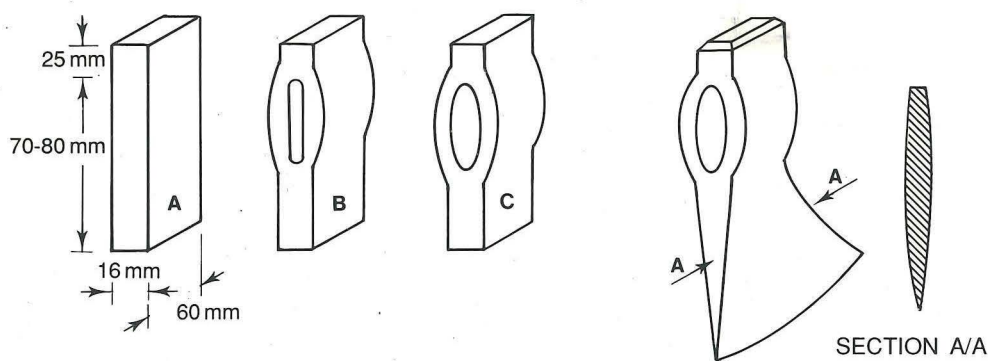


Agricultural engineering in development

Advanced blacksmithing: a training manual

FAO
AGRICULTURAL
SERVICES
BULLETIN

88/3



FOOD
AND
AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS

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Advanced blacksmithing:
a training manual

by
J.B. Stokes

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Rome, 1992

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Preface

Advanced blacksmithing is the last of three FAO technical papers written and illustrated by J.B. Stokes. As in the first two manuals, the practice jobs increase in difficulty and assume the acquisition of techniques and tools resulting from earlier descriptions.

This manual begins with the forging of a blacksmith's tools and continues on to the production of tools for mechanics and carpenters and of hardware and tools for the fabrication and repair of agricultural tools and equipment commonly used by small-scale farmers in developing countries.

Although well aware of modern welding and grinding equipment and of the time and labour that can be saved by its use, the author is equally cognizant of the lack of such equipment or electrical power in many rural areas. Thus the emphasis is on self-reliance and on the use of scrap materials and such skills as hard-facing with cast iron that can be of great benefit to farmers far from modern machine shops.

Having spent 15 years in Africa training blacksmiths and metalworkers, J.B. Stokes has a wealth of experience and knowledge of what will and what won't work in rural areas of developing countries.

R.C. Gifford

Chief

FAO Agricultural Engineering Service

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Practice jobs

1. Making an anvil cutter

Material. Carbon-tool steel about 0.75 percent carbon; or flat vehicle-spring steel, 12 mm or more thickness; or square-section spring steel from heavy-duty spring-harrow tines, 25 to 40-mm square section.

Additional tools. Side set; set hammer; 25-mm top fuller; hot set; flatter; top and bottom swages, 12, 16 or 20 mm, according to size of punching hole in the anvil used.

METHOD

For many cutting operations, a cutter fitted either into the tool hole of the anvil or into the punching hole can be of benefit. Such a cutter is called a hardy and is of most use to a smith working single-handed on a variety of small jobs, like cutting off metal for chain links. A skilled smith will, on occasion, use a hardy in conjunction with a hot set for cutting quite heavy sections. The common hardy has a straight chisel-like cutting edge, but others can be made with curved or V-shaped cutting edges (Fig. 1).

Where suitable steel of a sufficiently large section is available, an end is set in and drawn-down to match the tool hole of the anvil, usually 20 to 30 mm square. Use a side set, fuller and set hammer as in Figs 2A, B and C.

When the tenon end fits well into the tool hole, the tenon and the shoulder are heated to a bright red and the shoulder is squared up by hammering the job into the anvil tool hole (Fig. 2D).

Next, mark off about 40 to 45 mm from the shoulder, heat and cut off at this point. Using tongs that are a good fit on the tenon peg, reheat to yellow heat and, using the fuller, set hammer and flatter, draw out the end to a large chisel point similar to Fig. 1A. Bring the whole workpiece to red heat and allow to cool (normalizing). After cooling, grind or file the cutting edge to an included angle of about 60 degrees and harden and temper as for a cold chisel.

Where metal available is a little too small to allow a good shoulder to be formed, the piece can be upset in the shoulder position before setting down the shoulders of the tenon.

If only flat spring steel is available, making cutting tools to fit the punching hole instead of the tool hole of

the anvil should be considered (Fig. 1B). A useful thickness of steel for this is about 12 mm. For ease of working, the width of the spring leaf decides the overall height of the tool. Mark off a 45-mm length of the flat spring steel. A 12-mm leaf will be 70 to 85 mm wide in general, and this will decide the tool height. Heat, flatten and square up the edges of the piece.

Next, mark off 20 to 25 mm from one end of the

workpiece, heat to a yellow heat and set in with a side set (Fig. 3A). Reheat and forge a tenon using a set hammer (Fig. 3B). The square tenon should be just a little larger than the punching hole of the anvil at this stage. If the punching hole is, say, 12 mm, the tenon should be about 13 mm square. Reheat, and still using the set hammer remove the corners of the tenon to form an octagonal section (Fig. 3C). Finish to round section

FIGURE 1

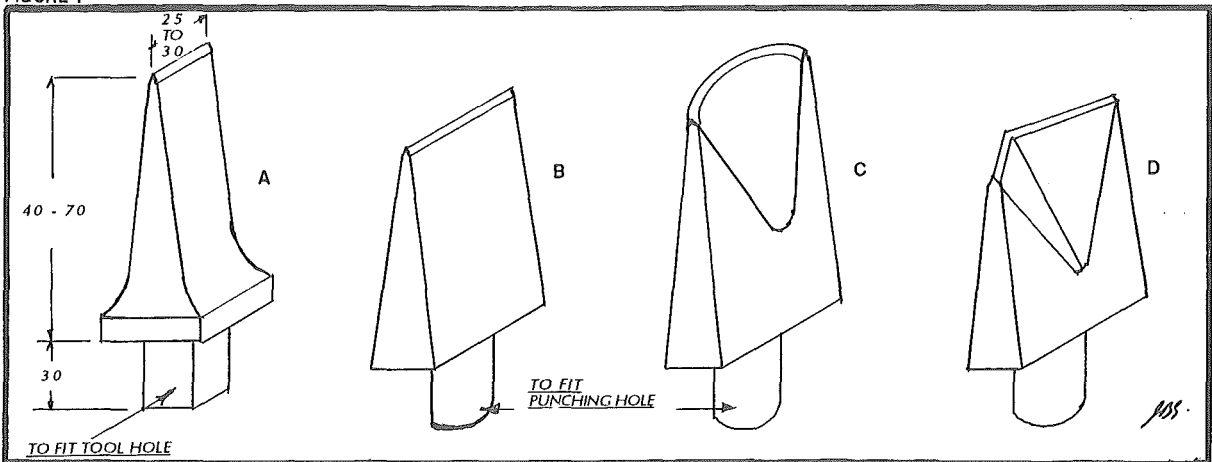


FIGURE 2

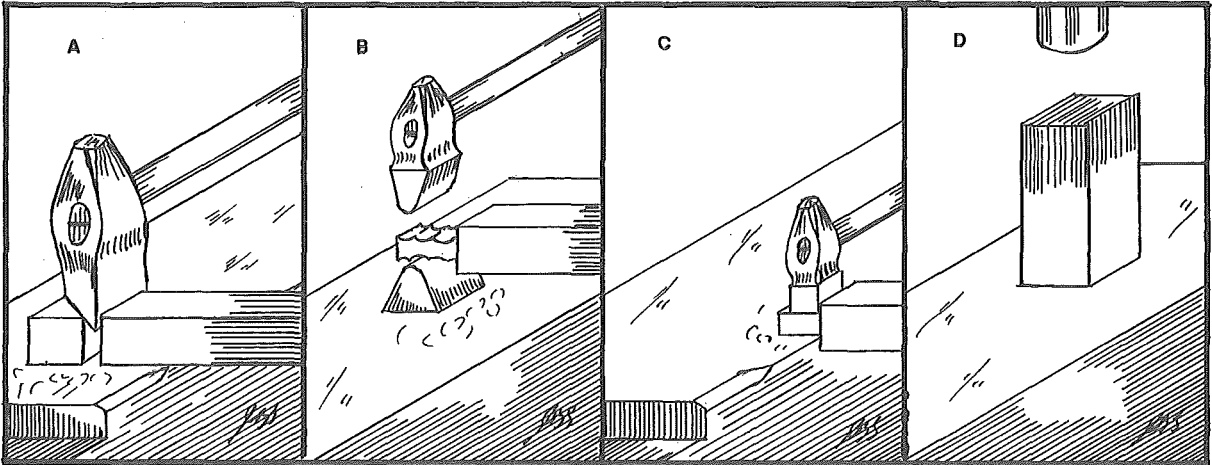
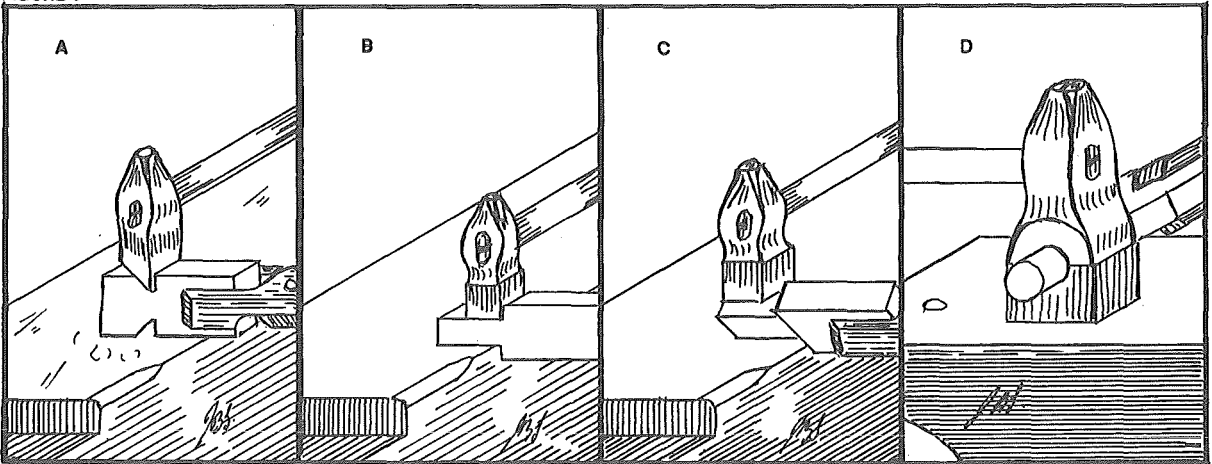


FIGURE 3



and correct size using top and bottom swages (Fig. 3D).

If swages are not available, the octagonal stage can be converted to a reasonably round section by using the set hammer and light blows from a sledgehammer while rotating the work between anvil face and set hammer. When the peg reasonably fits into the hole in the anvil, reheat peg and shoulders, slightly cooling the opposite end if needed, place peg into punching hole of the anvil and apply hammer blows to the upper end to settle the shoulders neatly on to the anvil face, ensuring that the work is at right angles to the anvil face when in position.

The tool is completed by drawing-down the unworked end to a flat point, filing or grinding the cutting edge, then hardening and tempering. The finished tool should look like Fig. 1B. If a gouge-type cutter is required the procedure is similar, but after drawing to a flat point for the cutting edge, a bottom swage and top fuller are used to curve the cutting edge (Fig. 4). Some final adjustments can be made over the beak of the anvil (Fig. 5).

If a suitable swage and fuller are not available, a crease may be made in the angle formed by the cutting

table of the anvil and its face using a small fuller, a cross-peen hammer or a piece of rod as in Fig. 6. The curve can be adjusted over the beak (Fig. 5). Grinding or filing as well as hardening and tempering are carried out after normalizing.

An angled cutter (Fig. 1D) can likewise be made by creasing (Fig. 4) or by using a small fuller, cross-peen hammer or rod (Fig. 6). Edges can be trued up (Fig. 7), after which the angle can be adjusted by opening over the beak or hammering on the edge to make the angle more acute. Again, hardening and tempering are carried out after normalizing. If using vehicle spring, the work is tempered at a brownish oxide colour after hardening from a dull red heat. If a higher-carbon steel is used, tempering is carried out in the transition between brown and blue.

FIGURE 4

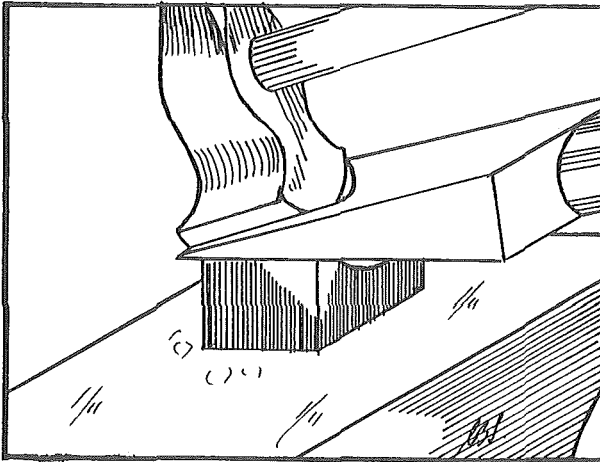


FIGURE 5

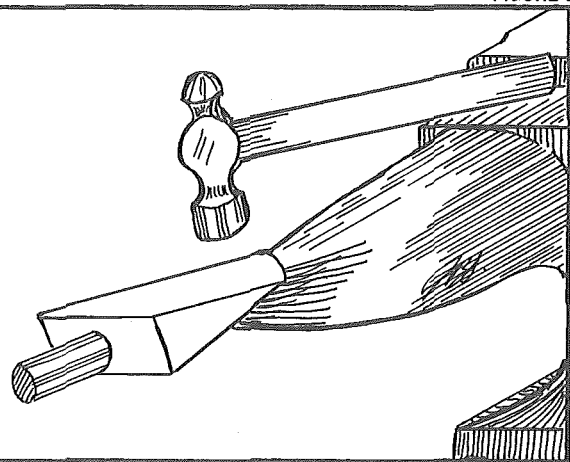


FIGURE 6

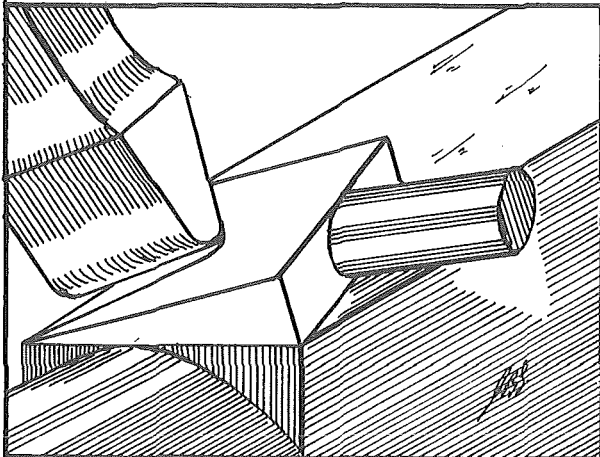
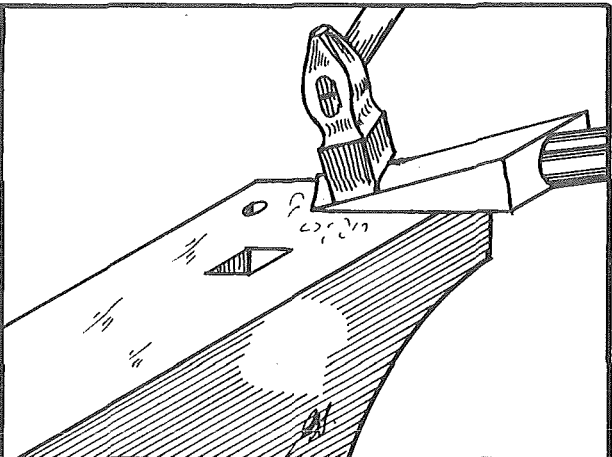


FIGURE 7



2. Making spanners/wrenches

Material. Assorted flat spring steel; assorted flat mild steel; round-section spring steel, 12 mm or more in diameter.

Additional tools. Hexagonal drifts (to be made); one-sided hot chisel or hot set.

METHOD

In many developing countries spanners are expensive and scarce. Furthermore, special spanners or odd sizes are often required. With a little practice, spanners can be forged with few tools. In Figs 8, 9, 10 and 11, where dimensions are given, they are for guidance.

Spanners made from spring steel and left in the normalized condition can be of smaller sections than if

made from mild steel. Mild-steel spanners must be at least 25 percent heavier (i.e. thicker) than those made of spring steel and case-hardened to give a longer useful life. For example, dimension T in Fig. 8 could be about 0.75 AF for spring steel but 1 to 1.25 for mild steel (AF indicates distance across the flats of a nut).

The open-ended spanners in Figs 8 and 9 can be made double-ended if so required. Two types are shown, but the forging process is similar in both cases, except that drawing-down of the stem or shank is central in Fig. 8 and offset in Fig. 9. Although 15 degrees is indicated as the angle between the centre line of shank and jaws, this need not be strictly followed. Other angles are often required.

Ring-spanners (sometimes called box-wrenches) are

FIGURE 8

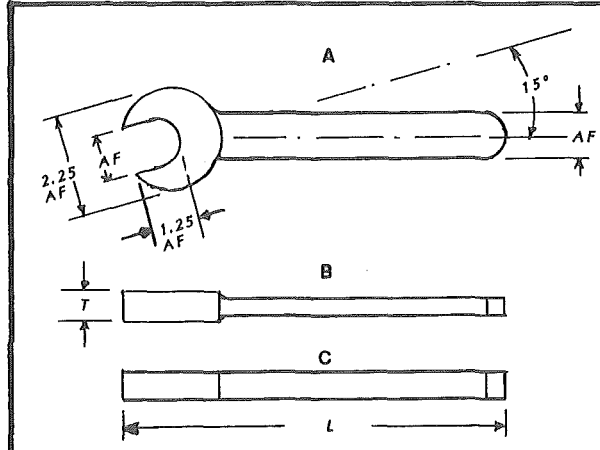


FIGURE 9

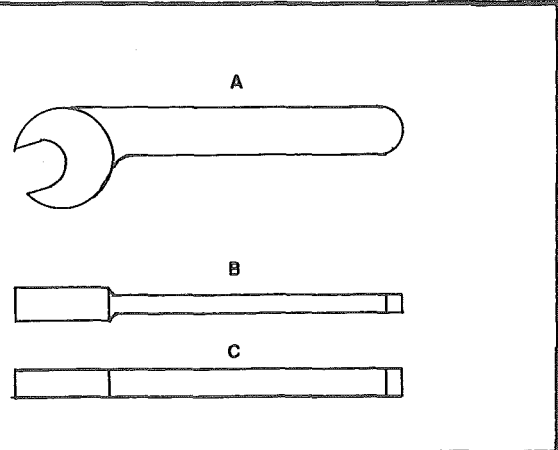


FIGURE 10

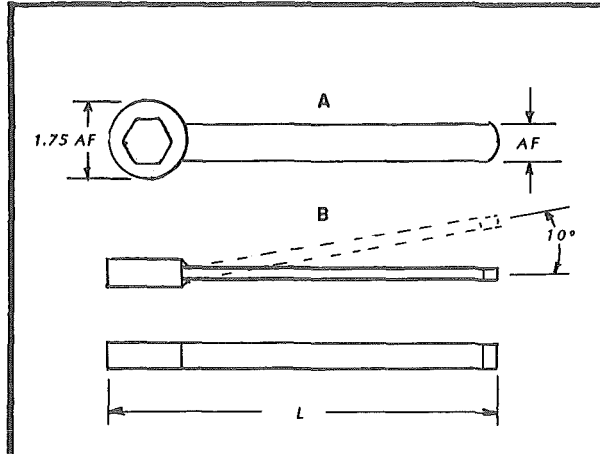
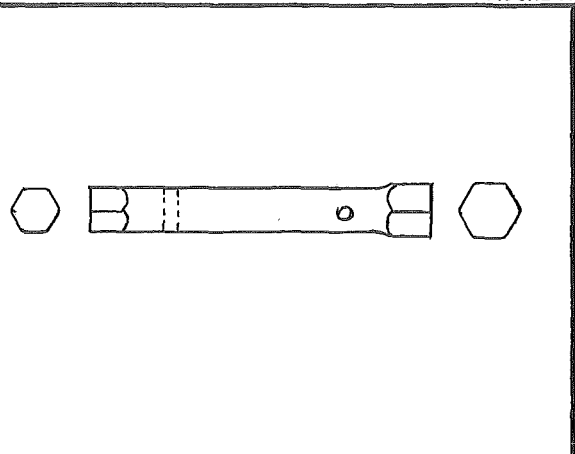


FIGURE 11



very useful (Fig. 10), as are box-spanners (sometimes called socket-wrenches) (Fig. 11).

To make ring- and box-spanners you will need one or more hexagonal drifts, similar to that in Fig. 12. A selection should cover the size of spanners to be made. These should be 100 to 150 mm long, with an included angle of only about 10 degrees. This angle restricts the number of sizes of spanner that can be made with any one drift, but if larger angles are used a great deal of filing will be required.

To make such drifts, draw-down a round point as neatly as possible, then forge the flats as for hexagonal bolt heads shown in *Basic blacksmithing*. Accuracy should be checked with callipers. To give long service, these drifts should be made of spring steel or similar material. After forging, anneal the drift and finish to final dimensions with file or grinding machine. A file usually gives the best results. If forging is carried out neatly and accurately, little filing will be needed.

For open-ended spanners a one-sided hot chisel or hot set will be needed, as well as a neatly made round-

section punch (Fig. 13). Make up a number of such chisels so that if one is damaged during work another is at hand, allowing the work to continue. Punches of different sizes will be needed both to punch the holes and to act as drifts for the various sizes. For example, for a 12-mm-AF spanner, a punch/drift can be made of steel 16 mm in diameter. The flat working end in this case should be about 8 mm in diameter and carefully looked after during work. Larger and smaller punches will be needed to cover a range of spanner sizes.

It is useful to have pieces of steel bar of thicknesses equal to the AF sizes of the spanners to be made and about 30 mm long. These are used to close the forged jaws and to true up to final size (Fig. 21). These can be cut from suitable bar stock or forged from scrap to the sizes required. You can also use nuts of the correct size.

To forge a spanner of, say, 10 mm AF, see the stages of work in Figs 14 and 15.

Cut off and true up a piece of spring steel 6 mm thick or a piece of mild steel 8 mm thick, 25 to 26 mm wide and about 100 mm long. Mark off 25 to 26 mm from one

FIGURE 12

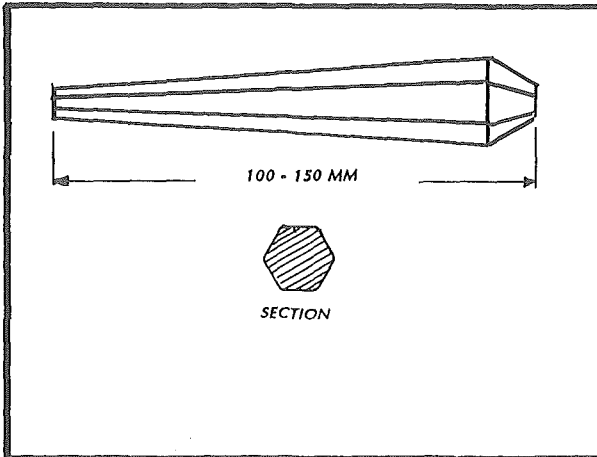


FIGURE 13

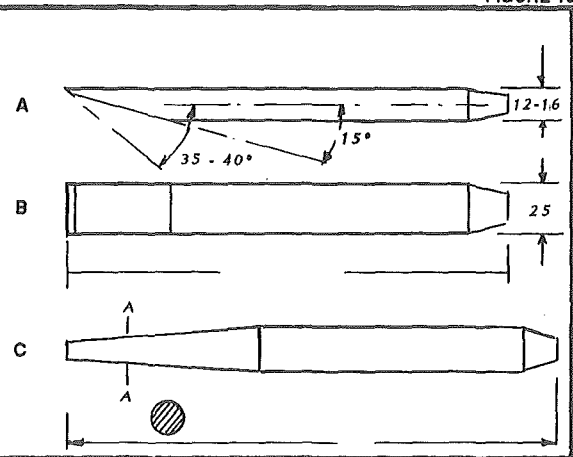


FIGURE 14

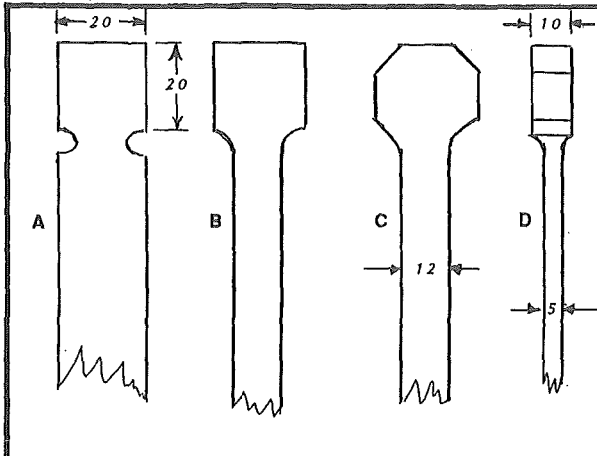
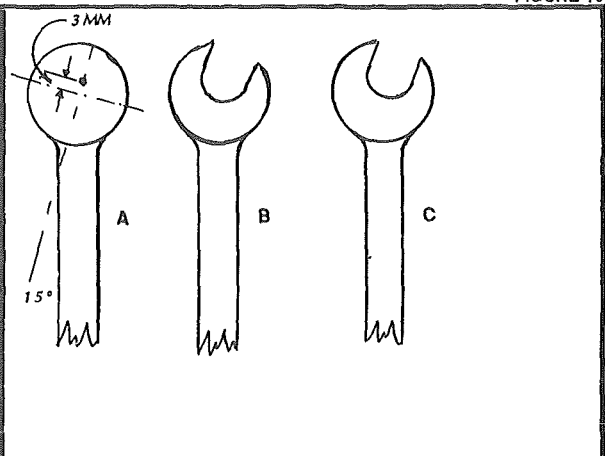


FIGURE 15



end. Use a centre punch to mark this position on both edges of the piece. Bring to a bright red heat and fuller (Fig. 16). Make sure that top and bottom fullers are exactly in line with each other and that the centre-punch mark can be seen at the side of the fuller at the short end. Take the fullers into the work until 16 to 17 mm is left between them. True up the thickness. Next, draw out the length of the shank handle of the spanner to a width of 16 to 17 mm while maintaining its thickness. If you want to thin the shank, start as in Fig. 18 and then draw out along its length. Reheat the end and forge to round, proceeding as in Fig. 17. Next, punch the hole (Fig. 19). Punch, in the usual way from both sides, the drift out of the hole to 10 mm. If the punching hole of the anvil is so large that it is likely to cause excessive distortion, a bolster plate should be used over the hole. Ideally the hole should be only 2 to 3 mm larger than the finished punched hole.

The next stage is to open the spanner jaws by cutting away surplus material (Fig. 20). This can be carried out on the cutting table of the anvil or on a soft steel saddle

FIGURE 16

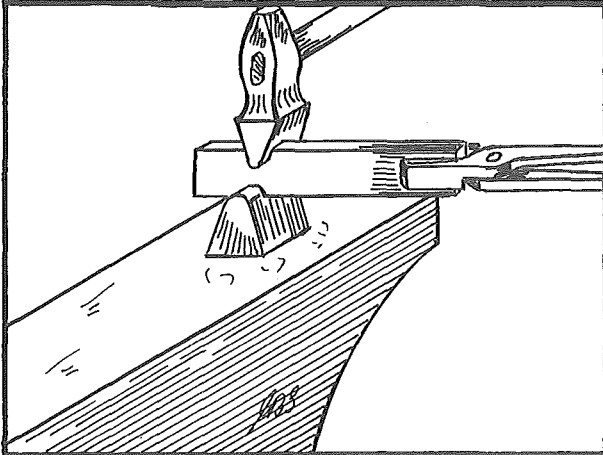


FIGURE 17

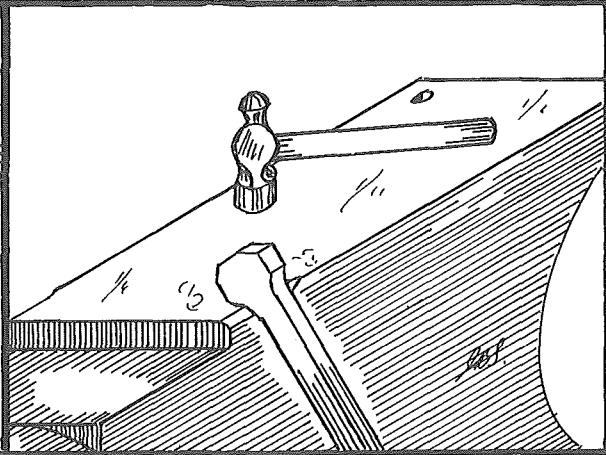


FIGURE 18

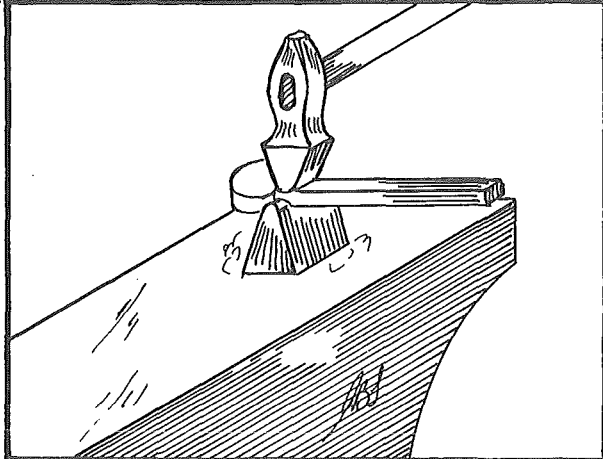
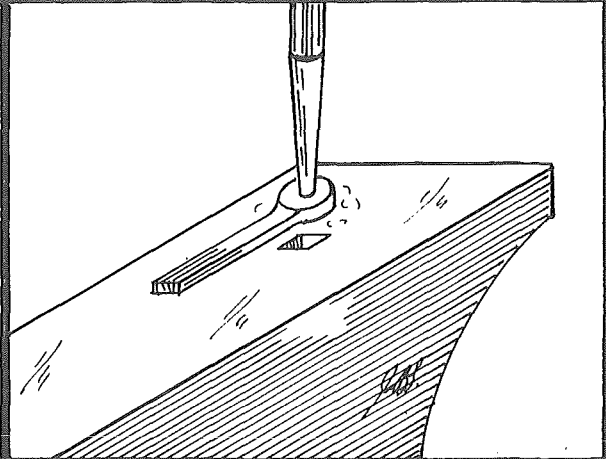


FIGURE 19



(S in Fig. 20). It is a good idea to mark the 15-degree angle on the cutting table or saddle with chalk to act as a guide when positioning the hot chisel. Cutting is carried out as in Fig. 20, leaving the inside of each jaw as flat as possible, with most deformation taking place in the waste. This is the reason for the one-sided chisel. After removal of the waste, the jaws are trued up with light hammer blows (Fig. 21). Reheat and normalize.

Small errors can be corrected with a file after the piece has cooled. After final work is completed, a mild-steel spanner may then be case-hardened.

Ring-spanners (Fig. 10) are made by using the round punch and hexagonal drift previously described. Shanks may be left flat or angled a little as shown dotted in Fig. 10. A blank is forged in a similar manner to that used for open-ended spanners, and a hole is punched about 1 mm less in diameter than the required AF size (Fig. 22). The hole is formed to a hexagon by use of the drift (Fig. 23). Since a slight taper will be present in the hole because of the tapered nature of the drift, drifting is carried out from each side of the spanner to minimize the tapering

FIGURE 20

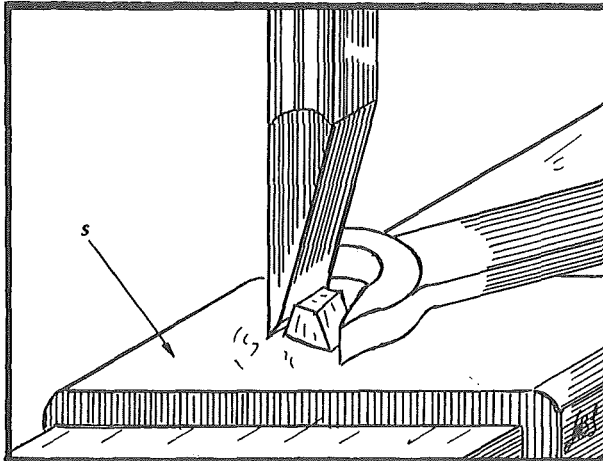


FIGURE 21

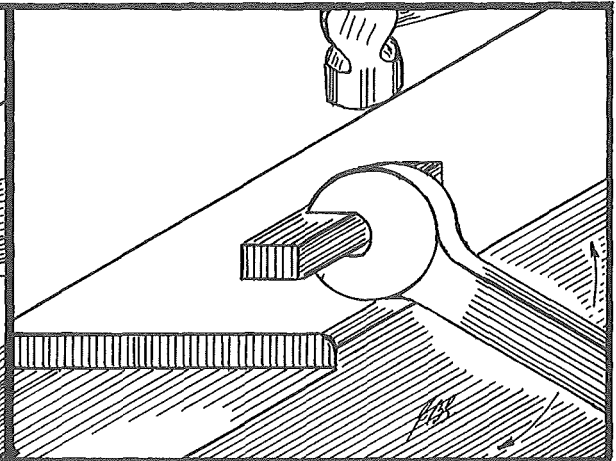


FIGURE 22

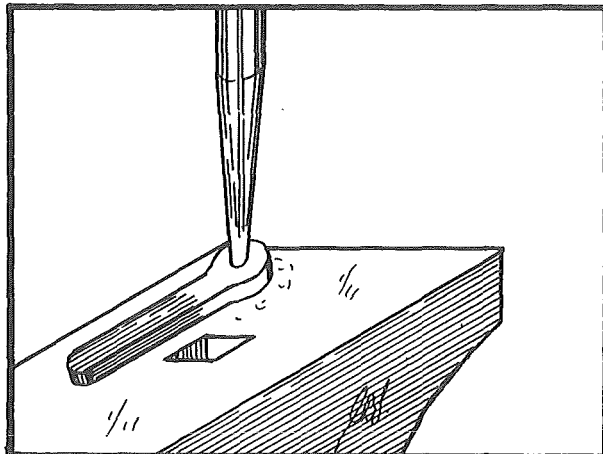
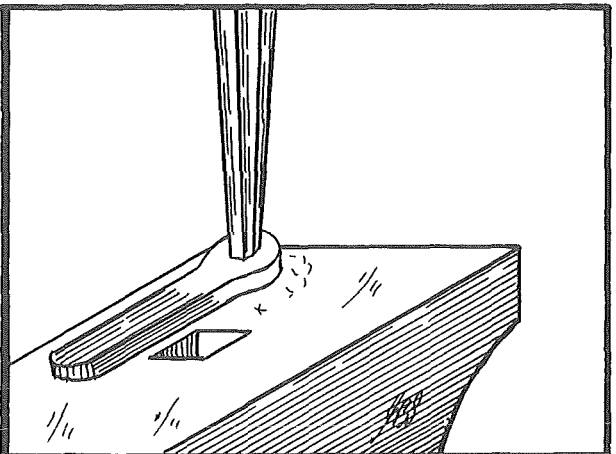


FIGURE 23

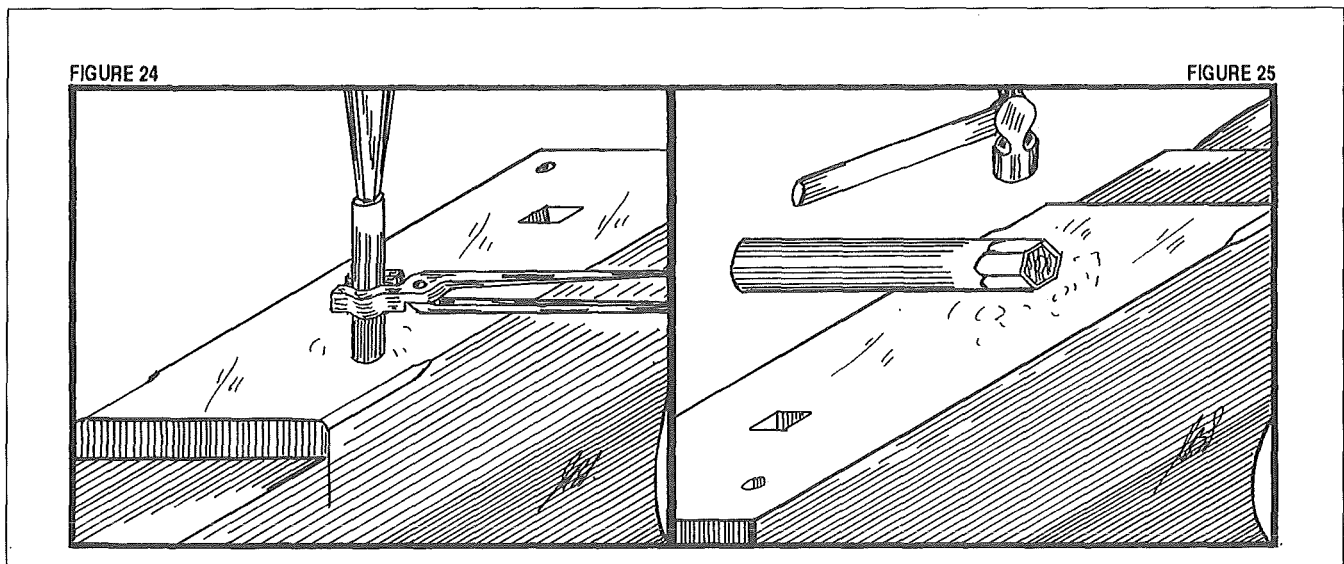


effect. Final sizing can be done at very dull red heat with a little oil or grease on the drift. A little filing might be necessary to remove any sharp edges and to ensure a good fit. If spanners are made of mild steel, the working end can be case-hardened to give longer life.

Box-spanners (Fig. 11) are easily made from suitable tube or pipe. Even thin-walled tubes give quite good results for smaller sizes. Water-pipe, electrical conduit and steering rods are suitable materials. The end of the tube is heated to a good red heat, and the hexagonal drift inserted to shape a hexagonal hole into which a nut of the size required can just enter (Fig. 24). Take another heat, place the nut on the anvil face and drive the spanner over the nut. Lightly hammer on each face of the hexagon to size the spanner and to stretch the metal as it cools and contracts on to the nut (Fig. 25). A good fit can be made in this manner. It is wise to case-harden the spanner ends.

