Victorian Institute of Engineers
(Established 1883.)

1942, MAY 28TH

PROCEEDINGS

An ordinary General Meeting of the Institute was held in the Scots Church Hall, Russell Street, Melbourne, on the evening of 28th May, 1942. The President (Mr. W. E. Pyke) occupied the chair.

Minutes of the meeting held on 30th April were read and confirmed.

The President said that many valuable written contributions to the discussion upon Pumping Problems and Cracks in Reinforced Concrete, had been received, and would be dealt with by the Publication Committee.

Mr. George D. Thompson read a paper entitled "Pattern Making and the Foundry as Related to Manufacturing Processes." The lecture was illustrated.

After brief discussion, the President moved a vote of thanks to the lecturer, which was carried by acclamation.

The meeting terminated with light refreshments.

PAPER

PATTERN MAKING AND THE FOUNDRY AS RELATED TO MANUFACTURING PROCESSES.

By George D. Thompson M.V.I.E.

The need of the knowledge of manufacturing processes, and related sciences cannot be overstressed.

To the engineer it means a broadening of his education, and tends to awaken a new sense of the subject as a whole. A subject that is of considerable value to the engineer, when treated as applied in industry, is that of castings and pattern design, also pattern construction, for the production of small or large quantities of castings. In either case, the design of the casting and arrangement of the pattern should be such as to facilitate the work to all concerned, in making of the mould in the foundry, also to the machining of the piece in the machine shop.

Faulty pattern and casting design, from a production standpoint, is a problem that is daily confronted in commerce, causing considerable monetary loss. The engineer and designer, well informed on the subject of design and manufacturing processes of castings and pattern equipment, can greatly overcome this position.

Close collaboration between drawing office, pattern shop, foundry and machine shop is a necessity that should be fostered by the engineer.

An error in dimension or design, not easily seen on a drawing, becomes apparent when the pattern is taking shape. The patternmaker is thus very often responsible for alteration in design to suit drawing office errors, and
also to improve the mouldability of a casting. Although a casting of difficult design can be made successfully under strict supervision, such close attention may not be available when a repeat of the casting is required; this results in dissatisfaction. There is also the designer's weakness for artistic lines and curves, due to his unfamiliarity with manufacturing methods. Considerable expense in pattern construction is often incurred this way.

The manufacturer of welded steel structures is allowed every concession in this respect. A casting is often replaced by a welded structure, owing to its high cost. A new design is supplied to the welding department. If the same design was also submitted to the foundry for a price, it is quite possible that the casting would compare in cost favourably with the fabricated form. In obtaining casting quotations, the engineer would probably get better results if he went to the foundry specialising in a particular class of work. Some foundries are experts on light work, while others prefer the heavier class of work. Very little fitting is required on small castings produced by light work people, whereas the same job supplied from the heavy specialist would be much rougher owing to the sand conditions. Although the main object of this paper is to present some aspects of pattern design and manufacture, and also to impress on designers the need for some work-shop experience in the pattern shop and foundry, it is felt that the importance of casting design for ferrous and non-ferrous metals must also fill an important place. To achieve this purpose the lecture will be divided into the following sections:

**Design Office Co-operation.**

1. **Casting Design.**
   (a) Design for Solidity of Casting.
   (b) Design for Mouldability.

2. **Design and Manufacture of Patterns.**
   (a) Drawings supplied to the Pattern Shop.
   (b) Machine shop and pattern shop co-operation.
   (c) Pattern materials, standards, types of patterns. Foundry co-operation.
   (d) Pattern shop equipment and personnel. Checking.
   (e) Storage of patterns.

**Casting Design for Solidity.**—The forging of metal objects is a direct process, work being done on the actual component; this also applies to built-up structures, before assembly tests can be made of the individual parts, and adjustments, if necessary, made to secure the desired whole. The production of castings differs from forgings in that it is an indirect process. The metal-founder shapes the casting through the medium of the sand mould design, which in turn is dependent upon the pattern supplied to meet this purpose.

A casting cannot be subject to tests until it is too late to make adjustments. To minimise these after cast troubles science must be applied; the particular science which treats of shape as related to moulding and molten metal requirements. Herein lies the peculiarity of casting design. The design determines the mould; the mould, if the design is such that will accommodate shrinkage stress, a casting will be produced, the result being commonly known as "a waster." This means that however accurate load calculations are made, and generous safety factors allowed, unless shrinkage effects are taken into account the casting may fail in service, even if it is
delivered from the foundry in one piece. A casting badly designed can even fall to pieces in the mould under its own casting stresses.

The efficient foundryman has various methods of combating shrinkage stress, but it is the designing engineer’s or draughtsman’s job to allow for this trouble whilst the project is still in the drawing office. Here commences Foundry and Pattern Shop co-operation. It is by no means uncommon to find castings designed in a manner that would be quite satisfactory if they were composed of wood, as examples, frames with light sections in close contiguity with heavy sections of metal, sharp re-entrant angles, lack of fillets, etc.

