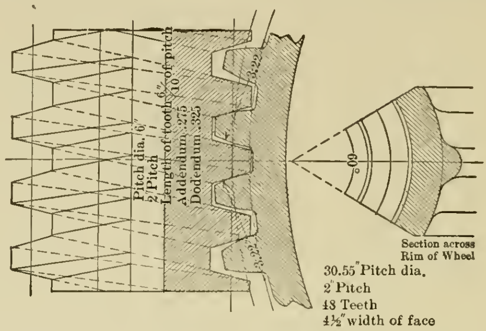


Fig. 20. Right Hand Single Threaded Worm and Gear

wheel of 30.55 inches pitch diameter and 2 inches circular pitch. The worm wheel contains 48 teeth and has an extreme face width of 4½ inches. The shape of the worm wheel tooth is taken from Grant's Odontograph for involute gear teeth. The usual length of tooth for this class of gear is 6-10 circular pitch, the addendum being equal to 275-1000 and the dedendum to 325-1000 of the circular pitch.

As in practice the worm pattern is usually required to doctor the teeth of the worm wheel for clearance it should be made first. The pattern is parted longitudinally and is made as follows: Glue up the stock and turn the outside diameter with the core prints attached. Do not destroy the centers used in turning, as after the thread is cut the pattern can be returned to the lathe and revolved at a slow speed while the threads are sand papered.

When the pattern has been turned to the proper diameter and length, wrap a piece of drawing paper around it and cut the exact length and circumference. Place the paper on a board and lay off space on each end equal to the circular pitch as shown in Fig. 21. If the worm is to be single threaded, draw diagonal lines as shown by the full lines. These will represent the pitch of the worm. If the worm is to be double threaded, draw diagonal lines as represented by the dotted lines, each line rising two divisions. If it is to be triple threaded, each line should rise three divisions, and so on for any number of threads, the angle increasing until the number of threads is so great and the angle so steep that we cease to call it a worm and term it a spiral gear. If the worm were to be left hand the diagonal lines would rise to the left in place of to the right as shown.

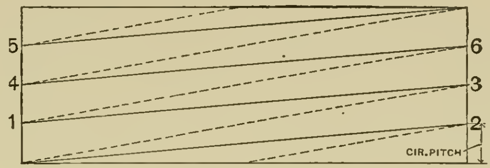


Fig. 21. Paper Template for Worm

If the drawing has been done correctly, when the paper is returned to the pattern the point 1 will meet point 2, point 4 will meet point 3, point 5 will meet point 6, and so on, thus forming a continuous spiral line about the pattern.

After the paper has been returned to the pattern a tracing wheel or some sharp pointed instrument should be used to prick the outline of the thread through the paper upon the pattern. The paper should

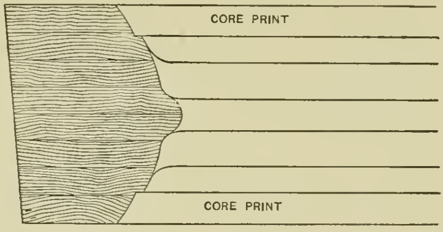


Fig. 22. Stock Glued Up for Worm Gear

then be removed and the outline marked in with a pencil. The paper may be attached to the pattern either by thumb tacks or by a few spots of glue while pricking the outline through on to the pattern. Do not cover the entire surface of the paper with glue as the paper would stretch and the pitch of the thread be altered.

The outline or cross section of the worm thread is the same as the outline of an involute rack tooth and hence has straight sides, as shown in Fig. 20.

The roughing out of the thread can be done quite closely by clamping strips of wood to the sides of a back saw, so as to give the desired depth, and then sawing down on the line already laid out. Or the outline may be formed by revolving the pattern in a V block placed over the circular saw.

After the worm pattern is completed, the stock for the worm gear should be glued up and the rim turned to the proper form as shown in Fig. 22. The arms should be set in as in spur gears.

Worm gear teeth may be molded in cores or by parting the pattern through the center and screwing each half of it out of the sand. The former method the author considers somewhat simpler and hence has illustrated it. For this reason the outer face of the pattern is turned

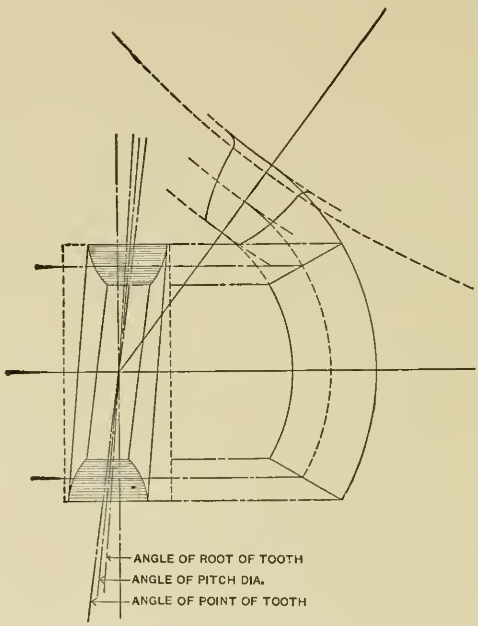


Fig. 23. Laying Out of Worm Gear Tooth

with draft and core prints to attach to both sides, as shown in Fig. 22. If the pattern were made complete it would be necessary to make the total number of teeth, while by the use of a core box it is possible to get along without forming so many teeth, and thus reduce the work. Also, if the pattern is made in halves and the two parts of the mold should shift slightly it would deface the teeth.

There are a number of different ways in which worm gear teeth can be laid out and made and there is much difference of opinion as to the best method, but the following shows one which practice has proven to be successful. Fig. 23 shows the manner in which a block can be laid out and worked to shape from the solid. The outline of the block is shown by the dotted lines. The block should be so formed that it will fit the curve of the worm at the top of the tooth and the curve of the face of the wheel at the bottom of the tooth. In this case the outlines are laid off on the two ends and connected as shown.

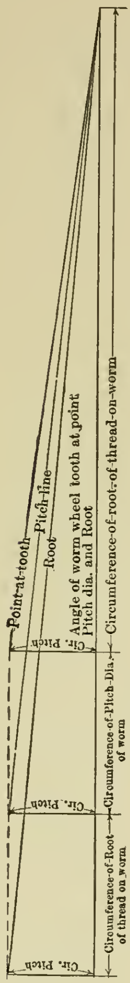


Fig. 24. Laying Out Angles for Worm Gear Teeth

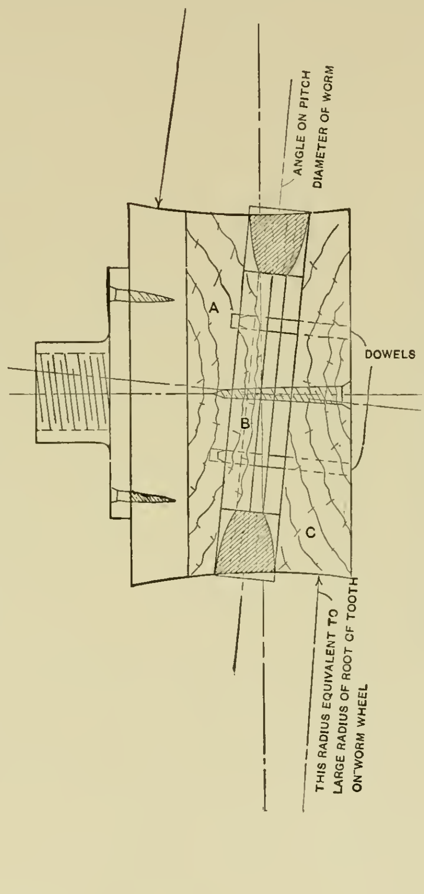


Fig. 25. Face Plate and Angle Rig for Turning Teeth

The method of obtaining the angles corresponding to the root of the tooth, the pitch diameter and the point of the tooth as necessary for the lay out shown in Fig. 23, is shown in Fig. 24. This is done by developing the circumference of the worm at the root, pitch diameter and point of the thread and erecting at one end of each of these lines a perpendicular equal to the circular pitch. The diagonal lines connecting the tops of these perpendiculars with the end of the lines representing the different circumferences will give angles as shown.

Another method of making the tooth is shown in Figs. 25 and 26 and 27. In this case they are made by turning up rings and cutting one tooth from each ring. While this does not give a theoretically correct form of tooth it will give one close enough for all practical purposes. The angle of the tooth is determined as shown in Fig. 24.

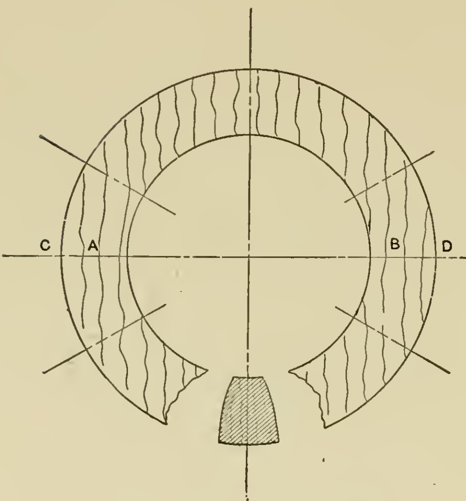


Fig. 26. Ring for Making Tooth

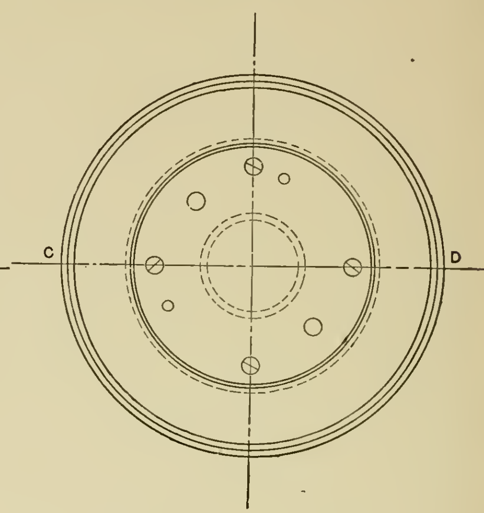


Fig. 27. Face Plate with Center Line Drawn on It

In carrying out this method a faceplate is placed on the lathe and the angle piece A, Fig. 25, is attached to it. This should have an angle corresponding to the angle of the tooth on the pitch line, that is, it should be the same angle as the center line of the thread on the paper lay out for the worm pattern. To this block should be secured the center disc B which is turned to a diameter equal to the inside diameter of the rings shown in Fig. 26 and clamped. Piece C is fitted with the necessary dowel pins to properly locate it and also with the clamping screw. The rings, Fig. 26, are then turned up to the proper cross section, the outside diameter being left somewhat larger than required.

The piece of the ring to be used for a tooth should be cut from the portion having the grain running lengthwise, that is, either the piece A or B, Fig. 26, should be used. This point must be observed in securing the rings in the chuck.

After the rings are secured in the chuck, the outer diameter is turned to coincide with the outer diameter of the worm wheel or the segment of the same which is used in the core box. Before the ring is removed from the lathe a center line corresponding to the line C-D, Fig. 26, should be drawn upon it.

In Fig. 27 the face plate is shown with the clamp and ring removed and with the center line C-D drawn upon it. Fig. 28 shows the manner in which the core boxes are arranged with the tooth sections in place. The portion of the rim carrying the teeth should be cut diagonally as shown at A and B, so as to allow the rim to be drawn back from

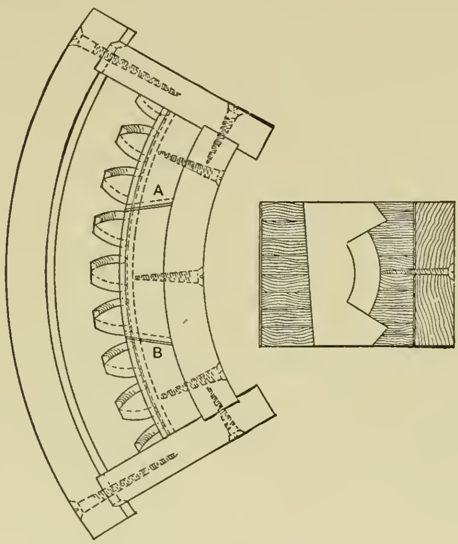


Fig. 28. Segment for Core Box

the core in sections. In the case of a worm having a very coarse pitch the teeth are usually made loose and secured in place by dowel pins so that the rim is withdrawn first and then the teeth withdrawn from the core.

No matter whether the teeth of the worm gear pattern are worked from the solid block or are turned and shaped, it will be found necessary to try the points for clearance, as otherwise they will interfere when leaving the worm. Fig. 29 shows a way in which the segment of the core box or the worm gear pattern can be mounted and revolved past the worm for this purpose. The worm being arranged to revolve on the centers in its core prints and the segment to swing on a post or in any other convenient manner.

Usually it is best to attach two or three teeth first, try them and dress them for clearance, and then dress the balance of the teeth to correspond with these.

The following modification may be preferred by some pattern-makers and has much to commend it:

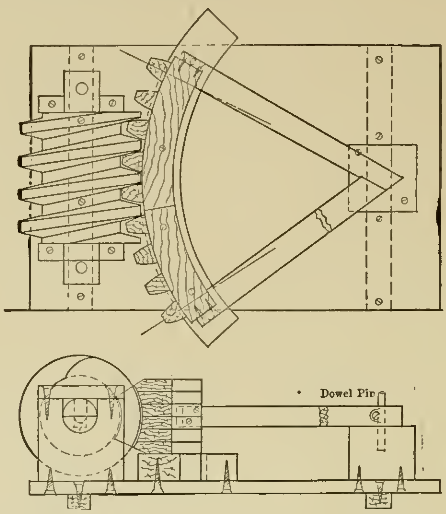


Fig. 29. Testing Teeth of Segment for Clearance

To make large worm wheels without making all of the teeth and without a core box, make the pattern the same as if you were going to core the teeth, placing a core print or clearance piece around the outside of the pattern as shown in Fig. 30. Then make a short segment of the pattern with a few teeth, as shown. After the pattern is

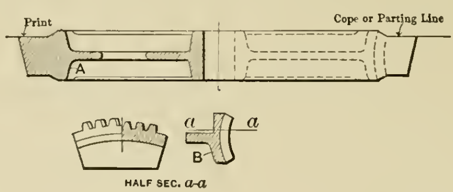


Fig. 30. Section of Pattern for Worm Gear

rammed up and drawn from the mold take the segment, Fig. 30, and keeping the shoulder B against the shoulder in the mold left by A, step the piece around the mold, marking with flour or parting sand. In this stepping off care should be taken to see that you have the right number of teeth, as it is very easy to lose or gain a tooth in a large wheel. After the spacing has been done place the segment at the starting point and place a block to make a parting at one end of the segment. This block, however, is only necessary for the first ramming.

Sand should then be rammed up opposite the segment and the segment screwed out and placed into the next mark, this section rammed and so on, until the wheel is finished. This method will often make a truer wheel than any made in cores, as there is always a fin where cores meet. Then, too, if the cores do not space accurately and have to be filed, this will result in either a wide or a narrow space where the cores meet.

Sanding Gear Teeth to Form

In place of the method of jigging the teeth to form with the aid of a plane they may be ground to form with a sand paper roller. This can be applied to either spur or bevel gear teeth and will be found much more rapid than the jigging process and just as accurate. Fig. 31 illustrates two views and a cross section of the sand roller or mandrel,

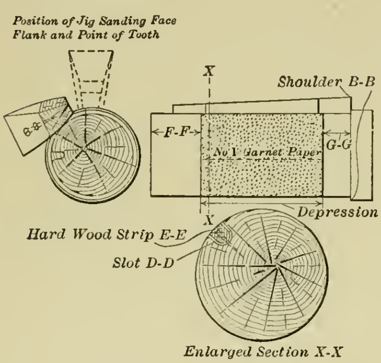


Fig. 31. Sanding Gear Teeth

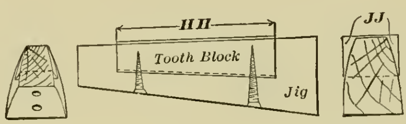


Fig. 32. Gear Tooth in Jig

with the jig in two positions during the operation of sanding. The roller is turned up of any convenient diameter, say 4 to 4½ inches, with shoulder B-B at one end for guiding the jig. A depression C-C of about 1-16 inch in depth and in width a little larger than the length of tooth, is now turned down and a piece of garnet paper cut to the length C-C and secured to the roller by the aid of the slot D-D and strip E-E. This manner of securing the paper to the roller has a decided advantage over gluing, as the paper is readily replaced without the usual delay waiting for the glue to set. It also avoids the trouble apt to occur by the paper swelling or buckling by the moisture from the glue.

The dimensions F-F and G-G, which are of sufficient width to give a good bearing for the jig, are now turned down on a line with the garnet paper, or to the same diameter. The completed jig is shown in greater detail in Fig. 32, the opening H-H in the center being cut out to receive the tooth blocks. The latter is shown in position and is secured in place by two screws. As the bottom of the tooth block must conform to the diameter of the rim of the wheel upon which the

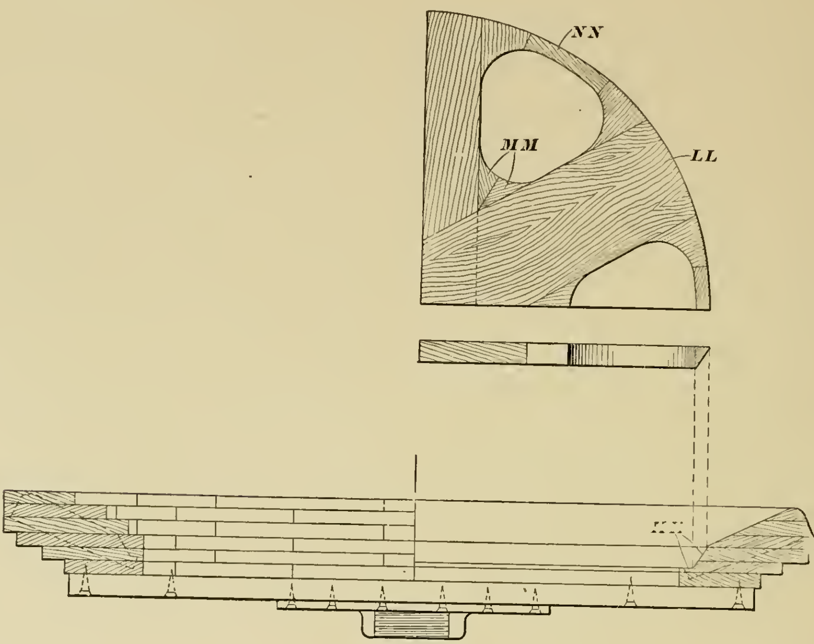


Fig. 33. Building a Bevel Gear Body

teeth are placed, so must the bottom of the opening H-H in the jig be identical with the same diameter.

With the jig and roller completed the sanding of the teeth takes our attention, and this is a good job for the cub. The tooth blocks having been gotten out of sufficient width, both ends are trimmed to the exact length and angle, and next with a round sole plane, or the bit in the jack plane rounded up. The edge of the block is dressed up to conform to the bottom of the opening H-H in the jig, Fig. 32. The tooth block is now placed in the jig and secured with the two screws, and after the cutting off with a chisel of the surplus material at the corners J-J of blocks, the sanding follows in order.

Controlled by the shoulder B-B, Fig. 31, the jig is held against the roller and guided over it as it revolves.

Construction of Bevel Gear Pattern Bodies

Fig. 33 illustrates two cross-sections of the rim in the course of completion, also a part plan and cross-section of the web. To the left

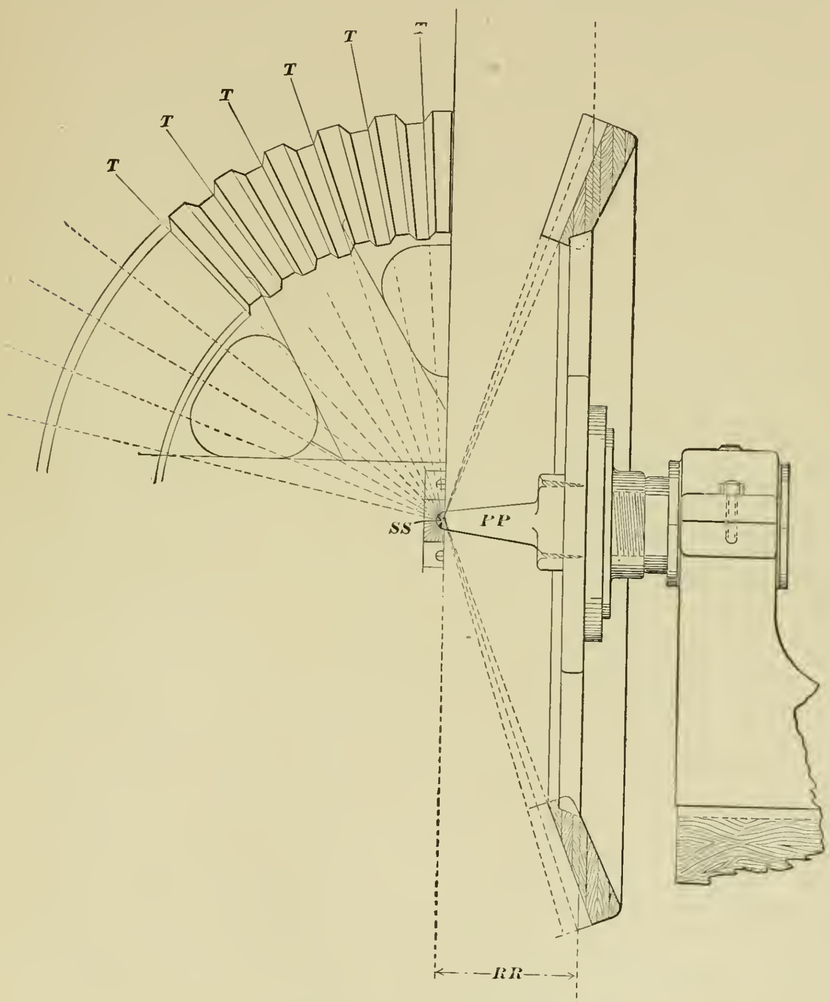


Fig. 34. Setting Teeth on a Bevel Gear

of the center line is shown a cross section of the segment work prior to turning, which also shows the manner in which it is built up on the face plate, while to the right of the center line is shown a cross-section of the rim at the completion of turning the back or inside of the rim, the offset or shoulder K-K being turned down to receive the web. A portion of the latter is shown directly over and in position for placing into the rim. The three pieces of material, one being shown by L-L, which form the greater portion of the web, are overlapped and secured together with glue and screws. The corners M-M and segments N-N are fitted in place and glued. This portion of the pattern is now secured to a face plate, and the outer diameter turned to fit snugly into the shoulder K-K of the rim, in which position it is secured with screws and glue. It will be found more convenient if this web portion of the pattern is gotten out first and the outer diameter turned to shape, and the offset, or shoulder, K-K, in the rim, turned out to fit the web, and the latter can then be secured in place before removing the rim from the face plate. The back of the rim is then given a coat of shellac and sandpapered down and removed from the face plate, turned over and centered and chucked directly upon the web of pattern, as shown in Fig. 34. This illustration shows one manner of accurately placing and securing the teeth upon the rim.

The face of the rim or the root of the tooth line is now turned to the required angle with the aid of a templet, which should extend across the entire diameter of the rim. Next attach to the web at the center of the work, as shown, the block or post P-P. The post should extend far enough out to allow the apex of a cone, of whch the rim is the frustum, to be turned at its outer point, S-S. If the face angle of rim is correct, the distance R-R from the plane of the pitch diameter of wheel to the apex of cone thus formed should be equal to the pitch radius of pinion. Spaces corresponding to the number of teeth are next spaced off on the face of the rim, near its outer diameter. The lines T-T-T are now drawn across the face of the rim through the points stepped off and intersecting at the point S-S of post. In placing the teeth on the rim, glue is applied to the tooth and the side of the tooth is set to one of the lines T, in which position it is held for a moment until the glue slightly sets. The sides and top are then tried for accuracy with a straight edge, for if the tooth has been accurately set, all lines of the tooth should intersect at the point S-S. The spaces should also be tried for correctness, with the calipers from the adjacent tooth. When all the teeth have been so placed and their correctness assured, they are nailed down and a leather fillet rubbed in. With the getting out of the hub and ribs and the remainder of the pattern, our work is completed.

SECTION V

REPRESENTATIVE PATTERNS

CHAPTER I

PATTERN FOR A THROTTLE VALVE BODY

While all valves are throttles, a throttle valve is generally understood to designate that design of valve used in regulating or controlling the steam supplied for reversible engines. These conditions usually require a quick action; hence, the valves are generally operated by levers. This necessitates the balancing of the valve so as to counteract the steam pressure, which changes the interior body somewhat from that of an ordinary globe valve.

The valve body illustrated and described in this article is known as a three way, 12 x 12 x 14½-in. throttle valve. This particular design is frequently used in connection with a pair of heavy reversible blooming mill engines. Fig. 1 shows two views of the valve body, and also a section on the line A-A; this section being taken through the intake opening.

To many persons the interpretation of the valve body drawing is always a perplexing problem, but this problem has a comparatively simple solution, for with the aid of a sheet of carbon paper and piece of drawing paper, the outline of the core can be traced in each view together with their center lines. Now by folding these carbon sheets along their center lines and placing them in a vertical plane in their relative positions, with regard to the accompanying views, the results will be surprising, as it will readily be seen what is required and the manner in which the cores can be made and placed together in the mold.

Before laying out of a full size section, and the commencing of the construction of such a pattern, its position and method of molding must be decided upon.

This pattern might be parted in the plane of Fig. 2, which shows the completed pattern. This would, however, necessitate a loose flange and a more intricate core; or it can be parted as in the case under

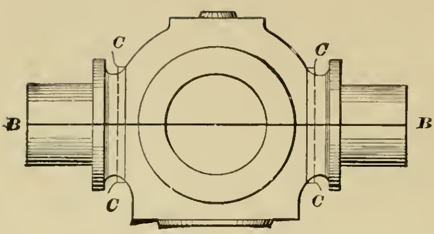
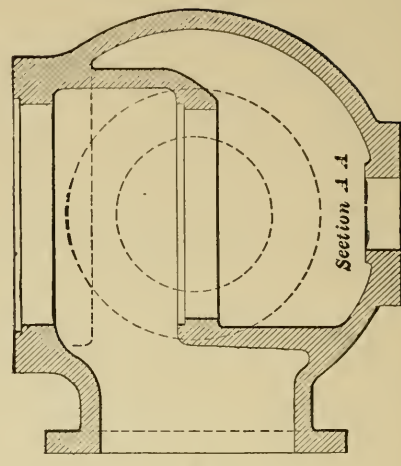


Fig. 2. Pattern for Throttle Valve



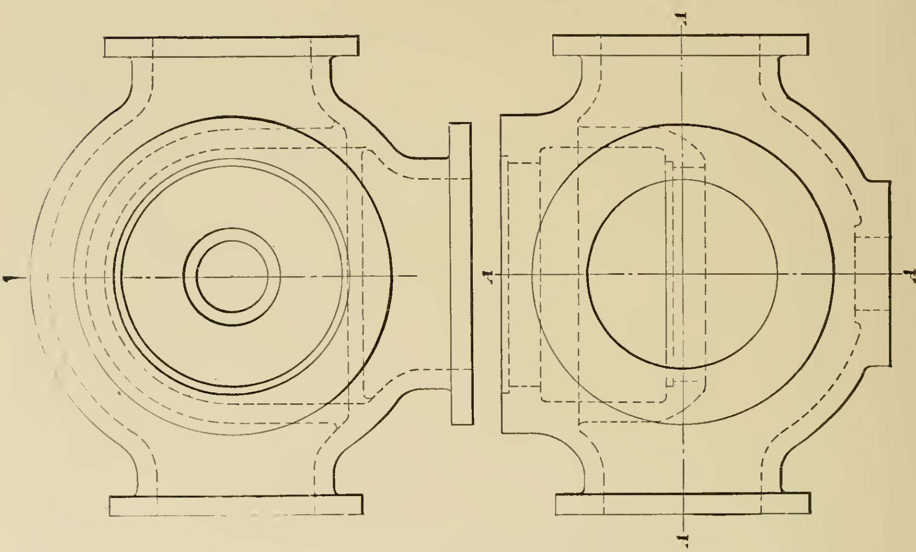


Fig. 1. Two Views and Section of Throttle Valve

discussion at right angles to the plane—that is, vertically along the line B B, with the bonnet opening downward. This method of starting provides a convenient and positive manner of setting the cores as well as simplifying the construction of the core boxes.

Fig. 3 shows the cope and drag parts of the pattern built up of segments and ready for turning. These two parts can be dowled together or fitted together with a male and female joint. The former method probably being preferable, as it does not require the parts to be rechucked. After the parts have been turned separately, they are placed together, marked, and the dowel pin holes bored.

The manner in which the opening connections are built up in halves and turned is shown in Fig. 4. To avoid a feather edge, and also to assist in turning and gluing these parts to the pattern body, ample stock is left as shown at C, and afterwards worked off into the fillet. The core prints are shown in Fig. 5. The core prints and connections could be built up and turned entire, but it is more convenient to turn them separately and attach later.