Oversize pipe or tube can be reduced in diameter by heating one end and forging to a hollow hexagonal shape. Then light hammering on all faces in turn will reduce the AF of the hexagon. Final truing up and shaping are done with drift and nut as before.

Where a tube or pipe is a little undersized, heating one end and upsetting on the anvil face will allow for larger spanners to be made. Holes for tommy-bars are drilled after forging but before case-hardening. In many cases such box-spanners are a reasonable substitute for expensive factory-made ratchet-wrenches and can be made to any size and length.



3. Making drill bits for drilling metal

Materials. Carbon-tool steel or vehicle-spring steel, round section preferable, of various sizes.

Additional tools. Sharp cold chisel.

METHOD

Where modern twist drills are too expensive for rural artisans or not available at all, and where grinding facilities for twist drills do not exist, very effective drill bits can be made from carbon-tool steel or vehicle-spring steel. They can be made in many sizes by forging operations plus a little filing. If they break they are easily refurbished. They are most effective when used at low cutting speeds with plenty of lubricant and are ideal where hand-powered drilling machines are used.

Figure 26 shows at left a drill bit with a forged hexagonal shank for use in a three-jawed chuck, and at the right is a bit with a square, tapered shank end suitable for a carpenter's boring brace and some types of ratchet drill. To make these bits, prepare the metal to round section or use the round section of a steel vehicle coil-spring. The diameter must be large enough to make the size of drill bit needed. The shank of the drill must be smaller than the drill cutting edges, so for small drills the shank must be drawn-down. Draw-down the shank end to the size and section required; draw-down the shank if needed for smaller size, reheat and flatten the opposite end to a little more than the size you want the

bit to be. Neat and accurate work is needed to keep the cutting point on centre with the shank. Final adjustments can be made by filing.

Next, square off the flattened end, mark out the centre line and 45 degrees either side of this (Fig. 26). Cut the point with a sharp hot chisel on the cutting table of the anvil. Cutting must be carried out only on the right-hand side of the centre line, so you must turn the work after the first cut (Fig. 27). Cutting in this manner pre-forms the clearance angles and reduces the amount of filing needed. Reheat the job to a red heat all over and finally true it up as well as possible, then fully anneal it. After cooling the bit, in order to ensure that the cutting edge is central, file the angles to give clearances as shown in Fig. 26. Test the angles by rotating the drill bit. When you are satisfied, harden and then temper the bit to a brown colour. Use at slow speed with plenty of coolant (old motor oil will do).

FIGURE 26

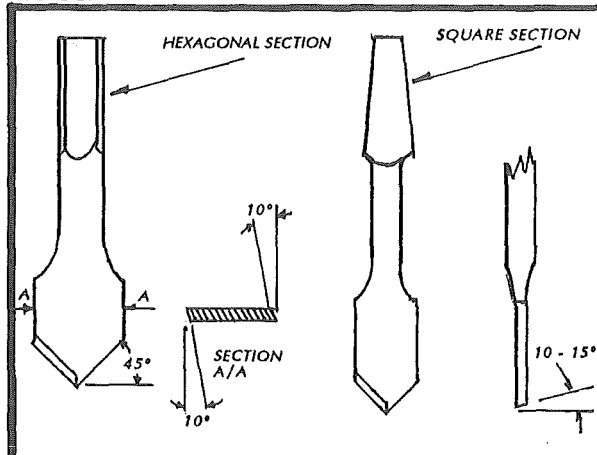
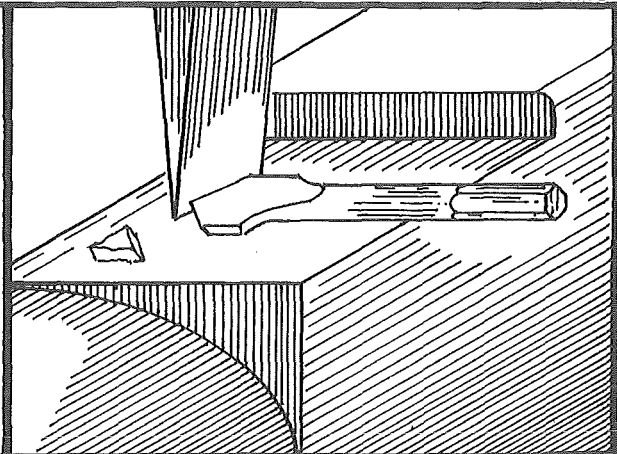


FIGURE 27



4. Making a simple wood-boring brace

Material. 12-mm round-section mild steel or larger as available.

Additional tools. Bolster plate; round punch; square punch.

METHOD

Where a more modern carpenter's boring brace is not available, a satisfactory and quickly made alternative is shown in Figs 28 and 29. This type can be turned with a wooden lever to drill holes in steel, using drill bits similar to those in Job 3. The sizes shown in Figs 28 and 29 may be varied but should not be smaller. Here we are using round-section steel 12 mm in diameter, but larger sizes may be used. Thicker sections will permit more

FIGURE 28

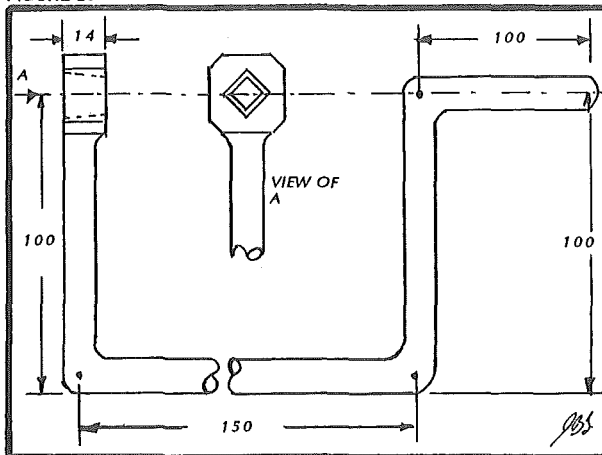


FIGURE 29

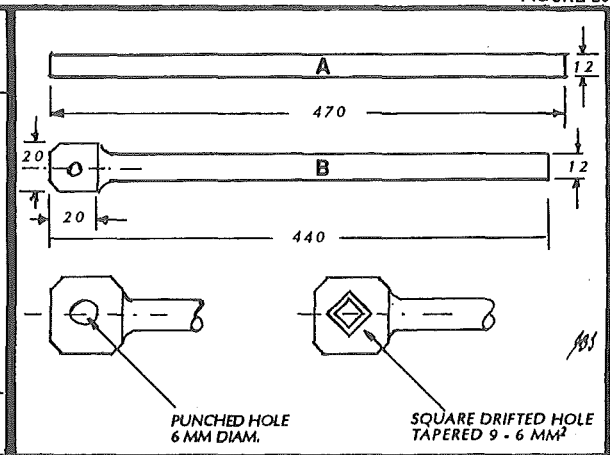


FIGURE 30

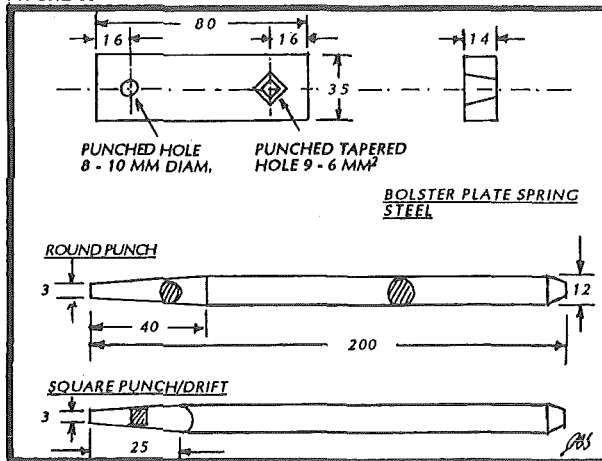
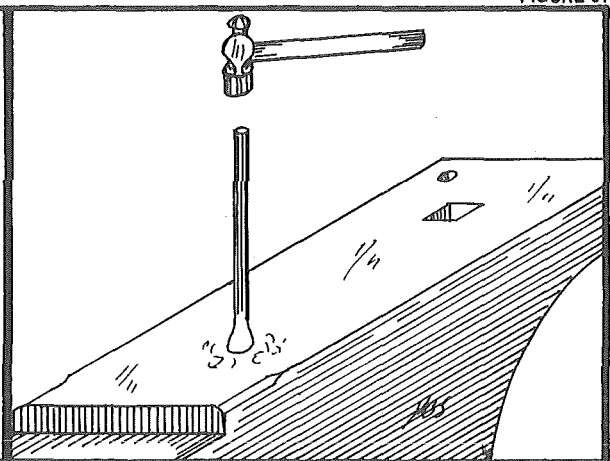


FIGURE 31



pressure to be applied to the boring or drilling bit. For normal boring a pressure plate is made from hardwood, about 75 x 75 x 25 mm thick, with a shallow recess to accommodate the rounded end of the tool. For making this tool and boring bits to suit, the tools shown in Fig. 30 are required and should be kept in good condition.

First the round and square punch must be made as shown, and then used to make the bolster plate. Take care not to overheat the punches during use.

Cut off about 470 mm of mild-steel rod 12 mm in diameter. Upset one end and work until the end is 20 mm square and 14 to 16 mm thick (Figs 31, 32 and 33).

When the end is to size, punch a round hole on the centre of the upset, using the bolster over the punching hole of the anvil, then use the square punch to convert the hole to tapered square form (Figs 34 and 35).

From the centre of this hole, mark out the bending positions and centre-punch in line with the side of the upset so that the punch marks will not be on either the inside or outside of the bends and cause cracking (Fig. 36). Heat to a bright red heat; restrict the heat to

FIGURE 32

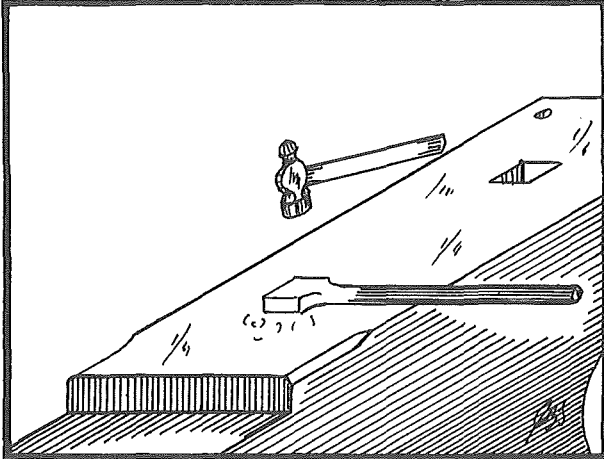


FIGURE 33

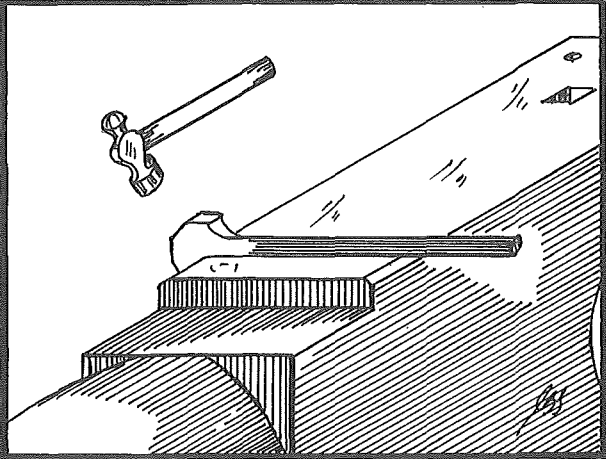


FIGURE 34

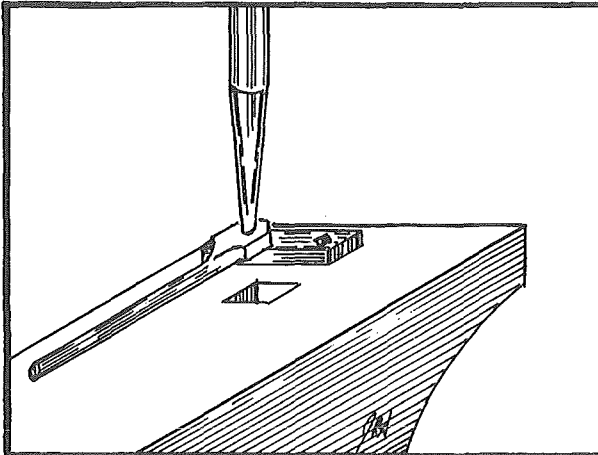
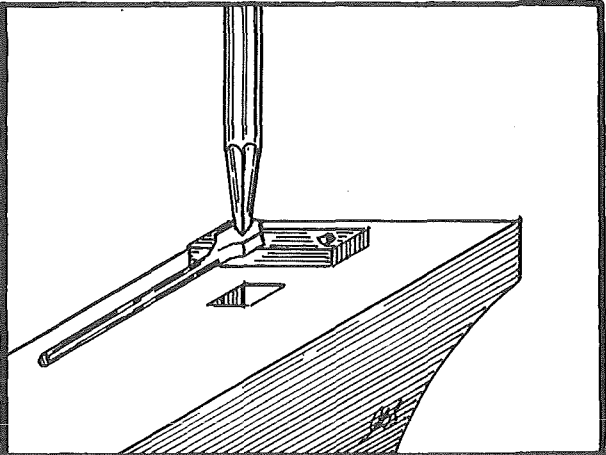


FIGURE 35



about the thickness of metal each side of the bend mark by cooling with water (Fig. 37).

Bend using the punching hole as in Fig. 38 or in a fork tool or in a vice. Correct the squareness (Fig. 39).

Any unwanted twist in the punched end may be corrected by heating between the punched end and the first bend, and adjusting the head (Fig. 40). Complete the other bends and finally flatten it (Fig. 41).

FIGURE 36

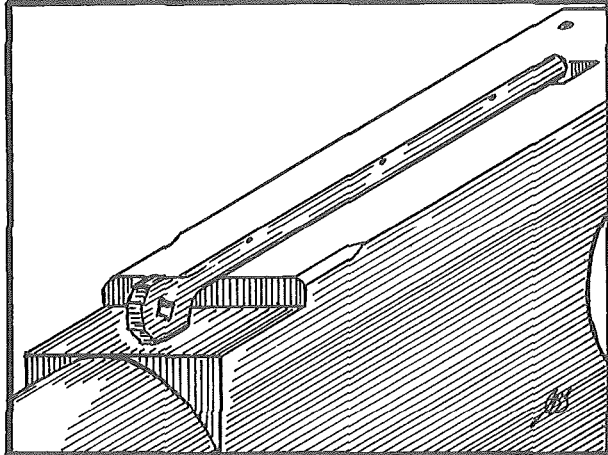


FIGURE 37

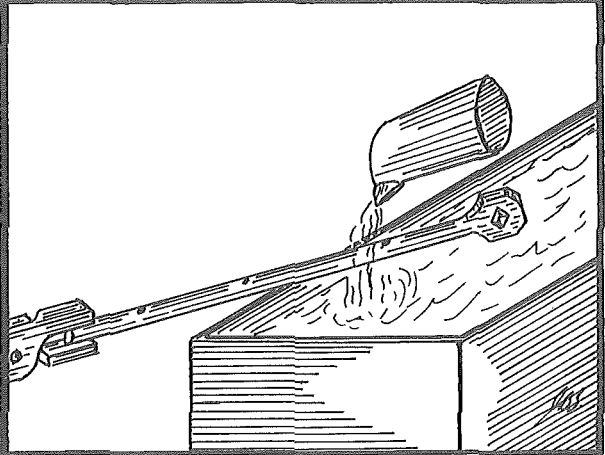


FIGURE 38

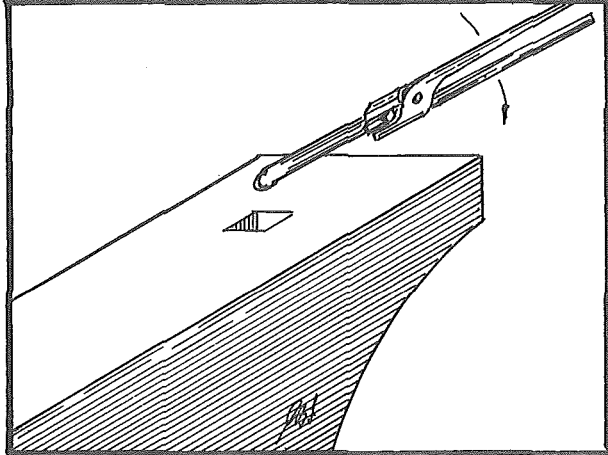


FIGURE 39

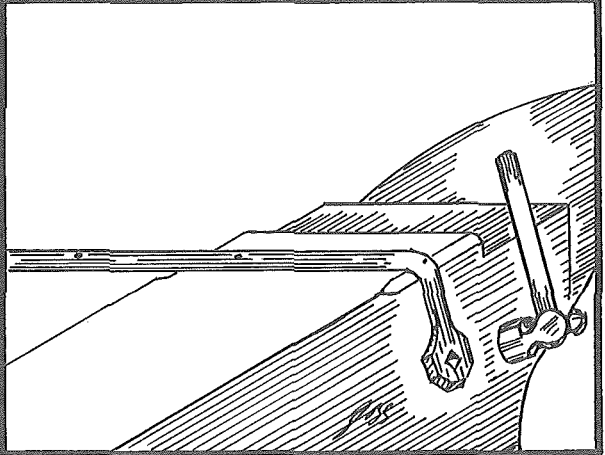


FIGURE 40

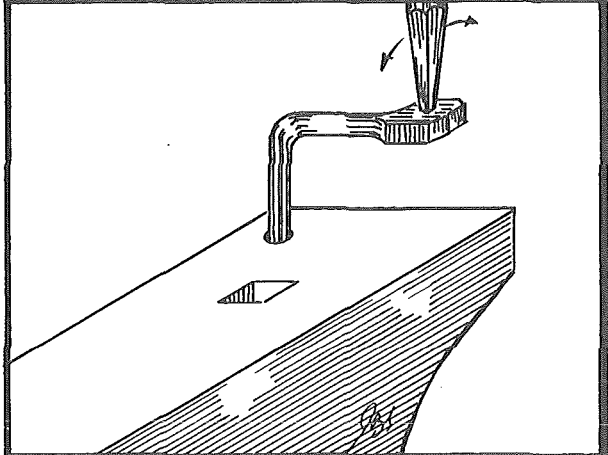
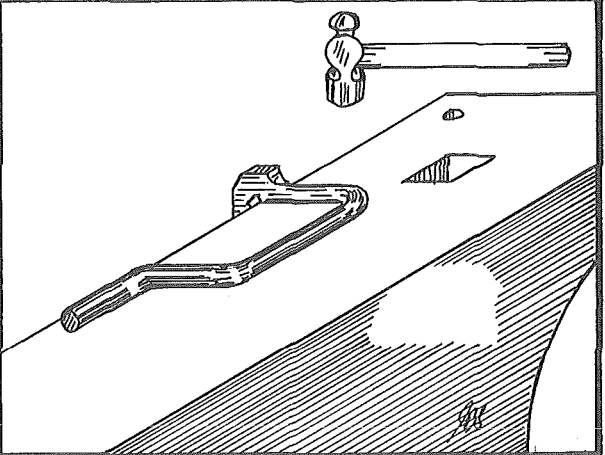


FIGURE 41



5. Making wood-boring bits

Material. Round-section spring steel.

Additional tools. Punches and bolster plate to make the boring brace in Job 4.

METHOD

Many types of wood-boring bits may be fairly easily made by a skilled smith and will work well. The flat bit in Fig. 42 is the easiest to make, as are its variations. The auger bit in Fig. 43 is more difficult to produce, but it is essential if you need deeper holes.

To make the flat bit, select or forge up a piece of spring steel of a diameter suitable for the finished bit. Remember that the shank of the bit must be smaller than the diameter of hole to be bored. For example, a piece of steel 12 mm in diameter can be forged to make a bit of up to 35 mm across the flat. The square taper on the shank must always be formed to fit the square hole in the bolster by the punch/drift, as in Job 4. For small bits the shank must be reduced beneath this square taper. For a 6-mm bit, the shank will be reduced to about 3.5 to 4 mm, the end flattened and the cutting edges formed. It is sufficient to leave the shank octagonal in section, but it can be rounded up if you want to.

The forging procedure is: select steel of sufficient size to form the square tapered end and forge (Fig. 44), finishing the taper in the bolster plate (Fig. 45), keeping

FIGURE 42

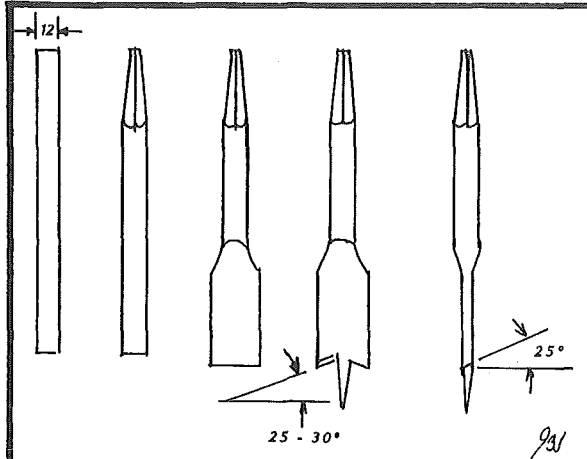
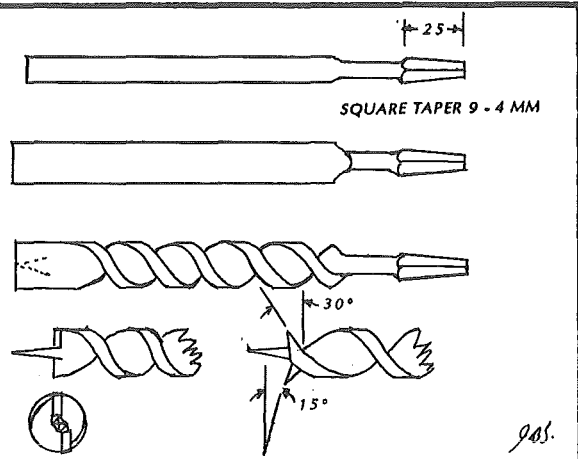


FIGURE 43



the work as nearly as possible at right angles to the surface of the bolster plate.

For small-diameter bits the shank is reduced at this stage to less than the hole to be bored, keeping the work as straight as possible. For larger bits this will not be necessary. Next, flatten the end of the bit (Fig. 46) with hand hammer or set hammer to about 2 mm in thickness and to a width slightly more than that required for the hole to be drilled. This surplus allows for filing and finishing.

After flattening the end, mark out the centre line and the cutting lines to form the point and cutting edges. At a bright red heat and using a sharp hot chisel, cut out the unwanted pieces, working only on the right-hand side of the centre line (Fig. 47).

Cut one side, then invert the work and cut the opposite side. This method partially forms the cutting angles. True up the work and fully anneal it. After slow cooling, finish it to final dimensions and angles using a fine-toothed file. Heat treatment can be carried out by the two-heat method. Harden from red heat in clean water,

FIGURE 44

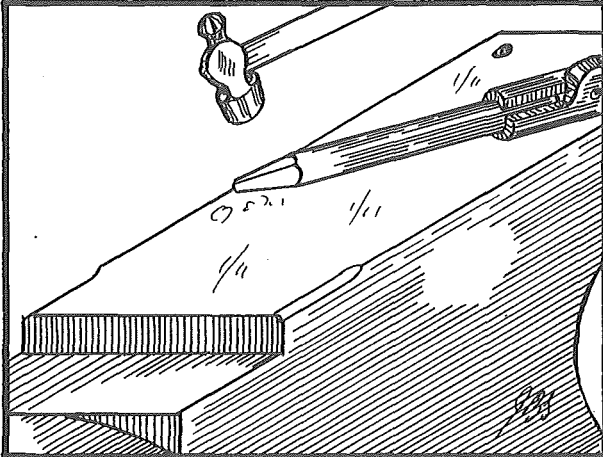


FIGURE 45

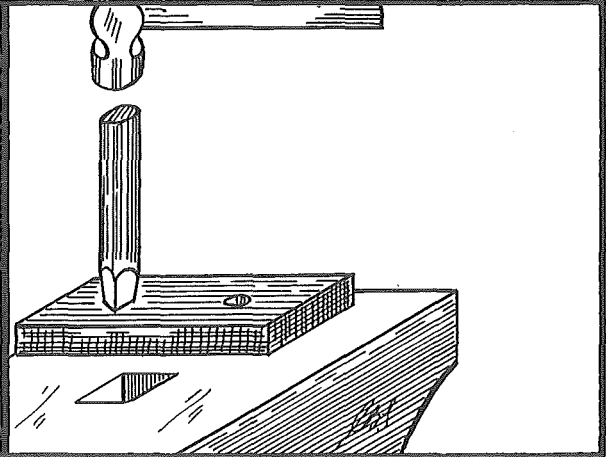


FIGURE 46

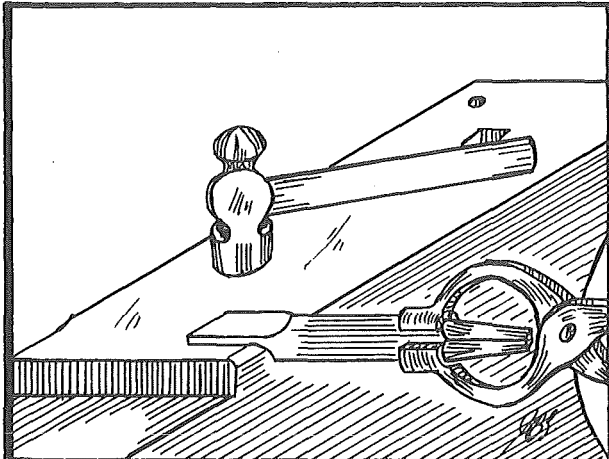
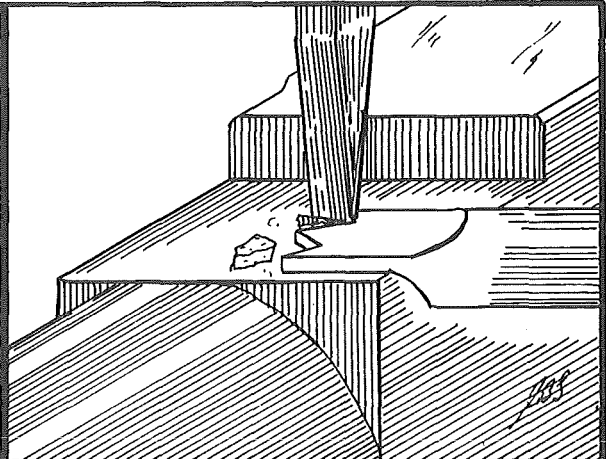


FIGURE 47



then clean and reheat to a dark straw/brown and re-quench. With spring steel it might be found that, with thin sections, merely cooling in the air from red heat will give sufficient hardness; it is worth a try.

Auger bits can be made by a smith capable of neat and accurate work. The shank end is drawn-down as before and the blade length drawn-down to about 3 mm in thickness and a width equal to the diameter of the hole to be bored. The thickness may be tapered slightly, thinning toward the cutting edge. Even with a hand hammer alone it is possible to give a clean smooth finish to the work. Width and thickness can be checked with callipers (a cheap vernier calliper is useful). If forging is not sufficiently accurate, fully anneal the work and correct by filing. To form the spiral use a vice if you can. Failing this, clamp the bolster plate so that the shank can be placed into the square hole. A neat-fitting pair of tongs is needed to grip the flat end of the blade.

Carefully heat the length of the blade to a good red heat, keeping the shank cool. Heat on top of the fire until the blade is of equal temperature along its length, judging this by the colour. Do remember that metal bends or twists most at its hottest point and even a few degrees' difference will have an effect. Grip the shank end in a vice or place into the bolster plate, grip 25 to 30 mm of the other end and twist in an *anticlockwise* direction. Twist slowly and note the evenness or otherwise of the spirals forming. If the work is twisting more in one place than another, carefully drip a little water on to the place twisting most easily to cool it slightly (Fig. 48). The slightest amount of cooling will have a noticeable effect, so take care.

When twisting is complete, carefully straighten the work, checking with a straight-edge and reheating to a

FIGURE 48

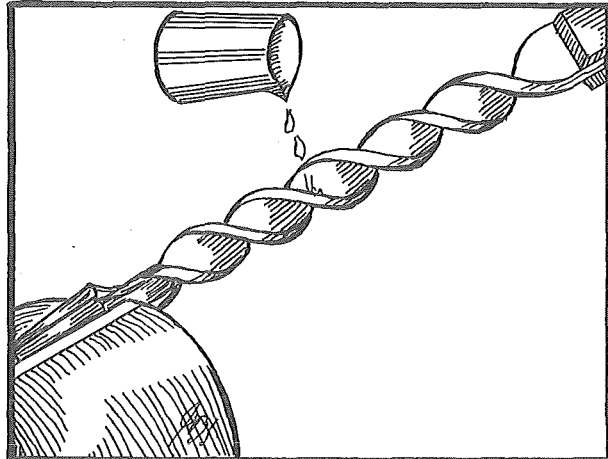
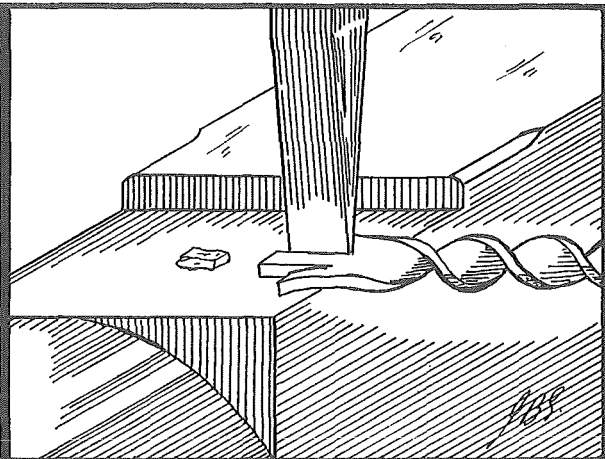


FIGURE 49



dull red heat if necessary. Next, mark out the centre and cut (Fig. 49), leaving plenty of length on the centre point. Cutting is again carried out only on the right-hand side of the work. With cutting completed, reheat the end to a bright red heat taking care not to overheat the point, then bend down the flaps to form the cutting edges (Fig. 50). Next, draw-down the centre part to a fine point 10 to 12 mm in length, cutting off any surplus material.

If this work proves to be too fine for the smith, fully anneal and complete the point by filing and at the same time file the cutting edges to the angles shown in Fig. 43. Harden and temper using the two-heat method and colours as for the flat bit. Again, merely heating to red heat and cooling in the air might give sufficient hardness. Fig. 51 gives an idea of the finished appearance of the cutting end. It is not always necessary to make the spiral the full length of the boring bit. Often two to three turns are enough (Figs 52 and 53).

Such bits can be further embellished by slightly flattening the centre point and giving it a tight twist, as

in Fig. 53, to give the effect of a screw thread. This reduces the pressure needed to cause the cutting action.

For large sizes of bits, a T-handle can be made by punching a square hole into a suitable size of bar that can then be placed over the shank to give leverage to the twisting action for boring holes. Final cleaning up can be done with a wire brush and light filing.

FIGURE 50

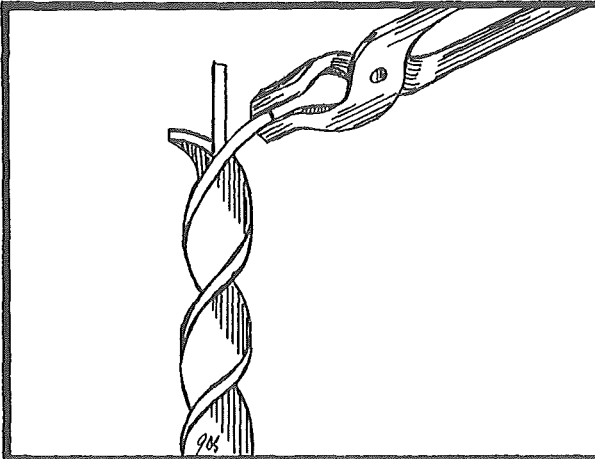


FIGURE 51

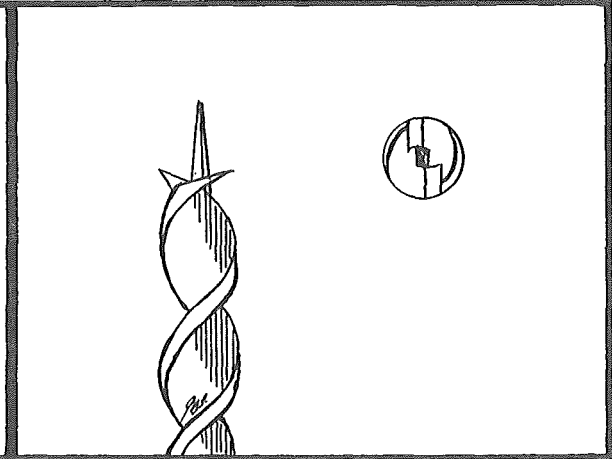


FIGURE 52

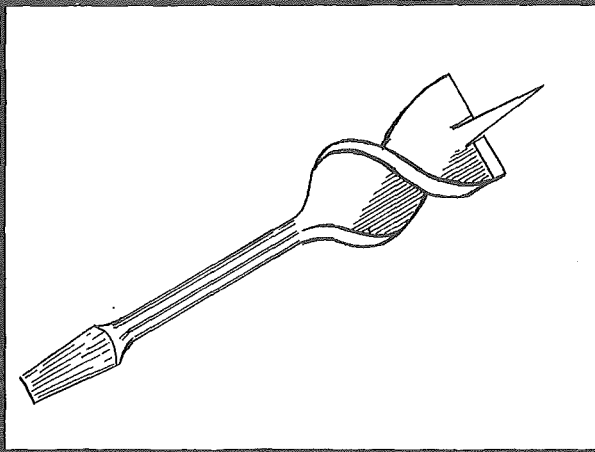
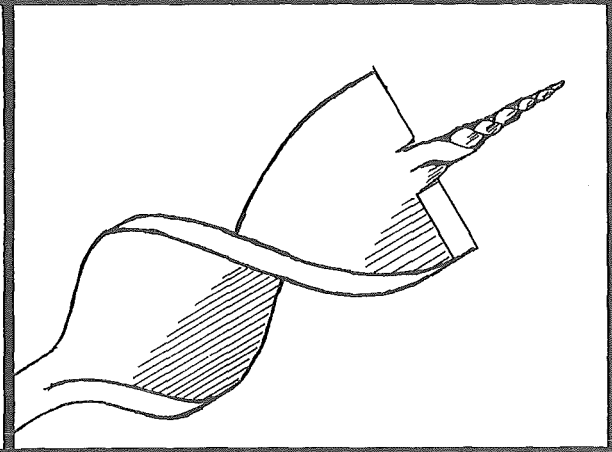


FIGURE 53



6. Fitting wooden and metal handles

Materials. Metal pipe 25 to 30 mm in diameter of suitable lengths; wood with suitable physical properties, tough and resilient (ash, hickory or similar).

Additional tools. Possibly a hand-held mandrel.

METHOD

Wherever possible, good-quality timber should be used to make handles for tools such as hammers that deliver blows to work or to other tools. Tools that are merely held in position can be fitted with metal handles. An example is set tools for forge work. Wooden handles are generally more comfortable to use and provide better control of the tools.

For hammers and similar tools, the eye, which accommodates the handle, must taper toward its centre. Hammer handles are fitted so that the centre line of the tool head and the centre line of the handle are at right angles to each other. The handle must fit well into the eye. A wooden wedge must be driven into the handle in line with the long axis of the hammer head. Then a metal wedge must be driven in at a right angle to the wooden wedge (Fig. 54).

Metal wedges are easily made by a smith, scrap mild steel being most often used. Draw-down a piece to about 4 mm in thickness and a little less than the width of the eye. Draw this down to a flat point (Fig. 55). While the metal is hot, cut it nearly through with a hot set or chisel. Then, by applying the hot chisel at an angle (Fig 55), small barbs can be cut to help prevent the wedge from becoming loose. After cutting the barbs, quench the work in water and break off the wedge. It is now ready for use.

Where no suitable timber is available and metal has to be used, the method shown for hammer shafts in Fig. 56 is preferable to welding, and where electrical welding is not available similar techniques must be adopted. In the case illustrated, a piece of tube or water pipe is flattened along its length to fit the hand comfortably. A near-oval section gives better control of the tool. By careful forging, the end is reduced in size until it tightly fits into the eye of the tool.

When prepared, the reduced length should be long enough to pass through the eye and stick out of the top

6 mm or so. The reduced end is heated and driven tightly into the eye. The additional length can be flanged on the hammer head (Fig. 56D). The eye is not damaged as with welding and, if required, the handle can be removed later.

Where metal has to be used for a hoe handle, one method of attaching it is shown in Fig. 57. Even where electric-arc welding is available, this method is useful and does not lead to the cracking that invariably occurs when low-carbon steel is welded to high-carbon steel using only mild-steel electrodes.

A suitable length of pipe is heated to bright red heat, keeping the heat to within 30 or 40 mm of the end. The pipe can be upset by bumping the hot end on the face of the anvil or by applying hammer blows to the heated end. Distortion from the round should be corrected over the beak as soon as it becomes obvious. Increase the diameter of a 30-mm pipe to about 40 mm. This will also increase the thickness of the wall at this point. When it is still at a bright red heat, start spreading the end over the edge of the anvil with hammer blows on the inside edge of the tube and with about 20-mm overhang of the anvil. Work the edge until it is angled out from the pipe at about 45 degrees all round and as even as possible. Next, by hammering flat on to the end, a flange can be produced (Fig. 57C). Some flattening from the back face of the flange will be needed and can be carried out with a hand hammer or set hammer. Sufficient flange must be produced to take four rivet holes 6 or 8 mm in diameter. These can be drilled or punched. Matching holes are drilled or punched in the hoe blade and the handle riveted into position.

The hoe handle can also be slightly flattened as for the hammer handle. Furthermore it can be reused when the hoe blade is worn out and needs to be replaced. It can also be bent to suit the requirements of the user.

Handles for sickles, draw knives and similar tools are best made of wood in the way illustrated in Fig. 58. Tangs are drawn out to a long taper of sufficient length to pass through a handle and leave enough to be bent back over the handle end in order to retain the handle in position (Fig. 58A). Such handles need to be about 110 mm in length and fitted with a ferrule to prevent splitting. A small washer is sometimes used over the

tang at the end of the handle to facilitate the bending without damaging the wood.