To aid in standardising cast metal thicknesses and sections, Foundry Associations and Institutes have made some of the following recommendations as a guide for designers.


Grey Iron castings are made in a wide variety of section thicknesses. Essential differences between white and grey irons are that white irons may become a grey if poured into heavy sections, while grey irons may become white if poured into very thin sections. Soft grey iron may be poured into 1/8 sections and retain its greyness. A well designed gray iron casting is one that can be made commercially and whose sections are no thicker than is essential to secure the desired strength and whose members are proportioned evenly to avoid local slow cooling. Uniformity of section thickness is very desirable from a foundry standpoint. This equalises the rate of solidification, simplifies gating and feeding, and reduces internal strains, shrinkage defects and cracks. A pedestal casting shown at “A” Fig. 2, can be greatly improved by equalising the metal section as shown at “B.” Although the idea behind the design shown at “A” may be to eliminate the cost of a core box, whereas all that is necessary to suit “B” would be a core board to form the core. The weight saved in casting would possibly offset the board cost. If there were more than three castings required a half core box is all that is necessary, the two half cores being pasted together. Most foundries prefer half core boxes these days, so as to facilitate the drying of the cores on flat plates.

Steel Castings, with wall thicknesses as low as 1/4 inch, are poured regularly in the modern Steel Foundry. Special cases of 3/16 inch, depending on the design of the casting, are sometimes used. The best practice is to use wall thicknesses that can be poured without danger of mis-runs and that will provide the necessary strength and weight.

Malleable Iron is commonly cast in sections 1/8 inch in thickness, although the average casting section is approximately 1/4 inch. Castings in this material are made in weights varying from a fraction of an ounce to more than 1000 lbs., although the greatest production of malleable iron is in castings under 25 lbs.

Non-Ferrous. The minimum section thickness for non-ferrous castings varies with the alloy, size and intricacy of the casting. With brass and bronze 3/32 inch is considered the minimum metal section. With aluminium alloys 1/8 inch sections have been cast satisfactorily, although a minimum thickness of 3/16 inch is preferable.

Generally speaking the class of pattern equipment sent to the Foundry governs the minimum thickness to which a casting can be made. Castings with cored openings, etc., present greater difficulties on account of core trouble such as sagging, distortion and metal contraction. The hard baked
core retards contraction, therefore creating tears and cracks in light sectioned castings.

Use of Fillets.—Adequate fillets at all intersections increase the strength and soundness of castings. Through the liberal use of fillets and round corners, waster castings, caused through sand wash, shrinkage and cracks, can be avoided. The use of fillets and round corners also tends to enhance the appearance of a casting.

Size of Fillets.—Sizes of fillets depend upon—(a) metal used, (b) shape and thickness of casting walls, and (c) size of the casting. Fillets that are too large or too short permit the possibility of a crack at the intersections of casting members. Too large a fillet promotes increased sectional thickness, thereby causing shrinkage troubles at that point. Increased metal sections call for extra feeding precautions by the moulder. This increases moulding costs.

When light brackets or ribs which adjoin a heavier section are required in a design, or possibly a pipe flange or similar construction, the strength is improved by running the fillet for some distance down the light section and blending into the heavier, as shown at Fig. 3, “A” and “C.” Where sections are even, an ordinary radius is all that is necessary, as shown at “B.”

Progressive Solidification.—Application of progressive solidification or feeding of lighter through heavier sections, obtained by proper casting design and location of heads and risers, should be utilised where possible. This is important in steel casting design.

Fig. 4.—This steel casting indicates the manner in which the location of sections in relation to others influences the soundness of a casting. The casting is represented by sections A1, A2, B, B1, C1, C2 and Risers A and C. In cooling A2 is fed by A1, which in turn received metal from riser “A.” Sections B and B1, due to their lightness, will cool almost immediately, and will require little feeding, such metal as is needed being supplied by the adjacent sections. The location of heavy section C2 below the lighter section C1 shuts off its supply of liquid metal, because sections C1 and B1 solidify before C2 is solid, leaving a shrink hole as at “D.” Design of these sections as at A1 and A2 would prevent this possibility of a shrink (A.F.A. Cast Metals Handbook). Heavy sections formed by the rim of a gear blank create uneven shrinkage and shrinkage cavities. To meet this the foundryman adds shrink heads to the casting. These have to be of sufficient size to be able to supply the required liquid steel to fill the cavities while the heads are themselves freezing. The cavity or fault is thus formed in the head instead of the casting. Fig. 5 is an example of a standard gear blank with “H” section arms. The head metal in this case is known as “an all round head,” and has splitting cores to cut it in sections, thus saving fettling and handling costs.

