Pattern Making

J. G. HORNER.

THE PRINCIPLES OF PATTERN MAKING

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WRITTEN SPECIALLY FOR APPRENTICES, AND STUDENTS IN TECHNICAL SCHOOLS

BY

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"LOCKWOOD'S DICTIONARY OF MECHANICAL ENGINEERING TERMS,"
"PRACTICAL IRONFOUNDING," "METAL TURNING,"
"THE AMATEUR'S WORKSHOP," "TOOTHED GEARING," ETC.

ILLUSTRATED WITH ONE HUNDRED AND ONE ENGRAVINGS

AND INCLUDING A

GLOSSARY OF THE COMMON TERMS EMPLOYED BOTH IN PATTERN MAKING AND MOULDING

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PREFACE.

This volume has been written in order to enable apprentices, and the students in our technical schools to grasp the principles or elements of the trade of the engineers' pattern maker. The examples illustrated are selected, therefore, as being in the author's opinion, of the best and most suitable types, from the wide range of patterns of diversified forms made in our shops. Principles once grasped, details and modifications are relatively easy. This is the reason then, why, instead of describing a number of patterns at random, I have first laid down the principles which underlie the craft, and then treated my subject under the heads of moulders' joints, and constructional joints—most important and fundamental matters—and have then taken (Chapter V.) one good example only of a pattern which illustrates in an excellent manner the subject matter of Chapters III. and IV. Following this, I have made gear wheels the occasion for giving practical examples of the same subject matter. I have also given some attention to machine-moulded wheels, comprising in a brief outline a description of the parts which the pattern maker has to prepare. Remarks on swept-up work, and some miscellaneous examples of patterns follow, and the book concludes with a chapter on pattern turning

The Glossary of terms embodied in the Appendix should prove of especial value to those who have as yet had no experience in the pattern shop or foundry.

In order to produce the book at a cost which will place it within the reach of all, much condensation of descriptive matter has been necessary, but I have made most of the illustrations almost self-explanatory by the introduction of suitable shading. I think I have therefore contrived to say as much about the essentials of my trade as could well be said in the compass of a small volume; and I offer it to my readers in the most perfect confidence of its accuracy, and I believe and hope, utility.

J H.

CONTENTS.

LIST OF ILLUSTRATIONS

PRINCIPLES OF PATTERN MAKING.

CHAPTER I.

FIRST PRINCIPLES, AND MATERIALS.

In so small a volume as this it is quite impossible to attempt much of detailed description of patterns of various types. I shall therefore explain and illustrate only **fundamental principles** of the trade, so that my readers shall be able to obtain a comprehensive and correct idea of the essentials of this particular craft, without being overburdened with details,—details which can only be properly gathered in the shops. I shall therefore not so much seek in this volume to show how particular patterns are made, for I can take but a few out of an infinite number, but I shall deal with the principles that underlie the construction of all patterns.

Pattern making and moulding are so intimately connected, that it is impossible to describe one without making frequent reference to the other. There is almost as much of pattern work learned in the foundry as there is in the pattern shop. This will explain the frequent references to foundry practice which will occur in this volume. So intimately connected in fact are the operations of pattern making and moulding, that one of the chief qualifications of a good hand is the ability to form a rapid and reliable judgment as to the best method of moulding a given pattern, out of perhaps several methods possible. An experienced man will "see through" a job at once, with an almost unerring instinct. But so many matters have to be borne in mind, that it is almost needless to say that this faculty can only be the result of long experience. Such matters as the relative difficulties, cost of moulding, the cost of cores, the soundness of faces that have to be machined, the strongest method of construction, among other lesser details, have to be considered when forming a decision. Pattern making being therefore regarded primarily from the standpoint of the moulder, and only secondarily from that of the wood worker, the following matters are of first importance. (1) Patterns being rammed and entirely enclosed in matrices of sand, due provision must be made for the withdrawal of those patterns. This involves *taper*, or a thinning down of certain portions; division into sections, or *jointing*; *loosening*, or rapping; and provision for *pulling out*. (2) Since metal shrinks in cooling down, moulds, and therefore patterns, have to be made *larger* than the cooled down castings, by the amount which castings shrink in cooling down from the temperature of molten metal. As different kinds of metals and alloys have different coefficients of contraction, much care has to be taken to allow due amounts for shrinkage in various patterns. (3) Since moulding sand is always used damp, and since patterns are used roughly during the rapping and pulling them out of their moulds, provision has to be made in their construction against *distortion and fracture* due to moisture and rough usage. This involves constructive details for diminishing the effects of moisture, for insuring the maximum of strength and permanence of form, and it also includes the selection of material most suitable for any given work. (4) Patterns may be entire and *complete*, being then precisely like the castings taken from their moulds, or similar, except for the presence of prints, which represent hollow cored out spaces. Or they may be *sectional*, representing a small portion only of the actual mould and casting. Or instead of complete patterns, or sectional portions of the same, *striking* or *sweeped boards* may be used for sweeping up moulds of forms that can be suitably made from profiled edges. These main divisions, I think, embrace all examples of pattern work that can arise. (5) The practice of pattern work is governed by the requirements of the engineer, as well as by the conditions of moulding and construction, and these conditions separate it in nearly all essentials from other wood-working trades. A pattern maker is an engineer, that is, he should be, and has little in common with carpenters, cabinet makers, and wood turners, notwithstanding that he employs many tools and performs many processes in common with these. Therefore, to understand the fundamentals of pattern work aright, we must not only master the principles of moulding and much of its detail as well, but must remember that mere finish and polish can count for little in the absence of correct *construction.* From the engineer's point of view, the primary requisite is to make the pattern to correspond with the drawing given, to see that dimensions and centres are all correct, and to give such allowances as are required for turning, boring, or other machining. In order to do this it is necessary to understand the principles of orthographic projection, and, in all intricate work, drawings should be made to full size on the workshop drawing boards. Beyond the fact that pattern work is mostly done in wood, and that therefore pretty much the same tools and processes are employed as in the practice of carpentry and wood turning, there is no similarity between this work and that of the carpenter and wood turner. A pattern maker must of course possess skill in the use of wood workers' tools, but to that skill he must add a comprehensive knowledge of foundry practice, and of the practice of the machine and fitting shops, and further of the relations and functions of the several parts of motors and mechanisms. In short, the wider the grasp which a man has of general engineering practice, the better, the more complete he will be as a pattern maker. It is therefore a trade which taken in its broadest bearings opens up an unlimited field of interest, one in which a receptive man may be ever learning, one in which there is little repetition or monotony, one eminently suggestive and fascinating.

By far the largest number of **patterns are made in wood,** a material which is very susceptible to the influence of moisture. It might appear as though wood ought to be the last material employed in a sand matrix, which is always damp, and for a purpose where rough usage incidental to the ramming and rapping which are necessary for moulding and withdrawal is essential. But there are several reasons why wood is used. It is cheap, easily shaped or altered, is light, portable, and by the adoption of several precautions the evils incidental to its weakness and porosity may be partially and largely counteracted. Yellow pine is chiefly used for patterns because it is the only material which is at once cheap, readily available, and tolerably permanent in form. Mahogany stands rather better, and is stronger and more durable, but is too expensive for any but select and small work. Both pine and mahogany are straight in the grain—an important point for facility of working, and having less liability to warp and curve than crooked grained woods. Red deal is cheaper than yellow pine and answers well enough for the rougher kinds of patterns, and for core box frames, but it should not be employed for the best work. Spruce and white deal, though very cheap, should be discarded altogether except for very temporary and rough patterns, because they are harsh in grain and very unstable. Elm is used for foundry strickles, being a wood which stands the wet loam very well. For large strickles, but for nothing else, pitch pine also may be used.

It seems almost unnecessary to say that no precaution should be spared to guard against **change of form in patterns,** due to want of seasoning. Not only should the material be well seasoned in board by stripping, but also just previous to working up into a pattern, as much opportunity as possible should be afforded to it to warp or shrink to the full extent of any such tendency still remaining in it. All stuff will "go" or become "cast" to some extent on being cut out of board, and therefore it is best when practicable, and when time will allow, to saw out and plane over all the stuff for a pattern or for a set of patterns, before cutting to final outlines and fitting together. Forethought of this kind will often save lapping joints and shrunk dimensions subsequently.

The chief disadvantage of the use of a wood for some kinds of patterns—those for example which are much curved in outline—is the difficulty of obtaining straight and continuous grain; cross grain being inherently weak, and liable to fracture, and to alteration in form. Then in these cases it is usual **to build up,** arranging the grain in such a fashion that one series of segments shall bind its fellows. Where this cannot be done, metal is used for patterns; iron when of moderately large dimensions, brass when small. To obtain many forms, involving curved and ornamental outlines, lead, or plaster of paris, or modelling clay are used, being seldom moreover employed for permanent service, but for the temporary purpose of obtaining a mould from which to cast the actual pattern in iron or in brass. Iron, gun metal, white metal, lead and tin are variously used for such patterns. Iron and gun metal are employed when patterns made of timber would be too inherently weak to stand the rough usage of the foundry for any considerable time. Metal patterns are mostly of small size, when large they are of a very slender or ornamental character. In either case temporary patterns of wood or other material have to be made first, *double shrinkage* being allowed. The metal patterns require a deal of filing and cleaning up before being fit for use, and although a roughly made pattern suffices from which to mould these, yet as much regard must be paid to accuracy in the first as is required in the second. Iron patterns are *rusted*, with a solution of sal-ammoniac in water, previous to being varnished. Without the slight roughing up of the filed and polished surfaces effected by rust, the varnish or beeswax would not be retained on the surface of the metal. The slight roughening favours adhesion, and prevents the formation of rust in quantity. Gun metal is usually left unvarnished, or the blacklead brush simply may be brushed over it. The white metals are sometimes used for patterns and core boxes, as being cheaper than gun metal. But they lack the rigidity of the latter, and are therefore best employed for those of a solid character, and for core boxes. Lead, and the mixtures of tin and lead, are employed when patterns have to be bent to outlines that could not be readily cut in wood, these patterns being either moulded from directly, or used to cast patterns from in the more rigid cast iron or gun metal. For special purposes the plastic modelling clay, plaster of paris, and leather are found serviceable. They have however a very limited use in constructive engineering, being most valuable in ornamental work.

CHAPTER II.

TOOLS.

I CANNOT occupy much space for the description of the tools used in pattern making without encroaching too largely upon matters of construction. Yet it seems to me that to say to a youth that much the same tools are used in this trade as in carpentry, cabinet making, and wood turning, is not quite what the youth, who is approaching the subject for the first time, would look for. I will therefore offer a few remarks on the essential tools employed in pattern work, which, if I were writing for skilled workmen, would be superfluous. Those remarks will be rapid and concise, but they will embody the sure experience of many years. I will also note in brackets the average cost of each tool, the prices being always those for which thoroughly good tools can be purchased.

Saws.—If one large saw only is kept, the "hand saw" (4*s.*), is the most useful. Its length is 26″, the number of teeth to the inch averages about five, and it is set moderately coarse, to be serviceable both for ripping and for cross cutting. If a second saw is afforded, the choice will lie between a *half rip* (6*s.*), 28″

long, with four teeth to the inch, and a *panel saw* (3*s.* 9*d.*), 18″ or 20″ long, with about seven teeth to the inch. If the character of the work done is generally heavy, the half rip will be the more suitable, because stuff can be sawn down more rapidly with it in the direction of the grain than with the hand saw. If the work is light, the panel saw will be very useful for cutting ends and halvings, and doing work which the tenon saw would effect more slowly. A brass back *tenon saw* (4*s.* 6*d.*), 12″ long, and a *dovetail saw* (3*s.* 9*d.*), 6″ long, are required. Finer, more delicate and exact sawing can be done with these than with the others, and those with brass backs are slightly preferable to those with iron backs because of their greater weight. A *keyhole saw*, with "pad" or handle (2*s.*), a compass saw (1*s.* 6*d.*), and a *bow* or *turning saw* (4*s.* 6*d.*), 12″ long, are used for cutting sweeps and holes. For setting the saws, a plyer set, or preferably a setting hammer and block, are required, and for sharpening them, the three square files. I cannot stay to describe how these operations are performed.

Planes.—The *jack plane* (5*s.*), 17″ long, with cutting iron $2\frac{1}{4}''$ wide, is used for removing the rough outside from boards, and for reducing the bulk of the thickness. Its iron is slightly convex, say $\frac{1}{16}''$ in the transverse direction, in order to facilitate its freedom of action. The *trying plane* (6*s.* 6*d.*), 22″ long, with cutting iron $2\frac{1}{2}''$ wide, is employed for finishing surfaces, edges and ends to the highest degree of accuracy possible. It is the only plane which will produce perfect accuracy, and in order to this it is essential that its sole or face be kept true by occasional facing up, or "shooting," with another plane, that the iron be sharpened without any sensible convexity, that the top iron is kept screwed close down, or say within $\frac{1}{64}''$ of the cutting edge, and that the bedding of the iron upon its seating, and the fitting of the wedge, be practically perfect. The *smoothing plane* (3*s.* 6*d.*), 8″ long, with a 2″ or $2\frac{1}{8}''$ iron, is used for planing ends, edges, and surfaces of small area, where the most precise accuracy is not essential. It is a useful tool, because it is held easily in one hand, leaving the left hand free to manipulate the work. It is, however, of no value when very accurate work is required, because, being so short, its guidance is correspondingly reduced. Its iron is sharpened, and its top iron set in pretty much the same manner as the trying plane iron. The *rebate plane* (2*s.* 6*d.*) is used for planing narrow surfaces which are set down below the face of a board. Since the iron is flush with the edges of the plane, instead of being enclosed by wood at the sides, the material is removed in exact line with those edges. It is employed mainly for shouldering one piece of stuff into another, as in Figs. 21, 22, p. 37. A *skew-mouthed plane* works sweeter than one which is square in the mouth. These planes range from $\frac{1}{2}''$ to $1\frac{1}{2}''$ in width. One of about $1\frac{1}{4}''$ in width is the most generally serviceable. *Round planes* (2*s.* 6*d.*) of various curvatures—the curvatures being indicated by numbers from 1 to 18—are useful for planing hollows or fillets, and for mouldings. Four or five of these are quite sufficient. Hollow planes are scarcely used, neither are any of the various moulding planes employed in joinery. An *old woman's tooth* (2*s.*) is, however, useful for letting in rapping and lifting plates, because it will plane the bottoms of the recesses at a uniform depth from the face of the stuff. For working large concave sweeps a *compass plane*, or plane with convex face (4*s.*), and with an adjustable stop at the front end, for the purpose of adjusting the sole of the plane to any curvature, is used. It is of about the same size as the smoothing plane. The *spokeshave* (1*s.*) is used for working small curves, rounding edges, etc. It is not an accurate tool, but finishes a surface cleanly, and with rapidity. Of the *iron planes* I need say nothing. All the forms I have named, and many others, are obtainable in iron. They are, however, but sparingly used in pattern shops, being of more value to cabinet makers and amateurs. An iron smoothing plane and a bull-nosed plane are, however, very commonly found in pattern makers' kits.

Bench Chisels and Gouges.—These are of two types, the "*paring*" and the "*firmer*," the first being long, the second short. The first are thrust to their work mostly by the pressure of the hand; the mallet is used largely upon the latter. The upper edges of both types of chisels are sometimes bevelled in order to permit of their free entry into dovetailed grooves. The paring tools are quite indispensable to the pattern maker, because blocks have frequently to be cut to various outlines across a width of several inches, over which the firmer tools would not reach. There is more freedom of movement possible also with these long tools than with the short ones, rather less stooping over the work being required. The short ones are, however, very valuable for roughing down and removing material in quantity, with the aid of the mallet. The paring chisels and gouges are made from $\frac{1}{4}''$ in width to $1\frac{1}{2}''$, advancing by eighths of an inch. Useful sizes are $\frac{1}{4}'$ (7*d.*), $\frac{1}{2}''$ (9*d.*), $\frac{3}{4}''$ (10*d.*), $1''$ (1*s.* 1*d.*), $1\frac{1}{4}''$ (1*s.* 6*d.*), $1\frac{1}{2}''$ (1*s.* 10*d.*). Each width of gouge is made in three curvatures, the *flat*, the *middle flat*, and the *quick*. Useful sizes are $\frac{3}{4}''$ flat (1*s.* 4*d.*), $1\frac{1}{2}''$ flat (2*s.* 4*d.*), $\frac{3}{4}''$ middle flat (1*s.* 4*d.*), $1\frac{1}{4}''$ middle flat (2*s.*), $\frac{1}{4}''$ quick (11*d.*), $\frac{3}{8}''$ quick (1*s.* 2*d.*), $\frac{1}{2}''$ quick (1*s.* 3*d.*), $1''$ quick (1*s.* 7*d.*), $1\frac{1}{4}''$ quick (2*s.*).

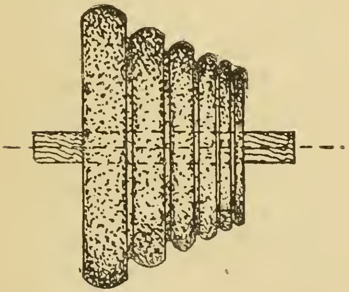


Fig. 1.

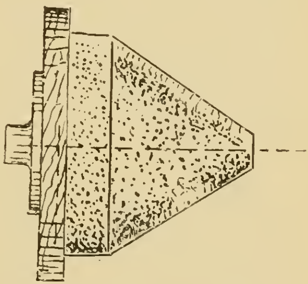


Fig. 2.

Grindstones for Paring Gouges.

The **paring gouges,** being ground upon their *concave* curves, require properly a **special stone** for that purpose. The flatter gouges are frequently ground upon the edge of an ordinary stone. But it is difficult to form a regular facet in this way. Hence stones of the forms shown in Figs. 1 and 2 are employed. These are turned down from small blocks of broken grindstone. In the first, Fig. 1, which is mounted upon a wooden mandrel and run between lathe centres slowly, there are a number of convex edges, upon which gouges having a wide range of curvature can be ground, for flat gouges can always be ground easily upon edges which are quicker than their own radius. In this the tools are held at right angles with the axis of the stone. In Fig. 2 the stone is turned conically, and cemented upon a face plate, also run in the lathe. The various curvatures for grinding different gouges are obtained by holding the tools at the different zones which correspond with their curvatures, quick or flat, as the case may be, the axis of the tool being held in parallel line with the axis of the grindstone.

Firmer Chisels and **Gouges** are sold in sets of a dozen each, ranging from $\frac{1}{16}''$ to $2''$ in width. Chisels of useful size are $\frac{1}{16}''$, $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, $1''$, $1\frac{1}{2}''$, at prices ranging from 5*d.* to 1*s.* 3*d.* Useful gouges are $\frac{1}{4}''$, $\frac{3}{8}''$, $\frac{1}{2}''$, $\frac{3}{4}''$, $1''$, $1\frac{1}{2}''$, at prices ranging from 6*d.* to 1*s.* 4*d.* each.

Turning Tools.—The pattern maker has to do a good deal of wood turning. But few tools are required for this. They consist of the gouges, chisels, side tools, diamond points, and the round-nosed tools. Of the *gouges*, two, or at the most three, are commonly sufficient, one $1''$ wide (2*s.* 2*d.*), for heavy roughing down of work, one $\frac{5}{8}''$ wide (1*s.* 6*d.*), for commonest use, and one $\frac{1}{4}''$ wide (11*d.*), for small and delicate work. Of the *chisels*, there may also be three of the same widths, and costing respectively 1*s.* 2*d.*, 10*d.* and 8*d.* The side *tools*, or diamond points, are ground right and left handed, and are used for finishing broad faces, both internal and external, against which the common chisels cannot be brought to operate. They are sold ground to these shapes, but most pattern makers use old files for the purpose. Coach maker's chisels ground to suitable angles, form excellent diamond points, because, being thicker than ordinary chisels, they are very rigid. The same remark applies to the *round nose tool* which is used for finishing turned hollows on bosses, the concave parts of mouldings, and filleted parts. Both diamond points and round nose tools should be kept in two or three sizes, ranging say from $\frac{3}{4}''$ wide down to $\frac{3}{8}''$. These tools are handled with specially *long handles* shown in Fig. 89, p. 114, and Fig. 92, p. 118. Illustrations are given on the same pages for their mode of use. For roughing down wood for the lathe, as well as for the bench, the axe or hatchet (2*s.*) is essential.

Boring Tools.—First, there is the *brace and bits.* These may be bought at all prices between about 8*s.* and 32*s.* An iron brace, with from eighteen to twenty black bits, will cost the first named sum; an ebony brace, with thirty-six straw-coloured bits, will cost the second. Before attempting to sharpen centre and nose bits which have become dull by use, it is best to ask a practical workman how to do it, because those bits can be spoiled completely by error in sharpening. I strongly recommend the purchase of a few *auger bits,* costing on an average about 1*s.* 6*d.* each. They will bore into any way of the grain much more cleanly, quickly and accurately than the common centre bits, and if used carefully will last for many years. Half a dozen assorted *brad awls*, at about 1*s.* 4*d.* a dozen, handled, and as many *gimlets*, at about 2*s.* a dozen, are wanted. I think the shell form of gimlet is preferable to the twist, as being less apt to split the stuff in short grain.

Hones.—The best and cheapest hone in my opinion is the *Charnley Forest.* The more costly Washita and Arkansas stones are sold extensively, but I prefer the other for bench tools. It is neither too hard nor too soft, it does not become scratched, and the tool "hangs" to it just as it should do. The same of course applies to *gouge slips*, sold at about 6*d.* each, therefore have these of Charnley Forest.

Tools for measurement and test. Two *rules* are required, an ordinary, or *standard* (2*s.* 6*d.*), and a *contraction rule* (2*s.* 6*d.*). The first is employed for measuring castings, the second for making patterns by. Each of these rules may be bought in wood, and in steel, either two feet long, and unjointed; or two feet long, "two-fold," that is with a single joint. The first are better for bench use, the second are more convenient to put in the pocket when going out to take dimensions of work. The contraction rule may also be had doubly divided, that is, divided down one edge for brass contraction; and on the other for iron. This is convenient, provided one edge is not used instead of the other by accident. It is safer to keep two separate rules, one for brass, the other for iron. Iron *castings shrink*, on an average, $\frac{1}{8}''$ in $15''$, brass $\frac{1}{8}''$ in $10''$, steel $\frac{1}{4}''$ in $1' 0''$. But the pattern maker soon learns that these are only averages, and part of his skill consists in modifying the skrinkage allowances in different classes of castings, allowing more for some, less for others, as suggested by previous experiences.

A scale, or scales (2*s*. 6*d*.), open divided, are essential for taking dimensions from drawings which are made smaller than the work delineated. *Open divided*, means that only the end primary divisions, that is those corresponding with the foot, are subdivided into divisions corresponding with the inch; leaving the central primary divisions undivided. Dimensions can be read off more quickly and readily with these than with fully divided scales. More scales will be wanted of course, but it is better to buy two, or even three, open divided scales, than one fully divided, universal scale. The most useful scales for pattern makers are those corresponding with $\frac{1}{2}''$, $\frac{3}{4}''$, $1''$, $1\frac{1}{2}''$, $2''$, $2\frac{1}{2}''$, and $3''$ to the foot, respectively. These will be contained in two open divided scales. For dividing out work, marking centres, and circles, the compasses, dividers, and trammels are used. The *wing compasses*, from $6''$ to $7''$ long (2*s*.) are best; *spring dividers* (2*s*.) should be strong, and from $4''$ to $5''$ in length. Of *trammels*, there may be two sizes, large, and small, ranging from (3*s*. to 6*s*.) per pair. Workmen usually make their own trammels. For gauging stuff to thickness, the small *bench marking gauges*, made by the workmen, are essential. *Cutting*, and *mortice gauges*, are not wanted, but a *long toothed gauge* (Fig. 3), also made by the workman, is necessary for sweeped work, and for marking lines on faces upon different planes. Either the flat or the sweeped face of the gauge is used, as required, for flat or for sweeped work, and the marker is adjustable for height, being tightened by the wedge. *The timber scribe* (6*d.*) is used for marking centre

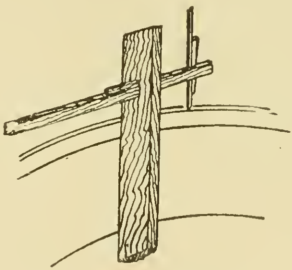


Fig. 3. Long-toothed Gauge.

lines, end lines, and working lines generally upon timber, as guides for cutting and planing by. Pencil lines are never used for such purposes, being neither accurate enough, nor permanent. The *straightedge*, and *winding strips* are employed for testing the accuracy of stuff that is being planed. These are made by the workman. For testing angles the squares and bevels are employed. The most useful *try squares* for the pattern maker are the 12″ (3*s.*), and the $4\frac{1}{2}''$ (1*s.* 4*d.*). *Set squares* of wood are made by the workman to angles of 45°, and of 30° and 60°, respectively. These are in constant service. A *sliding bevel* (2*s*. 6*d*.) can be set to any angle by means of a protractor, and employed for planing edges and ends. A *centre square* (Fig. 4), made by the pattern maker, is used for finding centres of circular work at once, without compasses. It is extremely useful. *Inside, and outside* calipers, one pair of each (9*d*.), are in perpetual request. A

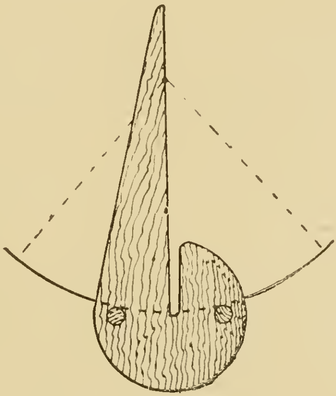


Fig. 4. Centre Square.

pattern maker's *hammer* (1*s*. 6*d*.), a *mallet*, made by the workman, two *screw-drivers* (1*s*. 6*d*.) and (10*d*.), and a pair of *pincers* (1*s*. 6*d*.), complete the kit of the pattern maker.

The selection of tools given in the foreg ing list is an average one. Thus, a youth on going to the trade may begin with one fourth, or even one third less tools than I have named. A workman who takes a pride in his trade will soon accumulate double the number. Many tools and appliances, however, will have been made by himself.

I can make no reference to the methods by which the tools are kept in **working order,** their accuracy tested, and to their modes of operation. These matters would occupy the whole of this volume. My readers must learn these in their shops and schools. In such matters, as well as in the purchase of the first kit of tools, it is well to enlist the kind services of a honest workman, for in tools as in other goods there is some rubbish sold. Failing this, go to a firm whose reputation is above suspicion.

CHAPTER III.

JOINTS FOR MOULDING.

The jointing of patterns is a fundamental matter. It has to be considered from two points of view; that of the moulder, and that of the wood worker. The first named is concerned with delivery from the sand, the second is constructional. I will treat of the first in this chapter, and of the second in the chapter succeeding.

The problem of the **best methods of jointing,** in order that patterns shall deliver from their moulds, is this:—When a pattern has been rammed up, and entirely enclosed in sand, how is it to be withdrawn with the least possible damage to the mould? In all but the plainest work, some jointing of the moulds is necessary to effect this, and corresponding jointing of the pattern. I will illustrate these points by the aid of common figures.

The **bracket casting** (Fig. 5), is an example of a plain casting, moulded with the minimum of trouble. There is only one joint in the mould, that along the plane A–A, the cope or top part of the mould occupying the position B, and the drag or bottom part is represented by C. The pattern is withdrawn vertically in the direction of the arrow. Clearly, now, the main condition of delivery of the pattern from the sand, is that the lowermost portions in C shall be a little smaller, a little thinner than those in the uppermost portion. This is the *taper* of patterns. I have shown this taper in the figure at A A, representing the foot of the bracket pattern, and at B B, representing a

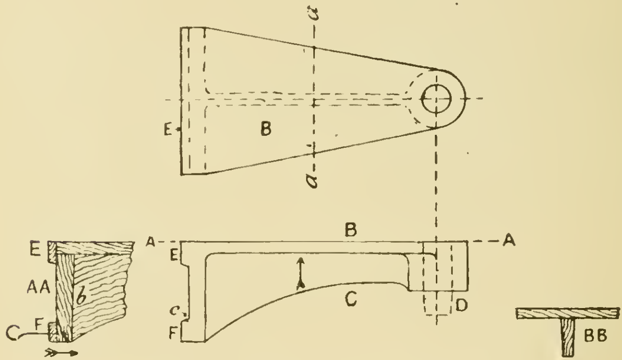


Fig. 5. Casting of a Single Bracket.

cross section taken at *a–a* across the middle of the bracket. As the pattern is being lifted from the enclosing sand, the thinner, lowermost portions of these webs become disengaged from the flanking sand, and do not drag against, and tear it up. The amount of this taper depends on the size and class of work. For ordinary patterns, an $\frac{1}{8}''$ per foot of depth may be considered an average amount. In the case of faced portions, the taper is given wholly, or almost wholly, to the inner faces, as at *b*, at A A. In ribs that are not working parts, the taper is symmetrical, as at B B, which is a section taken across the line *a–a*. There is a hole in the boss of the bracket. This is cored out, the core being placed in the impression formed by the print D, the position and taper of which are shown dotted in the figure. More taper is imparted to prints than to patterns. At EF are shown *chipping strips*. While there is nothing to prevent the free delivery of E, it is clear that F will not deliver if fastened to the pattern, because withdrawing the pattern with the strip F fastened to it, would tear up the overlying sand at *c*. This strip is therefore, wired, or *skewered on*, loosely, as shown at A A. The skewers are withdrawn, as soon as sufficient sand is rammed round F to prevent any alteration in its correct position, and on the withdrawal vertically of the main pattern, the strip is left behind, to be subsequently withdrawn in the direction of the horizontal arrow into the space left by A A, through which space it is taken out from the mould. This is an example of *loose pieces*.