Ferrules must be a tight fit on to the wood and can be easily made from thin-walled tube. If tube or pipe for this application needs to be increased in diameter and have its wall thickness reduced, this can be carried out with the aid of a hand-held mandrel (Fig. 59). A suitable length of pipe is cut off, heated and placed on the mandrel. One end of the mandrel rests on the face of the anvil, and the ferrule is kept tight up to the anvil's edge, while hammering is carried out to thin and stretch the ferrule to size. During hammering, the work should be rotated so that hammer blows are applied evenly around the workpiece.

As mentioned before, metal-rod handles for smithing tools are useful and easy to make. Tools are made with fullered grooves or recesses to accommodate rod 8 or 10 mm in diameter. About one metre of rod is bent on its centre, as in Fig. 60A. This should fit snugly around the tool (Fig. 60B). The tool is held in a vice, and the rod is brought to a bright red heat on the centre and for about

FIGURE 54

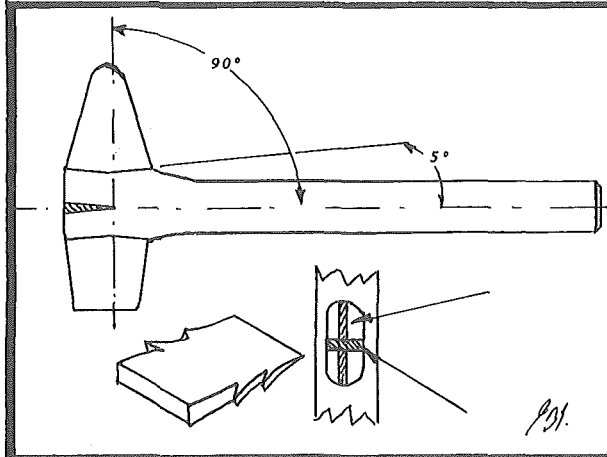


FIGURE 55

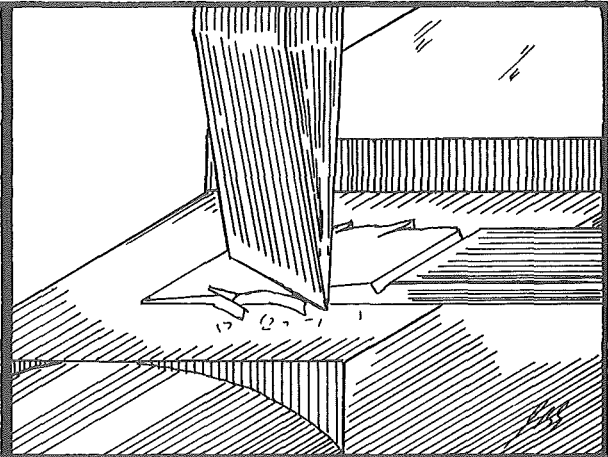


FIGURE 56

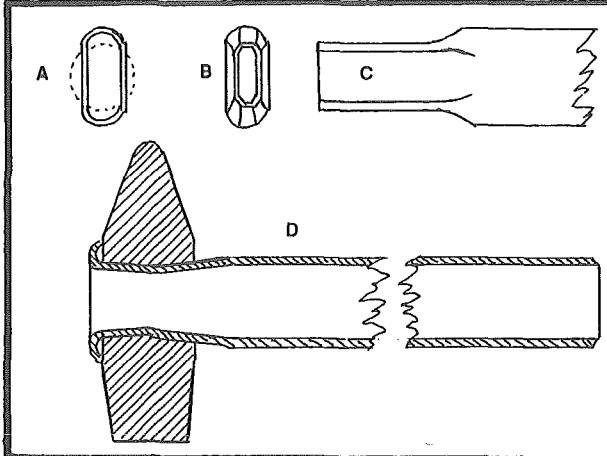
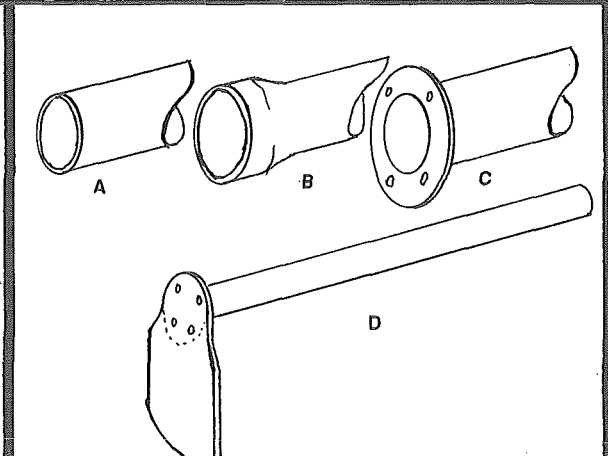


FIGURE 57



100 mm from the bend. The rod is then placed on the tool and quickly wrapped around it. Work is transferred to the anvil and the rod is lightly hammered to a tight fit. Finally, the rod is closed together near the tool (Fig. 60C).

After quenching the head, a welding heat is taken on the rod ends. They are welded together and then opened out (Fig. 60C). If and when they eventually work loose from the head, a tight twist close to the tool will retighten such handles.

Some tools for cutting and slashing work are fitted with wooden slabs riveted to the blade (Fig. 61). The handle is a continuation of the blade and is shaped slightly to suit the hand. Partially shaped wooden slabs are drilled to match punched or drilled holes in the metal and are riveted into position. Final shaping and smoothing is carried out after riveting.

FIGURE 58

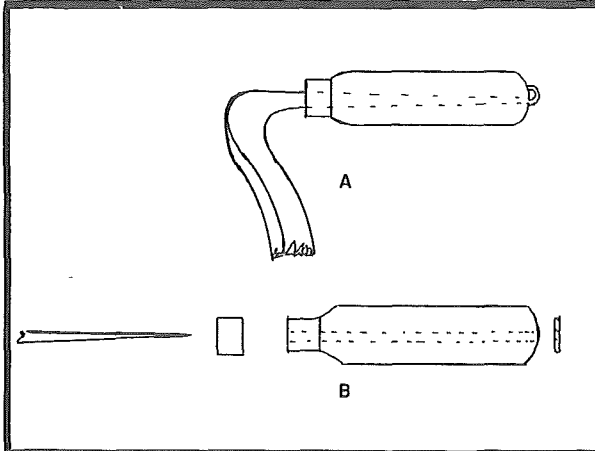


FIGURE 59

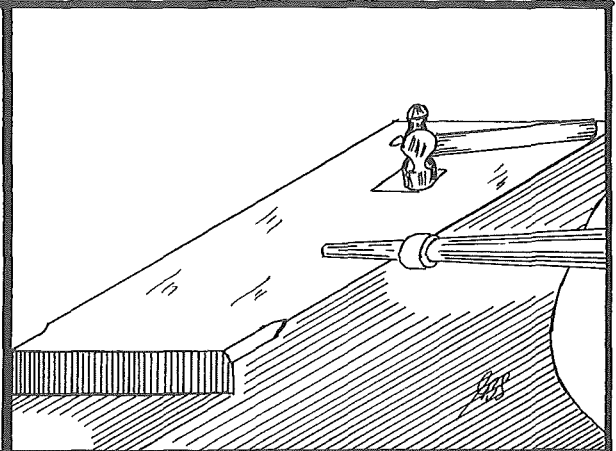


FIGURE 60

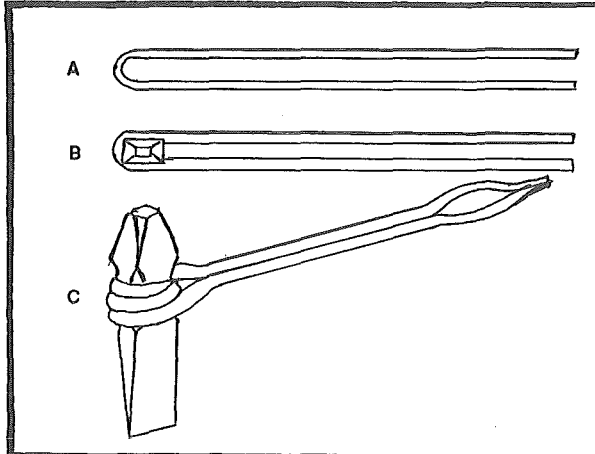
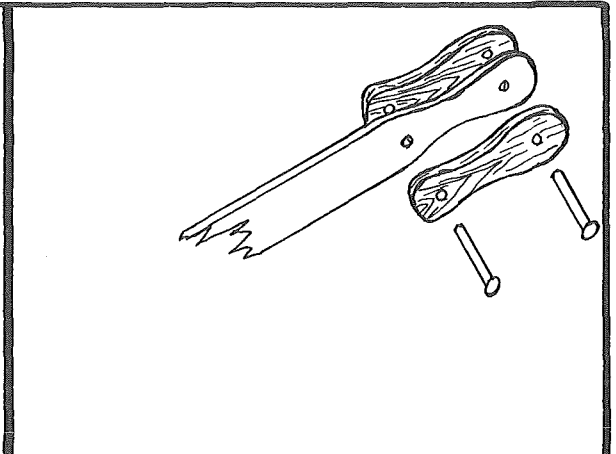


FIGURE 61



7. Making carpenters' chisels

Materials. Carbon-tool steel or vehicle-spring steel as available, round section of 12 to 20 mm in diameter or flat spring leaf 4, 8, 10 or 12 mm thick.

Additional tools. 16-mm top and bottom fullers; set hammer; bolster plate with holes 6 and 8 mm square.

METHOD

A skilled smith can make good carpenters' chisels of many types. They can have all-metal handles or be tanged and have wooden handles attached. Two kinds of firmer chisel are shown in Figs 62A and B. The simplest is the rectangular-sectioned blade A. The bevel-edged chisel B requires more effort to produce but is highly desirable for woodworking.

A mortising chisel (Fig. 63A) is similar to the firmer chisel in Fig. 62 but with a thicker tapering blade to withstand blows from a mallet. Fig. 63B shows a tanged chisel blade to be fitted to a wooden handle. This tang requires more work to produce.

Figure 64 illustrates two wooden handles fixed to tanged chisels: A is for a firmer chisel while B is for a mortise chisel with the tang passing through the handle to take the force of blows from a mallet. Figure 65 shows the steps in making the simple chisel form, in this case, from round-section vehicle-spring steel.

Cut off and straighten a 180-mm length of round-section mild-spring steel 12 mm or larger in diameter. Alternatively a piece can be cut from a flat spring leaf 10 to 12 mm thick and 16 to 20 mm wide. This you will

FIGURE 62

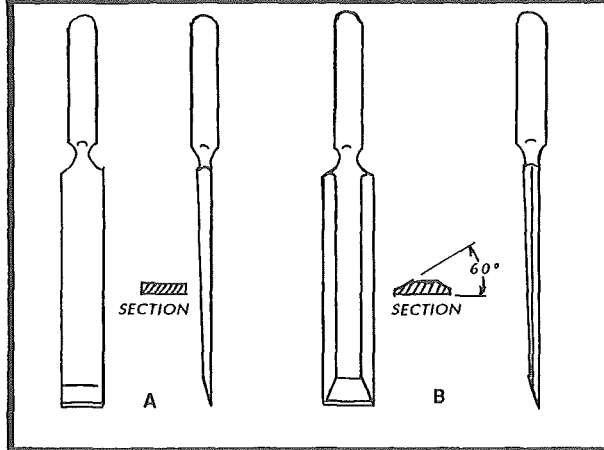


FIGURE 63

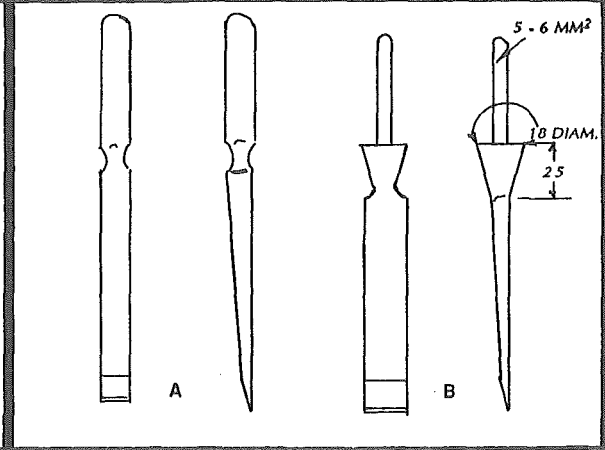


FIGURE 64

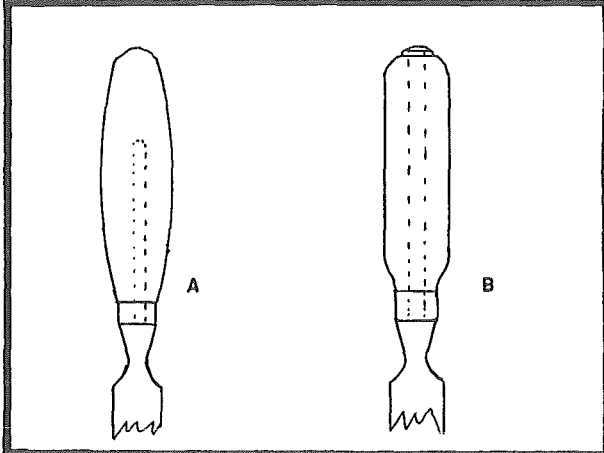
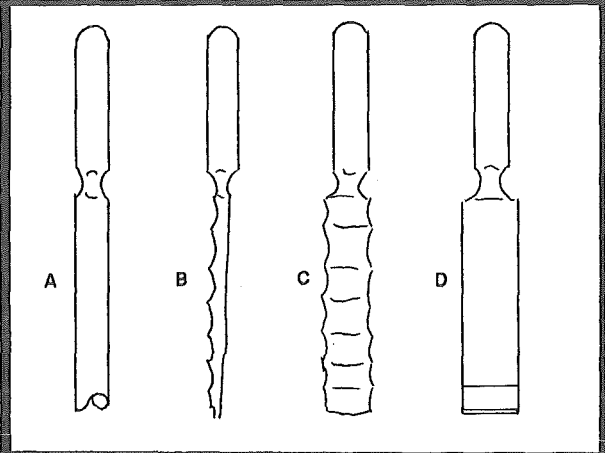


FIGURE 65



have to forge to a square section along its length, then forge in the corners to give an octagonal section and finish to a round section. Heat to a good red heat and round off one end to begin the handle. Mark off 90 mm from that end, heat in the marked position to a bright red heat and make a groove (Fig. 66) using top and bottom fullers. Draw to a square section, then forge in the corners to give an octagonal section about 8 mm across the flats. This divides the material between handle and blade.

Next, heat the blade end along its length to a near-yellow heat and either flatten with the hand hammer or reduce with a fuller (Fig. 67). Then flatten to the desired thickness, usually 6 to 8 mm near the fullered groove and 4 to 6 mm near the cutting edge. At the same time, reheating as needed, carefully forge the piece to the required blade width. If forging is neatly done, only 0.5 mm or less will be left for cleaning up by filing. The more carefully the forging is carried out, the less work is needed later. Where a helper is available, a flatter can be used to give a good clean finish (Fig. 68). This is done

on a clean anvil face. Heat the job to a bright red heat and cover it in lime, sand or ashes to soften the job.

When the piece is cool, the cutting edge may be ground or filed to the angles required, and the remainder of the job neatly filed to the final dimensions and cleaned up to the standard required.

Heat treatment is next. Hardening and tempering are best done by the two-heat method, although the one-heat method can be used if only the end of the blade must be heated. Polish about three-quarters of the blade along its length with emery-cloth, carborundum-stone or any similar material. Tempering can be carried out by heating a heavy piece of bar, brushing off the oxide and placing the blade on this heated bar with the thin end clear of the bar. Watch for the appearance of oxide colours, moving the work about on the heated bar as necessary to give even heating. Quench again when a medium straw colour is seen, not quite into the dark straw/brown range. This method is detailed in *Basic blacksmithing*.

An alternative is to carry out the tempering by holding

FIGURE 66

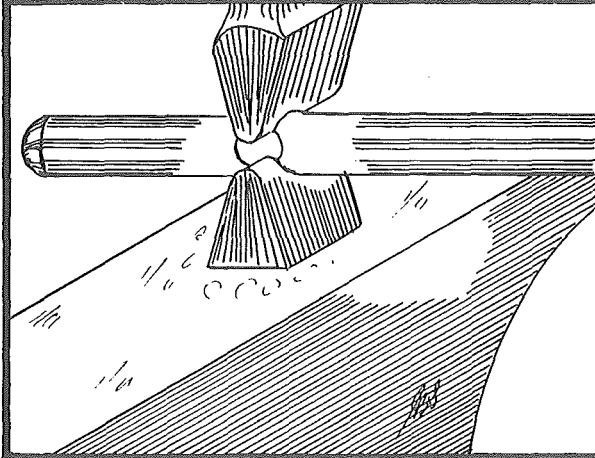


FIGURE 67

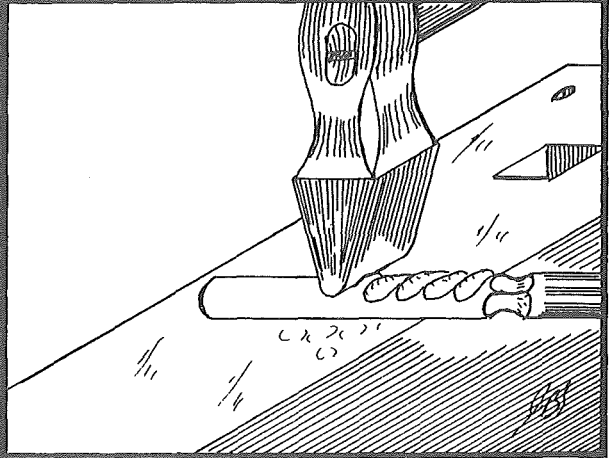


FIGURE 68

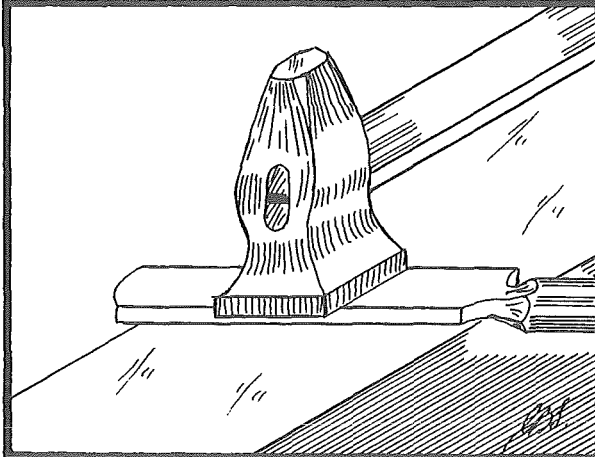
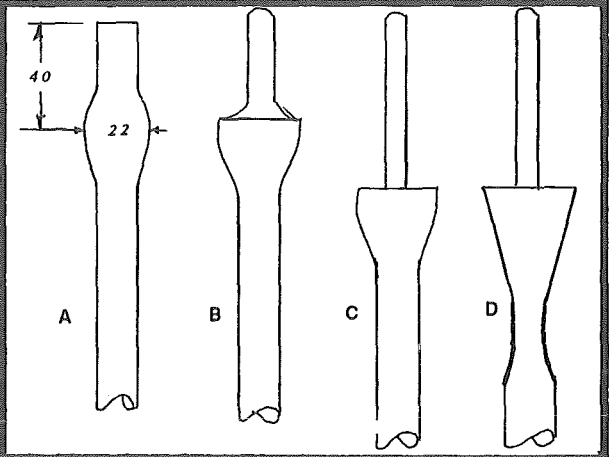


FIGURE 69



the hardened blade a little above the fire and moving it about, as needed, to give even heating. With care and practice at least 75 percent of the blade's length can be tempered in this way, giving it a long working life before reconditioning is needed. After heat treatment, the blade can be cleaned up to the required standard of finish and honed to its final cutting edge.

Fig. 69 shows the steps in making a tanged chisel. If steel of suitable thickness is not available, it is necessary to upset the piece to about 22 mm in diameter some 40 mm from one end. As before, another possibility is to cut a piece from flat spring leaf and forge it to 22 mm diameter. Again, an octagonal section is quite acceptable as an alternative to round.

Upsetting is carried out if necessary (Fig. 70), restricting the heat to the correct position by cooling. Do not fully quench any part of the steel, in particular the end. This would result in maximum hardness, causing fracture of the work and damage to the anvil and hammer face. Merely reduce the temperature where upsetting is not needed. This upsetting is a slow process

FIGURE 70

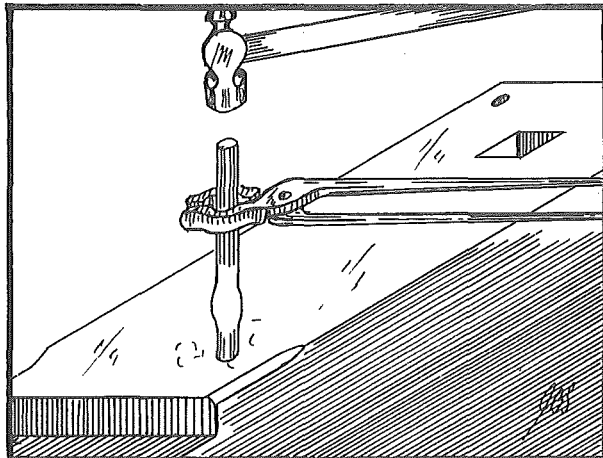


FIGURE 71

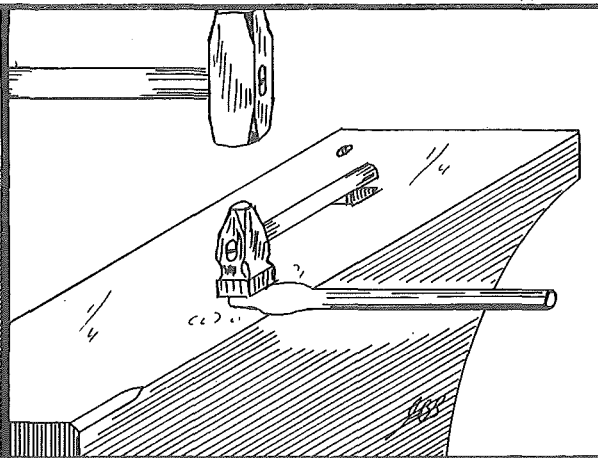


FIGURE 72

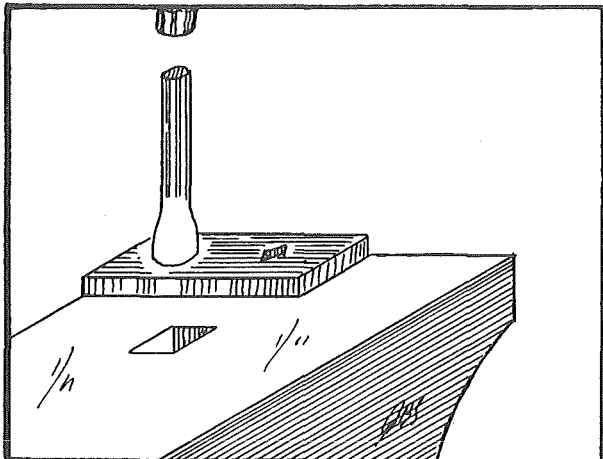
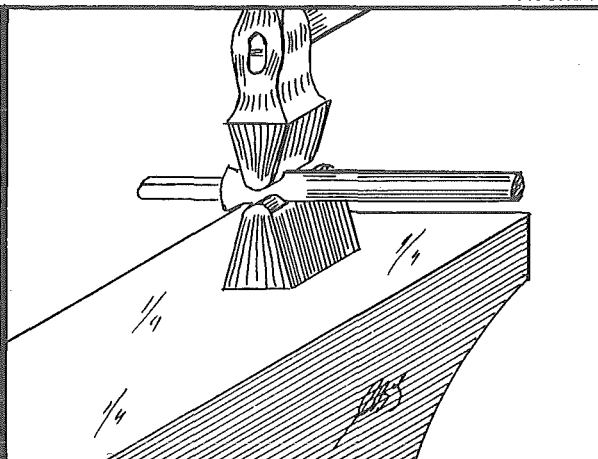


FIGURE 73



in spring steel and, as with other upsetting jobs, do not let the work bend too much before correcting it.

Next, the work is set in over the edge of the anvil, using a set hammer (Fig. 71), and drawn-down to about 8 mm square and a nice fit into the hole in the bolster plate. The tang so formed should pass through the hole easily, and the tang length should be about 50 mm at this stage for the firmer chisel. Carefully reheat at the shoulder, taking care not to overheat the thinner tang, place through the bolster plate (Fig. 72), and hammer on to the uppermost end to square the shoulder. Again, keep the work straight up.

The next step is to fuller a groove as before about 22 mm below the shoulder (Fig. 73). Reduce the work at this point to about 10 mm round or octagonal section. Next, give the buttress a nice neat taper by working over the anvil (Fig. 74). A final light hammering into the bolster plate might be required after this. True up and straighten the tang, buttress and blade part. Heat up and draw out as before (Fig. 75). After this, reverse the work, heat the tang and draw-down to final size, 6- to 8-mm square section and 50 to 60 mm in length. Heat up and fully soften the finished piece.

For a mortise chisel the tang length must be 110 mm in length, so additional material will be needed. Some 60 or 70 mm could be drawn-down at the shoulder, then finally drawn out to the required length. Final finishing is as mentioned earlier, including hardening and tempering. The tangs must be left soft.

Bevel-edged chisels are made in the same way with the side edges of the blade being bevelled with hand hammer or set hammer, working alternatively from each edge to maintain straightness.

Handles are made from straight-grained, dense semi-

hard to hard wood (boxwood is a favourite where available). Mortise chisels have the tang passed through the handle. A small washer is fitted and the tang lightly bent over it. Handles must, of course, be fitted with a ferrule to prevent the wood from splitting.

FIGURE 74

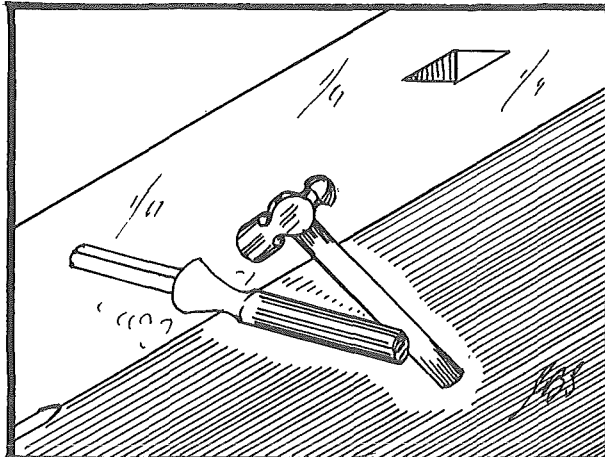
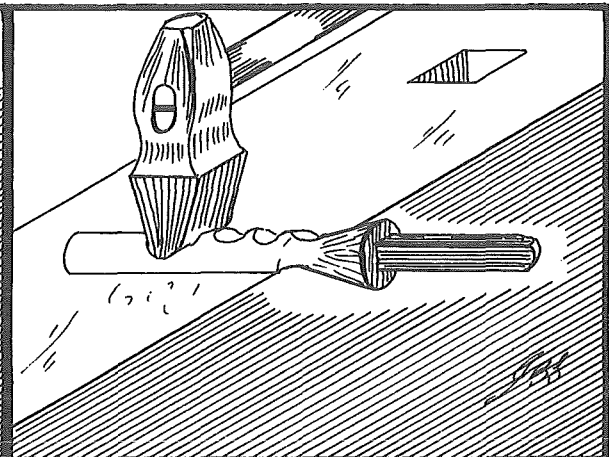


FIGURE 75



8. Making carpenters' plane blades

Materials. Carbon-tool steel or vehicle-spring leaf, thinner sections preferred.

Additional tools. Gouge; chisel and punch; 12- to 16-mm fuller; flatter; possibly a set hammer.

METHOD

Making plane blades should present little difficulty for the smith. There are a number of types, styles and sizes in general use. Dimensions in Fig. 76 are taken from a factory-made smoothing plane, but these can be adjusted to suit the tool for which the blade is to be made. Figure 77 is a type of blade sometimes used in wooden planes and is simpler to make. This job assumes that no drilling equipment is available.

An anvil with a face in good condition is required. If this is not possible, a saddle should be made to fit over the anvil face. This can be made of spring steel 10 to 12 mm thick and smoothed to give a good face for finishing. The neater and more accurate the forging the less need there is for subsequent filing or grinding.

Tools as in Fig. 78 should be made. The gouge is merely a flat chisel with the blade curved in a swage using a fuller, or formed around a suitable bar. It is sharpened on the inside of the curve. The chisel at B is a normal hot chisel but sharpened on one edge only so that it can make a neat square cut. The punch at C is a normal flat-ended punch. All these must be kept in good condition during the work and any damage corrected immediately.

FIGURE 76

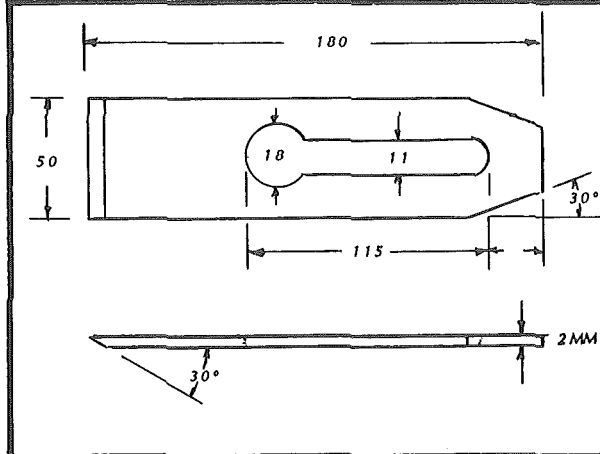


FIGURE 77

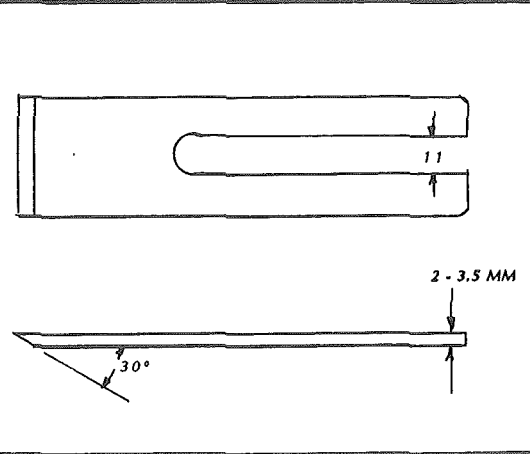


FIGURE 78

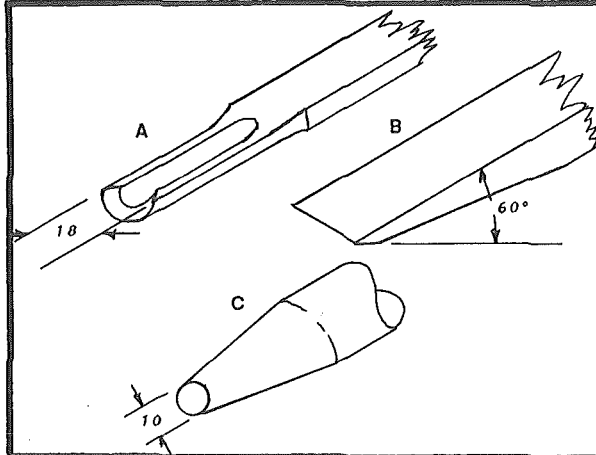
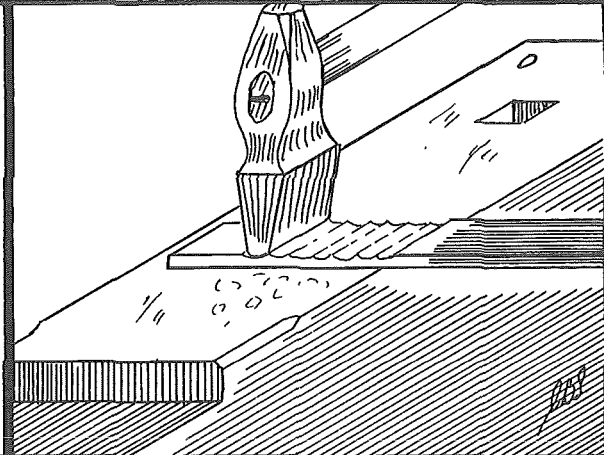


FIGURE 79



As plane blades are fairly thin, choose the thinnest spring leaf available in order to keep down the amount of work. Heat the end of the spring leaf to bright red-to-yellow heat and fuller (Fig. 79). Keep the fuller grooves close together. Reheat as necessary (thin sections cool quickly), and fuller a length of a little more than the length of the finished blade. Check the thickness of the material in the fuller grooves using callipers. When a suitable length has been fullered with grooves of correct and consistent depth, flatten with a flatter or hand hammer to a neat finish with no tool marks showing (Fig. 80). Rather than forging the material to width, cut the surplus with a hot set and finish with light hammer blows, keeping the thickness correct.

Next, mark the centre line, the width of slot and the position of the large hole at the end of the slot. Mark with a centre punch. If the steel is a little hard, centre-punch while at a very dull red heat (this is likely to spoil the temper of the punch).

Heat the piece and punch a hole about 10 mm in diameter (Fig. 81), working from both sides and finishing

over a bolster plate with the correct size of hole. Work quickly and reheat if necessary. Two or three blows from each side should be sufficient. With the same punch and procedure, punch a hole at the other end of the slot-to-be, opening this out to 11 mm in diameter with the same punch. If care is taken, the edges will swell only slightly. This can be ignored at this stage.

Reheat, and with careful use of the gouge cut out the large hole from one side. Start on the face of the anvil (Fig. 82) and finish carefully on the cutting table or on a piece of soft steel placed on the anvil face. Work all around the hole, reheating as needed. The scrap piece should drop out leaving a clean-sided hole with little distortion. Flatten any distortion at this stage.

Reheat to a bright red heat and cut along the sides of the slot (Fig. 83) using the one-sided chisel, holding the flat face toward the edge of the blade. Do not attempt to cut right through in any one place, but cut along the length until very nearly through. Repeat on the reverse side and remove the waste.

The cut edges should have a good finish, but if they

FIGURE 80

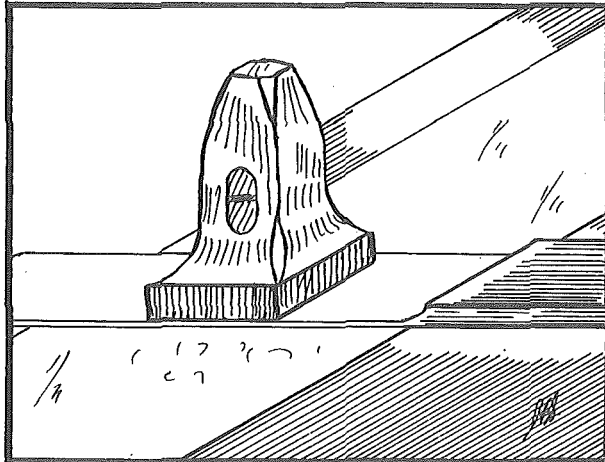


FIGURE 81

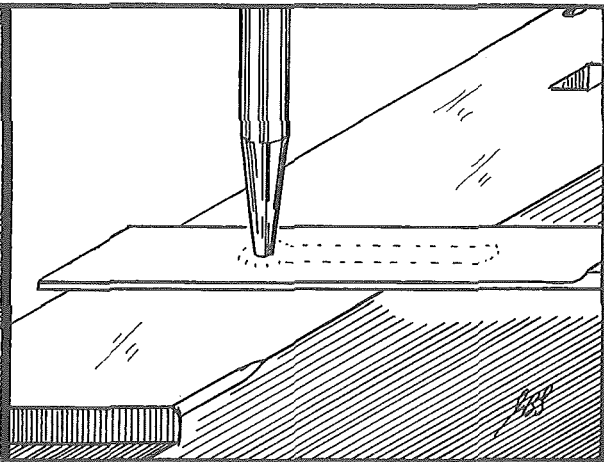


FIGURE 82

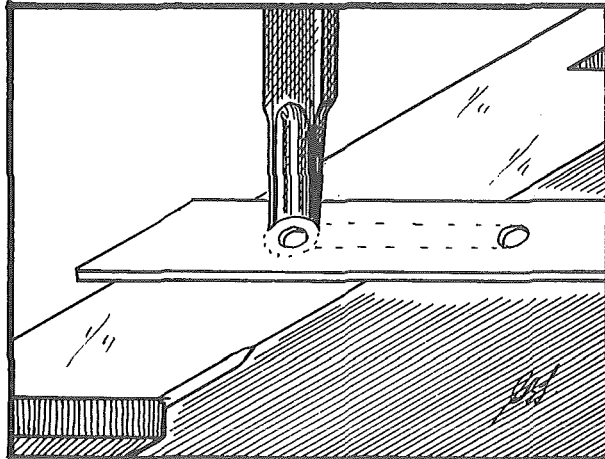
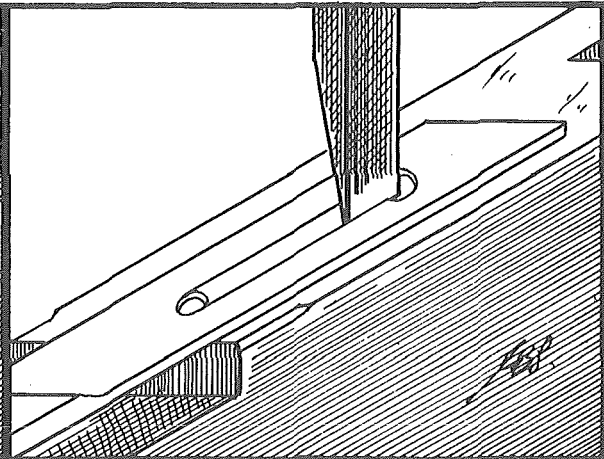


FIGURE 83

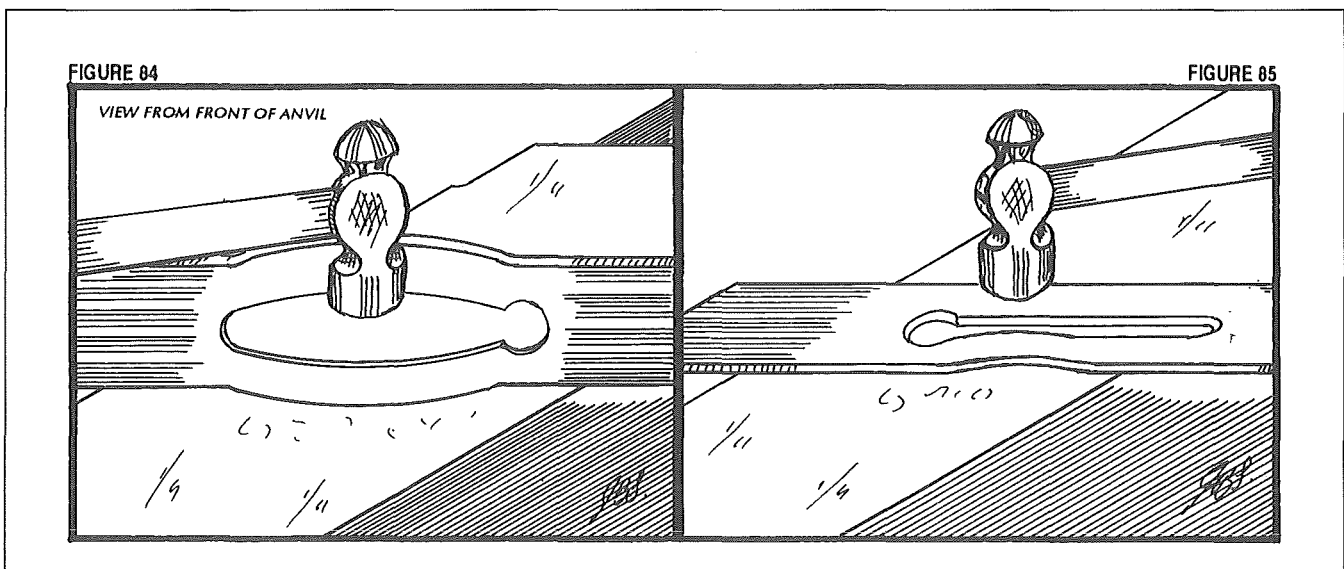


don't and filing presents a problem, bend the work (Fig. 84) and carefully remove any burrs or rough edges with light hammer blows, then straighten it (Fig. 85) and finish with a flatter. Get the blade flat and the slot edges parallel along its length. Fully anneal the job.