Design of Bosses and Lugs.—Properly designed bosses, by the elimination of loose pieces on the pattern, may be of great assistance to the foundryman in reducing moulding costs. Loose pieces on patterns are always a source of annoyance as they are easily broken or lost.

Fig. 6 is an example showing the elimination of loose bosses. There should be as great uniformity of metal section between bosses facings and lugs and the body of the casting as possible. Proper design of bosses, etc., permits not only the production of a sounder casting, but in many cases results in a saving of material.

Fig. 7 is an example of boss design, showing bosses on the wall of a cylinder. A boss as shown at “A” would probably cause a fault or shrinkage
cavity, due to the thin section at "C" not having enough metal to feed it. The improved design showing equalisation of metal is shown at "B." Although this would possibly increase pattern cost it would be well compensated for in eliminating the possibility of a waster; the total casting weight is also reduced.

Chamber cores as shown at Fig. 11 should always be adopted where possible. Solid bosses call for extra foundry labour for hand feeding of heavy sections, and at the present time this is important, due to the shortage in foundry labour.

Rib Design.—The design of ribbing in cast sections is important. They not only increase the ultimate casting strength, but, if properly proportioned and correctly located, serve to check tears and cracks during casting solidification. In this direction it is necessary that the ribs solidify earlier than the section which they adjoin and act as a bond to prevent cracking, also serving as conductors of heat, thereby promoting cooling of the involved section. Sections of ribbing are shown in Figs. 8, A, B, C, D. A and B are poor, due to uneven section which would cause internal shrinkage. C and D, being T and H sections, are preferable, due to uniform metal section. H section arms are very common in gear wheels, etc. Standard sections being available in most handbooks.

Where possible ribbing on plates, etc., should be staggered to avoid local increased section thickness. Fig. 9.

Holes are often cored through rib sections to reduce local section thickness. Figs. 10 and 11. Fig. 11 shows wheel with "H" section arms.

Holes in Castings.—Small holes in steel castings which require a finished surface are usually drilled and not cored. Small diameter cores in steel castings usually have the tendency to burn in. It is preferable to drill holes up to about 1 inch in diameter. Large holes are usually cored and then bored to the finished diameter. The introduction of cored holes in large bosses, etc., tends to eliminate unequal metal sections, which, as mentioned, prevents metal shrinkage troubles. It is usual to cast all holes in manganese steel castings. Where holes are cored in castings of heavy sections it has been found advisable to case the core in a piece of pipe or tube to prevent the burning in of the core.

DESIGN FOR MOULDBABILITY.

Although a design be created to give a casting free from shrinkage and stress troubles, the question of the simplest and most economical method of producing the mould must be considered. To enable one not having foundry experience, and to visualise a moulding operation, I will describe what is known as a two-part job, an example being shown by Fig. 12, A, B, C, D, E, F, G.

A. The pattern is placed flat side down on a board.

B. The drag, or bottom box, is placed over the pattern. After placing the drag over the pattern sand mixture known as facing sand is tucked around the pattern, ordinary floor sand is then rammed in, filling up the box part.

C. The whole is now turned over and the board is then removed. Actually the board forms the mould joint. The joint so formed is dusted with parting sand, which is really fine sea-sand dried.

D. The cope, or top box, is then placed on and rammed up; provision known as a runner, is made for the introduction of the metal.

E. The cope is removed and the pattern rapped and withdrawn from the mould, which is repaired if necessary, and dry sand cores inserted if required.
F. The cope is finally replaced and weighted down, the mould being then ready for the metal.

G. Resultant casting.

The formation of the mould joint and the withdrawal of the pattern is the principal concern of the draughtsman. After having decided on the general shape or contour of the casting, he should make arrangements in the design to secure the simplest form of mould joint as well as to assist with the withdrawal of the pattern.

The ideal mould joint is one that has just been described, and commonly known as a *flat joint*. The absence of projections coming into the top part or cope is also welcomed by the foundry. This creates a term known as a "flat top part." Wherever possible generous taper should be allowed in the direction of pattern withdrawal. Ribs, flanges, webs and bosses, etc., could often be designed with a generous taper on them without affecting the general shape of the casting. Not only is the taper of tangible assistance in moulding, but also results in a casting being nearer the estimated weight, due to the pattern not having to be excessively rapped. The life of the pattern is also prolonged.

Fillets and round corners are equally valuable for mouldability as for solidity.

*Mouldability.*—Examples of flat top part design are shown in Fig. 13. Note the difference in Fig. 14 showing the departure from the square corners and parallel sides.

The moulding comparison can be seen in Figs. 15 and 16. The superiority being evident in Fig. 15. Taper clearance between the pattern and the mould sides is shown at "C". This clearance increasing as the pattern is withdrawn. "D" shows mould distortion (Fig. 16).