The **double bracket** (Fig. 6), affords an example of *loose pieces* of another type. It is a duplication of the bracket in Fig. 5. In a good pattern, the upper portions would be made loose or detachable from the lower part; that is, the parts which come into the cope would be dowelled to the part which comes in the drag, and be lifted off with the cope sand, to be withdrawn afterwards, instead of the cope sand being lifted away from those parts. Thus, if A–A represented the moulder's joint, the parts above A–A would be dowelled to the parts below that plane. If the moulder's joint were carried round from B to A, as shown by the dotted lines, then C and D only would be dowelled, the foot E remaining in one piece, with the strips F G skewered on. If the moulder's joint were carried round from B to H, as shown by the fine shading, then the rib C only would be dowelled, and the foot E and boss

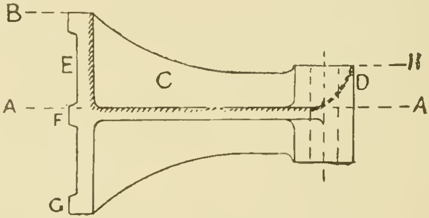


Fig. 6. Casting of a Double Bracket.

D remain fast. Each of these are equally common methods, and the moulder's choice of method is decided sometimes by the way in which the pattern happens to be made, sometimes by the kind of flask he has available.

Fig. 7 is an example of a large and typical class of work. It is a **trolly wheel,** with a single flange. No joint is necessary in the pattern, although as a rule it is desirable to dowel on the boss A that comes into the cope. A little taper is imparted to both outside and inside of the rim, as shown by the prolonged dotted lines. The moulder's joint, between cope and drag, is made along the line B–B. The print for the

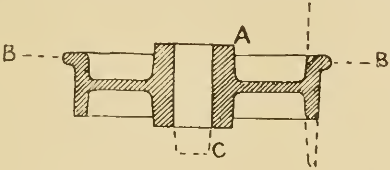


Fig. 7. Casting of a Trolly Wheel.

central hole is shown dotted at C. In the *double flanged trolly wheel*, Fig. 8, B–B corresponds with the similarly lettered joint in Fig. 7, and there is an additional one, C–C, between the middle part and the drag. The space D is therefore that occupied by the

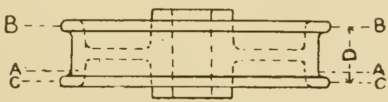


Fig. 8. Casting of a Trolly Wheel—double flanged.

"middle part." The joint of the bottom flange in the pattern is made along the line A–A, so that the portion between C and A comes into the middle part. The taper of the wheel is like that in Fig. 7.

Fig. 9 is a **worm wheel,** an example of a casting which is moulded in cope, drag and middle, and for which the pattern is divided along the middle plane. The moulder's joints are made along A–A, B–B, corresponding with the extreme tooth points; D being therefore the thickness of sand in the "middle," and the pattern is jointed along C–C. The whole of the teeth E E therefore come into the middle sand, and are withdrawn from it in the direction of the arrows.

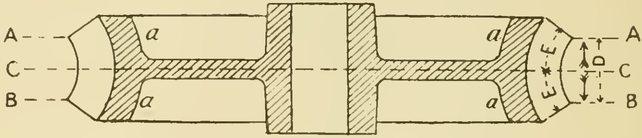


Fig. 9. Casting of a Worm Wheel.

Except the middle joint C–C, there is nothing made loose, and the inner curves *a a a a* of the rim afford abundance of taper.

Fig. 10 is a **sheave wheel.** The moulder's joints are at A–A, and B–B, and the pattern joint at C–C. There are no loose parts. Such a wheel, especially when recessed out for the individual links, is not unfrequently made without a jointed pattern, and with cores. In such a case, the internal portions of the rim, the boss, and the plate are made of the correct shape of the casting, but a print, seen dotted and shaded at D, is

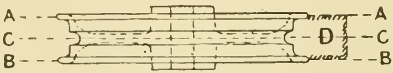


Fig. 10. Casting of Sheave Wheel.

substituted for the recessed rim, and a segmental core box is made to the section of the sixth, or eighth part of the rim, and to fit the print. This saves expense, if but one or two castings are required.

Fig. 11 is a double shrouded **bevel wheel**. Evidently the sand at *a* and *b* would prevent the delivery of an unjointed pattern. In the pattern, therefore, the top

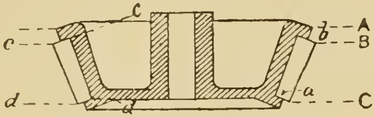


Fig. 11. Casting of Bevel Wheel.

shroud is jointed along the line *c–c*, and the bottom shroud along the line *d–d*. The moulder's joints are three in number, along A, B, C.

Fig. 12 is a **double armed pulley**. The rim B is in one piece, and the cope joint is made along the line A–A. The outside of the pulley rim B is moulded entirely in the drag or bottom part of the mould, lifting therefrom through its entire depth B. But the internal portions of the rim, with the arms and bosses, are made in separate *cores* of green or of dried sand. There are three cores, C, D, E, necessary to form these internal portions, jointed at the middle planes of the arms F, G, and at the top and bottom edges of the rim. The two sets of arms F, G are made separately in the pattern, and loosely detached from the rim B, being set in position by the moulder. The middle boss is also made in three pieces, H, J, K, pinned to the arms. Prints, shown dotted at L, L, carry the central core.

Fig. 13 illustrates a **branch pipe**. If it were not for the occurrence of two branches, with flanges at A and B, at right angles, the pipe would be moulded in a single

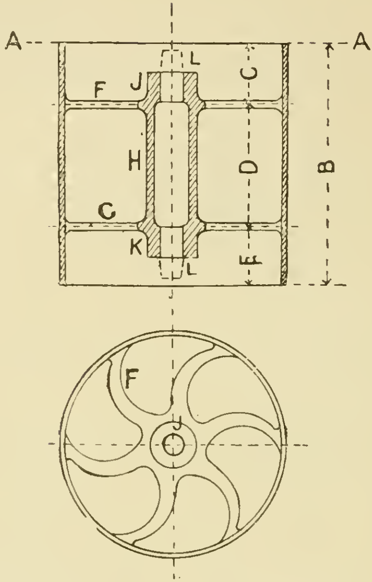


Fig. 12. Casting of Double Armed Pulley.

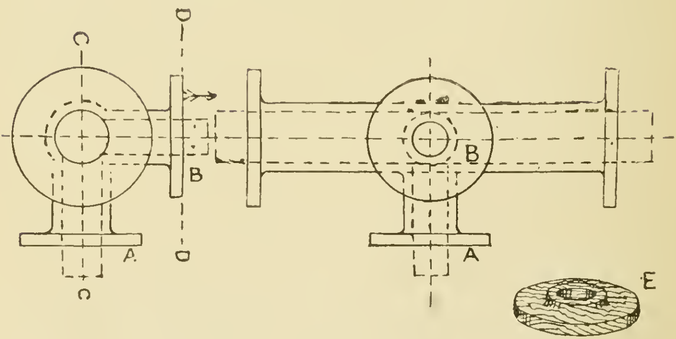


Fig. 13 Casting of Branch Pipe.

jointed mould, the joint being along the plane C–C. But the occurrence of the flange B necessitates another joint, at D–D, to leave an open space for the withdrawal of the flange in the direction of the arrow. Such a joint as this may be formed in a separate flask, but more frequently with a piece of loam cake. The details of this, however, do not concern us here. The jointing of the flange B to its branch is usually made in the manner indicated at E in the figure. The prints for the main pipe and branches are seen dotted.

Fig. 14 is an illustration of a cast iron base, for the

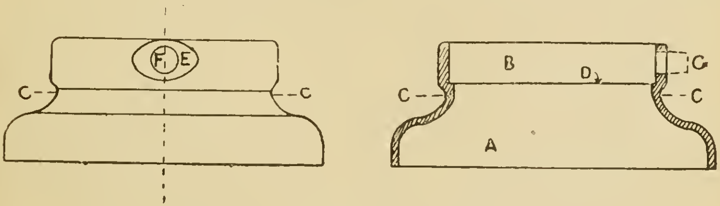


Fig. 14. Casting of Chimney Base.

chimney of a vertical boiler. The portion A surrounds the uptake, and B receives the bottom of the chimney. The pattern is divided along the plane C–C, and the moulder's joint is made along this upon the outside, and along the shoulder D on the inside. A gland-shaped facing E receives the flange of the blast pipe which passes through the hole F. The facing E is skewered on the side of the pattern, and a print G carries the round core.

Fig. 15 shows the section of a corner tank plate. The moulder's joint is at A–A. As the flanges B B will not lift with the pattern in the direction of the arrow, they are left loose in the bottom of the mould. During ramming they are retained in place with screws, shown at C, which are withdrawn after the lifting of

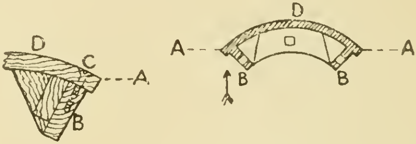


Fig. 15. Casting of Corner Tank Plate.

the cope. The curved plate D is then withdrawn, and the flanges B are afterwards taken out separately at the angle in which they lie.

Fig. 16 shows a double flanged **steam chest,** with stuffing box A, and branch B, for steam inlet. The joint of the cope is along the plane C–C, and the joint between the middle part and the drag is along the plane D–D. But the joints of the flanges of A and B are made along the plane E E, that is along the centres of the flanges and of their prints. So that from the edges *a a* outwards there is a sloping joint made from C C downwards to the centres of the flanges. The directions of these curved joints are shown at *b*, *b*. It will be noticed that the upper halves of the branches, above the centre line E–E, are carried straight up to facilitate delivery. This is shown at F in the figure. The alternative to this is shown at G. In this latter case the branch cannot be lifted vertically with the top part of the pattern, because of the sand at *c c*, but must be kept loose and drawn backwards. The prints for the holes in the stuffing box and branch are shown dotted at H H. Usually the top halves of the branch flanges are made to lift freely with the top sand. This is shown

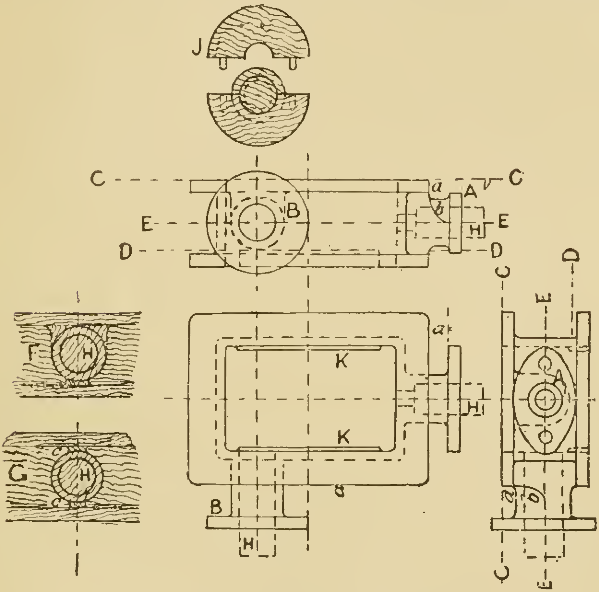


Fig. 16. Casting of Steam Chest.

at J. If made fast, the sand would become torn on being withdrawn from them. The guide strips K K, for the slide valve, are skewered on loosely and withdrawn sideways, because the sand overlying them would prevent them from being lifted with the body of the pattern.

Fig. 17 is a **counterbalance weight** for a lever. There is a rectangular hole through it. This pattern is withdrawn from the sand in the direction of the arrow, and the moulding joint is made at A–A. A *pocket print* or *drop print* is used to carry the core. The print is shown dotted, at B B. It is deeper than the thickness of the core, being brought up to the joint face A–A, and the upper part of the print impression is filled up, or *stopped over* the core. The alternative to

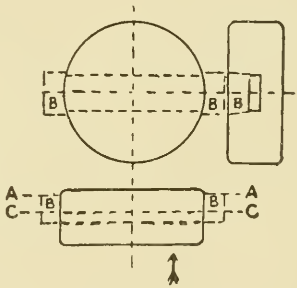


Fig. 17. Casting of Counterbalance Weight.

this would be to make the print of the same thickness as the core, in which case its top face would terminate at C–C. Then no stopping over would be requisite, but the cope sand would have to be jointed down to C–C, against the perpendicular sides of the pattern, which is not desirable.

Fig. 18 is a **weight** with a wrought iron eye A cast in it. This necessitates the use of a core. The print is shown dotted at B, and an enlarged view of one-half the core box is shown at C. There the eye is seen laid into a suitable recess made in the joint of the box, in which it is rammed up. The core being put into the

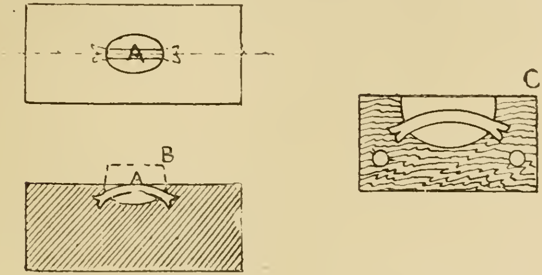


Fig. 18. Casting of Weight with Eye.

print impression, the projecting jagged ends of the eye become surrounded with molten metal and are held firmly.

Fig. 19 illustrates a **worm.** It is also typical of helices of other types. The patterns are usually jointed along the line A A, and each half withdrawn

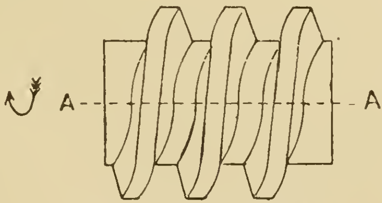


Fig. 19. Casting of Worm.

by a partial revolution or twist. Sometimes, however, the patterns are made solid, and are twisted out of the mould endwise, as shown by the arrow.

These are typical illustrations of the jointing and construction of patterns necessitated by the conditions of moulding. My next chapter will treat of constructional details regarded chiefly from the wood-worker's point of view.

CHAPTER IV.

CONSTRUCTIONAL JOINTS.

The outlines of work in timber are subject to incessant alterations, by reason of dryness and moisture. Timber shrinks, swells, warps and curves. Moreover, it is strong in some directions of the grain, weak in others. The aim of the pattern maker should be so to construct patterns that they shall be capable of resisting the dampness of the foundry sand and the heat of the pattern stores; that they shall be strong enough to withstand the somewhat rough usage of the foundry, and the fair wear and tear due to often repeated mouldings. The principal way in which these results are attained is by a judicious disposition of the fibres of the timber. I will illustrate this in considerable detail.

The simplest case that can occur is that of broad plated work. Large plates of rectangular and of circular form are invariably made with what are termed **open joints.** That is, if a plate of two, three, or more feet in width were wanted, it would not be made up by gluing narrow boards side by side, but they would be laid side by side with intervening open spaces of from $\frac{1}{16}''$ to $\frac{1}{8}''$ in width. If the boards expand with moisture, the width of the plate as a whole does not increase; the only effect of the moisture being to partly close up these open spaces. If the boards shrink with heat, the only effect is that the spaces increase in width. Since broad plated work is usually stiffened with ribs and flanges, the fact of the joints being open seldom lessens the rigidity of the pattern. An example of open joints is shown in Fig. 20 *a*, *a*, *a*.

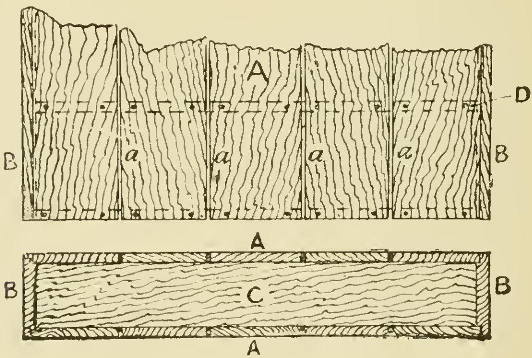


Fig. 20. Open Joints and Boxing-up.

This figure illustrates also the method of **boxing-up** large patterns which cannot be made of solid wood without being unduly heavy, and without being specially liable to become affected by moisture and dryness. In this illustration there are top and bottom plates A A, made as before mentioned with open joints, two sides B B, end C, and cross bars D, the number of the latter depending upon the length of the pattern. They should be placed at from 12″ to 18″ apart. Two other examples of rectangular boxed-up work occur in Figs. 21 and 22. Fig. 20 illustrates broad work of several feet in width; Figs. 21 and 22 work which is relatively narrow, or from 6″ to 12″ in width. In Figs. 21 and 22 there are top and bottom A A, sides B B, end C, and cross bar D. The difference in the figures is this, that

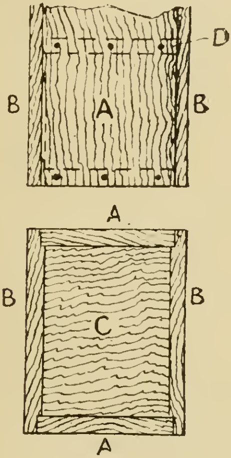


Fig. 21.

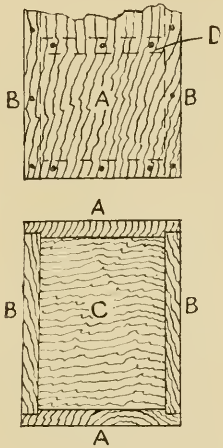


Fig. 22.

Examples of Boxing up.

Fig. 21 shows a better method than Fig. 22 of rebating the boards together. In Fig. 21, the boards B pass straight up from top to bottom, and A A lie within them. In Fig. 22 the edges of A A come out to the faces of B B. This is objectionable, because when A A swell with the moisture in the sand, they overlap B B, and on withdrawal of the pattern, tear the sand up, and produce a rough mould. The method illustrated in Figs. 20 and 21 is therefore the correct one. Note also the rebating or shouldering of A and B into each other in these figures, in preference to simply nailing flat faces upon flat edges. This rebating prevents the sides and top pieces from becoming rammed inwards in the spaces between the cross bars, which would occur unless the boards used in boxing up were very thick, which it is not the practice to make them. The boards are united to each other and to the cross bars either with nails or with screws.

Fig. 23 is an example of **boxing up applied to sweeped work.** It is a semicircular end of an engine bed, but is equally applicable to any sweeped work, whether of regular or of irregular form. A is a plan view, B is a side elevation, and C a plan view with the top plate D removed. There are top and bottom plates D E; made not in one piece of stuff each, but with three pieces united with half lap joints, glued and screwed. The timber shading will render this clear without further explanation. The advantage of making these plates in short segments, halved together, is that there is less short grain than as if these were cut out of single widths of board, and their liability to shrink is correspondingly diminished. For the same reason the inner and outer curves of the portion between the plates are formed each of several short pieces F, G, H, J, K, L, M. The ends of these pieces are either abutted simply as shown, and nailed with skew nails, or they are abutted and tongued, or they

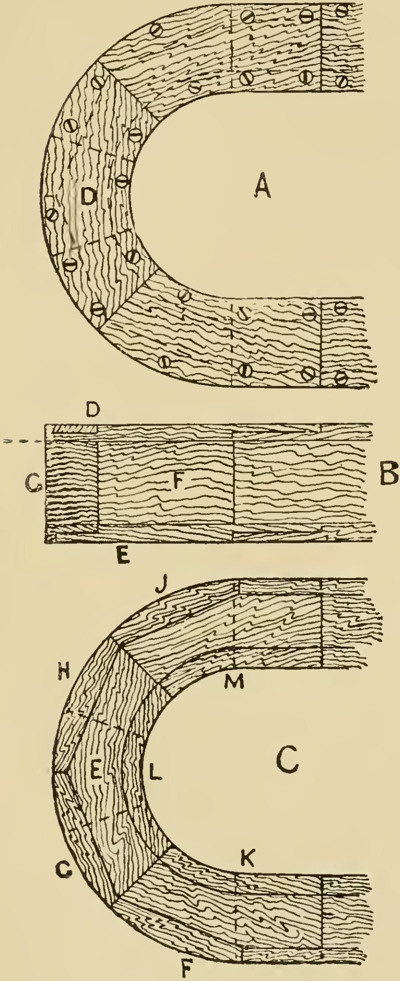


Fig. 23. Examples of Boxing-up.

are halved into one another. The top and bottom plates are screwed to these pieces, as seen in plan at A.

Fig. 24 is an example of hollow work of another type. It is not, however, termed boxing up, but **lagging,** or **lagging up.** It is used for turned work. The figure represents a section of the pattern of a pipe or column of any diameter over three or four inches. A–A is the the joint of both pattern and mould, B B are cross bars dowelled together. These bars are set at distances of from about 12″ to 18″ apart, dependent upon the dia-

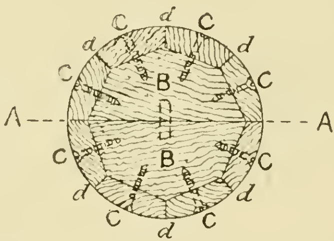


Fig. 24. Example of " Lagging up."

meter of the work. The lagging strips C are jointed longitudinally at *d*, and glued. At the same time they are bedded upon the flats of the cross bars B, and either nailed or screwed to these. In the joint face A–A they are abutted without glue. After this is all done, the two halves of the pipe or column are secured with centre plates Fig. 101, p. 124, and turned. The result is a pattern very strong, yet light, and the possible shrinkages or expansions due to heat or moisture are localized in thin narrow strips, so that there is hardly any risk of the pattern losing its correct form. All standard patterns for pipes, columns and cylinders, over about 4″ or 6″ diameter, should be lagged up in this manner. The number of lagging strips C will depend entirely on the diameter. Speaking roughly, I should say that for work of 6″ or 8″ diameter, six strips to the circle will be suitable; from 8″ to 12″, eight strips; from 12″ to 18″, ten strips; from 18″ to 24″, twelve strips; from 24″ to 36″, about twenty strips. When cylindrical work is required from over 2′, 6″ to 3′, 0″ in diameter, patterns of wood are seldom made use of, patterns of loam, or loam moulds becoming more economical.

Fig. 25 is an example which bears some resemblance to Fig. 24, yet the purpose of the arrangement there

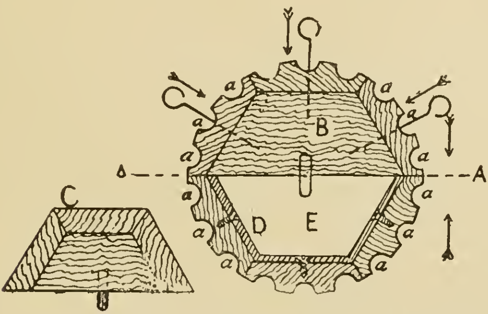


Fig. 25. Example of Loose Lagging for Moulding.

shown is different. It is an illustration of **loose pieces arranged for moulding,** and also of alternative pattern arrangements. It is a section of a fluted column. The pattern maker's and moulder's joints are both made along the plane A–A. Since each half pattern must be withdrawn in the direction of the vertical arrows, it is clear that the under-cut flutes will not deliver in that direction without tearing up the sand at the parts marked *a*. The flutes therefore are all worked in narrow lagging strips, and these are attached to a central piece of blocking B, with screws or skewers. This blocking is a continuous piece, not cross bars. After B is removed from the mould, the fluted strips are withdrawn separately in the direction of their arrows. But in the case of patterns of large diameters the central blocking B is liable to shrink, and cause distortion of the column to occur. In such a case there are two courses open: either to lag up a central blocking in the way shown in Fig. 25, C, and lay the fluted strips against that, or to make a light central blocking of cast iron as at D, with, of course, a few light cross bars E to stiffen it. The lagging strips can then easily be screwed from the inside of the blocking.

Although I show six fluted strips to the circle in Fig. 25, it will of course be understood that the number will increase with increase of diameter, as in the case of Fig. 24.

Fig. 26 illustrates another kind of **building up.** It is a section of a large core box, which may be either straight or sweeped in plan view. The dowelled joint is made along the line A–A. The method in which the timber is glued up, before the hole is cut out, is seen by the dotted lines. The advantage of building up the box thus, is, that several pieces of thin stuff shrink less than one thick piece. When any thick piece of stuff, even though well seasoned, is cut and opened out to the air, it almost invariably undergoes more alteration in form than several thin pieces would do. By adopting the device shown in Fig. 26, there is also a little economy of timber effected in the central part of the box, only a portion of the hole being cut away to waste. At B B battens are shown. These are screwed *across* the longitudinal strips C C, and prevent curving

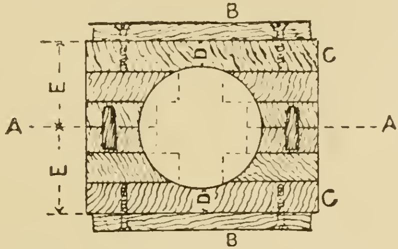


Fig. 26. Section of built up Core Box.

in the direction of the width, which in boxes of this kind is always liable to occur, because of the difference in thicknesses at D and E.

In Figs. 27–31, common constructional joints of another type are shown. These are termed **half lap joints**, or **halvings**. They are used on all thin, open framings for base plates, engine beds, vertical cheeks, side frames, etc.

Fig. 27 represents a **framing** such as would be used, variously modified, for many purposes in pump and engine work. Now imagine such a frame cut from

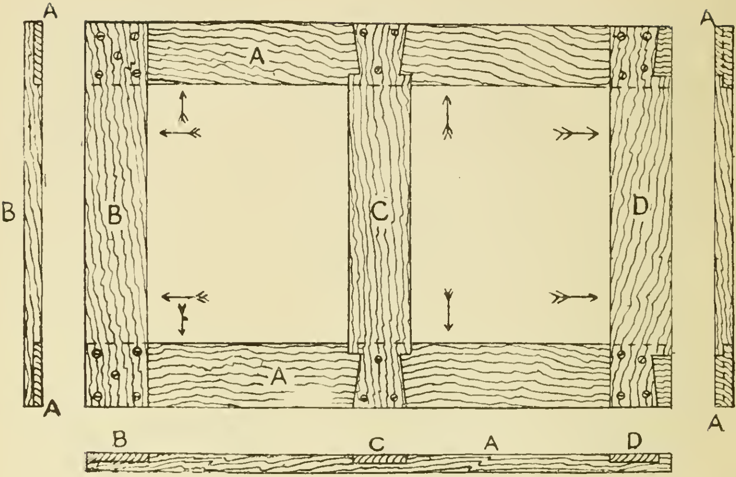


Fig. 27. Example of Framed Work.

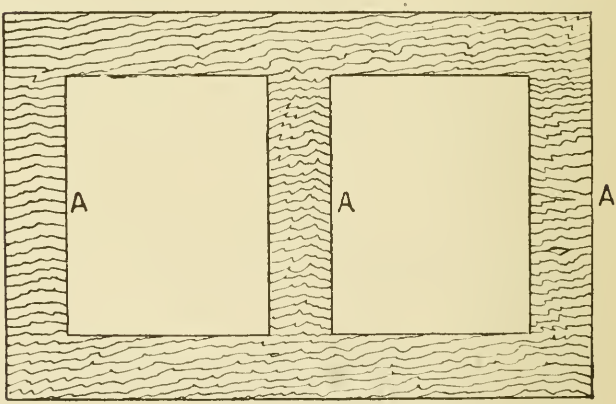


Fig 28. Frame cut from the solid.

solid wood, Fig. 28. It is clear that strength and permanence of form must be entirely lacking in the cross bars A A A. Contrast this with Fig. 27. In this there cannot possibly be any material alteration either in width or length, in general or local dimensions, and there is the maximum of strength. The frame is formed of five narrow strips, A A, B, C, D. Alternative methods of making half lap joints are shown. The plain halving is shown in the case of B. B is seen also in perspective in Fig. 29. At C and D, Figs. 27 and

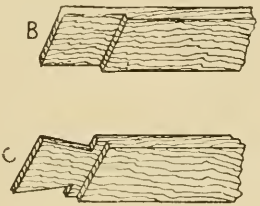


Fig. 29. Halvings.

29, the dovetailed form of halving is illustrated. The advantage of this over the simple halving is, that it ties the sides AA together, so that they cannot be rammed outwards in the direction of the arrows. Neither can a bar coming at the end of a frame, as D, be rammed outwards in the direction of the arrows. With a plain halving as at B, badly made, both A A and B might become disturbed and rammed outwards from their relative positions in the direction shown by the arrows. Still, much depends on the workmanship of the joint. A good half lap joint, glued and screwed, is very strong and permanent. Yet for standard and permanent patterns it is advisable to employ the dovetail form.