With a thin section it is sometimes necessary to heat it with a thicker piece of metal, placing them both close together in sand, lime or ashes and allowing them to cool slowly. After cooling the work, it may be filed or ground to a better finish and any distortion along the outside edges removed. The cutting edge can be filed square with the centre line and sharpened to the correct angle, usually about 30 degrees.

Hardening and tempering are as for the wood chisels. It is worthwhile experimenting a little here. Heat the cutting-edge end of the blade to a little more than blood red and just cool it in the air. Such thin sections are often sufficiently hard after this treatment and may be tested with a file to make sure. If the work is too soft, try quenching it in oil from the same temperature and test it again. If necessary, go back to the standard two-heat method but quenching in oil. Thin sections are likely to crack. It is very important not to work thin sections when they are too cold. They cool quickly so work quickly, but reheat as often as needed.

The type of blade shown in Fig. 77 should need no explanation; the same tools and similar methods are used.



9. Making carpenters' rasps and files

Materials. Low-carbon (mild-steel) flat bar 20 to 30 mm by 4 to 6 mm, length to suit files to be made; case-hardening compound.

Additional tools. Flat-edged and round-nosed chisels.

METHOD

In some countries, particularly in rural areas, rasps and files are expensive and scarce. With low-carbon steel and a little case-hardening compound, good files and rasps can be made. Examples of flat and round rasps and flat files are illustrated in Figs 86 and 87. Rather than forging a pointed tang for a wooden handle, it is more practical to forge the handle as part of the tool (Fig. 86A). This makes it easier to cut the teeth and

requires less work. Any mild steel will do for this job, so if flat bar of the right size is not available, other pieces can be forged to suit. You can also use angle-iron flanges.

Forge, harden and temper a flat cold chisel (Fig. 88). The edge must be wide enough to span the width of metal used. Note that this chisel is sharpened from one side only. For rasps, a round-nosed chisel is made (Fig. 88B).

Forge the handle end on a blank of required length, take off the sharp corners from the opposite end and then fully anneal the piece. After cooling it, remove loose oxides. In the case of the rasp the round-nosed chisel is used (Fig. 89A). Support the work (Fig. 90), using an anvil tool to form a stop in the tool hole of the

FIGURE 86

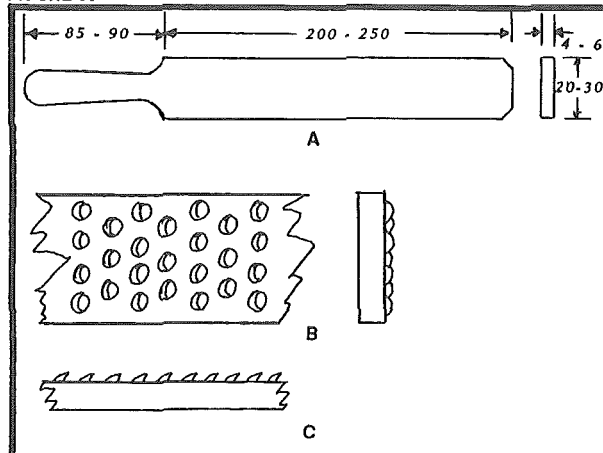


FIGURE 87

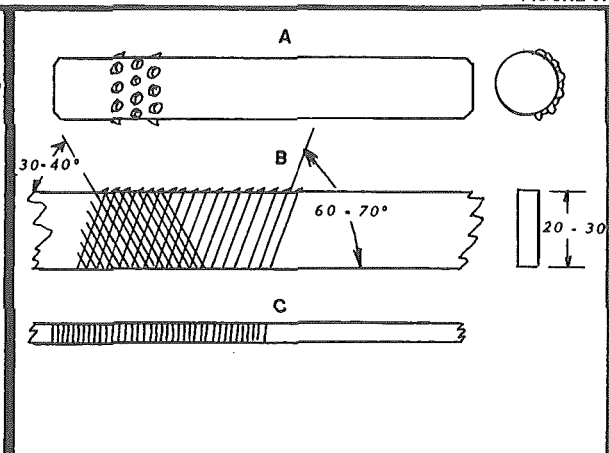


FIGURE 88

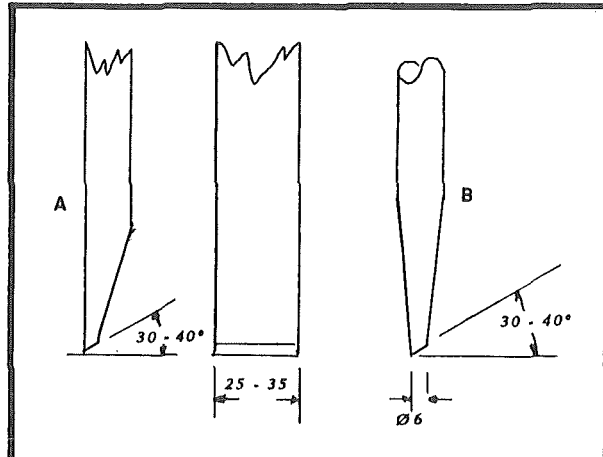
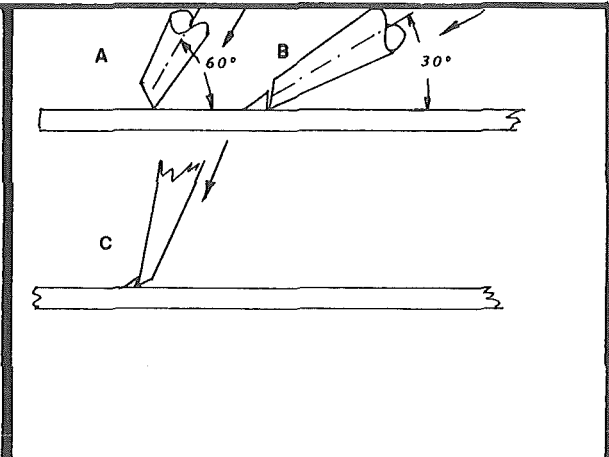


FIGURE 89



anvil. Offer the chisel to the work at an angle of 60 degrees or so and give it a firm blow to make an indentation, lower the angle to about 30 degrees and give one or two more blows to raise the tooth to the size required. Repeat this for each tooth. Spacing is not critical and can be judged by eye. It is better to stagger the teeth (Fig. 86B). The size of the teeth depends on the force of hammer blows applied. With practice this can all be carried out quickly, making a rasp in 15 to 20 minutes. For half-round rasps, a piece of water pipe can be used with any zinc plating removed (Fig. 87A). This is cut to length and sharp edges are removed. Teeth are cut in a similar manner one-third to halfway around the circumference of the pipe. The blank will need to be held in a vice or firmly clamped to a bar.

Files are cut in a similar manner but with the chisel held as in Fig. 89C, nearly vertical and across the width of the blank. A sharp blow is given to the chisel and, because of the angle of its edge, a lip will be raised to form a file tooth. Repeat all along the blank.

The coarseness of the teeth depends on the weight of hammer blows given and to the spacing of the teeth. The angles indicated for teeth in Fig. 87 are not critical and, for most purposes, a single-cut file will do. A second cut can be taken as in Fig. 87B if so desired. Teeth can be cut only on one side of the file blank and on one edge.

Blanks will tend to bend upward toward the chisel. This can be corrected by straightening on a wooden block (Fig. 91), without damage to the teeth. All this cutting is done in the cold condition after annealing.

Hardening is carried out after straightening by case-hardening the toothed part of the tool only. Heat the file or rasp evenly to a bright red heat all along its working length and apply a small amount of case-hardening

compound evenly over the teeth. This will melt over the work and carbon will be absorbed into the surface of the steel. After a few moments when the work has cooled below red heat, reheat evenly to red heat and quench in cold clean water, averting your face while doing so. The treated surface will be very hard and effective as a file or rasp until the thin layer of hardness has worn away. When this occurs the tool can be fully annealed, the teeth recut and rehardened.

Case-hardening compound can be applied either by sprinkling it on to the work or by having a small amount on a piece of sheet metal near the fire and placing the heated job face down on it. After hardening, clean the job with water and a wire brush. You can store any compound left over for later use.

The "pack" method of case-hardening can be used, but it is only viable where a large number of files are to be made. It is too complicated for use in the small smith's shop.

FIGURE 90

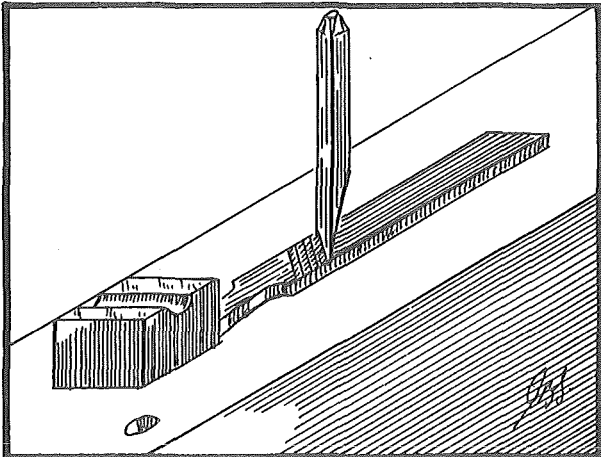
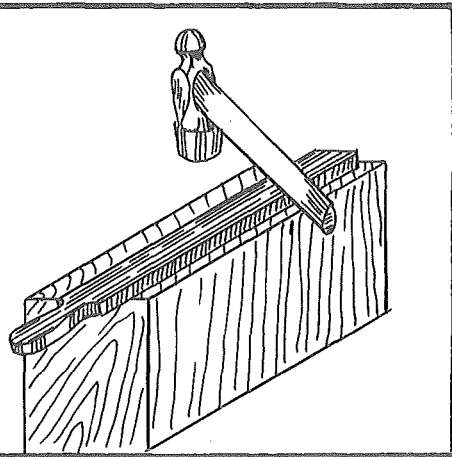


FIGURE 91



10. Making taps and dies for screw threads

Materials. Nuts and bolts of sizes required, mild steel unplated; case-hardening compound.

Additional tools. Small round files and a flat file.

METHOD

Workable taps and dies can be made from low-carbon-steel nuts and bolts. They do not give the precision and service of commercially made tools but are useful for cleaning damaged threads and, where no alternative exists, for producing internal and external threads. When using them to thread new work, do not attempt to get more than about 60 percent of the depth of thread and use plenty of lubricant.

Take a bolt of the size required and file four flats on to it (Fig. 92). File to a taper at an angle of about 10 degrees and heat to a bright red heat. Apply case-hardening compound, reheat after a few moments to red heat and then quench and clean. The tool is now ready for use.

Dies or nuts can be made by filing three or four grooves into the threads of a nut, tapering the threads internally by filing (Fig. 93) and then case-hardening, making sure that the compound covers the internal screw threads.

FIGURE 92

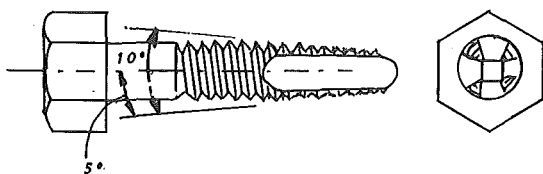
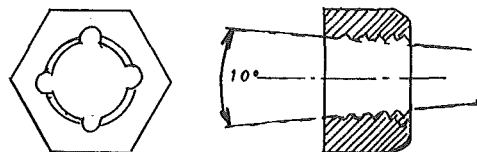


FIGURE 93



11. Plough repairs: making plough bolts

Materials. Round-section mild-steel rod of 8, 10 or 12 mm in diameter.

Additional tools. Bolster plate; holding clamp or adapted tongs; taps and dies of correct size to make the bolts; hole gauge.

METHOD

Plough bolts are usually as shown in Figs 94A and B, either countersunk with a square section beneath the head or countersunk with a spigot under the head. Both are designed to prevent the bolt from turning when the nut is tightened or loosened.

The making of such bolts is not very difficult. The bolster plate (Fig. 95) should be made from carbon-tool steel or vehicle-spring steel. The correct size of hole for the bolt to be made is either drilled and countersunk or punched and drifted to size and countersunk with a punch. A square punch can be used to form the square in the hole. The spigoted former in the bolster plate can, again, be drilled and countersunk or punched and drifted to the correct size. The spigot recess can be formed with a small punch made to the right shape and size.

An alternative is to have at hand an undamaged bolt of the size and form to be made. Drill and countersink or punch the plate as before and then heat the plate to a

FIGURE 94

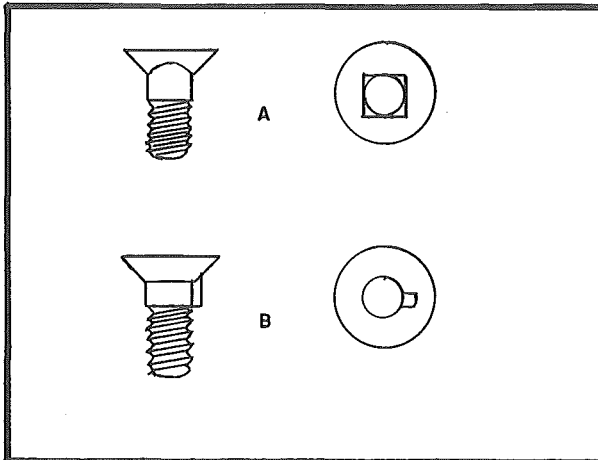


FIGURE 95

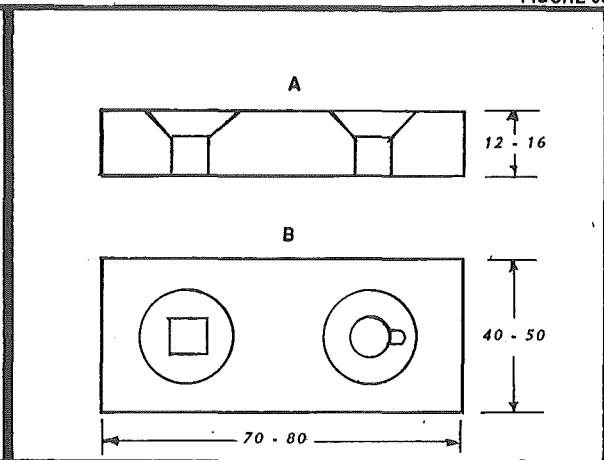


FIGURE 96

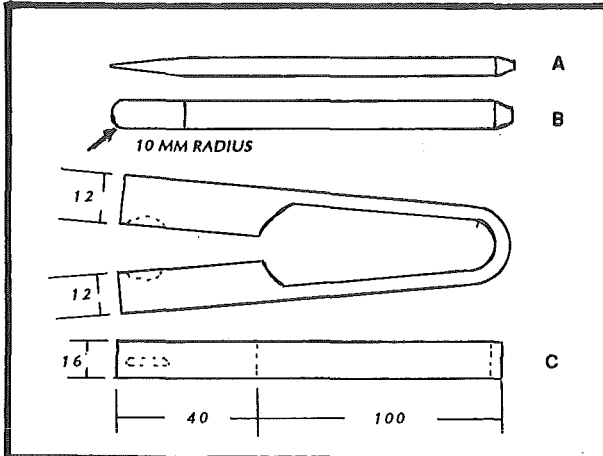
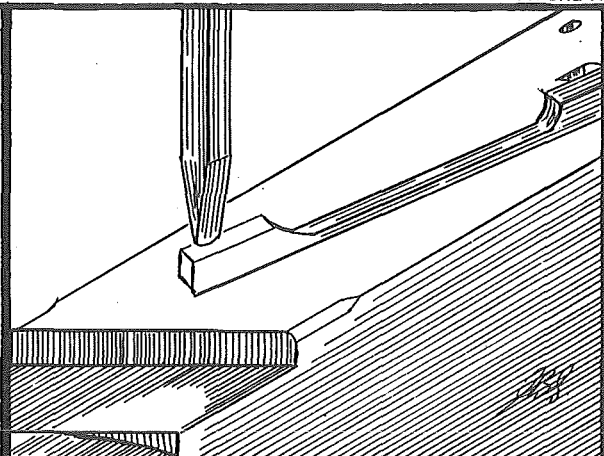


FIGURE 97



bright yellow heat, quickly place the bolt in the hole and hammer it in. This must be carried out rapidly and completed before the bolt has time to heat up and soften from the heating effect of the plate. If the work is carried out speedily enough, the bolt will remain undamaged and the hole will be exactly formed, allowing other bolts to be made. Let the plate cool and clean off oxides. It is now ready for use.

Next, to make a bolt, cut off a piece of rod of the same diameter as the bolt to be made and at least twice its length. The additional length is to allow the piece to be held in tongs. Heat one end and upset that end. The exact amount of upset will be found with practice but, for example, a 12-mm rod will be upset to about 14 mm very close to the end. Correct any deformation on the other end and make sure that the piece will pass easily through the hole in the bolster plate. Reheat to bright yellow, place in the hole in the bolster plate and hammer into the formed hole. If the upsetting was correct, the square and countersink or spigot and countersink will be neatly filled with metal giving the correct form of bolt head. Reheat the shank of the bolt, straighten and cut to length with a sharp hot set or chisel. Check the hole gauge to see that the shank is the correct diameter, then allow it to cool in the air.

Plough bolts are difficult to hold while cutting screw threads, so it is advisable to make a tool as in Figs 96 to 98. A piece of mild-steel bar of about 12 x 16 mm is fullered and drawn out to form a spring hinge. The length of this drawing-down is not critical but needs to be about 250 mm. A small chisel is made or adapted (Figs 96A and B). This is used to make semicircular recesses in the tool (Fig. 97). These recesses need be only about 4 mm deep. The tool is then bent to shape

with the recesses opposite each other. This tool is used as in Fig. 98 to hold the bolt while a die is used to cut the thread.

A simple alternative is to adapt a pair of tongs (Fig. 99). These are used in a vice in a similar manner to the tool. Threads can be cut with little or no damage to the bolt head.

While making a bolster plate, it is worth a little extra time to form holes for two or three different sizes of bolt. If needed, nuts can be made by punching and drifting tapping-size holes in flat bar, then cutting them off to length before tapping the threads. The punch used is only slightly smaller than the hole required and has a flat end. This is to minimize the distortion in the bar. If drilling equipment is available, these holes should be drilled.

FIGURE 98

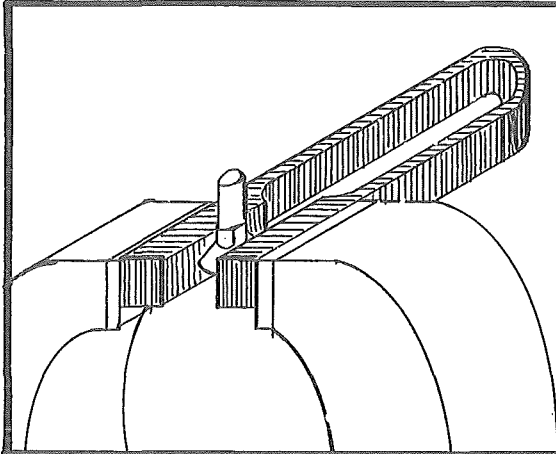
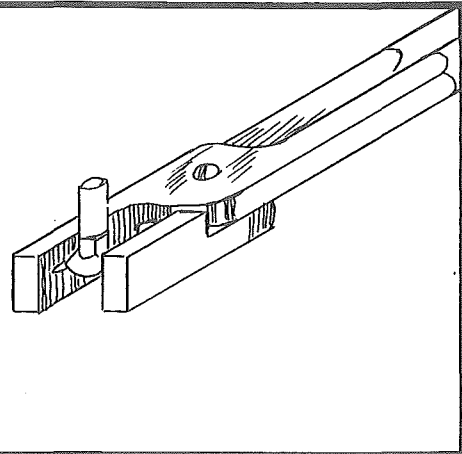


FIGURE 99



12. Plough repairs: making a replacement frog

Material. Mild-steel plate 4 to 6 mm thick; other dimensions depend on the size of the frog.

Additional tools. Large bottom swage about 25 mm; small top fuller about 8 mm; drill, if available.

METHOD

Although the frog is not directly subject to as much wear as other plough parts, when worn out it does present some tricky problems. If electric-arc or gas-welding equipment is available, repairs are easily carried out. In the absence of these, one is usually forced to make new ones. Given enough material, the forging of

a frog can be carried out on the anvil. Sizes and angles vary according to the design of the plough and the size of share and mould-board fitted. It is best to make a cardboard pattern of the old frog and to check the various angles. An example of a frog is seen in Fig. 100.

Because the initial forging requires the smith to work with a neat right-angle bend, the piece of steel required must be larger than the finished article, with allowances made for cutting to the correct angles and size after shaping. An approximation of such allowances is given in Fig. 101. Having made a pattern of the old frog, allowing for wear and cutting to size after forging, cut a piece of plate 4 to 6 mm thick. Mark the position of the

FIGURE 100

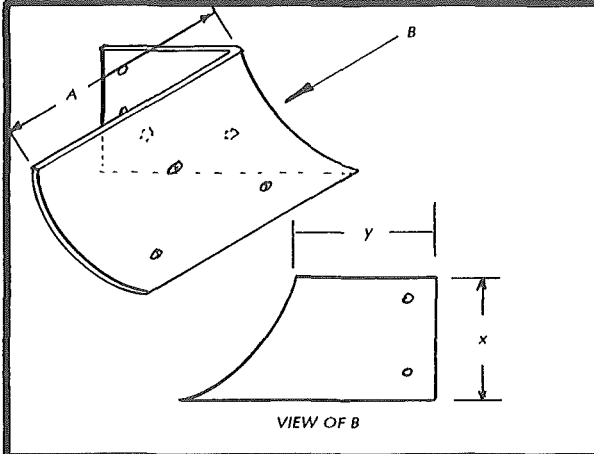


FIGURE 101

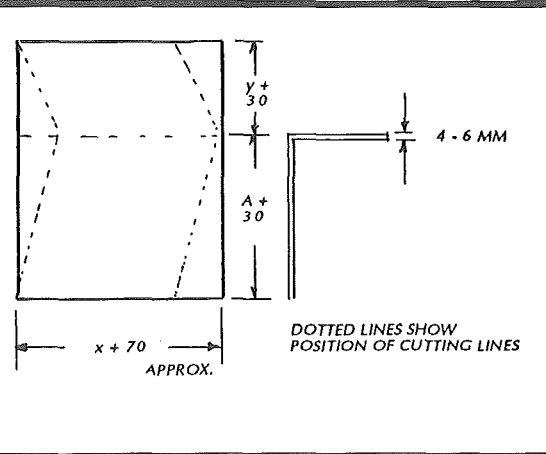


FIGURE 102

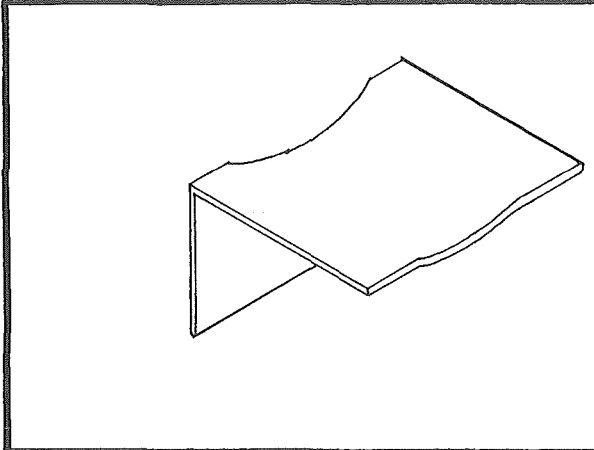
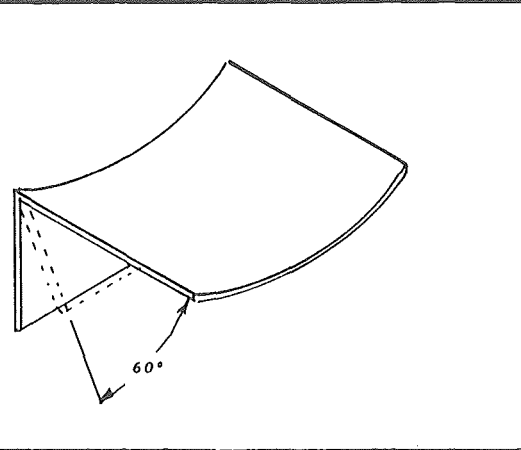


FIGURE 103



right-angle bend in a manner similar to that in Fig. 101. After bending, shaping is carried out (Figs 102 and 103).

To form the first right-angle bend, heat along the bend line to a good red heat. This is best done by moving the work over the fire to get an even heat. Place over the large bottom swage and start the bend using the small fuller (Fig. 104), then forge the bend to a tight corner (Fig. 105). The hammer is used both in the direction shown and in the direction of the arrow.

For the next step, a hammer with a slightly convex face is used to start the curve to match the ploughshare (Fig. 106). By heating the corner and applying blows from the centre of the bend, working toward the end, a pronounced curve can be produced on one side of the piece. By reversing the work on the anvil some stretching of the metal can be carried out to complete the curve (Fig. 107). Both ends are worked in this manner, but the curve should be repeatedly checked against the ploughshare.

The spreading of the metal must be corrected at the

FIGURE 104

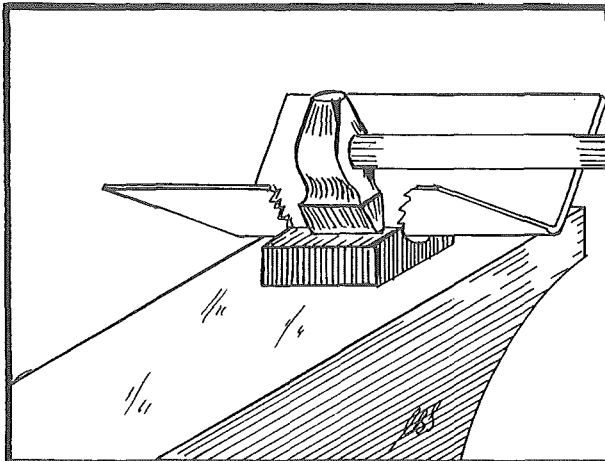


FIGURE 105

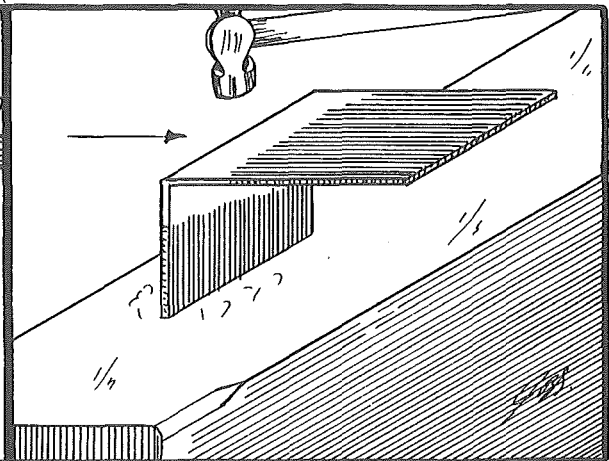


FIGURE 106

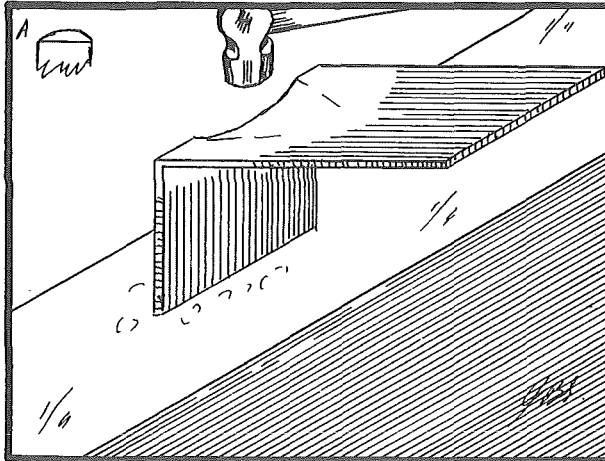
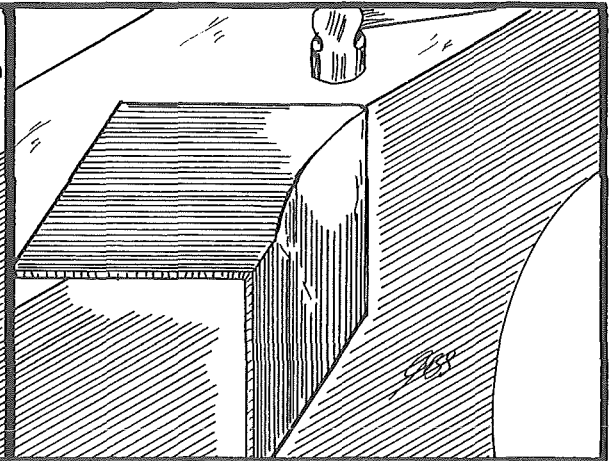


FIGURE 107



ends of the curve (Fig. 108). When you are satisfied with the corner, the curve can be completed over the beak (Fig. 109). Next, with the corner at a good red heat, work the bend to the correct angle (Fig. 110), with the flat side of the frog on the anvil face.

Mark out the material for cutting to match the original and cut with a hot set (Fig. 111). The set will need to be held at an angle, with cutting on the anvil face and ending on the cutting table of the anvil. Finally, bring the piece to a red heat all over and allow it to cool to normalize the work. After cooling, mark out the position of the bolt holes, which can then be drilled. Holes should be drilled as punching would require special tools to be made or the frog to be bent out of shape in order to punch the holes and then reshaped.

Do not drill or punch holes before forging, as this will create problems with forging.

FIGURE 108

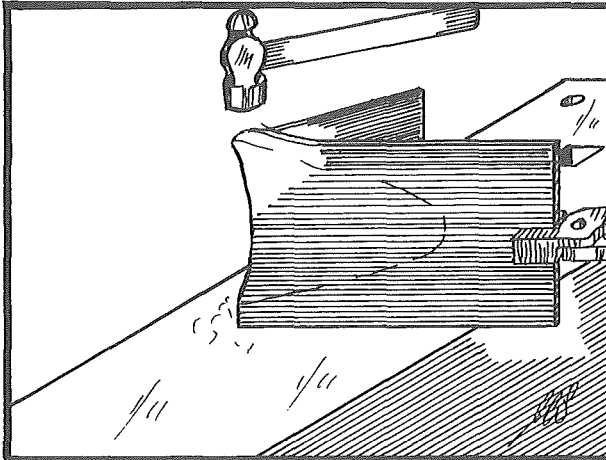


FIGURE 109

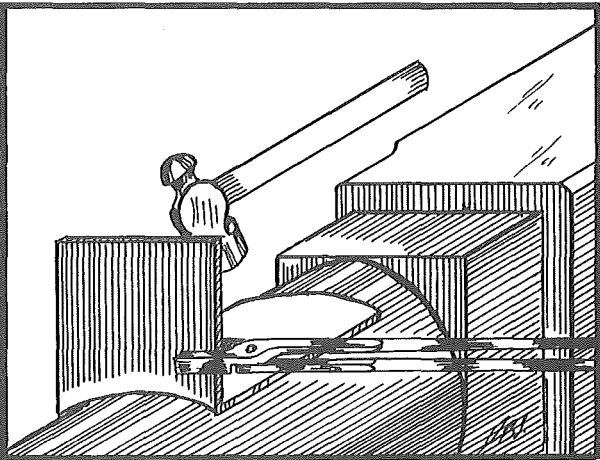


FIGURE 110

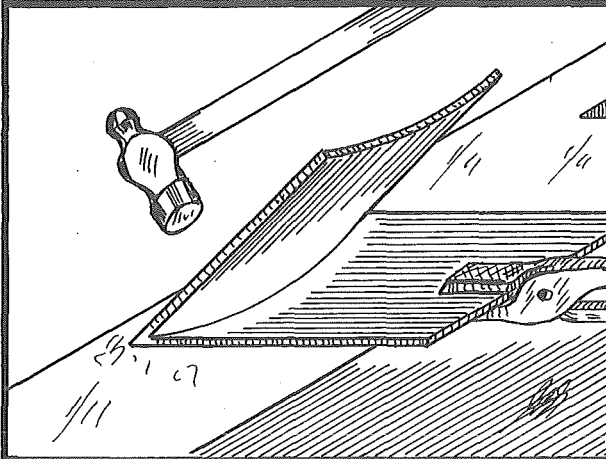
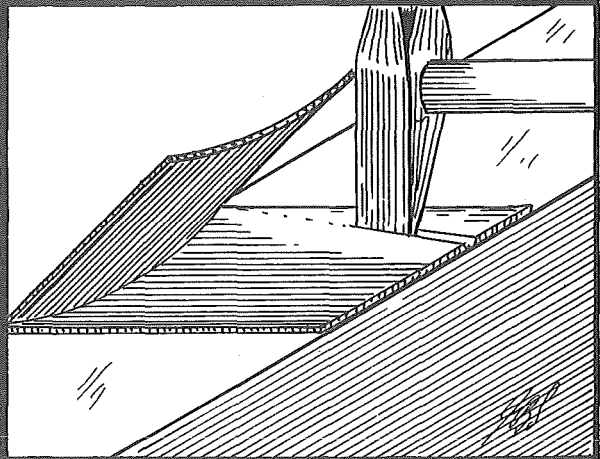


FIGURE 111



13. Plough repairs: repairing or making ploughshares

Materials. Old ploughshares; scrap plough or harrow discs; mild-steel plate 4 to 6 mm thick; assorted flat about 25 x 6 to 8 mm thick; mild-steel rod 6 and 8 mm in diameter; scrap cast iron of thin section.

Additional tools. Punches and a former; drill, if available; borax or commercial flux if hard-facing only.

METHOD

Where replacements for worn-out ploughshares are not available, shares can be repaired in a number of ways or new ones may be made. Shares are usually made from steel containing about 0.7 percent carbon with,

occasionally, other alloy steels. Ploughshare sections can vary in size (Figs 112A and B). Modern lightweight ploughs often rely solely on bolts to take the stresses generated during ploughing, so bolts must fit tightly. Where shares have to be made, a former like that in Fig. 113 should be made from mild steel or vehicle-spring leaf about 12 mm thick and 50 mm wide.

One end is forged to fit the tool hole of the anvil and the curved section to match the curvature of the ploughshare and mould-board. For hole-making, punches (Fig. 114) should be made from carbon-tool steel or vehicle springs. Figure 114A is a round punch with a flat end equal to the diameter of bolts to be used.

FIGURE 112

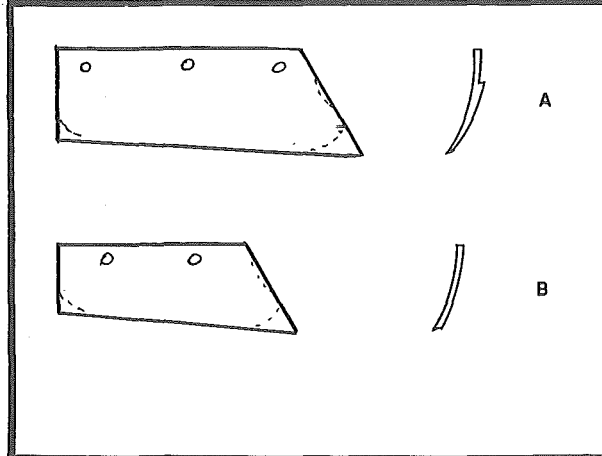


FIGURE 113

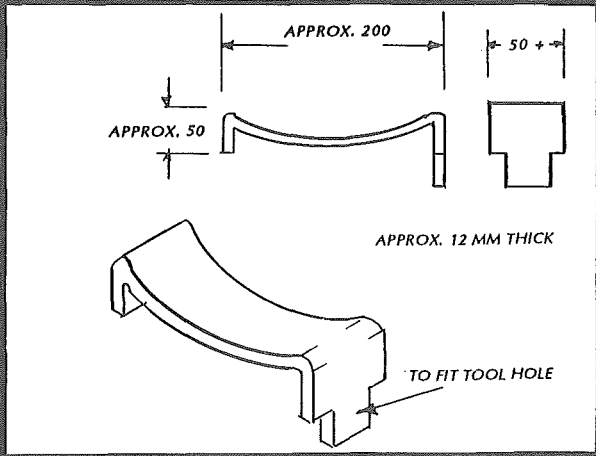


FIGURE 114

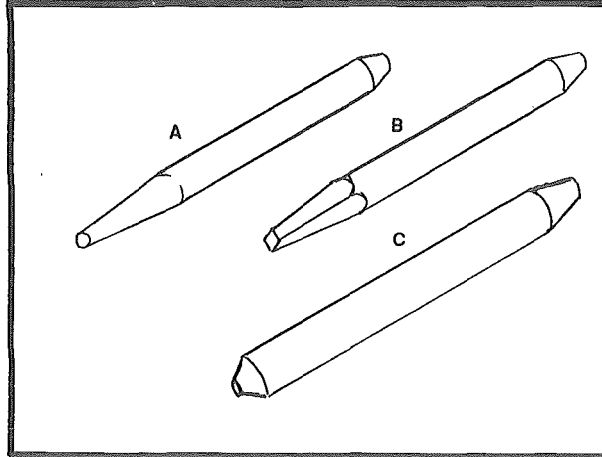


FIGURE 115

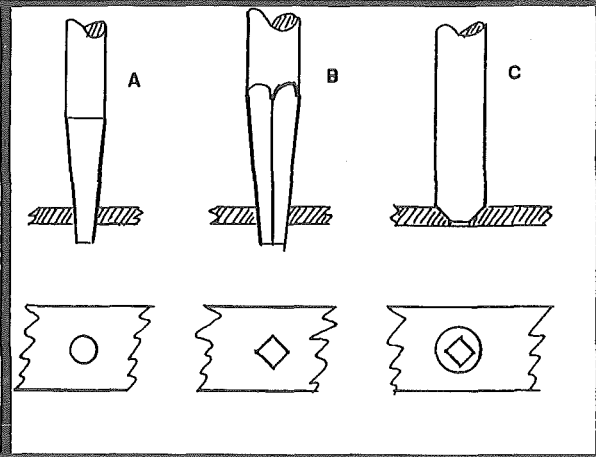


Figure 114B is a square punch to give the necessary shape to accommodate bolts. Figure 114C is a punch used for countersinking. Where drilling equipment is available, only the square punch is needed. Figure 115 illustrates the sequence of hole-punching: round hole punched, hole made square and then countersunk.