Where taper is neglected, and the mould is disturbed, extra labour is entailed in "making up" and finishing; also there is always a possibility of scabbing, due to the made-up sections of sand being weak, and lending itself to displacement which creates the scab in one part of the job and a hole in another section. The taper or draft allowance is usually about 1/8 to 1 inch. Where possible make designs such that they will eliminate the need for a jointed or split pattern. Split patterns have to be moulded in a two parted moulding box, therefore there is always a possibility of the box parts becoming cross-jointed, which will result in a distorted casting.

Projecting parts such as bosses, and ribs, etc., should be designed to form a fixed part on the main body of the pattern, therefore avoiding the necessity of loose sections.

Where plates or similar castings require flanges, the best design is that in which the flanges are arranged on one surface only.

Figs. 17, 18 and 19 illustrate how a slight change in design may secure a flat top. The circular boss "C" was altered to a "D" shape. If possible make provision in a design to enable the casting to be made with the machined faces down in the mould, to ensure a clean surface and soundness of metal. Make allowance for the supporting of cores, in jobs such as jacketed cylinders, or any design where a core appears to be totally enclosed.

Avoid the addition of arms or other protruding shapes on a casting. It is often more economical and produces a better product if such sections are made as separate castings, and secured to the main section later. This principle can be applied to pipe sections. Occasionally pipe castings are asked for in the shape of a straight section, with a branch forming a bend at right angles to the body. In such cases it would be an improvement to make two castings and attach the bend to the straight section.
DESIGN AND MANUFACTURE OF PATTERNS.

"A"—General.—Drawings Supplied to the Pattern Shop.—When a drawing is supplied to the Pattern Shop it is desirable that it be drawn to scale so as to show the different sections and views on one sheet. The examples given in the following list are very important in Pattern Shop drawings, and are often overlooked, causing loss of time and often waster castings.

1. See that all dimensions are on drawing and link up correctly from one view to the other.
2. Note that dotted lines are not drawn where there should be full lines shown.
3. Be careful that lines are not drawn where there should be no lines.
4. Arrows should be placed correctly.
5. Intermediate dimensions when added together should correspond to over-all dimensions.
6. It is important that all machined surfaces be clearly marked.
7. Do not place the word "bore" when a core is required. This is not applicable to pipes.
8. Do not cramp the views on the paper, thus creating a need for small figures, calling for a magnifying glass to see them.
9. Show clearly the number of castings required, also the material from which they will be made.
10. Mark clearly where diameters are required.
11. Faintly printed blue-prints are a constant source of annoyance.
12. Where designs are altered to any extent, altered sizes should be encircled to enable the pattern-maker to check these sizes on an existing pattern immediately, without having to find them out himself.

Discussion between the designer and patternmaker will often save time and expense.

"B"—Machine and Pattern Shop Co-operation.—Increased production and an improved product can be gained through these departments working in harmony.

Where the pattern is made in an outside Pattern Shop any points about machining clearances and allowances should be noted on the order or drawing. The average patternmaker usually allows the following amounts for machining:

- Cast-iron 1/8 inch on surface, 1/4 inch on diameters.
- Non-ferrous metals 1/16 inch on surface, and 1/8 inch in diameters.
- Cast-steel 3/16-1/4 inch on surfaces, 3/8-1/2 inch on diameters.

Although these are general allowances they should be adjusted according to their manner of moulding and method of machining. Castings made with metal patterns on moulding machines require less machining allowance than castings hand-moulded. Where cylinders are cast in pairs it is wise to increase the machining allowance, as contraction may affect the centres during the cooling of the casting.

In gear blank castings it is usual to allow more machining on the top side than the bottom, as dirt, etc., rises to the top surface of mould.

The machining allowance on a set of locomotive cylinders made by me some time ago, was 1 inch on the diameters and 1/4 inch and 3/8 inch on surfaces. They were made of cast steel.
Lathe beds and plate shaped castings should have ample machining, as they are liable to warp during cooling.

Many cases of allowances varying from standard could be mentioned, hence the need for a discussion with the machine shop.

Fig. 20. Provisions for Machining Castings.—In planning a pattern some consideration should be given to the shop facilities for handling the casting during the machining operations. A very little extra work in the pattern shop will often save hours in machine shop work. A small boss cast on pieces that cannot otherwise be fastened conveniently to a face-plate (see Example A, Sheet 1), or a bridge left in each end of a hollow cylinder to accommodate the lathe centres (see Example B), often greatly facilitates the machining of castings of this type. Lugs (a) and feet (b) on a casting of the general type shown at C are frequently used to facilitate levelling and clamping for the machining operations. Ring pipes D, used for making piston rings, are ordinarily provided with lugs for fastening to a face-plate. The number of lugs used should be regulated by the slots in the shop face-plates; four is the usual number, but on small rings sometimes only two lugs are provided, with the addition of two feet for steadying. The lugs may project either outward or inward, depending upon the size of the pipe and the size of the face-plate to which it is to be fastened. If the pipe is as large, or larger, than the face-plate, the lugs should be placed on the inside, but if it is smaller than the face-plate, the reverse method is used. The lugs, instead of being fastened directly to the bottom of the ring, are more often made with an added thickness between the lug and the ring. This permits using the entire ring.