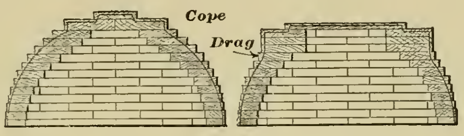


Fig. 3. Stock Glued up for Throttle Valve Pattern

Before proceeding with the discussion of the construction of the two core boxes with their detachable parts, let us familiarize ourselves more fully with the form and manner of jointing the cores required in forming the interior of the body. If the carbon tracings have been obtained, as heretofore explained, and are laid out in their relative positions to one another, they will appear, of course, without the joints

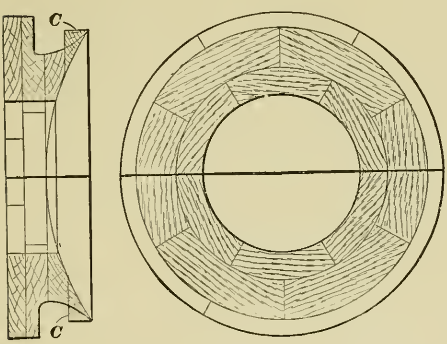


Fig. 4. Pattern for Opening Connection Throttle Valve Body

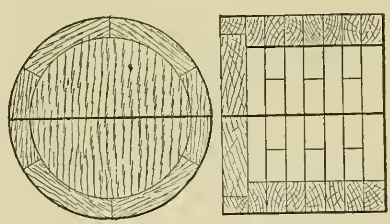


Fig. 5. Core Print for Throttle Valve

and print portion. The assembled cores, together with a section of the mold, are shown in Fig. 6. The two half cores, D and E, forming one portion of the body, are made in the same box and are jointed in the vertical plain, or at right angles to the joint with core F or the parting of the mold. Cores F and G are jointed as shown, and are made from the same box—core F forming the drag portion of the body while core G forms the cope half of the intake opening. To assist in locating and setting the cores, D, E, and F together in the mold, a projection with corresponding depression is formed in the joint as shown at H.

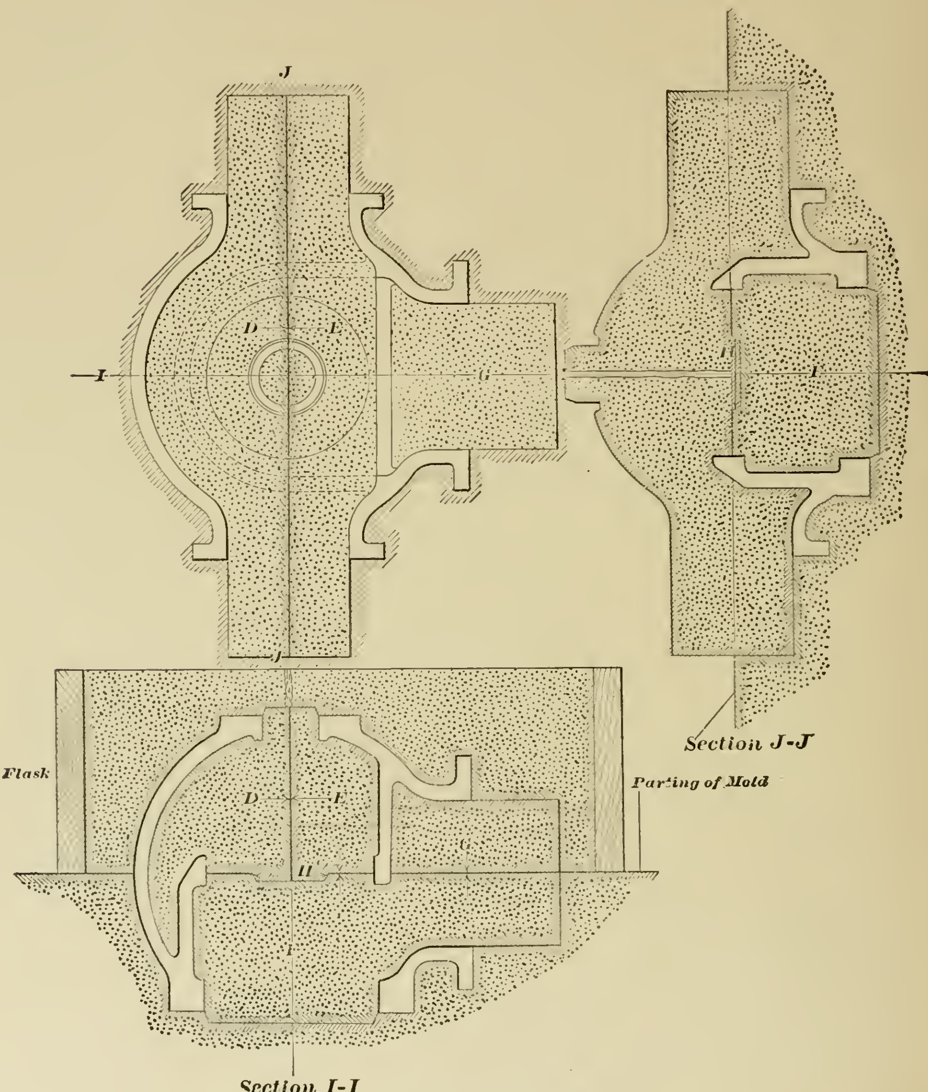


Fig. 6. Sections of Cores and Molds

In placing the cores in the mold, core F, with core G attached by pasting and wiring, is set in position. Cores D and E are next secured together in like manner and set upon the ones already placed.

The plan and three sections of the core box used in forming the cores D and E are shown in Fig. 7. The spherical portion of the box is built in segments and turned out. It is then flattened off as shown to receive the material forming the opening K, and also the board A B, to which is secured the parts L, Z and M, forming the valve

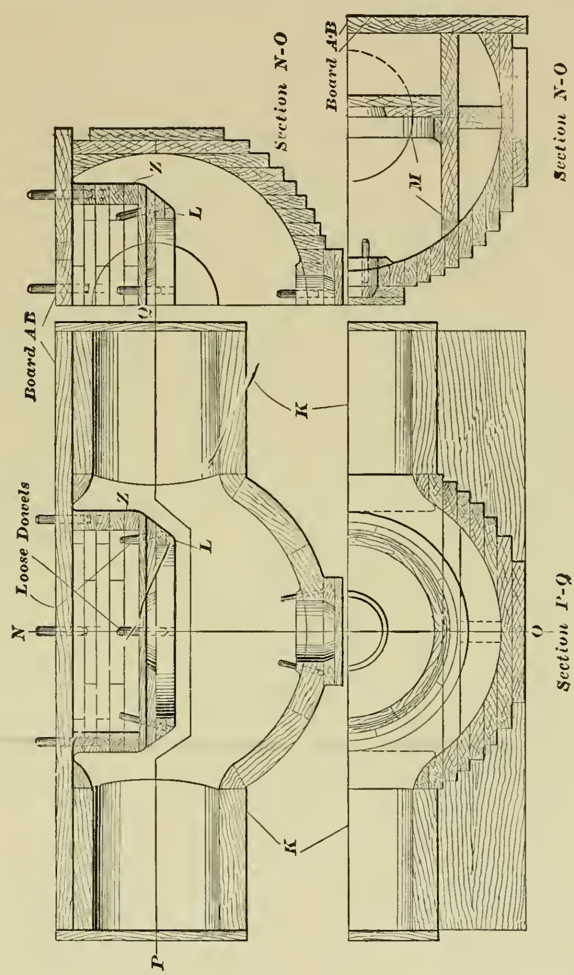


Fig. 7. Core Box for Cores D and E

chamber. The part M is shown in position in the lower right hand section, N O. As these two half cores, D and E, are made from this box, it requires the loose parts to be changed for each core—that is, parts L and Z are used in forming core D, while part M is substituted for forming core E.

Prior to the rolling over of this box, when forming core D, part Z is removed and piece L drawn back. The depressions left vacant by these two parts are filled with green sand to support the overhanging portion of the core while it is being dried.

It will be observed that the part M consists of a board fitted into

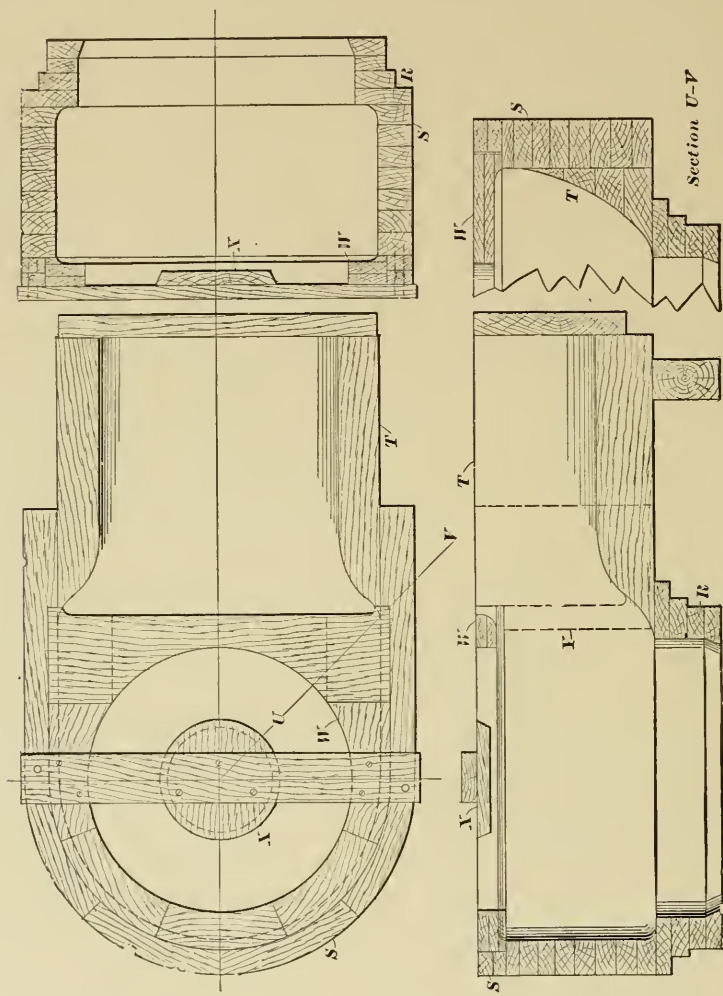


Fig. 8. Core Box for Forming Cores F and G

the spherical portion of the box to flatten it off, and to which is secured this portion of the valve chamber.

Cores F and G are formed in the box shown in the plan and sections in Fig. 8; the portion R, forming the lower part, being built up by segments, turned and secured to the frame S, which is built up, sawed out and attached to the material T, as shown, so as to form the intake opening. This portion of the box is then dressed out with the aid of a templet to the proper spherical form as shown by the section U V. Plate W is dropped into the top of the box as shown to form that portion of the metal thickness of the valve chamber which extends beyond the center line of the valve body.

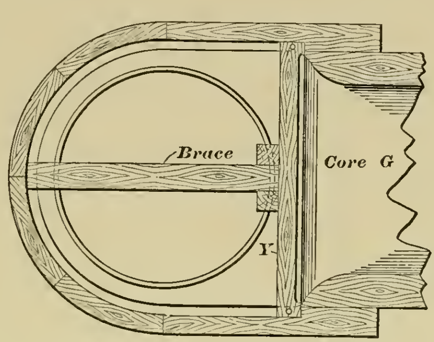


Fig. 9. Stop-Off used for Forming Core G

Print X is suspended in the center of the opening and forms the depression H, shown in core F, Fig. 6. Core G is formed in this box also with the aid of the stop-off piece Y, which is dropped into the box and braced as illustrated in a partial section of the core box shown in Fig. 9.

CHAPTER II

PATTERN FOR A PINION HOUSING

Of the accompanying illustrations, Figs. 10 and 11 show one-half of an enclosed pinion housing weighing about 28,000 pounds and of a design frequently used on modern roll trains. In constructing large patterns of this description, when part of the mold must be lifted away before the pattern can be drawn, it is often advantageous to arrange the mold somewhat after the manner of loam molds, that is, with the aid of a cast iron plate or flask, so that the side of the mold, usually termed the cheek, can be lifted away from the seat or bed, leaving the pattern free to be drawn.

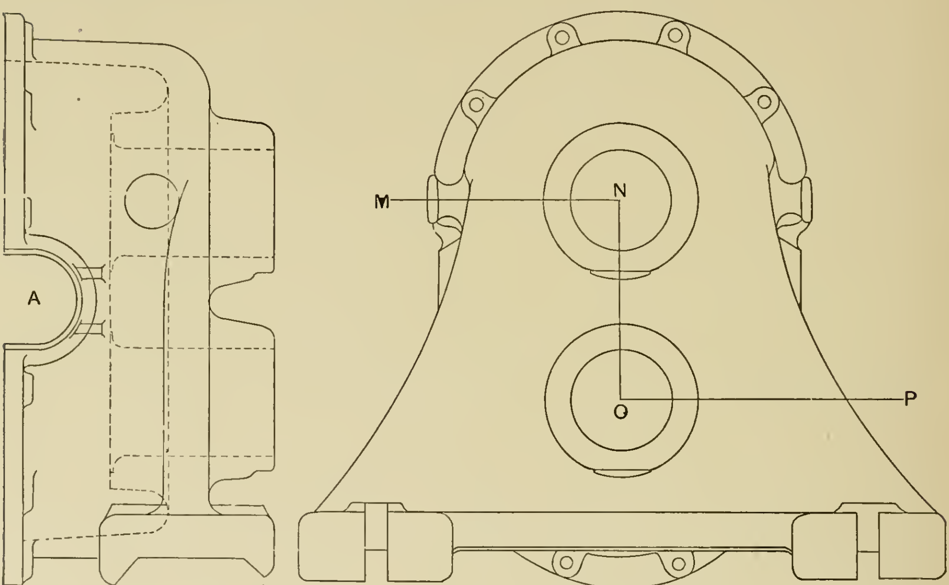


Fig. 10. Pinion Housing Pattern End and Side Elevations

When beginning the pattern, it is necessary to lay out a full sized plan and cross section upon a good substantial board. The straight portion of the pattern is built up of segments, as shown in the upper part of Fig. 12. In doing this work care should be taken to saw the segments to as near the finished size as possible, so as to reduce the amount of finishing to the minimum. If the parts are laid out carefully and band-sawed accurately to lines, it will only be necessary to clean up or smooth the surface. A little care at this point will save a great deal of work and time.

After the parts are built up, the openings for the doors A, Figs. 10 and 12, are cut out of each side as shown. It will be noticed that a flange is necessary at the bottom of the main body of the pattern and a fillet piece at the top, as shown by the dotted outlines in the upper part of Fig. 12, the flange being shown at B and the fillet piece at C. Both the flange and the fillet piece are built of segments turned and cut in halves, as shown at the bottom of Fig. 12. The halves are then secured to the body in the position shown by dotted lines. The intervening space from D to E, between the two halves of the pattern, is filled in with segments and dressed off to correspond with the section of the ends.

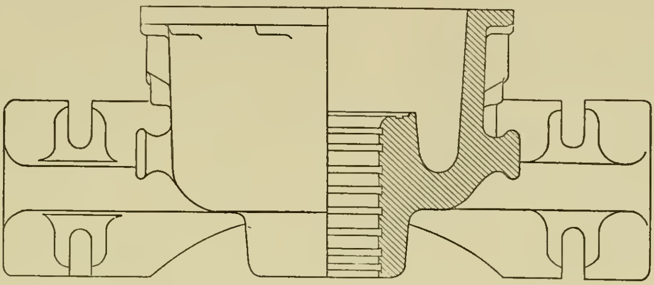


Fig. 11. Half Plan and Half Section of a Pinion Housing

It is necessary to make a door frame to go around the doors A. Three views of this frame are shown in the lower part of Fig. 12 between the flange and the fillet piece, and, of course, it is necessary to make one of these for each of the doors. These parts are built up of segments and worked out to fit the body of the pattern, to which they are secured.

The pads to reinforce the flange at the bolt centers are gotten out as shown above the door frame, Fig. 12., and secured to the flange at the proper points, as shown in Fig. 10. By referring to Fig. 11 and the dotted lines in Fig. 12, it will be noticed that the inside hubs project into the pattern some distance. Fig. 13 shows a plan and cross section of this portion of the pattern as it will appear after being built up, the parts turned and fitted together. It will be noticed that they are joined by a good substantial rapping bar shown at R. The space between the two hubs is filled in and worked out into a large fillet. The cross supports A and B are used in holding this portion of the pattern in place, while the inside of the body is being rammed up. To facilitate the ramming of the inside of the body it is necessary to provide a series of oblong openings as indicated by the dotted lines at HH, in the upper part of Fig. 12. One-half of each of these openings is shown on the hubs in Fig. 13, and the other half on the portion of the fillet piece shown in the lower left hand corner of Fig. 12, the half openings in each case being indicated by the letter H.

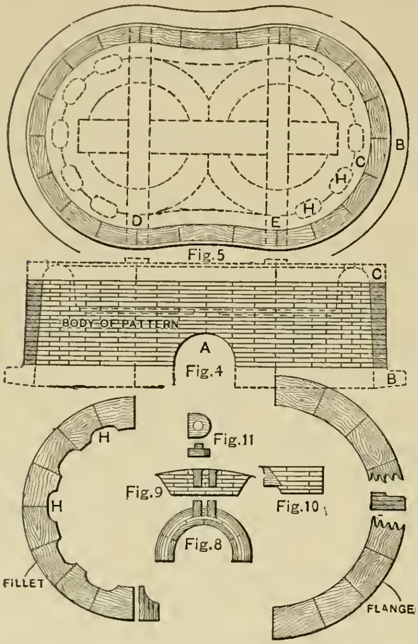


Fig. 12. Body of Pattern, Flange, Fillet Piece and Details

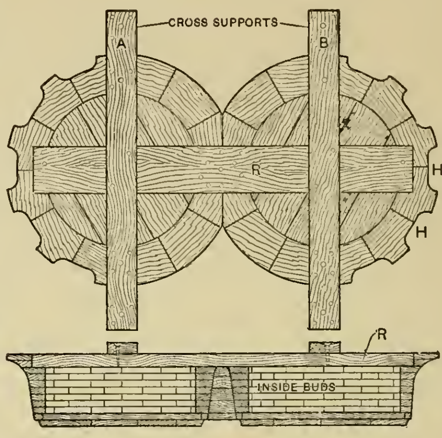


Fig. 13. Interior Hubs

The body portion of the pattern is now completed and building the web is next in order; to facilitate the handling and storing of this part of the pattern, it may be made in halves with a longitudinal joint through the center and the halves lined and bolted together while being molded.

One-half of the partially completed web is shown in Fig. 14, illustrating the manner in which it is built up of segments and one side closed. After the two halves of the web are completed, they are pinned and bolted together and dressed off.

The two outer hubs required are shown in Fig. 15, built up and turned ready to be placed in position and secured by dowels.

The feet of the housing must be also be gotten out and secured in the same manner. The details for this portion of the work are shown in Fig. 16, the three figures at the top showing the details of one foot.

There would be one of these parts required for each hand, that is, right and left for each half of web. It will be noticed that the projecting lip at the lower portion of the foot is secured with loose pins so that these parts can be drawn into the mold after the main portion of the pattern has been removed. The foot for the opposite side of

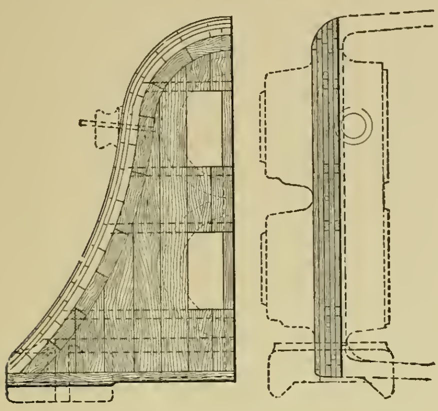


Fig. 14. Web Portion of Pattern Lagged up

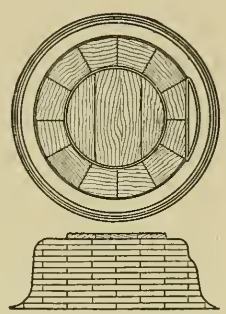


Fig. 15. Outer Hub

the web is shown in detail in the three views in the lower part of Fig. 16, and it will also be necessary to make two pieces of this, one right and the other left hand. These two parts of the foot, together with the intervening thickness of the web, give the desired bearing

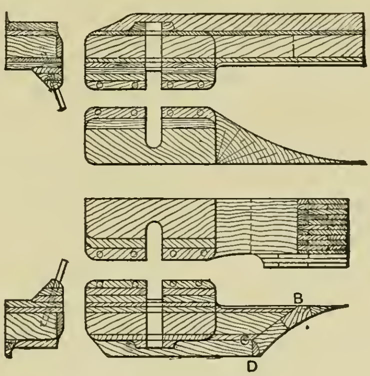


Fig. 16. Foot of Housing.

for the foundation of the housing. It will be noticed that in the piece shown in the lower right hand corner of Fig. 16 there is a parting along the line B C D, and that the intervening space between this joint and the body is filled in and worked out in the fillet as shown.

After the top or cope side of the web has been finished it is turned over with the open side up and the body of the pattern placed upon it, located, and secured in place with dowels: The portion of the foot shown by the three views at the bottom of Fig. 16 is also placed and secured with screws and pins. The portion of the web extending

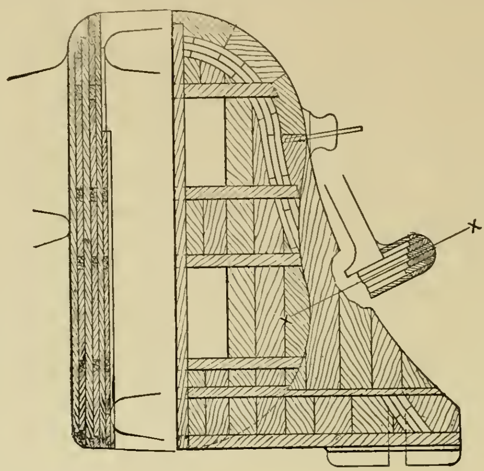


Fig. 17. Web Portion of Pattern Completed

outside of the body and up to the fillet of the foot is now filled in with material of the necessary thickness to give the required thickness of web as shown in Fig. 17, the partial cross section on the line X X indicating the thickness of the pattern at that point.

A cross section of the finished pattern taken along the line M N O P, Fig. 10, is shown in Fig. 18. This also shows the manner in

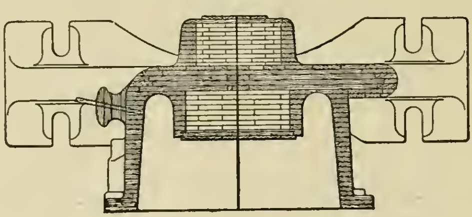


Fig. 18. Section of Finished Pattern

which the trunnions are turned and fitted to the pattern, being secured with loose dowels and pins.

A plan and section of the core box for making the cores for the two babbitted bearings in the hubs is shown in Fig. 19. The core prints shown in the core boxes ar to receive the dovetailed cores made in the core box shown at the bottom of Fig. 19, and intended for forming the rests or anchorage for the babbitt, as shown in the cross section of the casting in Fig. 11.

When molding the pattern, a hole is dug in the floor to such a depth that it will bring the parting line of the cope about level with the floor and a level bed is struck off. The body of the pattern is now placed upon the bed and the inside rammed up to about the height of the bosses. The bosses secured to the supports A-B, shown in Fig. 13, are then set in place and screwed down. If a cast iron plate with suitable lifting lugs and an opening in the center, conforming somewhat to the outline of the body, is to be used for supporting and lifting away the cheek, it is now lowered over the pattern and placed upon the bed, and the ramming up of the cheek is the next operation.

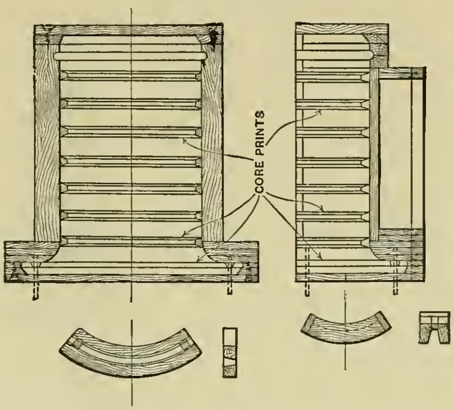


Fig. 19. Core Boxes for Bearings

During the operation of ramming up the cheek, and when this portion of the mold is nearly completed, the web portion of the pattern with the lower feet secured to it, is placed upon the body, the trunnion set in place, and the ramming of the cheek completed, up to the parting for the cope. The inside of the mold about the hubs must also be rammed up to the oblong openings. The supports for the inner hubs are now removed, and the outer hubs and upper part of the foot set on the web. The cope is then placed in position, rammed up and lifted off in the usual manner. The web of the pattern is then drawn. The cheek is next lifted away, so as to leave the body of the pattern exposed and free to be lifted from the core. The mold is now dressed and skin dried, when it is ready to assemble. The gates and runners are prepared, the mold assembled, and is then ready for weighting down and pouring in the usual manner.

CHAPTER III

HAWSER PIPE PATTERNS

Hawser, or "hawse" pipes, as they are generally called, are usually made in pairs, consisting of a right and left hand pipe. The length of the pipe, its diameter, and the angle of the ends, are governed by the angle upon which the pipes are set with the deck, by the outlines of the hull and the size of the anchor chain.

The pipe with the out board flange is cast entire, as shown in Fig. 20, while the deck flange as shown in Fig. 20 is cast separate and subsequently riveted upon the deck. These pipes are usually of cast

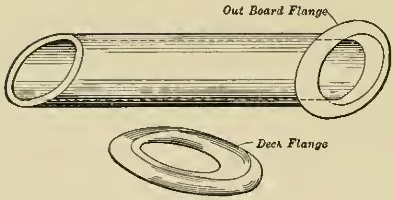


Fig. 20. Hawser Pipe

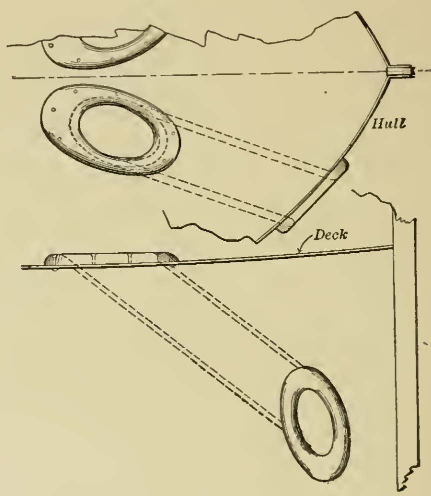


Fig. 21. Bow of Hull

iron and their construction affords a very good example of what may be termed cross templet and hollow pattern work.

It will readily be seen that this form of templet and method of making a pattern can be used in a very large number of ways for special pipes, etc. The outboard opening of these pipes often assumes different forms, to accommodate the stock of the anchor. In some cases the pipe flares outward in the form of a bell. When this is the case, it requires a complete pattern parted longitudinally with the inside, worked out to form the desired metal thickness. The inside of the pattern then serves as a core box for forming the green sand core, the core being lifted out with the aid of a core bar or skeleton.

To illustrate more fully the position and arrangement of these pipes when in place, two views of the bow or forward part of the hull are shown in Fig. 21.

The customary practice in most ship yards for transferring the angle of the deck and the hull to the pattern is as follows: The pattern is made solid or lagged up, and of about the required length. It is then shoved down through the openings provided in the deck and the hull and secured in place. The outline of the opening is next scribed around the pattern and is dressed off while in this position. Material equal in thickness to the contraction in the length of the pipe is added to one end. Next a core print is dressed off to conform to the angle

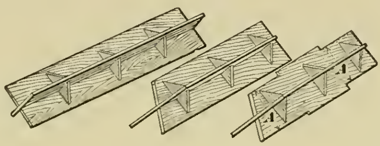


Fig. 22. Three Views of Cross Templet

of the deck and attached to the pattern. Any patternmaker who has been so unfortunate as to fall heir to this particular job will agree with the writer that the method illustrated and to be described is far superior to the method mentioned.

The form of templet used in connection with this method is termed a cross templet, as a cross section of the templet would be in the form of a cross, as shown in Fig. 22, which illustrates three views of the templet during the three stages of its completion as applied to the hawse pipe pattern. At the left in the figure is shown the templet nailed and bracketed together, and ready for the next operation which is the cutting of the angle on the ends. To cut the angle on the ends the templet is shoved down through the opening on the deck and out through the opening in the hull and clamped in position. The ends are next sawed off and dressed to conform to the angles of the deck and hull. The templet would now appear as shown in the central view of Fig. 22. The work thus far is done by the templet maker, who now turns it over to the patternmaker.