To make a replacement for a small share with a section similar to Fig. 112B, make a paper pattern of the old share with allowances for wear. Mark this out on a piece of steel of the right thickness. Centre-punch the outline, heat the piece and cut it with a hot set. After cutting, true up the edges. Mark out and drill or punch the holes. If holes are punched, some excess metal will be pushed outwards and distort the top edge of the share. It is best to cut this off with a sharp hot set or chisel. The working edge of the share is slightly bevelled from the back by hammering or cutting. Reheat and hammer into the former (Fig. 113).

If made from an old plough disc or vehicle spring, heat the share to a dull red and quench in oil. If made from mild steel, give the share a hard surface using thin,

scrap cast iron from an old cylinder block or something similar. The piece must be large enough to be held in tongs. Powdered borax or a commercial welding flux is needed. The areas to be treated are brought to white heat. The cast iron can be smeared on to the share where it will form a very high-carbon steel layer.

Treat each position in turn, then reheat the share to dull red heat and quench in water. The treated surfaces will be very hard and, although not smooth, they will take on a polish when put to work.

Where a stepped section similar to Fig. 112A is needed, the share can be made as outlined above. A bevelled piece made from a flat bar can then be riveted to the share (Fig. 116). Rivet holes should be countersunk to give a smooth finish. If such a share is to be treated with cast iron this must be done before riveting.

If the smith is experienced in welding, new tips can be welded on to worn share points and heels as needed. Welding skill is important. Two methods are illustrated (Figs 117A and B). A piece of bar about 25 x 6 mm is prepared as shown and partly cut through. The share is

FIGURE 116

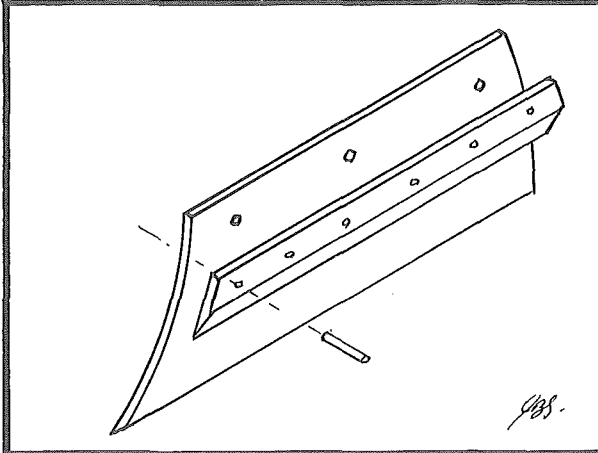


FIGURE 117

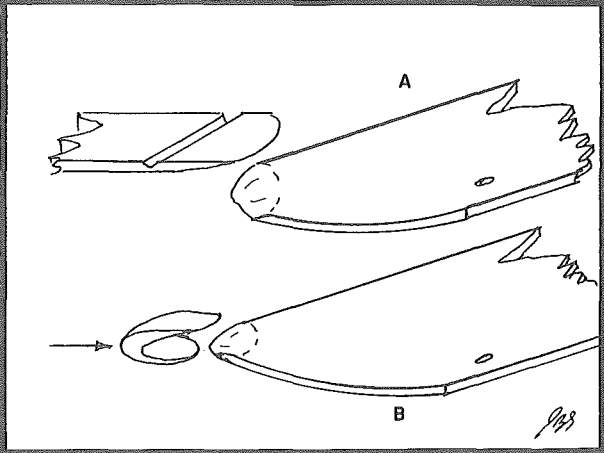


FIGURE 118

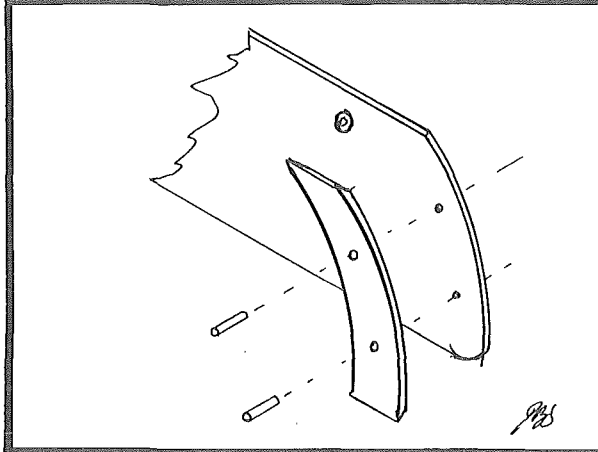
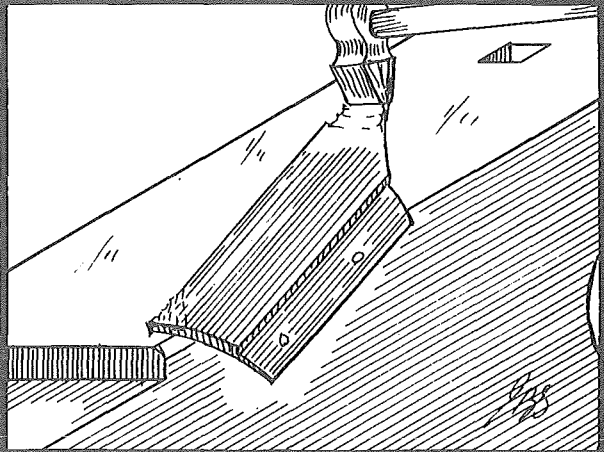


FIGURE 119



tapered to match. Both are brought to welding heat, with borax or a mixture of borax and sand being applied. The pieces are placed together and welded with quick, light hammer blows. Care is needed to avoid overheating and burning the share. The preparation in Fig. 117B is perhaps easier to carry out. Mild-steel bar is formed as shown and placed over the end of the share. A small hole is punched and a small piece of rod riveted into it to keep the pieces in place. Bring to welding heat with a little flux and hammer together, then trim to shape. Where welding presents great difficulty, the life of a share can

be extended by riveting pieces to the share (Fig. 118). Holes should be about 8 mm in diameter and spaced equally on either side of a centre line so that, when worn, the piece can be reversed and reused. If mild-steel pieces are used they can be treated with cast iron as described above.

When a share is not too badly worn, its life can be extended by drawing out with a fuller (Fig. 119) and then hammering to the correct shape. Take care not to thin the section too much. A skilled smith should be able to carry this out quickly and easily.

14. Plough repairs: repairing or making mould-boards

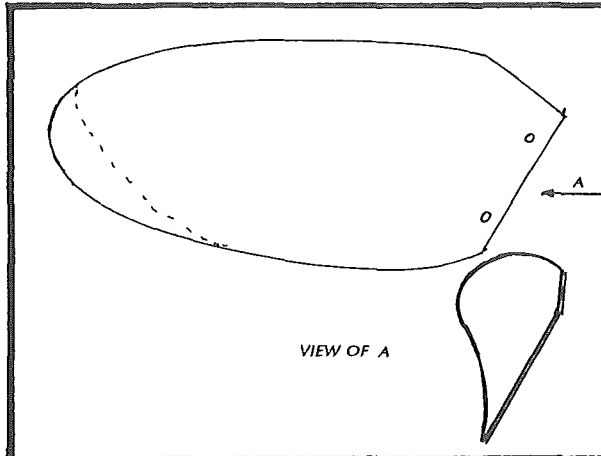
Materials. Old mould-boards, steel plate 4 to 6 mm thick, medium carbon or mild steel.

Additional tools. Punches and former (Fig. 116); drill, if available.

METHOD

Mould-boards for ox or donkey ploughs do not present any great technical problems, apart from material supplies. Mild steel can be and often must be used. One old mould-board will often provide enough material to repair two or three others. Steel from a heavy-duty lorry chassis is a fair substitute for new plate when cut and

FIGURE 120



VIEW OF A

FIGURE 121

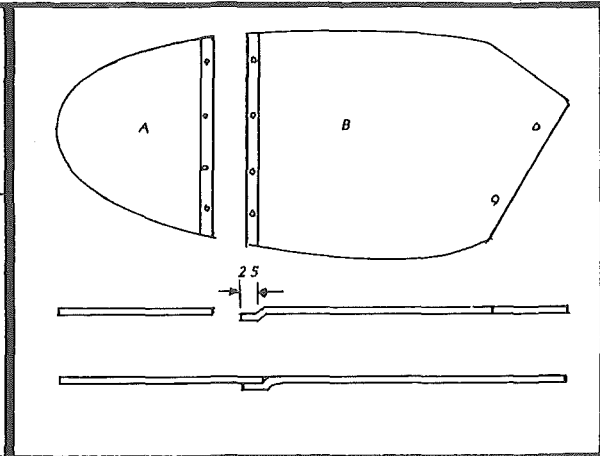


FIGURE 122

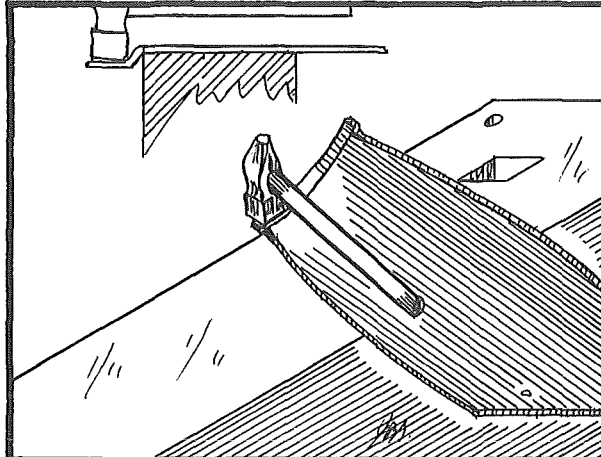
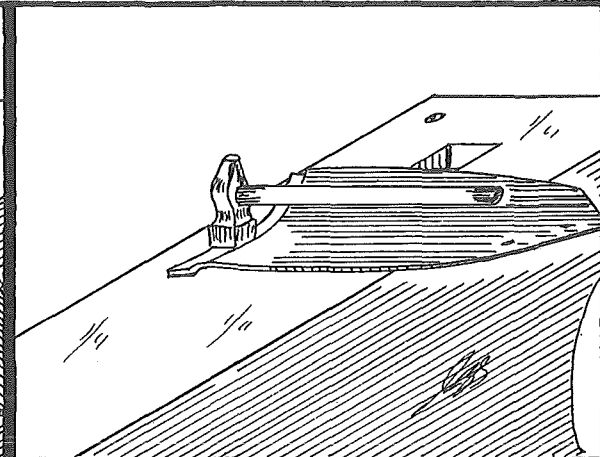


FIGURE 123



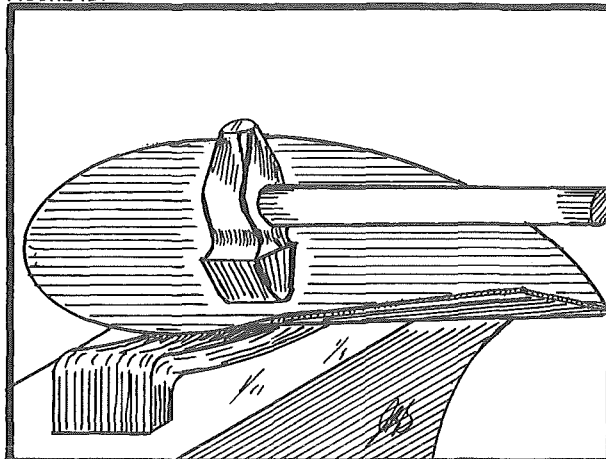
straightened. Mould-boards wear differently in different soil conditions, but usually most wear occurs at the tail or rearmost part of the mould-board in a manner similar to that shown by the dotted line in Fig. 120.

To repair, the worn section must first be cut off, back to thicker material (Fig. 121), removing the least amount of material possible. Cut and shape a piece to replace the worn section, adding 25 to 30 mm for overlap. At a bright red heat, place the old piece (B in Fig. 121) across the anvil face with about 25 mm overlapping, and set in a step using a set hammer (Fig. 122) while maintaining the curved shape. The step should be as deep as the thickness of the metal. Irregularities can be corrected (Fig. 123).

The new part is curved to fit into the stepped section. Drill or punch holes for rivets. About four holes are required, 6 to 8 mm diameter and countersunk on the face side. Small pieces of rod may be used as rivets to join the two parts.

If a new mould-board must be made, start by making a paper pattern of the old one, allowing for wear. Mark this out on a suitable piece of steel and place and cut to shape, either hot or cold. A set sharpened from one side gives the best finish. The curvature of the mould-board is achieved by using the former (Fig. 124) and a fuller of about 20 to 25 mm. Do a little at a time, working along the mould-board from end to end. Some adjustments can be made on the beak. If this is carried out hot, only a dull red heat is needed. Mild steel can be treated with cast iron as before.

FIGURE 124



15. Plough repairs: making landsides

Materials. Vehicle-spring steel, flat, 8 to 10 mm thick.

Additional tools. No special tools are needed.

METHOD

Landsides are made of thicker steel than other wearing parts and are more difficult to repair, so it is more practical to make new ones. Take measurements of the original, allowing for wear. Select a suitable spring leaf, heat, straighten and mark off the length. Reheat and cut with a hot set; reheat and correct any roughness caused by cutting. Next, punch holes or fully soften for drilling.

Many landsides are fitted with small sole-plates (like the angled piece at left in Figs 125A and B). These are easily made by cutting a pattern like in Fig. 126 and bending to shape. Alternatively, they may be cut from a piece of angled iron. Holes must be drilled and the sole-plate riveted into position. All holes must be countersunk on the landside, as shown by the dotted lines in Fig. 125B. Mild steel can be used for landsides, but they need to be hard-faced with cast iron as described before or they won't last long.

FIGURE 125

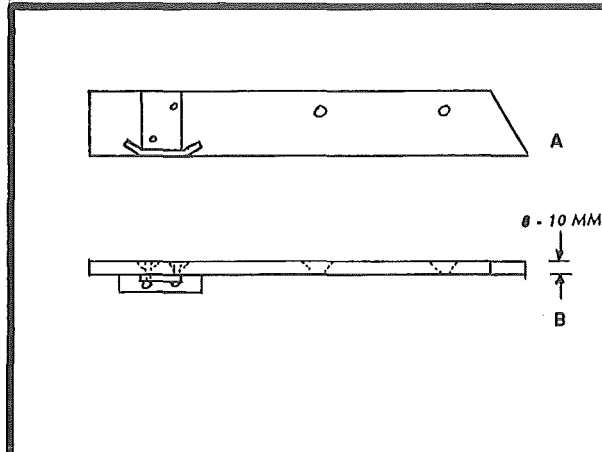
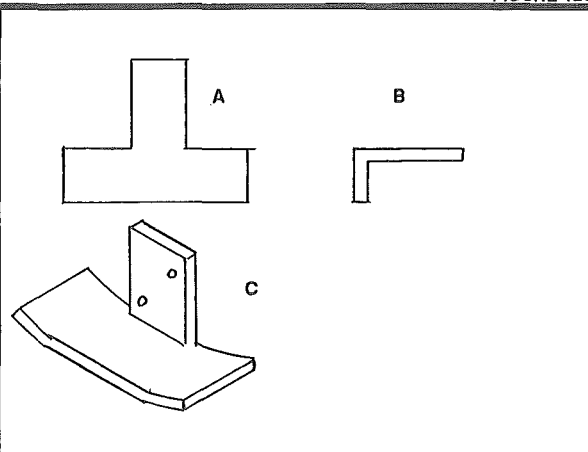


FIGURE 126



16. Plough repairs: coulter

Materials. Vehicle-spring steel 6 to 8 mm thick or pieces of worn plough or harrow disc.

Additional tools. No special tools needed.

METHOD

Fixed coulters can be repaired in a number of ways. Where there is only limited wear, they can be drawn out, reshaped and hardened. Where there is greater wear, material must be replaced (Fig. 127). The most effective way of adding on material is by welding. A worn coulters is reforged to a rectangular section (Fig. 129); some upsetting on the end of the blade might be needed. The end is then given a short taper (Figs 128A and 130).

A piece of spring steel or similar material is forged to

FIGURE 127

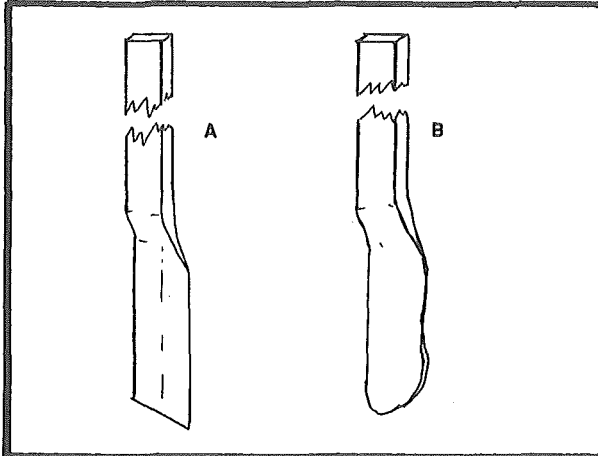


FIGURE 128

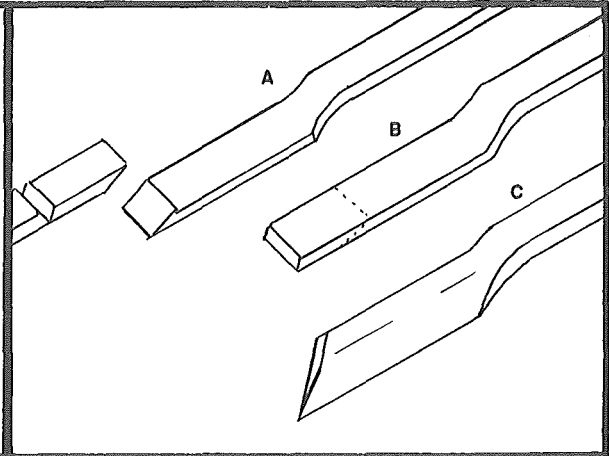


FIGURE 129

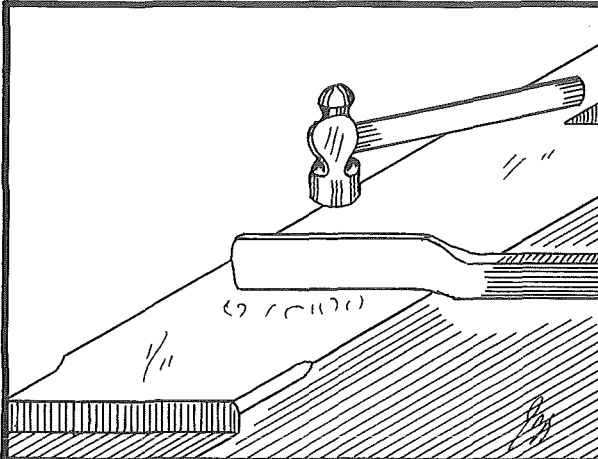
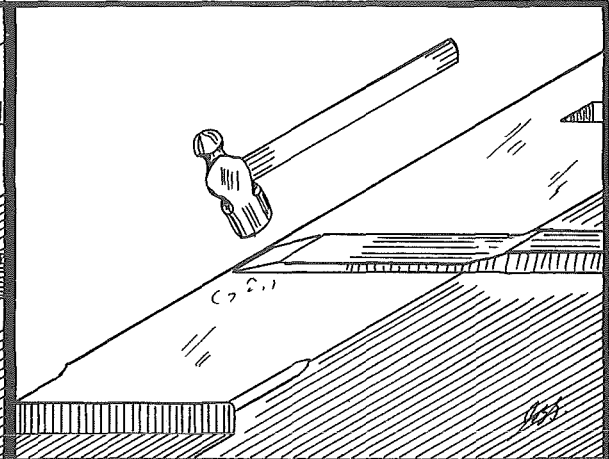


FIGURE 130



match and also tapered, and then partly cut through, leaving enough length to substitute for worn-out steel. If in doubt, leave a little extra. Using either borax or a sand/borax mixture such as flux, weld the two pieces together (Fig. 128B). The cutting edge is then drawn out using a fuller, followed by flatter or hand hammer (Fig. 131). The end is then trimmed to the point angle, usually 35 to 40 degrees (Fig. 132). Straighten and normalize. If spring steel or similar material has been used, heat the cutting edge to dull red and quench in oil. This hardens the edge, leaving the back softer and tougher. Any filing should be done before hardening.

Instead of welding, the coultter can be cut off (Fig. 133A) and a piece cut to the shape of Fig. 133B. Forge it (Fig. 133C), drill or punch holes, and rivet it to the old stem (Fig. 134). Use 10-mm rivets, hammering them in while hot. Heat treatment is as before.

FIGURE 131

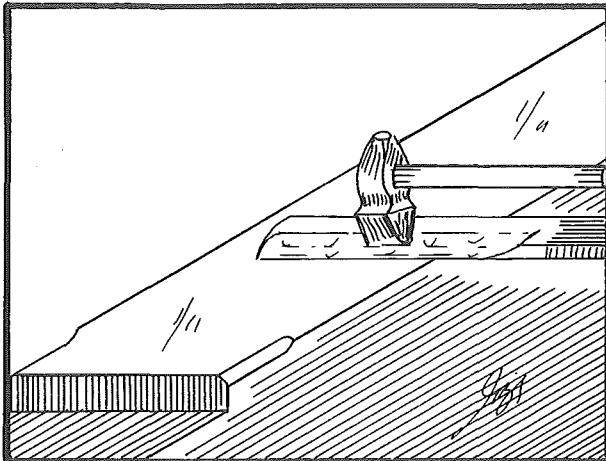


FIGURE 132

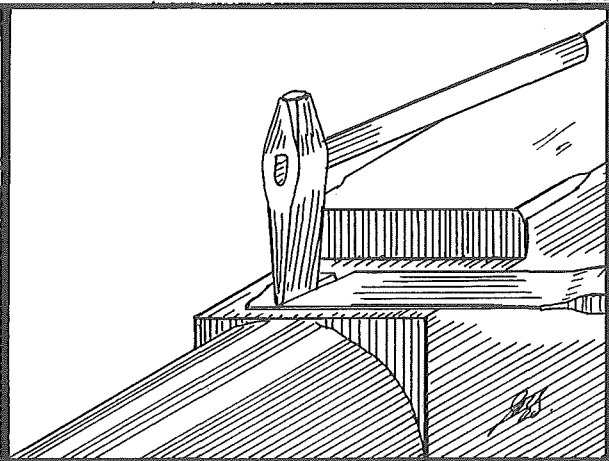


FIGURE 133

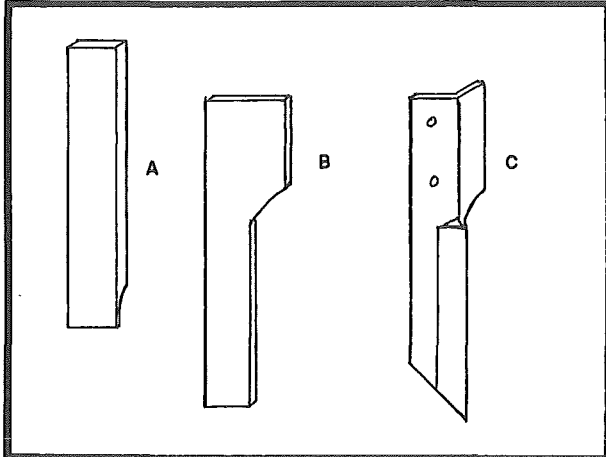
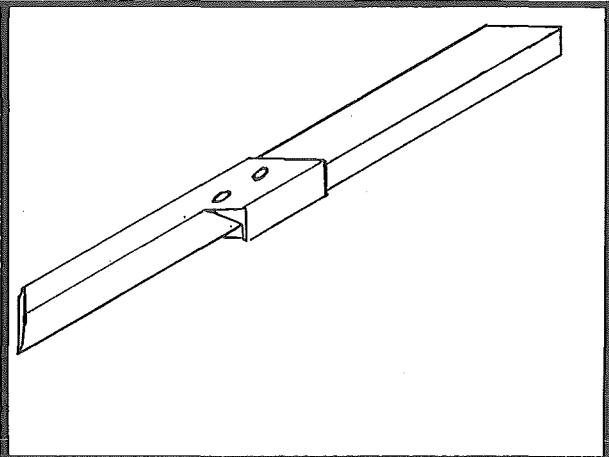


FIGURE 134



17. Plough repairs: handles

Materials. Flat mild-steel bar to match size of plough-handle material.

Additional tools. Punch and drift equal to diameter of bolts used.

METHOD

Plough handles often break at one or the other of the bolt holes used to fix cross stays (Fig. 135B 1 and 2). Such breaks are easily repaired. Heat the broken ends to bright red or yellow and upset (Fig. 137). Scarf both ends (Figs 136B, 137 and 138). Weld together and forge back to original size (Fig. 136C). Mark the position of the bolt hole and punch with a small-ended punch (Fig. 139A), removing minimal material. Work back the

FIGURE 135

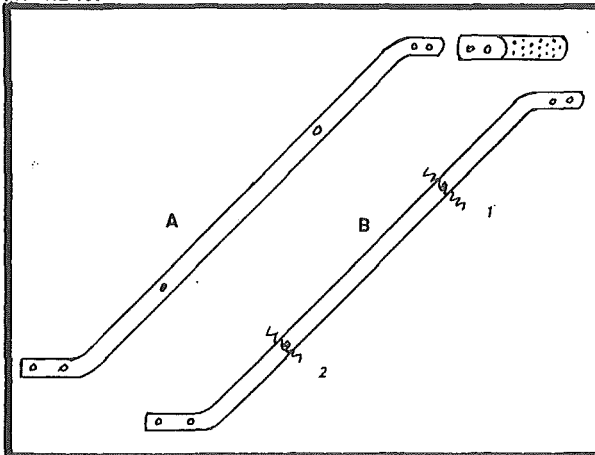


FIGURE 136

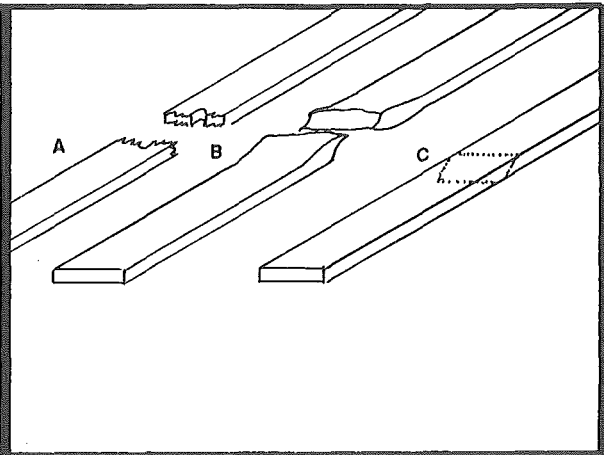


FIGURE 137

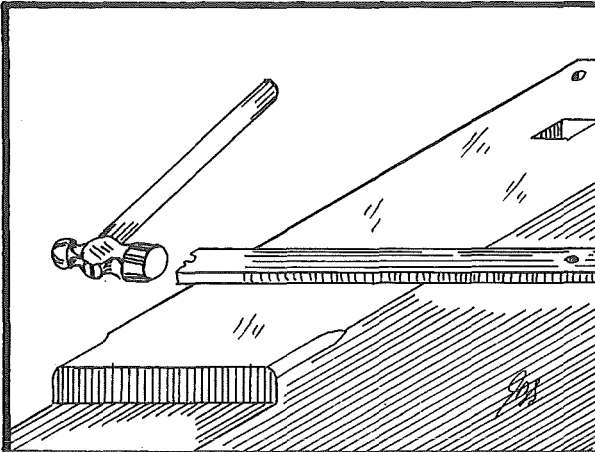
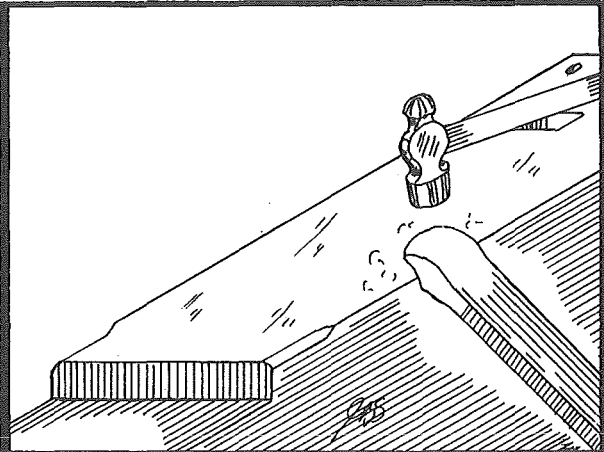


FIGURE 138



material that swells around the hole, then drift the hole to the correct size. Some loss of material will occur, but careful drawing-down with a fuller will correct the length (Fig. 140). The slight loss in thickness will have little effect on strength.

Where welding is not possible a good strong job can be carried out by plating (Figs 141 and 142). The plate needs to be the same width and thickness as the plough handle and about 160 mm long (Fig. 141). The broken ends are forged straight so as to fit together neatly. Slightly bevel the ends of the repair plate, then drill or punch the holes: one central hole to fit the bolt (you will need a longer one to go through two thicknesses of metal) and two on each side of it for rivets, 6 to 8 mm in diameter. Mark these holes on the broken pieces and punch or drill to match. Rivets are pieces of rod cut off to allow at least the thickness of the rod extra at each side of the holes to form rivet heads. Riveting can be done cold or the rivets can be heated to yellow, inserted and hammered while hot. The finished repair is shown in Fig. 142.

FIGURE 139

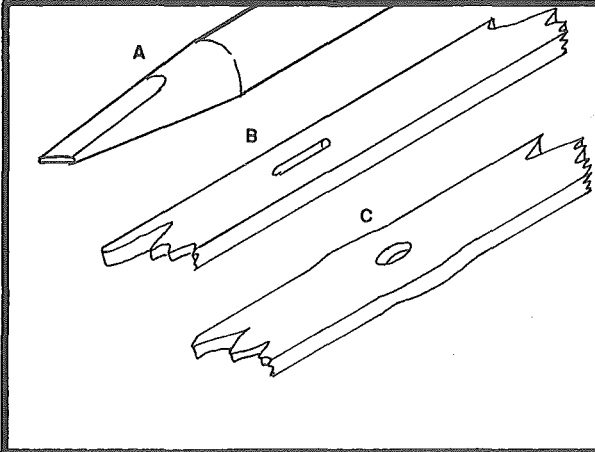


FIGURE 140

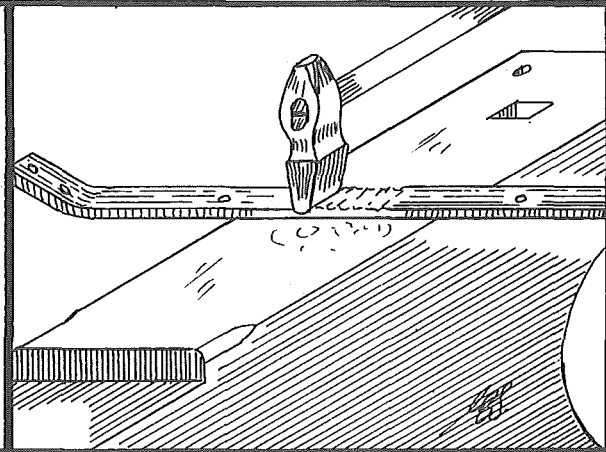


FIGURE 141

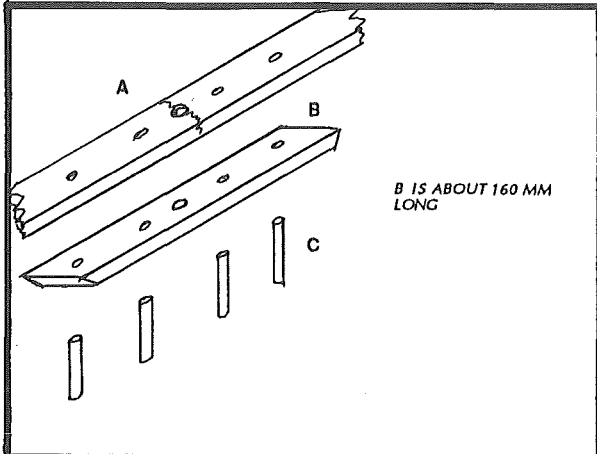
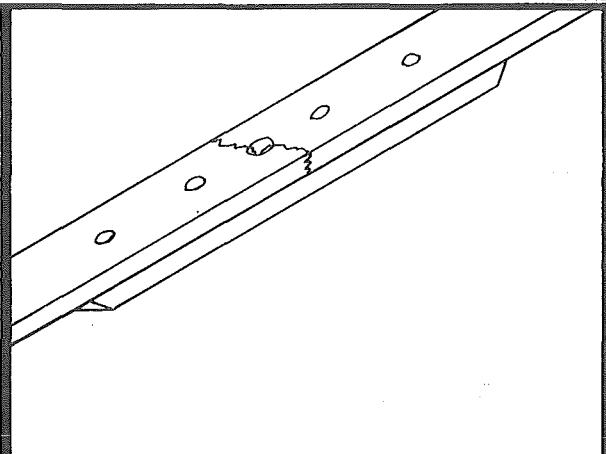


FIGURE 142



18. Plough repairs: plough beams

Materials. None are required.

Additional tools. Large drifts.

METHOD

Solid plough beams of flat or I section can be straightened fairly easily on a normal anvil. Unless beams are severely bent, corrections can be made cold. Severe bends will require heating, but this must be kept to a minimum and just to red heat. Use a heavy sledgehammer with a larger fuller to direct the blows accurately. Make sure that heating is in the correct place, that is, where the metal has to be moved.

FIGURE 143

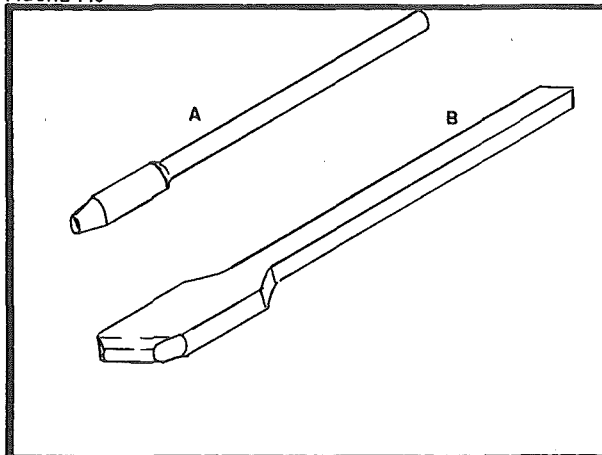


FIGURE 144

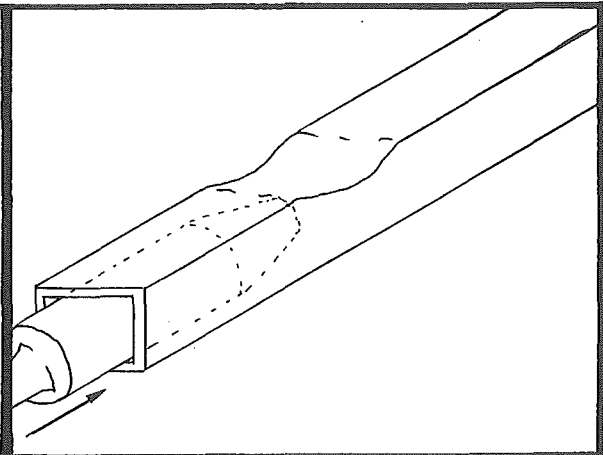


FIGURE 145

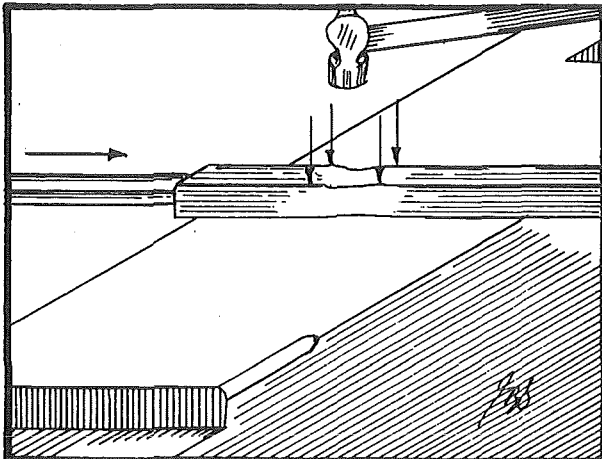
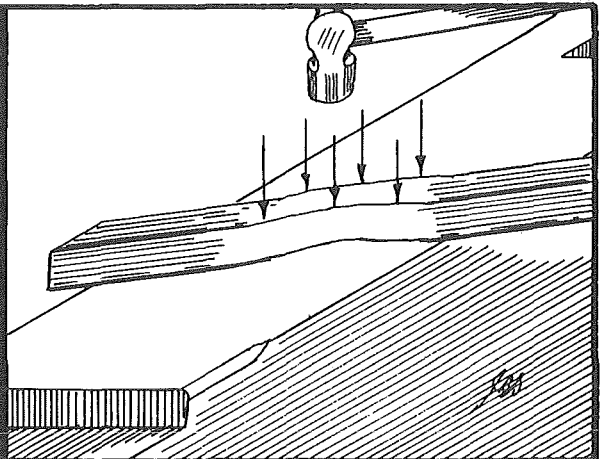


FIGURE 146



With many modern lightweight ploughs the beams are of square or rectangular hollow-section steel. Such sections do present some difficulty in working on an anvil. Where denting or creasing has occurred, use a drift or mandrel similar to those in Fig. 143. For correcting square hollow sections, a drift like that in Fig. 143A can be used. For a 25 x 25-mm hollow section with 3-mm walls, the drift should be 19 mm in diameter. A piece of bar 16 to 18 mm in diameter can be upset, then tapered as shown. Its length must be sufficient for it to pass through the work to beyond the damage. Apply a little grease and hammer the drift into the work, raising the dented sides.