In Figs. 30 and 31, further examples of half lap joints are seen. Fig. 30 illustrates the pattern, com-

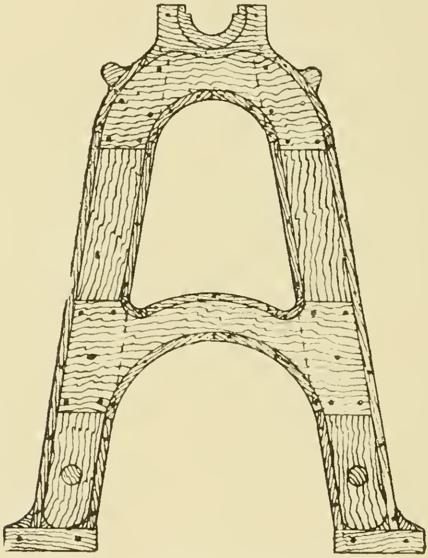


Fig. 30 Pattern of Pump Standard.

pleted, of a pump standard. Fig. 31 shows the plated portion only, framed together, and marked out in readiness to be cut to outline. A comparison of the two figures will show their relations.

In Fig. 31 there are four main pieces A, A, B, C, halved together, and either pegged or screwed. The pieces A A are planed to the exact width of the sides in Fig. 30, but B and C are cut roughly large enough to include the corresponding curved portions in Fig.

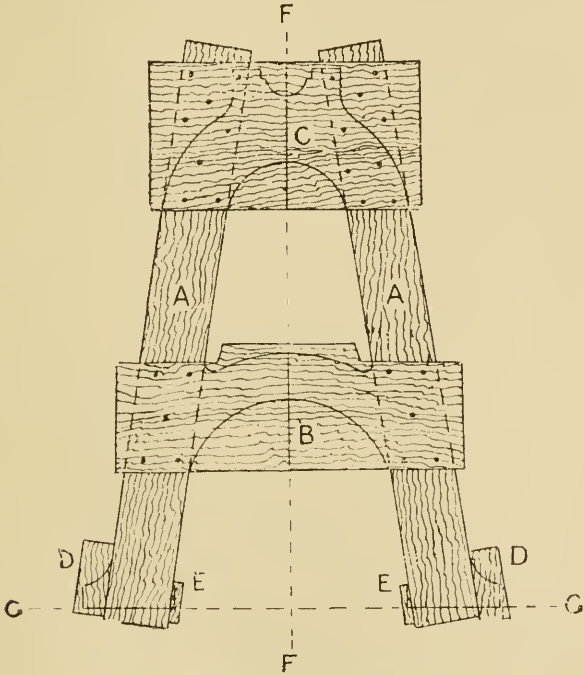


Fig. 31. Framing for above marked out.

30. Blocks D and E are glued to A A to make up width sufficient for the feet. The centre line F–F, carried vertically midway between A A; and the base line G–G, at a right angle therewith, are the funda-

mental lines from which all centres and dimensions are taken for lining out. After the outlines of the frame are sawn and cut, the bearing, the feet, and the ribs, both straight and sweeped, are glued and nailed, or screwed, Fig. 30. Note how all these are put on in short pieces, in order to prevent very short and consequently weak grain from occurring in any part of the pattern. The result is a pattern of a rather flimsy type, constructed with the maximum of strength possible. I have indicated so clearly by the timber shading the disposition of the separate pieces which form the pattern, that no further detailed description is necessary.

Fig. 32 is an illustration of quite another type of

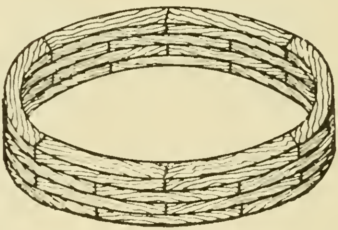


Fig. 32. Example of Building up with Segments.

construction. It is termed **building up with segments.** Light circular and curved work is usually made in this fashion. A number of thin, short segments are sawn out, and glued in courses, one over the other, with the end joints alternating, or "breaking joint," being pegged or nailed in addition; and when the structure is complete, the correct outline is imparted by turning or otherwise. This is an extremely strong form of construction, and the shrinkages of the segments are practically nothing.

The remaining figures illustrate the formation of **corners,** and **hollows.** Fig. 33 shows a method of form-

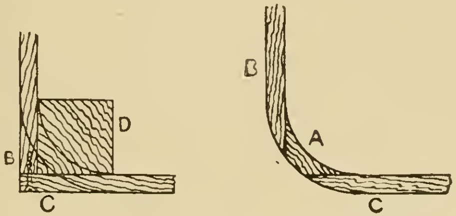


Fig. 33. The formation of Corners.

ing the curved corner A. Two pieces B and C, which are the sides of a pattern, are abutted and screwed. A cubical block D is glued in, and left till dry. Then the inner and outer curves of the corner are struck out and worked, forming the curved corner A.

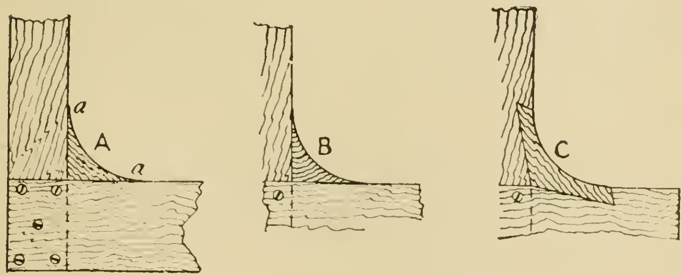


Fig. 34. The formation of Corners.

Fig. 34 illustrates three methods of forming corners in plate patterns. The first method is to glue blocks in as at A; but the grain becomes short at the termination of the sweep, that is at *a a*. At B the grain runs vertically, and then the terminations are not weakened by short grain. If, however, the plate is thin, the grain is then so short vertically, that it is liable to become chipped out in its thickness; C shows therefore the best way of filling in corners. The piece which has to form the hollow is dovetailed in and glued, and when dry the curve is worked out, and one part of the

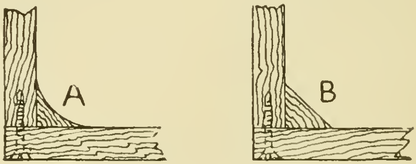


Fig. 35. The formation of Hollows and Angles.

sweep is as strong as another. Fig. 35 shows how the hollows A, and angles B are put in patterns. They are worked in an angle board, and glued and nailed in, or

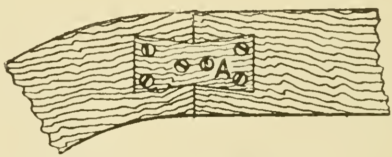


Fig. 36. Dovetailed Fastening.

merely nailed. Fig. 36 shows how curved parts are frequently fastened to straight pieces, that is with a dovetailed piece A sunk in flush and screwed to both pieces.

Since pattern making is one of the most comprehensive of trades, it is clear that a vast deal more must be omitted from any volume written upon the subject than can be included in it. Yet there are certain classes of work to which one naturally expects to find reference, either because they are of a fundamental or typical character, or because they are of very frequent occurrence in practice. This, therefore, is the object I have in view in my treatment of pattern work in this volume, to give the most comprehensive view of the trade which is possible in the limit at my disposal, a method which is inconsistent with too much of detail. I have given, therefore, in Chap. V., a very full account of the construction of a rather intricate engine cylinder, which will be a capital object lesson for the student and apprentice. But in the subsequent chapters I have treated the illustrations selected in a more general and briefer fashion.

CHAPTER V.

AN ENGINE CYLINDER.

The engine cylinder illustrated in succeeding figures is an example of a rather intricate piece of pattern work. Before troubling about the method of making the pattern and core boxes we will take a good look at

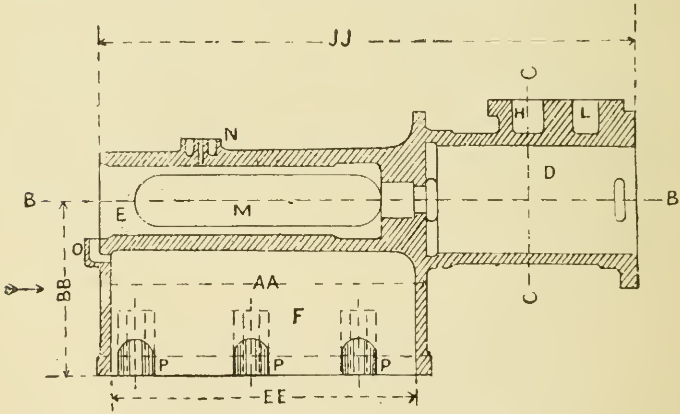


Fig. 37. Cylinder—Sectional Elevation.

the casting. This is shown in Figs 37–40. Fig. 37 is a sectional elevation taken through the plane A–A in Fig. 38. Fig. 38 is a sectional plan taken along the line B–B in Fig. 37. Fig. 39 is a cross section taken through the lines C–C in Figs. 37 and 38, and Fig. 40 is a front view of Fig. 37, looked at from the direction of the arrow. In these figures D is the cylinder bore, E is the guide bored for the crosshead, F is a foot by means of which the cylinder is bolted to its bedplate. Lesser details are, G G the steam passages, H the exhaust ditto, J the steam chest, one half of its depth being contained in the cylinder casting, the other half

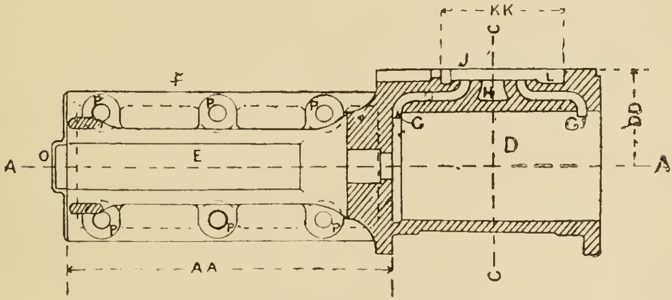


Fig. 38. Cylinder—Sectional Plan.

in the steam chest casting,—the joint being made in the centre of the valve rod thus, in order to afford facility for taking off the cover for setting the valve. One half the facing to match the gland of the stuffing box is shown at K. L, Fig. 37, is the opening for the steam inlet. Its sectional outline is precisely like that of the exhaust passage H, in Fig. 39, and it enters the steam chest at L, in Fig. 38. There are openings M cast in the sides of the guide E, and an oil cup upon it at N. There is also a waste oil cup at O to carry the oil away from the end of the guide within the foot F, to be drained away. Lugs P are used for hold-down bolts, by which the foot F is bolted to its bed-plate.

The difficulties of moulding a pattern of this cylinder in any other way than that which I am going to describe are so numerous that they would be obvious on a little consideration. I cannot spare space to enumerate them, but will pass at once to the de-

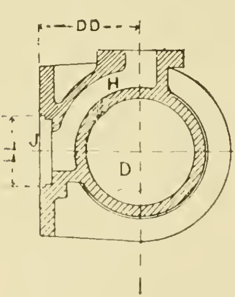


Fig. 39.
Cylinder—Cross Section.

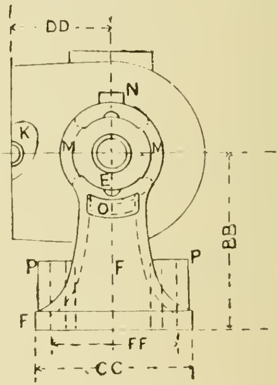


Fig. 40. Cylinder—End View.

scription of the pattern and core boxes, shown in succeeding figures.

Figs. 41 to 44 illustrate the construction of the **cylinder pattern.** Fig. 41 is an outside view. Fig. 42 is a front view, looked at from the position of the arrow in Fig. 41; Fig. 43 is a cross section in the plane A–A, in Fig. 41; and Fig. 44 is a cross section in the plane B–B, in Fig. 41. If we compare these figures with those which represent the casting, we find that there are certain double reference letters that occur in both sets of figures. These indicate similar dimensions in casting and pattern, and are put to facilitate the comparison of casting and pattern by the student. The same letters are also repeated in some of the core boxes in subsequent figures. The first thing noticeable in the pattern figures is that the foot F is not present in the pattern at all, but that a large print C, Figs. 41, 42, 43, formed by boxing up, is substituted for it. The inner and outer curves of the foot are therefore imparted with cores. Another point is that there is a belt D, not seen in the casting. This is "head metal" and it receives the scurf that rises to the top of the mould. The cylinder is therefore poured

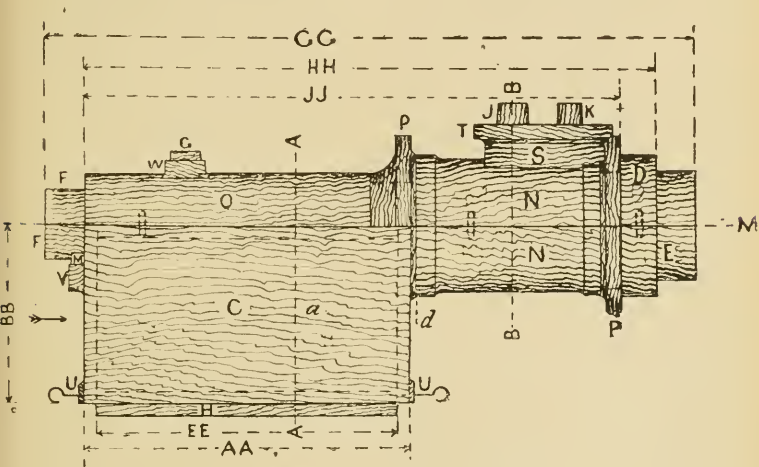


Fig. 41. Cylinder Pattern—Outside View.

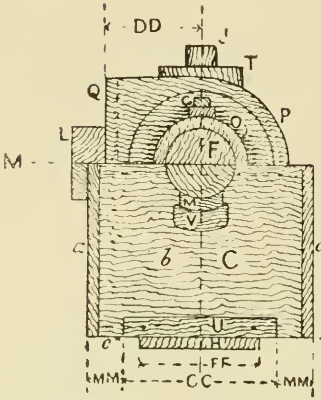


Fig. 42. Cylinder Pattern—Front View.

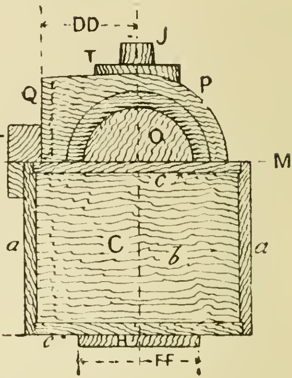


Fig. 43. Cylinder Pattern—Cross Section A–A, Fig. 41.

with the belt uppermost. There are also sundry core prints, E, F, G, H, J, K, L, corresponding in position with holes in the castings. Another matter is that the pattern is jointed and dowelled along the line M M.

The first care is to turn the pattern of the **cylinder body** N, and of the guide O. When of small diameter,

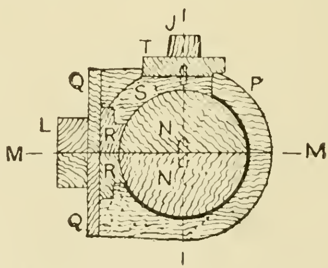


Fig. 44. Cylinder Pattern—Cross Section B–B, Fig. 41.

say under 6″ or 7″ diameter, this is made of solid wood, dowelled of course, in the central longitudinal plane. When of larger diameter it is lagged up in the manner illustrated in Fig. 24, p. 40. The two halves are secured while being turned, in the manner described on p. 124. The pattern flanges P P of the cylinder are not in one piece with the body, because that would cause their edges to be very fragile. They are made "plank way" of the grain, and are bored to fit into turned recesses in the cylinder body, as shown at the right hand end of Fig. 41. These flanges are not turned, but are cut to the outline shown in Figs. 42, 43, 44. The steam chest flange Q, Figs. 42, 43, 44, is fitted between P P. The blocks R R, which form the metal round the steam chest and steam passages, are fitted between the steam chest flange Q and cylinder body N, and between P P at the ends. The exhaust and steam inlet block S is fitted around the curve of the cylinder body, and the elliptical flange T is dowelled loosely upon it, and the prints J and K fastened upon T. A comparison of Fig. 44 with Fig. 39, and of Fig. 41 with Fig. 37, will render the relation of pattern with casting obvious. The print L is screwed upon the flange Q to carry the steam chest core.

The print C, in Fig. 41, for the foot, is boxed up (see p. 36) with sides *a a*, ends *b b*, and top and bottom *c c*; *c c* being rebated into *a a* and *a a*, offer a plain face without a joint, favourable to moulding, as explained on p. 37. Since the print C extends up to the joint

M–M, one half of the guide O which was turned in one piece with the cylinder body N is cut off at the line *d*, and that portion of the cylinder body N is attached to C with a dovetail, like that illustrated in Fig. 36, p. 50. The lower half of the print F is screwed to C. The print H, Figs. 41–43, is dowelled upon C. Its length and width E E, F F, respectively correspond with the length and width of the recess underneath the foot F in Figs. 37 and 40. Two strips U U are skewered on to C, Figs. 41 and 42, corresponding with those seen in Figs. 37 and 40. Then there is the waste oil cup V, with its print M, Figs. 41 and 42, and the oil cup W on the guide, with its print G, Figs. 41 and 42. Various small matters, as directions of grain, hollows, or fillets, and the taper of prints are shown in the pattern illustrations, and require no special remark. The drawings are well proportioned, and a good idea of the thickness of prints necessary can be gathered from the illustrations. Thus, the print H being of large area, and having to sustain its core without any *overhang*, is thin. But the print L, being of smaller area, and having to carry a core that overhangs into the mould, is of considerable width. The amount of taper given to those portions of the pattern which are not prints is not much. The flanges P being shallow are not tapered at all upon their faces, the foot C need not have more than $\frac{1}{16}''$ given to each of its sides; all faces that have to be machined, as the bottom face of the foot C and the hinder flange P, are made to stand out $\frac{1}{8}''$ farther and thicker, to allow for facing, and the print E of the cylinder is made $\frac{1}{4}''$ smaller in diameter than the finished bore. The bottom of the foot C, and the top of the flange T, must be parallel with the joint face M, and the face of the flange Q must be at right angles with it. Inaccuracy in these matters will soon be found out when the casting goes into the machine shop.

The core boxes for this cylinder illustrate the fact that there is often more work involved in the core boxes for a casting than in the pattern itself. There are eight boxes in this case, some of them rather elaborate, and all demanding a very great amount of accuracy. For the larger the number of sections which form a mould the more necessary it becomes to adhere precisely to dimensions, because when slight inaccuracies are multiplied, they become in the aggregate a source of much trouble.

Fig. 45 illustrates the core box by means of which the bore D of the cylinder and that of the guide E, Figs. 37-40, are cored out. The main portions of the core are connected with a narrow neck that forms that portion of the casting which is bored to receive the piston rod gland and a neck ring of brass, at the end of the packing farthest from the gland. Comparing the core box in detail with the casting and pattern, we note the following correspondences :—

The diameter A of the cylinder end of the box corresponds with the diameter of the print E in Fig. 41. The diameter of the part B corresponds with that of the print F in Figs. 41 and 42. The length G G corresponds with the similar length G G over the prints in Fig. 41, the length H H with that over the casting, including head metal in Fig. 41, and the length J J with the finished casting Fig. 37. Two half sections of the box are seen at the right hand, one taken through that portion of the box D–D which corresponds with the bore of the cylinder, the other through that, C–C which corresponds with the guide. One of the facings which are bored is seen at E, the recesses at F F in the sides of the box form the openings M M in Figs. 37 and 40. The two halves of the box are alike.

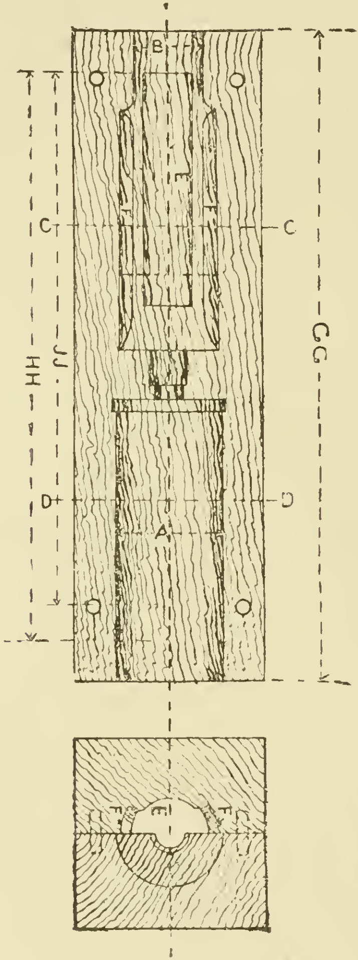


Fig. 45. Core Box for Cylinder and Guide.

The **core boxes for the steam chest,**

steam passages, and exhaust passage, are illustrated in Figs. 46-48. They are drawn to a larger scale than the previous figures in order to render their details sufficiently distinct. Fig. 46 takes out the recess J in Figs. 38 and 39, and fits into the recess formed by the print L in Figs. 42-44. The length K K of the box and of its print corresponds with the length of the

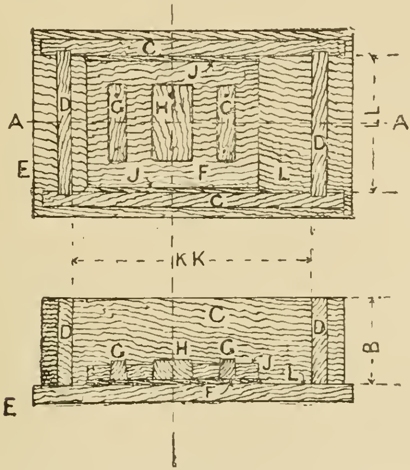


Fig. 46. Core Box for Steam Chest.

recess K K of the steam chest in Fig. 38; and the width L L with the width L L in Fig. 39. The depth B of the box equals the depth of the recess in the steam chest, plus the thickness of the print L. The method of construction of such a box is clear from Fig. 46; C C are sides into which ends D D are fitted by grooving, the ends being screwed to the sides. This framing is dowelled upon a bottom board E. The valve facing F is nailed upon E, and the prints G G for the steam passage cores, and H for the exhaust core are nailed upon F. The side facings or guides J J for the valve are nailed to the box sides C C. The timber shading is self explanatory of the arrangement of the several pieces of wood with which the box is made.

The steam passage cores made in the box, Fig. 47,

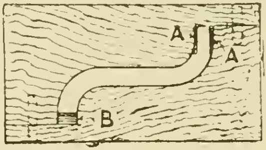


Fig. 47. Core Box for Steam Passage.

fit into the impressions made by the prints G G in Fig. 46. The box is made in two pieces, dowelled together. The facings A A afford allowance for filing or machining out the ports for accurate cut off of the steam. The piece B forms that end of the core which has to fit the curvature of the body core of the cylinder. The thickness or depth of the box is equal to the breadth of the passages.

The exhaust core box is shown in Fig. 48. The corresponding section of the exhaust passage is shown at H, in Fig. 39. That end of the core made at A in this box fits into the print impression H, in Fig. 46, and the end made at B in the box, fits into the print

J. in Figs. 41 and 44. The centre E corresponds with the centre of the cylinder, whence the curves of the passage core are struck.

I need not illustrate the box for the steam inlet core. The passage has the same curvature, and almost the same section throughout as the exhaust passage H,

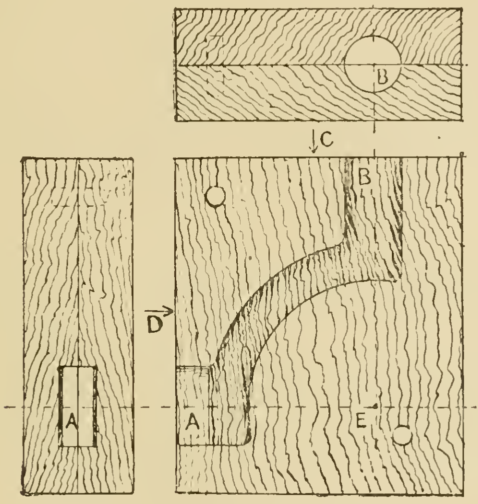
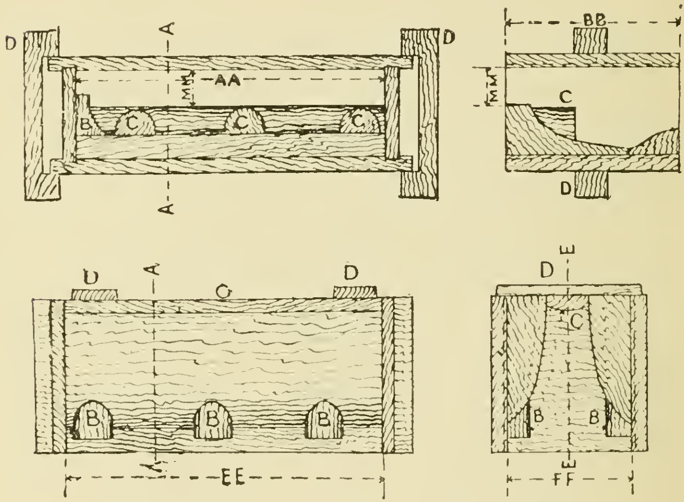


Fig. 48. Core Box for Exhaust Passage.

in Fig. 39, and it is made from a box very similar to Fig. 48. The round end of the core fits into the print K, in Fig. 41, and the opposite end abuts against that end of the steam chest core formed in the portion of the box marked L, in Fig. 46.

The cores for the foot, F in Figs. 37 and 40, are made from the boxes illustrated in Figs. 49 and 50. Fig. 49 (above) forms the cores for the outside of the foot; Fig. 50 (below) the core for the inside of the foot. The two cores made from Fig. 49 fit, one on each side of the print C, in Figs. 41, 42, 43. A comparison of the double reference letters, A A, B B, M M, with the corresponding



Figs. 49 and 50. Core Boxes for the Cylinder Foot.

letters on Figs. 37, 41, 42, will render the relations of the box, pattern, and the casting clear. The piece B, put in the box, forms one portion of the flange P. The bosses C C C form the bosses P, in Figs. 38 and 40. The box is framed together with grooved ends. These framed core boxes are commonly screwed together at the corners, as I noted in connection with the core box, in Fig. 46. An alternative and equally common method of holding the boxes together during ramming of the core, is shown in Fig. 49. Instead of screws, wooden clamps, D D, are used for pinching the box sides to the ends. The advantage of clamps is, that when a number of cores are required out of one box, there is a saving of time effected in the use of clamps, because they can be removed instantly, while the turning out of screws occupies a minute or two.

In Fig. 50, the length E E, and the breath F F of the core box, correspond with the length and breadth of the hollow portion of the foot in Figs. 37 and 40, and with the print in Figs. 41, 42, 43. The bosses B B B form the portion of the hold down bosses that come within the foot, as seen dotted in the end view, Fig. 40. The curved strip C forms the under portion of the circular guide E in Figs. 37 and 40. It is carried with battens D D. The shading illustrates the arrangement of the parts of the box.

Two small core boxes complete the work for this cylinder. There is **the box which cores out the oil** cup N in Figs. 37 and 40, fitting into the impression made by the print G in Figs. 41 and 42. The box, Fig. 51, though small, is framed like the others, and has a bottom board. There is a central stud which leaves a boss in the casting, through which the oil hole, seen in Fig. 37, is drilled through the guide. Fig. 52 is **the box for coring out the waste oil cup** O, in Figs. 37 and 40. It fits the print M in Figs. 41

and 42. The shading renders its mode of construction clear.

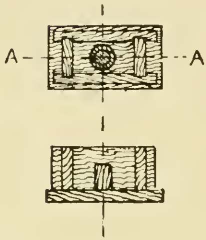


Fig. 51.

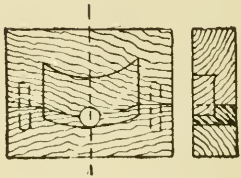


Fig. 52.

Core Boxes for Oil Cups.

I have been precise in going through the details of this cylinder, and I have shaded the figures to show exactly how such a pattern is made.

CHAPTER VI.

GEAR WHEELS—PATTERNS.

In this and two following chapters I want to illustrate a few typical examples of pattern work, a very few selected from the almost infinite number that occur in the shops.

It is not possible to treat this subject of **gear wheels**, Figs. 53–62, except in an elementary way, in the space of a single chapter. Yet the subject cannot be entirely neglected in any treatise on pattern work. I shall, therefore, endeavour to touch lightly on its more salient and fundamental aspects, and allow the shaded illustrations to become, to a considerable extent, self-explanatory.