The separate parts of the pattern are shown in Fig. 23. At the right and left of the figure are the two barrel or cylindrical sections which have been sawed and dressed to conform to the angles of the ends of the templet which is shown in the center of the figure. These two cylindrical ends of the pattern are lagged and glued up over cylindrical heads having a diameter equal to the inside diameter of the pipe. A dry joint is left in the lagging on each side to permit the removal of the pieces from the heads and the cleaning of the inside of the pieces. The outer diameter is next turned to size, the lagging being secured to the circular heads with screws, which are removed as soon as the turning is completed. The heads are then taken out and the inside of the lagging cleaned up. The cylinders are then glued together as shown at the right and left of Fig. 23.

The templet being made of the same diameter as the outside of the pipe necessitates the cutting down of each end of the templet as shown at A, to allow this portion of the templet to enter the inside of the pattern. The ends are then slipped over the templet and secured with screws, the cylindrical ends being dressed off to conform to the

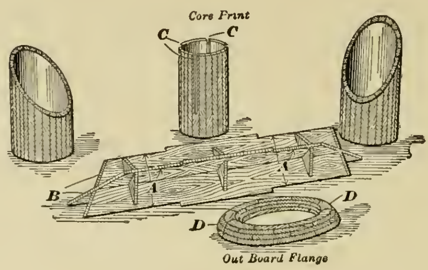


Fig. 23. Separate Parts of Pattern

angle of the templet as shown. Of course, allowance has to be made for the shrinkage of castings and this is accomplished by nailing strips on one end of the templet as shown at B, Fig. 23, the thickness of these strips being equal to the shrinkage which would take place in the length of the pipe. At the top of Fig. 23 is shown a core print which is attached or inserted into the end of the pattern which is without a flange, that is, the deck end of the pattern. This core print is lagged up in the ordinary manner and the outside turned to the proper diameter. If the inside diameter of the pattern has been lagged up carefully the core print should slip into it snugly. Of course, it is necessary to make some allowance for clearance. The slots shown at C in the core print must be cut to allow the core print to slide past the templet. A temporary head is used in the upper or open end of the core print when lagging it up and turning it and is subsequently removed, after which the slots are laid out and sawed to suit the templet.

The assembled pattern is shown in Fig. 24, in the correct position for molding. It will be observed that the pattern is so placed as to cause the flange to set in a perpendicular position, this being necessary to allow the coping off of the flange end of the pattern.

The flange, ready to attach to the pattern, is shown at the bottom of Fig. 23. It is built up in segments and worked out to form, being parted along the line D D, so that the upper half can be allowed to lift off with the cope when molded. Loose dowel pins are used to secure the entire flange in position. A chipping strip E, Fig. 24, of

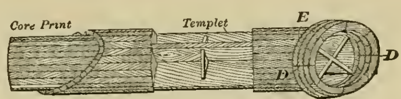


Fig. 24. Assembled Pattern

about one inch in width and ⅜ inch in thickness is attached around the outer edge of the flange with loose pins. The object of the chipping strip is to facilitate the fitting of the flange to the hull. Where hawse pipes are of the same diameter, one templet may be made to serve for several pipes, or the circular end may be readjusted upon a templet trimmed to the new angle and the old pattern thus made to serve for more than one vessel.

Molding of the Pipe

The molding of this pipe contains some points of interest, particularly in connection with the checking off of the flange end. A plan and two cross sections of the completed mold are shown in Fig. 25. At the top of the illustration is shown a plan of the mold with the pattern in place ready to have the flask placed in position for ramming the cope. At the right is shown a cross section through the cheek on the line F F, while at the bottom of the figure is shown a longitudinal section of the complete mold on the line G G. In beginning this work provision is first made for checking off the end containing the flange, after which the pattern is bedded in. During this operation that part of the mold occupied by the open space H between the two lagged up ends of the pattern is made up by ramming the sand about the pattern at the ends, removing the pattern and striking out the central portion with a straight edge to conform to the rammed up portion. Parting sand is now applied to this struck off surface and the pattern returned to place. A parting is next made around the pattern and up to the line of the cheek. Sand is used to fill up the opening H in the cope, the sand being struck off to conform to the ends as shown.

A bed is made to receive the cast iron lifting plate I which is dropped in place. For illustration a plate of triangular form is shown, but the shape and size of the plate is generally governed by the available material about the foundry. The flange which is not fast is now secured to the pattern with loose pins and the ramming up of the cheek commenced. A parting is made at the rounding surface of

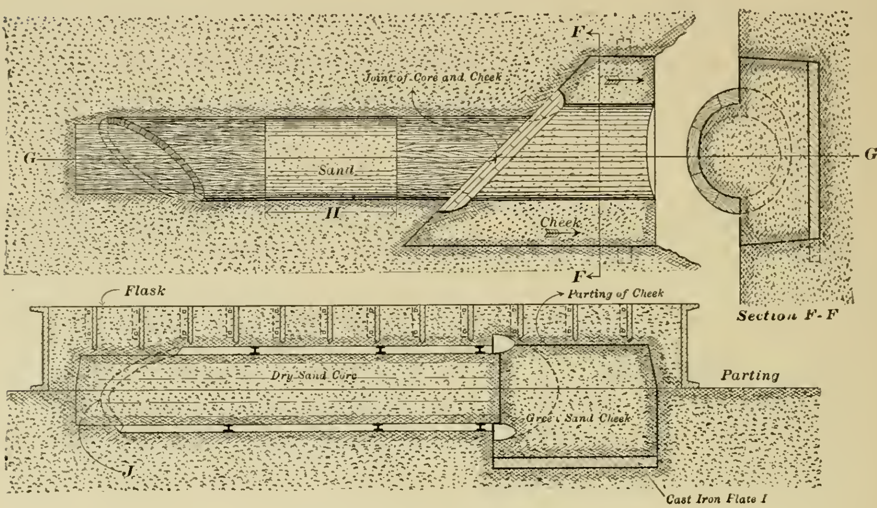


Fig. 25. Plan and Section of Mold

the flange above the parting of the mold as shown. A parting has also to be made along the line of the joint of the dry sand core in the cheek. This is accomplished by ramming sand into the end of the pattern and making a parting by striking it off even with the pattern. This parting is then covered with paper while the cheek is being rammed.

The cope is now placed in position and staked down. It is then rammed up and lifted off in the usual manner. The upper half of the flange lifts off with the cope. The cheek is next slightly lifted and drawn forward in the direction of the arrow, allowing the lower flange to be drawn back out of the cheek. The body of the pattern is then free to be drawn, with the exception of the point J, which necessitates a slight longitudinal movement of the pattern toward the cheek to allow this point to clear before the pattern is drawn from the mold.

The mold is then dressed in the usual manner, the cheek moved back into position and backed up by ramming the sand behind it. The dry sand core which forms the interior of the pipe and which is constructed with the aid of a frame and angle box, is now set in position upon chaplets and butted up to the cheek as shown. The cope is placed on, weighted, and the mold prepared for pouring. This entire mold is made in green sand, with the exception of the dry sand core mentioned.

CHAPTER IV

A NOZZLE PATTERN

Nozzles or saddles are usually employed in forming connections with shells or similar boiler work, and are made in various forms and sizes. The illustrations show a common form of nozzle. The pattern work and the operation of molding a piece of this shape is of a comparatively simple nature. It may contain some points of interest, as,

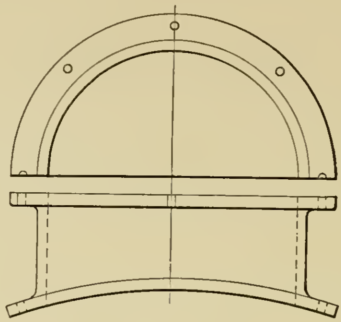
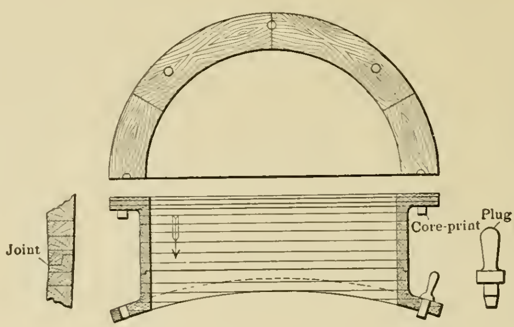


Fig. 26. Nozzle Casting

for example the plugging of impressions to receive cores when core-prints cannot conveniently be used, also another feature is the arrangement of the three-part flask.

Fig. 26 shows a nozzle casting as it would appear ready to be



7. Nozzle Pattern Assembled

riveted to the shell. The assembled pattern is in two parts and appears in Fig. 27. This illustration gives the general construction, which of course is segment work, also the location and formation of the joint, the latter being shown in greater detail at the left. It will be observed that the entire draft of the inside diameter of the pattern is in the direction of the arrow, while the draft on the outside diameter of the pattern is toward the joint.

As the upper part of the pattern is a simple lathe operation, we will discuss only the turning and working out of the lower portion, or that part of the pattern containing concave flange. To the left of the center line in Fig. 28 is shown a cross section of the first operation, that of building the ring up in segments. At the right of the center line is shown a cross section of the piece after having passed through the operation of turning and of fitting the joint.

Next the concave surface must be dressed out. This can be accomplished very nicely and accurately by nailing together a light

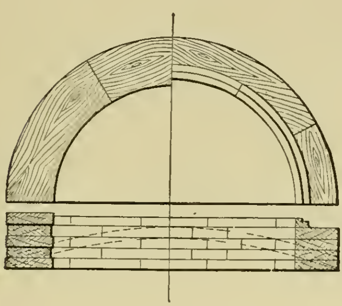


Fig. 28. Details of Saddle Flange Construction

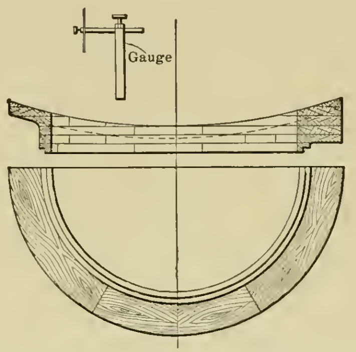


Fig. 29. Working of Saddle Flange to Form

frame of the proper depth, the two ends of which are cut out to the required radius of the flange. The frame is now tacked down on the work table, and the work dropped into it, secured and dressed out to conform to the circular ends of the frame. A cross section of the flange would now appear as shown to the right of the center line in Fig. 29.

The thickness of flange is scribed around the outer diameter, and the dressing of the flange to thickness accomplished with the gouge and calipers. When this operation has been completed, a cross section of the flange would appear as shown to the left of the center line in Fig. 29.

As the outer diameters of these flanges are usually made on a radial line with the center of the shell upon which they are placed, this will cause the edge to be irregular; it must be laid out on the concave side of flange and dressed off with the aid of a templet and the eye.

A handy little tool for laying off or scribing the width of the flange and rivet circles is shown at the top of Fig. 29. The gage is applied and guided by the inside diameter of pattern.

Next the rivet centers are stepped off around the rivet circle and holes radiating toward the center of shell are bored. The diameters of these holes are equal to the diameter of the cores to be used. A plug, shown in greater detail at the right in Fig. 27, is turned up to fit these holes, the shoulder allowing it to project through the flange the desired distance.

In molding the pattern the section of pattern containing the straight flange is placed upon the follow-board in the reversed position

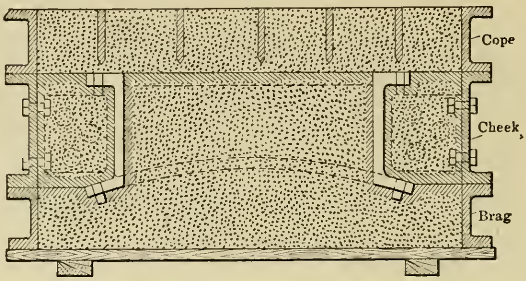


Fig. 30. Section of Mold

as shown in Fig. 27, and the cheek placed over it. This is followed by the operation of ramming up the inner and outer diameter until the joint of the pattern is reached. The balance of the pattern is now put in place and the ramming of the cheek completed with a parting made around the outer edge of the flange as shown in Fig. 30. The drag is now located and rammed up in the usual manner. These two parts of the mold are now clamped together, rolled over and the parting for cope made. At the completion of its ramming the latter is lifted off. The upper section of the pattern drawn, the cheek is lifted off, the depressions to receive the cores formed with the plug shown in Fig. 27, leaving the concave flange portion of the pattern free to be drawn up over the center core which is formed by the inside diameter of the pattern. The mold is now dressed, the cores set and the parts of the mold returned to place and clamped together as shown in Fig. 30.

CHAPTER V

MOLDING CAST STEEL TRUCK BOLSTERS

The truck bolster shown in Fig. 31 is that of the American Steel Foundries and the drawings also show their method of molding it. Green sand molds are employed in the production of practically all of this class of work. This is true whether the bolster pattern be mounted on a stripping plate machine, as in the case under discussion, or be molded upon the floor.

The method of molding is comparatively simple, but affords a very good example of the ramming up of a green sand core in place. This operation may be applied to very good advantage in a great variety of ways, especially in the producing of light steel castings where the presence of dry sand cores is to be avoided if possible, owing to their tendency to retard the shrinkage, as this shrinkage is apt to result in a badly strained or cracked casting when resisted by hard cores. This method may save some of the expense otherwise incurred in the making up of dry sand cores and in the handling of the same.

The success of the patternmaker in dealing with any problem of this kind depends wholly upon his ability to see how the object or pattern to be made will appear and how it may be molded in the most practical manner. With these two points constantly held clearly in mind the construction of the pattern becomes a secondary consideration. For this reason the writer believes that large returns often result from time spent over a drawing in studying every detail and getting a thorough idea of what is desired by the draftsman and what is required in the way of material, etc. When beginning any pattern, whether it is to be mounted on a machine or molded on the floor, its position and manner of molding must first be determined.

The truck bolster to be molded is shown in several views in Figs. 31 and 32. At the top of the illustration, Fig. 31, is shown a half-side elevation and half-longitudinal section on the center line of the bolster. At the bottom of the figure is shown a half-top and half-bottom plan, while Fig. 32 shows two cross sections of the bolster on the lines A-A and B-B, Fig. 31. The section A-A gives a cross section of the bolster at the middle through the center plate, while a section through the side bearings is shown at B-B. The stripping plate line or the line of the parting is located at C-C, Figs. 31 and 32.

In beginning the work, let us first take up the construction of

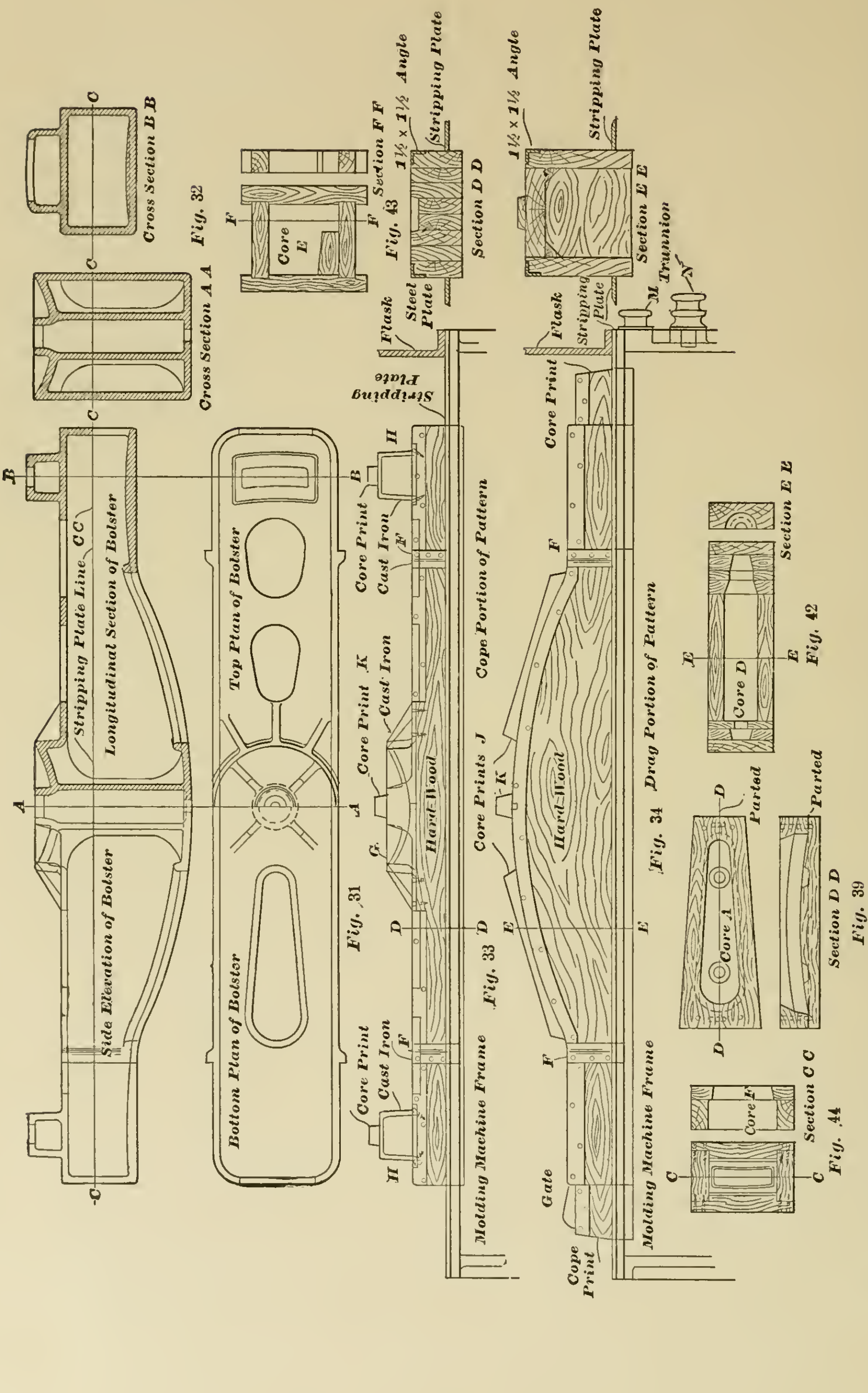


Fig. 31. Cast Steel Truck Bolster Fig. 32. Cross Sections of Truck Bolster Fig. 33. Cope Pattern on Molding Machine Fig. 34. Drag Pattern on Molding Machine
Fig. 39. Core Box for Forming Core A Fig. 42. Core Box for Forming Core D Fig. 43. Core Box for Forming Core E Fig. 44. Core Box for Forming Core F

the cope and drag portions of the pattern, as shown in their mounted position upon the molding machine, Figs. 33 and 34. These parts should be made of hard wood, maple preferred, although in some cases pine is used. The parts should be substantially put together and the corners protected by light angle iron as shown. Fig. 33 illustrates the cope portion of the pattern, which, owing to its shallowness, is usually made solid, the material being glued up edgewise, as shown at the right in the cross section of the pattern on the line D-D. This section is taken through the depression in the pattern which forms one of the openings in the top of the bolster. In other words, these openings in the top of the bolster are depressed in the pattern to a depth equal to the metal thickness of the top of the bolster. These

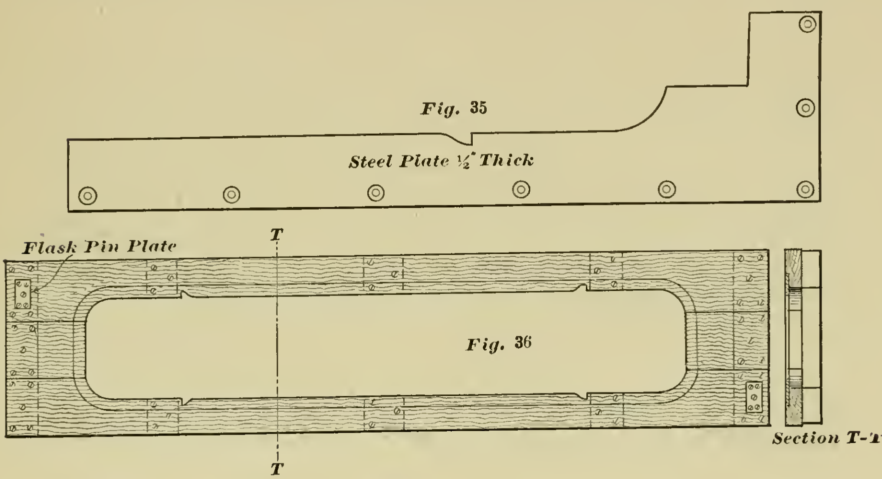


Fig. 35. One Quarter of Steel Stripping Plate Fig. 36. Plan of Wooden Stripping Plate

depressions or openings thus form their own green sand cores during the operation of molding.

Temporary patterns are made for the center plate G, side bearings H, and guide flanges F, these parts being made of cast iron fitted or turned up and subsequently properly located and secured in position upon the pattern.

The drag portion of the pattern is shown in Fig. 34. This portion of the pattern is constructed as a box section as shown at the right in the cross section on the line E-E. The two ends of the pattern are practically built in solid, to allow for the forming of the core print at each end.

In constructing this portion of the pattern the sides may be gotten out about 2½ inches thick, laid off, sawed and dressed to form. This portion of the pattern, as well as the cope portion, should extend about two inches below the stripping plate line. After the two sides have been placed upon a level surface and squared up, they are secured together with separating pieces and the two ends filled in solid. The top is next filled in and dressed off to conform with the sides. As the two oblong openings in the bottom of the bolster are formed by a dry sand core with a core print setting, these two core prints J are gotten out and secured in position as shown, as is also the center pin core print K. With the binding of the corners of the pattern with angle iron and the securing of the guide flanges F in position, this portion of the pattern is completed, after it has had the usual application of shellac.

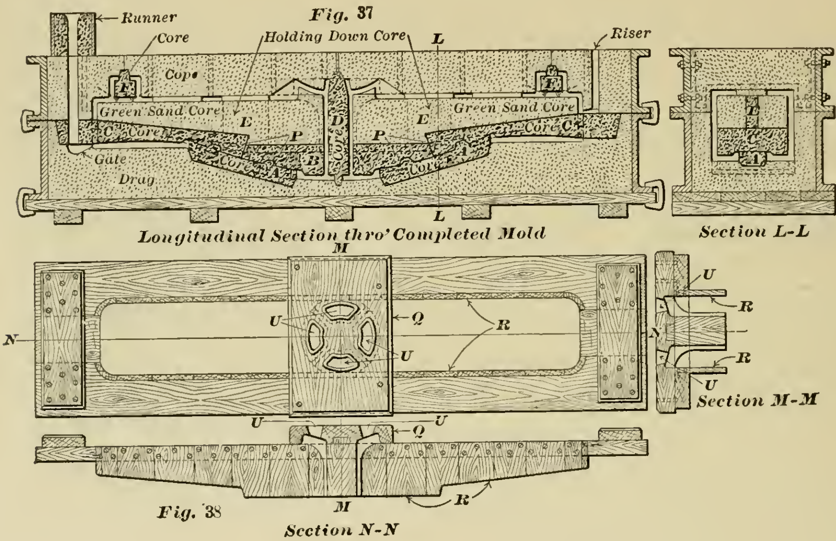


Fig. 37. Section of Mold Fig. 38. Rig for Ramming up the Green Sand Core

As the mounting of the pattern upon the machine depends entirely upon the raising and lowering operation and the arrangement of these parts of the machine we will not discuss that part of the work, but proceed with the fitting on of the material forming the stripping plate.

In most cases a steel plate about ½-inch in thickness is used, but the writer has fitted up molding machines for this class of work with a pine stripping plate about 1¾-inches in thickness, the lumber being substantially cleated together, and has found that such stripping plates have successfully withstood the action of pneumatic rammers in the production of several hundred castings.

If it is determined to equip the machine with a half-inch steel stripping plate, the pattern is located and secured in its correct position upon the operating device. A wooden templet is next gotten out and fitted up to the pattern. While in this position the outer edges are dressed off to conform to the outer edge of the flange of the frame, also the longitudinal and cross center lines are laid out, as the plates must meet at these points. One of the quarter plates is illustrated in Fig. 35.

These plates are gotten out in four pieces by punching and chipping to the outline of the templet, after which they are secured to the flanges of the side frames of the machine with countersunk head screws.

The center line of the pattern is next carefully tried for exactness and the templet for drilling the flask pin holes applied. This operation should be very carefully conducted, as the matching up of the cope and drag portions depends entirely upon the care with which it is performed.

Should a wooden stripping plate be desired, material equivalent in length and width to the top of the side frame flanges may be cleated together in a temporary manner and the pattern placed in its correct position upon it. With a small pair of dividers set to about 1-16-inch a parallel line is next scribed around the pattern. The cleates are then removed and the material enclosed by the scribed lines sawed out. Permanent cleates are next applied and the whole secured together. To protect the edge of the opening and to insure a closer joint around the pattern without a large bearing surface, 1½-inch by ⅛-inch band iron is laid in around the opening, as shown in the plan and elevation, Fig. 36.

The pattern having been secured to the machine, the plate or top is set down over it and secured to the side frames with bolts. Plates containing holes to receive the flask pins are now located by the aid of the flask pin templet as previously stated, these plates being let down flush with the top surface and secured with screws as shown.

With the machine fitted up, our attention is next given to the matching up of the cope and drag portions of the mold. The most satisfactory manner of ascertaining this fact and detecting any discrepancy is to have two or three castings made and check them up carefully. The making and checking of one casting is not always reliable, as a little variation in the flask pins may make it appear as if the setting up of the machine was not correct.

The drag portion of this pattern is mounted upon a roll-over machine, that is, a machine which is inverted with the flask in place and the pattern subsequently drawn up out of the sand, this being necessary on account of the fact that no bars are used in the drag flask and hence it cannot be lifted off and rolled over. The attaching of the flask to the machine of course changes the center of gravity of the machine. For this reason two trunnions are required, as shown at the right of Fig. 34, the fixed trunnion M being employed when inverting the machine with the flask attached, while the attachable trunnion, N, which is secured to the end frame with a pin and socket, as shown, is used in returning the machine to its upright position when the flask has been detached.

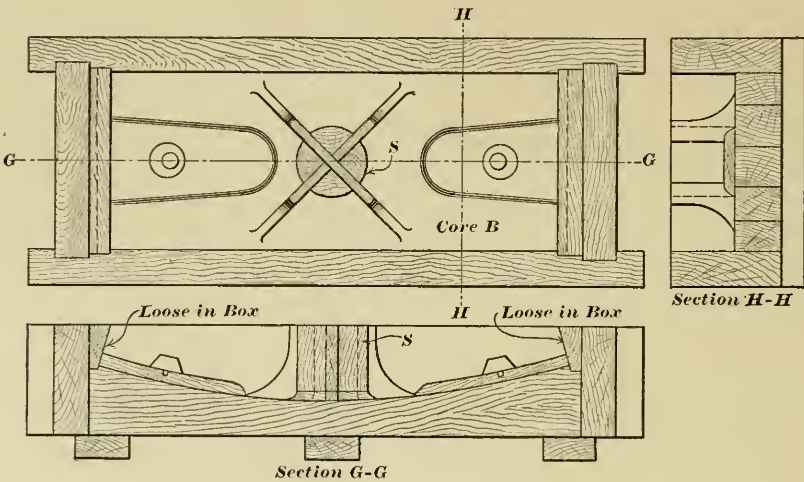


Fig. 40. Core Box for Forming Core B

Everything being in readiness we will now proceed with the molding of the drag portion of the pattern. The pattern is first raised and locked in position as shown in Fig. 34. The flask is placed on and securely clamped down to the flange of the machine, a thickness of prepared sand is applied over and tucked around the pattern. The balance of the flask is filled with heap sand, which is rammed in, the top being struck off in the usual manner. A bottom board is next applied and clamped down, and this is followed by the rolling over of the machine and the drawing of the pattern as previously described.

The next operation is the setting of the several dry sand cores which form the metal thickness or bottom member of the bolster. Before proceeding further it will be well to study Fig. 37, which shows the manner in which these different cores are placed together in the mold. In setting the cores, the cores A, which form the two oblong openings in the bottom of the bolster, are first placed in the depressions left vacant by their respective core prints J.

It will be observed that these two core prints J are provided with projections P, which might be termed dowels. These serve to locate and secure the center core B in its correct position and also one end of each of the cores C, the outer ends of the latter mentioned cores being received by core print settings as shown.

When these five cores have been located, the holding-down cores E are placed in position, directly underneath or opposite the depressions in the cope pattern which form the openings in the top members of the bolster, as shown in the cross section of the mold on the line L-L, Fig. 37.

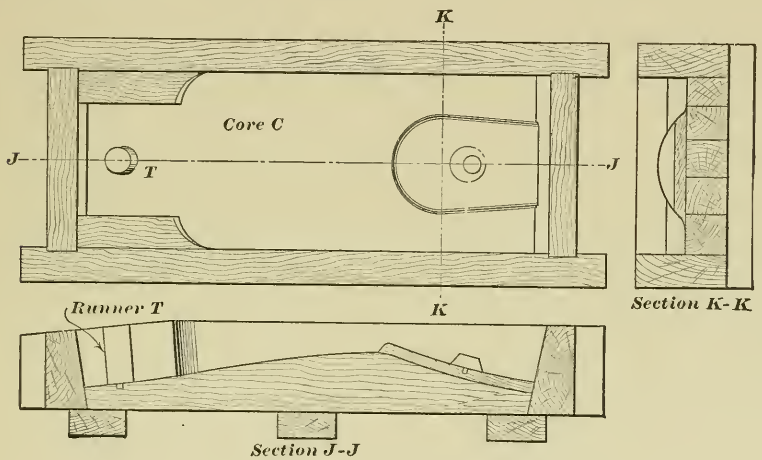


Fig. 41. Core Box for Forming Core C

These two cores E are rammed up in the green sand core and are used to prevent the dry sand cores at the bottom from rising, due to the pressure of the metal exerted underneath the cores as the mold is poured.