Tool Clearances.—Tool clearance spaces are sometimes formed on a pattern to provide an open space for the tool to enter when finishing portions of the casting that are partially or entirely enclosed. Holes that are to be tapped for screw pipe connections in bosses or other thick portions of castings should be provided with a chamber or recess larger than the outside diameter of the tap so that the end of the tap will have a clearance space (see Sketch E). Frames that are to be machined inside should have tool clearance provided at the corners, as at F. Slots closed at one or both ends should be similarly arranged as at G. These examples cover but a few of the cases that arise in practice, but they are typical and serve to emphasise the importance of considering the work in the Machine Shop.

Pattern Materials.—Patterns are constructed of a number of materials. the main being wood, metal, and plaster of Paris. Great care should be taken in the selection of material for wood and metal patterns. For wooden patterns for general use the timber should be the best obtainable. If possible, it should be kept for about a month inside the shop where it is to be used. The change from cold storage to a warm atmosphere invariably changes the timber's character. A well-ventilated shop means a great deal to the timber pile. 

Sugar Pine has been the most popular timber for general work in Victorian shops for many years. For small work, such as valves, small gear patterns, etc., New Zealand Kauri or Tasmanian Huon Pine are hard to equal, as the fine edges and corners stand up to foundry usage. Californian Red Pine is quite good for large jobs where only a few castings are required. Although it is excellent in plates, etc., as it keeps its shape, the drawback to Red Pine is that it is soft and bruises easily. King William Pine, from Tasmania, is excellent for general work, providing it is dry.
Since the outbreak of war, timber prices have soared, and many other species of timber are now being used, most of them coming from around the north-east of Australia. Timbers now being used are—Milky Pine, Putts Pine, Candle Nut and Silver Ash. For small patterns of a permanent nature some firms use Queensland Beech or Mahogany.

Generally speaking, pattern timber should be such that it can be easily worked to smooth surface, easily carved with hand tools, and correctly seasoned. After kiln drying, some firms prefer about a 5% to 7% moisture content. It should be sufficiently fine-grained to take a good coat of shellac varnish—which is necessary for keeping out sand moisture.

Due to progress in mass production methods in the engineering field, the demand for suitable patterns and core-boxes, to meet the increased wear and tear requirements in the foundry, has had the result of constructing pattern equipment in different metals. Metal patterns and core-boxes also increase the accuracy and finish of the casting. Moulding costs are also reduced. Master patterns made to double contraction are first constructed in wood or plaster of Paris.

Metal Patterns.—The following metals are used for metal pattern making:

Aluminium.—An alloy of 89% of aluminium to 11% of zinc is good for general work, as it is light and hard. When alloyed in the proportion of 92 lbs. of aluminium to 8 lbs. of zinc, the composition is suited for long, thin patterns as it is a soft alloy and will not crack in cooling. Aluminium alloy melts at about 1200°F. Contraction allowance about 5/32 inch/foot.

Brass.—Where the design is composed of thin ribs and partitions, the pattern needs to be stiff and smooth. A soft yellow brass is most suitable as it is easily finished. Contraction 3/16 inch, melting point 1600°F.

Grey Iron.—Cast Iron can be used where the pattern is of a light shell design, otherwise it is too heavy for general use. Contraction 1/10-1 inch, melting point 2200°F. Grey Iron patterns stand up to excessive wear.

White Metal.—A white metal alloy of 76% tin, 14% antimony and 10% lead, is useful for casting off a pattern which has had only one contraction allowance provided for, as this alloy has very little contraction. It melts at about 600°F.

A composition to the proportions of 86 lbs. of tin, 9 lbs. of zinc and 5 lbs. of aluminium is useful for filling cracks, etc., in aluminium patterns and core-boxes.

Plaster of Paris.—Plaster of Paris is very useful for patterns requiring a few castings off. Die blocks for drophammer work and forming dies can be produced in plaster at a greater saving in cost. Core-boxes can also be economically produced. Plaster can be cast or strickled. It is also useful for making test moulds to check out metal thicknesses, etc., in pattern equipment. Plaster expands about 1/64 inch in setting. Dental plaster preferred.

Model dies for use on tracer or duplicating machines can be made in plaster, or, better still, Granolite or Titanite.

PATTERN STANDARDS.