The object of *building up* work, as explained in Chapter IV. pp. 35, 48, is to confer permanence of form, and strength. If a thin ring or slender sweep of quick curvature were cut from solid wood, however well seasoned, it would inevitably lose its true curvature, and in many cases become broken very quickly. If we make the ring or sweep of numerous segmental pieces with over-lapping joints, and well glued together, no alteration in shape of any moment will occur for a reasonably long period. This method is very widely adopted in standard patterns, and the writer has in present use patterns made in this way, from which, to his personal knowledge, several scores, and, in some cases hundreds of castings have been moulded. The general process is as follows:—

A wooden **face plate**, Fig. 53, A, is first selected of suitable dimensions and screwed upon the face chuck (see Chapter IX., p. 120), of the lathe. The wooden plate is faced over true, circles C C of the rough diameter of the segments marked thereon, by which to lay the

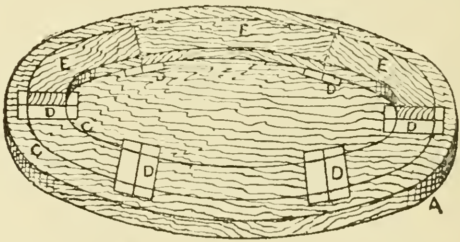


Fig. 53. Method of Building up Segments.

first course of segments, and the building up is then commenced. Slips of paper, D, are interposed and glued between this first set and the plate, in order that the ring may be lifted off subsequently without the grain of the wood becoming torn out thereby. The paper joint retains the ring securely during turning, yet it parts through the centre on the application of slight leverage with a chisel.

The **segments** are jointed carefully with a trying plane, and allowed to set quite firmly before being faced off. This facing off is usually done in the lathe, but may be done with a trying plane. After the first course is faced, the fitting of the superimposed courses proceeds, with intervals for drying of the glue between each. The trued face is whitened over with chalk in order to afford an index and test of the jointing of the segments above. The points of transference of the chalk indicate localities for the removal of material by the plane. The end joints are properly made with the

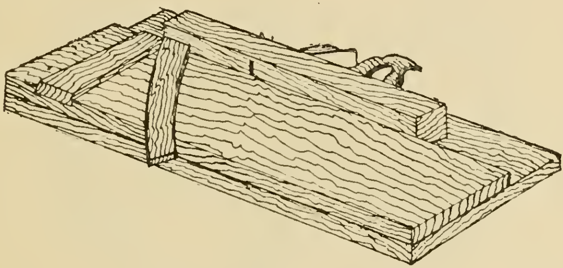


Fig. 54. Shooting Joints.

trying plane on the shooting board, as in Fig. 54, a mode of jointing which is very expeditious and very accurate. The glue should be strong, hot, and thin, and rubbed out tolerably well, but not too much so. Good glue will bear more rubbing out than poor glue. For

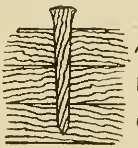


Fig. 55. Peg for Segments.

further security the joints should be pegged: Fig. 55

showing a view of a peg securing segment A to segments B and C.

Fig. 56 shows a **spur wheel pattern,** from which the

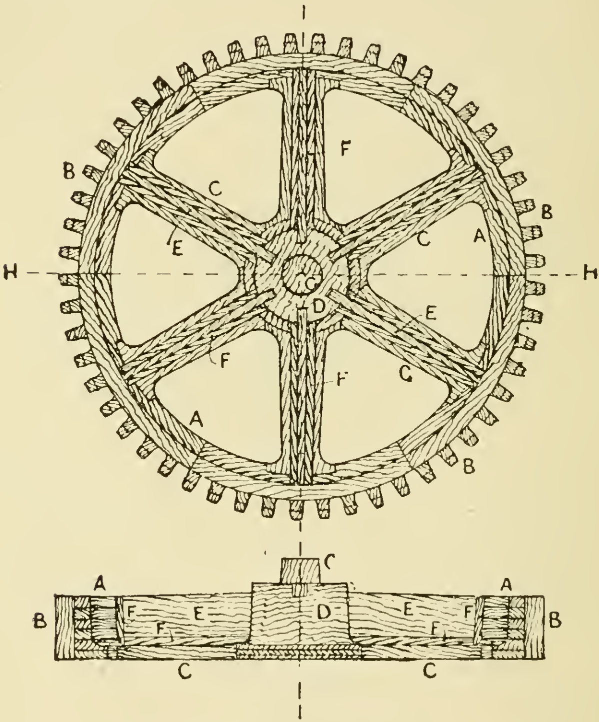


Fig. 56. Pattern for Spur Wheel.

general construction of built up work is apparent. The section of the **rim** A is usually turned to templets, made directly from the drawing board, on which the wheel is properly struck out to full size. The arms C are made to possess the maximum of strength, and in order to lessen risk of shrinkage, by being framed together of three parallel strips with lapped or scarfed joints about the centre. The arm strips thus scarfed together and marked out ready to be cut to shape, and

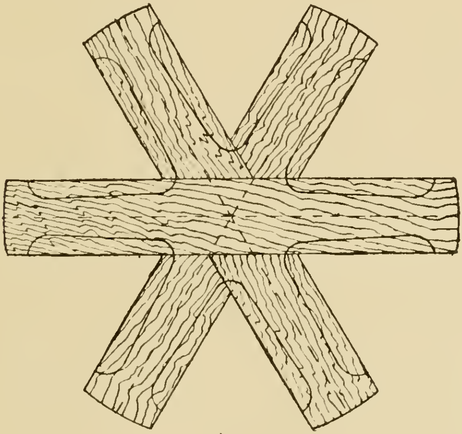


Fig. 57. Wheel Arms, prepared for cutting out.

with sufficient extra length at the ends to permit of their being recessed, or "let into" the rim, are shown in Fig. 57. An enlarged view of the end of one arm illustrating the method of its attachment to the rim is seen in Fig. 58. Observe that all the radii by which the edges of the arms merge into one another and into the rim are cut out of solid wood, and not in this case

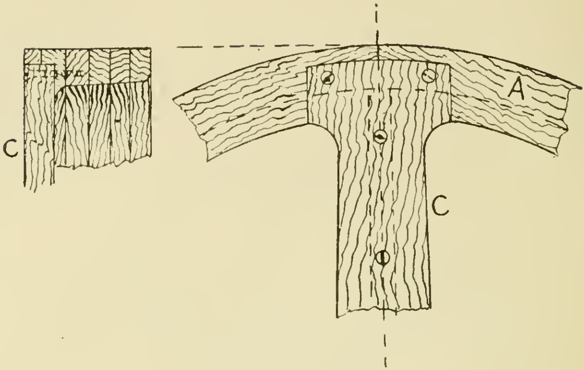


Fig. 58. Attachment of Arm to Rim.

fitted in separate pieces by the methods illustrated on p. 49.

The boss D, Fig. 56, is turned of a single piece of stuff, with a radius or hollow at the bottom. The vertical arms or ribs E are either abutted against the boss, or they are fitted into grooves cut in the boss, in the manner illustrated in the figure. At the other end they are fitted against the inner portion of the wheel rim. They are screwed to the flat arms C, Figs. 56

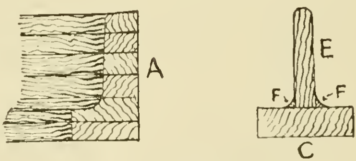


Fig. 59. Rib and Hollow.

and 59. Lastly, all the sharp angles in the pattern are filled up with **hollows** F; these are seen. They are shown in Fig. 56, and in Fig. 59. These hollows were described and illustrated on p. 50, Fig. 35.

This, in brief, is the method of construction of the rim and arms of the pattern of a spur wheel. The description will also apply in its essentials to the construction of other work, as fly-wheels, pulleys, trolly wheels, and much beside; but I have purposely chosen a gear wheel as an illustration of built up work, in preference to anything else, because the formation and fitting of *wheel teeth* should receive some notice in a volume of this character.

The **teeth of gear wheels** are fitted in various ways. In the case of small pinions they may be worked from a solid block,—the grain in the block running longitudinally,—so that even if subsequently affected by moisture or dryness, the circular form will remain intact, which could not be the case if the stuff were cut "plank way" of the grain. Or, the block may be turned to the diameter at the roots of the teeth, and the teeth made distinct, and fastened thereon. They may then (*a*) either be marked and worked quite independently of the block, or (*b*) they may be first fitted and screwed, or else dovetailed, marked while in position, and removed for working, to be returned and glued permanently. Or (*c*) they may be fitted and glued as rough blocks, marked out and worked in position with a gouge, chisel, and plane. Either of these methods, except that of working from the solid, also applies to the teeth of built up wheels.

When the teeth are worked separately they are shaped with planes, either without any guide except the profile lines marked with dividers or compasses on each end, or within a box, Fig 60, the outlines of which are the same as that of the teeth, and which is notched out to the exact length, A, of a tooth; to fit within which, the tooth blocks, B, are squared at the ends.

The teeth are either set on the rim by centre lines, or by their edges, to centres divided out equi-distantly

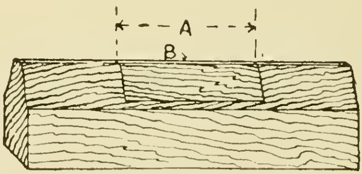


Fig. 60. Box for working Teeth in.

around the periphery. Very much care is necessary in such fitting, both to secure uniformity of pitch, and to assure the teeth being at exact right angles, or square across the face. Lines alone do not afford a sufficiently accurate guide for this purpose, but square and calipers have also to be brought into request.

While the glue is warm, any slight adjustment found by these delicate tests to be necessary, can be made. After the glue is hard, and not before, the permanent adhesion of the teeth is best secured by driving brads through them into the rim.

The amount of **taper** given to wheel teeth should be extremely small, less than for any class of patterns. Arms, boss, and the inner face of rim may have abundance, but the teeth scarcely any, because it interferes with their correct working. If the teeth are made and pitched accurately, the merest shade of taper will suffice—the difference of two or three fine shavings only on teeth of 3″ or 4″ in depth—not more than $\frac{1}{32}''$ on teeth of so much as 8″ or 10″ deep.

Glass papering of teeth should always be done with a rubber, never with the fingers, and the rubbing should mostly take place transversely, to remove any slight ridges left by the planes and chisels, and to

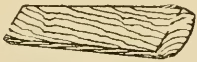


Fig. 61. Glass Paper Rubber for Teeth.

prevent the tendency of the rubber to impart a slightly rounding contour near the ends when it is worked longitudinally. The rubber should be rounding for the hollow curves, but flat for the rounding faces. Fig. 61 shows a suitable form of rubber for wheel teeth.

The pattern maker should **design** his **wheel teeth** either by means of generating circles, or by means of Willis's Odontograph. The first of these gives absolute, the second approximate cycloidal forms. Involutes are so seldom required, that I need take no account of them here. The principle of tooth formation should be, that all wheels of the same pitch be so constructed as to gear with all other wheels of the same pitch, irrespective of the numbers of their teeth. This is a matter of economical importance in manufacture, where wheels have to be interchangeable, and employed for scores of different jobs. If a constant size of generating circle is employed for the flanks and faces of all the wheels of the same pitch, then any one wheel will gear with any other of the set. The smaller the size of this generating circle in relation to the pitch circle, or *base circle*, upon which it is rolled, the narrower will the teeth be across the roots. It is undesirable that any pinion roots should be narrower than those given by radial flanks, and this therefore sets the practical limit to the size of the generating circle of a set—a generating circle whose diameter is equal to the radius of the pitch, or base circle, striking radial flanks. The smallest pinion of a set is therefore chosen as the base of the system, and the circle which strikes its radial flanks also strikes all the flanks and all the faces of all the other wheels and pinions of the same pitch. The size of this pinion is usually taken at 12 teeth. Should pinions of smaller teeth be wanted, as occasionally happens, they are struck with the same circle, the effect being to impart *convex* and undercut flanks thereto. Above 12 teeth all flanks are *concave* and spreading.

It occasionally happens that for specially strong gears, or gears to match old wheels, **special generating circles** have to be employed. But this does not often happen, and constitutes no objection against the use of a constant size of circle. On no account should gears

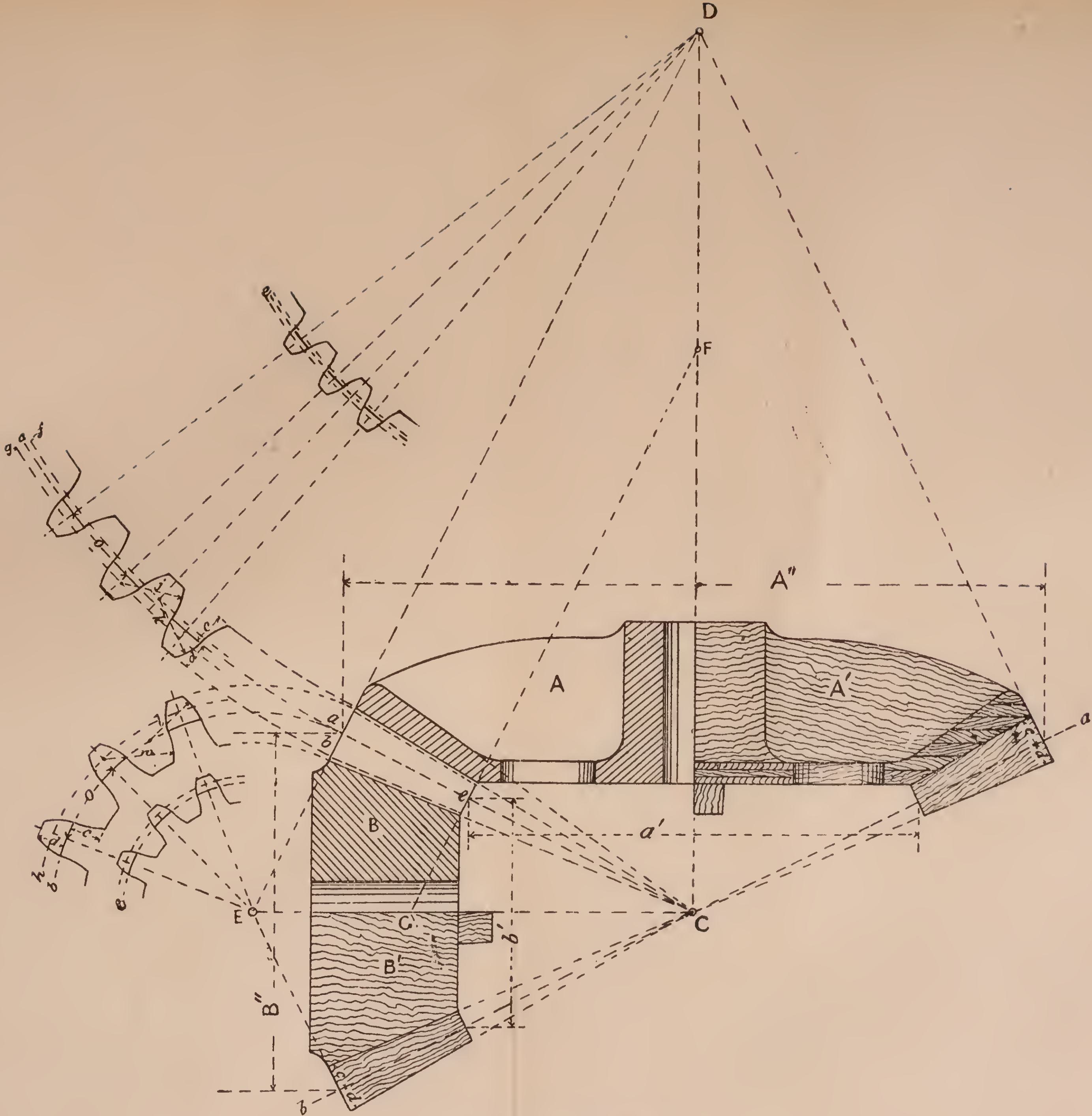


Fig. 62. Bevel Wheels.

ever be struck out by rule of thumb, merely to please the eye. They should invariably be designed on some rigid principle. There is no method which for simplicity and accuracy can even compare with the employment of cycloidal curves. A very close approximation to true cycloidal curves—so close that it is practically identical therewith—is given by the use of Professor Willis's Odontograph scale. By its means the centres of the circle arcs, forming for the short distance required, the closest possible approximation to true cycloidal curves, are obtained directly.

Fig 62 is drawn to illustrate the method of **striking out bevel wheels**, and also the method of construction of the patterns. A is a half section through the wheel casting; A′, a half section through its pattern; B, a half section through the pinion casting; B′, one through its pattern. A″ is the pitch diameter of A; B″ is the pitch diameter of B; C is the common centre of the pitch cones of wheel and pinion—*a a* and *b b* respectively. A″ and B″ are the major diameters; *a′* and *b′* the minor diameters. The pitch, or distance from centre to centre of the teeth, is always reckoned on A″ and B″.

To **mark out** these wheels, the centre lines D–C, E–C are struck at right angles; the pitch diameters A″, B″, pricked off equidistantly from these, and the pitch cones of *a*, *a*—C, *b*, *b*—C, projected. The lengths of the teeth, *c*, below, and *d*, above pitch, are pricked off, and being drawn to the centre, C, give the bevels of the roots and points respectively. The line which gives the thickness of the rim in the wheel is also drawn to the centre C. The flat arms, vertical arms, boss and hole are also drawn out. The teeth are not drawn on the actual pitch diameters, but on the projected diameters, D—*a*, E—*b*; that is on a plane at right angles with the pitch cones, *a*—C, *b*—C. The teeth on the minor diameters are struck on the planes F—*e*, G—*e*. The thicknesses of the teeth are pricked off on the projected pitch lines, *a* and *b*. The curves of the faces and flanks having been obtained by the Odontograph scale, or by means of generating circles, suitable radii are obtained, and the centres of these radii are set in lines, *f*, *g* and *h*, struck concentric with the pitch lines. The radii for the wheel are, *j* for the flanks, *k* for the faces; and for the pinion, *m* for the flanks, *l* for the faces, the latter being struck from the pitch line. The pitches *o o* set on the major diameter are projected to D and E, to the minor pitch diameters, F—*e*, G—*e*; and the thickness of the teeth, the striking lines, and radii for the minor diameters are reduced in like proportion. The drawing renders these relations so clear that I think no further description is necessary.

CHAPTER VII.

GEAR WHEELS—MACHINE MOULDED.

I HAVE described the construction of a wheel moulding machine in my previous work, on "Iron Founding," in this series, and also the work of the moulder. I shall here therefore restrict my remarks to the construction of **tooth blocks, core boxes,** and **boards**, which comprise the pattern maker's part of the business, and about which a very great deal might be said with advantage.

The tooth block is of the first importance;—core boxes and boards may be slightly inaccurate without affecting seriously the moulding or the casting; not so the tooth block. There is no taper in the working part of the teeth, and any error existing in the block will be repeated on every tooth of the casting. Hence we make such blocks in mahogany, take the utmost pains in marking out and working, and set them on the carrier of the machine with spirit level and diameter gauge. Let us consider these before the boxes and boards, taking for example, spur, and bevel wheels, worm wheels, and screw wheels.

In Fig. 63, representing a **spur wheel block,** A B are the teeth, ***a*** represents the thickness or "breadth of face" of the wheel, the space *d* inclosed by A and B is that which forms the tooth shapes, corresponding with the inter-tooth profiles, and C is the block or backing to which the carrier of the machine is attached. Since the space *d* alone forms the inter-

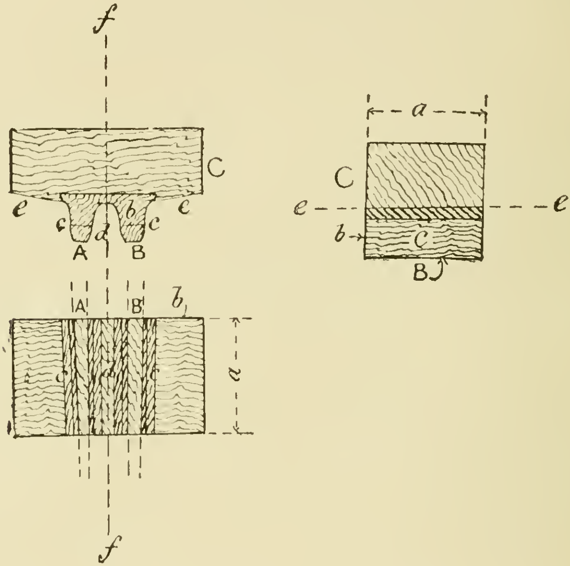


Fig. 63. Tooth Block for Spur Wheel.

tooth shape, it is clear that the outer profiles *c c* are of no importance. They might be cut straight back, so long as they clear the sand on the carrying round of the block. But it is usual to cut them as accurately as the inter-tooth profiles, for a good and practical reason. As the block is carried round and lowered, the side *c* slides down the face formed by the left hand side of *d*, exactly coinciding therewith, and no loose sand from the ramming of the succeeding tooth can tumble between the two to the detriment of the mould. But since it is undesirable that any actual pressure should be exercised by side *c* against the slender sand which represents the tooth space, the outer edges, *c*, are chamfered or tapered slightly downwards, so that they only coincide precisely at the top edge. This taper is shown in the face view of the block in the figure. Also for a similar reason the faces *e e* of the block C are tapered down, clearing the inner faces of the sand.

Different methods of making these blocks prevail. Some are cut from solid wood—the grain running in the direction of the depth of the block, the teeth being cut from the solid. Or the grain may run horizontally, and the teeth be simply glued on. Fig. 63 represents a third method in which the grain of C runs horizontally, and the teeth A B are let in with a single dovetail, and glued, and worked in place. The advantage of this is that it economizes material. Some hard superior wood, preferably mahogany, should always be used for the actual teeth themselves, which are subject to so many repetitions of ramming and withdrawal from the sand, while yellow pine is amply good enough for the backing C.

The marking of the teeth is similar to that of an ordinary wheel. The block is first planed to a parallel thickness, and tested carefully with calipers, and the pitch lines, pitch, and thickness of teeth—all divided from the *centre line ff* of the block, which also represents the centre of the carrier of the machine,—are marked on one side. The centre line then is carried over by squaring it upon a surface plate or other true face, and the divisions for the other side marked. If the centres for the tooth curves come beyond the wood of the block,

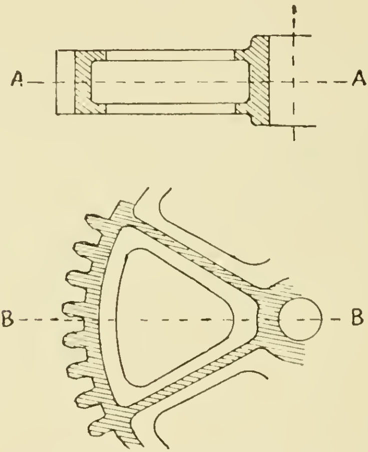


Fig. 64. Wheel with Arms of H Section.

temporary slips are held or tacked in place to receive the divider points. As the block is being worked through with chisel, gouge, and planes, much care is taken to preserve the faces straight by means of a thin narrow straight-edge of hard wood, having its edge coloured with red lead, or whitened with chalk. The square should also be used, as the work nears completion, until at least the internal space *d* is straight, properly shaped, and at precise right angles with the face. The outsides may be finished with less care. Then a very slight amount of glass papering, performed with a rubber only, and three or four coats of rather thin varnish, will complete the block.

The interior portions of machine moulded spur wheels

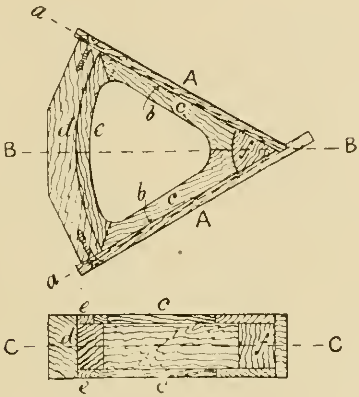


Fig. 65. Core Box for Wheel with Arms of H Section

are almost invariably made from cores, and there is one special **form of arms** almost invariably made use of: the H section, shown in Fig. 64, both in vertical and sectional plans. The *core box* for arms of this section is illustrated in Fig. 65, the upper figure being a plan section of the box along the line C–C, the lower figure a cross section along the line B–B. There are twc sides A A rebated and screwed together, and their inner faces *b b* form the inner faces of the vertical arms; also a sweeped piece whose inner face *d* forms the interior face of the wheel rim, flat arms *c c* at top and bottom, the inner sweeped ribs *e e* which stiffen

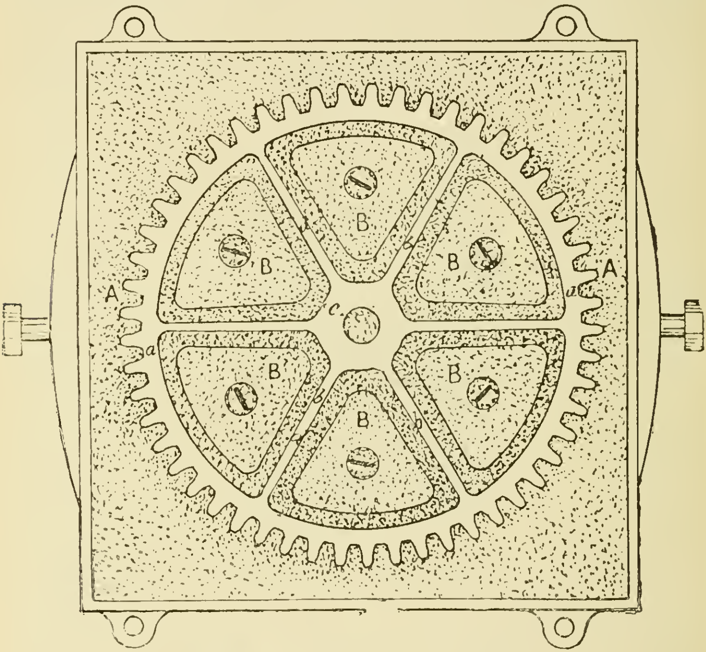


Fig. 66. Cored up Mould of Wheel.

the rim, and the segmental boss *f*. **A cored up mould** ready for the cope is shown in Fig. 66, from which the relations of the several parts can be understood. A is the ring of teeth moulded from the tooth block, B B are the cores made from the box in Fig. 65, C is the central boss core, *c* the thickness of metal in the boss, and *d d* the thickness of the vertical arms. A core box for arms of cross section is shown in Fig. 67, where A A are the sides, B the sweeped piece for forming the interior of the rim, C the segmental boss, D the stiffening rib within the rim, E E the flat arms. But

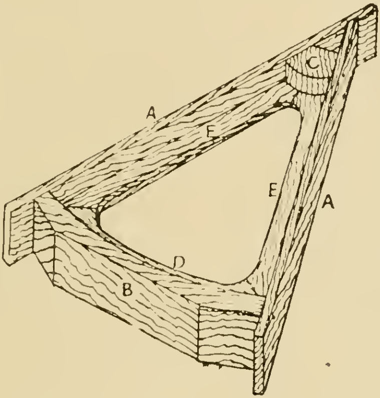


Fig. 67. Core Box for Arms of Cross Section.

these boxes are not used nearly so frequently as those for arms of H section.

Bevel wheel blocks are made as shown in Fig. 68. I have dotted in the outline of the rim and arms, not because these have any existence in the block, but to illustrate the relation of the block to the wheel. The same remarks as to the fitting of mahogany teeth will apply as in the example of a spur wheel block. The teeth, however, are worked alike on the outer and inner tooth faces, because their bevel prevents any contact with the sand occurring before they are actually in place. The block is marked out by taking lines off the wheel drawing, in horizontal and radial directions, to obtain certain definite intersections. Thus, by taking radii *a b c*, corresponding with gauged horizontal lines *a′ b′ c′*, we obtain at once correct positions for root, pitch

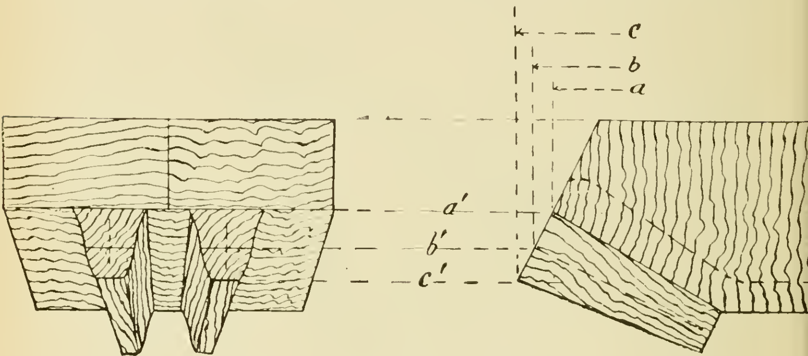


Fig. 68. Tooth Block for Bevel Wheel.

line, and point of teeth on large diameter, and by means of trammels, and long toothed gauge, these dimensions are easily transferred to the tooth. The dimensions on the minor diameter are obtained similarly. Bearing in mind that the tooth block is merely a short segment of the outer portions of the actual wheel rim, it is clear that it will be marked out by essentially the same principles as a pattern wheel. These were explained in the previous chapter in connection with Fig. 62.

Before moulding the ring of teeth for a bevel wheel, it is necessary to **strike a bed** of sand for the bottom face of the wheel arms, and for the tooth points. The board is shown in Fig. 69. The joint A of the mould corresponds with the plane c' in Fig. 68. By means of the outline of the tooth, dotted in Fig. 69, the relation of the board to the toothed ring is apparent.