The method of ramming up the green sand core is illustrated in Fig. 38. It will be noticed that there is a frame used for ramming up the green sand core, the construction being made clear by the illustration. The center part Q which contains the center post and vertical ribs of the bolster is made detachable and secured to the frame with dowels, this being done to allow this part to be drawn first, so that the top of the green sand core may be slicked and dressed up before removing the frame proper. The core is rammed up as follows:

After the dry sand cores are set, as already explained, the frame without the center, Q, is lowered into the mold so as to rest upon the parting. The material R passes down into the space between the wall of the mold and the dry sand cores as shown by the dotted lines in Fig. 37, thus closing up this space and preventing any sand falling into it during the ramming up of the green sand core. The center part Q of the frame containing the center post, etc., which passes down into the depression in the core B is also located.

The depression in the core B is formed by the material in the core box shown in Fig. 40. The openings U, Fig. 38, are to facilitate the ramming of the sand underneath the top portion of the frame. After the sand has been rammed into the green sand core frame the top portion Q is removed, the surface slicked up, and then the other portions drawn away so as to leave the green sand core in place.

As the molding of the cope pattern shown in Fig. 33 is of a simple nature and embraces no special points of interest, we will proceed to discuss the construction of the core box employed in forming the various cores. Fig. 39 shows a plan and cross section of the core box used in forming core A, which gives its construction and the manner of parting. In Fig. 40 is illustrated a plan longitudinal and cross section of the core box used in forming the center core B. It is in this box that the portion of the center post, with its ribs, is formed by the material S, the remaining portion being made up in the green sand core as explained previously. Within this box is also placed a portion of the reinforcement around the oblong opening, the remaining portion being placed in the core box shown in the plan and cross section in Fig. 41. This latter box is employed in forming the two end cores C, which are identical, with the exception of the runner T, which is rammed up in one core only. The center pin core D, the holding-down cores E, and the side bearing cores F are formed in their respective core boxes, as shown in Figs. 42, 43 and 44.

CHAPTER VI

RIG FOR PRODUCING CYLINDRICAL CASTINGS

The mold for a cylindrical casting like that shown in Fig. 45, may be produced without the use of complete patterns or sweeps, as described in this chapter. The parallel portion of the cylindrical body is made with a cast iron ring similar to the ring used in molding

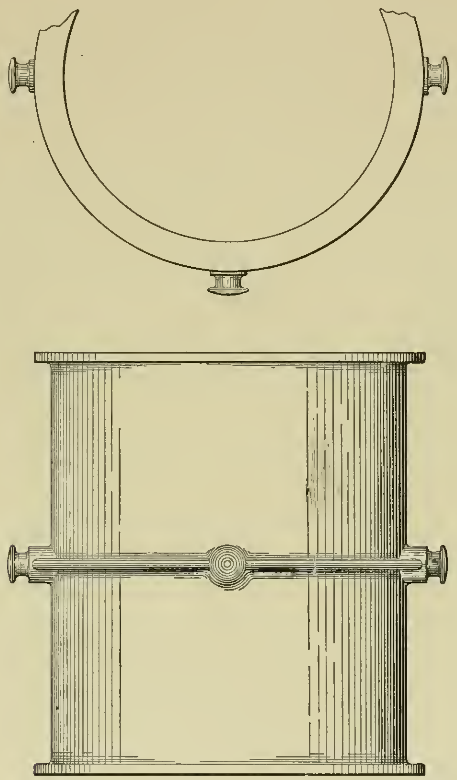


Fig. 45. Cylindrical Casting

pulley rims. While this method of drawing up a ring to produce a pulley rim or other cylindrical shell is not new by any means, it may be of interest to some and serve to show how this manner of molding can be applied to different pieces.

A section of the mold is shown in Fig. 46. In beginning this it is at first necessary to dig a pit having a depth about equal to the length of the desired casting and of such diameter that it will allow a molder to work around the outside of the rim when ramming it up. A level bed is then struck off in the bottom of the pit and a good substantial

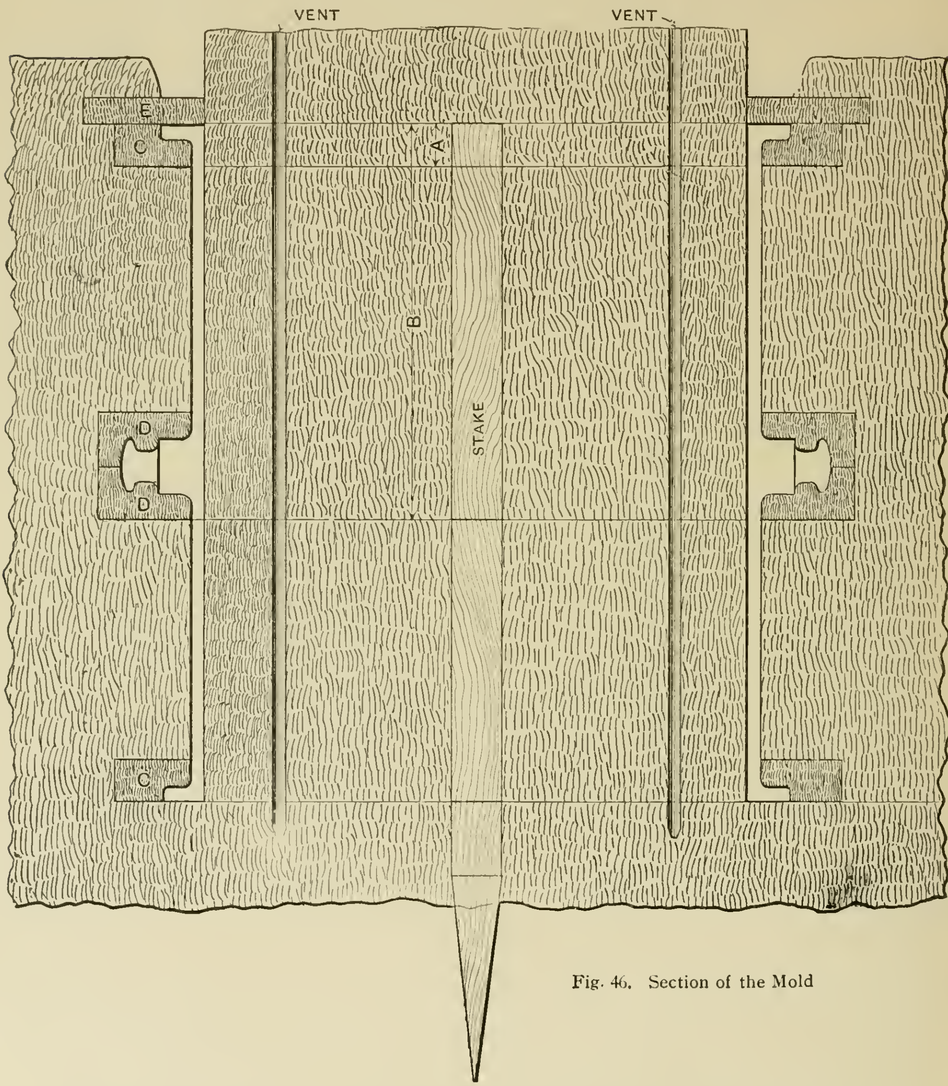


Fig. 46. Section of the Mold

stake driven in the center of the same. The stake should be of such a length that that portion projecting above the bed will be equivalent to the length of the desired casting. The distances A and B from the top of the stake to the under side of the cores forming the top and middle flanges, is then scribed around the stake as a gauge for drawing the ring to these heights, which correspond to points at which beds must be struck off to receive these cores.

A cast iron ring of the required diameter and thickness and having a width or face of 6 or 8 inches is then placed upon the bed with the stake about in the center. A number of round sticks 12 or 14 inches in length are then driven around the inside to form the vents shown in Fig. 46. The inside of the ring should then be rammed up for several inches so as to insure its remaining in the required position. The cores C forming the lower flange are now set up to the ring and the outside and the inside firmly rammed to the top of the ring. This portion of the mold is then thoroughly vented and the ring and vent

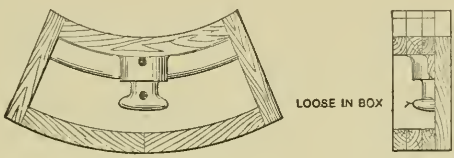


Fig. 47. Core Box for the Trunnions

stakes drawn up several inches. The operations of ramming and venting are repeated. During these operations some iron rods or core irons should be set inside of the ring to hold the central portion of the mold or green sand core in place. These would be parallel with the rods forming the vents shown in Fig. 46. A spirit level should be used on the upper edge of the ring during each drawing to insure a straight and even casting. This process of ramming and drawing the ring is continued until the top of the ring comes in line with the gauge mark or line on the stake representing the under side of the cores D used to form the middle flange and trunnions.

At this point, when the outside has been rammed, a level bed or seat is struck off at the top of the ring, the ring drawn up as before and the cores D set on top of the bed and in contact with the ring. These cores should be pasted together before being placed in the mold. After the cores D are in position the ramming and drawing is continued until the under side of the upper flange cores C is reached, as indicated by the mark on the stake at the distance A from its top. The ring is then drawn to the level of the bottom of these cores and a bed struck off at this point to be used for setting the cores C.

After the cores C are in place the ring is drawn up so that its upper surface is level with the top of the required casting and a joint or bed struck off for setting the covering cores E. The ring is then drawn several inches higher, and the inside of the mold rammed up as shown. The ring and vent sticks are then drawn out, and the covering cores E, placed in position on top of the cores C, care having been

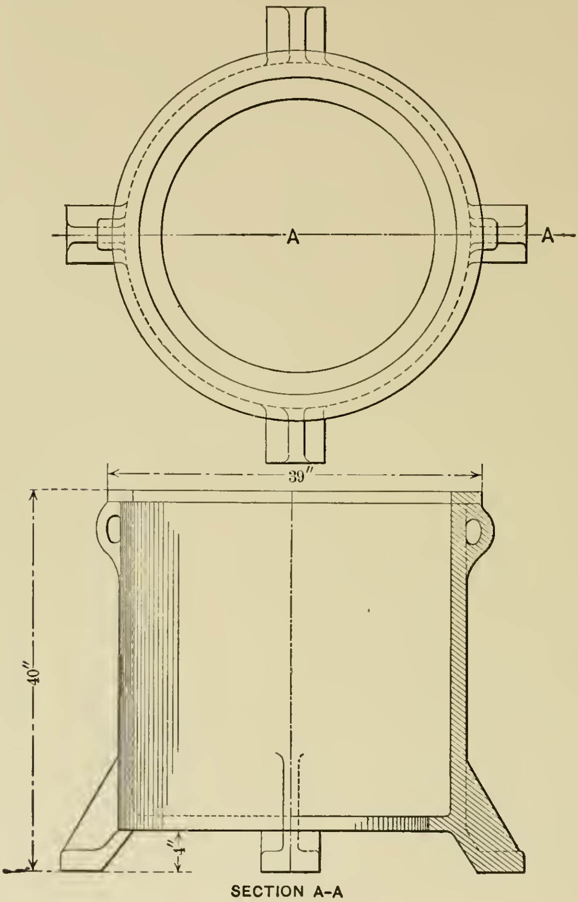


Fig. 48. Casting for Strainer Tank

taken first to file or cut the necessary gates in the cores E. A runner is formed on top of the cores E as shown, and weights placed over the outer portion of the cores E to hold them in position. The necessary pouring basin is then formed in connection with the runner on top of the cores E, when the mold will be ready to cast.

The core box for forming the cores D is shown in Fig. 47, and a similar core box without the trunnion pattern is used for forming the cores C.

During this work care must be taken to see that the sticks for forming the vents are drawn up at each ramming as, if they are left in the mold too long, considerable difficulty will be experienced in drawing them. On account of the fact that comparatively thin courses are rammed at a time, that is, from 4 to 5 inches, it is not necessary to have the ring pattern over 6 or 7 inches wide, and in most cases, any

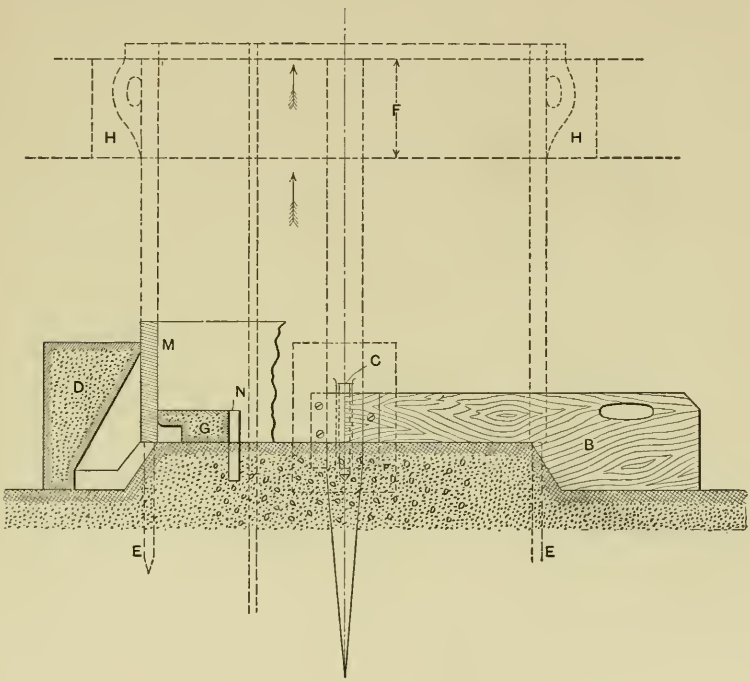


Fig. 49. Sweeping the Bed

additional width beyond this is entirely unnecessary, as it only adds to the difficulty of drawing the pattern if too great a width of it be rammed up at one time. In case no ring pattern is in stock, it would be necessary for the patternmaker to build up a ring of segments, turn up a wooden pattern with the necessary finish on all faces and have a casting made from which the iron ring pattern can be turned up in the machine shop.

A somewhat more intricate casting of the above mentioned type is shown in Fig. 48. It will be noticed that this has an internal bottom flange, four cast feet, an external top flange, and a pair of ears. The casting is to be used as a filter, or strainer tank.

The method of proceeding with the work is shown in Figs. 49 and 50. It is first necessary to strike off a level bed and in the center of it drive a stake containing the dowel pin C, Fig. 49. To this dowel pin is attached the sweep B, the striking edge of which contains the form of the under-side of the feet. By revolving the sweep about the stake a bed is struck off as shown. The dowel pin C is then removed from the top of the stake and right-angle lines are drawn

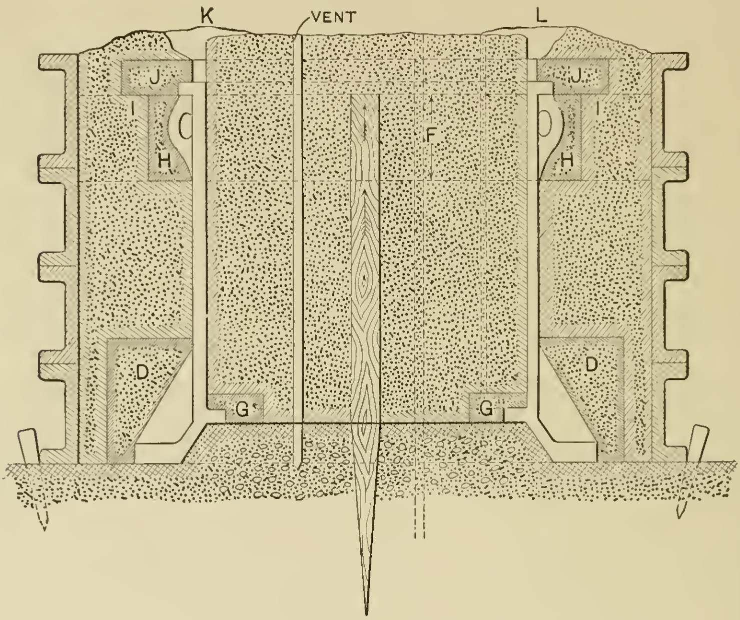


Fig. 50. Section of Mold

from the center of the stake across the bed to locate the four cores D, which are made in halves and pasted together. These cores are placed in their correct position against the swept surface of the bed. To prevent the weight of the cast iron ring pattern from being born entirely by the foot cores D, four pieces of bar or rod iron are driven into the bed as indicated at E. These rods, however, should be placed half way between the cores D.

The sweep stake is now removed, and in its place is firmly driven the long stake as shown by the dotted lines, Fig. 49, and the full lines in Fig. 50. This stake extends up to the level of the under-side of the top flange of the casting. As in the previous example, the distance F is marked off on the stake to locate the under side of the cores H, which serve to form the lifting ears. The cast iron ring M, of the required inside and outside diameter and having a face of about 8 inches, is placed in position, being supported by the rods E and the cores D. They should be tested with the spirit level.

As in the previous example a number of one-inch pins about 16 inches long should be driven down into the bed at various points to form vents. The first section of the flask is then placed into position and staked down as shown in Fig. 50, after which the operation of ramming is proceeded with. The outside is rammed first to the height of 2 or 3 inches above the lower edge of the ring, care being taken to see that the ring is not rammed out of place.

Any sand that may have been rammed under the ring and into the inside of the mold is then removed, and the cores G, which form the internal flange at the bottom are set into position, and the rods N are driven into the bed back of them. The inside and outside are then rammed up to the height of 5 or 6 inches, a vent wire being used between the vent sticks. The ring and vent sticks are then drawn up several inches, the operation of ramming and vented repeated, care being taken to see that the green sand core is well rodded.

The spirit level should be used on the upper edge of the ring during each drawing operation to insure a straight and even casting.

The process of ramming and drawing the ring and vent sticks is continued until the top of the ring comes in line with the gage line marked on the stake representing the under-side ear cores H. At this point the outside is rammed up and a level bed struck off at the top of the ring as shown in the dotted lines, Fig. 50. The ring is then drawn up in line with the top of the stake, the ear cores H set in position against the ring and diametrically against each other. The operations of ramming, venting and drawing the rods, together with the introduction of the iron rods necessary for supporting the core are continued to the top of the ring and cores H, at which point the bed is struck off to receive the flange core J. These are then set in place and backed up with sand to the top of the flask, as shown in Fig. 50. The forming of the pouring basin and risers and the weighing of the cores J, completes the mold.

The core boxes for forming the four different cores are shown in Figs. 51, 52, 53 and 54. Fig. 51 shows the box used in forming one-half the foot core, an opposite hand piece M being required in the box to form the other half of core. Fig. 52 shows the box for forming one half the lifting ear core, which also requires an opposite hand piece N for the other half. Figs. 53 and 54 show the frames employed in forming the upper flange core J and the lower internal flange core G. The ring casting can be made with the aid of a segment pattern attached to a stake, and subsequently turned to dimensions.

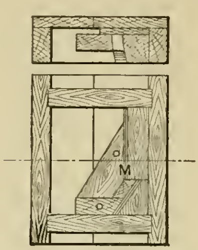


Fig. 51

Fig. 52

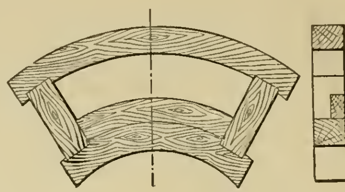


Fig. 53

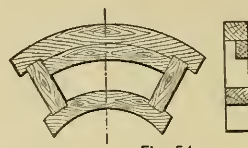


Fig. 54

Fig. 51. Core Box for Feet. Fig. 52. Core Box for Lifting Ears
Fig. 53. Core Box for Upper Flange Core. Fig. 54. Core Box for Internal Flange Core

CHAPTER VII

SKELETON PATTERNS

As the building of a complete pattern for large irregular castings such as nozzles, saddles, etc., is not always practical, the form of pattern commonly known as skeleton or frame pattern is resorted to.

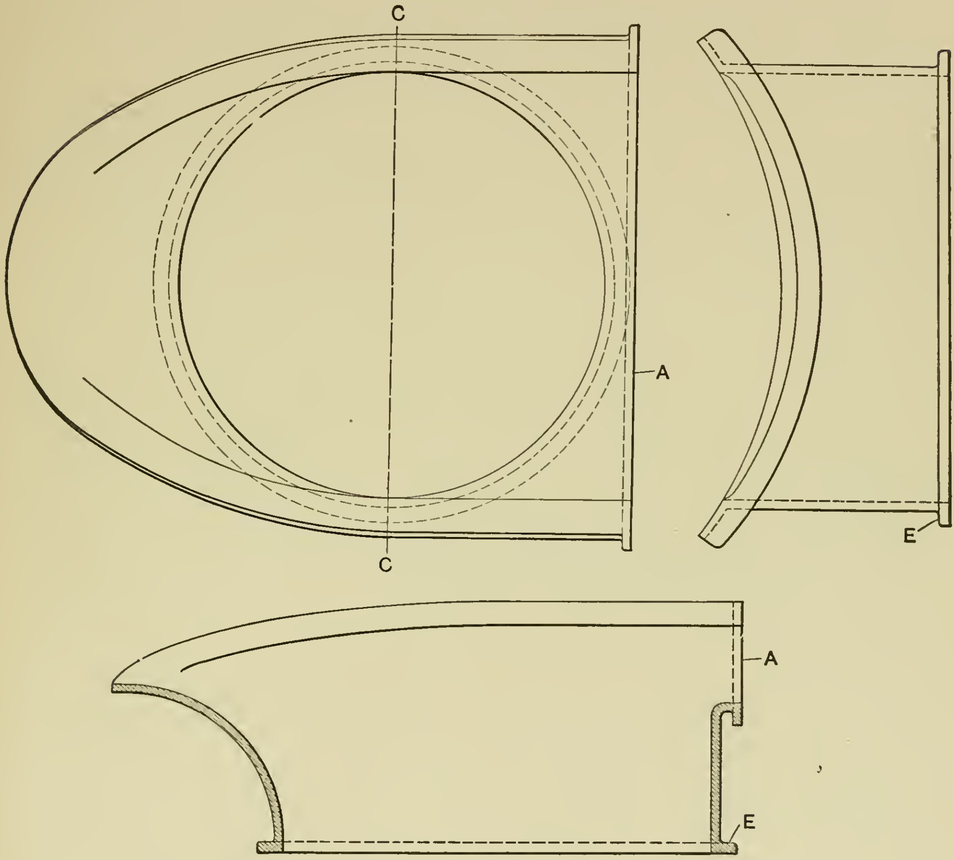


Fig. 55. Cast Steel Nozzle

This practically consists in the construction of a skeleton or frame, the interior and exterior form and the thickness of which correspond to the required casting. The pattern work can be made more or less elaborate, according to the manner in which the molder desires to proceed in the construction of the mold, and upon the ability of this individual the evenness of the casting to a great extent depends, as the skeleton gives an outline only and a partial guide for the strikes.

Three views of one section of a cast steel nozzle weighing about 19,000 pounds are shown in Fig. 55, two of these castings being bolted together at A and subsequently riveted to the shell. While there may be several ways in which a skeleton pattern for a casting of this description may be constructed, the one under discussion has proved very satisfactory.

The completed skeleton is shown in the reverse position to that in which it is built and cast in Fig. 56. The contraction of steel cast-

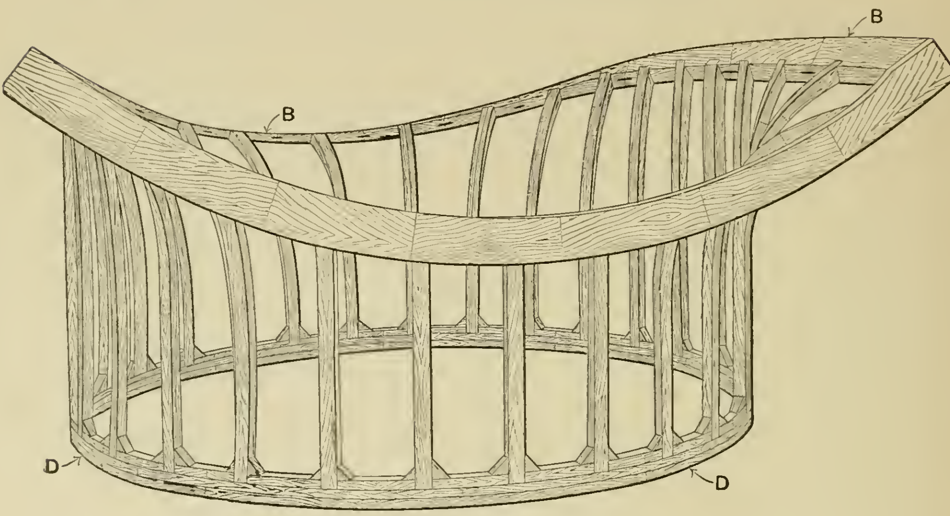


Fig. 56. Skeleton Nozzle Pattern

ings of this description and size is uncertain, and in most cases they will not contract, the usual allowance of 3-16 per foot, hence, an allowance of 1/8 of an inch per foot, with an extra allowance for finish for exact dimensions will generally be found sufficient.

Construction of the Skeleton

Following the general practice of laying out the required full size sections, the building of the concave flange B is the first part of the work to be undertaken. To facilitate this operation, a form can be lagged up as shown in Fig. 57, conforming to the concave surface of the flange and upon which the flange is laid out and built, one quarter at a time. The segments for the flange are fitted, dressed to thickness separately and then tongued together as shown. A number of forms as shown in Fig. 58 are next gotten out and lined and leveled up on the floor, taking care to see that they are securely braced. The four quarters of the flange B are located and fitted together over these forms and secured to one another.

To facilitate the handling and storing of the pattern, if desired a joint can be made on the lines C C, Fig. 55, and the two halves screwed together.

The ring D, Fig. 56, forming a part of the skeleton and to which the ribs are secured is built up of segments turned to size and then

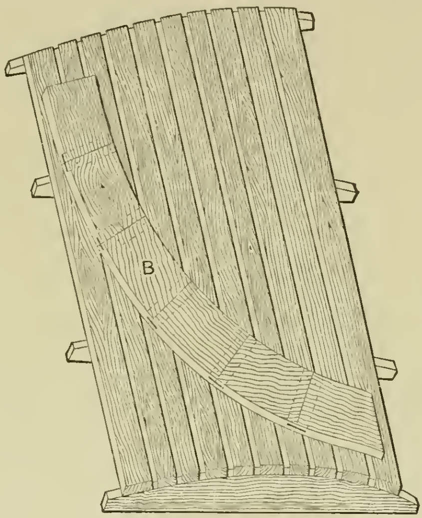


Fig. 57. Form for Base Flange

elevated and secured with suitable supports and braces in its proper relation to flange B.

It is next necessary to space off and locate the ribs. To facilitate the cutting out of the ribs, material about ⅞ of an inch thick can be used, each piece being fitted in place and gotten out as a templet and later when the templets have been dressed to form they are reinforced on both sides for strength and replaced in position as ribs. This method results in a saving, both of material and time.

As the only sections shown by the draftsman are those illustrated in Fig. 55, it becomes necessary without developing the section at each rib, to work from one section to another. The templets for one-half of each end are gotten out with the outer edges, sawed roughly to form. They are then placed in position and temporarily secured, when with the aid of a flexible strip and the eye the outer edge of each templet is dressed to form, working from one section to the other. The templets for the opposite half of the end are now marked from those already made and tried in place. The templets are then reinforced for the proper thickness, after which the metal thickness or interior form of the skeleton is laid off on each rib and they are dressed to the proper thickness. They are then returned to place and secured in position. It will be observed that no provision is made on the skeleton for the flange E, Fig. 55, this flange being made up during the molding operation by using a segment.

Fig. 58. Form to Support Pattern

Making the Mold

A hole is first dug in the floor to the required depth and two of the forms shown in Fig. 58 which were used for supporting the skeleton while it was being built are used for striking up a bed upon

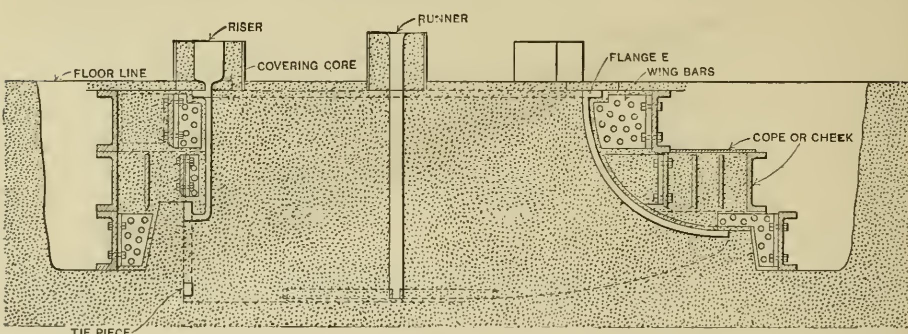


Fig. 59. Section of Nozzle Mold

which the skeleton may rest. The forms are then removed and the skeleton set in position upon the bed. The core is then rammed up. To facilitate this operation and to prevent the sand from ramming out through the openings, boards can be set up to the openings and braced from the walls of the pit.