For rectangular hollow sections make a flat drift like Fig. 143B. It must be an easy fit into the work and can, again, be hammered into the work with a little grease applied (Figs 144 and 145).

If corrections cannot be made to the work in its cold condition, heat slightly but only just to red heat and try again. If, as often happens, the drift gets wedged in the work, hammer the beam on the flat of the anvil at the position of the stuck drift in order to stretch the metal slightly and loosen the drift. Hollow sections can often be straightened out by hammering on the outside edges of the work (Fig. 146). Occasionally slight heating may be needed, but keep this to a minimum.

19. Plough repairs: depth wheels

Materials. Mild-steel flat bar 12 to 16 mm thick x 30 to 40 mm wide x about 300 mm long for jig-making; round bar of same diameter as pipe used for centre hub, usually about 25 mm in diameter, sufficient for centre stud of jig plus enough for drift (above 150 mm).

Additional tools. Slot punch; drift to match size of pipe used for centre hub; round-end punch.

METHOD

Badly worn depth (or gauge) wheels are often very difficult to repair, particularly when made of cast iron. With worn-out steel wheels, some use can often be

made of the materials.

Simple depth wheels are fairly easily made by a competent smith. The method indicated here has been well tested and gives good results. Figure 147 shows the component parts of the wheel: A and C form spokes, B the rim and D and E the hub.

An assembled wheel is shown in Fig. 148. The rim is made of mild steel 30 to 40 mm wide and about 6 mm thick. Measure the outside diameter required, deduct one thickness of metal and multiply by 3.14 or 22/7. Take the metal thickness as 6 mm and the outside diameter of the wheel as 250 mm and we will need: $250 - 6 \times 3.14 = 766.16$ mm of metal, say, 766 mm. Cut

FIGURE 147

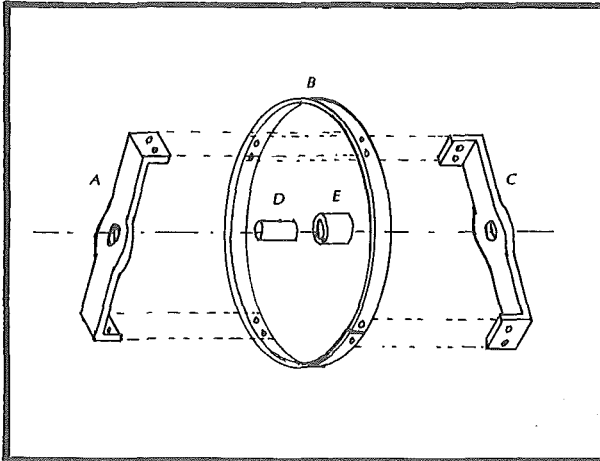


FIGURE 148

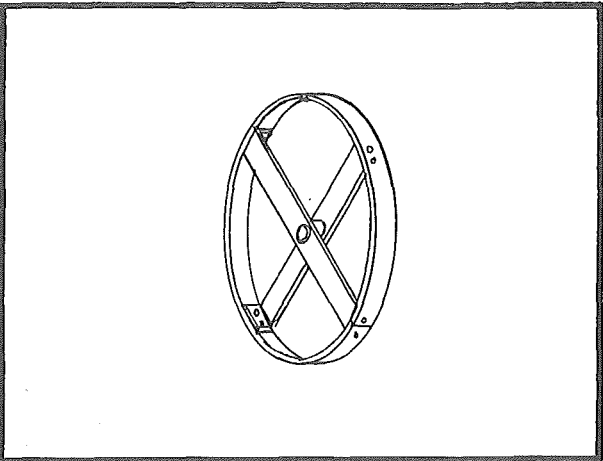


FIGURE 149

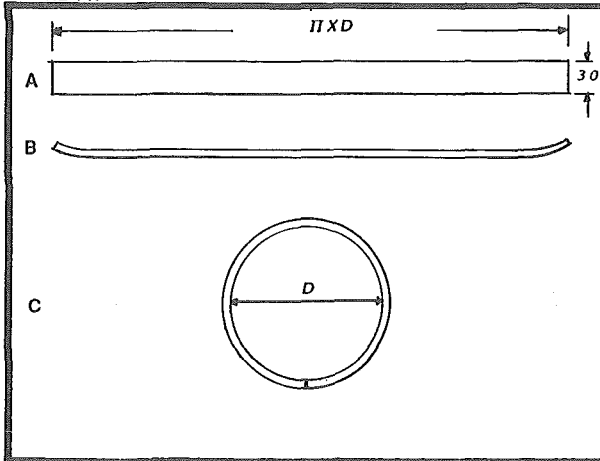
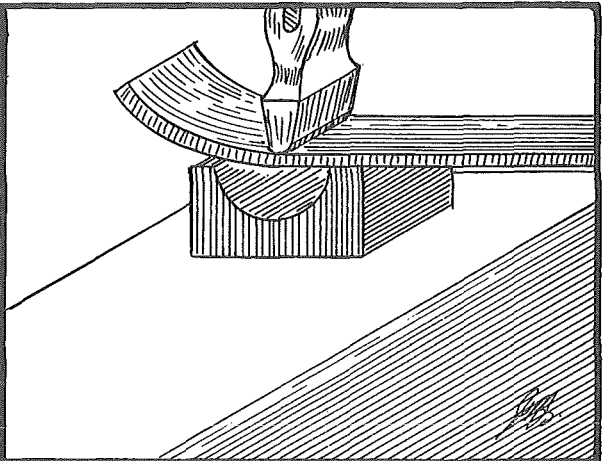


FIGURE 150



off a piece of bar of the required length, keeping the ends as square as possible. Scribe a circle on a piece of sheet metal or wooden board equal to the outside diameter of the wheel, and this will act as a guide when bending the wheel rim. Bend each end a little (Fig. 149), then continue bending with a fuller and light hammer blows (Fig. 150). Check from time to time against the scribed circle and correct as needed. This bending is carried out with the metal cold. Make sure that the ends meet up neatly and that the newly made rim is not distorted but lies properly on a flat surface. (Sometimes an old wheel rim can be used as a guide.)

Next a jig is needed (Fig. 151) to help in assembling the wheel. To get extra thickness on the top end of the jig the metal can be bent over. This end is then given a radius equal to the inside diameter of the wheel minus *two* thicknesses of metal. Finish this curve neatly by filing. A peg is fitted into this bar of metal at a distance from the top of the radius equal to the radius of the wheel minus *one* thickness of metal. This peg is of the same diameter as the pipe used as an inner hub. It can be

riveted into place or fixed with a screwed stud. The length of this peg need be only about 20 mm.

Two pieces of metal are cut off for the spokes. These should be equal to the diameter of the wheel plus twice the width of the metal used for the rim. Mark the centres carefully, then heat and punch slot holes in each (Fig. 152B). The slot should be about 22 mm long. Open these slots out to the same diameter as the pipe for the hub by using a drift. Make the hole a neat fit on to the pipe. The ends of these spokes are heated, the piece slipped on to the jig peg and the hot end bent over (Fig. 154). The bent end should be formed to the radius of the jig and be at right angles to the main body of the spoke. Do the same for all four spoke ends.

The two short pieces of pipe are now needed. The smaller should have an inside diameter to take the axle pin, while the other should fit over it. Cut off the larger-diameter pipe to a length equal to the width of the wheel rim minus the thickness of the spokes and make sure that the ends are at right angles to the centre line. Cut off the smaller-diameter pipe to a length that will pass

FIGURE 151

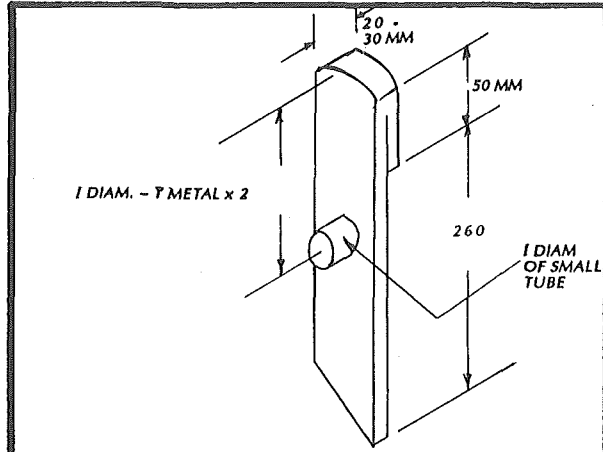


FIGURE 152

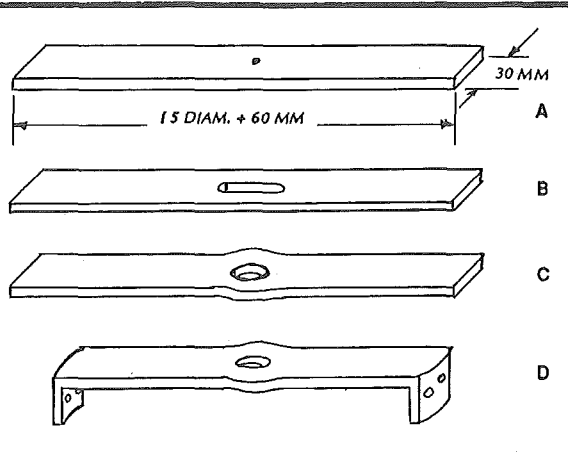


FIGURE 153

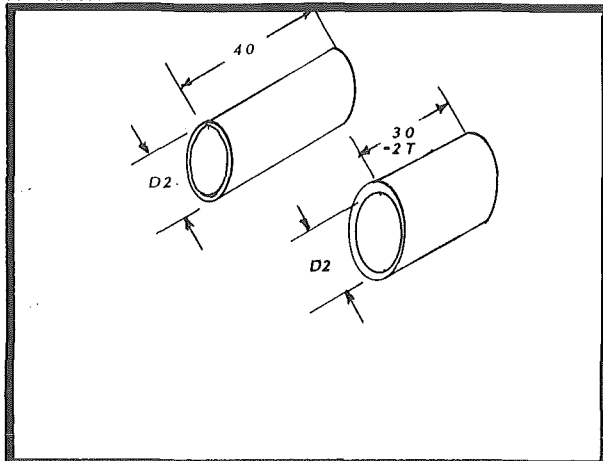
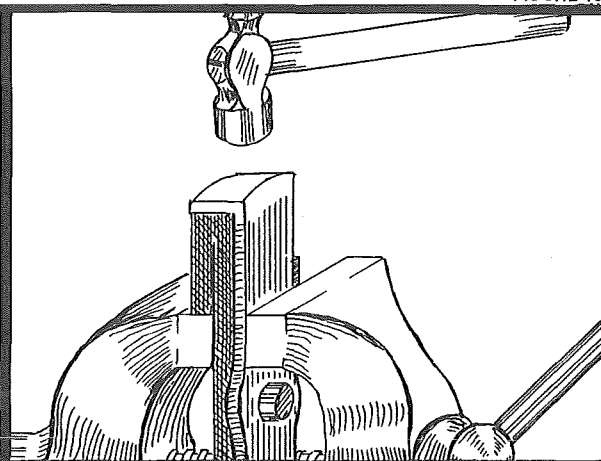


FIGURE 154



through the spokes with the other piece between them, and leave 4 to 6 mm protruding on either side. This piece must also have ends at right angles to the centre line. Figure 153 gives a guide as to lengths.

Assemble the spokes within the rim with the pieces of pipe in position and hammer from both sides (Fig. 156) using the punch (Fig. 155). The hub assembly is shown in Fig. 157. Make sure the spokes are at right angles to each other. Correct any errors, correctly position the spokes within the rim, clamp into place and drill two small rivet holes 6 mm in diameter in each spoke end and through the rim. The joint in the rim is spanned by one spoke end and fixed by two of the rivets. If possible, clamp and drill holes in one spoke end and fix with temporary bolts while drilling the next, and so on. Rivet holes should be countersunk on the outer rim. The riveting can be done cold.

When axle pins require renewing, this is merely a matter of forming a shoulder on to a suitably sized piece of bar and inserting it in place of the worn one. The wheel can be held in place with a washer and split cotter.

FIGURE 155

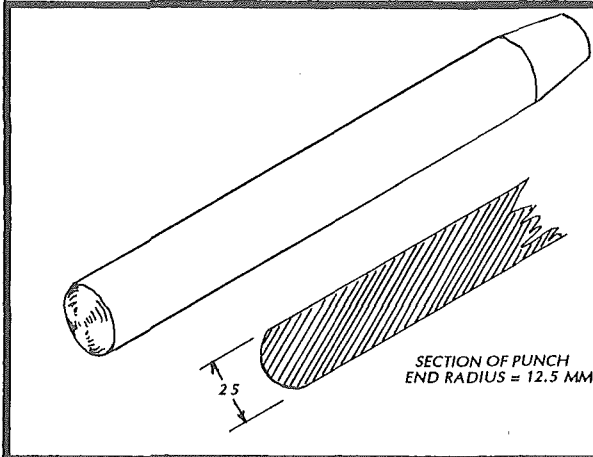


FIGURE 156

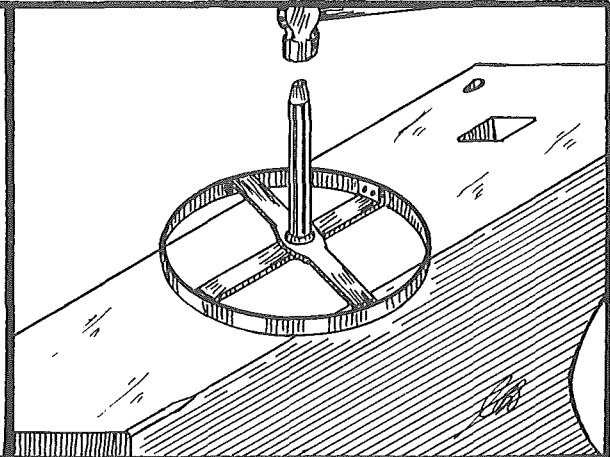


FIGURE 157

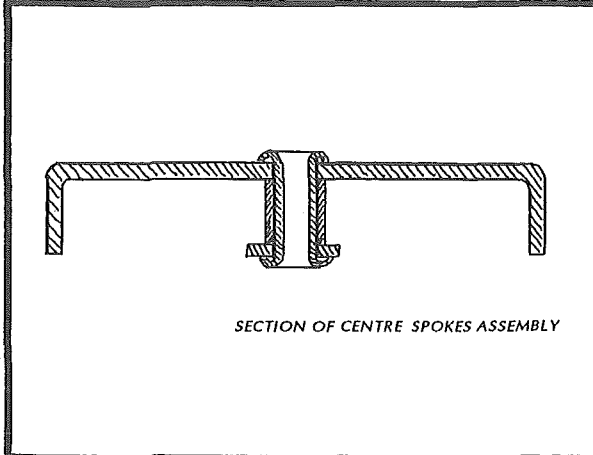
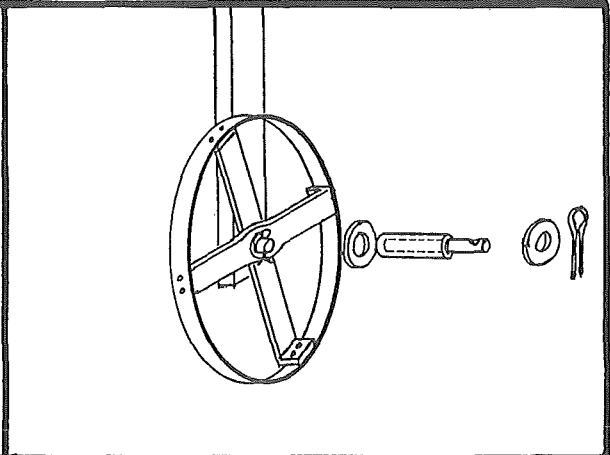


FIGURE 158



20. Harrow repairs: repairing spike-harrow tines

Materials. Scrap mild-steel square section of same size as worn-out tine or odd bits to forge to this size.

Additional tools. No special tools are needed.

METHOD

Spike-harrow tines are usually made from 10-, 12-, 15- or 18-mm square-section mild steel. Examples shown in Fig. 159 are: straight tine (A); tine with buttressed shoulder (B); angled tine (C); and worn-out tine (D). Figure 160 shows the end of a tine ready for screw-threading.

If thread ends are bent they can be heated, placed on

FIGURE 159

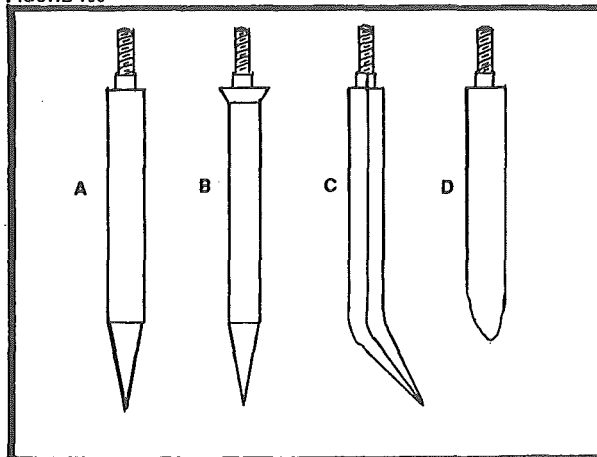
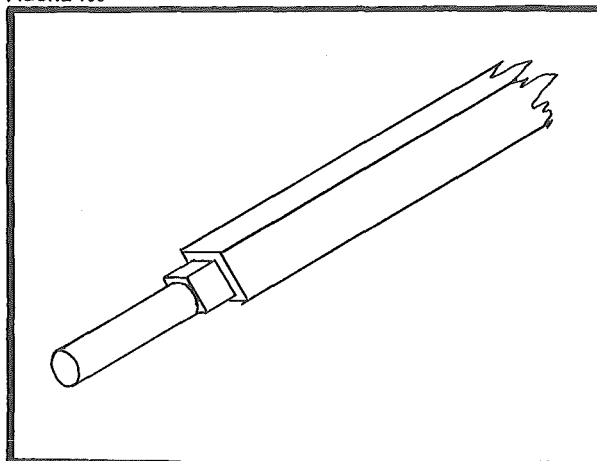


FIGURE 160



a hardwood block and straightened by hammering with a hardwood mallet. If worn, they can be upset, reformed to size and rethreaded.

Repairing the working end of tines is a large part of the work needed on harrows. The worn tine is forged to a flat point (Fig. 161) and a small new piece forged as shown, about 50 mm long. Use an old pair of tongs to hold the tine and new piece (Fig. 162). Keep tongs as far from the end and take a light welding heat on the end of the tine and the new piece, without overheating the tongs, and weld the two together. Stop hammering as soon as they are stuck together.

Cool the tongs and use another pair to grasp the top of the tine. Take a full welding heat and complete the weld. Draw-down the piece to a point and quench in water (Figs. 163 and 164).

FIGURE 161

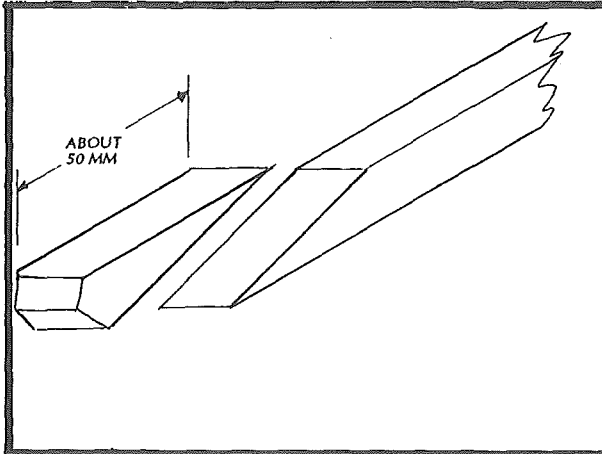


FIGURE 162

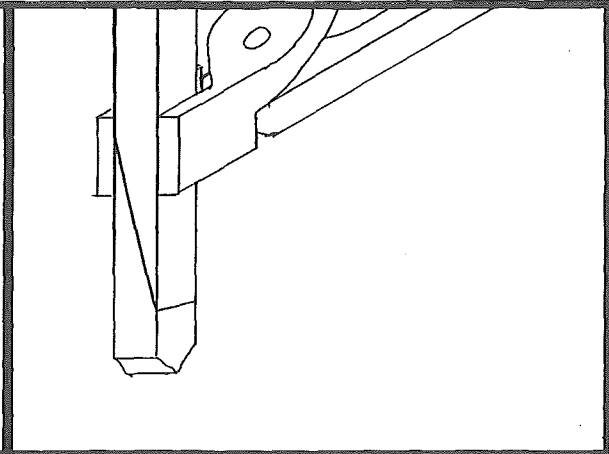


FIGURE 163

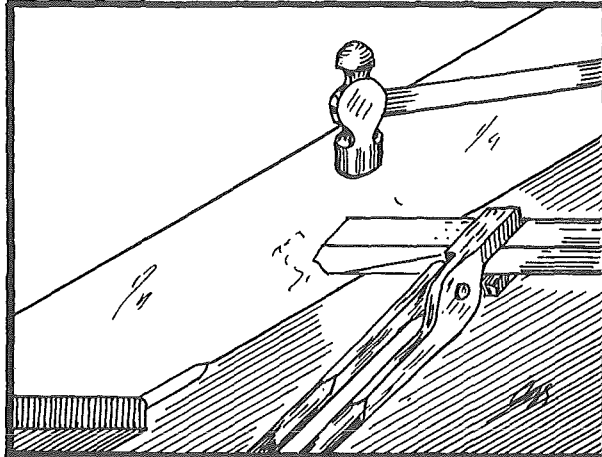
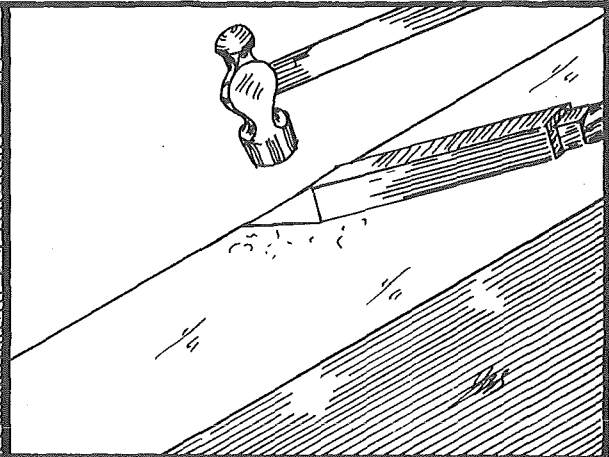


FIGURE 164



21. Harrow repairs: making spike-harrow tines

Materials. Mild-steel square section equal to size of tines to be replaced, usually from 10 to 18 mm square.

Additional tools. Bolster plate; top and bottom swages to fit tip for threading.

METHOD

When tines are too badly worn to allow reforging, new tines can be made. Where material is scarce, two old tines can often be combined to make one new one if welded together and drawn out to the correct section. Where a number of tines are to be made, a good supply of the correct material is essential.

To form good clean shoulders on tines, a bolster plate (Fig. 165) is needed. This is easily made by punching and drifting square holes in a piece of heavy spring steel. The raised edges around the holes are obtained by doing most of the punching and drifting from one side of the plate. A little filing might be needed after forging.

Figure 166 shows the steps in making a standard tine. Dimension X is decided by the size of material used in the harrow under repair. Length Y is the finished length of the tine plus about 20 mm. It is best to make one to check the exact length of material needed. The measurement given for the length of thread ends is

FIGURE 165

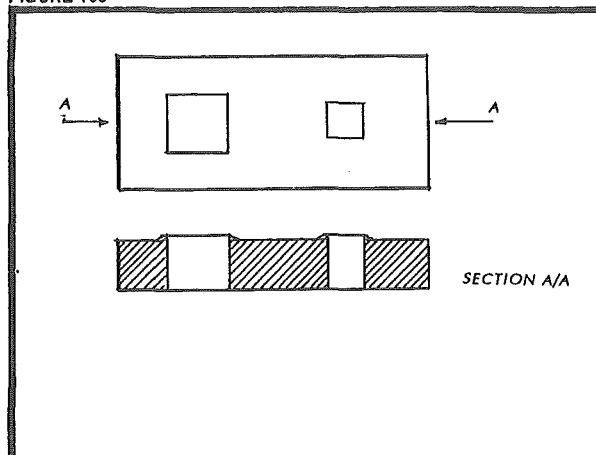
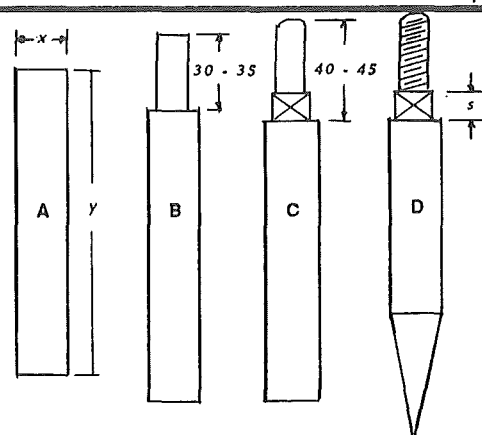


FIGURE 166



variable, depending on how many bars of the frame the tines pass through, plus enough for a nut and lock washer. The measurement *S* in Fig. 166D should be slightly less than the thickness of bar through which the tine passes to allow maximum tightening of the nuts.

To make the tine, heat one end of the length to a good red heat and square it up with the set hammer (Fig. 167). While it is still hot, put the heated end over the large hole of the bolster plate (placed over the tool hole of the anvil) and hammer it straight down in order to make the large shoulder (Fig. 168). Reheat and hammer the shouldered end into the small hole (now over the tool hole) of the bolster plate to make the small shoulder. With the flatter, forge the small tip into an octagonal shape (Fig. 169) and then, using the top and bottom swages, hammer it round (Fig. 170), checking for size with a hole gauge. Reheat the rounded end and slightly chamfer the tip (Fig. 171) to allow easy starting of the screwing die.

If a number of tines are to be made, it is a good idea to allow cooling at this stage while the same operations

FIGURE 167

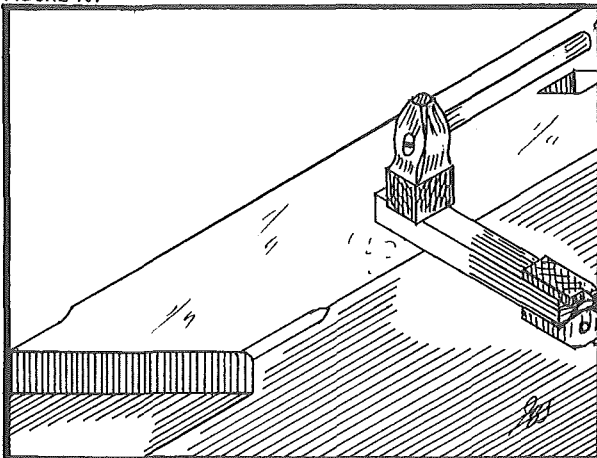


FIGURE 168

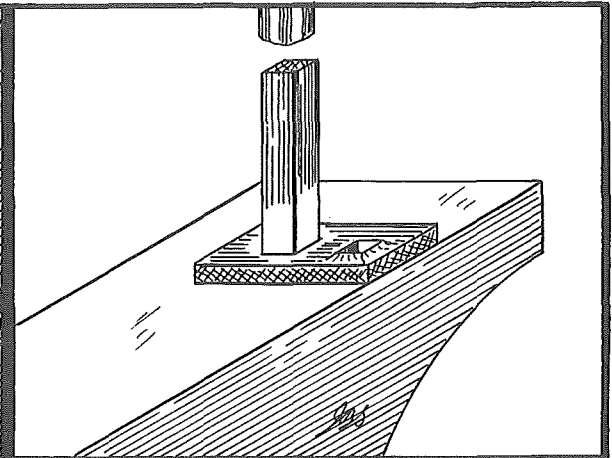


FIGURE 169

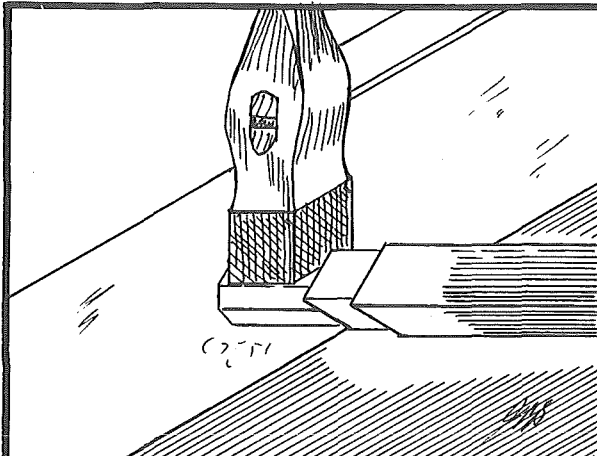
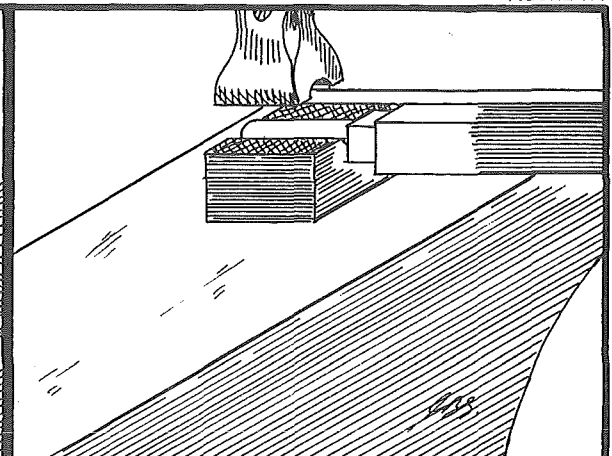


FIGURE 170



are carried out on the next tine. To be efficient, a skilled smith will work one tine while the next one is heating at each stage.

The next step is to draw the point on the working end. The metal will increase in length by 12 to 20 mm, depending on the size of the tine, and allowance must be made for this. Once a true length is known, it is easy to cut off lengths and to make finished tines the same length each time. Pointing the working end is a straightforward operation (Fig. 172). Quench the pointed end in water while still hot to increase its hardness. It is important that tines are a good neat fit into the harrow bars. Poorly made, badly fitting tines are soon bent, broken or lost.

Tines can be fastened (Fig. 173) by putting a sheet-metal locking washer between the harrow frame and nut, with its sides or corners hammered against the frame and nut to prevent loosening of the nut.

If nuts have to be made, these can be fashioned from flat mild-steel bar. For a 12-mm thread the nut can be made of steel 22 mm wide x 12 to 16 mm thick. If

possible the holes should be drilled and then tapped with the thread.

Alternatively, by using a punch and drift (Figs 174A and B), holes can be punched then drifted to size. A drift of a little under 9 mm in diameter will serve for a 12-mm thread. After punching and drifting, the nuts can be cut off the bar using a hacksaw or sharp hot set. A tap, as in Job 10, will serve if only a limited number of nuts are to be made. If it is difficult to make a drift the correct size, use a nut as a gauge. The drift should fit tightly into the nut. Final drifting of holes in nuts should be done only at a dull red heat with a little grease on the drift.

FIGURE 171

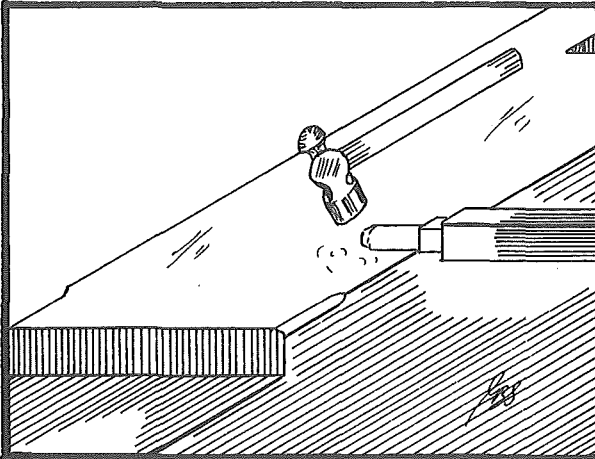


FIGURE 172

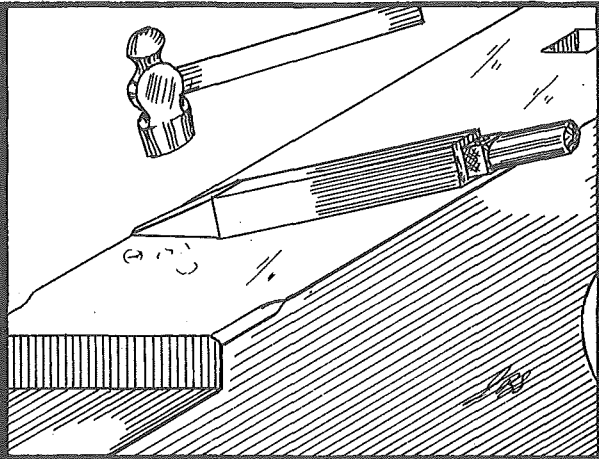


FIGURE 173

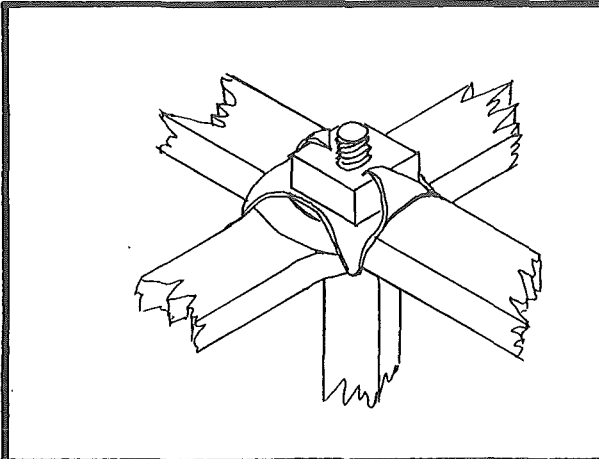
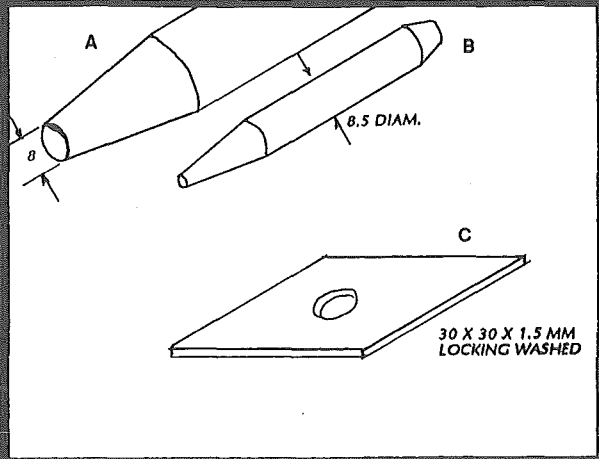


FIGURE 174



22. Harrow repairs: repairing or making harrow-frame bars

Materials. Mild-steel flat bar or square section to match existing frame bars.

Additional tools. Combination flat-to-round and flat-to-square punches; marking gauge; for heavy frame bars, both round and square slot punches and drifts.

METHOD

Harrow-frame bars are usually of flat or square section. Holes are punched so as to leave as much material as possible around the holes. Lower bars are punched with square holes, while the upper bars have round holes (Fig. 176). Holes can be punched with combination

FIGURE 175

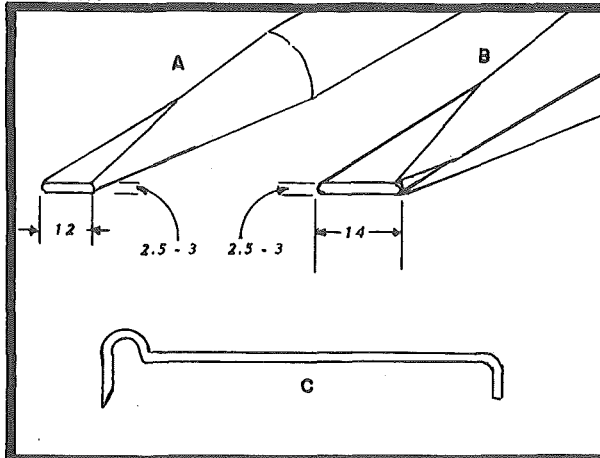


FIGURE 176

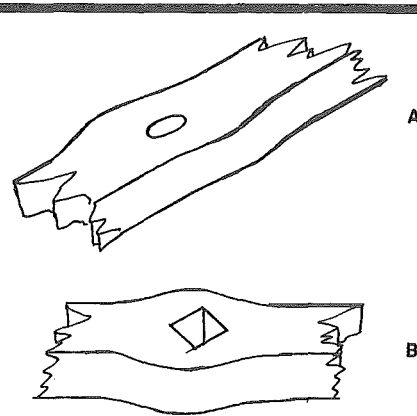


FIGURE 177

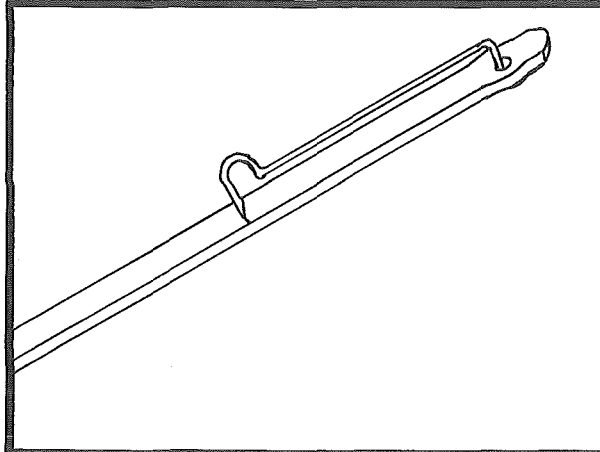
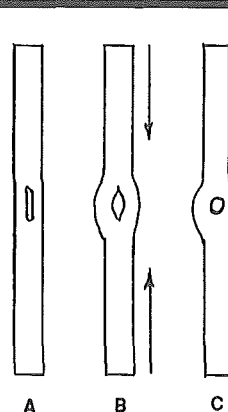


FIGURE 178



punches as shown in Fig. 175. These punch a slot, then open the slot out to round or square holes. Some smiths prefer to use slot punches followed by drifts, but this is more appropriate to working heavy-section bars. Punches are used from both sides of a bar. Bars must be straightened after each hole is punched. Frame bars often break through one of the tine holes. These can be repaired like the plough-handle repair in Job 17. Hole centres must be correct after repair.

When new bars are required, a scribe gauge (Fig. 175C) must be made. One hole is punched, then the next hole centre-marked with the gauge as in Fig. 177. In this way accurate centres can be maintained.

When slot punches and drifts are used, the procedure for punching is as in Fig. 178. Mark the centre, punch the slot (A), upset to open the slot (B), then drift to size and shape (C). All operations are straightforward smithing operations.