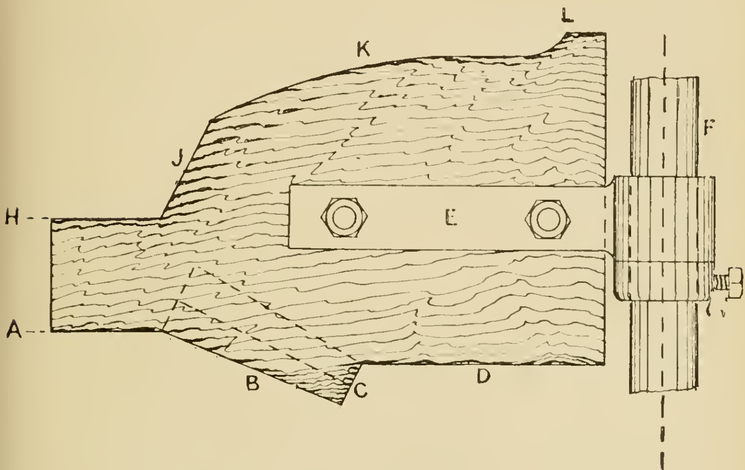


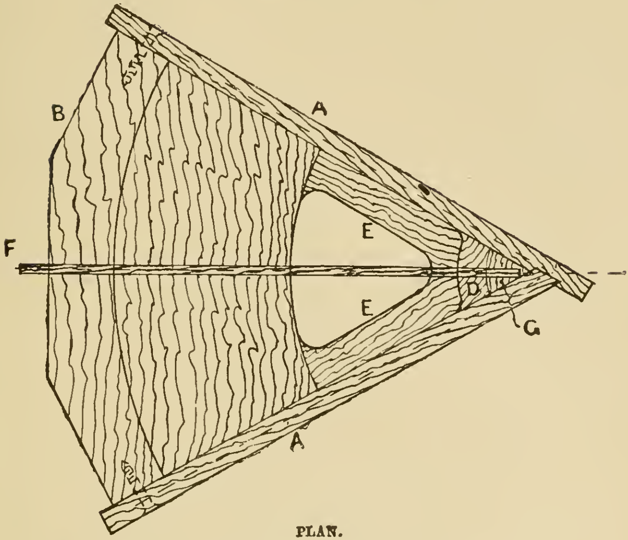
Fig. 69. Board for striking Bed and Cope.

When the tooth block is lowered, the faces of the teeth rest on the sand struck with B, and their inner ends on the sand struck with C. The arm cores rest on D. E is the strap or striking bar to which the board is bolted. It swivels around the turned pillar F, and the strap is kept at the correct height by means of the collar G. The other edge of the board is cut to strike the cope. H forms the joint face, which, being turned over, rests upon the face struck by A. J strikes the sloping outer ends of the teeth, K the contour of the top of the vertical ribs, L the boss. Of course during striking the cope, the position of the board is reversed upon the strap, the edge H, J, K, L being set lowermost.

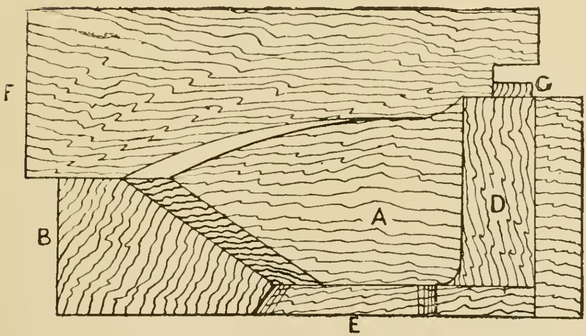
Fig. 70 illustrates the **core box** for this bevel wheel; A A are the sides, and their inner faces form the faces of the vertical arms; B is the sweeped piece that forms the interior of the rim, shown dotted in Fig. 68; D is the segmental boss; E the flat arms; F is a strickle swept round to form the top of the core, and maintained in a radial position with the templet piece G.

The tooth blocks for **helical wheels,** both spur and bevel, though coming under the same general rules as these just noted, differ therefrom in many details. Though not perhaps so apparent in the sketch, Fig. 71, as it is in the actual mould, the ramming up of the lower portion of a helical tooth is not easily done unless a division is effected along the line *a–a*, and the upper half of the block is removed. This division is therefore made, except in the case of shallow wheels of coarse pitch where the interference is but slight.

There is another thing. Many machines are only properly constructed to lift their tooth blocks vertically, a mode of withdrawal which is clearly impossible in the case of helical teeth. By making, therefore, the actual teeth distinct from the backing, yet united temporarily in such a way that they shall



PLAN.



SECTION.

Fig. 70. Core Box for Bevel Wheel.

be as one, the carrier block can be lifted vertically, leaving the teeth behind, to be withdrawn in the horizontal direction. Being made in this way, the division along the line *a–a* gives no extra trouble, but is really convenient for marking out the teeth on their middle planes, and the lower portion of the teeth can

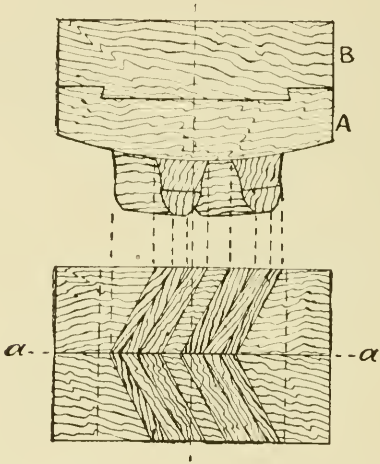


Fig. 71. Tooth Block for Helical Spur.

be rammed while the upper portion is temporarily removed.

Though helical gears are true screw gears, they are not marked out as portions of screws, but the helical form is simply developed during the working through. The amount of angle of the teeth is that which is determined first, and is decided by the condition that as one tooth leaves contact, say at the centre, its fellow will have commenced contact at the edge. So that the amount of obliquity will increase with coarseness of pitch and breadth of face.

There are three or four methods by which the teeth are attached to the hinder portions of the block. Fig. 71 shows a very common method, where the teeth being divided in the horizontal plane *a–a* are united as a whole to the backing by means of a broad dove-tail, so tapered that though the fit is close without slop when the parts are in actual place, there is freedom of movement directly the hinder block is started. Actually there is a total of about $\frac{3}{8}''$ of taper on the edges of the dove-tail, on a block of from four to six inches deep. Sometimes two narrower dove-tails side by side are employed instead of the single broad one.

It often happens that the curvature of a wheel of small radius is such that the outer flanks of the teeth on the block are under-cut in relation to each other,—the outer faces standing beyond parallel lines carried out from the flanks. Then another division in the block is necessary, passing down midway between the teeth, as shown in Fig. 72.

The **shape of the teeth in helical wheels** is marked as in ordinary gears, taking care to have their centre lines on the faces, and on the middle joint truly *radial*. The surface sweep corresponding with the points of the teeth should then be cut round before anything else is done, and the lines representing the terminations of the tooth faces marked round with a bent steel or thin lath of wood. The working of the tooth faces and flanks from face to joint is then done with gouge and chisel, assisted with templet, and it will be found that the amount of twist corresponding with the pitch and width will be developed in the act of working through.

The **shape of the teeth in angle wheels,** Fig. 72,

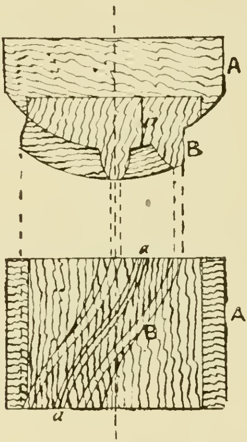


Fig. 72. Tooth Block for Angle Wheel.

and worm wheels, Fig. 73, is rather difficult to obtain. In angle wheels the best plan is to draw diagonals on paper taken from the development of the wheels on the drawing board, and glue this paper around the face of the block, the diagonal lines representing the tooth points ;—thus establishing the connection between the tooth faces, the curve being developed by the gluing around. Very much can be done with paper templets in screws and screw gears more readily than by obtaining a number of points of intersection. The paper method exemplifies the fact that an inclined plane wrapped around a cylinder develops the screw. In angle wheels and in worms the use of paper affords the best and readiest method of marking the profiles.

Fig. 73 illustrates the block for a worm wheel. The teeth may be made fast to the backing, or loose to slide away, as shown in the figure. If made fast

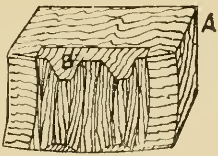


Fig. 73. Tooth Block for Worm Wheel.

they can only be drawn back horizontally. If made loose the backing A can be lifted vertically, and the teeth B withdrawn by the fingers in a horizontal direction. This is the better plan. For the same reason it is better to make the teeth B for the screw wheel in Fig. 72 separate from the backing A; and in addition it is also frequently necessary to joint the teeth at *a–a*, as shown, because the under cutting of the outsides of the teeth would often prevent them from being drawn backwards together. In such wheels, therefore, the block A is lifted first vertically, and the blocks B, each carrying one tooth, separately with the finger, in a horizontal direction.

Wheels of small diameter are generally made with a **central disc,** or plate, instead of with arms, Fig. 74.

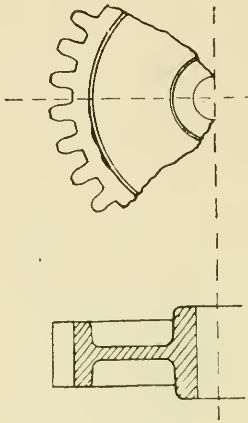


Fig. 74. Plated Wheel.

Then their central portions are made with ring cores, from the box, Fig. 75. These are set in the mould without prints, and the space between them corres-

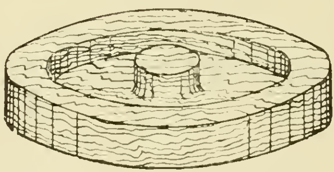


Fig. 75. Core Box for Plated Wheel.

ponds with the thickness of the plate or disc. So much of the boss thicknesses as stand beyond the wheel faces is bedded in the sand in top and bottom

CHAPTER VIII.

SELECTED MISCELLANEOUS EXAMPLES.

A very large and important branch of the pattern maker's work consists in the preparation of **sweeps and strickles** of various kinds for foundry use. The mere making of these is easy enough, but it is not this of which I am going to speak, but of the economical importance of this branch of work, very much of which, in some shops at least, depends upon the initiative of the pattern maker himself, who may often either go to a deal of unnecessary expense in making actual work in wood, in sheer ignorance, when the cheaper strickles would have answered the purpose as well. But he must, nevertheless, be able to discriminate between what is actual economy, and that false economy which simply transfers the cost from the pattern, to the moulding department. For there are plenty of cases in which, though strickles would answer the purpose, the making of a pattern would be cheaper, either because of the large amount of difficult work involved in the foundry, or because the work, though comparatively simple, has to be repeated several times over for several distinct castings. The balance of economy must be struck in each individual case; each separate job must be decided on its merits.

Having given this necessary caution by way of preface, I will divide, for convenience, strickled work into that which is symmetrical, and that which is unsymmetrical in character. In each case the edge of the board or strickle corresponds with the sectional profile of the work. In the former is included all revolving work, as core, and loam boards; in the latter all "strickles," properly so called.

In revolving work there are two conditions; one, in which the striking board is moved, the other, that in which the work is revolved. In the first case, the board is attached to a central bar which turns upon its axis; in the second, the board is laid upon trestles, and the distance from the centre of the revolving core bar, upon which the work is built or struck, to the edge of the board, governs the diameter of the work. The board is revolved when the work is massive; the work is revolved when it is convenient or necessary that the work shall be portable. Thus, in all loam work built with bricks, the board is turned, and beds or copes for machine-made wheels are also struck with sweeping boards; but in all circular cores made without bricks, the core bar is turned, and the board is stationary. In each case it is essential that the correct radius be obtained. In loam work the central bar is of a definite size,—$2\frac{1}{4}''$, or $2\frac{1}{2}''$, and one-half of this is deducted from the length A of the board, Fig. 76, so that its working length is equal to the radius B, minus $1\frac{1}{8}''$ in the first case, or $1\frac{1}{4}''$ in the second. This is sufficiently accurate for all shallow moulds; but in very deep moulds the sway of the upper end *a* of the bar, due to the wearing of the step C, often produces

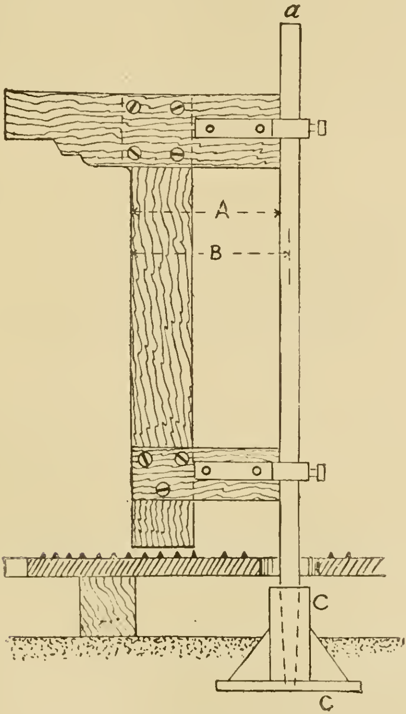


Fig. 76. Striking Board for Loam.

inaccuracy in the mould to the extent of from an $\frac{1}{8}''$ to $\frac{3}{8}''$. Besides this, there is such a thing as inaccurate cutting, and levelling of the board. For these reasons the diameters of the mould itself are properly checked by means of diameter gauges.

The proper way to set **a shallow board** attached with one strap only, Fig. 77, is to plane the top edge and end at right angles with each other, the top edge being strictly parallel with the bottom edge. Then if the socket C of the bar B is truly levelled in the

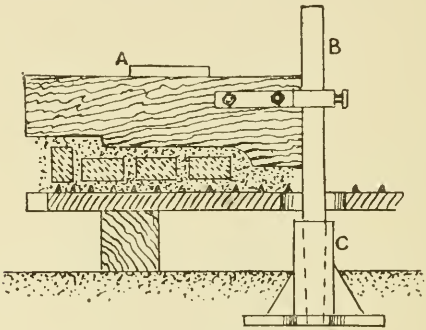


Fig. 77. Striking Board for Loam.

foundry floor, and the spirit level A shows truth on the top edge of the board, the latter must be truly horizontal.

In the case of core boards used with core bars, the radius is obtained by direct measurement at the time of setting up the board on the trestles, and when the correct position is obtained the board is loaded with weights, or clamped to the trestles. When the core is nearly finished the diameter is checked with calipers, and readjustment for radius is made when necessary.

In repetitive work where many cores, all precisely alike, are being made, a rigid attachment of some kind, as a turned cast iron collar, is properly made to preserve the radius of the board constant throughout.

The edges of striking boards, whether used for loam, or for cores, or for green sand, are properly cut as shown in Fig. 78 A, which is a section drawn to large

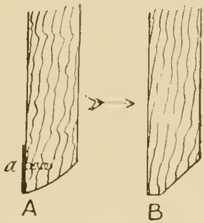


Fig. 78. Edges of Striking Boards.

size. The angle of the edge may vary, of course, but it is not desirable to have it vary much less than that shown in the figure, or the loam surface will be roughened up; and it is not well to increase it greatly, or the edge of the board will be weakened thereby. The edge should never be left sharp and angular as in Fig. 78 B, since that will roughen up the surface of the loam, but always rounding as in Fig. 78 A. When a board is being used over and over again, as for standard column cores, the edge should be protected with a sheet of hoop iron screwed along, Fig. 78 A *a*. The board is swept against the loam in the direction of the arrow.

Boards used on trestles should always be long enough to include the core prints, and also be six or eight inches at each end beyond, for support upon the trestles. They should also be rigid, not flimsy, or they will "sag," and yield before the body of loam, so that the core will become larger in the central parts than next the ends. When boards are so long that the requisite rigidity cannot be secured without using wood of excessive thickness, say of over $1\frac{1}{4}''$ or $1\frac{1}{2}''$, then a stiffening rib should be screwed along the top face, or along the bottom face, so that it clears the trestles. From $1''$ to $1\frac{1}{4}''$ should not as a rule be exceeded for the thickness of loam boards and core boards of moderate length.

Boards having irregular outlines must often be framed together, in order to avoid shortness of grain. An example of such a form occurs in Fig. 76.

Striking boards are frequently employed to make **patterns in loam,** to save the cost of wood. From a pattern made in loam, dried, and coated with tar, a good many moulds may be taken,—eight, or ten, perhaps, if used carefully. A good many patterns of large size, which are required for temporary purposes only, are made in this way. Fig. 79 shows the board and bar arranged for striking up the pattern of a large air vessel. This method is adopted in many cases. Thus, if the diameter of the casting is such that a man cannot stand within to strike a board around—say of two feet or less in diameter—a loam pattern is made, and moulded either in green, or in dry sand, just as though it were of wood. A loam pattern in this case is much cheaper than one in wood, and answers the purpose very nearly, or quite as well. In other cases the choice would lay only between patterns made in loam, or in wood, a loam mould being altogether too costly. In Fig. 79, A is the board, B the trestles, C the loam pattern, D the core bar, E the handle by which it is revolved, F the core print, G the neck of the vessel, *a a* the turned journals of the bar.

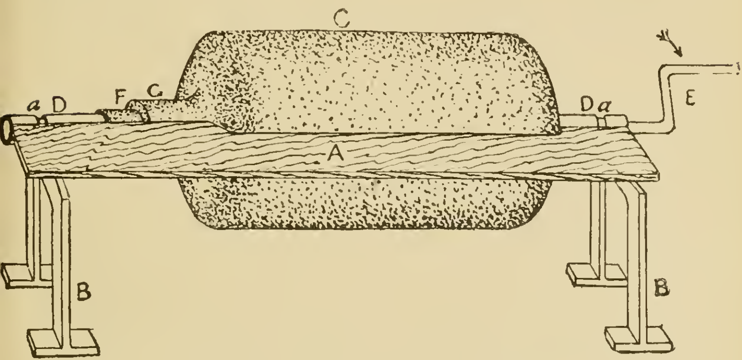


Fig. 79. Striking up a Loam Pattern.

It is evident that these boards will only strike symmetrical forms. When castings are in the main symmetrical, they often have flanges, facings, brackets, bosses cast with them also. These are then necessarily prepared just as though the entire pattern were of wood, and are fitted and attached to the loam pattern, or embedded in the loam mould, as the case may be. When these fittings are very numerous, it becomes in some cases a question whether, considering the better facilities which patterns in wood afford over those in loam for the fastening of attachments, it is not worth while making the whole in wood. The question is then one of relative dimensions, because very large patterns, even though plain, are expensive. Here the pattern maker must use his judgment. Both in composite patterns, and in loam moulds, much care is necessary in the correct setting of the various attachments, and this is usually the pattern maker's work; the moulders seldom take responsibility in these matters.

It is obvious that joints cannot be made in loam patterns, as in those of wood; the jointing of the mould is done therefore around **solid patterns**, and the lifts are often bad in consequence.

In many cases of hollow work, as in those where a single casting only is wanted off a loam pattern, the core intended to be used is struck first and dried, a thickness of black wash laid upon it, and a thickness of loam, representing the thickness of the metal in the casting, is struck on. This then forms the pattern. After the mould is made, the "thickness" is stripped or peeled off, at the parting made by the black wash, and the core laid in place. When several castings are wanted, a separate pattern is made, and the cores made quite distinct therefrom.

Unsymmetrical work embraces that which is not revolved, but swept up with strickles working against guides of various kinds. The commonest application of the principle is seen in the striking of a pipe pattern or pipe core, Fig. 80, A, the guide iron B being a length of square bar bent to the required curvature, and becoming a guide to the strickle, Fig. 80, C, with which the core or loam pattern is struck up. Often the edge of a cast iron plate is made the guide, and then the core is dried upon the plate. Two such halves cemented together form in section a complete core section. In shops where much loam work, and work of a temporary and at the same time massive character is done, strickling or sweeping up assumes an important character and is done in multifarious

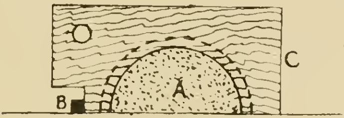


Fig. 80. Strickling.

methods. The simple strickles working against guide irons are capable of sweeping up almost any forms, even though the cross sections and dimensions change perpetually, and even though it may not, owing to change in section, be possible to move the strickles longitudinally. Yet they will leave impressions at definite localities, and the loam which is intermediate between these localities can be swept off by other strickles moving transversely, or at right angles to the others. Thus a centrifugal pump casing in which the form is that of a volute, and in which no two sections are alike, can be made with strickles, the only actual pattern work necessary being feet and flanges. Such a method would not of course be pursued unless the pump were a casual job only. For standard work a complete pattern and core box would be made. The beds for propeller screws are struck by sheet iron templets bent to a helix corresponding with the pitch of the screw, the board being guided in its travel by the edge of the sheet iron. The mould, or the loam pattern of a screw barrel used for cranes is struck against a templet screw, which is variously fixed according to the nature of the mould or pattern, whether struck in the vertical or horizontal direction.

Enough has been said to illustrate the economical importance of a strickle used in combination with a guide. Of no less importance is the **obtaining of thicknesses.** I mentioned just now the striking a body of sand on a circular core of equal thickness to that required in the casting. The practice of striking thicknesses on cores whose forms are unsymmetrical is also adopted; first, by having a strickle sufficiently large, and a "check," as it is termed, in such a position that the core, and pattern strickles shall be concentric with each other, Fig. 80, the full line representing the core strickle, the dotted line the pattern one, the check B being at an equal distance from the *centre* in each case. The guide iron remains thus fixed in the same position during the striking of both core and pattern. This method is adopted when practicable.

In work which is rubbed to shape by a strickle working transversely to the shapes moulded by strickles working in the longitudinal direction, other methods are necessarily adopted. There are at least two ways equally good. One is to plane up strips, if the work is straight, or cut sweeped strips where the profiles are curved, of the precise thickness of the metal required; to tack or lay these on the loam core, and fill up the interstices with loam, strickling it off level with their upper edges. When it is fairly set, but not baked, the strips are withdrawn and their spaces filled with loam, level with the rest, and the core baked. A slight touching up with glass-paper afterwards finishes the surface ready for blackening. Another mode is to drive a number of flat-headed chaplet nails into the loam

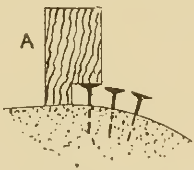


Fig. 81. Gauging "thickness" with nails.

core, allowing their heads to stand above its surface to a distance equal to the thickness of metal, a gauge like Fig. 81 A being used for obtaining uniformity. These nail heads are the guide for laying on the thickness loam uniformly over the surface. They are easily withdrawn after the pattern is moulded, and when the core is wanted for placing in the mould.

Irregular joint faces sometimes occur, and then a bed of sand is strickled off to the form required. Certain portions of the outlines of cores made in boxes are sometimes strickled to avoid cutting material to waste.

The faces of moulds are often strickled at some distance below the general level of the pattern face to avoid jointing the pattern itself. In a vast number of ways the strickle and striking boards are utilized to save the cost of pattern work.

The obtaining of sweeped outlines by the ramming of green sand against **sweeps of wood**, though not strictly coming under this head, is yet so near akin thereto that the present is the most suitable place to allude to it. A ring can be made either by cutting a sweep to

Fig. 82. Sweep.

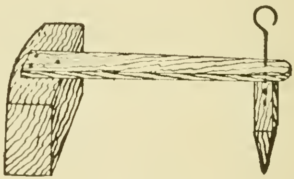


Fig. 83. Sweep.

the radius, and the sectional form of the ring, Fig. 82, and ramming the sand around; or if the ring is broad, by using two sweeps, one for the outer, and the other for the inner radius. The sweeps in each case may either be worked round at the end of a radius rod pivoted on a central stake of wood, Fig. 83; or a level bed of sand being struck with a board, or being levelled with winding strips,—lines corresponding with the diameters of the circles are struck thereon and the sweeps rammed to these lines. Not only plain sweeps, but foundation plates, bed-plates, base plates, and many similar castings may be moulded in this way, and brackets, facings and other attachments can be bedded in at any required positions, while central portions can be formed with cores. It is desirable that there should be little work in the cope; but still with care a goodly number of fittings can be included in that, either by direct measurement, or by ramming a plain bed and laying thereon the portions which are to come in the cope, and then staking the latter in place, and ramming it upon the bed, when the impressions of facings, brackets, etc., will be left in the position which they are finally to occupy. All such measurement is the pattern-maker's work.

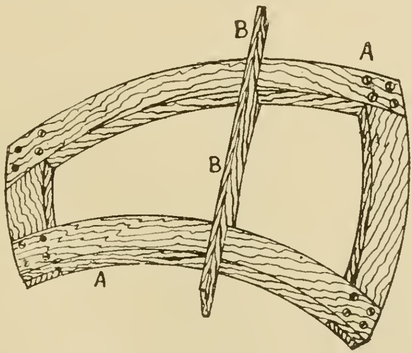
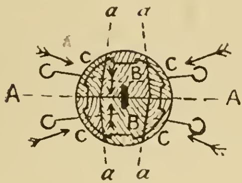


Fig. 84. Strickling a Panel.

Fig. 84 illustrates **a method of strickling** which is much in use to save the cost of timber and of labour.

This is for a boiler-maker's templet block, used for hammering the sheets of wrought iron buoys upon to their curvature. Instead of laboriously cutting out an entire solid plate, a frame only, A is made, of sides and ends halved together, and the interior is completed in sand with the strickle B. Flat plates, when of large area, are almost invariably made in this way, with open frames and strickles, and the flat plated portions of many patterns which are made complete in all other respects, are also frequently plated and strickled.

Fig. 85 is an illustration of **an ornamental column** used for railings. Its shaft is enveloped with a double helix, and shallow circular recesses break the monotony of the inter-spaces. Scroll work is cut in relief in base and capital, and a square flange on the base serves to fix the column in position. It is obvious that if this column were only divided through the centre like an ordinary column or pipe, it would not deliver from the mould at all, because the helices, the shallow recesses at the sides, and the spaces between the relieved scrolls would tear up the sand. Therefore the method shown in Fig 25, p. 41, but slightly modified, is adopted. The pattern is jointed as usual along the middle plane A—A, shown in the upper part of the figure, in which is represented a section through the shaft of the column. But each half of the column on each side of the joint plane A—A is formed in three pieces, B, C, C, jointed along the lines *a a*. Skewers retain C C in place during ramming. When withdrawing the pattern, B B are brought out first in the



CROSS SECTION.

direction of the arrows, and afterwards C C C C are drawn in the direction of their arrows, into the spaces left by the removal of B B. The whole of the shallow circular recesses, and the helices, and the relieved scroll work will then deliver in detail freely, without fracture of the mould. The joint lines *a a* are seen in the elevation of the pattern. The square base is unjointed except the joint in the middle plane A—A, and any prints put upon the ends would be jointed only in the middle plane. When making such a pattern as this all the rough strips of stuff are jointed up before any turning is done. They are secured during turning in various ways. The centre joint A—A is dowelled and secured with centre plates, see p.

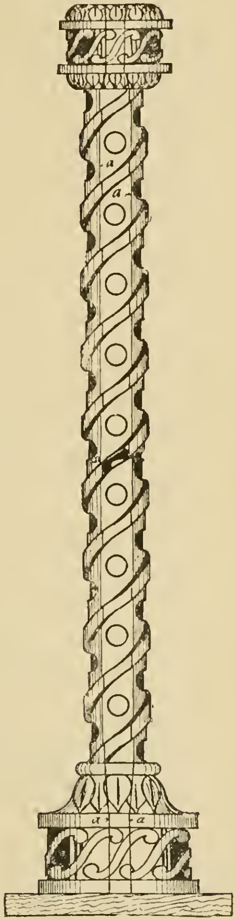


Fig. 85.
Ornamental Column.

124. The side pieces C C may be screwed to B, the heads of the screws being countersunk sufficiently deep not to come in the way of the turning tools. Or they may be held with paper joints: that is, narrow slips of paper, two or three inches in width, three or four in number in the length of the column, will be glued in the joint faces *a* of C and B. The opposite sides of the paper are glued to B and C respectively. This joint holds very firmly, yet when the turning is done the joint can be easily broken with a chisel, the paper dividing through the centre of its substance. I have not shown any timber shading in the column, fearing to interfere with the clearness of the details. The whole of the grain runs longitudinally, except that in the square bottom flange, which runs as illustrated.

Patterns jointed thus along the sloping lines *a a*, the middle part delivering first and the side pieces after, are employed to a large extent in ornamental work. When we have very ornate capitals to make, there will also be a number of minor and local joints necessary to get scrolls and leaves out of the sand.

Fig. 86. Bottom Board.

Fig. 86 illustrates a very common device. It is a **turn-over board**, or bottom board. When light flimsy patterns, and when almost any patterns are made in considerable quantity in flasks, and when patterns have irregular outlines, turn-over boards are often employed. One portion, usually one-half the pattern, is laid upon the bottom board, the drag part of the moulding box put over it, and rammed up and turned over. The bottom board keeps the pattern true, and forms the joint face of the mould. This face is then ready to receive the remaining portion of the pattern which is rammed in the cope. The bottom board A in the figure is formed of stout boards, with open joints, and battens B. The pattern C is a pipe.

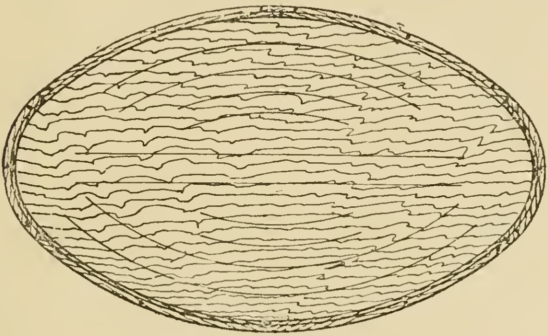


Fig. 87. A Name Plate ready for Lettering.