The gates are arranged as shown in Fig. 59, and the runner prepared as the ramming progresses. After the core has been rammed up the boards surrounding it are removed and the core or body of sand dressed and slicked to the shape of the outside of the skeleton. The exact form and evenness of surface will depend to a large extent upon the molder's ability and judgment. The cope or cheek is then rammed up upon this outer surface. In order to do this, the parting is prepared, the flask placed in position and rammed up in the ordinary manner. The depression forming the upper flange E being made with

Fig. 60. Core After the Skeleton has been Removed

the aid of a segment representing a section of the flange and at the same time a seat for the covering cores is swept off on each side of the segment. The cope or cheek is now lifted off, blocked up and finished in the usual manner.

The sand between the ribs of the skeleton which represents the metal thickness of the casting is now removed from the core and the skeleton lifted off. The accompanying half tone, Fig. 60, shows a

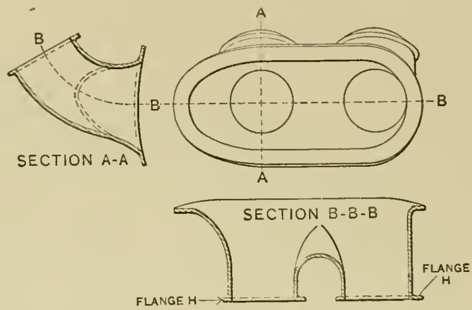


Fig. 61. Double Nozzle Casting

view of the mold at this stage. The core is now dressed to form, after which it is dried. The various parts of the mold are next assembled, the cope or cheek lowered into place, the covering cores to form the

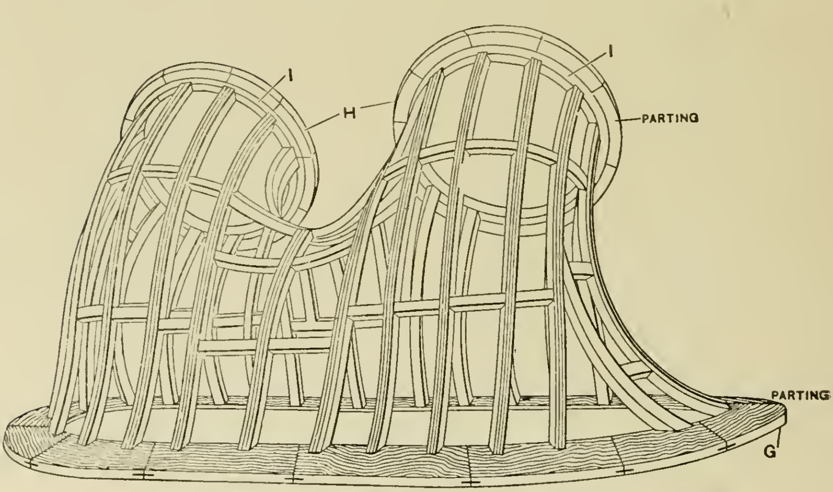


Fig. 62. Skeleton Pattern for a Double Nozzle

upper face of the flange E set, and risers prepared, and the space between the walls of the pit and the flask firmly rammed with sand. The mold is then weighted down ready for pouring. A cross section of the complete mold is shown in Fig. 59.

A Double Nozzle Pattern

Three views of a steel casting for a double nozzle as shown in Fig. 61. This differs considerably from the one already shown and brings out some different principles in molding. A plan of the nozzle is shown in the upper right hand corner. A section on the line A-A, is shown at the left, and a section on the line B-B at the bottom. The pattern is parted upon the line B-B. A view of the completed pattern in the position in which it is built is shown in Fig. 62.

In building the pattern the required sections are first laid out full size. The building of this skeleton is similar to the pattern already described. The lower flange G is gotten out and built up over a form. The two upper flanges H-H are built up and turned with the lower half left loose, so that these two half flanges may be drawn separately. The rings I are secured by supports and braces in their proper relationship to the flange G, after which the ribbing of the skeleton is pro-

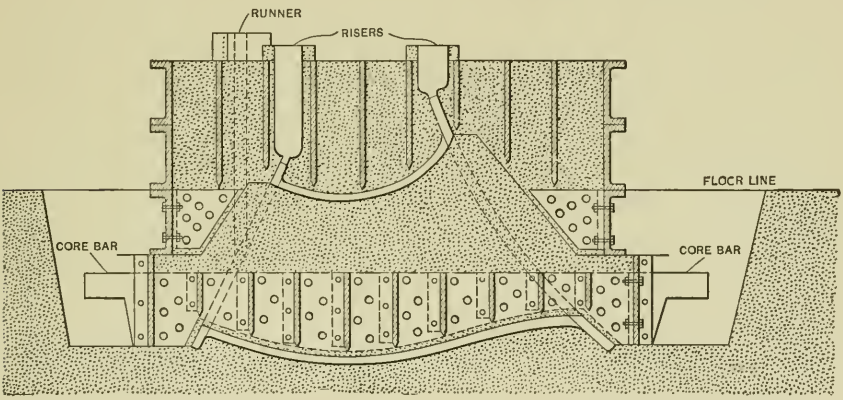


Fig. 63. Section of Mold for Double Nozzle

ceeded with. To assist in getting out the ribs forming the parting of the skeleton, a form may be lagged up corresponding to the parting, the outline of the rib laid out upon this convex surface and the rib built up in segments. After one rib has been built in this way, the one on the opposite side of the parting may be made to fit it. The location and building of the other ribs is similar to that already described.

Making the Mold

The molding of this skeleton differs from the one previously described in as much as it is cast upon its side, and with the aid of a core bar the core or inside is lifted out. This necessitates the preparation of a seat for locating and supporting the core when it is returned to the mold. A hole is first dug to the required depth and the drag half of the pattern is bedded in to the thickness of the ribs. The inside is then slicked and dressed to form and the seat for the core prepared as shown in the cross section of the mold, Fig. 63.

The core bar is next placed in position and the drag half of the core rammed up. The parting outside of the skeleton is prepared and the cope half of the skeleton placed in position ,after which the ramming of the interior is proceeded with.

Owing to the angle on which the flanges are set, the faces of the flanges from the parting line down are formed by the core as shown in the cross section of the mold in Fig. 63. In other words, as far as this portion of the flange is concerned, the core forms an intermediate part for the mold. When the core is lifted out, the lower portion of the flanges are exposed and left free to be drawn.

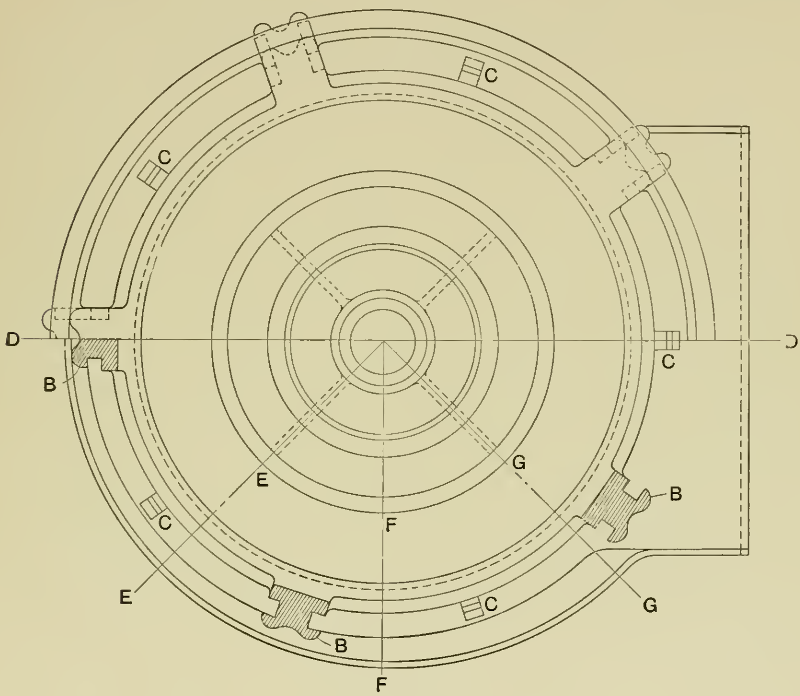
When the ramming of the upper half of the core for the interior of the skeleton is completed, this portion of the skeleton is lifted off and the core slicked and dressed and paper applied, after which the skeleton is returned and the openings between the skeleton filled with sand and slicked off so that it will form a body upon which the cope is rammed in the usual manner. When the cope is completed, it is lifted off, together with the cope half of the skeleton. The cope is then blocked up, the sand between the ribs removed and the half of the skeleton pattern drawn.

With the aid of the core bar, the core is then lifted out, blocked up, and the sand between the ribs of the lower or drag half of the skeleton removed and the skeleton lifted out. The drag portion of the mold is then finished, the runner and risers are prepared during the ramming up of the mold. The mold and the core are then dried assembled, and prepared for pouring in the usual manner.

CHAPTER VIII

PATTERN FOR A CHILIAN MILL MORTAR

Several views and sections of the casting to be made are shown in Figs. 64, 65, 66, 67 and 68. In Fig. 64 there is given a half plan and sectional plan on the line AAA, Fig. 67, which shows the upright members of the casting located between the screen openings, together with the wedge chucks B and C. These wedge chucks are used for wedging or securing the screens in place. Fig. 65 shows the bottom



SECTION AT A-A-A

Fig. 64. Plan of Chilian Mill Mortar

or inverted plan of the mortar, while Fig. 66 gives a side elevation, and Fig. 67 a longitudinal section of the mortar taken on the center line DD, Figs. 64 and 65. This section, with the radial sections shown in Fig. 68, which are taken on the lines EE, FF and GG, Fig. 64, should receive careful attention in order that the construction and molding of the pattern may be more readily understood. It is from these four sections that the pitch of the trough is obtained and the laying out of which will be described during the construction of the pattern.

Of course a full size working lay-out is essential for reasons well-known. The sectional lay-out should be taken through the center of the mortar as shown in Fig. 67, and this view will also serve for laying out the trough, etc. A lay-out of the plan is also required, but as the mortar is symmetrical about the center line DD, Fig. 64, a half plan lay-out is all that is required.

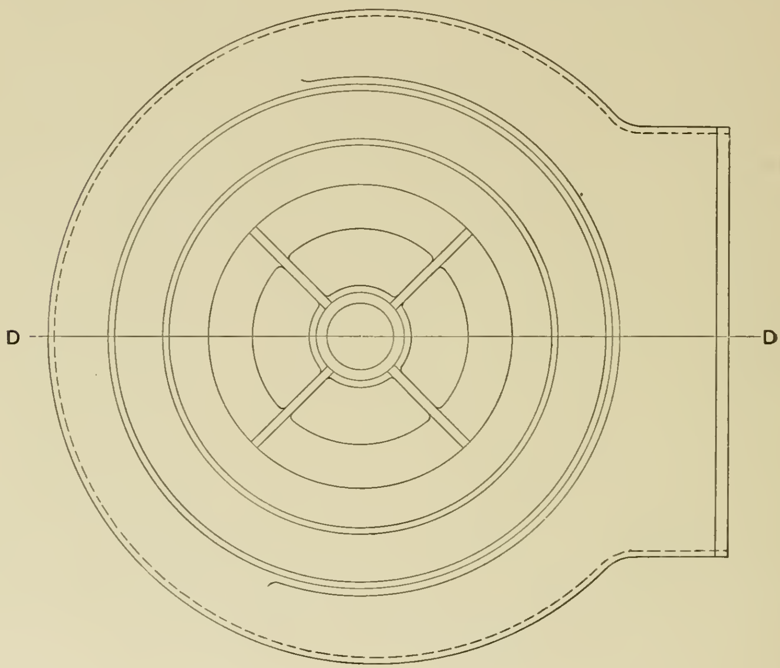


Fig. 65. Bottom of Mortar

Construction of the Pattern

While a mortar pattern of the design shown is not of a particularly intricate nature it nevertheless contains some very good features in patternmaking and also in molding. The writer has made a number of mortar patterns of this general type in the manner described and this method of constructing the pattern as shown has been found to give a durable pattern and at the same time is as economical in time and material as could be desired.

The upper view in Fig. 69 shows a longitudinal section of the assembled pattern taken on the center line DD, Fig. 64. This section should give a fairly good idea as to how and where the various parts of the pattern are joined and fitted together. While all of the partings

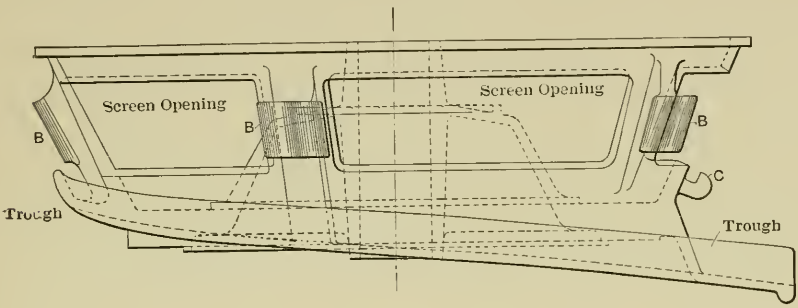


Fig. 66. Side Elevation of Mortar

shown are not essential or required in molding they nevertheless facilitate the drawing and also tend to prolong the life of the pattern, on account of the fact that the different parts can be removed from the sand separately and with less rapping as the dressing of the mold proceeds.

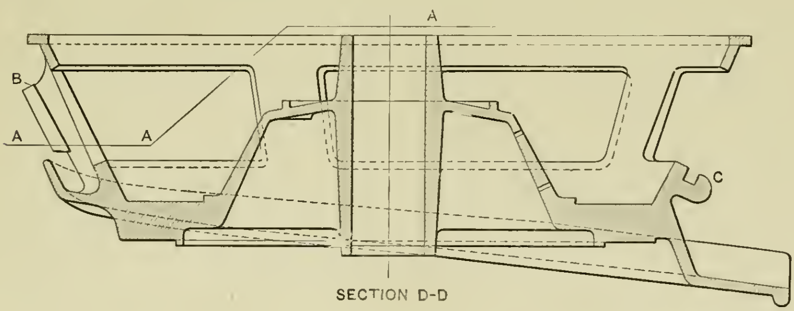


Fig. 67. Longitudinal Section of Mortar

Another advantage in constructing the pattern in sections is that it is easier to handle and store. This sectional construction also affords protection to the hopper sections, which is of rather light and frail construction.

Shown at the left in the upper view of Fig. 69 can be seen one of the wedge chucks B. By studying a section of one of these chucks as shown in Fig. 64 it will be seen that it would be necessary to core out the slots and if this were done with a dry sand core it would necessitate a troublesome core setting, as it would come on the parting line of the drag and cheek portions of the mold. To avoid this objectionable feature this part of the pattern was arranged as shown by a section of the chuck at the upper left hand corner of Fig. 69. This has overcome the difficulty very satisfactorily, as the arrangement allows the two ears to be drawn in and the dry sand core set in place to form the outline of the back of the chuck as indicated by the dotted lines. Wedge chuck C is shown to the right in the figure and the manner of coring out the slot is self-explanatory.

Shown at the bottom of Fig. 69 are the four separate sections or parts that form the body or center of the pattern, arranged in the order in which they are placed together. In beginning the building and turning up of the parts the center portion H receives attention first. This part can be built up on the face plate of the lathe somewhat after the manner and in the position shown. This is followed by the turning of the face, with its two offsets I and J. Offset I

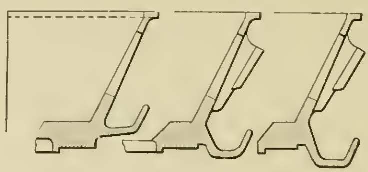


Fig. 68. Sections of Rim of Mortar

receives and locates the lower rail K of the hopper, while offset J locates the center or conical portion L of the pattern.

The most convenient manner of disposing of the two parts K and L is to build them up and turn them in position upon part H, as shown by the dotted lines. It will be seen that all that is necessary is to fit the first course of segments in their respective offsets, pin and screw them in place, taking care to leave the heads of the screws exposed so that they may be removed and then proceed with the building up and turn in in the usual manner.

At the completion of the two members they are removed and part H rechucked so that it can be turned on the outer diameter and back. During this turning the offset M is formed to receive the core print N, as shown. The hub Q is of course turned independently and fitted in place during the turning of the portion L.

Our attention is next given to the upper rail O of the hopper which is built up and turned as shown.

The center lines and widths of the five standards P are next laid off on both rails K and O, the rails are then cut out to receive the standards and the latter portions secured in place as shown. After fitting on of the wedge chucks B and C, the building up of the trough which is shown in plan and section in Fig. 70 next takes our attention.

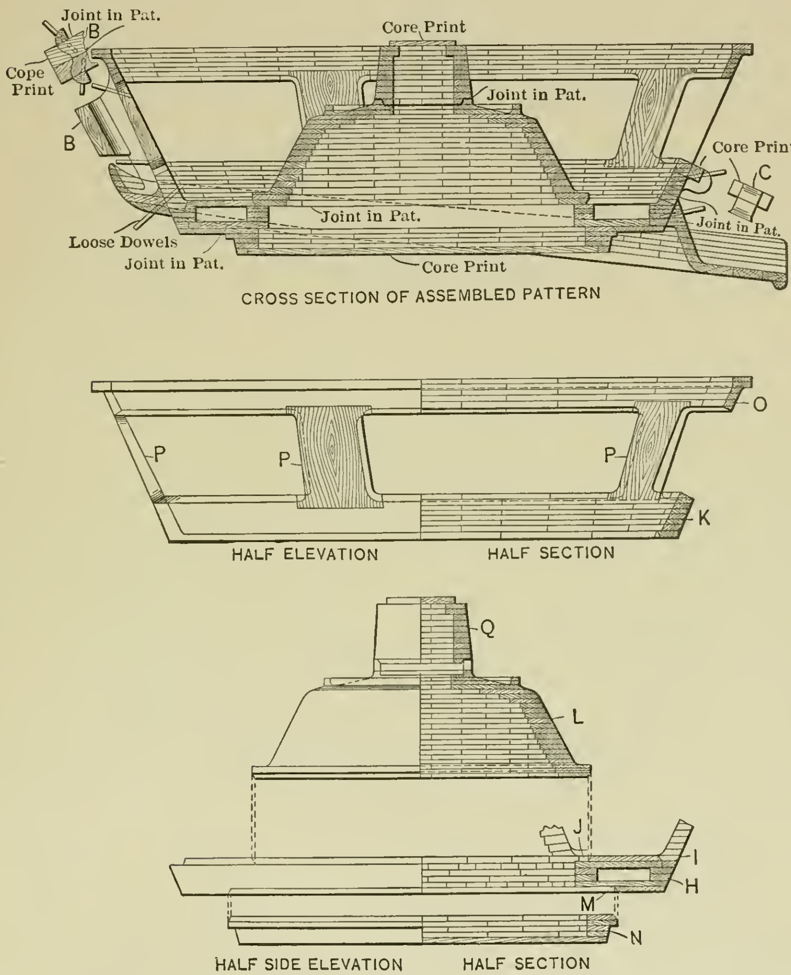


Fig. 69. Details of Construction of the Pattern

This figure shows a half plan and longitudinal section through the center on the line DD, also radial sections on the lines EE, FF and GG. These latter sections serve to illustrate the general construction of the pattern. By studying the figure it will be observed that the pitch of the trough is not regular, as is the usual practice in the designing of mortars of this type, that is, it does not have a uniform pitch or drop from back to front, which would, of course, bring the bottom of the trough always in the same plane. In the case under discussion the

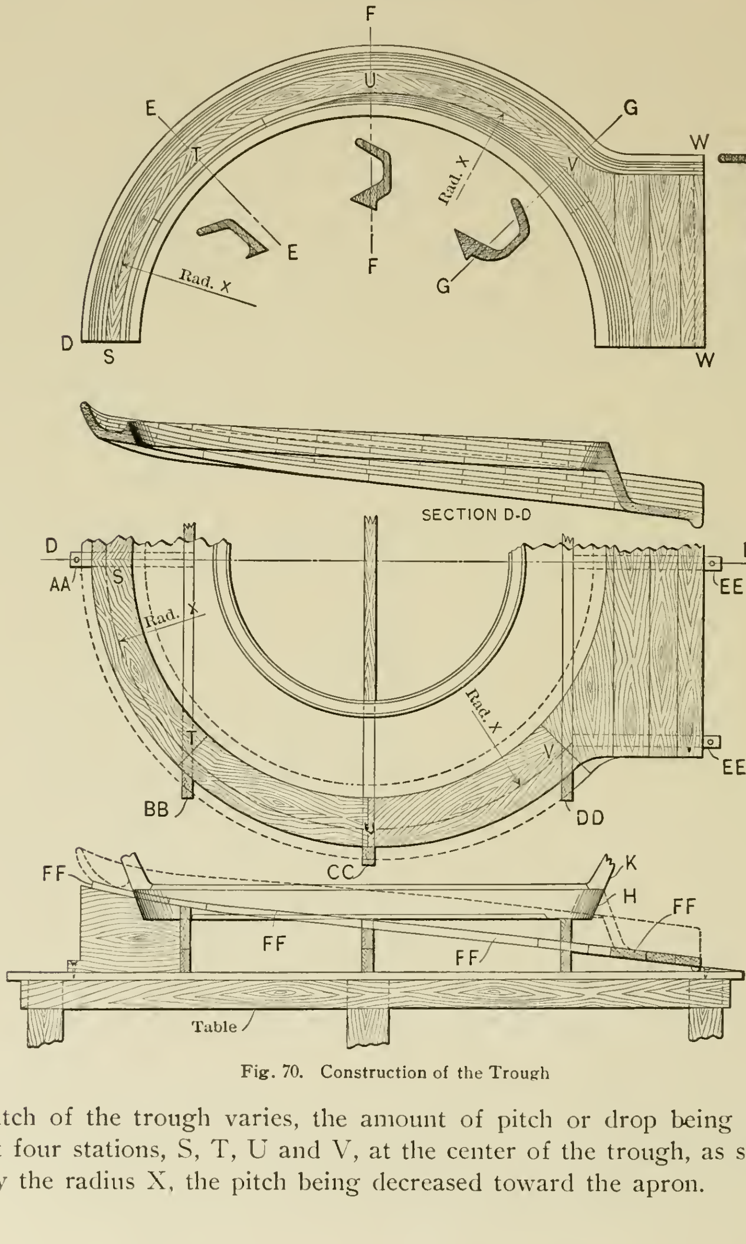


Fig. 70. Construction of the Trough

pitch of the trough varies, the amount of pitch or drop being given at four stations, S, T, U and V, at the center of the trough, as shown by the radius X, the pitch being decreased toward the apron.

In the lower part of Fig. 70 is shown one way in which the trough may be laid off and built in position up to the body portion of the pattern. This manner of constructing the trough will be found about as convenient as any other method. The five stringers, AA, BB, CC, etc., representing the five stations of the drop or pitch of the trough, are first gotten out and dressed to the required height of the underside of the trough as shown. They are next secured to the work table in their respective positions and their proper relationship one to another and also to the body of the pattern, which is placed in position and secured temporarily as shown.

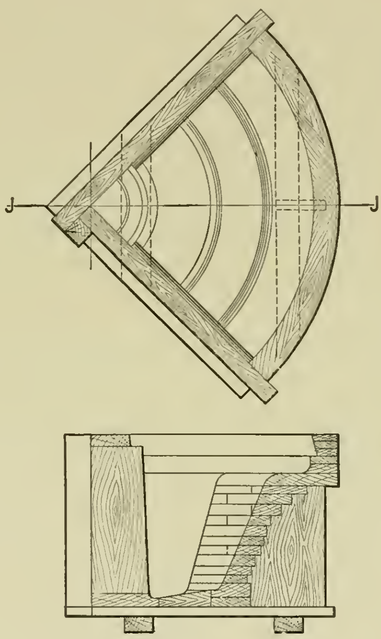


Fig. 71. Core Box

The segments or material FF, which is to form the bottom of the trough are next gotten out roughly to size and of ample thickness and width to allow for sawing and dressing to form. In length the material FF is gotten out equal to the distance between stations, at which points it is butted together as in segment work and temporarily bradded down.

Next, with the trammels so arranged that one point will extend down over the center portion, H into the center of the trough, the center line of the trough or the radius X is scribed. The different widths at the bottom of the trough are now taken from their respective layouts as shown in the upper part of Fig. 70 and transferred to the material as shown at AA, BB, CC, etc. This is followed by the sawing of the segments to size.

The next work consists in the dressing off of the underside of the segments from station to station so that the segments will conform to the pitch. This is done carefully by the eye, and the exercise of a little judgment is all that is necessary, as there is nothing of great importance attached to the trough and a slight variation one way or the other will not make any material difference.

Having the underside of the material or segments worked to form, it is next necessary to reduce them to the required thickness, which is a very simple operation. After this the segments are returned and bradded in place. The lower part of Fig. 70 shows the work at this stage of completion, ready to secure the segments, the positions of which are indicated by the dotted lines. The first course of segments at the inner and outer diameters of the trough must be applied to the irregular surface, hence it will be necessary to chalk and fit them for a glued joint.

After these two courses are fitted and glued in position their upper faces can be joined straight, which will allow the remaining course to be joined in the usual manner. If each course of segments is carefully marked from the previous course, applied and sawed to line and beveled, very little work will be required in dressing them to form.

As the first course applied forms the fillet, it will be necessary to work this out with a gouge. It will be noticed that the first two courses of segments which form the inner wall of the trough are fitted up to part H of the pattern for about half of the distance around the pattern from which point they extend or flair outward on to the apron, as shown.

Before removing the work previous to dressing up the under surfaces holes should be bored for loose dowel pins to attach the trough to the body of the pattern to facilitate the process of molding.

Next, the usual provisions for rapping and drawing the various parts of the pattern must be made, the pattern finished with shellac, etc., when our attention will be given to the construction of the core box.

The core box necessary is shown in Fig. 71. The core made in this box forms the interior of the conical center of the casting, as shown in the cross section of the completed mold, Fig. 72. The illustration of the box shows its construction fully so that no detailed description is necessary.

Molding

The manner of making the mold is clearly illustrated in Fig. 72. As this section is taken at the center line of the mold the parting appears about on a line with the joint of the flask. This fact would not be the case at the right or left of the section shown, owing to the pitch of the trough to the right and left of the line, upon which the

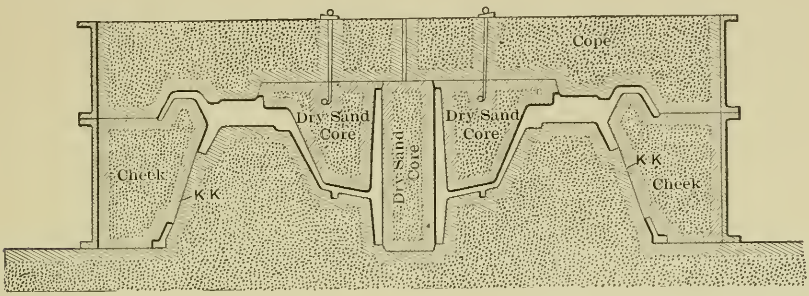


Fig. 72. Section of Mold for Mortar

section was taken. The parting would, of course, extend up into the cope on one side and down into the cheek on the other. By inverting the upper view in Fig. 69 the line of the parting can be easily followed.

In drawing the pattern from the sand the cope is lifted off first, the trough portion of the pattern drawn out, and this permits the lifting off of the cheek. The line of parting between the cheek and the interior body of sand which forms the interior of the hopper is shown along the lines KK. After the cheek has been removed the other sections of the pattern can be withdrawn in their respective order and the mold finished in the usual manner.

CHAPTER IX

THE MAKING OF A CROOKED ELBOW

Life is made interesting for the patternmaker at times by the various problems, mechanical, geometrical and otherwise, which are presented to him for solution in the course of his daily duties. The making of the elbow described in this Chapter presents a few of these.

This elbow was made to connect with a rectangular pipe 6 x 9 inches, which passed around a cylindrical body with a flat, conical head having an opening 7 inches in diameter. Metal thickness was specified as 3-16 inch, but the patternmaker and the molder between them probably increased this a little by the process known as playing safe. The variation, however, was not more than 1-16 of an inch, as weight was an important item.

In producing a pattern of this character, or, in fact, in producing any pattern, the first consideration with the practical patternmaker is the manner of molding it. Notwithstanding the opinion of our friends, the molders, to the contrary, a goodly number of patternmakers are wearing gray hairs (when they are not bald headed) from worrying over this very question of the moldability (to use a newly coined word) of patterns.