23. Harrow repairs: draught hooks

Materials. Small pieces of scrap mild steel or round or square section 12 to 16 mm.

Additional tools. No special tools needed.

METHOD

Making new draught hooks is simply a matter of drawing-down, bending and punching; however, repairs must be done in a workmanlike manner as a considerable amount of material is required. One of two methods is usually adopted (Figs 179 and 180). The damaged hook is removed from its frame, heated and straightened (Fig. 179B). A small piece of scrap mild steel 30 to 40 mm long, about 12 to 14 mm wide and 6 to 8 mm thick is shaped (Fig. 179B). This is placed in position (Fig. 179C) with the hook bent tightly around the piece, trapping it in place. A full welding heat is taken and the whole welded up into a solid mass then drawn-down (Fig. 179D). The hook is then reshaped and installed. An alternative procedure is shown in Fig. 180. The worn hook is straightened out and cut off about 50 mm from the shoulder, upset and scarfed. A piece of round or square section of near-matching thickness is also upset and scarfed. The two are welded together, drawn-down to the correct length and reshaped. The alternative to welding is to make new hooks, an exercise that only requires drawing-down, bending and punching holes.

FIGURE 179

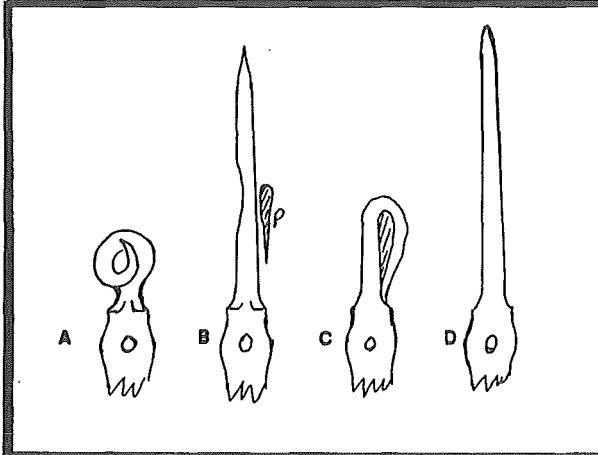
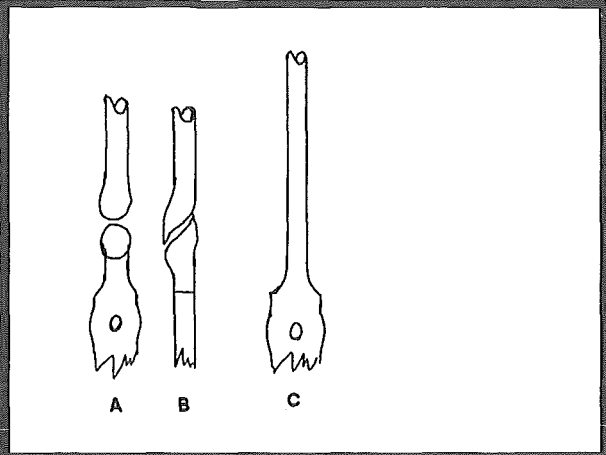


FIGURE 180



24. Harrow repairs: spreader-bar attachments

Materials. Mild-steel flat bar about 30 mm wide x 6 mm thick, length according to diameter of spreader bar; round-section mild-steel rod of 12 to 16 mm in diameter.

Additional tools. No special tools needed.

METHOD

Spike harrows are used singly or in gangs of two or three or more, according to the draught power available. With animal draught one or two units are most common. Figure 181 shows a typical arrangement for towing a pair of harrows. The attachment fitting for towing rods is illustrated at A. Similar fittings are used for attaching

the harrows: a centre towing rod (B); a linkage ring for rods and towing harness (C); and side bracing rods (D). The linkage ring must be central and, as indicated, set at a distance from the spreader bar equal to about one-quarter of the spreader bar length. Rings, rods and chain links need no explanation, except to say that the eyes on the rods are merely bent and closed up and not welded (Figs 182B and D). Chain links and rings should be welded.

As timber is most commonly used for spreader bars, making suitable attachments is important. The type described here fits around the timber and presents a large surface area to the timber. No weakening holes are

FIGURE 181

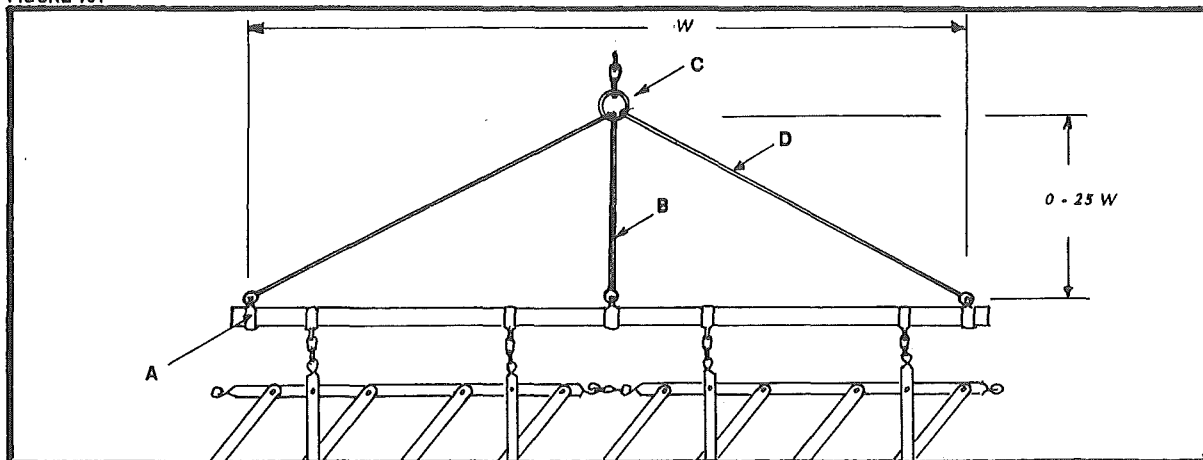


FIGURE 182

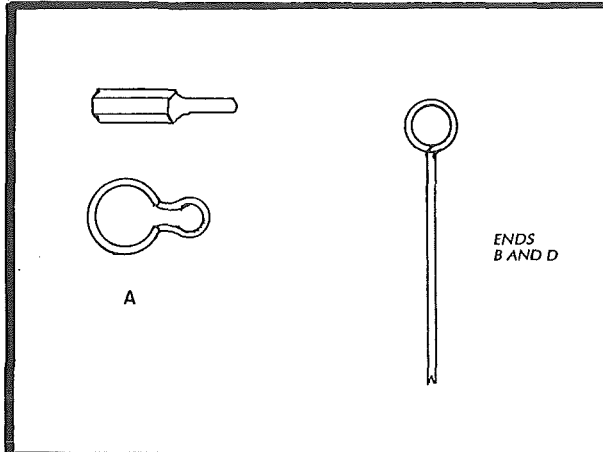
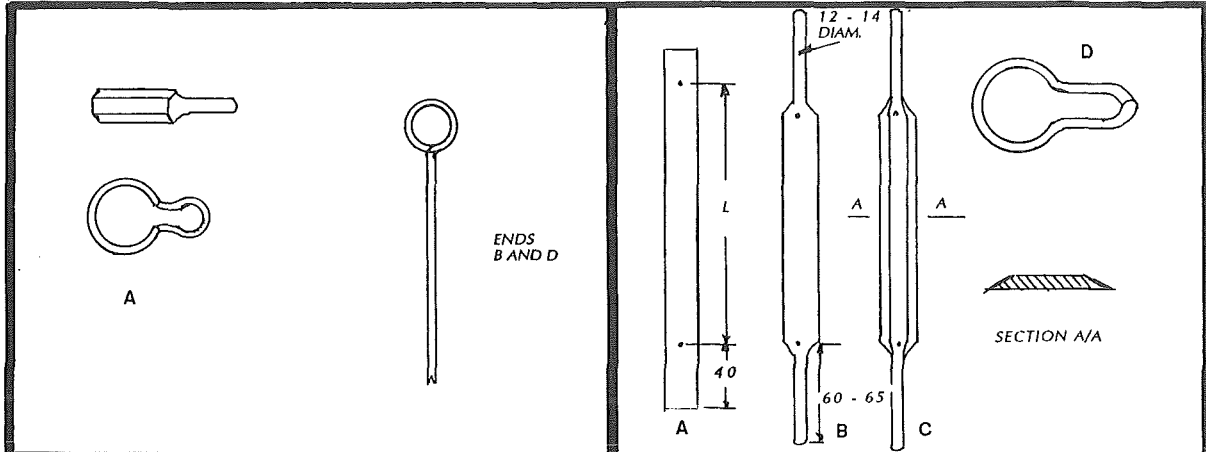


FIGURE 183



present, as is the case where eye-bolts are used. Figure 182A gives an idea of the completed link attachment while Fig. 183 shows the steps in making the piece. Material length is calculated by simply measuring around the timber and deducting about 25 mm. That is near enough for length L in Fig. 183A. Add 40 mm or so to each end and cut off the length of steel required.

Mark with a centre punch 40 mm from each end. Heat one end and crease with the ball of the hammer as in Fig. 184, making use of the anvil step. This can also be done with a bottom swage and top fuller. Close up the fold in the metal as in Fig. 185, take a full welding heat and weld the fold while forging to a round or near-round section (Fig. 186). Reheat the flat back from the shoulder and thin down the edges as in Fig. 187. Reverse the piece and carry out the same operation on the other end.

Reheat the flat centre section to a good red heat and bend over the beak to the approximate curvature of the timber. Prepare the forged ends for welding as for a chain link, inserting the attachment links (Fig. 188).

FIGURE 184

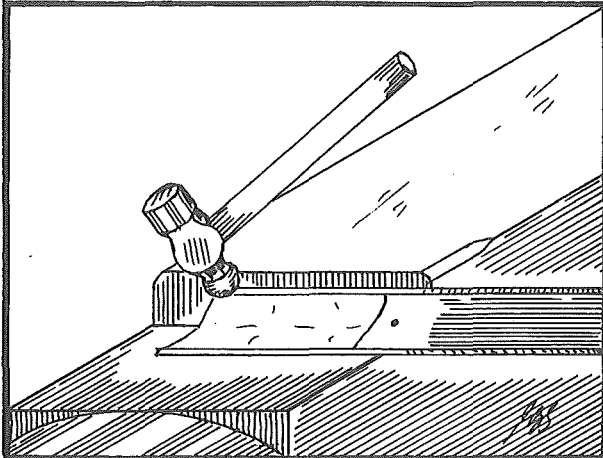


FIGURE 185

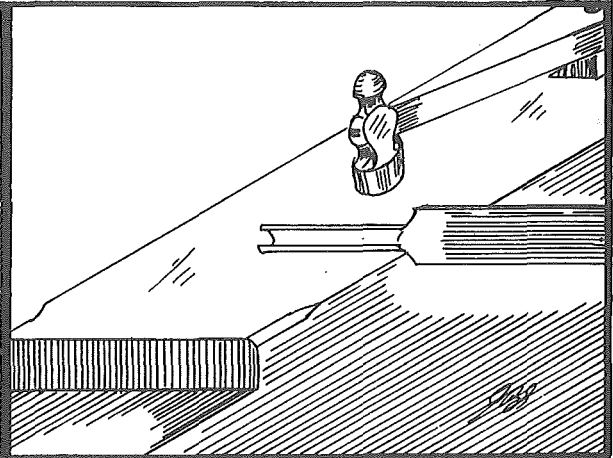


FIGURE 186

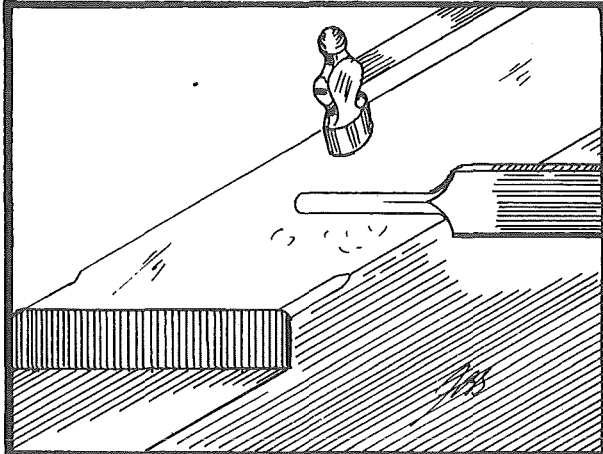
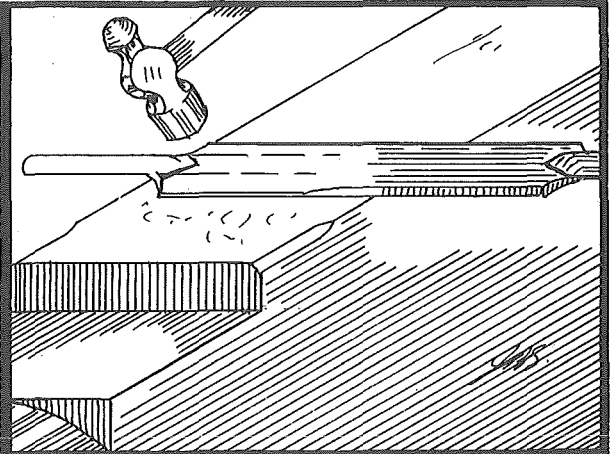


FIGURE 187



Weld up and shape so that the attachment piece will just slip over the timber to its correct position. The positions of all attachment fittings should be marked on the timber in advance of fixing, but not necessarily before making them. After completing the final shaping, heat to red heat all over and allow to cool slowly.

Fixing is a simple matter. Slip the fitting with its links over the timber to its marked position, then close tightly on to the timber (Fig. 189), using top and bottom fullers or using a hammer over the beak.

FIGURE 188

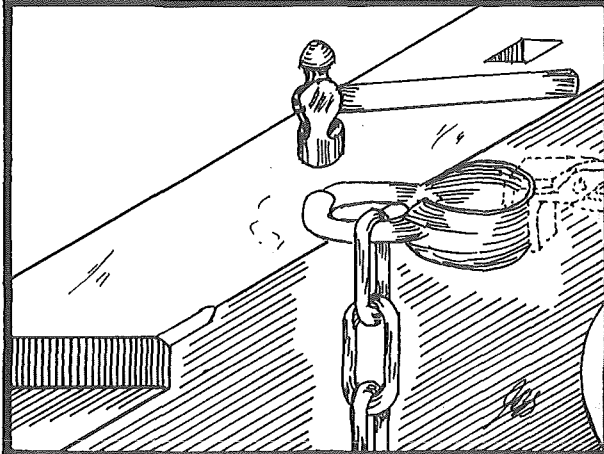
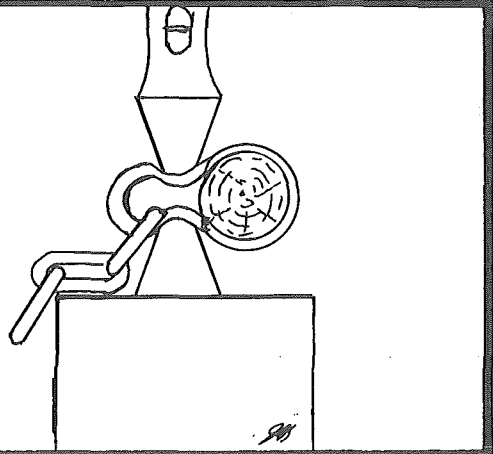


FIGURE 189



25. Ox-pole fittings

Materials. Mild-steel flat bar 40 x 6 mm, 50 x 4 to 6 mm, 35 to 40 x 8 mm; mild-steel round section 12 and 16 mm in diameter, all assorted lengths according to work in hand.

Additional tools. No special tools needed.

METHOD

Ox-pole fittings are many and varied in design, usually dictated by materials and skills available. Here are a few suggestions.

The most common pole is of round-section timber, but the fittings mentioned here can be adapted for other sections. Yoke and other draught attachments are often fastened to eye- or U-bolts passing through the wood.

They function fairly well but often cause the timber to crack or split. This can be avoided in a number of ways. A tightly fitting steel ring driven on to the end of a pole will help prevent cracks (Figs 190 and 191).

Such rings can be made of flat mild-steel bar 40 to 50 mm wide and 6 to 8 mm thick. Take the mean diameter of the required ring in the usual way and calculate the material needed. No allowance is made for welding in this instance. Ends are upset and scarfed (Fig. 190B). Start bending as in Fig. 190C and continue as at D. Weld up over the beak to form a ring. The ring must be a tight drive-on fit to the pole.

Having made no allowance for welding, the ring might be a little undersized; if so, it is a simple matter to heat and draw it out a little over the beak. When fitted

FIGURE 190

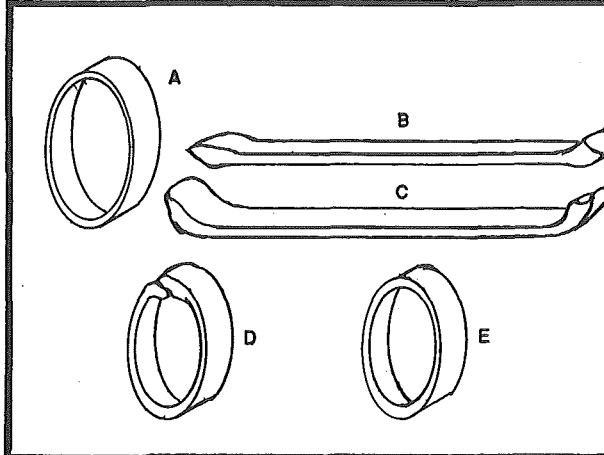


FIGURE 191

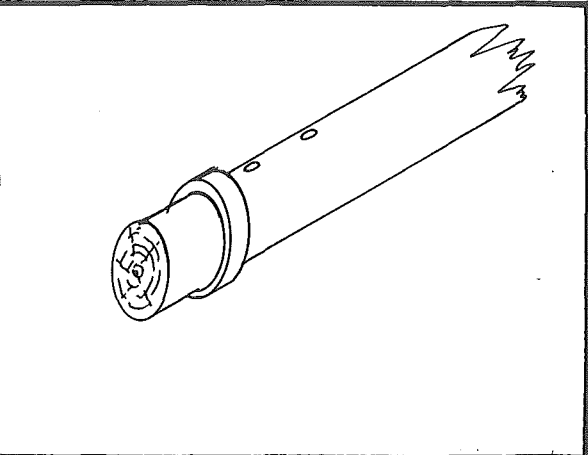


FIGURE 192

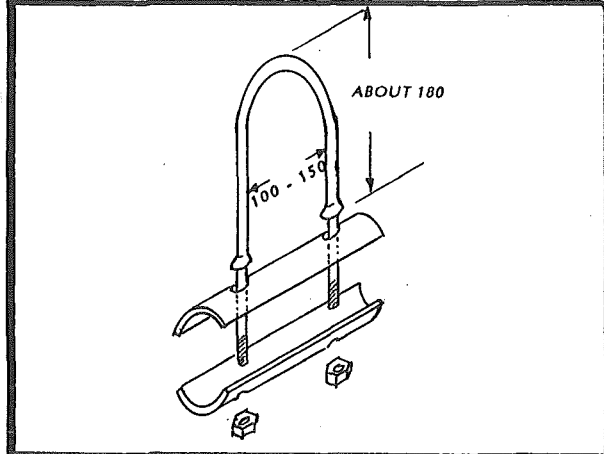
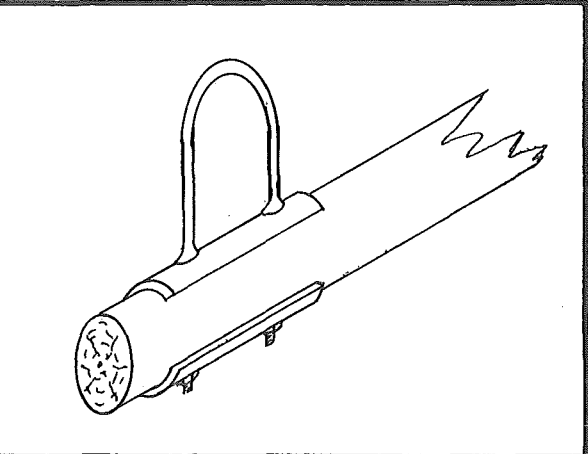


FIGURE 193



to the end of the pole, about 50 mm of pole should extend beyond the ring (Fig. 191).

Any holes for U-bolts or other fittings are bored to the rear of the rim. An improved U-bolt fitting is shown in Figs 192 and 193. The U-bolt is made with shoulders. The screw ends are passed through two plates with the pole between them. The clamping action of the U-bolt and plates makes a very strong fixing. The U-bolt is made as in Fig. 194. Cut off the material. Mark off sufficient length from each end to allow for: thickness of pole + thickness of plates + thickness of nuts + about 25 mm. Mark these shoulder positions with a centre-punch mark and upset at these points to increase the diameter by about 30 percent. Set in over the edge of the anvil using a set hammer as in Fig. 195. Square up the shoulders in a bolster plate as in Fig. 196. Thread the bolt ends, then bend the bolt to shape. Plates should be slightly curved to match the pole. Holes in the plates are punched.

If the work to make the U-bolt is impracticable, an alternative is shown at B in Fig. 197. Eyes that fit neatly

around bolts are formed on each end of a length of rod. The bolts should be about 12 mm in diameter and long enough to pass through the pole, eyes and plates. After forming the eyes, bend the work into a U shape and fix it to the pole with the bolts passing through the plates and pole.

Where a non-rigid fixing is required, something similar to Fig. 198 can be made. It is a clamping ring to fit around the pole, with a large link retained by a bolt that also clamps the ring to the pole. The distance between the corners of the bend can be calculated as for a ring less 20 to 25 mm plus about 80 mm. Two right-angle bends are made as shown, holes are drilled or punched and the bending is then completed. This type of fitting also allows alternatives to the link to be fitted when required.

An efficient fixing of poles to cart cross-members can be seen in Fig. 199. This is an adaptation of the forging method used in Fig. 198. The objective is to provide a strong fixing that does not encourage the timber to split. Deduct 6 to 8 mm from length of U-shape in order to

FIGURE 194

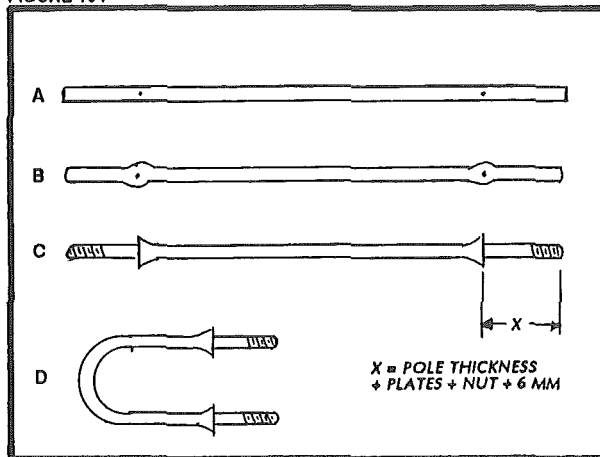


FIGURE 195

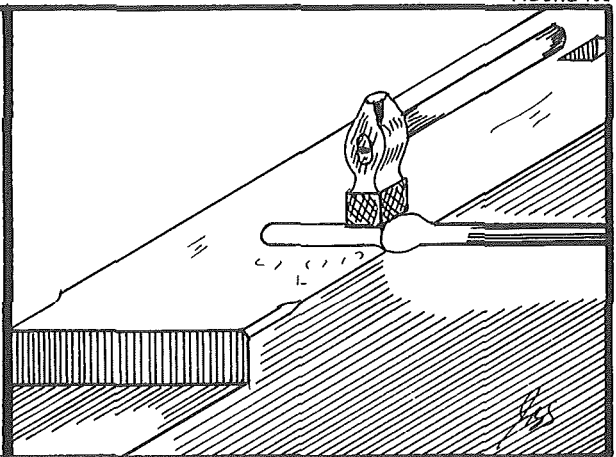


FIGURE 196

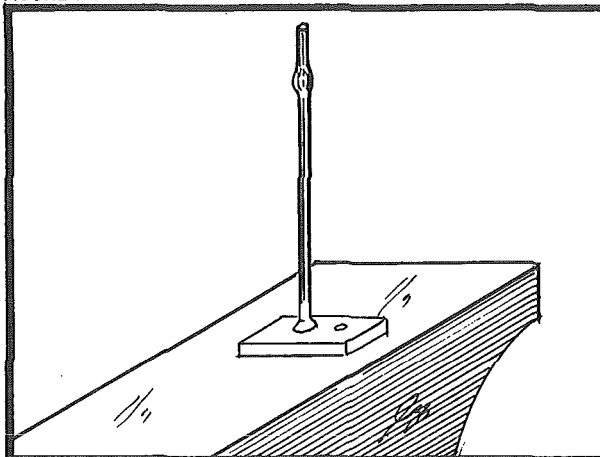
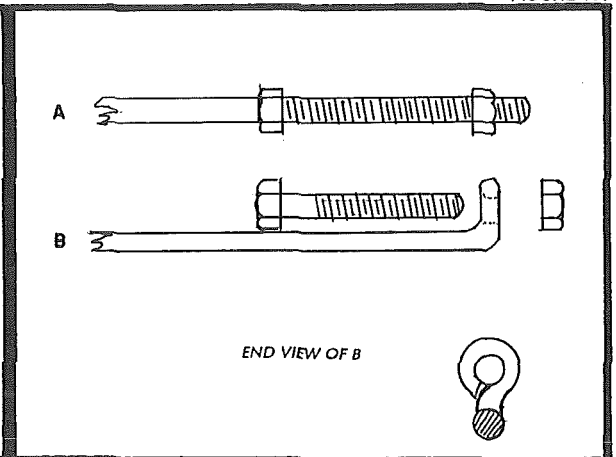


FIGURE 197



permit clamping. Metal should be 40 to 50 mm wide x 8 mm thick with bolts about 12 mm in diameter. Such fittings add to the overall strength of the cart as opposed to bolts passing through both pole and cross-members.

For easy fixing of some types of yoke, and where trek chains are used, a fitting similar to that in Fig. 200 can be made. Two near-semicircular clamps are made in a similar manner to that in Fig. 198. Hooks as in Fig. 200 are forged of 30-mm-wide bar.

This bar should be 8 mm thick. Hooks should be just large enough to take the size of chain-link used. The hook end is drawn-down thin and formed into an eye to take a small ring or link as shown (Fig. 201). This link prevents the chain from slipping off the hooks. Hooks and clamps are held in place by bolts passing through the clamps and hooks. There is some danger of injuring the animals with this type of fitting, so care must be exercised.

FIGURE 198

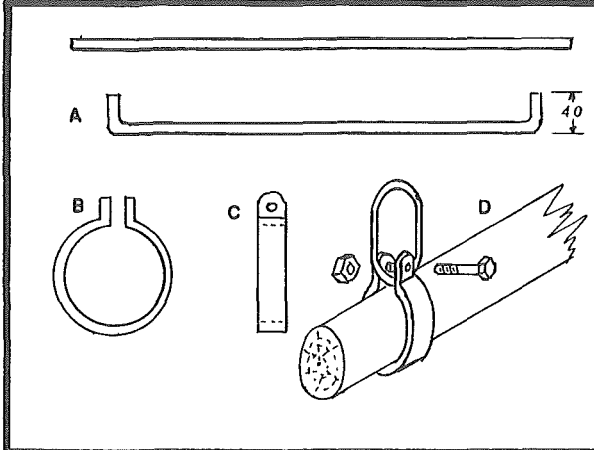


FIGURE 199

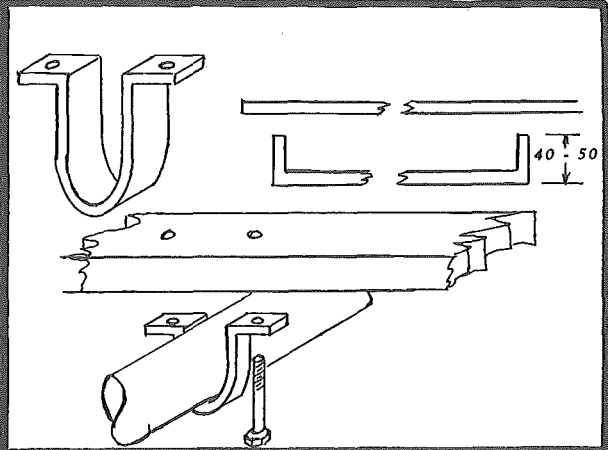


FIGURE 200

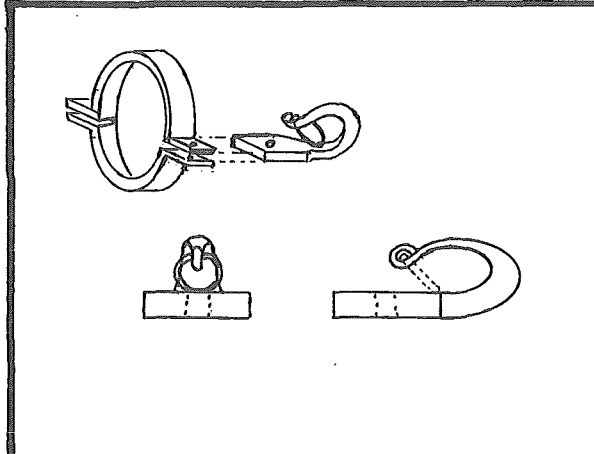
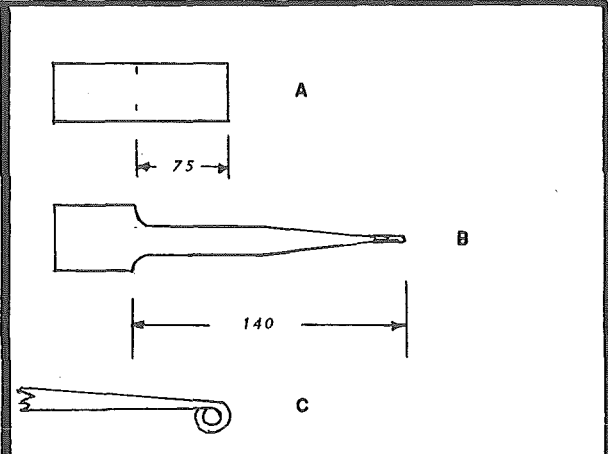


FIGURE 201



26. Ox-cart tailboard fittings

Materials. Round-section mild steel 22 mm in diameter and 16 to 18 mm in diameter; mild-steel flat bar 25 x 6 mm; small pieces of scrap sheet about 2 mm thick.

Additional tools. Slot punch.

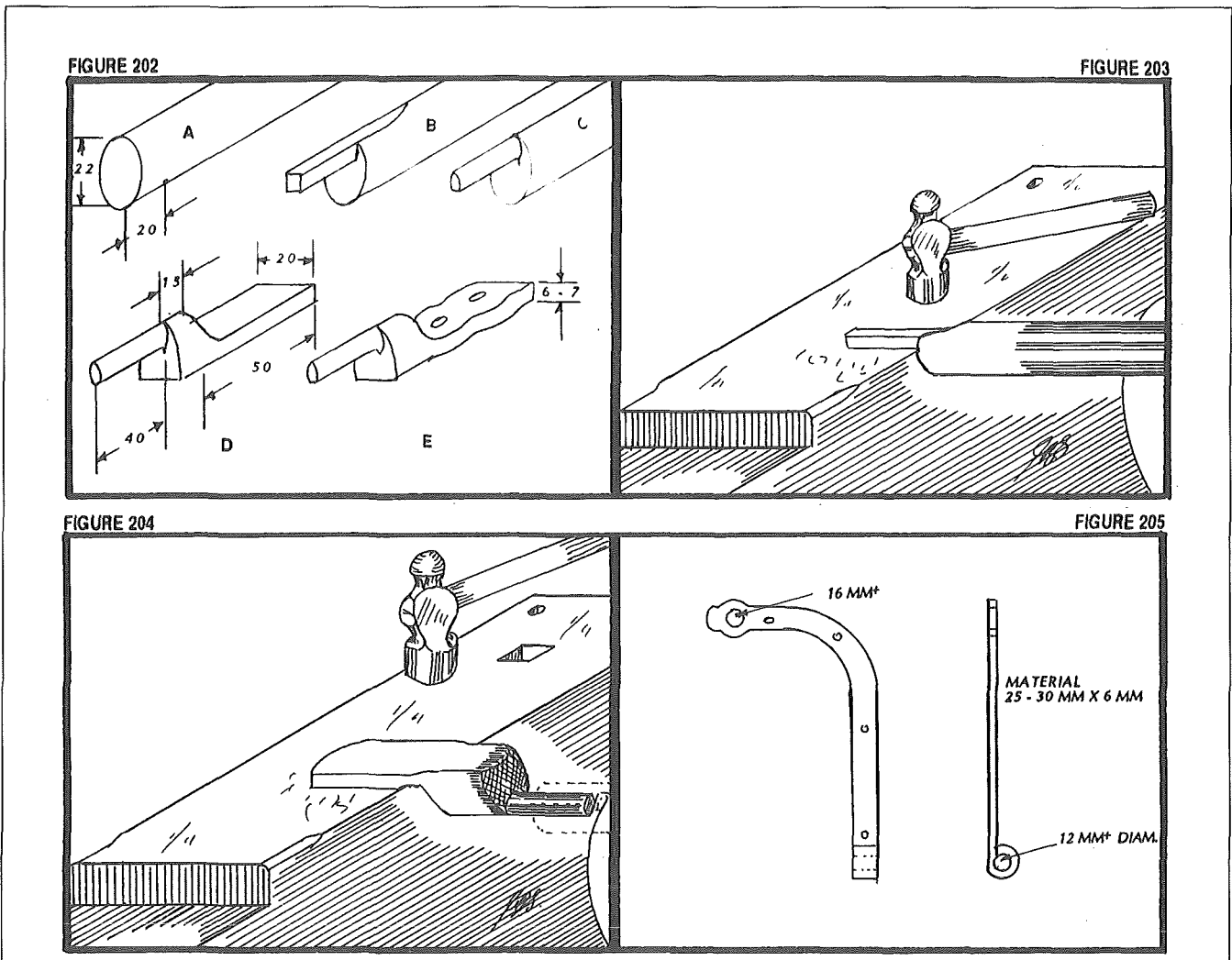
METHOD

Suitable hinges for tailboards can be made several ways. Those suggested here are strong and easy to make; the dimensions are optional.

Hinge pegs to be bolted into place can be made of mild steel 22 mm in diameter. Mark off 20 mm from one end of a bar. Bring this end to white heat, place the mark on the anvil's edge and, with the hammer face overlapping the anvil's edge, draw out an offset square

tenon (Figs 202B and 203). Reheat if necessary and forge off the corners of the square; finish to a round section of 12 mm in diameter. This can be done with a hand hammer or finished in top and bottom swages. Cut off the bar 50 to 60 mm from the shoulder formed. Mark off 15 mm from this shoulder. Hold the peg in tongs, bring the rest of the work to near-white heat and flatten from the mark as shown in Fig. 204. Flatten to 8 mm thick and 20 mm wide. Punch holes for bolts and cut off to the desired length.

A suitable strap hinge for a tailboard is shown in Fig. 205. This needs little explanation, except to say that the end with the large hole should be upset by about 25 percent before the hole is punched. Other holes can be drilled or punched. A locating and locking peg is shown



in Fig. 206, with the parts in their relative positions in Fig. 207. The locking peg is riveted through an angle-iron upright; however, it may be fixed to a plate that can be screwed to timber. These pegs are made by drawing-down 16-mm round, or larger, to a rivet end 8 mm in diameter, punching the slot hole, then cutting off to length (Figs 206A, B and C). The slot punch used is shown in Fig. 208 and must be kept cool while in use. Punching is carried out in a bottom swage (Fig. 209).

A simple flat cotter (Fig. 207) can be made by folding over a pre-shaped piece of sheet or plate.

FIGURE 206

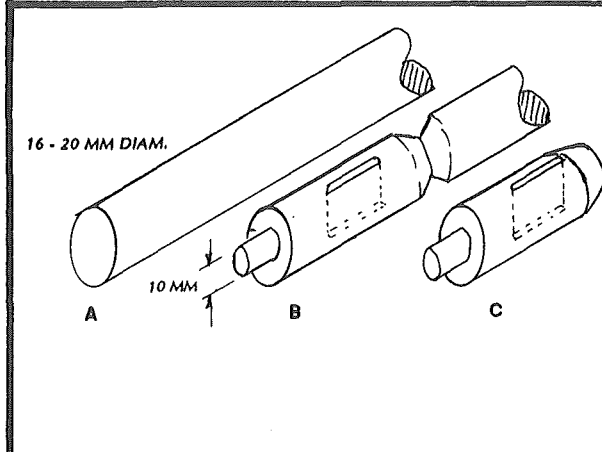


FIGURE 207

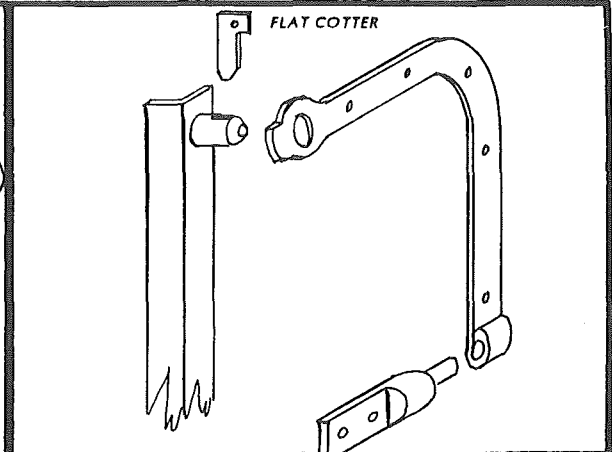


FIGURE 208

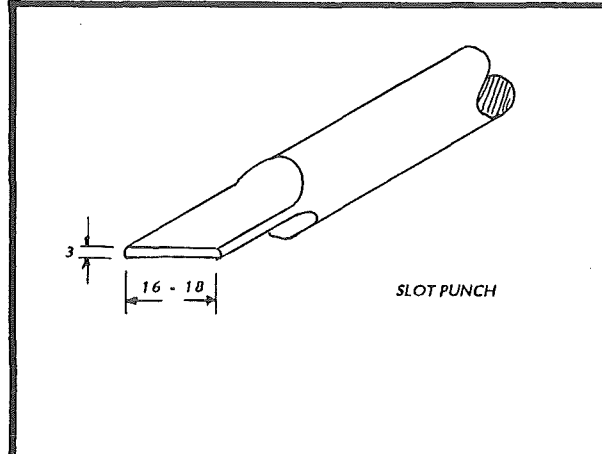
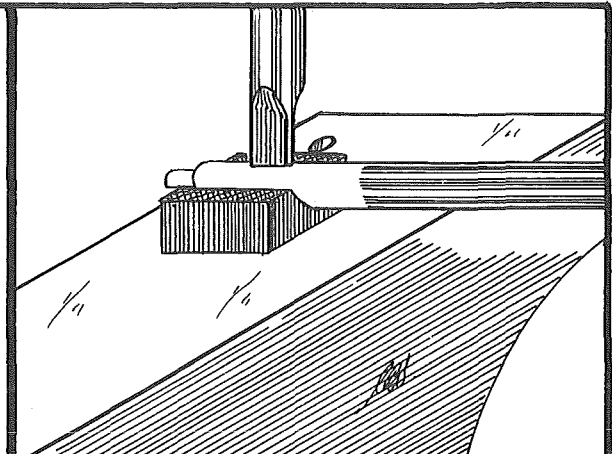


FIGURE 209



27. Yoke fittings

Materials. Round-section mild steel 12 mm in diameter; flat mild-steel bar 30 mm wide x 6 mm thick; flat mild steel 50 mm wide x 3 to 4 mm thick.