For control of pattern costs, etc., patterns could be classified into the three following groups:

1. Temporary Patterns.—This heading covers skeleton patterns, strickles, plaster-patterns, and all patterns of a make-shift character, their sole object being to reduce pattern costs without over-increasing moulding
costs. The cheapest of materials are generally used in this class of work. Generally used for "1 off" and breakdown jobs. Fillets are usually indicated by a chalk mark in corners.

2. Temporary Patterns.—This type of pattern could be ordered where the demand for castings is only few but may come periodically. They could be made of average pine timber, and where the pattern is of the parted type wooden dowels would suffice. Half core-boxes could be supplied in place of full core-boxes. Loose pieces can be attached with nails. Fillets can be made in leather.

3. Standard Patterns.—Standard wood patterns are those jobs which are in general use and are supplied where it would be impracticable to use metal patterns. This type of construction calls for best class timber of a tough nature such as mahogany, New Zealand kauri, or Tasmanian huon, or well seasoned yellow or sugar pine—yellow being preferable as it is tougher than sugar. If using pine all fine edges can be faced with some of the harder timbers or metal strips.

If it is a parted pattern it should be fitted with metal dowels, also rapping or lifting plates placed in a convenient position to suit the foundry. All loose pieces should be dovetailed in place, using aluminium pieces where suitable.

The joints, and parts of core-boxes, that come in contact with the moulder's trowel, etc., should be faced with metal plate or hard wood. Core-boxes should have metal dowels fitted. Hard wood rapping battens or cleats should be fitted to patterns and core-boxes where possible. All loose pieces should be correctly marked. Where the design means a weak part in the pattern, that part should be formed with a core, so that the core print will help to strengthen the job at that point. All fillets should be added to the pattern and carved from the solid where possible. Stuck fillets, such as leather and wood, can be applied in circumstances not permitting the carving possible. All joints of construction to be glued and screwed. Correct allowances should be made on core prints for core clearance, due to core expansion. Allow good tapers where permissible to avoid excessive rapping of pattern. Indicate machined surfaces on the pattern by some approved method.

Metal Patterns for permanent production materials, etc., are covered in the section on metal pattern materials. The metal pattern equipment is made to suit moulding machines and facilities available in the foundry. As the runner and gating arrangements are supplied with the metal pattern, it is well to co-operate with the foundry concerned on these points. Runners and gates to be kept as small as possible and located in a position most convenient for casting, dressing.

Since the outbreak of war the demand for metal patterns, fitted up on plates and boards, has been in greater demand than ever contemplated in this country. The agricultural implement industry have possibly been the forerunners and pioneers of this class of pattern work in Australia. Sets of pattern equipment for mass production of aircraft parts have been supplied by this branch of the trade. Pattern plates are divided in a number of classes, such as single-sided, double-sided, and cast pattern plates, the type being generally governed by the machine equipment and foundry capacity. Cores are also made by the aid of core blowing and other types of machines. Female labour has been used in this class of work. Core drying shells improve production and prevent distortion of cores where semi-skilled labour is used. A core drying shell is simply a duplicate half of the core-box in which the core is left to dry. They are generally made of cast iron.
Pattern Design.—Pattern design plays an important part in casting production. It is always advisable to co-operate with the foundry in deciding on pattern design. Although this condition of co-operation is warranted it is not always possible, unless the foundry control is in the hands of somebody well versed in blue-print reading from the Pattern Shop and Foundry angles. Many foundries have foundry engineers or patternmakers in executive positions. Where this is the case, pattern design can be well discussed before production.

In America a special drawing of the pattern correctly designed from every angle is sent to the pattern production department instead of the usual general blue-print. This work is carried out by pattern designing engineers who are in contact with the various engineering production departments. Material allowed and labour hours are stated in the drawing. The Caterpillar Tractor Company carries out this principle.

The aim of correct pattern design should be to produce a casting true to size, shape and strength at a minimum cost of moulding, also at a minimum cost of pattern construction. The pattern shop should be well informed as to the number of castings required from a particular pattern. This point is usually a deciding factor in the design of a pattern. Jobs coming under the heading of temporary patterns call for the most economical form of pattern construction. Patterns for pipe castings are good examples of the temporary type, and are generally known as a skeleton. The pattern in this case is part wood and part sand. The core is formed with a frame and strickles. This type of job is illustrated by the Y pipe (20 inch bore) shown by Fig. 21 A and B. Large condenser covers can also be made by a simple skeleton construction as shown at Fig. 22. Where a casting is plain and symmetrical in shape, such as large wheels, flanged cylinders, acid mixing pots, and similar castings, all the pattern equipment necessary is strickles, and where there are arms, as in a wheel, a section core-box is all that is required.