The elbow is shown as projected in the three views at the left of Fig. 73 and the first thing to determine is just where or how to mark the parting line in order to avoid waste of lumber in gluing up the necessary block from which to make the pattern. The first piece should be large enough to include all of the curved part of the pattern, the end flanges and core prints being made separate, and as these latter are of known shape and dimensions they are an easy proposition, and when finished can be screwed to the main portion of the pattern. Lines A and B, while not a true projection, will give the average patternmaker a better idea of the method of parting this pattern than the projection lines would.

The material being glued up for the several parts, the part for the drag or lower half of the pattern is then cut to conform to the parting line. To aid in this work free use should be made of the surface table if you are fortunate enough to possess one, or a trued-up board can be made to answer if no surface table is at hand. This will result in a saving of both time and lumber, especially if the patternmaker can secure a surface gauge of sufficient size from his friend, the machinist, for it is not likely that one will be found in the pattern

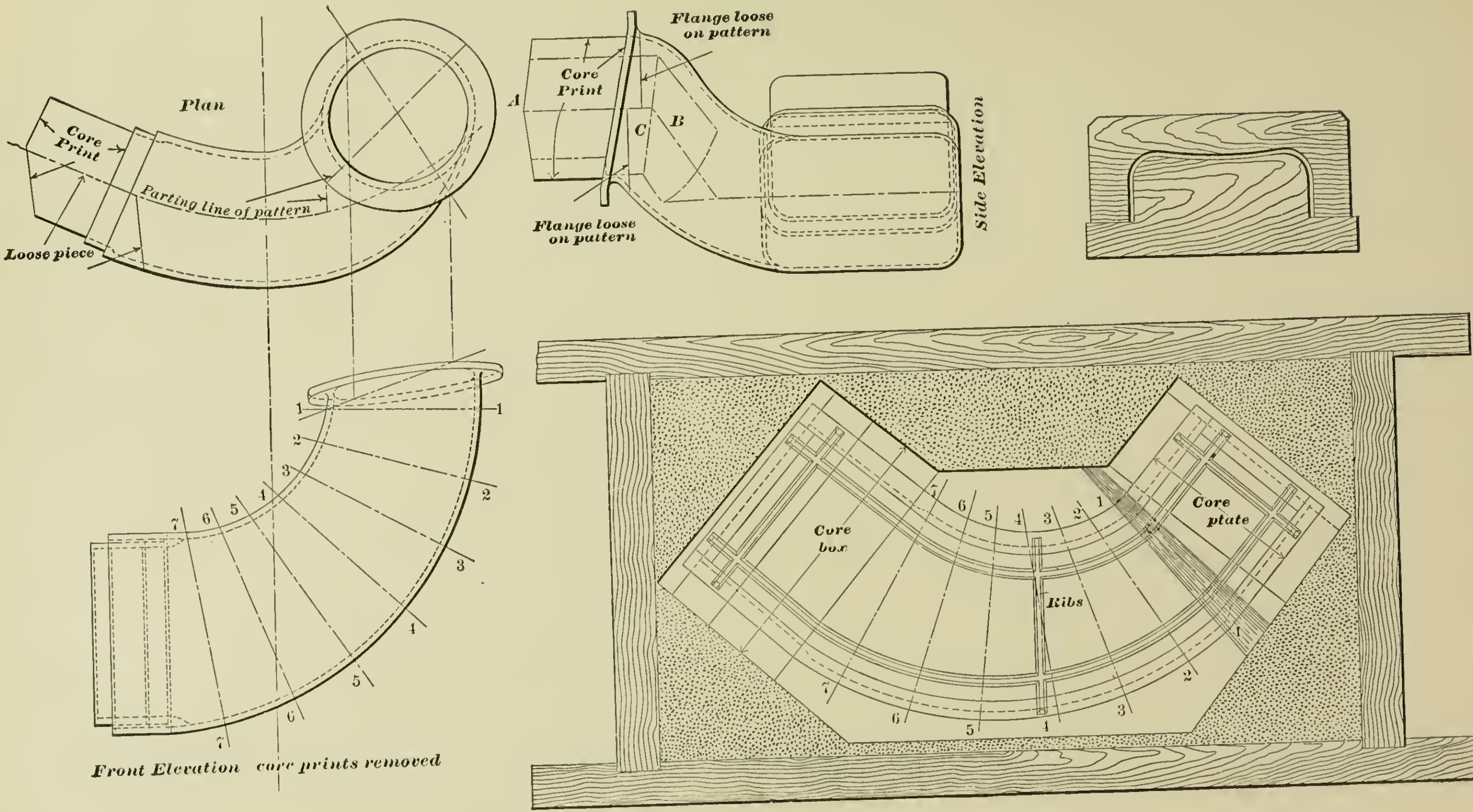


Fig. 73. Rig for Molding a Crooked Elbow

shop equipment, though it should be there. By clamping the base of the surface gauge to the table, it is easy to turn it into a sliding trammel which can be raised or lowered at will and still keep the same radii, the stem being set up perpendicular to the face of the board. This makes it easy to lay out many lines, even on a rough surface, and to do it in shorter time than can be done by projection. It is also accurate.

You will notice that the parting line has to be twisted at the round end of the pattern in order to make it possible to place the core into the mold in one piece and also to produce a pattern with as few loose pieces as possible. It will be found easier to make this part from the bottom of the slope (line C, Fig. 73), separate and then set it to the correct angle and screw it in position, after which the bevel from this to the main line of parting can be worked out. This being done, the upper or cope half of the pattern is then fitted to the lower half, forming a complete joint, and the two doweled together. Next, the form of the pattern is laid out on the joint and the two parts are finished together. In this work we must again depend upon the surface plate to make sure that there is no back draft, care being taken to place the pattern in exactly the same position each time it has to be removed from the surface plate.

It is necessary that the flanges be loose from the body of the pattern, on account of the angle at which they are placed and the curve that fits the cone. Otherwise it will not be possible to draw the pattern. These loose pieces should be placed in a groove, in order to insure their staying in position while ramming and also to give them strength. The portion of the upper part of the pattern marked "loose piece" should also be doweled on separately, as the angle of the end is such as to prevent a straight draw.

In making the core box, the block for the lower half of which is shown embedded in the sand, it is first necessary to make the block, which is composed of three pieces for the body and two pieces to close up the ends. These are screwed together and fitted at the joint to the upper half of the pattern. This done the construction lines 1-1, 2-2, 3-3, etc., are marked on the pattern and transferred to the joint of the core box. The outline of the pattern is also marked by a scratch awl while it is lying in position upon the core box. Another line is then made inside of this corresponding to the thickness of the metal.

Templets are next made of thin pieces of wood and fitted to the pattern at the lines marked, and at as many additional places as the patternmaker thinks necessary. From these other templets are made for the core box, allowing the thickness of the metal between them, as shown in the upper right hand corner of Fig. 73, which illustrates the templet for line 6-6 of the drag half of the pattern.

Before we proceed to cut out the core box, it is necessary that we provide for the requisite core plates upon which to dry the core and it is highly important that these be true to shape, as otherwise the cores will not joint up and the results will be either too thick metal or a defective casting from the cores cutting through where they should not. As a simple method to insure the shape of these plates the writer uses the block prepared for the core box as a follow board, as indicated in the lower left hand corner of Fig. 73. Upon this were fitted two pieces, say ¾ inch to one inch wide, as an outline for the core plates, these pieces being 5-16 inch thick. Between them sand was filled in and swept off to the required thickness. This sand was then freely sprinkled with parting sand and upon it placed ribs, as indicated. These ribs are intended to bring the plate to a level bearing and also to strengthen it and prevent its losing its shape from the heat of the core oven. A flask was then placed over this and molded in the usual manner, first ramming up and placing the bottom board, then rolling over and making the cope half after lifting off the frame. The strips are then removed and the sand lying between them removed, the ribs drawn, and, except for the connecting gates, etc., we will have the mold for the core plate for the lower core. The same method is used for molding the core plate for the upper half.

We next proceed to cut out the core box, using the templets for this purpose, put in the finishing touches, varnish, etc., when the job is completed.

SECTION VI

HINTS, SUGGESTIONS AND RIGS

CHAPTER I

CUTTING THE SCORE IN A CHAIN DRUM PATTERN

Frequently when a number of drums are required, the casting of scored chain drums, as shown in Fig. 1, is resorted to; and when of too small a diameter to sweep conveniently, a complete pattern is required, parted longitudinally through the center and molded likewise. In some cases, particularly that of a coarse pitch, which requires the pattern to be partially revolved while being drawn from the mold, as

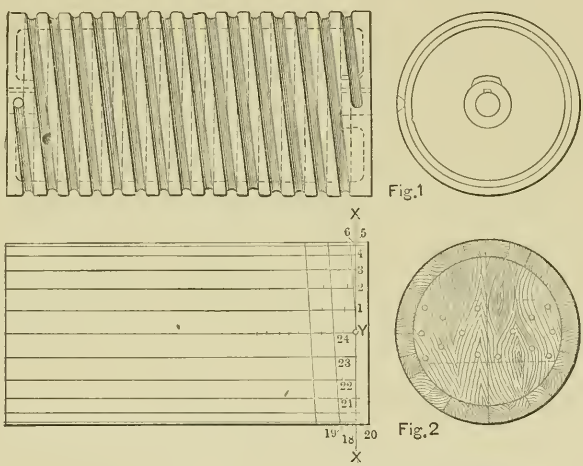


Fig. 1. Chain Drum. Fig. 2. Pattern for Chain Drum

the revolving of the pattern will cause it to travel forward in the mold, a detachable core print may be placed at one end of the pattern, leaving a depression into which the pattern may protrude while being drawn.

The barrel having been staved up in the ordinary manner, of material of sufficient thickness to permit the cutting of score, it is placed in the lathe and turned to the required outside diameter and the center line of score marked off before removing it from the lathe centers, as shown in Fig. 2.

One way in which the laying off of this center line can be easily accomplished is to locate the starting point of the score Y, and scribe a line around the barrel as shown by XX, Fig. 2. Now from starting point Y step off the circumference into any number of equal points, and through these points draw longitudinal lines from end to end of the barrel as shown.

The lead or pitch of the score or the lead or pitch of any screw is the distance it would travel forward in one revolution. Hence, if the circumference of the barrel be developed as shown by V, Fig. 3, and a perpendicular line W be erected at one extremity, in height the equivalent of lead or pitch of score, the line Z or the hypotenuse of the right-angle triangle thus formed will be the angle of center line of score about the barrel.

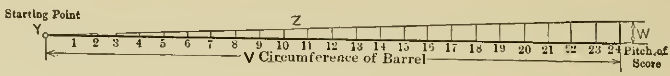


Fig.3

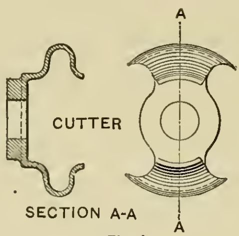


Fig.4

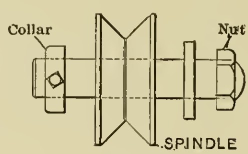


Fig.6

Fig. 3. Development of Score. Fig. 4. Cutter Head. Fig. 6. Cutter Spindle

Now if the developed circumference V be divided into the same number of equal parts as the barrel, 1, 2, 3, 4, etc., the transferring of this center line Z to the barrel becomes a simple operation, for by using the line X scribed around the barrel at the starting point of score, Y, Fig. 2, as the base line, V, of the developed circumference, Fig. 3, with the dividers, transfer the distances 1, 2, 3, 4, etc., to the corresponding longitudinal lines on the barrel. Then with a flexible rule or strip connect these points, which will give the center line of the score for one revolution, the continuation of which is very simple.

As a right or left-hand thread is confusing to some, a good point to bear in mind is that a right-hand thread raises to the right and a left-hand thread raises to the left; or to observe the thread of an ordinary wood screw, which is invariably a right-hand thread. If the score is to be cut by hand, lay out the width of score from center line and proceed with back saw-gouge and templet. Any workman who has worked out the scoring on a drum by this method has no doubt found it a slow and tedious job.

Illustrated in Fig. 5 is an arrangement of lathe with a cutter attached and the barrel so placed as to permit the cutting by power. While the initial cost of fitting up the cutter, etc., should not exceed six or seven dollars it would reduce the actual time of cutting to a minimum, and would do the work at a cost below that of cutting by hand a drum 30 inches in diameter and 54 inches long at 32½c per hour.

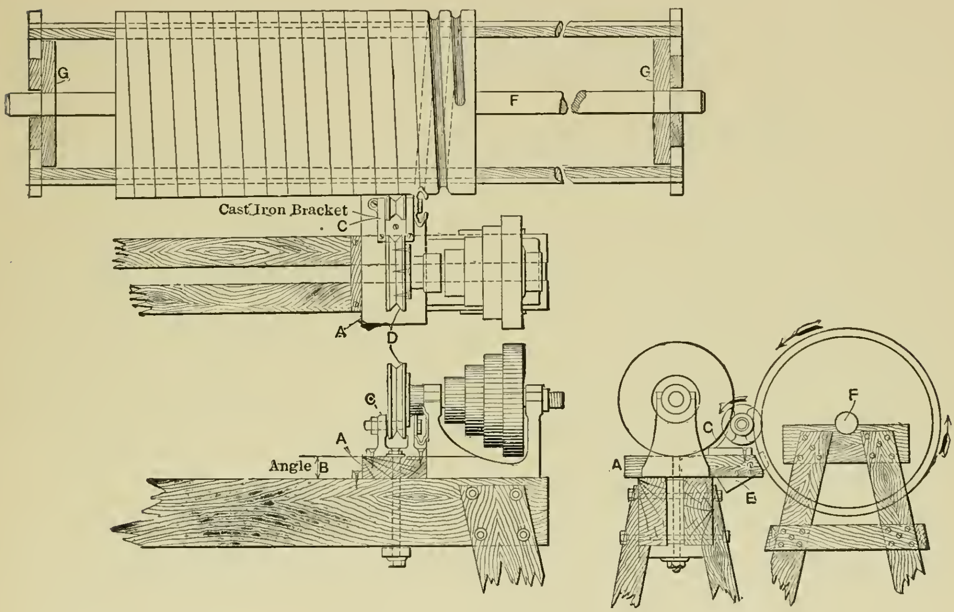


Fig. 5. Lathe Rigged to Cut Score

The spindle and cutter are shown in greater detail in Figs. 4 and 6, the cutter being turned to form and cut out as shown, and filed up to form a cutting edge. A good, substantial block, A, having been gotten out with slot cut out to receive guide E, and the top dressed off to a sufficient angle, B, to bring the cutter in line or in the same plane as that of the score of drum. The bracket C is now attached and this arrangement secured to the lathe bed as shown, and in line with a pulley, D, previously turned upon face plate. The center line of score having been layed off on the barrel as previously described, a portion of the score long enough to take in the cutter and guide E is cut out by hand to exact templet. The shaft or spindle F, which will be governed by what can be found around the machine shop or the spindle used in the foundry, should be twice the length of the barrel plus the width of supports G. The barrel-heads having been cut out to receive the spindle, the barrel is placed upon the spindle, set upon supports G and clamped down.

The barrel is now placed in position with the portion of the completed score opposite the cutter, which is now moved forward to its correct position and secured, as is also the guide E, which must fit the completed score snugly. The cutter, revolving in the direction

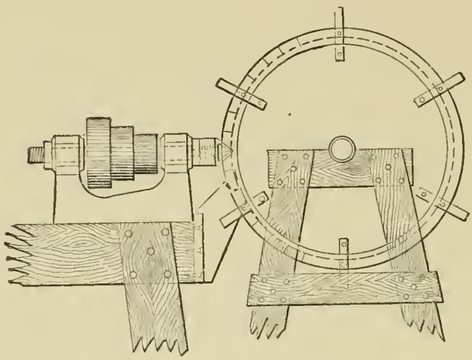


Fig. 7. Cutter on Back of Spindle

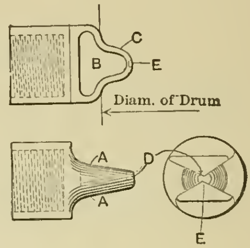


Fig. 8. End Mill Type of Cutter

indicated by arrow, is now set in motion, the barrel revolving toward the cutter and upon spindle F, guide E, following the cut score, giving the lead and forcing the barrel along the spindle.

To lessen the friction of the barrel and spindle a roller can be adjusted underneath the barrel if necessary. Also, pieces can be screwed to the end of the barrel to facilitate revolving. If the score is very deep, a portion of the material may be removed and the score completed with a second cut.

There is another way of getting out this work and it differs in several respects from the one already described. The principal variations from the other plan are in the location of the barrel—which is in a transverse position—and in the cutter which is of an entirely different shape and is shown attached to the lathe spindle in Fig. 7. The setting and handling of the barrel during the cutting operations remain identical with the former arrangement.

The cutter is seen in greater detail in Fig. 8 and may be attached to the lathe spindle as illustrated or it can be provided with a taper shank to fit the center of the spindle. The cutter having been turned to the required form and fitting the spindle, the sides A are milled off and the material at B removed by drilling—leaving the wall C of about 5-32 of an inch in thickness. The cutter edges are then filed up, tempered and whetted to a freely cutting condition. To overcome the plain blunt surface D at the extreme point of the cutter and which would not remove the stock, a small slot E is filed in it and this will be found sufficient to remove any possibility of trouble.

CHAPTER II

A CORE BOX AND CLAMP COMBINED

A combined core box and clamp, which will be found convenient and a time-saver where a number of cores are to be made, is shown in Fig. 9. While the illustration may be self-explanatory, a few remarks will not be out of order. The central figure shows the plan of an assembled rectangular core-frame, or box, with clamp in place. To the left is shown the end view and the arrangement of wedges, A,

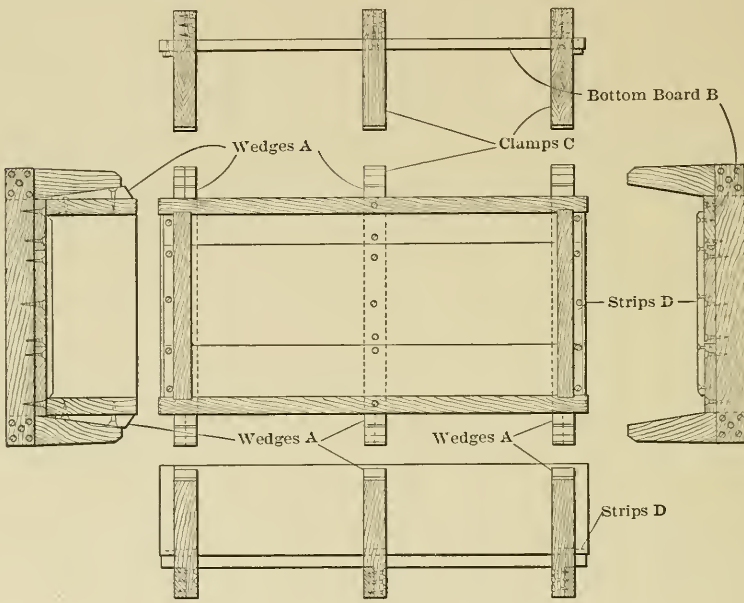


Fig. 9. Combined Core Box and Clamp

which are attached to the sides of frame, while the side view of box is shown at the bottom. At the top and right is shown the bottom board B, with clamp C attached, also stop D for locating the frame on the bottom board.

CHAPTER III

SOME LATHE TOOLS

A number of lathe tools which shops equipped with screw feed lathes are using, and which give very good results, are shown in Fig. 10.

The roughing tool or gouge is shown at 1. The cutting edge should slant downward somewhat as it approaches the end or tail, to give a drawing cut, and the outside face ought to overhang at least 10 degrees from a perpendicular all the way around, so as to take hold nicely at the very edge, and not have any point of contact below where it is doing work, to retard its action. An emery wheel

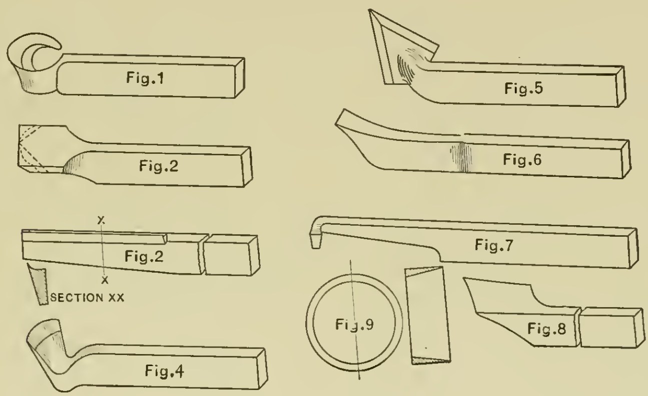


Fig. 10. Lathe Tools

about 8 inches in diameter gives a good concave to the outer face, and when this tool has a few finishing touches with an oil stone, it is surprising to see the heavy chips it will take from a rough piece without even previously removing the corners.

The ordinary flat tool which can be ground round or pointed, as indicated by the dotted lines, is shown at 2.

A boring tool is shown at 3, and there should be one right and one left. I have used tools of this shape a great deal, and for deep boring know of nothing better. They also work equally well on outside work and are especially useful when the piece being turned is too large in diameter to slide the carriage along under it, for it can be placed in the tool-post in such a manner as to overhang a long distance and work clear to its limit.

A nice tool for facing off segments and the surface of any disk which may be on the face-plate is shown at 4. It works quite well also when turning on the outside diameter, but is especially for facing.

The tool shown at 5 is known as the "arrow point" tool and is used for finishing. It should be set slightly angling to the work. When properly sharpened it will cut almost as smooth as glass, and on straight work, like rolls, etc., it works as nearly perfect as one could wish. The action, it will be noticed, is similar to a wood-turner's skew chisel.

A cutting-off tool, which does not tear and scrape like the ones generally used, that are flat on top, is illustrated at 6. It is intended to be sharpened on an emery wheel, about 6 or 8 inches in diameter, and then be touched up on an oil stone, as in fact are all of the tools described. The curvature on the upper side of this tool allows it to enter the work easily and take a fast cut, while the curve below removes the stubbed end frequently seen on tools of this class. One of these tools, made in every respect like No. 6, except with a wider cutting face, is excellent for shouldering down on work. With it a number of cuts can be made down to almost the diameter required, then get the exact diameter, and finish by moving the carriage along. The tools cut quite smoothly moved along in this manner, but not quite as well as the "arrow point."

A boring tool which is useful in holes of small diameter where the one shown at 3 cannot be conveniently operated is shown at 7.

A tool for general work, which is good for smoothing and shouldering down, is illustrated at 8. It will be noticed that it has two cutting edges which can be used, and the top is shaped by the curve of the emery wheel something as in No. 6. The angle of the point should be less than a right angle, as if so made the tool can be set so as to be started in with the slide rest, and then be stopped and moved along by the carriage. A much deeper chip can be taken with this tool when the carriage is moved than with the one shown in No. 6, as its action is more of a drawing cut.

A handy lathe dog which will be found convenient while turning pieces in halves, avoiding the accustomed use of screws, is shown at 9.

CHAPTER IV

WOODEN BALL TURNING

As patternmakers are frequently called upon to do work a little outside of their regular line, I feel that the following may be found useful to some. In turning a ball, first rough out as shown at the bottom of Fig. 11, forming two, three or more balls per stick, as size will permit. This turning should be done to within 1-16 of an inch of the finished diameter, using an ordinary sheet metal templet of the form shown in the upper right hand corner of Fig. 11.

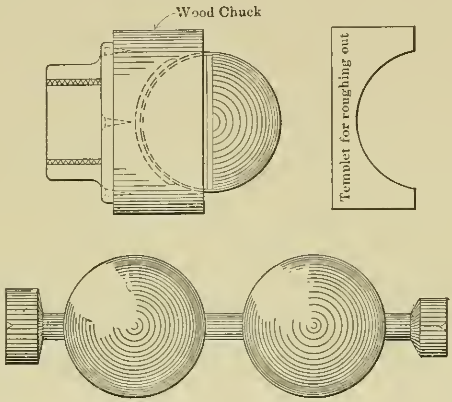


Fig. 11. Bolt Turning

The balls are then sawed off and the unturned spots rounded over. A chuck should be turned and backed out as shown in the upper left hand corner of Fig. 11. This should receive the ball to within an eighth or a quarter of an inch of its center line.

The ball is first placed in one position and the groove turned around the center line about an eighth of an inch wide and to the required diameter, as shown in the illustration. The ball is then removed, given a quarter of a turn and a small groove turned at right angles to the first. All that now remains is to turn off the surplus material between quarters formed by the grooves. The ball is then returned to its original position and the other half finished. Chalking the inside of the chuck will assist in holding the ball in position.

CHAPTER V

SHRINKAGE

All metals passing from the liquid to the solid state undergo expansion when in the plastic condition. It is this feature in the transition that enables the metal to take and retain the impressions of molds. In cooling from the plastic condition to the solid state most metals contract. The amount of this contraction in passing to a normal temperature will vary for the different kinds of metals. Patterns have therefore to be made larger than the desired casting by this amount. Here comes the necessity on the part of the patternmaker for the use of discreet judgment based upon extended experience in order to obtain the best possible results; different mixtures of iron as well as alloys will contract varying amounts. Moreover, the varying proportions of the castings will vary in the amount of contraction. An extended and plain casting will contract differently from one of more compact form, though both may be of equal weight and cast at the same time and of the same material. A heavy casting will contract less than a light one, while a small casting will often come out as large or even larger than the pattern. Hard metal will contract more than soft metal, and the presence of large dried cores in a mold will diminish or retard the contraction. A plain cylinder will contract less in diameter than in length.

The contraction or shrink rule, as the name implies, is a rule that is made longer than the standard measure by the amount which the various metals will contract in cooling from the plastic to the solid state. Though a standard rule is required for the measurement of castings it would be obviously inconvenient to use it in patternmaking. The workman would be perpetually making allowances for contraction in fractional parts of an inch. So the shrinkage rule economizes his time and insures something more accurate than approximations.

The conventional allowance for cast iron is 3-32 inch to the foot, but this rule needs modifications in its application as already discussed. Heavy bed plates, etc., are usually made with an allowance of 1-16 inch per foot, and sometimes with the standard rule. The contraction of steel is quite uncertain, ofttimes varying from ¼ inch per foot to ⅛ inch. However, the usual allowance is 3-16 inch per foot for ordinary work.

The common allowance made for the shrinkage of castings made of different metals is as follows:

Cast Iron	$\frac{3}{32}$ inch per foot	Aluminum	$\frac{7}{32}$ inch per foot
Steel	$\frac{3}{16}$ " " "	Zinc	$\frac{7}{32}$ " " "
Brass	$\frac{3}{16}$ " " "	Lead	$\frac{7}{32}$ " " "
Yellow Brass	$\frac{7}{32}$ " " "	Tin	$\frac{3}{16}$ " " "
Bronze	$\frac{5}{32}$ " " "		

A method of graduating a shrink rule by hand—with the aid of a standard scale—is illustrated in Fig. 12, and when this is carefully done it will give entire satisfaction. Secure a standard rule to a board in such a manner that the upper surface will be clear. Erect the perpendicular line B C at one end. Now lay off the amount of shrinkage as indicated at D. With A as the center and with a radius equivalent to the length of the standard rule plus the amount of shrinkage

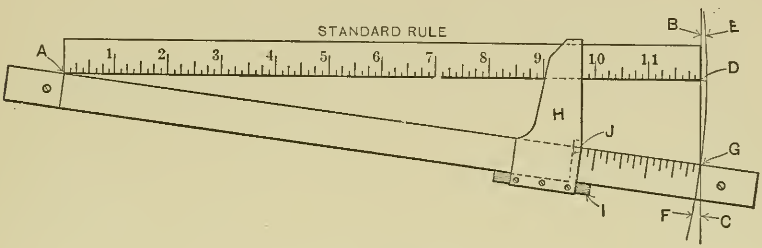


Fig. 12. Making a Shrink Rule

D, scribe an arc of a circle E F. Note the point of intersection with the perpendicular line B C which is shown at G. A strip of suitable material and of the same thickness as the standard rule is then secured to the board in the position shown, its inner edge passing through the point of intersection at G. The guide H can be made of steel plate or wood with the strip I attached to bear against the outer edge of the blank. If the guide is made of wood a piece of tin or steel may be inserted at J to give the marking instrument a positive bearing. The marking instrument should be thin and sharp.

CHAPTER VI

SOME HANDY DEVICES

Box Square

The accompanying illustration, Fig. 13, shows what is usually termed a vertical plumb or box square. It is a handy device, which will be found very convenient in transferring lines to irregular surfaces which do not lend themselves readily to the use of a square or

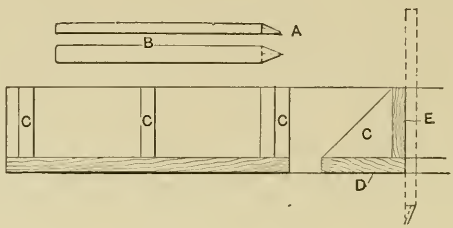


Fig. 13. Box Square

even a flexible rule. The device consists of a box square made of wood and shown in Fig. 13. The marker consists of a straight piece of hard wood shown in the upper part of Fig. 13, and in dotted outline at the right-hand side.