The patterns of **name plates** are made in all sizes and forms, usually of wood. A thin piece of wood is planed and cut to the outline required, and filleting is glued or nailed around the edges. Lines are drawn upon the plate, and letters of lead or brass are cemented on with varnish, or are nailed on, or in the case of heavy patterns, are screwed on. Fig. 87 shows an elliptical plate prepared for the letters. Fig. 88 illustrates a rectangular plate with the letters fastened on.

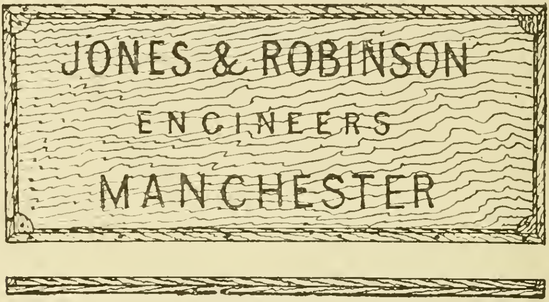


Fig. 88. A Name Plate Finished.

CHAPTER IX.

PATTERN TURNING.

The proper use of tools cannot be taught even in an elementary way in a treatise of this kind, and I am not going to attempt it. Still, it seems to me that some little space should be devoted to that section of the trade which is performed in the lathe, and without this even an elementary treatise would be regarded as wanting.

Pattern turning, however, has few points in common with ordinary wood turning beyond the employment of similar lathes and tools. I have referred to these tools on p. 9. Accuracy is of more importance in pattern work than finish and polish. In common wood turning the contrary usually holds good. Further, much pattern turning is of large dimensions, while cabinet turning is usually small and delicate. Then there is some taper, more or less, wanted on nearly all sections of pattern work, while there is nothing of the kind to trouble the cabinet turner. I will consider a few typical illustrations of pattern turning in order to elucidate these points. And I will for convenience consider the several illustrations under the heads of turning between centres, turning in cup or bell chucks, and finally turning upon face plates.

Turning between centres is performed while the work is pivoted at one end upon the centre of the sliding poppet, and driven at the other with the fork, or prong centre of the fast head-stock. The stuff is roughed down with the gouge, held generally as in Fig. 89. The cutting is done in a slightly diagonal direction; which diagonal cutting, now to right, now to left, removes the material more easily, and with less stress, and leaves the surface cleaner than as if the gouge were presented normally to the work. Observe the position of the hands in the figure; while the right hand grasps the end of the handle firmly and so manipulates and thrusts the tool to its work, the left hand controls the cutting edge. The tool is gripped upon the rest between the forefinger and thumb so that it cannot "kick" away from its work under the stress of cutting, which stress, tending to drive the tool outwards is very severe when turning down sloping faces.

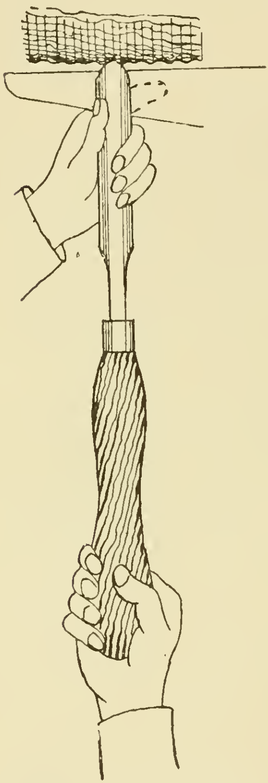


Fig. 89. Method of holding Turning Gouge.

More troublesome than this, however, to a beginner is the manipulation of the *turning chisel.* It is held similarly to the gouge, and presented as in Fig. 90. When cutting straight and convex profiles it is invariably used as in the figure. That is, it is tilted upon the rest, and cutting is done only with about one-third or one-half of the edge nearest the corner *a*. If cutting is carried along too near to the corner *b*, the chisel will hitch in the wood and tear it out in an unsightly fashion. But when the cutting is done towards *a* in a

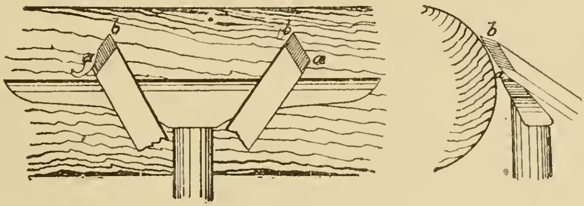


Fig. 90. Presentation of Turning Chisel.

proper manner, a very smooth surface is imparted to the work, because the cutting takes place in a diagonal direction, which is always most conducive to perfection of results. This is seen in the skew mouth rebate plane, in diagonal cutting with a chisel in the mitre cutting machine, and in other common examples.

But because the chisel operates along so narrow a section of its cutting edge, the surface of the work becomes, in the hands of an unskilful man, a series of minute ridges. The larger the diameter of the work and the more irregular its outline, the more difficult it is to prevent the formation of these ridges. For this reason, most pattern makers, who perhaps are not quite so skilful at lathe work as those who are turners by profession, use a firmer chisel to smooth down the ridges left from the common turning chisel. And in all work of large diameter, that is, say of over about 3″ or 4″, and in all flat or face work, the firmer chisel is used directly after the gouge, and so the finish of large surfaces is imparted entirely by scraping.

To scrape a surface truly and smoothly, some practice is required. The tool is apt to yield before the wood, and presently the wood wobbles and becomes eccentric. Then the grain becomes torn out in certain places. It is torn out in minute splinters when the turning is being done parallel with the grain. When being done "plank way," the end grain not being cut properly, becomes dragged up and has a rugous appearance. No amount of glass-papering will smooth such surfaces and make them true, so that the art of scraping lies in keeping the chisel as sharp as possible, and holding it rigidly to its work. Also, as the gouge is a true cutting tool, and the chisel when used as a scrape is not, as much material as possible should be removed with the gouge, leaving the veriest film to be smoothed and levelled with the chisel. It is as well to add that the chisel when used for scraping should be sharpened more obtusely, or "thicker" than when employed for bench work.

The corner *b* of the turning chisel is used for **cutting down faces which are perpendicular,** and nearly so, to the axis of the lathe. The corner *a* is not suitable for this. When employed thus the chisel kicks back. When cutting downwards with the corner *b*, Fig 90, as shown in Fig. 91, the part of the chisel towards *a* must not be allowed to come into cutting contact with the work, or the tool will kick back. The corner *b* is also used for parting or dividing off work, which it does

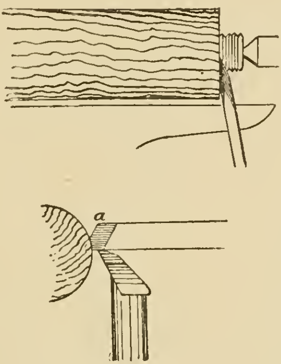


Fig. 91. Chisel turning Perpendicular Faces.

with much ease and freedom. When turning down a perpendicular face with this corner, either for finishing its surface, or for parting off, the chief difficulty is to cut the face true; it is apt to become slightly wavy. The remedy is to keep the chisel well sharpened, and to grasp it firmly. Frequently, however, when the face is of considerable depth, the right or the left hand side tools, Fig. 92, are employed to finish them by scraping.

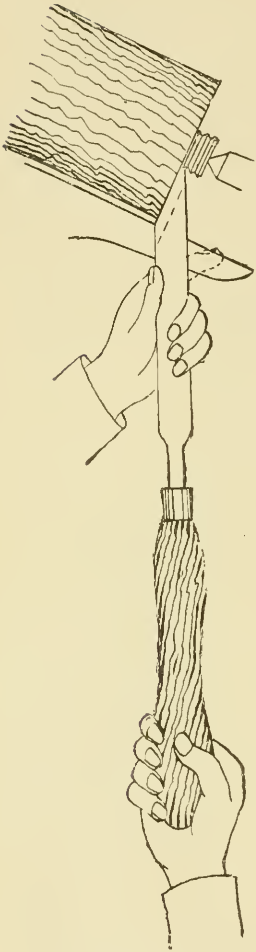


Fig. 92. Side Tool.

Turning in the cup chuck, or bell chuck, is done instead of turning between centres, when a recess has to be bored in the front end of the work, which could not be done if it were centred upon the back poppet; or when a number of small articles have to be turned and cut off in succession from a single piece of wood. The piece of stuff to be turned is driven into the bell chuck with a hammer, or with the poll of the axe, having been first roughed out with the axe, or by rough turning, to fit the hole in the cup chuck tightly. A very long piece of stuff cannot be turned in the cup chuck without such vibration as would be fatal to accurate turning. In an exceptional case of this kind, a wooden steady must be employed. For boring holes in the front of work held in this chuck, the gouge and side tools are employed. And if there are concave profiles, these are finished with the round nose tool.

Turning on face plates is done in quite one-half of the pattern work effected in the lathe. The work which is done on the face plate ranges from two or three inches in diameter to six or eight feet. The *face chucks* themselves are of metal, screwed to fit the mandrel nose. But for most work it is convenient to make use of chucks of wood intermediate between the metal chuck and the work. Flat work is secured to face chucks by five general methods. First, for small light blocks which do not require to be bored, the screw of

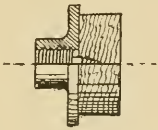


Fig. 93. Taper Screw Chuck.

the taper screw chuck, Fig. 93, affords sufficient hold. For work of somewhat greater weight, three or four wood screws are run into the wood through the holes

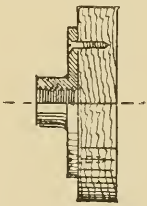


Fig. 94. Face Chuck.

which are drilled and countersunk in the plate, Fig. 94. For the bulk of turning, however, the intermediate chuck of wood, Fig. 95, A, is employed. This is screwed upon the metal chuck B, and faced over in the lathe, and the block C which has to be turned, being first planed truly on the face which is intended to go against the face of the plate, is screwed to it. By using this intermediate plate of wood, rings and flanges can be turned even when their internal diameters are larger

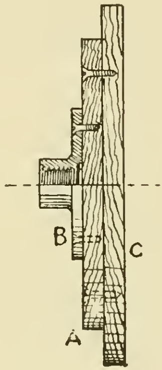


Fig. 95. Intermediate Wood Chuck.

than the metal chuck, because the screws which hold the work pass through the wooden chuck beyond the radius of the metal plate, as seen in Fig. 95. Also, when finishing bored holes, the tools do not come into contact with a metal face; but only with one of wood. Further, work can be chucked and re-chucked on wooden plates by convenient methods which would not be practicable in the case of the metal chucks. For instance, paper joints are frequently made for the first course of segments employed for building up rings of wheels and pulleys, see Fig. 53, p. 68. And work is rechucked either by a shallow annular recess in the wooden chuck, or by screwing three or four blocks, A,

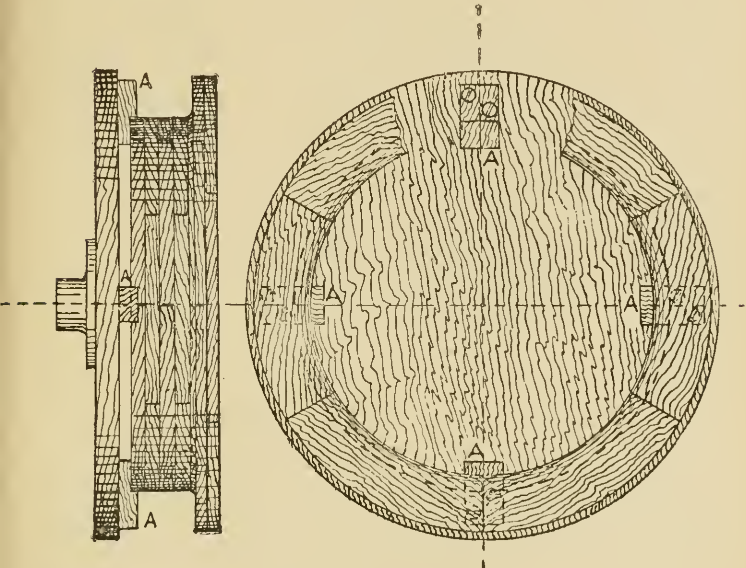


Fig. 96. Chucking with Blocks.

Fig. 96, upon the plate, and recessing these to receive the face and edges of the ring already turned, so that when re-chucked, the opposite face and adjacent edges, if need be, may be turned.

The intermediate face chucks are made of soft wood, as yellow pine, or red deal. If small, they are solid. If of moderate size, say over 15″ or 18″ in diameter, they are made of two or three strips held together with battens, Fig. 97. But if of large size, say from 3′ 0″

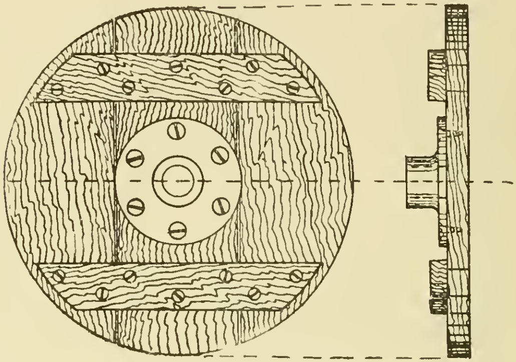


Fig. 97. Face Plate with Battens.

upwards, they are better if framed together in the way shown in Fig. 98. A cross of stout wood is halved together, and segments are screwed to this to form the face of the chuck. It is with a view to preserve these large plates as long as possible for service that chucking blocks like those in Fig. 96, A, are screwed to them, in preference to recessing the plates themselves.

Turning jointed patterns is properly done after the timber has been jointed and dowelled. That is, instead of turning a solid piece of wood and sawing it down to make a joint, the wood is jointed first and then turned, and its circular form is perfect. The work thus jointed is secured during turning by the following methods. The halves of small light patterns turned

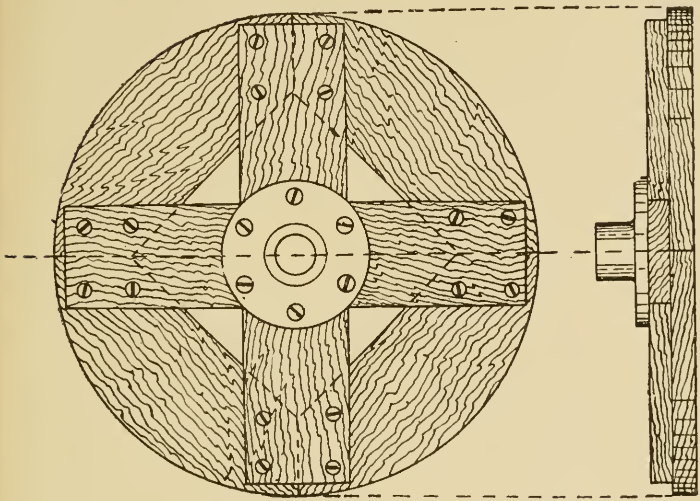


Fig. 98. Face Plate with Cross.

between centres are frequently held with wood screws, Fig. 99, run into waste wood just beyond the ends of the actual pattern, or if in the pattern portion, they are

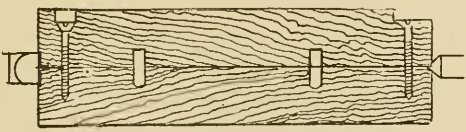


Fig. 99. Jointing for Turning.

countersunk so that they will occupy a smaller radius than the turned surfaces. Or, small dogs or staples are driven in, two in each end. In these cases the prong and point centres of the lathe enter directly into the wood of the pattern. But in large heavy work done in soft wood, these centres become enlarged so much that another method of centring and holding is employed. Metal centre plates are substituted, one for the prong, and one for the dead centre. These are

Fig. 100. Centre Plates.

of two forms, one shown in Fig. 100, like a broad staple, acting therefore both as staple and centre plate, the other being fastened with screws into both halves of the pattern, Fig. 101. When jointed work is turned

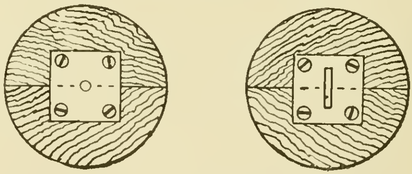


Fig. 101. Centre Plates.

upon a face chuck, sufficient security for the two parts is obtained by running screws into both halves of the pattern.

PREFACE TO GLOSSARY.

I DO not claim that this glossary is exhaustive, either in respect to number of terms, or completeness of definitions. My idea here is to give brief explanations only of the leading terms employed in pattern shop and foundry, in order that the apprentice and student may be able to peruse the book intelligently, and to derive as much assistance as possible from it in the practice of daily duties. Many years elapse before a pattern-shop apprentice picks up the meaning of many of even the commonest terms employed in the foundry; and the same is true of the moulder's apprentice in regard to pattern-shop terms. The student in the schools is placed at a still greater disadvantage. I have also thought it well to prepare the glossary, because, though some of the terms recur many times in this book, or in "Practical Ironfounding," while their meaning is only given in one locality, it will be easier to look up a brief defintion in an alphabetical arrangement than to hunt the meaning up in the body of these volumes. Some terms again are not explained in either volume, their definitions not coming within the range of the subjects treated, and when therefore to explain them would have necessitated digression; hence another advantage of a fairly comprehensive glossary.

GLOSSARY.

A

Air Belt, or wind chest. An annular chamber which surrounds the tuyere zone of a cupola, and receives the blast from the pipes, directing it through several tuyere openings among the fuel. The blast is thus rendered equable.

Air Drying. The surface drying of cores by the air, due to delay in putting them into the stove. This is injurious, being productive of fragility.

Air Furnace. A reverberatory furnace (*q.v.*).

Air Vents. *See* VENTS.

All Mine Pig. Pig which is smelted entirely from ore, as distinguised from cinder pig (*q.v.*).

Angle Board. A board of from 2′, 0″ to 6′, 0″ in length, provided with shallow V shaped grooves running lengthwise, and used for holding angles and hollows steadily while they are being planed to shape. A stop is fitted across near the end to receive the thrust of the strips which are being planed.

Angles. Strips of wood, triangular in section, which are fitted into the corners of patterns for the purpose of strengthening their castings.

Arc of Contact. That portion of the pitch circle of a wheel within the segment of which the contact of a single pair of teeth begins and ends.

Arms. The radial strips which connect the rim of a wheel with its boss.

Axe. Used by pattern-makers for roughing down wood which has to be turned.

B

Back Plate. A rough stout plate of cast iron bolted to the outsides, or backs, and against the edges of the bars in deep flasks, whose enclosed moulds are poured vertically. The back plate serves to sustain the sand against the great liquid pressure.

Back Saw. A saw whose blade is supported and rendered rigid by a back of iron or brass. Tenon saws and dove-tail saws are back saws.

Barring. Poking away the coke from the immediate vicinity of the tuyere openings, by means of an iron bar inserted through the sight hole.

Bars. *See* STAYS, AND STRIKING BAR.

Base Circle. The fundamental circle upon which the describing circle (*q.v.*) is rolled to develop the curves of cycloidal teeth (*q.v.*). The base circle corresponds with the pitch circle.

Batten. In cases where a thin pattern has broad superfices and is not provided with flanges or ribs which would maintain it straight and true, it is customary to screw ribs on either the top or the bottom face; and after the pattern has been withdrawn, to fill up, or "stop off" the ribs with sand. Such ribs are termed battens.

Bed Charge. The lowermost charge of coke, or that lying upon the bed of a cupola. The bed charge is necessarily deep, in order to raise the charges of metal above the height of the tuyere openings.

Bedding in. The moulding of a pattern by embedding it in the sand in the precise position in which the casting is to be poured.

Beeswaxing. The rubbing over of cast iron patterns with beeswax. The patterns are warmed first of all to a sufficient degree to melt the wax. Beeswaxing facilitates their withdrawal from the sand, as shellac varnish does that of wooden patterns.

Bellows. Used in foundries for blowing away parting sand and loose sand from moulds.

Belly Core. A core enlarged in the central portion for the purpose of lightening out a boss, beyond that effected by the straight portion of the bore of the same. It is also enlarged, or "bellied," to prevent "drawing" of the casting in cooling. Called also chambered, and roach bellied core.

Bench. The base or table upon which a workman performs his tasks. A pattern maker's bench is usually made of red deal, and provided with a single screw vice, and a drawer. A core maker's bench is of cast iron plate.

Bench Hook. A block of wood furnished with a stop at each end, but set on opposite sides of a central web. The web is laid on the bench, and the lower stop presses against the edge of the bench, while the upper one takes the thrust of the wood which is being operated on by the saw.

Bench Knife. A small piece of old knife blade which is used to prevent circular or irregularly shaped work from shifting upon the bench while being planed over. It is driven partly into the hinder portion of the wood, and partly into the bench.

Bench Planes. The planes which a workman always keeps on his bench. They are the jack, trying, and smoothing planes only.

Bevel. A tool consisting of a stock and a blade, the latter being capable of adjustment to any angle with the stock, and tightened with a screw. It is used similarly to a try square, but angles other than right angles are checked by means of it.

Bevel Wheel. A cog wheel in which the teeth are disposed radially around the frustrum of a cone. These wheels are used to transmit power through shafts, the axes of which are not parallel.

Bisect. To cut in halves.

Bit. A boring tool which is operated in a stock or brace. A full set of bits contains, centre bits, shell bits, nose bits, countersunks, rymers.

Blackening, or blacking. A thin facing of almost pure carbon, consisting of oak charcoal, or of plumbago, by which the fusible ingredients of the sand are protected from the action of the intense heat of the molten metal. Blacking is applied as a powder in most green sand moulds, but in moulds which are skin dried, and in dry sand, and loam moulds, and for cores, wet blacking or black wash, or core wash is used; being common blacking mixed with water thickened with dissolved clay. Wet blacking slightly hardens the surface of the mould.

Blacking Bag. A muslin bag from which blackening is dusted over moulds.

Blackleading. Brushing over the surfaces of wood or iron patterns with common blacklead imparts a glossiness which facilitates delivery from the sand.

Blacking Mill. *See* Coal Mill.

Black Sand. The sand which forms the floor of a foundry, and which by repeated usage, and the admixture of coal dust, has become black.

Black Wash. *See* Blackening.

Box Filling. The shovelling in, and ramming of all the sand enclosed in a flask, with the exception of that employed for facing.

Boxing Up. The framing together of heavy patterns by the fastening together of thin boards into rectangular or other forms, as required. It is practised in order to economise timber, and to avoid the warping which is unavoidable where heavy timber is used.

Blast. The current of atmospheric air delivered from the blower or fan, under pressure, through the blast pipe into the cupola.

Blast Pipe. The pipe through which the air necessary for combustion passes from the fan or blower to the cupola.

Blazed Pig. *See* GLAZED PIG.

Blower. A box fitted with revolving wafters or pistons, from which air is forced under pressure into the blast pipe leading to the cupola.

Blow Holes. Holes occurring in castings, usually in groups, due to the entanglement of air and gas by the molten metal. Blow holes usually result from insufficient venting, and from moisture.

Blue Lines. These are used in drawings as centre lines, or dimension lines, so that they may not be confounded with actual working or structural lines, which are black.

Body Core. A main or principal core, as distinguished from branch, and smaller cores.

Body Flange. A pipe flange which is not shouldered into a recess in the usual fashion, but cut to fit over the body of a pattern, so that it may be slid to any position on the body to facilitate the alteration of the pattern to different lengths for jobbing work.

Bore. (1) The size of a hole after it has been turned to finished sizes in a lathe or boring mill. The bored dimensions are always given on drawings, and the pattern maker has to make due allowance for boring in his core prints. The ordinary alowance is $\frac{1}{4}''$ in the diameter for iron, $\frac{1}{8}''$ for gun metal. (2) The diameter of the rough hole in a pipe.

Bottom Board. A board upon which a pattern or a section of a pattern is laid during ramming up. Also called a "joint board," because the joint of the mould is formed by its face; and "turn-over board," because it is often turned over with the pattern after ramming. Its face may be either plain, or of an irregular form, according to the nature of the work.

Bot Stick. A bar of iron pointed at one end and flattened at the other, used for opening and closing the tap hole of a cupola.

Bow Saw. A thin narrow saw, from 8″ to 18″ long, strained between a frame, and used for cutting small curves. Also called "frame saw," and "turning saw."

Bradawl. A boring tool which acts less by cutting than by pressure. The chisel like end, when thrust transversely to the direction of the grain, divides the fibres, and the body of the awl pushes aside the divided fibres as it is thrust downwards. The best bradawls are made smaller in diameter towards the handle in order to clear themselves, and to lessen the labour of driving them in.

Brad Punch. A short blunt-pointed bit of steel, used for driving the heads of brads and nails down below the surface of timber in order that they may be covered up and hidden. It is struck with a hammer. Two or three punches are required to suit brads of various sizes.

Bricking Up. Building up the skeleton of a loam mould by means of bricks, cemented together with loam, and made to break joint.

Bricks. Used as a backing for the loam in loam moulds.

Bull Nose Plane. A single iron plane in which the cutting edge acts close to the front end of the stock,—used for planing into corners. The stock is made in metal, and the plane does not exceed 4″ or 5″ in length.

Buckling. The curving and twisting of timber, caused by the drying up of the moisture present in the timber cells.

Building Up. The construction of patterns in a number of independent pieces, the joints of which overlap. A vast deal of work is thus built up, the joints being glued, and pegged, or nailed.

Burning On. Or casting on. The union of iron to iron while in a semi-fused condition. It is a practice sometimes resorted to when sectional portions of castings only are damaged, a new piece being burnt on by pouring molten metal over the fractured surface, until fusion takes place.

Burnt Sand. Sand, the constituents of which have been partially fused and converted into oxides by the action of molten metal. The sand which forms the face of the mould invariably becomes burnt.

C.

Caliper. A tool used for gauging diameters of work where an end or sectional measurement cannot be taken, hence termed "outside" calipers; also for measuring internal diameters, and then called "inside" calipers.

Camber. Signifies the curving of certain types of castings in cooling, being due to want of symmetry in their sectional forms, by reason of which one portion cools off more rapidly than the other, causing distortion of figure in the longitudinal direction.

Carrier. A casting which is attached to the arm of a wheel moulding machine, and to which the tooth block (*q.v.*) is attached.

Casting. A piece of metal work obtained by pouring the metal while molten into a suitable matrix.

Casting On. *See* BURNING ON.

Casting Upright. Pouring work on end, adopted for castings whose length exceeds by many times their width, the direction of greatest length being vertical. Such work is cast in the foundry pit (*q.v.*). The object of casting on end is to secure the greatest soundness possible.

Centre Plate. A metal plate used for fastening the halves of a circular pattern together while it is being turned between lathe centres.

Centre Square. Or Radius finder. An instrument used for finding the centre of a regular curve, or circular disc. It consists essentially of a straight-edge at right angles with a line drawn through the centres of two guide pins which are made to touch the periphery of the curved work.

Chalk. The uses of chalk are various in the pattern shop. It is used to whiten drawing boards (*q.v.*), to whiten the opposite surfaces of timber which has to be jointed; generally to rub over any irregular surface of wood or metal against which another piece has to be fitted; to powder and mix with varnish to make a stopping for screw and nail holes (bomontague), and to rub on chalk lines (*q.v.*).

Chalk Line. A thin line of whipcord or string used for the making of straight lines upon timber for sawing by. The chalk line is whitened with chalk throughout its length, and strained from end to end of the timber. It is then lifted in the centre and released, when the chalk is transferred to the timber.

Chambered Core. *See* BELLY CORE.

Chamfer. A bevelling of the edge of a piece of work. The edges of loam boards and of strickles are always chamfered, so that the actual striking edge is not more than $\frac{1}{16}''$ or $\frac{1}{8}''$ in thickness. The loam or sand is struck with more freedom, and has a smoother surface than would be the case if the striking edges were left square.

Changing Hook. A crane hook which is double, and whose use consists in the transference of ladles of molten metal from one crane to another near it.

Chaplet. May be either a chaplet nail for the support of a core, or an article which is a gauge for thickness only, in the latter case being double headed for interposition between two opposing faces whose proper distances asunder are preserved by the interposition of the chaplets. Spring chaplets are made of hoop iron bent round to form two parallel faces.

Chaplet Block. A block of wood rammed in a mould to receive the spike of a chaplet nail, the block affording the requisite steadiness to the chaplet when in position.

Chaplet Nails. Malleable iron nails having broad flat heads; used for the support of cores, and as gauges for thicknesses of metal.

Charcoal. Is used for drying small moulds. Oak charcoal ground in a mill is employed for blackening moulds.

Charcoal Blacking. Blackening made of ground oak charcoal, so named to distinguish it from plumbago, and patent blackings.

Check. A short shoulder or "set off," cut on the edge of a strickle (*q.v.*), and which slides against the edge of a core plate (*q.v.*), or of a guide iron (*q.v.*), so controlling the movement of the strickle.

Chill. A metallic body of any required definite outline, against which the iron is poured to produce a chilled casting.

Chilled Casting. A casting whose surface is rendered hard and steely by pouring the metal into a metallic mould.