An urgent pattern was recently required for an 8 inch pump body and corer. As this was a ship repair, the pattern had to be delivered in a week. To overcome this problem, a full pattern was made, and all core-boxes took the form of a skeleton design. These are shown in illustrations, Figs. 23 and 24. The casting proved to be successful. Where patterns are of the secondary or permanent nature, more supervision to enable simpler moulding must be observed. Large patterns for machine frames and beds, and similar castings, are usually rigidly made, the object being to withstand the heavy ramming and usage in the foundry. A pattern that will collapse or buckle while in the sand will give untold trouble in the foundry and machine shop. Correct jointing of a pattern should be watched to eliminate deep lifts and pockets. This can be often achieved by the addition of a covering core, a simple example being an ingot mould (Fig. 25). A core point, marked "A," has been placed over the end lugs therefore presenting a flat top. Provision for locating and balancing cores, to do away with the use of chaplets, is necessary when designing pattern equipment and for the production of pressure castings. The pattern shown by Fig. 26 is a steam trap, and is provided with a balance core-print, "E"; on the end of this print is attached a flange "D"; this regulates the distance that the core can project into the mould, thus governing the thickness of metal at the base of the trap. A square core-print "F" is used to balance and locate the side port. Where a number of cores have to be inserted in the mould, it saves considerable time and chance of errors if the core-prints and core-boxes are numbered. Fig. 27 shows the pattern required to make the cylinder for the "H" class locomotive for the Victorian Railways. Note the marking of core-prints to enable the correct order of core assembly.
The cylinder bore prints, "M" and "J," were made square and parted diagonally, the reason being to locate this main core in position in relation to the position of the steam port cores. The set of cylinders for this engine were cast in steel by a Victorian foundry.

A special type of core-print is used on motor piston patterns to enable the core to be supported from one end without the use of chaplets. Pattern and core-box shown at Fig. 28. Note jointing of core-box to aid in removing core without excessive rapping of core-box.

The examples just described are only a few of the many ways in which the pattern shop can co-operate with the foundry and supply an improved product.

Pattern Shop Equipment and Personnel.—Whilst the casting and pattern design has been perfected, it is also necessary from the engineer's standpoint to aid in the actual production of patterns. A well-equipped and trained staff is essential.

The shop should be well lighted and ventilated, and dust extractors fitted to machines where possible. Benches should be arranged around the walls under windows, thus making the centre of shop available for machines.

Much time and exertion can be saved if men have easy access to the machines, especially a band saw, as this is in continual demand. If possible all machines should be of the motorised type and suitably guarded.

Machines necessary for the average shop could be:
1. Band saw (36 inch).
2. Circular saw, 16-20 inch, with tilting saw.
3. A high speed lathe, about 6 inch centres.
4. Face-plate lathe for large work. Some shops have lathes with double-ended spindles; this is quite practical provided the speed range is wide enough to do work from 2 inch in diameter up to work 6 feet in diameter. About 1200 feet per min. is considered a good cutting speed for wood.
5. A bobbin and disc sanding machine is a distinct asset in any shop (disc about 30 inch in diameter).
6. A 12 inch planing machine.
7. 20 inch thicknessing machine.
8. A high speed drilling machine, with Forstener bits and cutters.
10. A portable drill for bench work.
11. Wood miller. This is a most useful machine which will save much time and labour in a large shop. It is wise to train one man to specialise in the use of this tool.

A surface plate should form part of the shop equipment. Melting of glue is effected by the means of electric glue pots.

A timber rack should be such that the timber stock can be checked easily at any time. Timber can be stored on edge in racks set out for different sizes, heavy timber being on the lowest rack.

Personnel.—It should be the policy of the management to obtain men with good trade and technical training, the type of tradesman whose aim is to supply a pattern to suit the job in hand, meaning where the "one off" job is required he would be willing to understand the amount of labour to
expend, and at the same time to be able to make a first class job when necessary.

Apprentices should have sound technical training in the theory and practice of their trade; also, if possible, some of their apprenticeship period should be spent in the foundry, drawing office and machine shop.

**Checking of Patterns.**—A responsible man should be in charge of all pattern checking; it is not always possible in large shops for the foreman to carry out this duty. In large foundries it has been found advisable to have a patternmaker check moulds and castings.

**Colours of Patterns.**—To avoid mistakes being made in the foundry pattern, equipment is varnished different colours. The coloured part saves the time in understanding the pattern; the moulder at a glance can follow the moulding routine also in assembling the parts of the pattern. The parts that are coloured differently are the body, the machined surfaces, core-prints, the location faces of loose parts, and stop off sections of a pattern. The colouring arrangement is varied to indicate the metal of which the job is cast. There are three standard colour systems available—American Foundryman's Association, The British Standards Association, and The Australian Standards Association. The foundation of all pattern varnish is shellac, as it waterproofs the pattern and gives the surface a fine finish. The different colours are added to the plain shellac varnish in powder form.

In varnishing patterns, the following standard is suggested to suit the standard of pattern:

- Temporary—One coat of varnish.
- Secondary—Two coats of varnish.
- Standard—Three coats of varnish.