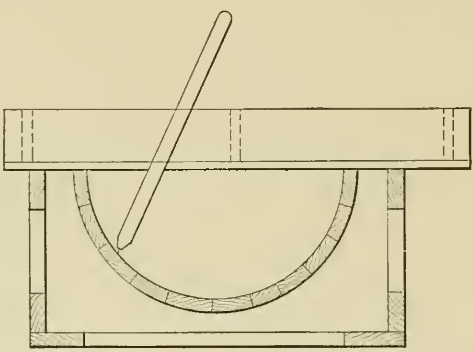


Fig. 14. Box Square in Use

This marker has a brad driven into the end and filed to a point, as shown at A. Sometimes the point is formed by a metal plate let into the face of the marker at the point A. Care should be taken to see that the scribing edge is in exact line with the face B. The manner of using this device for drawing a line across a core box is shown in Fig. 14. This can be used for drawing lines at right angles to a center line of the box, or at any other angle, as in the case of core boxes for pipe angles such as Y's, etc. This form of square is very useful in drawing lines across carved work, as in stove plate patterns.

Fig. 15 shows the application of a little different form of the box square for external work. The square shown in Fig. 13 cannot readily

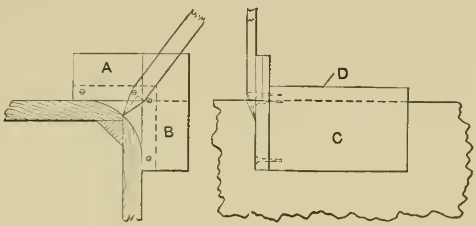


Fig. 15. External Box Square

be adapted for this class of work on account of the webs C, which are used to hold the pieces D and E in place. The form shown in Fig. 15 receives the necessary stiffening by the pieces A and B which are attached to the end of the square proper, which is composed of pieces C and D.

A Core Box Plane

In the accompanying figures I show a method of making a rabbet plane serve as a core box plane. In the lower part of Fig. 16 side and end views of the plane are shown, and it will be noticed that a block of

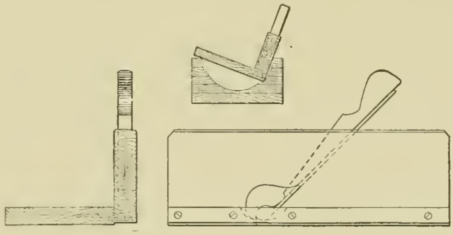


Fig. 16. Core Box Plane

hard wood has been screwed to the body of the plane at right angles to it, the face of the block being allowed to project slightly beyond the sole of the plane, so that it will come opposite the cutting edge of the bit. The edge of the block should be gouged out slightly opposite the throat of the plane to allow shavings to clear themselves freely. In the upper part of the figure the plane is shown in use.

Wooden Calipers

For calipering large work it is frequently difficult to obtain a pair of calipers large enough which will at the same time be delicate enough. Large metal calipers are very heavy and hence not as delicate as might be desired. Fig. 17 shows a light wooden frame caliper made up of

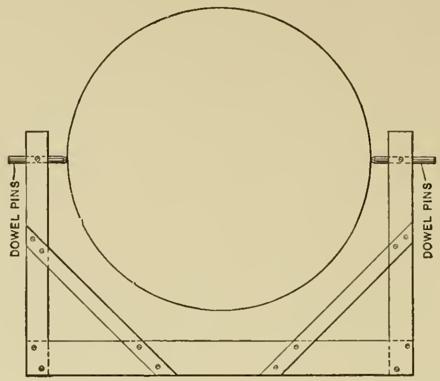


Fig. 17. Large Wooden Calipers

strips of hard wood screwed together and provided with adjustable pins made from ordinary dowel pin stock. This device will be found very handy indeed for turning large parallel work.

CHAPTER VII

SOME HANDY KINKS

Elbow Core Boxes

All patternmakers have had to construct core boxes for elbow patterns, and in many cases the pattern is wanted yesterday. This means a decidedly hurry-up job. Fig. 18 illustrates one method of performing such a hurry-up job. This shows the outline of the elbow

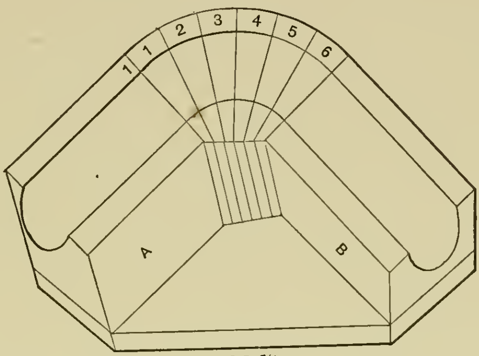
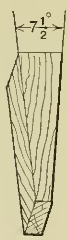


FIG. 18



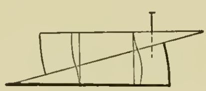


FIG. 19

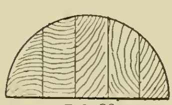


FIG. 20

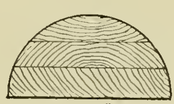


FIG. 21

Fig. 18. Elbow Core Box Fig. 19. Wedges Tacked Together
Fig. 20. Joints Parallel to Parting Fig. 21. Joints Perpendicular to Parting

core box and also shows the method of construction. The bend, it will be noticed, is formed by a series of wedge-shaped pieces—six in all—these pieces being fitted in place, laid out, numbered, taken apart and then tacked together in pairs, as shown in Fig. 19. They are then band-sawed, taken apart and replaced. The rest—that is, the finishing—is a very easy job, particularly if the ends, A and B, have been band-sawed to line. The job can be made still easier by the use of the $7\frac{1}{2}$ degree wedge, shown at the left of Fig. 2. This can be used in each of the separate blocks, in place of tacking them together in pairs.

It will be noticed that the angle of the sides of the wedge block is only one-half that of the other wedges. By using this device, the

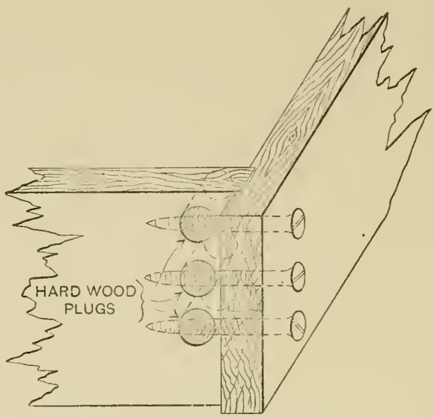


Fig. 22. Screws in End Grain

stock to be trimmed off by hand after sawing will be reduced to a minimum.

The old-time way of turning the bend and throwing away one-half or three-quarters is much slower than the one here shown.

Stock for Cylindrical Patterns

In gluing up stock for cylindrical shaped patterns, it is customary to have the joints parallel with the parting, as shown in Fig. 21. This is certainly not good practice in many cases, as the parting does not remain straight across the grain, while the job is being made. If the glued joints are made at right angles to the parting, as shown in Fig. 20, there will be very little, if any, trouble from open joints, and the pattern will last much longer.

Screws in End Grain

When inserting screws into end grain, especially in the case of pine, they do not take a very firm hold, especially when the screws have to be removed frequently as in core boxes where the work requires the separation of the parts. In such a case the thread formed by the screw into the wood will soon become stripped off. A very good manner of overcoming this trouble is shown in Fig. *22*, in which case holes are bored and hardwood plugs inserted, the screws being allowed to pass through the plugs at right-angles to the grain. When the plugs become badly worn from the repeated removal and reinsertion of the screws, they may be knocked out and new plugs inserted.

CHAPTER VIII

WARPING OF CASTINGS

The warping of castings, owing to variations in the thickness of metal, is an obstacle quite often encountered by the patternmaker, and one not always considered by him until his attention is called to a badly warped casting and he is asked to explain its cause. The chances are that too often he will say "Consult the foundry foreman, for he is to blame. They probably lifted the cope off too soon." Or he will make some similar statement.

A good illustration of this kind came under the writer's observation not long since, when a casting like that shown in Fig. 23 was to be made. In this illustration the casting is shown by the full lines distorted as it came from the mold, and the dotted lines show the outline of the required casting. The distortion has been exaggerated for the sake of making it plainer in the illustration. This was one of four sections for a floor plate, as used in machine shops doing heavy work, and when placed together the four pieces form a surface of 1,024 square feet, each section being 32 feet long, 8 feet wide, and 16 inches in depth. Each casting weighed 22 tons. In the flanges and lower part of the casting the metal was 1⅜ inches thick, while in the upper surface, which contained the T slots for the bolt heads, it was about 4¾ inches thick.

On inspecting the first casting, it was found to be warped as shown in Fig. 23. This warping amounted to 1⅝ inches in the length of the casting. An attempt was made to straighten the casting by heating, but it was finally rejected and broken up for scrap.

The cause of the casting warping to such an extent was then discussed and the conclusion reached that, owing to the upper part of the casting when molded being of a much lighter section, it cooled first. Also the cores for this section tended to counteract shrinkage. Later, when the heavy surface containing the slots for the bolts cooled it shrunk and sprung the upper surface out of true as shown. Of course the piece was molded with the heavy face down in order to secure good metal for this finished surface.

To avoid this warping it was decided to rebuild the pattern which was constructed as before, in length about 12 inches longer than one-half of the required casting, only that the surface of the pattern was made to conform with the warped surface of the first casting, except that the pattern was warped in the reverse direction. This pattern is shown in Fig. 24, the warp here also being exaggerated for the sake of clearness. When the castings from this pattern were taken from the mold they were all that could be desired, as none of the four varied more than ¼ inch.

In making the mold a hole was dug for the total length of the casting and a half pattern placed in one end of this hole with one end blocked up to the required height. It was then rammed and tucked up and the two sectional cover flasks A and B, Fig. 25, placed in position and rammed up with the parting between them as shown. Wing bars were bolted to the outside of the flasks to support this overhanging sand. The parting was made at an angle so as to allow the flasks to be lifted off and replaced separately. The ramming of this portion of the pattern being completed, the flasks were lifted off and marks

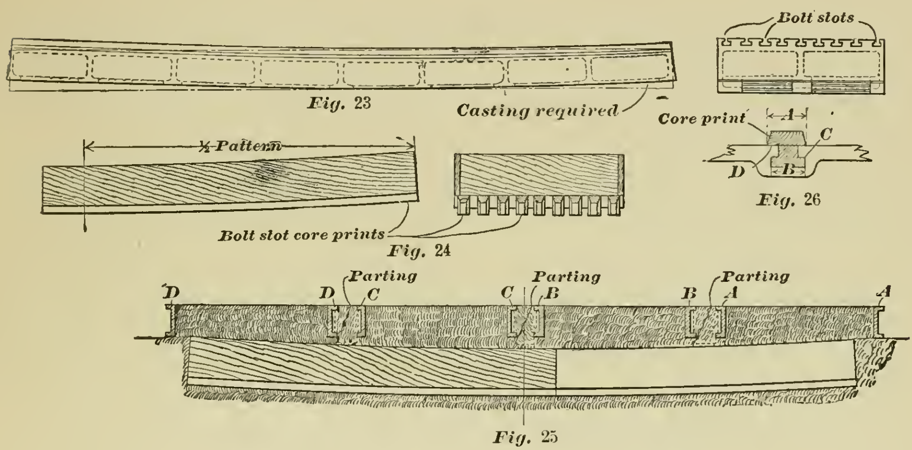


Fig. 23. Warped Casting. Fig. 24. Pattern for Bed Plate
Fig. 25. Mold for Bed Plate. Fig. 26. T Slot Core Print

made on the mold opposite the center of the pattern, the pattern drawn, turned end for end, and placed in the opposite end of the hole, care being taken to see that the center line of the pattern came opposite the mark made on the side of the mold.

As the pattern was constructed 12 inches longer than one-half of the casting, this insured a 24-inch bearing upon the portion of the mold already completed, and thus assisted in lining up and setting the pattern for the second half. After the pattern was in place and tucked and rammed up, the flask B was returned to its place, and the flasks C and D placed successively in position and rammed up, the partings being made as shown. The flasks were then lifted off, the pattern drawn, the mold finished, the cores set, gates cut, and all made ready for pouring. In Fig. 25 the pattern is shown in its second position in the mold.

In order to avoid the use of a large number of chaplets on top of the cores for the T slots, a very simple device was resorted to. This device has been described in the Section on Molding in Cores, but is also shown in Fig. 26, as applied to this particular case. It will be noticed that the core print is wider than the T slot, and hence when a core of the cross section of the core print and T slot is placed in the opening made by such a core print, and the metal flows into the mold, there will be more area exposed in the width A than in the width B, and hence the metal which exerts a lifting force under the overhanging portions C will be more than balanced by the metal bearing down on the portions D. When cores are made and carefully set according to this system, no chaplets will be needed on top of them, and of course after the entire core is submerged it will be held down by the metal above it. The cores for forming the interior of the casting between the ribs were made separately and set in place before the mold was closed.

The interesting point in this matter is the fact that the pattern had to be sprung a certain amount to overcome the spring which would naturally result in cooling. The exact amount that any pattern will have to be distorted to accomplish this result can only be ascertained by experiment, though experience will enable a patternmaker to make a very close approximation at the first trial. The depth of cope used may in some cases have an influence on the results.

CHAPTER IX

ARCS OF CIRCLES

In patternmaking it is frequently necessary to draw arcs and chords of large circles and in many cases it is not possible to do this with trammels from the center.

An arc of a circle may be defined as any part of its circumference and is measured along its circumference.

A chord is a straight line joining the extremities of an arc.

A segment of a circle is any part of a circle bounded by an arc and its chord.

These various parts are plainly shown in Fig. 27. It often becomes necessary to lay off angles of a certain number of degrees and,

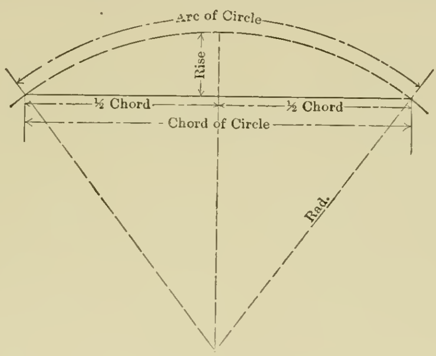


Fig. 27. Arc and Chord of a Circle

in many cases, especially in large work, the protractor or bevel is not accurate enough and in such cases the chord may be calculated for the given number of degrees and the largest diameter that the work will permit. This insures accuracy and usually saves time over trying to do an accurate job with the bevel. To obtain a chord for any given number of degrees and a given diameter, refer to any engineer's Pocketbook and turn to the table of Natural Sines, take the sine of ½ of the given number of degrees and multiply this by the diameter on which it is to be laid off.

For example, if it is desired to lay off a chord of 30 degrees for a 12-foot circle we would turn to the table and find the natural sine of one-half of 30 degrees or 15 degrees. This is .25882, and multiplying this decimal by 12 feet, the diameter, gives 3.10584 feet. Reducing this to inches by multiplying by 12 and reducing to common fractions we have 37 17-64 inches, as the length of the desired chord.

The accompanying table of chords dividing the circle into from 3 to 100 equal parts will be found very useful and will facilitate the laying out of segments, arms of wheels, etc.

TABLE OF CHORDS

N	S	N	S	N	S	N	S	N	S	N	S
3	.86603	20	.15643	37	.084804	53	.059240	69	.045515	85	.036953
4	.70711	21	.14904	38	.082580	54	.058145	70	.044865	86	.036522
5	.58779	22	.14232	39	.080466	55	.057090	71	.044232	87	.036103
6	.50000	23	.13617	40	.078460	56	.056071	72	.043619	88	.035692
7	.43388	24	.13053	41	.076549	57	.055089	73	.043022	89	.035291
8	.38268	25	.12533	42	.074731	58	.054139	74	.042441	90	.034899
9	.34202	26	.12054	43	.072995	59	.053222	75	.041875	91	.034516
10	.30902	27	.11609	44	.071339	60	.052336	76	.041325	92	.034141
11	.28173	28	.11197	45	.069756	61	.051478	77	.040788	93	.033774
12	.25882	29	.10812	46	.068243	62	.050649	78	.040267	94	.033415
13	.23932	30	.10453	47	.066793	63	.049845	79	.039757	95	.033064
14	:22252	31	.10117	48	.065401	64	.049068	80	.039260	96	.032719
15	.20791	32	.098018	49	.064073	65	.048312	81	.038775	97	.032381
16	.19509	33	.095056	50	.062791	66	.047582	82	.038303	98	.032051
17	.18375	34	.092269	51	.061560	67	.046872	83	.037841	99	.031728
18	.17365	35	.089640	52	.060379	68	.046184	84	.037391	100	.031411
19	.16460	36	.087156								

The quantities in the column headed S are the sines of half the angles as already explained. The quantities in the columns headed N are the number of equal parts into which it is desired to divide a circle. For instance, if it is desired to divide the circumference of a gear four feet in diameter for 23 teeth we would look in the column N for 23, and opposite this, under S, we would find the decimal .13617, multiplying this by 48 inches, or the diameter, will give us 6.536 inches as the distance to which our dividers should be set.

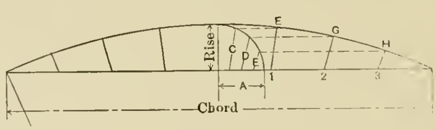


Fig. 28. Graphic Method of Drawing an Arc

The radius of a given piece of work is often so great that the floor space available is not sufficient to lay out the work, or it would be impossible to use a trammel beam of the desired length. In such a case as this it becomes necessary to draw the arc of the circle without the use of a center. The rise of the arc must first be obtained, and the following calculation is one way in which this can be done. Square the radius and from this subtract the square of one-half of the chord. Extract the square root of the remainder and subtract the result from the radius. This will give the rise.

A graphic method of drawing the arc is shown in Fig. 28. The chord is first laid out and from the center the rise is drawn. From the center of the chord scribe a quadrant of a circle with the rise as a radius as shown. The quadrant should be divided into any convenient number of equal parts. In the case illustrated, four have been

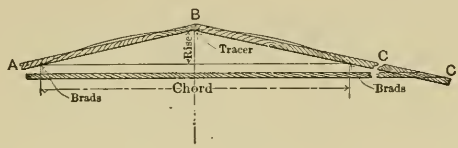


Fig. 29. Drawing Large Arcs

taken. Also the part of the chord A cut by the quadrant should be divided into four equal parts and the points connected by the lines C, D and E, as shown. Next, each half of the chord should be divided into four equal parts, giving the points 1, 2 and 3. Through the points 1, 2 and 3 draw lines parallel to C, D and E. From the points at which the lines C, D and E intersect the quadrant, draw lines parallel to the chord until they intersect the lines from the points 1, 2 and 3 in the points F, G and H, as shown. These will be points on the circumference of the desired circle. Brads can be driven at these points and a flexible strip bent along them to be used in drawing the arc of the desired circle.

Another method of describing the arc of a circle without the center is shown in Fig. 29. The rise of the arc having been obtained, a suitable wooden triangle should be constructed as shown, making A-B and C-D each longer than the chord of the arc. Lay off the chord and rise on a board and at the extremities of the chord drive brads and fasten the tracer point or pencil at the intersection of the inner edges of the legs of the triangle and then move the triangle back and forth, keeping the legs in contact with the brads. The tracer point will then draw the arc required.

CHAPTER X

CHORDS OF ANGLES

The accompanying table of chords of angles will be found very useful in many operations in both the foundry and patternshop. It will also tend to do away with much inaccuracy which is usually the result of laying out angles which extend beyond the line of the protractor blade.

To obtain the chord of any angle given in the table scribe an arc of a circle with one of the radii given. With the trammel lay off the chord of the required angle upon the circumference scribed. Now if lines be drawn through the ends of the chord to the center of the circle they will represent the angle desired.

Chords of intermediate angles not given in the table can be obtained

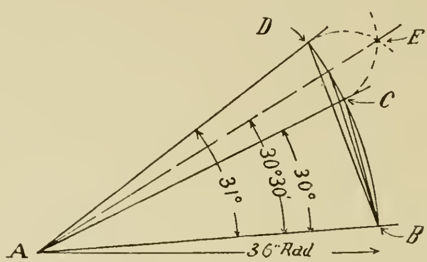


Fig. 30. Diagram for Chords of Angles

by dividing the difference between two given angles, as shown in the diagram, Fig. 30.

Example.—It is required to lay out an angle of 30° 30′. First: Draw with a radius of 36 inches an arc BD. The base line AB is drawn passing through the center of the circle, and by referring to the table the chord of the angle of 30° upon the 31 inch radius is found equal to 18 41-64 inches. With this length set off on the trammels the chord BC is laid off. The chord of 31° is found to be equal to 19′ 15-64 inches with a trammel set to this distance and B as the center, the chord is drawn through D. Next, with the dividers set to any convenient radius the chord CD is bisected and the line drawn through the points E and A will give the difference between the two angles, and the angle BAE will equal to 30° 30′.

CHORDS OF ANGLES FROM ONE TO NINETY DEGREES—Dimensions given in Inches

Ang.	18" Radius.	36" Radius.	72" Radius	Ang.	18" Radius.	36" Radius.	72" Radius.	Ang.	18" Radius.	36" Radius.	72" Radius.
Deg.	Chord.	Chord.	Chord.	Deg.	Chord.	Chord.	Chord.	Deg.	Chord.	Chord.	Chord.
1	5/16	5/8	1 1/4	31	9 5/8	19 15/64	38 31/64	61	18 17/64	36 35/64	73 5/64
2	5/8	1 1/4	2 1/2	32	9 59/64	19 27/32	39 11/16	62	18 35/64	37 5/64	74 11/64
3	15/16	1 7/8	3 3/4	33	10 7/32	20 29/64	40 57/64	63	18 13/16	37 5/8	75 1/4
4	1 1/4	2 1/2	5	34	10 17/32	21 3/64	42 3/32	64	19 5/64	38 5/32	76 5/16
5	1 37/64	3 9/64	6 9/32	35	10 53/64	21 21/32	43 19/64	65	19 11/32	38 11/16	77 3/8
6	1 7/8	3 49/64	7 17/32	36	11 1/8	22 1/4	44 1/2	66	19 39/61	39 7/32	78 27/64
7	2 13/64	4 25/64	8 51/64	37	11 27/64	22 27/32	45 11/16	67	19 7/8	39 47/64	79 15/32
8	2 1/2	5 1/64	10 3/64	38	11 23/32	23 7/16	46 7/8	68	20 1/8	40 17/64	80 17/32
9	2 53/64	5 41/64	11 19/64	39	12 1/64	24 1/32	48 1/16	69	20 25/64	40 25/32	81 9/16
10	3 9/64	6 9/32	12 35/64	40	12 5/16	24 5/8	49 1/4	70	20 41/64	41 19/64	82 19/32
11	3 29/64	6 29/32	13 51/64	41	12 39/64	25 7/32	50 7/16	71	20 29/32	41 13/16	83 5/8
12	3 49/64	7 17/32	15 3/64	42	12 29/32	25 51/64	51 39/64	72	21 5/32	42 21/64	84 41/64
13	4 5/64	8 5/32	16 19/64	43	13 3/16	26 25/64	52 25/32	73	21 13/32	42 53/64	85 21/32
14	4 25/64	8 25/32	17 35/64	44	13 31/64	26 31/32	53 15/16	74	21 21/32	43 21/64	86 21/32
15	4 45/64	9 25/64	18 51/64	45	13 25/32	27 35/64	55 7/64	75	21 59/64	43 53/64	87 21/32
16	5	10 1/64	20 1/32	46	14 1/16	28 1/8	56 17/64	76	22 5/32	44 21/64	88 21/32
17	5 21/64	10 41/64	21 9/32	47	14 23/64	28 23/32	57 27/64	77	22 13/32	44 53/64	89 41/64
18	5 5/8	11 17/64	22 17/32	48	14 41/64	29 9/32	58 37/64	78	22 21/32	45 5/16	90 5/8
19	5 15/16	11 7/8	23 49/64	49	14 59/64	29 55/64	59 23/32	79	22 57/64	45 51/64	91 19/32
20	6 1/4	12 1/2	25	50	15 7/32	30 27/64	60 55/64	80	23 9/64	46 9/32	92 9/16
21	6 9/16	13 1/8	26 15/64	51	15 1/2	31	62	81	23 3/8	46 3/4	93 33/64
22	6 7/8	13 47/64	27 31/64	52	15 25/32	31 9/16	63 1/8	82	23 39/64	47 15/64	94 15/32
23	7 11/64	14 23/64	28 45/64	53	16 1/16	32 1/8	64 1/4	83	23 55/64	47 45/64	95 13/32
24	7 31/64	14 31/32	29 15/16	54	16 11/32	32 11/16	65 3/8	84	24 3/32	48 11/64	96 23/64
25	7 51/64	15 37/64	31 11/64	55	16 5/8	33 1/4	66 1/2	85	24 21/64	48 41/64	97 9/32
26	8 3/32	16 13/64	32 25/64	56	16 29/32	33 51/64	67 39/64	86	24 35/64	49 3/32	98 13/64
27	8 13/32	16 13/16	33 5/8	57	17 11/64	34 23/64	68 23/32	87	24 25/32	49 9/16	99 1/8
28	8 45/64	17 13/32	34 13/16	58	17 29/64	34 29/32	68 13/16	88	25	50 1/64	100 1/32
29	9 1/64	18 1/32	36 1/16	59	17 23/32	35 29/64	70 29/32	89	25 15/64	50 15/32	100 15/16
30	9 5/16	18 41/64	37 17/64	60	18	36	72	90	25 29/64	50 29/32	101 53/64

CHAPTER XI

RIGHT-ANGLED TRIANGLES

A table of right-angled triangles, which will be found convenient in laying out large pattern and plate work, is given below.

In erecting a perpendicular at a given point upon the base line A B, Fig. 31, select from the table the triangle of the most suitable proportions to suit the work. Say for illustration we select the fifth from the top of the table. This is a right-angled triangle, the proportions of which are 8, 15 and 17.

From the desired intersection C with the base line A B lay off

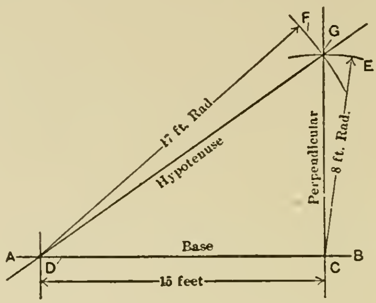


Fig. 31. Right-angled Triangle

the point D which would be equal to 15 feet. Now with the trammels set to an 8-foot radius, and C as the center, scribe the arc of circle E. With D as the center and the trammels set to a 17-foot radins scribe the arc of a circle F giving the point of intersection G and we have the perpendicular line C G accordingly.

Perpendicular	Base	Hypotenuse	Perpendicular	Base	Hypotenuse
3	4	5	15	20	25
5	12	13	15	36	39
6	8	10	15	112	113
7	24	25	16	30	34
8	15	17	16	63	65
9	12	15	17	144	145
9	40	41	18	24	30
10	24	26	18	80	82
11	60	61	19	180	181
12	16	20	20	21	29
12	35	37	20	48	52
13	84	85	20	99	101
14	48	50			

CHAPTER XII

A TABLE OF POLYGONS

This table of polygons will be found very useful in shop practice. It has been arranged in this handy form so as to save as much calculation as possible.

The diagram, Fig. 32, shows quite clearly what is meant by the words "diameter" and "sides." The formulas may be explained—if additional explanation is found necessary—by the following:

A TABLE OF POLYGONS

No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.
3	1.16	28	8.93	53	16.88	78	24.83	103	32.79	128	40.75
4	1.41	29	9.25	54	17.20	79	25.15	104	33.11	129	41.07
5	1.70	30	9.57	55	17.52	80	25.47	105	33.43	130	41 38
6	2.	31	9.88	56	17.83	81	25 79	106	33.74	131	41.70
7	2.31	32	10.20	57	18.15	82	26.11	107	34.06	132	42.02
8	2.61	33	10.52	58	18.47	83	26.43	108	34.38	133	42.34
9	2.93	34	10.84	59	18.79	84	26.74	109	34.70	134	42.66
10	3.24	35	11.16	60	19.11	85	27.06	110	35.02	135	42.98
11	3.55	36	11.47	61	19.42	86	27.38	111	35.34	136	43 29
12	3.86	37	11.79	62	19.74	87	27.70	112	35.65	137	43.61
13	4.18	38	12.11	63	20 06	88	28 02	113	35.97	138	43.93
14	4.49	39	12.43	64	20.38	89	28.33	114	36.29	139	44.25
15	4.81	40	12.74	65	20.70	90	28.65	115	36.61	140	44.57
16	5.12	41	13.06	66	21.02	91	28 97	116	36.93	141	44.88
17	5.44	42	13.38	67	21.33	92	29.29	117	37.25	142	45.20
18	5 76	43	13.70	68	21.65	93	29.61	118	37.56	143	45 52
19	6.07	44	14.02	69	21.97	94	29.93	119	37.88	144	45.84
20	6.39	45	14.33	70	22.29	95	30 24	120	38 20	145	46.16
21	6.71	46	14.65	71	22.61	96	30.56	121	38.52	146	46.48
22	7.03	47	14.97	72	22.92	97	30.88	122	38.84	147	46.79
23	7.34	48	15.29	73	23.24	98	31.20	123	39.16	148	47.11
24	7.66	49	15.61	74	23.56	99	31.52	124	39.47	149	47.43
25	7.98	50	15.93	75	23.88	100	31.84	125	39.79	150	47.75
26	8.30	51	16.24	76	24.20	101	32.15	126	40.11	151	48.07
27	8.61	52	16.56	77	24.52	102	32.47	127	40.43	152	48.39

To obtain the length of a side: Divide the diameter of the circle by the coefficient.