Chuck, Chucking. A chuck is the carrier in wood or metal to which work is attached for insertion in the lathe. Such work is said to be chucked, and the process is called chucking. Pattern work is chucked either by making a frictional fit, suitable for light patterns only; or by attachment with screws or other means.

Cinder Bed. *See* Coke bed.

Cinder Pig. An inferior grade of pig-iron obtained by smelting inferior ores with a large proportion of tap cinder, which is essentially a ferrous silicate containing nearly all the phosphorus eliminated from the pig during the puddling process. The cinder pig is therefore largely phosphoric and correspondingly inferior.

Cinders. Are used for venting moulds, either in a coke bed (*q.v.*), or between the joints of bricks in loam moulds, or in the midst of large masses of green sand.

Clagg. Clagging signifies the sticking of sand to a pattern, so that the withdrawal of the pattern damages the mould. It is due to rough surfaces, varnish not thoroughly dried moulding in hot sand, want of taper, etc

Clay. *See* Clay Wash.

Clay Wash. A solution of clay in water, used as a cementing agent, being swabbed over the bars of flasks, and over lifters to assist the adhesion of the sand, and used as a cement for jointing cores.

Clearance. The bottom clearance of wheel teeth is the difference between their actual and their working depth, and the flank clearance the difference between the thickness of the teeth and the width of the tooth space. If there were no clearance the points and root spaces and flanks would be in fast contact with each other

Coal Dust. Is mixed with facing sand to prevent chemical action from taking place between the metal and the constituents of the sand. The gases generated by the oxidation of the coal interpose a protective film between the metal and the particles of sand.

Coal Mill. Or Coke mill, or Blacking mill. A machine used for grinding the coal, for mixing with facing sand, and for making blackening.

Cod. (1) A large green sand core forming the central portion of a mould. (2) Any mass of sand carried upon a plate.

Cog. *See* COG WHEEL.

Cog Wheel. A toothed wheel, that is, a wheel which transmits motion and power by means of short projections upon its periphery, these projections being called "cogs" or "teeth." Often, however, the term teeth is understood to signify those made of metal, and cogs those which are cut in wood for mortice wheels.

Coke Bed. Or Cinder bed. A bed, or layer of cinder and clinker, laid to a depth of several inches underneath a core bed (*q.v.*). Its purpose is the providing of a receptacle for the gases which escape during casting, the gases passing down through vent holes into the coke bed, and being led off through pipes to the surface of the ground.

Coke Mill. *See* COAL MILL.

Cold Shots. Small globular particles of metal which often form on the first splashing of metal into a mould, and which, not becoming re-amalgamated, become detached when cold, leaving minute pits or depressions on the castings.

Cold Shuts. Produced by the imperfect amalgamation of metal which is poured too slowly, or too dead, into a mould. The thinner the casting therefore, the hotter, and the more rapidly should the metal be poured.

Compass. A tool used for striking curves, and circles of moderate radii. The best compasses are those in which the quadrant, or wing, and tightening screw are combined with an adjusting screw at one end of the quadrant.

Compass Plane. A plane with either a single iron (*q.v.*), or double iron (*q.v.*), of about 6″ or 7″ in length, the sole of which is cut lengthwise to an arc of a circle for the purpose of planing internal curves. An adjustable stop at the front end furnishes the means of adjustment for curves of different radii.

Compass Saw. A narrow saw about 15″ long, used for cutting sweeps, holes, and curved portions of work of moderate size. Called also "table saw," "sweep saw," "turning saw."

Contraction. All the ordinary metals employed in engineering construction shrink or contract in cooling down from the molten condition. This is a most important fact, since the accuracy of cast work depends upon a precise knowledge of the amount of contraction which the metals and alloys, iron, gun metal, brass, lead, copper undergo when cast in moulds. This is allowed for by pattern makers, who use a contraction rule (*q.v.*) to enable them to give exact proportions to their work.

Contraction Rule. A rule used by pattern makers only, in which the due allowance for the shrinkage of iron castings is given. Hence a pattern made from a contraction rule, and consequently above the standard length, will ensure that the casting made from it is of normal dimensions. Similar rules are made for brass castings.

Cope. The uppermost flask of a series, or the uppermost part of a mould. Often termed "top," or "top part."

Core. A body whose outline corresponds generally with that of the internal or hollow portion of a casting.

Core Bar. A hollow bar, upon which cylindrical cores are swept up, affording rigidity, and a vent channel to the cores. Core bars are either rigid tubes, or collapsible structures.

Core Bed. A bed prepared in the foundry floor for the reception and arrangement of cores required for the making of a casting. The bed is formed by strickling a layer of sand over a coke bed (*q.v.*), and venting down into the latter.

Core Board. A board whose edge is profiled into the sectional form of the core which it is designed to strike. A core board may rest on trestles, or it may be a loam board (*q v.*), or it may be a strickle (*q.v.*).

Core Box. The box or frame in which a core (*q.v.*) is made.

Core Boy. A boy who makes the smaller and less intricate cores in a foundry, and who generally assists the core makers.

Core Carriage. A long low carriage of cast-iron which receives the cores as they are made, and on which they are ran into the drying stove.

Coring Up. Placing the cores of a mould in position, and securing them properly.

Core Irons. Rods of bar iron, straight or curved, which are rammed up in a core to impart rigidity thereto. In large cores, grids (*q.v.*) are employed for the same purpose.

Core Plate. (1) A thin plate of cast-iron used in striking the cores of work which has irregularly shaped outlines, as in bend, or reducing pipes for example. Its outlines correspond roughly with those of the work to be built upon it, and one of its edges furnishes the necessary guide to the strickle (*q.v.*), which strikes the core outlines, or the pattern outlines, as the case may be. Core plates are made in iron, in order that they may be placed in the stove for the drying of the loam.

(2) A light plate of cast-iron, several of which when wedged at equidistant positions on a core bar, form a skeleton for the support of hay bands and loam in cores of large size.

Core Print. *See* PRINT.

Core Rope. *See* VENT STRINGS.

Core Sand. Is essentially a strong sand (*q.v.*), containing dung, and coal dust in various proportions. Its primary use is the making of cores, but it is also employed in moulds, or for portions of moulds.

Core Stove. *See* STOVE.

Core Trestles. Cast-iron standards, whose top edges are provided with V shaped notches, in which the turned ends of core bars are revolved when striking up cores.

Core Wash. Wet blackening. *See* BLACKENING.

Counter-sinking. Is the enlarging of a hole to a conical form to receive the head of a screw. Performed with a rose, or countersunk bit.

Crane Ladle. *See* LADLE.

Cross. A strong cast-iron frame, in shape like a St. Andrew's cross X, which is suspended in the crane, and from which depend the slings used for lifting and turning over moulding boxes.

Cross-cut Saw. A two-handed saw, whose teeth are formed like equilateral triangles, and which have the maximum amount of set (*q.v.*) given to saws. These saws are only used for cutting across the grain. Hand saws, having more than the usual amount of set, are often used in workshops for cross-cutting (*q.v.*).

Cross-cutting. Sawing performed across the grain. Saws for cross-cutting require more set (*q.v.*) than those used for cutting with the grain, and the teeth take approximately the form of an equilateral triangle. For cross-cutting very thick planking a special cross-cut saw (*q.v.*) is employed.

Cross Section. *See* SECTION.

Cupola. The tall, cylindrical furnace, lined with fire brick, in which cast-iron is melted for foundry use. It is sometimes hooded at the top, from whence the name is derived.

Cycloidal Teeth. Teeth, whose flanks and faces are formed of cycloidal curves, that is curves which are generated by a point in the circumference of a circle which is made to roll upon a straight line, or upon another circle.

D.

Daubing. Lining or smearing over the interior of a cupola, ladle, or receiver, with clay or sand, by means of the hands.

Dead Head. *See* HEAD METAL.

Delivery. The manner of the withdrawal of a pattern from its mould, as a good, or a bad delivery. "Lift," and "draw" have the same meaning.

Describing Circle. The generating, or rolling circle used for drawing the cycloidal teeth (*q.v.*) of wheels. Upon its size, relatively to the fundamental or pitch circle, depends the shape and curvature of the teeth. When wheels are made in sets, its diameter should never exceed the radius of the smallest wheel in the set.

Devil. An open frame or cage in which coke or charcoal are burnt, and which is used for drying foundry moulds, the cage being usually suspended in the mould.

Diameter Strip. A strip of wood by which a tooth block (*q.v.*) is set to its proper radius. The diameter strip may reach either from the root, or point of a tooth to the central pillar of the machine.

Diamond Point. A turning tool which is flat on the face, and has two cutting edges inclined to one another, meeting at an acute angle on the axis of the tool. Used for turning the outsides and insides of work, and for cutting off or parting it into various sections.

Dividers. Small compasses, which are furnished with a screw and wing nut, instead of the quadrant and set screw which are used in the larger instruments. They are employed where fine adjustment is necessary, and for circles of small radii. Also called "spring dividers," because they open automatically by means of a spring at the junction of the legs.

Dog. *See* STAPLE.

Dotted Lines. These, on drawings, signify that the portions thus represented are hidden from view by something in front or above.

Double Iron. A plane iron (*q.v.*) in which the cutting instrument is backed with a top iron.

Dove-tail Saw. A back saw, used for the finest sawing.

Dowell. A pin of wood or metal, used for the purpose of effecting a temporary connection only between pattern parts which have to be detached from one another in the process of moulding.

Drag. The lowermost flask of a series. Often called the "bottom," or "bottom part."

Draw. A casting is said to "draw" when the shrinkage of the metal causes depressions at the surface, or hollow open spaces in the interior. *See also* DELIVERY.

Drawback. A section of a mould which, instead of being rammed in one with the main body, is formed on a separate plate, suitable joints separating it therefrom, for convenience of being drawn away for repairs and finishing.

Drawback Plate. The plate of cast-iron which carries the drawback (*q.v.*) of a mould.

Drawing. (1) The setting out of work on a board. (2) The lifting out of patterns from the sand in which they have been rammed. (3) Increasing the depth of a mould without altering that of the pattern, accomplished by lifting out the latter to a definite distance and ramming around it a second time.

Drawing Board. A board used for striking out work upon, to full size, in the shop. Boards are made of pine, about an inch thick, and the joints are not glued, but clamped close together and held with battens. When the wood shrinks, it is clamped up still further and fresh screw holes bored.

Draw Knife. A cutting tool, used for roughing down the edges of timber. It is furnished with a blade several inches in length, provided with a tang at each end, turned round and inserted in handles at right angles to the cutting edge. The handles are grasped, one in each hand, and the knife pulled or drawn towards the workman.

Drop Out. Signifies the falling out of a portion, or the whole of a sand mould, from its flask, at the time of turning over, being due to imperfect staying.

Drop Print. *See* POCKET PRINT.

Drying. The evaporation of the moisture from a mould, either in the drying stove, or by means of devils, or of red hot masses of metal.

Drying Stove. *See* STOVE.

Dry Sand. Mixtures of sand which, after their perfect desiccation in a drying stove, remain sufficiently firm and coherent for casting into.

E.

Elevation. An elevation view of a drawing is that in which the observer is supposed to be stationed at the side or end of the work represented on the drawing, and to see nothing beyond the particular side at which he is looking. Parts lying beyond and in the same plane are, however, indicated by dotted lines. A view taken at the side is termed a "side elevation," one at the end, an "end elevation," while a view of a cut face is termed a "sectional elevation."

Epicycloid. The curve which is formed by a point in a circle that rolls outside of a fundamental or base circle.

F.

Face. The face of a tooth is that portion which lies between the pitch line and the point. The face of a wheel is the depth or width of the teeth.

Face Plate. A plate of wood or metal, or a combination of both, which is used for chucking work, the diameter of which exceeds its thickness. Face plates are made of various sizes, from 3″ to 6′, 0″ in diameter.

Facing. (1) A superficial area which is elevated above the main body of a casting, and which is planed or chipped to receive some attachment. Allowance has to be made for facing to the extent of from $\frac{1}{8}''$ to $\frac{1}{4}''$ on iron, and from $\frac{1}{32}''$ to $\frac{1}{16}''$ on brass. (2) The making the actual face of a mould, as distinguished from mere box filling (*q.v.*).

Facing Sand. The sand which lies immediately against the face of a mould, being rammed first against the pattern. It is mixed with coal dust to prevent sand-burning from taking place.

Fan. A box or casing, through which air is drawn by the rapid revolution of vanes, and delivered to the blast pipe of a cupola.

Feeder Head. The body of molten metal which is utilized for the purpose of feeding (*q.v.*) a mould.

Feeding. The supply of molten metal in small quantity to the heavier parts of a mould which has been recently poured, in order to compensate for the loss due to shrinkage. Sometimes termed "pumping."

Feeding Rod. An iron rod of $\frac{1}{4}''$ or $\frac{3}{8}''$ diameter, used for keeping the hot metal in a mould in agitation for the purpose of feeding (*q.v.*).

Ferrules. The brass bands which are driven over the ends of tool handles to prevent them from splitting by the driving in of the tang. They are made from gas tube, cut off either with a hack saw, or a file, or else in the lathe.

Fettling. Cutting off the runners, risers, heads, and fins, and cleaning the sand from castings immediately after they are removed from the mould. Chisels, hammers, files, and scratch brushes are used for the purpose. See also "Fettling drum."

Fettling Drum. A closed revolving cylinder, within which small castings are cleaned or fettled by mutual attrition. Variously termed rattler, rattle barrel, tumbler, rumble, rumbler.

File. A cutting tool in which each tooth may be considered as a chisel. Files are used to a very limited extent in pattern shops.

Fin. A thin film of metal produced by faulty jointing of a mould, or by the finning of a dry sand mould. The metal oozing into the joint forms a thin film standing out from the casting in the plane of the joint.

Finger Bit. Or "hold down piece." A thin bit of wood cut to fit the space between the teeth on a tooth block (*q.v.*), and employed to prevent the sand from becoming lifted up and torn by the withdrawal of the block.

Firmer Tools. The short ordinary chisels and gouges used by pattern makers and carpenters alike. The gouges are ground on the outside, and can be driven with the mallet with impunity. The chisels will also stand malleting.

Flank. The flank of a tooth is that portion of the side which lies between the pitch line and the root.

Flask. Or moulding box. The open frame, usually of cast-iron, in which a portion or the whole of a founders' mould is contained. A complete flask consists of drag, middle, and cope.

Flat. A curve is said to be flat when it is struck with a large radius, the term having a relative signification only, having reference to the particular matter under discussion.

Flow-off Gate. *See* RISER.

Fork Chuck. Or Prong chuck. The narrow pointed chuck used for driving lathe work between centres.

Formula. An association of letters and signs which signify quantities, and arithmetical operations.

Foundation Plate. A thick plate of cast-iron, studded with jaggers (*q.v.*), and used as the basis of operations when building up loam moulds (*q.v.*).

Founding. The casting of metals into moulds, as distinguished from the working of malleable metals by forging.

Foundry Pit. Work of considerable depth when cast vertically is sunk into a deep pit in the foundry floor, in order to bring the pouring basin at a suitable height. Pits are either sand pits—mere holes dug in the sand—or they are permanently encased with cast-iron plates, rings, or bricks.

Fretting. The abrasion of the minute particles of material removed in the process of sharpening (*q.v.*).

G.

Gate. The vertical opening which leads from the pouring basin (*q.v.*) into the runner (*q.v.*).

Gauge. A tool used for the marking of lines upon timber, which have to act as guides to the workman in planing and cutting to size, thickness, and shape. It consists of a stock or head, furnished with a tightening screw or a wedge, and a marker, formed of a bit of pointed steel driven into one end. The ordinary marking gauge is about 8″ or 10″ long, but for planing wide stuff a panel gauge, ranging from 16″ to 24″ long is used.

Gearing. A generic name commonly applied to signify cog wheels in general; though, strictly speaking, gearing includes much besides mere wheels, such as shafts, belting, bearings, etc., so that "toothed gearing" is the more correct term.

Generating Circle. *See* DESCRIBING CIRCLE.

Gimlet. A small boring tool which has a screw at one end. Gimlets are made in sets of twelve, ranging frem $\frac{1}{16}''$ to $\frac{3}{8}''$ in diameter. Twist gimlets are stronger, but shell gimlets are preferred as boring cleaner holes, and being less liable to split the grain of the wood.

Glass-paper. From Nos. 1 to 2, or $2\frac{1}{2}$ are the numbers of glass-paper most in request in pattern making. The flour paper is of no value for pattern work. Glass-paper should be used with caution in order that the shape and dimensions of work may be preserved intact. In the deep sides of work the glass-papering should be done *across* the grain, to remove the slight ridges left by the planes, the unsightly appearance of the scratches left by the glass being of no importance. Glass-paper rubbers (*q.v.*) should also be used where possible.

Glass-paper Rubber. A piece of cork or wood which is used to afford a backing for glass-paper. Rubbers are flat when used for level surfaces, but for special purposes they are made to follow the contour of the work to be glass-papered.

Glazed Pig. Or blazed pig. An inferior pig which is often produced when a blast furnace is first blown in. It is highly silicious.

Glue. A preparation of animal tendon. The best glue comes from Russia. When viewed in mass and held up to the light it should be of a pale transparency, and free from specks. Glue should be used sparingly in pattern work on account of its liability to work out in the damp sand, and to stick to, and tear the moulds.

Glued Joint. The union of opposing faces or edges by the intervention of glue. The joints must be close, and the glue rubbed down to an extremely thin film. Watery glue must be avoided.

Gouge. A tool employed for cutting concave surfaces, the section of the tool being curved correspondingly. "Paring" gouges are long, and ground upon their concave faces; firmer gouges short, and ground upon their convex faces. Each type is made in "quick," "middle flat," and "flat" curvatures, to suit different sweeps.

Gouge Slip. *See* OIL SLIP.

Green Sand. Mixtures of common moulding sand, which are comparatively friable, loose, and weak, and which therefore require the presence of moisture to render them sufficiently coherent to withstand the pressure of molten metal.

Grid. A plate, or a skeleton-like frame of cast-iron, variously formed, and used to carry, or to stiffen a core, or a portion of a mould.

Grindstone. A revolving stone which may be of either natural or artificial manufacture. The stone revolves in a trough which holds water, and it is commonly driven by a belt. The best natural grindstones are those quarried on the south bank of the Tyne, and called Newcastle grindstones. The best artificial ones are made in France.

Grinding. The process of abrasion of the bevelled portion of a cutting tool, effected on a grindstone (*q.v.*). Cutting tools are best ground with the stone running towards the workman, and sufficient water must be used to keep it always wet while in use.

Guide Iron. A strip of square bar iron, bent to any curve required, and used as a guide for strickling up cores and loam patterns.

Guide Line. A line which is marked parallel with the edge of the full-sized drawing of a bend pipe, and used as the guide for bending the guide iron (*q.v.*).

Gutters. Shallow channels cut in the lower joint faces of a mould. Their function is to collect the smaller vents which come from the pattern sides, and to discharge them outside the flask.

H.

Half Rip Saw. A saw 28″ long, having four teeth to the inch. It is used for sawing down in the direction of the grain, and, with a trifle more set (*q.v.*), for cross-cutting (*q.v.*).

Hammer. A pattern maker's hammer is usually furnished with a point longer and narrower than that of an ordinary carpenter's hammer, for convenience of putting in hollows. Both forms are, however, in use.

Hand Ladle. *See* LADLE.

Hand Saw. A saw 26″ in length, variously named according to the size of the teeth. Strictly speaking a hand saw has about five teeth to the inch; but rip saws (*q.v.*) and half rip saws (*q.v.*) are sometimes called hand saws. See also panel saw.

Hard Ramming. *See* RAMMER.

Hatching-up. Cutting and roughening up the surface of a portion of a mould with a trowel to assist the adhesion of new sand thereto. Usually done for mending-up purposes.

Hay. *See* HAY BAND.

Hayband. Hay spun into bands is used for circular cores which are struck in loam upon hollow bars. The hay becomes a bond of union for the loam, and affords a suitable vent for the gases.

Hayband Spinner. A light cross frame of wood, set revolving upon a pivot. The loose hay being fed to the frame by the hands, its revolution twists or spins it into haybands.

Head Metal. Or "head," or "sullage piece," or "dead head." A body of metal cast upon the upper end of castings which are wanted specially sound. The dross rises into and collects in the head, which is subsequently turned, or slotted, or sawn off. A head by virtue of its liquid pressure also helps to consolidate the metal below.

Headstock. The fast head of a lathe, which carries the riggers for imparting the rotatory movement to the work.

Hollow Plane. A single iron (*q.v.*) plane, the cutting edge of which forms in plan an internal arc of a circle. Used for planing circular parts of work.

Hollows. Strips of wood which have in section two sides at a right angle, and the third hollowed out, or concave. Inserted in the angles of patterns to afford strength to the castings.

Hone. *See* OIL STONE.

Hornbeam. A hard stringy white wood, largely used for the cogs of mortice wheels.

Horsedung. Used for mixing with strong sand, dry sand, and loam; partly to consolidate, partly for purposes of venting, the hay in the dung by its carbonization rendering the dried mould porous.

Hot Metal. Metal which is poured from the ladle immediately after being tapped from the cupola. Light thin castings are poured with hot metal.

H Section Arms. Arms whose cross section is that indicated by the shape of the letter H. They have been in use chiefly since the introduction of wheel machines, their cores being made more readily than those of the T or + shape. The forms corresponding with the uprights of the H are set in the plane of the wheel, and the cross-bar connects the flat arms together.

Hypocycloid. The curve formed by a point in a circle rolling within a fundamental or base circle.

I.

Internal Gears. Gears in which the teeth are arranged within a circle, instead of on its periphery. In internal gears the pinion and ring revolve in the same direction.

Involute Teeth. Wheel teeth, the curves of which are those formed by a point in a string unwinding from a base circle.

Iron Plane. A plane in which the stock or body is made in iron, instead of in wood. Being more rigid, these planes produce more accurate results than the wooden ones, and remain unaffected by changes of temperature, and by the attrition of their faces, due to use, which in wooden planes tends to render them inaccurate. Iron planes are made in soft cast-iron; those chiefly so made being trying, and smoothing, and rebate planes. Within the last few years vast numbers of iron planes of new designs have been introduced by the American tool manufacturers.

J.

Jacking Over. The act of removing the rough outside of boards with a jack plane (*q.v.*).

Jack Plane. A plane 17″ in length, used for taking off the rough outer grain of timber, reducing it approximately to thickness, and taking it out of winding. The iron, $2\frac{1}{4}''$ wide, of a jack plane, is ground more curved or rounding than that in a trying, or of a smoothing plane.

Jaggers. Pyramidal or conical projections of metal standing up from the plates on which loam moulds are built up; their function being the better retention of the body of loam.

Joint. (1) A "joint" in a pattern is not necessarily understood to signify a line of union between the stuff of which it is composed, but has reference chiefly to the method of moulding. Speaking generally but not invariably, joints in patterns coincide with the joints which the moulder has to make in the sand, in order to draw the pattern, and to clean and finish the mould. (2) The edge or face at which the separation of flasks and moulds is effected. These may be truly horizontal, or diagonal, or curved, according to circumstances.

Joint Board. A bottom board (*q.v.*) which is blocked up, or otherwise cut to the outlines of the joints of a pattern, and used for the purpose of ramming the sand joints upon, without the necessity of shaping and sleeking them with trowels.

Jointing Down. In a pattern of irregular outline, the moulder's joint will seldom be in one horizontal plane, but some portions will be lower than others. When the lower half of the pattern is rammed up, the moulder sleeks the sand-joint up and down, so that each part shall deliver freely. Where the line of jointure is low, he is said to joint that portion of the mould "down."

Joint Plane. A plane 28″ in length with a double iron of $2\frac{1}{2}''$ in width, used sometimes for making glue joints. Called also a jointer.

K.

Keyhole Saw. Or pad saw. A thin tapering saw about 10″ long, used for cutting sweeps and holes. It slides in a rectangular slot pierced through the centre of a wooden handle or pad; it is held fast in any position by a couple of set screws tapped into the ferrule.

L.

Ladle. A vessel from which molten metal is poured into a mould. "Hand" ladles are carried by one man, and are used for light work; "double handled" ladles are carried by two, three, or four men, according to capacity, and hold from one to four cwts. "Crane" ladles are of several types, and are used for loads up to ten or twelve cwts.; for the heavy loads these ladles are provided with gear, hence called "geared ladles," without which they could not be operated. The iron ladles are lined with fire clay to prevent them from becoming burned by molten metal.

Lagging. The building up of cylindrical patterns by laying longitudinal strips of wood on transverse end, and cross pieces of polygonal form. It is a common mode of building up patterns which are too large to be cut from the solid wood without the risk of shrinkage.

Lathe. A piece of mechanism employed for the production of circular work. It consists essentially of bed, head-stock, poppet, and rest. A lathe of 5″ or 6″ centres is handiest for ordinary pattern work; for the heavier work, one of 12″ centres or thereabouts is necessary.

Levelling. Making a bed of sand level with winding strips, straight-edges, and spirit level.

Levelling Strips. Winding strips (*q.v.*).

Lift. *See* DELIVERY.

Liftering. When the bars of a flask are insufficient in quantity, or when local masses of sand require support, lifters (*q.v.*) are used to give support to the sand, hence the term.

Lifters. Hooks of cast-iron roughly shaped like a letter S, and used for hanging from the top parts of moulding boxes to sustain the sand. Also termed S hooks.

Lifting. The act of withdrawal of a pattern from its mould.

Lifting Plate. A plate of iron screwed to a pattern, and having a hole tapped for the insertion of a lifting screw.

Lifting Screw. A screw cut at one end of an iron rod, at the opposite end of which there is a loop or eye for lifting. The screw is thrust into a hole in the wood pattern, or into the tapped hole of a lifting plate.

Lifting Strap. A strap of hoop iron, or thin bar iron, which is attached to the side of a deep pattern for the purpose of drawing it out of the sand.

Lime. Used to indicate the coincidence of joint faces, and of the tops of cores. Being strewn on lower joint faces, and on the upper surfaces of cores, it indicates by its transference to the cope, closeness of joint.

Line Bag. A muslin bag containing powdered lime, and from which it is sprinkled over moulds.

Lining Out. Marking out centres and lines on work.

Lining Up. Increasing the size or thickness of a pattern, by the attachment thereto of strips of wood, lead, or plaster.

Loading. Or weighting. The laying of weights on the upper part of a mould in order to prevent it from becoming lifted by the liquid pressure of the molten metal.

Loam. Mixtures of sand rendered plastic with water, and swept up by the edge of a board. After thorough drying, moulds made in loam are adapted for casting the heaviest work into

Loam Board. A board, the edge of which is profiled to the outline of the sectional form of the mould which it is designed to strike. It is swept around a central bar, to which it is bolted by means of a strap or straps.

Loam Bricks. Cakes of loam modelled like bricks of various sizes, and used in place of common bricks in the building up of certain sections of loam moulds in which the shrinkage of parts might lead to fracture, if occurring against the common unyielding bricks.

Loam Cake. A piece of dried loam having a flat face, and used as the face of some portion of a mould, being firmer than a face formed of green sand.

Loam Mould. A mould in which loam (*q.v.*) is the material employed.

Loam Pattern. A pattern similar to an ordinary pattern made in wood, the material only being different. Loam patterns are made for the bulkier classes of work, but chiefly or almost entirely for work which can be struck up either on a revolving bar, or by means of strickles. When irregular shaped attachments occur, they are made in wood and attached to the loam.

Loam Plate. A plate or ring of cast-iron, made in open sand, and usually studded with prods (*q.v.*), or jaggers (*q.v.*), upon which the brick work of a loam mould (*q.v.*) is built.

Loose Pieces. Portions of patterns made loose, or detachable from the main body, for convenience of moulding. They mostly occur at the sides, or on the top.

Longitudinal Section. *See* SECTION.

Long Toothed Gauge. A special gauge used for marking parallel lines around sweeps, and lines on different levels.

Lug. A projecting ear, or roughly semicircular web of metal projecting from the side of a casting, and provided with a hole for the reception of a bolt or pin.

M

Mahogany. A moderately hard, close grained wood used for the finer patterns. Its value consists chiefly in its non-liability to warp when well seasoned, and its hard surface, which enables it to withstand rough foundry usage. The variety known as Bay wood is used more than the Honduras variety.

Mallet. A wooden hammer used for driving heavy blows in cases where an iron hammer would bruise and split either the material or the handles of the tools. Ash and beech make the best mallets.

Mending up. The necessary repairs done to a mould after it has become damaged by the rapping and the withdrawal of the pattern.

Mending up Piece. Any strip, sweep, or block, which is used as a guide to obtain or to restore the damaged contour of a section of a sand mould.

Middle. Or middle part. The central division of a moulding flask.

Millwright. An engineer whose work is of a very general character. The name points to the origin of the trade which gave rise to a class of men skilled in mill work generally, in the fitting up of water wheels, pumping engines, shafting, and gearing. Millwrights were, and are still, to be found chiefly in country districts.

Mitre Wheel. A bevel wheel in which the pitch line taken in the direction of the axis of the wheel is inclined at an angle of 45°. Mitre wheels, therefore, which gear together must be of equal diameters, and their shafts must be situated at right angles.