In answer to a questionnaire recently sent out by the American Foundrymen's Association to pattern manufacturers.

- 80 per cent. favoured the use of shellac varnish.
- 11 per cent. were using both shellac and lacquer.
- 8 per cent were using lacquer only.
- 1 per cent. were using shellac and enamel.

Shellac varnish is made by dissolving gum shellac in methylated spirits. Metal spraying is now being used on wood patterns for machine moulding. An allowance has to be made on the wood pattern for the size increase due to the metal addition.

**Pattern Storage.**—This is a question which is a source of worry to everyone connected with the workings of a pattern shop. When the patterns come back from the foundry, a place must be found to keep them dry. To a shop which is working continually on large patterns that are only seldom used, this is a very great expense. Large sheds are required, but these need not be totally enclosed, because if about 5 to 6 feet from the floor is left open all round, the large patterns can be put quite easily into place, and it also provides a good air passage. For the smaller type of patterns racks must be provided, and these can be made quite cheaply, using 1½ inch angle iron for the framework and cross stays, and corrugated iron sheets for the shelves. This type of rack is very light to handle, and is much neater than if made from wood.

To keep a record of the movements of a pattern is the work of the pattern shop office, and various systems are used to achieve this end. A good system is as follows. The drawing office has a book in which every
new job is recorded and given a number. This number is put on the drawing which goes into the shop, and thus the pattern actually has a record before it is made. When the work is completed, the number is stamped on it, and the stamping is done on a horizontal face. If the figures are placed on a vertical face it interferes with the drawing of the job from the mould. All the core-boxes are marked with the same number, and it is a good plan to stamp the number of boxes for the job on all the core-boxes and on the pattern. This tells the moulder how many boxes he should receive with the job, and it also gives the pattern storeman the same information when the work is sent out of the foundry.

A card is filled up in the pattern shop office before the work is sent to the foundry, and this contains all the necessary information regarding the job. The cards are filed away in consecutive order, and constitute the only means the pattern shop has of keeping a record of the pattern. When a job has been returned to the stores from the foundry, the pattern storeman finds out the rack on which it must be placed. He then stamps the pattern and boxes with the number of the rack and shelf on which they are to be stored. This information is passed on to the office and duly recorded on the card. The two sides of a pattern card are shown in Fig. 1, the front side carrying all the information relating to the pattern, and the reverse side carries the movement of the pattern. This is very important when the pattern is sent to outside foundries.

If required to go to the foundry again, the pattern looker refers to the card to see the exact position where the job is stored, and is then able to locate it with a minimum amount of trouble. A fresh entry is made on the card, giving the date and the job number for which the pattern is now being used. A very useful purpose can be served if the pattern shop is equipped with a drawing store. This need not occupy a large space in the shop, about 10 ft. x 5 ft. being all that is required. Along each side shelves should be fixed with divisions about 8 in. apart. If the drawings are kept in stiff envelopes capable of holding 50 drawings, and each envelope is indexed with the numbers of the drawings it contains, there is very little loss of time in obtaining any drawings which may be required.

The pattern shop stores is also another very necessary item. If such articles as screws, sandpaper, dowels, rapping plates, and leather fillet are kept in such a way that the pattern makers have free access to them, the cost of the shop will rapidly rise. Whilst every facility must be made to see that the workmen’s time is not wasted by having to wait for material, it must also be carefully watched to see that as little waste as possible takes place.

A boy of between 14 and 15 years of age, who has not yet commenced work at the bench, would be quite capable of looking after both drawing and pattern shop stores. If he does this the saving of time and material will more than repay the firm for his wages.

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Patterns No.
Name of Pattern
Number of Core-boxes
Number of Loose Pieces
Pattern to be kept back: Rack
Shelf

Front Side.
Date  Job. No.  Sent to  Returned
Reverse Side.

Fig. 1.
Life of Patterns.—The length of time a pattern should be stored is doubtful. A lot depends on the frequency with which the pattern is to be used. If only a few castings are required and the pattern is simply made, it is often advisable to destroy it rather than pay storage and insurance costs. On the other hand, a pattern that is not often used may be altered with little expense to be used for an altered design. In some cases, the customer can be notified of the intention to destroy a pattern so as to give the option of purchasing it.

In conclusion, gentlemen, I thank you for the attention you have given me this evening, and hope you have gained a few seeds which will bear you fruit in your next argument with the foundry.

In lieu of the General Meeting in June, which had to be deferred on account of an accident to the lecturer of the evening, members assembled, by the kind invitation of the Institute of Automotive Engineers, at the Kelvin Hall, to hear a lecture by Major J. D. E. SHOTTER, entitled “The Bombing of Shanghai.” The lecturer, who was a technical adviser to the Chinese Government, had recently arrived in Australia.