To obtain the diameter: The length of the side is multiplied by the coefficient.

To obtain the coefficient: The diameter of the circle is divided by the length of the side.

This table will be found convenient in obtaining the chords of segments and similar work.

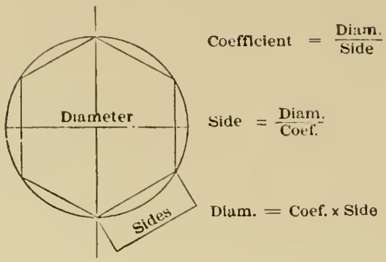


Fig. 32. Polygon Diagram

CHAPTER XIII

GENERAL SUGGESTIONS

Under the above heading the writer has arranged a number of remarks and suggestions pertaining to patternmaking, which, if given careful consideration and combined with a fairly good streak of self-confidence, will go a long way toward the make-up of a thorough and proficient workman. To become a good patternmaker one must become to some extent an engineer. He must be somewhat informed upon the principles of machine design and the construction of various kinds of machinery, and he must have a thorough knowledge of molding and also a knowledge of drawing. By the latter I do not mean merely the making of drawings or layouts which are copies of the drawings furnished by the designer or draftsman, but an understanding of the principles of projection as applied to geometrical figures.

He must be able to read any mechanical drawing readily and form a clear idea of what the draftsman intended to convey by the drawing and he must also comprehend all of the details to the minutest degree.

To become an expert in the handling of tools, which is one of the necessary requirements of the trade, it is only acquired by constant practice for a long time, and this practice is usually accompanied by scarred fingers.

What to Observe When Beginning Work Upon a Pattern

Upon receiving a drawing for a pattern to be made, note the metal to be used for the casting and the number of castings to be made. The number of castings to be made will determine whether a temporary, medium or standard pattern is required and will also determine the method of construction. The construction of the pattern should be governed in such a way as to produce a casting with the smallest expenditure of time, labor and material, in both the pattern shop and the foundry. In many cases extra time spent in the pattern shop in making a better pattern will be more than saved in the foundry, or vice versa. Next, check all of the intermediate or minor dimensions to see whether they agree with the over-all dimensions. This will often save trouble later on as an error is corrected more easily on paper than in wood or metal.

If detailed drawings of a machine or other device to be constructed are received they should be accompanied by a general drawing and this should be looked over and the general arrangements and dimensions checked.

Temporary patterns are those not likely to be used more than once. They should be made with as little expenditure of labor and material as possible to produce the required casting. Unless there is plenty of space in the pattern loft this grade of patterns should not be preserved, but taken apart and the material used up, if possible.

Medium patterns are that class of patterns likely to be used occasionally and hence more care should be taken in their construction than in the case of the class already mentioned, as they are required to withstand more hard usage in the foundry, as well as the distortion likely to occur during the storage in the pattern loft.

Standard patterns are those which are frequently used or in constant use and no pains should be spared in their construction, as they cannot be made too substantial.

Economical Use of Lumber and Supplies

If different grades of material are provided they should be used with discretion. Knots and shaky material will not affect the inside of a box or framed up pattern. When the pattern to be made is of large size, special provision should be made for rapping and drawing it. If the pattern is too large to handle and store conveniently, it should be made in sections which are pinned and bolted together during the construction of the pattern.

The Layout Board

This should only be used for such work or such sections of work as absolutely require it. For instance, in the making of web patterns or when there is a surface which can be laid out and the material then gotten out and laid down to this outline and worked to it. In such a case one layout answers both for the determination of the dimensions and for the fitting of the stock.

Center Lines

I wish to place proper stress upon this point in patternmaking, as it is one that is often overlooked. Prominent center lines should be scribed on all sides of the pattern and across the joint. If this is carefully observed the chances of error will be greatly reduced and the checking of the pattern facilitated. It will also improve the disposition of the pattern checker.

Contraction

The contraction or shrinkage should be carefully considered. The shrinkage of castings is to a large extent governed by their form and the metal distribution. The presence of dry sand cores in the mold has a tendency to retard or resist the shrinkage. Hard iron or steel will shrink more than soft iron. Yellow brass will shrink more than bronze, etc. Castings of a cylindrical or box section will shrink more in length than in diameter, that is, more along the core than across it, the shrinkage in the diametrical direction or at right angles to the core being retarded or resisted by the dry sand core. It is good practice in cases of this kind to allow one-half of the standard shrinkage for the diameter of the cylinder or across the box section.

Shrinkage for Cast Iron

The conventional allowance for the shrinkage of cast iron is 3-32 of an inch per foot for ordinary work. When castings assume large proportions, such as heavy engines or generator frames and large cylinders, the shrinkage is reduced, owing to the swelling of the mold, on account of the great pressure of the iron. Patterns for large cylinders are usually made with a 1-12-inch allowance per foot for shrinkage, while heavy engines or generator frames receive but 1-16 of an inch per foot. Heavy hammer blocks and counter weights are usually made with a standard rule, in other words, with no allowance for shrinkage.

Shrinkage of Steel Castings

The shrinkage of steel castings is not to be relied upon as a constant. The usual allowance is 3-16 of an inch per foot, but it is subject to frightful variations. Plain straight castings will often shrink from ¼ to 5-16 of an inch per foot, while in dry sand cored molds they will not shrink more than ⅛ of an inch per foot. When, however, a contraction of only ⅛ inch is allowed, a liberal allowance should be made for finish upon all surfaces to be machined to insure the proper dimensions should the shrinkage of the castings exceed the contraction allowed. In many cases the shrinkage appears to be an ungovernable element and is apt to vary either way. As a consequence, what is usually termed "playing safe" is generally resorted to, that is, the back of the outer flange is thickened up to counteract or overcome the bad results which would result if the shrinkage should exceed that allowed, for in the latter case the flanges would finish up too thin. It is better in most cases to have the flanges a trifle over thickness than below thickness. It will also be found well to make the outlaying pads a little wider than the drawing calls for.

Tie pieces or tie bars are placed upon the castings to prevent the spreading of certain parts in cooling, or to assist the shrinkage when such parts are separated by dry sand cores. These tie bars are more applicable to and, in fact, are an essential feature in the production of good steel castings, as in the latter class of castings shrinkage plays such an important part.

The introduction of these bars is really a point in molding that should be taken care of by the foundryman who is supposed to make such provisions as are necessary to produce a casting true to pattern, but provision for these pieces should be made in the core box or upon the pattern. If these precautions are not taken and the casting is delivered to the machine shop badly out of shape, the pattern shop will no doubt hear about the amount of finish it allowed.

Amount of Finish

The finish to allow is oftentimes a troublesome problem for the patternmaker. The amount that will satisfy one machinist will not satisfy another. The proper amount of finish depends to a great extent upon the size of the piece to be machined, the method of casting, and whether or not it is turned out like the pattern. It is advisable to make this allowance as small as possible, but at the same time to leave sufficient material for the proper finishing of the casting. As a rule, iron castings which are produced in loam molds and castings made from steel are apt to vary from the proper dimensions more than those molded by other methods.

Steel castings or loam molded iron castings should receive an allowance of from ¼ to ½ inch for finish and this should be sufficient for ordinary sized work. For the general run of green sand castings from ⅛ to ¼ inch should be an ample allowance. For small brass and machine molded iron castings which are of sound metal 1-16 of an inch should answer.

Tool Clearance

The patternmaker should consider the method in which the casting is to be finished or machined and then see that the proper tool clearance is allowed wherever it is required, as for instance, at the ends of all surfaces to be planed or milled. A little thought expended on this point will save many hours of chipping in the machine shop. Some unscrupulous fellow will say, "Oh, that's none of my business. They should look after the machining of the castings." This is not the proper spirit for the patternmaker to exhibit, as he should have an interest in the casting clear through to the final erection of the machine.

Construction of Patterns and Core Boxes

Having discussed some of the allowance and provisions for the molding and machining of castings, let us proceed with the pattern and core box work, taking up a number of points which will facilitate this work and economize material. These points will also serve to save time in the foundry.

Machines are placed in the pattern shop to do the work and hence the patternmaker should see that the machines do the work and thus save his own strength and labor.

Glue is an indispensable material in pattern construction, but it should be applied with judgment, as there is a time to use glue and a time to let it alone. Many a badly warped pattern can be traced to the manner of gluing up the stock. Cross gluing should be avoided wherever possible, for if any shrinkage or swelling takes place in such a case a distorted or twisted pattern will surely result. Unnecessary gluing often causes no end of trouble and expense when an alteration or change is to be made upon a pattern. Screws may appear more expensive than a few nails or a few spots of glue, but it is not always so, and their use should be encouraged.

Core Prints

This is one of the knotty problems for the patternmaker to solve, but we will not attempt to settle it this time. The length or width of a core print that will answer one molder to a nicety will not suit another at all. The writer, however, believes in a good liberal allowance for all core prints, despite the fact that patterns often come back from the foundry with a portion of the core print missing, it having been sawed off by the foundry carpenter so that the pattern could be used in a certain flask. Of course the length of any core print should be governed by the size or the diameter of the core to be set. When constructing core prints of irregular form, care should be taken and provision made so that their outline can be readily transferred to a core box, that is, such core prints should be built upon certain properly determined lines and these lines noted on the layout. This method of working will avoid the use of templets and other troublesome devices which are often employed when such precautions are not taken. A core print and core should be so marked and so constructed that there is no chance of placing it in the mold in any position except that in which it is intended to go. This point is often overlooked by the patternmaker and rarely detected by the molder unless the difference is quite noticeable.

Loose Pieces

Loose pieces on patterns, although objectionable, cannot always be avoided and in many cases would be found more economical and less objectionable than a core. When it becomes necessary to choose between the two methods of using a loose piece or a core it will generally be found better to use the former, because it will insure a truer casting and avoid the scare caused by the introduction of a dry sand core.

If loose pieces or core prints are attached by two dowel pins of different diameters, the error, often caused by the molders or coremakers attaching pieces in the wrong position, will be avoided. All loose pieces or core prints should be marked or numbered plainly so that their respective positions can be determined at a glance. It is also good practice to scribe a good, heavy line around them. This only takes a moment, but it will often save the molder or coremaker many a minute's search for the location of a detached loose piece.

The length and diameter of the core should also be marked upon the core print when standard sizes are used, as the molder rarely has a pair of calipers always at hand, as is the case with the patternmaker.

In the case of circular work when cores are used around the interior or outer diameter of a large pattern the patternmaker should mark the number of cores required to complete the circle upon the pattern and upon the core box. This will show the coremaker instantly the required number of cores to be made and save him the time and trouble of stepping the distance off around the pattern. When a special core is to be used and the core print does not distinguish it from the regular standard foundry core the core print should be marked "special core." This will often save the necessity of replacing the casting.

When making gear patterns it is well to get out several extra teeth, bore a small hole through them and attach them to the pattern. This will often save the pattern from mutilation by having several teeth ripped off by the molder should the pattern fail to draw properly.

Another method of saving the pattern from abuse is to get out a block five by three inches by two inches thick, with one side cut to conform to the inner diameter of the rim of a gear pattern. The molder is supposed to place this block against the inside of the rim and then rap upon it with a hammer. Of course this rapping is done after the cope has been lifted off. By this device the pattern can be well rapped without injuring it.

In looking up gears in the pattern loft it will often be found convenient to have the patterns marked on each side of the rim with the pitch diameter, circular pitch, width of face and number of teeth.

Old Patterns

These should always be treated with suspicion, as they are not to be trusted, and have proven the pitfall of many a good workman. Previous alterations are not always noted on the drawing and distortions are very apt to occur during storage. For these reasns an old pattern should be checked over thoroughly when making new additions. Alter old patterns cheerfully, for though it is not a clean and agreeable job, some of us must do it, so do it graciously, but we will not blame you for kicking if you get more than your share.

Core Boxes

Whenever the circumstances permit core boxes should be constructed of rectangular form and filled in with the necessary material to produce the required form of core. This manner of construction of core boxes will be found advantageous and convenient in many respects, and it will also save material, for when a good rigid frame is constructed to begin with it can be filled in with material almost of a temporary character, for such material cannot get out of place when supported by the frame. This construction also saves the box from the punishment it receives by rapping, for all that is required when the box has been rammed up is to remove the screws from the opposite corners of the frame and draw the frame away. The handling and the clamping of the box to the core plate is also facilitated by its rectangular form. The material which forms the core box proper should be fitted loosely in the frame, as it will have a tendency to swell and tighten itself up.

Keep the length and width of your core box scant, as the core would be liable to swell.

Bottom boards for core boxes should be made only when the form of the core requires it. The construction of bottom boards is usually only a waste of time and material and they are often thrown aside by the coremaker, for they cause him an unnecessary roll over if used, where by the use of the core plate the core is rammed up on the plate, plate, the box removed and the cores sent direct to the oven.

These suggestions are only a drop in the bucket in comparison to the number of little big things that serve to make up successful patternmaking and that present themselves day after day to every workman.

By all means think for yourselves, think twice before you do it, and then do not do it until you know why you are doing it.

Don'ts

Don't start your job until you have it well in mind, or you may strike a snag later on.

Don't proceed with the pattern without noting the metal of which it is to be cast.

Don't fail to inquire whether the grade of pattern is temporary, medium or standard.

Don't forget that the art of quick patternmaking lies in knowing where to slight it—but

Don't form the habit of slighting everything. The man that can work according to his job is a valuable man.

Don't trouble the "Boss" with fool questions. He has troubles of his own, besides you may expose your ignorance—at the same time

Don't try to get along without really necessary information on the job at hand, which the Boss may have neglected to give you.

Don't make unnecessary layouts of work above all.

Don't take time to lay out a job, then not use the layout; properly used, it will save time on the job.

Don't fail to study economy both of material and time; both cost your employer money.

Don't miss checking up all dimensions on the drawing before proceeding with pattern.

Don't make a pattern without knowing how it is to be molded, simply because the *old man* told you to.

Don't accept your first inspiration as to the molding and construction of a pattern; try and think out another way.

Don't start a job you don't see through, expecting to get an inspiration as you go along. This idea wears out the floor between your bench and the old man's desk.

Don't construct large patterns without provision being made for handling, shipping or storing.

Don't be stingy with your core prints.

Don't be afraid that well defined center lines will spoil the looks of your job. They will look good to the checker, and to the lad who may have to change the job later.

Don't fail to put center lines on your *core boxes*, as well as your patterns. A pattern like "Bread that is cast on the waters is seen again after many days," and it may be up to you to change it.

Don't pick out all the snaps for yourself, when you have help on a job. However good you may be—

Don't forget there are others.

Don't despise the help of the apprentice on the job. He did not come in simply to learn to varnish, so let him do things. If he falls down, pick him up, and—

Don't forget you had troubles, and when you are a *has been*, he may help you.

Don't think that you know it all; there are other men that know a little.

Don't do by hand that which the machine should do, but you

Don't have to wait your turn at the band-saw to cut off a toothpick.

Don't fail to study your machines and how to get the most out of them, but

Don't take liberties or long chances with the jointer, especially when the knives are dull.

Don't take long chances on the lathe, remember the adage, "An ounce of prevention is worth a pound of cure."

Don't waste time setting bevels for standard cuts that are arranged for on the saw table or trimmer. A little mental calculation and the indicator is better.

Don't think because you see a circle on the drawing that the work *must* be done in the lathe; other pieces fit on sometimes, and

Don't forget that a sharp band-saw is a good tool and sawing to the line, *not quite a lost art.*

Don't use your material for a footstool before working it up. It's hard on the machines.

Don't wait until the rip or band-saw is just sharpened, then saw nails; if it must be done, do it before.

Don't swear when your plane hits a nail. The chances are you put it there yourself.

Don't sandpaper each piece as you put it on the pattern, then plane it afterwards. It takes time to sharpen tools, and—

Don't forget you buy your own.

Don't round up the ribs and corners of a pattern until all pieces have been assembled.

Don't throw too much work on the foundry, but occasionally a little stopping off saves time, and—

Don't leave the making of the stop-off piece to the foundry carpenter; he may not see things as you do.

Don't glue two pieces of wood together that have just come out of the ice box. It's too chilly on the glue.

Don't carry your tools in a collar-box and expect the steady pins to furnish the ones you haven't got.

Don't borrow tools and forget to return them, and especially—

Don't borrow when the other man is not looking.

Don't assume any pattern is correct; treat them all with suspicion until proven.

Don't proceed with the alteration of an old pattern, without first carefully checking it up.

Don't proceed with another workman's job without checking his measurements.

Don't use screws when nails will do the work as well; nails go quicker and are cheaper.

Don't forget that supplies and lumber cost money; if the other fellow is paying for it—so

Don't fail to practise economy, and

Don't lug in a 16-foot plank and cut 4 or 5 inch print out of the middle; it's easier to turn over the scrap pile.

Don't keep your bench so littered up that it takes 5 or 10 minutes to find some small tool you just laid down.

Don't think (if you happen to be a relative of one or more of the firm) that you are entitled to more privileges than any other man.

Don't try to do as little as you can for the most you can get, and—

Don't do any fooling during working hours; you are paid for working—not playing.

Don't fail to report promptly when your job is completed.

Don't stand around and look wise when waiting for a job. Get busy with your oil-stone. There are always tools to be sharpened.

Don't fail to check up your pattern when complete.

Don't leave your mistakes for others to find; find them yourself, and if you do—

Don't let them go on a chance of its getting past the checker. Be sure your sins will find you out, even if it does rope in the other lad.

Don't say "that is near enough."

Don't fail to number and place location marks on all loose pieces of pattern and core boxes.

Don't forget to place a marker upon the core print, if the core can be reversed.

Don't fail to nail the lead letters and numbers on the pattern; one nail in each letter is not enough to ensure their staying right side up.

Don't number the core boxes upon the face of box; sand in time will wear it off.

Don't size up your job and guess at the amount of lumber; keep account of the boards as you cut them up.

Don't forget an easy way to figure lumber is multiply the length in feet by the width in inches, by the thickness in inches, and divide by twelve—example: 9 ft. $\times$ 8 in. $\times$ $1\frac{1}{2}$ in. $\div$ 12 = 9 ft.

Don't forget to mark upon the side of core boxes which way lifting hooks for the core are to be placed.

Don't forget to mark the length of standard cores upon pattern when used. This saves the molder's time, as well as the coremaker's.

Don't waste time doing unnecessary work.

Don't spend time and money giving patterns a *piano* finish—they are not used for ornaments.

Don't get into a rut of doing any certain work; try and improve upon your method, as well as lessen the time.

Don't think you know more than the boss, even if you do.

Don't expect the highest wages, unless you can produce the goods.

Don't make a practice of being late to work.

Don't do government work in the Company's time.

Don't keep one eye on the boss and another on your job; it's difficult to watch them both.

Don't take off your apron and look for a chance to wash up before quitting time.

Don't dig ditches in the grindstone.

Don't touch a broken band-saw until the machine has stopped running.

Don't leave the jointer with a heavy cut on; run the table up.

Don't make the final calipering of your work while the lathe is running.

Don't use double-ended turning tools, they are dangerous.

Don't forget that a tooth plane bit makes an excellent turning chisel for straight work.

Don't forget that dowel pins belong in the cope half of pattern.

Don't fail to secure your work well in the lathe either between centers or on the face plate.

Don't stand directly in front of the rip-saw, when sawing; they sometimes kick.

Don't provide bottom boards for core boxes unless necessary; they are often a waste of time and material.

Don't forget to make your core boxes scant in length and width, as cores, when drying, usually sag and swell.

Don't fail to make the necessary provisions for rapping and drawing the pattern.

Don't forget to allow ample material for finishing the casting.

Don't forget to consider how the casting is to be machined, and provide necessary tool clearance.

Don't forget to put in tie pieces when required, to keep castings from spreading or cracking.

Don't fail to consult the molder; his suggestions may be helpful, and we cannot do without him.

Don't forget that the molder will always try to blame the pattern-maker for his own mistakes, if he possibly can, and—

Don't forget that the molder is in a position to show you your shortsightedness, so

Don't fail to consider the convenience of the molder and coremaker at all times.

Don't think that your own time spent in the foundry is wasted; it may or may not be, it lies with yourself.

Don't be too important to do insignificant work.

Don't fail to have confidence in yourself, but

Don't think you are a patternmaker because you have been inside a pattern shop.

Don't lose your head when anything goes wrong; other people have made mistakes.

CHAPTER XIV

STRIKING AN ELLIPSE

Various and curious have been the devices contrived for striking an ellipse, and the fact does not seem to be universally known that the true way is the simplest. Fig. 33 shows how it can be done with the ordinary steel square, or in fact most anything that is handy, having two of its edges at right angles, and a thin stick, say about ¼ x ½ inch, a little longer than one-half the major diameter of the ellipse.

Take the pieces you wish to lay out the ellipse on, mark off the center lines, also the major and minor diameters, transfer the lengths of the semi-major and semi-minor diameters to the stick, driving in

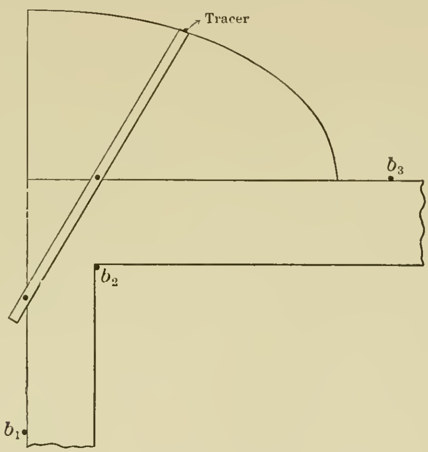


Fig. 33. Striking an Ellipse with a Square

two fine brads at these points. Next, place the square on the center lines, the intersecting outer edges at the center of the ellipse, drive in three small brads as shown in *b*1, *b*2 and *b*3; which will secure the square in position. Then placing the stick in position the two brads, which project through the under side slightly less than the thickness of the square bearing against the two outer edges, move carefully to the right and the tracer will mark out one-quarter of an accurate ellipse. The draughtsman can do the same thing on his drawing by utilizing his set square or triangle and thumb tacks, two pins and a sliver.

Fig. 34 illustrates the same principle, the application being slightly different. Take a piece of wood, large enough to make one-quarter of the ellipse, trim off one end square with one edge, placing the end against the edge of another piece of the same thickness, that is straight on one edge, brad them lightly to the table, taking a narrow strip and driving through it two brads, as stated in Fig. 33, placing the tracer at the end of the stick, draw to the right, allowing the brads to slide

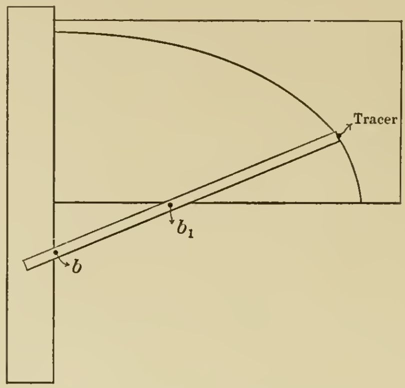


Fig. 34. Device for Striking an Ellipse

closely on the inside edges of the two pieces of stick, and the result is the same as Fig. 33, by simply reversing the pieces you can get the other parts, or you can cut out the quarter and use it as a templet. It is exactly the same as an ellipsograph and just as accurate; but how often do you rub against a patternmaker with one in his kit? Some are minus other things more essential than ellipsograph; but a few brads and a stick are always at hand.

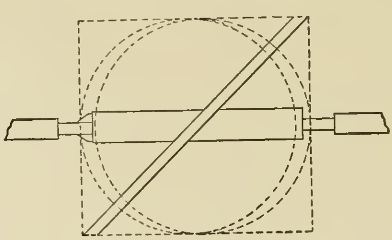


Fig. 35. Turning an Elliptical Valve

Fig. 35 is an illustration of turning up in the lathe an elliptical valve which will fit accurately in a circular pipe at an angle of say 45 degrees. Having the diameter of the pipe which is the minor diameter of the ellipse, ascertain the major or long diameter by laying out the angle; cut out of a piece of stock the required thickness of the valve, an approximate ellipse, leaving sufficient stock on the edges for turning off; then take two pieces large enough to take in the butterfly and tail stock centers and of sufficient length and rigidity, fasten them securely in the center of the piece for the pattern, at an angle of 45 degrees, center the ends and proceed to turn. It is not as difficult as it looks (the dotted lines in sketch showing the exact contour of the edge as the piece revolves), and with a modern screw feed lathe, would be a cinch. This is a very quick way and will insure a perfect fit in the pipe.

Fig. 36 is a fairly good approximate layout of an ellipse by the

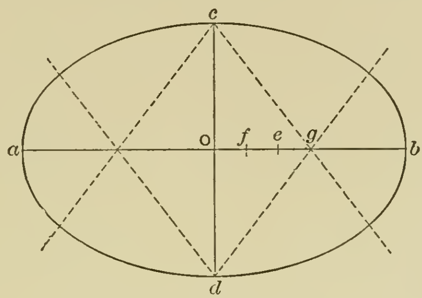


Fig. 36. Approximate Ellipse

divider route, A B is the major and C D the minor axis of an ellipse. Space off B E equal to the semi-minor axis CO, using AE as radius for the arc at each end of the minor axis. Bisect EO at F and space off EG equal to EF and use GB as radius for the arc at each end of the major axis. This is a very good approximate method, very nearly approaching perfection when the difference in length of each axis is not great.

CHAPTER XV

SAWING LAGS

Most patternmakers determine the angle at which to set the fence on the circular saw when sawing lags by trial or by guess. This method is certainly not satisfactory, especially when there is such a simple solution available. In the first place, to get the best results the lags should be made as narrow as is consistent with good work. After the lags have been cut to width and the sides to the proper angle, it is necessary to concave the inner surface. This is usually done by passing the lag diagonally across the circular saw. It must be borne in mind, however, that when cylinders are cut at angles other than 90 degrees the result is the outline of a true ellipse, and hence it is evident that this method would only give an approximately true circle.

To determine the proper angle at which to set the fence on the saw table, a circle representing the saw should be laid off as shown at "A" Fig. 37. The depth of the cut should be laid off as shown at "B"

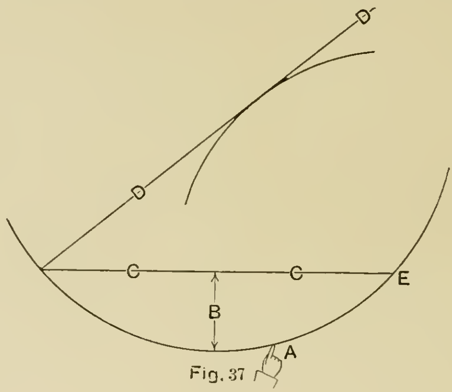


Fig. 37

and the chord "C C" drawn. With one end of the chord "E" as a center and with a radius equal to the inside width of the lag an arc of a circle should be drawn. A tangent as shown at "D D" should then be drawn touching this arc and passing through the other end of the chord "C C." The bevel should then be set at the angle "D D C C," which will be the proper angle to use in setting the fence on the saw table.

If the depth "B" is ¼ of an inch or less, as at "F," Fig. 38, the surplus stock can be removed by a series of cuts over the saw; but if "B" is more than ¼ of an inch, most of the stock should be removed by making the two cuts through the center from the right and left, as shown at "G," Fig. 38, thus cutting out a triangular-shaped piece and preparing the work for finishing in the usual manner.

The best results are obtained by using a sharp saw with a good spring set, and there is nothing to be gained by taking cuts so deep that the stock is partially burned and torn out. It would be best if the last cut does not exceed 1-64 of an inch in depth, providing the cut is

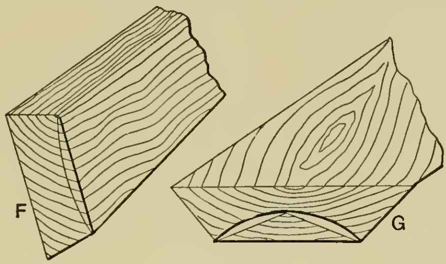


Fig. 38

narrower than the inside face of the lag; for if it is attempted to cut the entire face of the lag, the stock will shift as it is being passed over the saw, settling down after the bearing of the rear portion has been reduced and the front end of the sawed surface comes to a bearing upon the table.

By carefully observing the rules given work can be finished in a superior manner, and there is no better or quicker method of making core boxes of large diameter and considerable length than by building them up of lags upon half heads.

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