Mortice Wheel. A cog wheel which is provided with wooden teeth to secure the advantage of smooth and quiet working. The teeth are driven into mortices cast in the wheel rim, hence the name.

Mould. The matrix or reverse form of a given casting.

Moulding. Embraces in all its details the art of the preparation of the matrices in which metal is to be poured.

Moulding Box. *See* FLASK.

Moulding Machine. Any machine by which the operations of moulding are facilitated. There are many kinds. But they may be broadly divided into two great classes, those used for gear wheels, and those used for all other classes of work. In these manual labour is minimised. In some machines the patterns are placed on plates which slide on vertical guides, the ramming being done by hand; in others the ramming is performed automatically. Some are used specially for toothed wheels, in which, though the cost of moulding is increased, that of pattern work is diminished, and the castings are more accurate than as if made from patterns.

Moulding Sand. Specially the sand which forms the floor of the foundry. Also termed black sand, floor sand, and old sand.

Multiplier. Any constant number which it is convenient to use in mathematical formula.

N

Nailing. *See* SPRIGGING.

Nails. Nails are used but sparingly in pattern work, because owing to the necessity for providing for possible alterations, screws are preferable. Nails are used, however, for hollows, facings, and thin strips generally. The French wire nails are better than the old cut nails. *See also* Sprigging.

O

Oak. Used for the purpose of making cogs for mortice wheels.

Odontograph. A scale for striking out the teeth of wheels without previous calculation. There are several odontographs, but Professor Willis's is the handiest and most widely used.

Oil Slip. Or Gouge Slip. A narrow and thin strip of oil stone, having edges straight longitudinally, but curved in section, for adaptation to the inner curves of gouges, for sharpening (*q.v.*). They are used for inside and outside gouges: in the first named, for performing the actual duty of abrasion; in the latter, for turning back the feather-edge. They are employed in various sizes, and are sometimes mounted in a stock in a similar fashion to an oil-stone.

Oil-stone. Or Hone. A slaty stone used for the purpose of sharpening edge tools. There are numerous kinds of oil stones, as Arkansas, Turkey, Washita, Charnley Forest, Nova Scotia, Grecian. The Charnley Forest is the hone which can be depended on best, and has the merit of being cheap. Turkey is best of all, but is uncertain. An oil stone is mounted in a wooden case or stock, and provided with a cover to keep out dust and grit.

Old Sand. The sand which forms the floor of a foundry, and which has been repeatedly in use.

Open Joints. Joints in which the edges of stuff are brought near to one another, without actual contact being permitted to take place. They may be from $\frac{1}{16}''$ to $\frac{1}{8}''$ apart. The joints are kept flush either by other portions of work which are built over them, or by means of tight fitting dowels. The reason of open joints is, that patterns swell in the sand and shrink during storage, and by leaving the joints free, the expansion and shrinkage are localized in the joints only, without altering the outer dimensions.

Open Sand. A casting is made in open sand when the mould is not covered in with a top box or cope. Open sand castings are only suited for the roughest classes of work, such as foundry tools, etc.

P

π. The relation of circumference to diameter, or of semi-circumference to radius. The number 3·14159.

Panel Gauge. *See* GAUGE.

Panel Saw. A short saw 18″ long, having seven teeth to the inch, intermediate therefore between a hand, or half rip saw, and a tenon saw. It is handy for cutting shoulders, tenons, half lap joints, and narrow faces generally.

Paper Joint. A joint in frequent use in turned work, where the use of screws or nails is undesirable; a layer of paper glued between the face plate and the work will when dry, hold securely. By lifting the work with a chisel the paper will split in two, and permit of the wood being separated without injury.

Parallel Print. When a circular print is moulded on its side, that is with its longitudinal axis horizontal, it is parallel throughout its length, because in the direction of its lift it is able to deliver itself freely.

Paring Tools. Long gouges and chisels used for cutting across deep and flat surfaces, for which the ordinary short joiners' tools are unsuitable. They are light in substance, and therefore not suitable for driving with the mallet. The gouges are invariably ground on the inner or hollow side; the chisels as ordinary chisels.

Parting Sand. Burnt sand (*q.v.*), or sand which has been artificially dried, and which being strewn over the joints of patterns and moulds prevents union of opposed sand surfaces from taking place, and permits of easy and clean separation of the joint faces of moulds.

Parting Tool. *See* Diamond Point.

Pattern. A model into whose impression in sand, metal is poured to form a casting.

Pegs. Soft wooden pins, used for securing glued superficial joints. They are split in order to have their grain straight, and are slightly tapered throughout their length, and pointed at the end to facilitate entry.

Pincers. A tool used for the extraction of nails, wire, etc., and which depends for its value on the action of leverage. Hence pincers long in the handle, and flat on the face, are more economical of power than those which are short, and rounding on the face.

Pitch. (1) The angle of a plane iron in its stock is termed its pitch; the more obtuse the angle the "higher" the pitch, the more acute, the "lower" the pitch. (2) The distance between the centres of contiguous wheel teeth measured on the pitch line. It is the same thing, of course, if the dimension be taken from edge to edge, either right hand or left hand.

Pitch Circle. *See* Pitch Line.

Pitch Diameter. The diameter of the circle upon which the pitch (*q.v.*) of a wheel is measured.

Pitch Line. The line upon which the tooth centres of wheels and racks (see pitch) are divided out. In a rack the pitch line is straight, in a wheel it is a circle, and in each case the pitch line represents the actual working dimension from which velocity ratios are deduced.

Pit. *See* Foundry Pit.

Plan. In a plan view of a drawing, the eye of the observer is supposed to be set directly vertical over the drawing, and the illusions due to perspective are supposed not to exist. No portions of sides or edges are supposed to come into view, and the parts remote from the eye suffer no apparent diminution in size on that account. Parts lying underneath and actually hidden by upper surfaces are also supposed to be seen, being indicated by dotted lines.

Plane. A tool used for reducing the surface of wood to a definite outline, either level or to some other shape required by the special character of the work. The cutting edge of a plane projects very slightly beyond the face of the stock, the amount of the projection regulates the thickness of the shaving, and the surface of the material becomes thereby in time the counterpart of the face of the plane. The plane consists essentially of the body or stock, the iron, and the wedge.

Plane Iron. The cutting instrument in a plane (*q.v.*); and though termed an iron, it is invariably made either entirely of steel, or is steel-faced on the actual cutting edge. Plane irons vary in width, thickness, and shape; each class of plane having its special iron, so that the irons of the various classes are not interchangeable. Irons are single, or double: in the latter case the lower iron is the cutting instrument, and the top iron is used for the purpose of stiffening it and assisting its action. Irons are held in place, and set, either with a wedge, or a screw. The angles of irons vary also, those for planing soft woods being set at a more acute angle, or at a lower pitch than those for the harder woods. Irons are commonly used with the ground face placed downwards, but in the case of iron planes (*q.v.*) usually in the reverse way.

Plated Centre. A wheel centre is said to be plated when it is discoid in form instead of being made with open arms. Plated centres are employed for small wheels, but arms are used in the case of those of large dimensions.

Plate Moulding. Moulding in which the pattern is rammed upon a plate, of which it forms an integral portion, the face of the plate forming the joint of the mould. In most cases the plate forms a division between two portions of a pattern, the opposite sides of the plate forming the two joint faces.

Pliers. A pincer-like tool used for holding pieces of wire or other material. Those having flat and rough jaws are the only ones useful to the pattern maker.

Plyer Set. The commonest form of tool employed for imparting the set (*q.v.*) to saws. It is a plate of steel with a lever handle, the edge of the plate being notched out at intervals to embrace the teeth of saws of various gauges. The teeth are pulled over alternately by means of the handle attached to the plate. The objection to the plyer set is that the amount of set cannot be gauged so accurately as when the setting hammer and block are made use of.

Pocket Print. Or Drop Print. A form of print which is employed when the ordinary round print cannot be used for horizontal cores, the joint of the mould not coinciding with the centre of the print. The core is dropped into the print impression as into a pocket, and is stopped over.

Point. The point of a tooth is that portion which corresponds with the largest diameter, lying outside, or bounding the termination of the face (*q.v.*).

Poppet. The movable head of a lathe, which carries the dead centre upon which the work is pivoted and revolves.

Pouring. Or Running. The emptying of the molten metal from the ladle into the pouring basin (*q.v.*) of a mould.

Pouring Basin. The cup shaped depression formed on the cope for the reception of the metal from the ladle, and from which it passes directly into the gate (*q.v.*) or gates.

Print. Or Core Print. An attachment to a pattern, whose impression sustains a core in its proper position.

Prods. Rows of projections, conical and blunt pointed in form, cast on the plates upon which loam work is built, their function being the retention of the loam.

Prong Chuck. *See* Fork Chuck.

Projection. The representation of geometric figures in various positions, and in sections, by the carrying out of parallel lines from one view to another. The figures thus projected are not actual representations of objects, since the effect of perspective is eliminated; but they are geometrically accurate, and represent the true relations of lines and dimensions. All engineers' working drawings are constructed by the projection of lines.

Pulling up. Damage inflicted on a mould by the withdrawal of a pattern. Thus a mould is said to be "pulled up" badly, or a pattern to have drawn or pulled badly, or well, as the case may be.

Punch. *See* Brad Punch.

Q.

Quick. A curve is said to be quick when it is struck with a small radius. It has a relative signification only. *See* Flat.

R.

Rack. A form of gearing used for the production of directly reciprocating motion. Hence the teeth are arranged in a straight line.

Radius. The semi-diameter of a circle.

Radius Bar. A rod of wood attached to a sweep, which is used for moulding either a ring, or an arc of a circle. One end of the bar is attached to the sweep, and through a hole near the end opposite a pin passes, and furnishes a fixed centre around which the sweep is revolved.

Radius Finder. *See* CENTRE SQUARE.

Rammer. An instrument of iron; being a "pegging" rammer when narrow, and a "flat" rammer when broad. A rod attached to the rammer forms a handle by which it is driven with considerable force against the sand for the purpose of consolidating the sand around a pattern. Varying degrees of force are employed in ramming different kinds of moulds, or different portions of the same mould; hence the terms "hard" ramming, and "soft" ramming are relative. Speaking generally, however, too hard ramming is productive of scabs, and soft ramming of lumpy, and swollen, or strained castings, due to the yielding of the sand before the weight of the metal.

Rapping. The loosening of a pattern while yet in the sand, and during the act of withdrawal, in order to detach the sand therefrom without causing damage to the mould.

Rapping Bar. A bar of iron pointed at one end for insertion into a rapping hole, or rapping plate.

Rapping Hole. A hole bored in a pattern, or in a plate let into the pattern for the insertion of the rapping bar.

Rapping Plate. An iron plate screwed to a pattern, and containing a hole for the insertion of the rapping bar.

Rebate. An angular corner or recess cut in a piece of timber. Its two sides form a right angle with each other. A rebate plane (*q.v.*) is employed in its production.

Rebate Plane. A single iron (*q.v.*) plane, whose cutting edge is a straight line, and in which the edges of the iron are not enclosed, but are level with the side faces of the wood stock, in order that the cutting capacity shall be coincident with the edges of the plane; a condition essential to the planing out of rebates Rebate planes are either square, or skew mouthed; in the former instance the face edge of the iron stands at right angles with the sides of the stock, in the latter it is set at an angle. The latter cuts the grain more freely and sweetly than the former.

Receiver. A brick or clay lined vessel employed instead of a ladle for some very heavy castings. The metal is tapped from the cupola, and runs down into the receiver, where it accumulates, and finally is tapped from the receiver into the mould.

Red Lines. These are used on drawings as centre and as dimension lines, to distinguish them from actual working lines.

Reducing Bend. A bend which fulfils the same conditions as a reducing pipe (*q.v.*).

Reducing Pipe. A pipe in which the diameter diminishes. Used to make a connection between pipes of different diameters.

Rest. The support upon which a turning tool is laid when operating upon work in the lathe. On account of its shape it is often called a T rest, to distinguish from rests of other kinds.

Reverberatory Furnace. A furnace used for the melting of metal by the heat of incandescent gases. The fuel is burnt on a hearth separated from that upon which the metal lies, and the hot gases therefrom pass over a bridge, and are deflected upon the metal. Reverberatory furnaces are used for the melting of iron when mixtures of special purity are desired. Also termed "air furnace," because, unlike blast furnaces, it receives only natural draught.

Reverse Mould. A dummy mould upon which a portion of an actual mould, into which metal is to be poured, is rammed.

Ribs. The vertical arms of a wheel. Sometimes called feathers, and cross arms.

Riddle. A sieve of large mesh, or from $\frac{3}{16}''$ to $\frac{3}{4}''$. Anything below $\frac{3}{16}''$ mesh is termed a sieve.

Rim. The circular portion of a wheel to which the teeth are attached.

Rip Saw. A saw 28″ long, having $2\frac{1}{2}$ teeth to the inch. It is therefore a very coarse saw, and only suitable for ripping, or sawing down thick timber with. It contains a very slight amount of set (*q.v.*), and is therefore unsuitable for cross-cutting (*q.v.*).

Riser. Or Flow-off Gate. A passage which occupies a vertical position in relation to a mould, similarly to a runner, but into which the metal rises as the mould fills, and flowing away, relieves the cope of much strain.

Rodding. When bars or stays are absent from flasks, or when they are insufficient in amount, rods of bar iron are placed in the unstayed portion to carry, or to give support to the sand, hence the term.

Roughing Down. Turning off the angularities left from the hatchet, in lathe work. A turning gouge of large size is employed for the purpose.

Rolling Circle. *See* Describing Circle.

Root. The base of a wheel tooth, or that portion which springs from the rim. In calculating the load on a tooth the distance across the root corresponds with the depth of a loaded cantilever.

Round Nose. A turning tool, flat on the face, and having its cutting edge curved in plan. Used for working the hollows in turned work.

Round Plane. A single iron (*q.v.*) plane, whose cutting edge in plan is that of an external or convex arc of a circle. It is used for planing hollows (*q.v.*), and hollow curves generally.

Router. Or Old Woman's Tooth. A plane used for levelling over the bottoms of recesses. It is capable of adjustment for different depths. Useful for sinking in rapping and lifting plates.

Rubber. *See* GLASS-PAPER RUBBER.

Rubbing Board. A flat piece of board, used for levelling and roughening over the surface of a mould previous to the final sleeking.

Runner. The horizontal channel which leads from the gate (*q.v.*) directly into the mould.

Running. *See* POURING.

Running Down. The melting down of a charge of iron.

Rusting. Rusting of iron patterns is resorted to in order to impart a surface to the metal sufficiently rough to enable the varnish to adhere to it, without which precaution the varnish would peel off from polished iron surfaces. Rusting is performed with a solution of sal-ammoniac.

S.

Sal Ammoniac. Chloride of ammonia, NH_4Cl; used in solution for rusting iron patterns previous to beeswaxing (*q.v.*).

Sand Burning. A casting is said to be sand burnt when it has become roughened by the oxidation of the sand at the face of the mould, coal dust (*q.v.*) being either not present, or insufficient in amount.

Sand Sifter. A riddle or sieve of large size and of rectangular outline, to which a rocking to-and-fro motion is imparted automatically.

Saw Kerf. A slit or groove cut with a saw through a portion only of the thickness of a piece of stuff, not sufficient to sever it, but enough to permit of its being bent. By cutting a number of such kerfs side by side, moderately thick fillets and hollows can be bent round curved portions of work.

Scab. An excrescence upon a casting, usually formed by the disturbance and washing away of a section of the sand at the surfaces of a mould.

Scabbing. The formation of a scab (*q.v.*) or scabs upon a casting.

Scale. A tool used for the proportional measurement of drawings. The main divisions on the scale are fractional parts of a foot; thus an inch on the scale is $\frac{1}{12}$th of the foot. Each main division is sub-divided again into twelve equal parts to represent the inch division. Scales are "open divided," that is the scale of one kind occupies the whole of one side of the instrument; or "fully divided," in which case several scales occupy one side.

Screw-driver. A tool which is employed for turning in screws by the action of leverage. Screw-drivers should not be rounding at the point, but as straight as possible to enable them to bite the slit in the screw head most effectually.

Screwing Down. The securing of the parts of moulding boxes by screw bolts; distinguished from cottaring and from loading.

Scurf. *See* SULLAGE.

Section. In drawings, a view of an object which is represented as cut through in some definite plane, the cut face being presented to the eye. Sections are variously denominated, as "transverse," or "cross section," "longitudinal section," according as the view is taken at right angles to, or along the axis. A "sectional plan" indicates a section taken in a plane parallel with the horizon.

Segments. Applied in pattern work to short circular sweeps or triangular shaped pieces used for building up (*q.v.*) circular patterns

Set. The set of a saw is the alternate bending of the teeth to one side and the other. It is done either with a plyer set (*q.v.*), or with a set block (*q.v.*), or with a punch, or a patent set. Its amount varies with the nature of the work which the saw has to perform, being largest in amount for cross-cutting, and least for sawing with the grain.

Set Block. Set blocks vary in form, but the aim which underlies them all is the imparting to each individual tooth a uniform and measurable amount of set (*q.v.*). A bevel or chamfer is given to the edge of the set block, or the saw itself is laid on the block at a definite angle, and the teeth are punched one by one with a setting hammer or with a set punch.

Set Punch. A steel punch which is used for imparting set (*q.v.*) to saw teeth. One form is held and adjusted over the saw tooth by hand, another is confined loosely in a hole in the centre of a set block, an india rubber spring in the centre giving it the necessary rebound after every stroke to enable it to clear the saw teeth.

Set Square. A square used for checking the accuracy of interior angles. Its shape is that of a triangle, two edges being invariably at right angles, the third forming some definite angle with the others, 45°, or 30° and 60° being the commonest Set squares for shop use are made of wood, the largest being framed together in three strips, and tongued.

Setting Out. Signifies the marking out of work.

Sharpening. The production of a keen cutting edge upon a tool by a process of abrasion on the surface of a hone or oil stone (*q.v.*). The actual abrasion takes place only on the ground facet, the flat face of the chisel or plane being pressed on the stone only for the purpose of turning back the wire edge.

S Hooks. *See* LIFTERS.

Shooting. The planing of edges of stuff on a shooting board (*q.v.*).

Shooting Board. A couple of pieces of board, the upper one being about 3″ narrower than the other, and screwed together with two edges corresponding. A stop is provided at one end, and this stop receives the thrust of the timber while being planed. To shoot, the plane is laid upon its right side on the lowermost board of the two, and the edge of the cutting iron very nearly coincides with the edge of the upper board. The stuff being held in the left hand on the board, the right hand guides the plane by which the edge is shot.

Short Grain. Timber grain in which the longitudinal bundles of fibres are short in relation to their width, and consequently liable to fracture. Short grain must be avoided as much as possible, but where necessitated it must be stayed by independent means.

Shrinkage, or contraction. The diminutión in size of a casting during the process of cooling down.

Shrouding. The flanging around the teeth of a wheel. Shrouding reaches either to the pitch line, or to the point.

Side Tool. A turning tool, flat on the face, but having its cutting edge ground at an angle with the edge of the tool. A tool ground on the right hand is termed a right hand side tool, if ground on the left it is termed a left hand tool. The former is used for boring cylindrical work, and the latter for turning the outside of a boss or cylinder when material situated without it prevents the use of a squarely ground chisel.

Sieve. *See* RIDDLE.

Sight Hole. A hole in the back of a tuyere pipe, or in an air belt, through which the operation of melting can be watched. It is closed with a disc of glass or of mica.

Single Iron. A plane iron (*q.v.*) which consists of the cutting iron only. All rounds and hollows and rebate planes are made with single irons; but the jack, trying, and smoothing planes with double irons (*q.v.*).

Skewers. Or Wires. Short lengths of wire from $\frac{1}{16}''$ to $\frac{1}{8}''$ in diameter, used for the purpose of temporarily attaching loose pieces (*q.v.*) to patterns. The skewers are not drawn out until after the sand has been rammed round in sufficient quantity, in order to prevent the risk of disturbance of the loose pieces in the ramming up process.

Skimmer. A long rod of flat bar iron which is held across the mouth of a ladle at the time of pouring, to prevent the scum upon the surface of the metal from entering the pouring basin.

Skimming. The baying back of the scum from the surface of metal which is being poured from a ladle into the mould.

Skimming Chamber. A circular or globular chamber between the in-gate and runner of a mould, by which a rotary motion being imparted to the molten metal, that which is most dense and sound passes on into the mould, the lighter and more porous remaining at the centre, or coming up into a riser above.

Skin. The surface of a casting, as a "rough" skin, a "smooth," or "clean" skin.

Skin Drying. The drying of the surface of a mould made in green sand, to render it slightly harder and firmer than it would be in its natural state.

Slaking. SLEEKING (*q.v.*).

Sleeking. Smoothing and finishing over the surface of a mould with trowel, or sleeking tool. Also pronounced slicking, or slaking.

Slicking. *See* SLEEKING.

Slings. Loops formed at the ends of rods of bar iron depending from a cross beam, in which the swivels of moulding boxes are laid for turning over.

Slip. *See* OIL SLIP.

Smoothing Plane. A plane about 8″ long, used for smoothing or finishing surfaces where appearance is more essential than strict accuracy. Hence its work is intermediate between that of the jack plane and the trying plane. The irons of smoothing planes range from $1\frac{3}{4}''$ to $2\frac{1}{8}''$ wide, and are sharpened slightly more rounding than those of trying planes.

Soft Ramming. *See* RAMMER.

Spalting. The breaking or splitting out of timber at the end grain. It is the evil to be specially guarded against when end grain is being planed, to prevent which it is customary to chamfer the edge where the plane terminates its cut.

Spigot. The beaded end of a pipe, which, entering loosely into a socket upon a pipe adjacent, is rendered water-tight by caulking.

S-Pipe. A double bend turned in opposite directions to each other, and having the outline roughly of a letter S.

Splitting Plate. A plate of cast or wrought iron, used to divide some portion of a casting, usually a boss, or a wheel rim, in two.

Spokeshave. A tool whose action is that of a plane, but whose stock is narrower to render it suitable for the working of curves. Two or three spokeshaves of different widths are required by the pattern maker, in order to afford sufficient range of curves.

Spongy. A casting is said to be spongy, or honeycombed, when minute blow holes are interspersed throughout its substance. Honeycombing is the result of imperfect venting, so that the gas and air cannot escape quick enough before the in-flowing metal.

Spray. An assemblage of small runners diverging from a main runner. Used for the lighter class of castings.

Sprigging. Nailing the narrower, weaker sections of sand in a mould, in order to afford the support necessary to enable them to withstand the pressure of the liquid metal. The nails are thrust in with the fingers, and the sand consolidated around them.

Spring Chaplet. *See* CHAPLET.

Spring Dividers. *See* DIVIDERS.

Spur Wheel. A cog wheel (*q.v.*) in which the teeth are disposed radially around the periphery, and in lines parallel with the axis. These wheels are used to transmit power through shafts, whose axes are parallel with each other.

Stake. A tapering bar of wood or of iron driven into the sand of the foundry floor, as a guide to the setting of the cope in bedded-in work.

Staking. The setting of the cope of a bedded-in mould by means of stakes.

Staple. Or Dog. A metal clamp, in shape like the three sides of a rectangle, the two free ends being pointed for driving into adjoining timbers in order to pull them up close for jointing, or for other purposes.

Standard Pattern. A pattern which is in frequent use, and which is supposed to undergo no alterations. Standard patterns are made for all repetition work, and much pains is bestowed upon their construction, both with a view to accuracy of dimensions, to the lessening of fitter's work upon their castings, to their stability, and freedom from liability to warp and shrink, and to their durability.

Standard Rule. An ordinary rule for common measurement, as distinguished from a contraction rule (*q.v.*).

Stays, or Bars. The ribs which span a moulding box, and by which mainly the sand is retained in place.

Stopping-off. The alteration of the length or outlines of a mould effected without altering that of the pattern from which it is made, by introducing a templet or stopping-off piece into the mould, and ramming the sand against it, as though it were a pattern of the actual shape required.

Stopping Over. The filling up of the space over a core placed in a pocket print (*q.v.*), with sand.

Stopping-off Piece. Any piece used as a templet or guide in the process of stopping off.

Stove. A brick-lined chamber in which cores and moulds are dried with coke fires. The stove is usually built outside the foundry wall, but opens into the foundry, the opening being closed with a sheet iron door. The fire is made either in the floor, or at the sides. Also termed "core stove" and "drying stove."

Straight-edge. A thin strip of wood whose edges are planed as truly linear as possible, and used as the means of checking the linear accuracy of lines and surfaces. Straight-edges are best made in mahogany, if under about three feet in length, and in yellow pine if over that size.

Straining. The slight distortion, bulging, or lifting of weak or insufficiently loaded flasks by reason of liquid pressure of molten metal at the time of pouring.

Strap. The bar or bracket of wrought iron to which a loam board (*q.v.*) is bolted. It fits over the striking bar (*q.v.*) and is pinched at any required height with a set screw. *See* also LIFTING STRAP.

Strickle. Any templet whose edge is profiled to strike up cores, patterns, or moulds in core sand, loam, or green sand. Core boards (*q.v.*) and loam boards (*q.v.*) are, however, not usually termed strickles; but the term may be taken to include anything not embraced under these two heads.

Striking Out. Signifies the marking out of work.

Striking Bar. A square bar of iron slipped vertically into, and pivoting in a suitable socket, sunk in the foundry floor. The bar is an abutment for a loam board, which is swept radially round it.

Striking Board. May be either a core board (*q.v.*) or a loam board (*q.v.*).

Stripping Plate. A plate (*see* PLATE MOULDING) through which a pattern is withdrawn, the hole in the plate being of the same contour as that of the pattern. There is thus no tearing down of the sand, since the plate strips it from the pattern during withdrawal. No taper is required in the pattern either.

Strong Sand. Sand which will bear drying or partial drying without becoming pulverised. Strong sand is stiff and clayey by comparison with weak sand, and usually contains horse dung.

Sullage, or Scurf. The inferior open metal, scum, dross, dirt, and foreign matters generally, which collect on the surface of molten metal.

Sullage Piece. *See* HEAD METAL.

Swab, or Water Brush. A soft brush which is dipped in water, and used for the purpose of swabbing (*q.v.*).

Swabbing. The moistening of the joint edges, or of weak and broken sections of a mould, with a swab (*q.v.*), to ensure the coherence of the sand.

Sweep. A piece of wood having a curved edge, or edges.

Sweep Saw. *See* COMPASS SAW.

T.

Tap. Relates to the discharge of metal from a foundry cupola. To cause the metal to flow is termed "tapping," or "tapping out." If the clay in the tapping hole is difficult to pierce with the bot stick, the tap is said to be "hard."

Taper. The thinning down of a pattern from the top to the bottom, in order to relieve it from the pressure of sand as it is gradually withdrawn.

Tap Hole. The hole in a cupola through which the metal flows into the ladle.

Test Bar. A bar of cast-iron which is subjected to a cross breaking test for the strength of foundry metal.

Thicknessing. Striking the coat of loam on a loam pattern, which represents the thickness of metal in the actual casting.

Tooth Block. The prepared block, usually containing two teeth, used for moulding toothed wheels in a wheel-moulding machine.

Trestles. *See* CORE TRESTLES.

Trying Plane. A bench plane 22″ in. length, with an iron of $2\frac{1}{2}''$ in width, is used for truing up the surfaces of timber after the preliminary reduction with the jack plane (*q.v.*).

Tucking Under. Thrusting and compressing sand underneath overhanging portions of patterns in the operations of moulding, chiefly in bedding in.

Turning Over. The method of moulding by ramming the sand directly against that face of a mould, which, though uppermost during ramming, is to be lowermost at the time of casting. After ramming, the flask with the contained pattern is turned over into its final position This is, therefore, the reverse of bedding-in

Turn-over Board. *See* Bottom Board.

Tuyere. The short pipe, nozzle, or orifice through which the blast enters a cupola.

V.

Venting. The act or process of forming the vents (*q.v.*) in a mould.

Vent Ropes. *See* Vent Strings.

Vents. Minute passages and chambers by which the sand of a mould is honeycombed, and through which the air and the gases generated by casting find escape.

Vent Strings. Or Vent Ropes, or Core Ropes. Ropes or strings used for venting crooked cores, from which rigid rods or wires could not be withdrawn without tearing the cores.

Vent Wire. The wire or rod used in the formation of vents (*q.v.*).

W.

Waster. An imperfect or damaged casting which cannot be used for the purpose for which it was designed. Blow holes, scabs, draws, cold shuts, etc., are among the principal causes of waster castings.

Water Bosh. A tank of water in the foundry from which supplies are drawn for core making and moulding purposes.

Water Brush. A swab (*q.v.*).

Weak Sand. Sand which will not bear drying without becoming pulverised. It may, however, be skin dried It is loose and open, and contains no dung.

Weighting. Loading (*q.v.*).

Wet Blacking. *See* Blackening.

Wind Chest. An air belt (*q.v.*).

Winding Strips. Strips of wood or iron, of equal and parallel width, used for levelling, the coincidence in regard to parallelism of the uppermost edges being estimated by the eye cast over them. Called also "levelling strips."

Wires. *See* SKEWERS.

INDEX.

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