Additional tools. No special tools needed.

METHOD

Yoke fittings are many and varied with designs dependent on materials available. Centre fittings for attachment to poles are often simple U-shapes riveted through the timber with great difficulty (Fig. 210A) even when a powerful vice is available. A U with upset shoulders is much easier to rivet but it requires more time to make. In either case, fully annealing the ends makes riveting much easier.

FIGURE 210

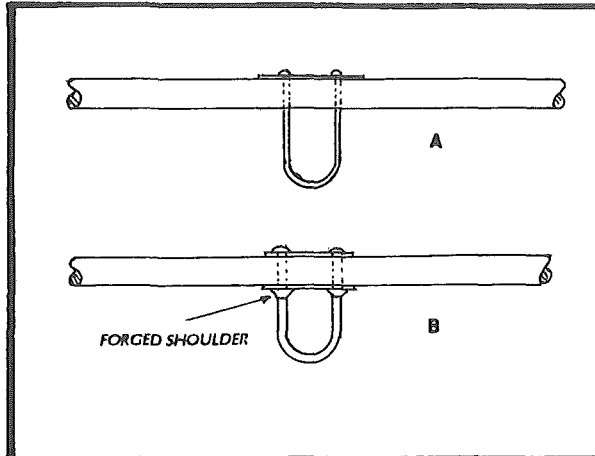


FIGURE 211

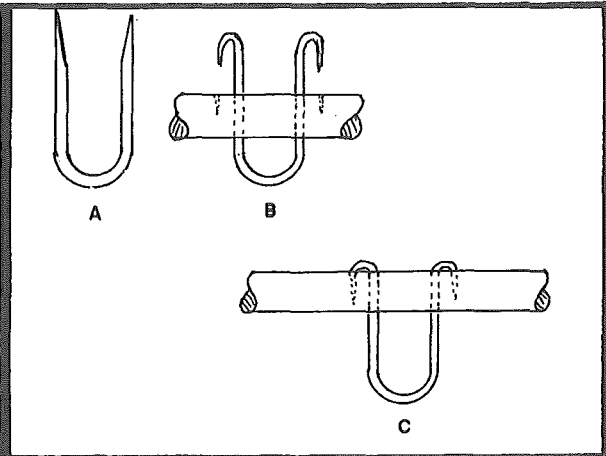


FIGURE 212

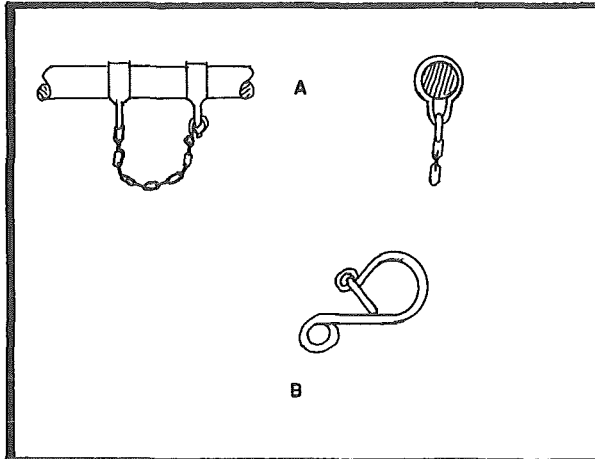
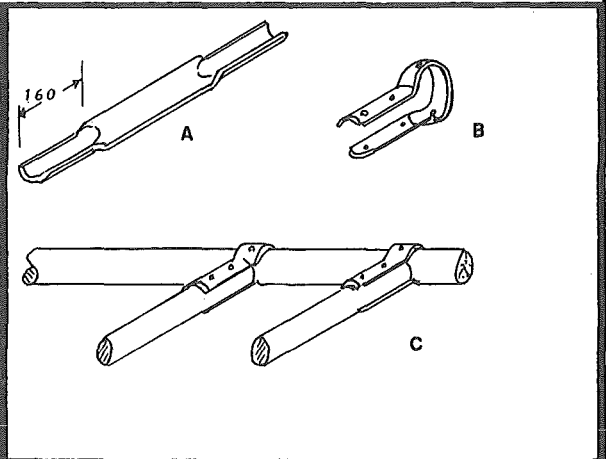


FIGURE 213



A simple alternative is shown in Fig. 211. This is effectively a large U made of 12-mm rod with long tapering points that are fully annealed. Holes are bored in the wood, the points passed through, bent over and hammered into the timber (Fig. 211). Where a stronger job is required, fittings similar to harrow spreader-bar fittings (Job 23, Figs 182 and 183) can be adapted. These are fitted to the wooden yoke (Fig. 212), with an attached length of chain that ends in a hook of 12-mm rod (Fig. 212B). A small ring or chain-link is fitted to prevent the hook from becoming detached during work.

Where round-section timber is used for yokes,

problems are sometimes encountered in making good joints in the attachments to span an animal's neck. Straps made as shown in Fig. 213 make a very strong fixing. Metal about 50 mm wide is used. Sufficient flat is left in the centre to wrap closely around the main cross-member. The ends are curved to fit the smaller pieces (Fig. 213A).

The flat centre section is bent to the shape shown in Fig. 213B. Short lengths of steel rod can be used to rivet these fittings into place. It is important to ensure a good fit before riveting. Rivet heads must be smoothly finished and the edges of the metal collar should be chamfered.

28. Making wheels

Materials. 3-mm mild-steel plate; 10-mm mild-steel rod; water-pipe of about 70 mm inside diameter with wall thickness of 4 to 6 mm; water-pipe to fit over previous piece; flat mild steel 60 x 8 x 2 380 mm for a wheel 750 mm in diameter; 48 standard 10-mm hexagonal nuts; 120 mm of round bar equal to axle diameter; 2 m of 50 x 50 x 6 mm angle-iron; 400 mm of mild steel 20 mm round.

Additional tools. Drilling machine, electric or hand-powered; threading dies; 10-mm bending tool; riveting former; assembly jig.

METHOD

Many types of wheels have been designed for local production in developing countries, all effective but often dependent on modern welding equipment that is not available everywhere. The design and construction methods used here are fairly simple and the wheel produced is strong and serviceable. With a little experience, and after having made the patterns and assembly jig, you will find that the production time is reasonable. It is essential that good clean materials are available.

This wheel consists of a rim, spokes, and a hub made up of two perforated steel plates, two nested pieces of water-pipe, and a hardwood bearing inserted in the pipe. The spokes are bolted through the holes in the steel

plates, one plate on each side of the hub, and the spokes are attached alternately, one to one metal plate and the next to the other. When the rim has been made, the spokes are put through holes in the rim and hammered flat like rivets (Fig. 220 shows the finished wheel.)

The parts that comprise the wheel hub should be made first (Drawing 1). The two pieces of pipe forming the centre should be cut off and the ends filed true and square with the centre lines and parallel to each other. The inner piece is 95 mm long and the outer is 80 mm long. Next, mark out two hexagonal side plates, including hole positions as shown, cut them to shape, and drill the 20-mm holes. Then, chain-drill, cut out and true up the large hole. This centre hole should be a neat fit on to the inner (longer) pipe. Cut the Vs from the 20-mm drilled pipe. Cut the Vs from the 20-mm drilled holes and bend on the bend lines to the 8-degree angle shown. This angle will change if the wheel diameter is altered. Next, drill the 10-mm holes. Plates and hub pipes can now be assembled with the 10-mm holes staggered as shown in Drawing 2.

The ends of the inner pipe are partly flanged as in Fig. 217, using the tool shown in Fig. 215. (With care this can be carried out using only a hand hammer.) Next, the hardwood bearing block is driven into the hub. These blocks can be made by hand or turned on a simple lathe. The bearing block should be soaked in hot oil and be a very tight fit into the hub. When the wood is in place, flanging of the inner pipe is completed on the face of the

FIGURE 214

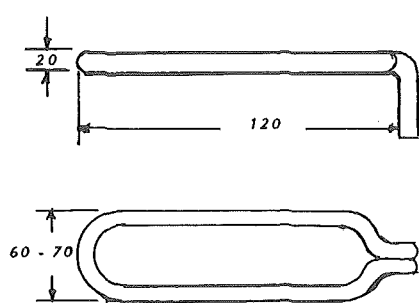
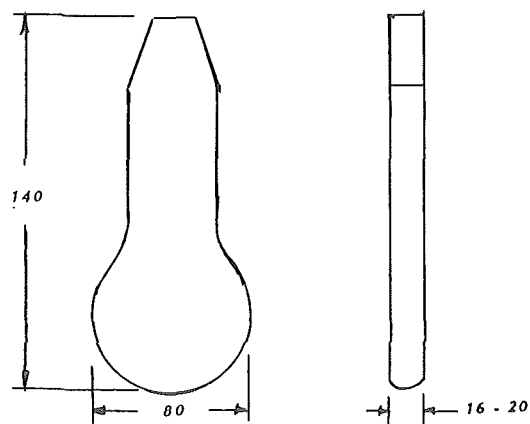


FIGURE 215



anvil using a flatter as in Fig. 218. This traps both the plates and the bearing into place.

The outer rim is made by cutting off the correct length of material calculated as for all other rings. In this case, it is 2 380 mm of steel 8 mm thick. A quickly made bending aid for this and other work is shown in Fig. 214. It is simply a large link made of bent rod to fit into the tool hole of the anvil and lie flat on the anvil face (Fig. 216). Carefully scribe a circle equal to the outside diameter of the wheel on a piece of sheet metal or wood. By using a top fuller and the link-bending aid, accurate circles can be bent. Use light hammer blows and check (Drawings 1 and 2) frequently against the scribed circle. It is important that the rim be a true circle free of twist. When the rim is correctly bent, a plate of similar-sized material is riveted across the rim joint as in Drawing 2. Rivets are 8 mm in diameter and countersunk on the outer face. Mark the position of the 12 holes around the rim all equally spaced but alternately staggered 10 to 12 mm either side of the centre line (see detail at upper right of Drawing 2). Drill these holes to

FIGURE 216

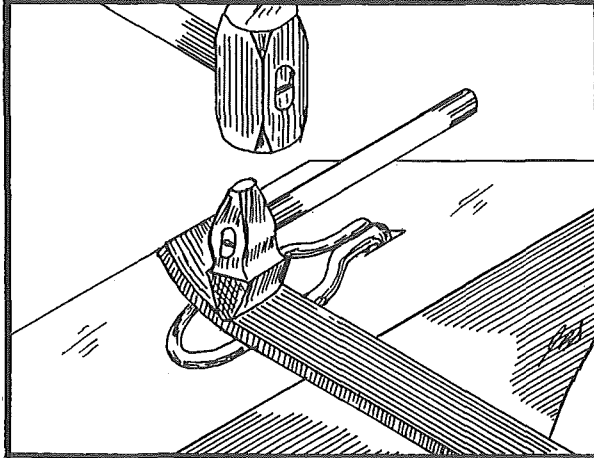


FIGURE 217

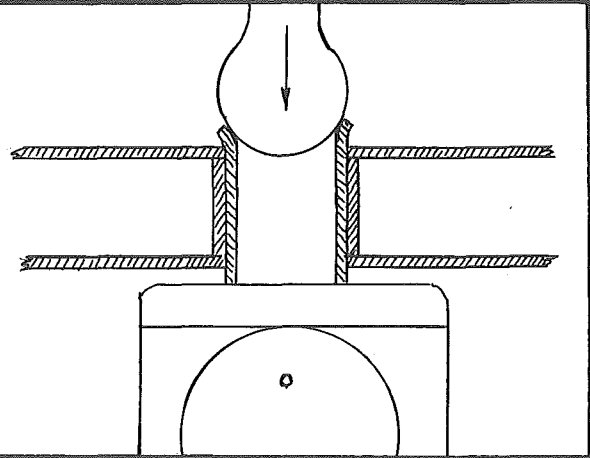


FIGURE 218

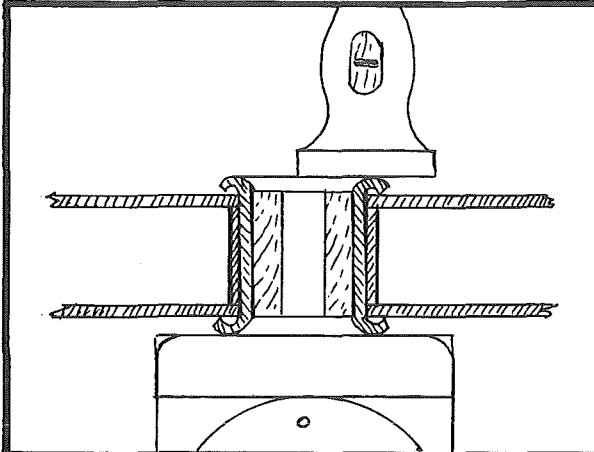
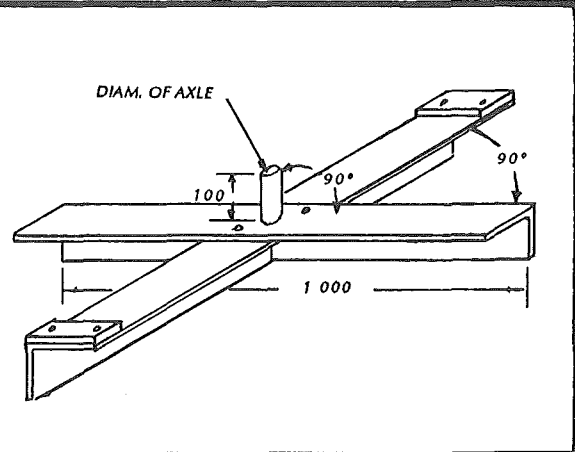
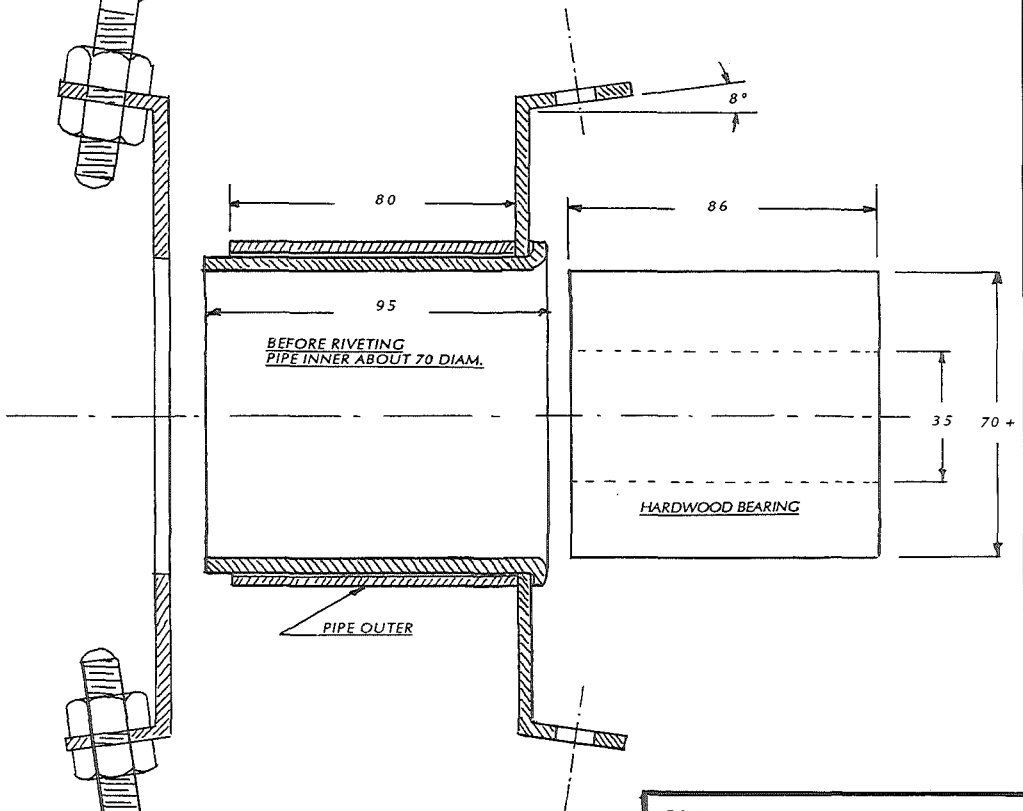
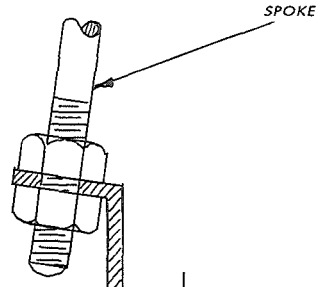
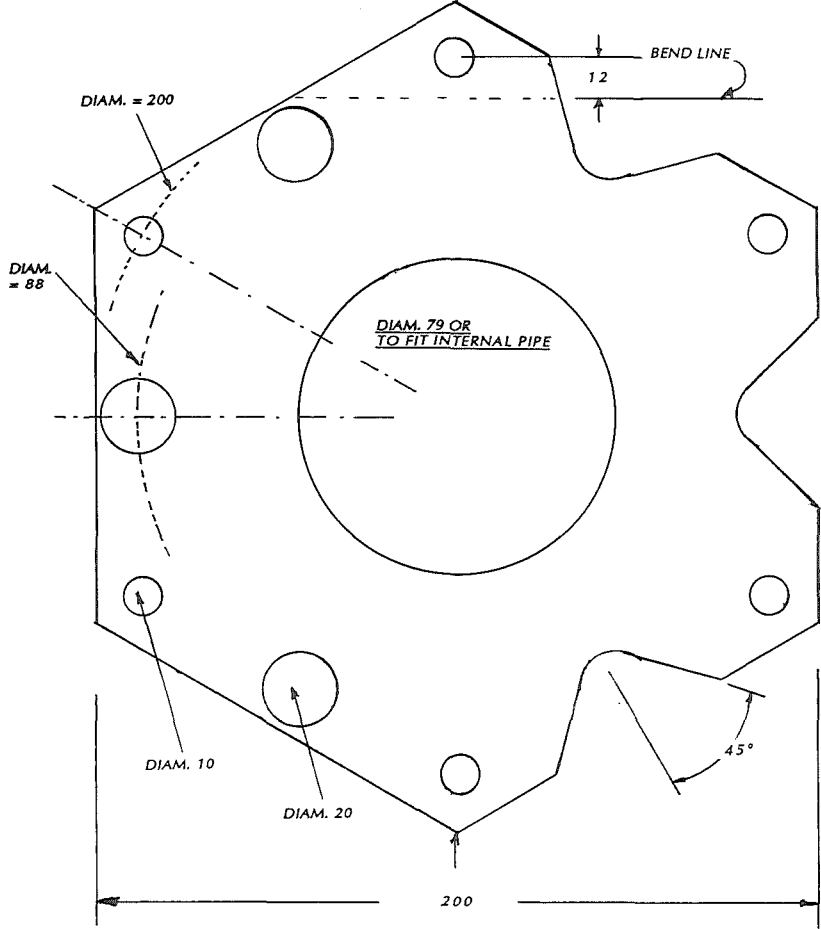


FIGURE 219



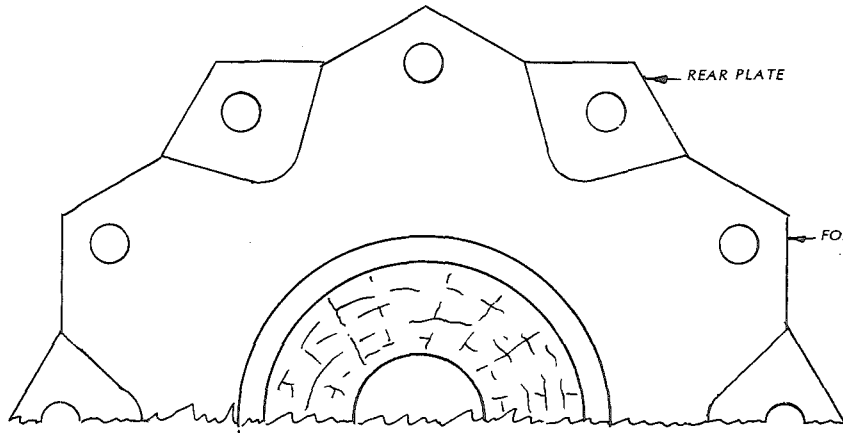
THIS SIDE AS MARKED
PLATE THICKNESS 3 MM

THIS SIDE AS DRILLED AND
CUT OUT. 10 - MM HOLES ARE
DRILLED AFTER BENDING

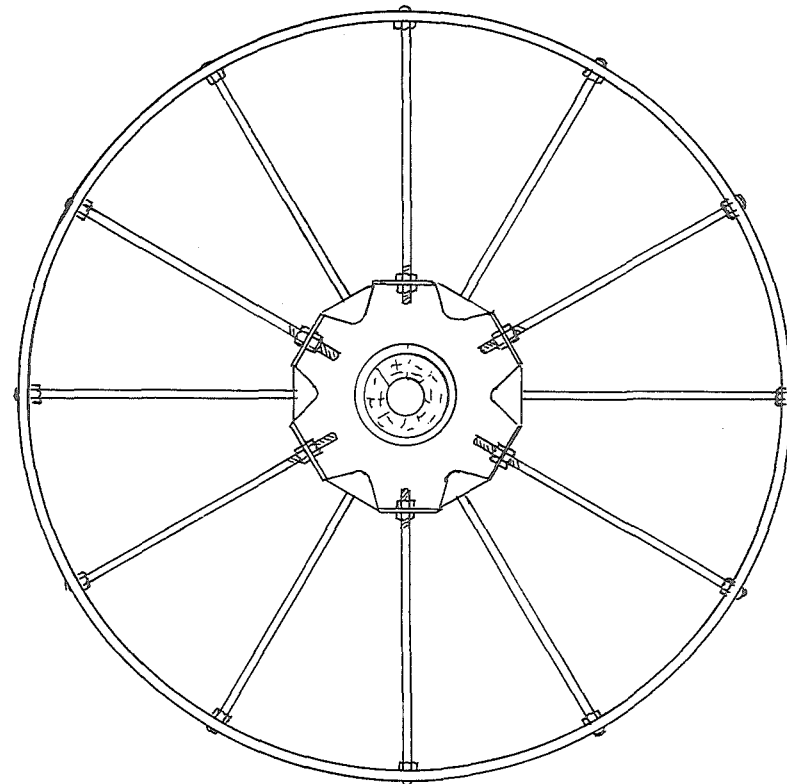
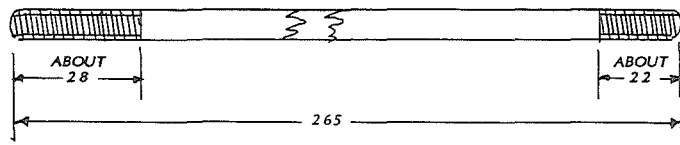
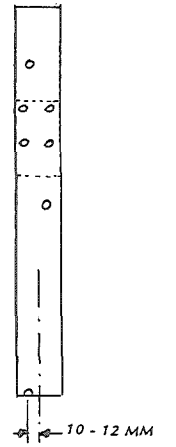
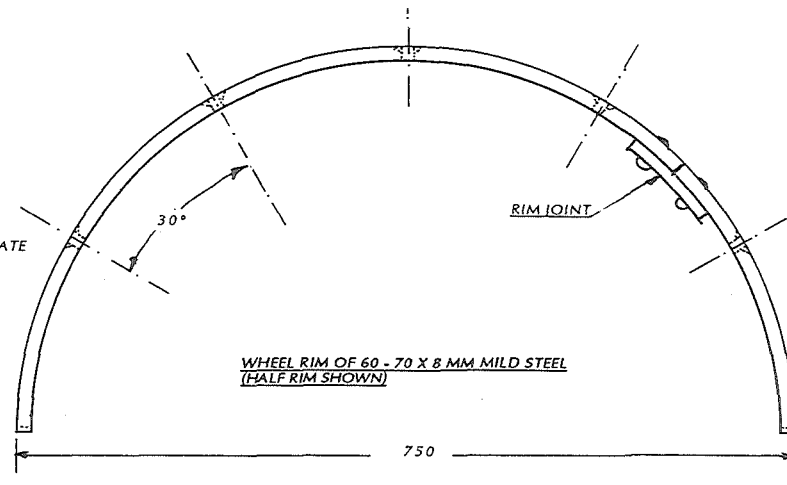


Advanced blacksmithing

DRAWING 1
OX-CART WHEEL
HUB PARTS
SCALE = 1:2
MATERIAL: MILD STEEL
DESIGN: J. B. STOKES
DRAWN BY: J. B. STOKES



HALF-HUB ASSEMBLY SHOWING ALTERNATE POSITION OF SPOKE HOLES
(BENDS NOT SHOWN)



DRAWING 2
OX - CART WHEEL DETAILS
NOT TO SCALE
MATERIAL: MILD STEEL
DRAWN BY: J. B. STOKES

accept 10-mm rod and countersink the holes on the outside of the rim. Next, cut off 12 spokes from 10-mm rod, fully soften one end and cut the screw threads as indicated (Drawing 2). The fully softened end has the short thread. Make up an assembly jig (Fig. 219). The centre pin should be of the same diameter as the axle. It must be perpendicular (i.e. at right angles) to the angle-iron cross-members. An alternative type of mounting pin is shown in Fig. 221; the peg is fastened to a plate, which is screwed to a flat board or bench top.

Rim, hub and spokes are loosely assembled on the jig. Packing pieces of wood or metal are used to centre the hub and rim. Clamp the rim into position in several places while checking by measuring that it is concentric with the hub. When satisfied, tighten up the spoke nuts at the hub ends. Lock nuts or locking washers can be used, although these are not shown in the drawings. Next, tighten the inside nuts to the rim and place temporary nuts on the spoke ends to grip the rim in place. Packing pieces and clamps can be removed and the wheel rotated and checked for trueness. Errors can

be corrected to a large extent by adjusting spoke tension. You can do this by loosening and tightening the spoke nuts as needed.

If you have removed the wheel from the jig to make adjustments, replace it on the assembly jig and replace the packing pieces and clamps. Removing one outer nut at a time, flatten the spoke ends as in Fig. 222. A sledgehammer is held against the hub end of the spoke and the other end is pounded flat by using a light hand hammer. Work alternately on opposing spokes. All work is carried out with the metal in a cold condition.

FIGURE 220

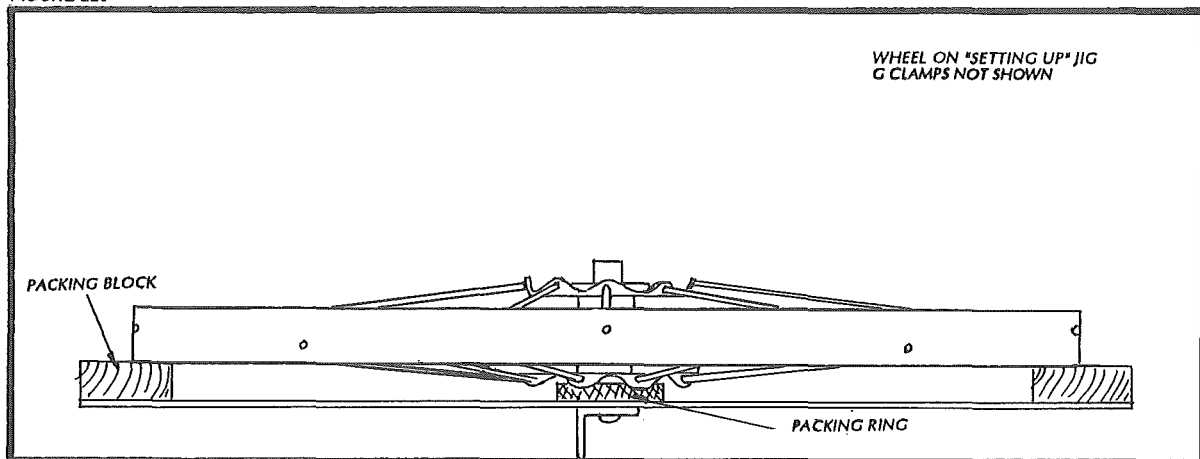


FIGURE 221

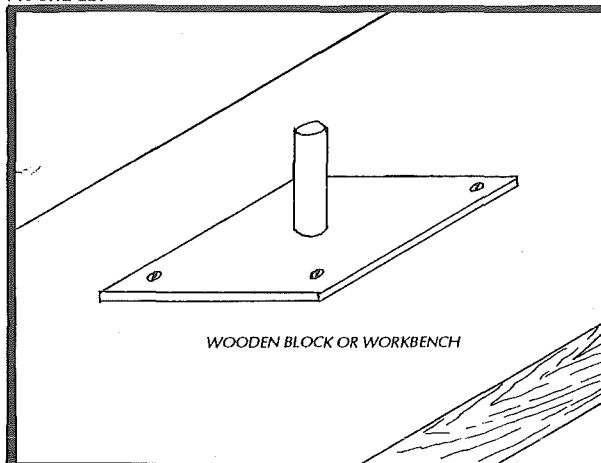
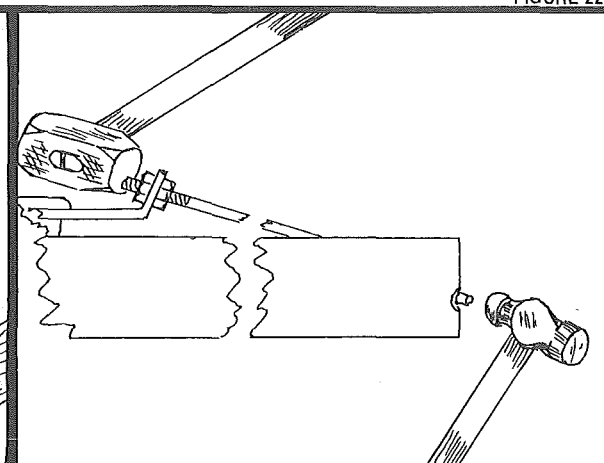


FIGURE 222



29. Making axes

Materials. Flat spring leaf 8 mm thick; flat spring leaf 16 mm thick.

Additional tools. Slot punch and eye drift; U-shaped drifting aid.

METHOD

Making eyed hand axes from mild steel combined with higher-carbon steel is described in Job 19 of *Basic blacksmithing*. Although eyed axe heads seem to be popular, few smiths make them. The wedge-shaped axe head fitted into a wooden handle is cheaper and easier to make and, if well made and correctly heat-treated, gives very good results. Where eyed axes are in demand they can be made from a solid piece of steel, thus avoiding the welding described in *Basic blacksmithing*.

Often the traditional wedge-shaped axe is made with a great deal of effort by drawing-down spring steel with a hammer. The use of a hot set and fuller, however, greatly reduces the time, fuel and effort needed. The proportions in Fig. 223A are a fair average. The abrupt taper and cutting edge in Fig. 223C is seen all too often. It tends to bounce off timber instead of cutting. D indicates a thinner cutting edge, which is much more effective. These axes are best made from steel about 8 mm thick and of a width to suit the size of axe head required. It is best to make them in pairs to save time, effort and fuel.

FIGURE 223

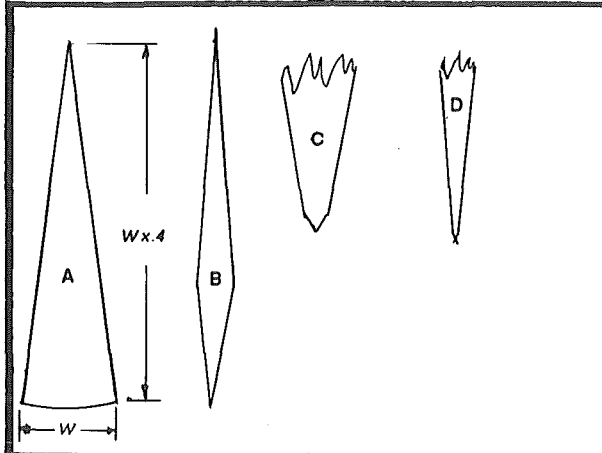
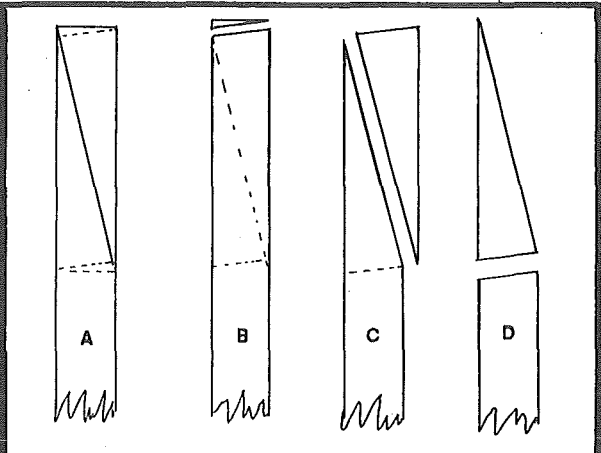


FIGURE 224



Mark out the steel (Fig. 224A). Chalk marks will do, as these will still show on the steel at red heat. Heat to red heat, and with a hot set lightly mark the cutting lines. Reheat to bright red and cut following the four-step sequence in Fig. 224. One piece is reheated to yellow heat while the other remains on top of the fire to keep hot. The pointed end is forged to remove roughness from the cutting, the taper corrected and sharp corners removed. The second piece is worked in the same manner while the first is reheating at its other end. Figure 225 illustrates the work on the upper pointed end.

The lower half of the blade is heated to yellow heat and drawn out using a fuller (Fig. 226). The fuller will spread the metal in the direction required, rather than in all directions as does a hammer face. Smoothing can be carried out with a hand hammer or flatter. The cutting edge is trimmed with a hot set to get rid of irregularities. If grinding equipment is available, the job is next brought to red heat and normalized. If filing has to be carried out, a full anneal is needed. After producing the cutting edge, fully harden the piece and temper it to a

FIGURE 225

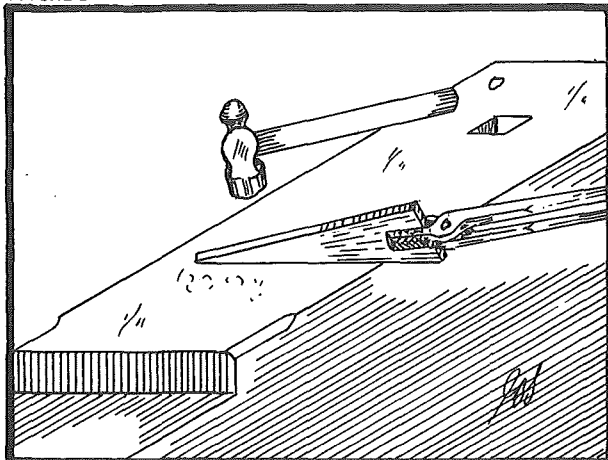


FIGURE 226

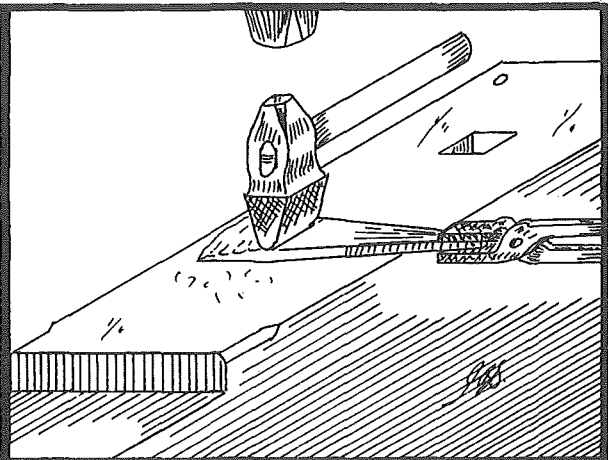


FIGURE 227

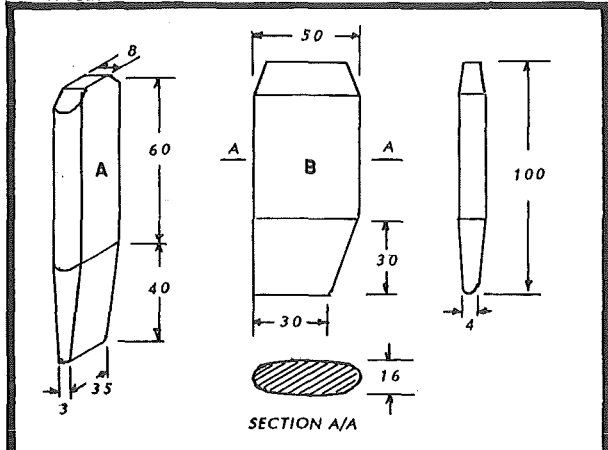
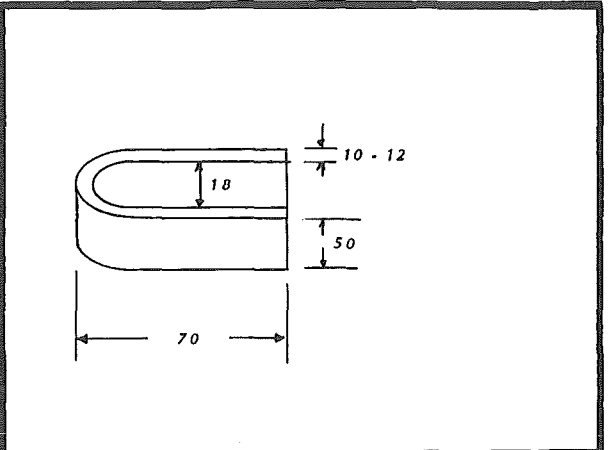


FIGURE 228



medium-straw colour. Final sharpening should be done by hand with a carborundum stone or similar.

For the production of an eyed axe head from solid, a slot punch and drift (Fig. 227) should be made, as well as a U-shaped piece similar to that in Fig. 228. Carbon-steel bar or spring steel 16 mm thick or more is needed.

Spring steel 12 mm thick can be upset to sufficient thickness; however, with steel less than 12 mm great difficulty will be experienced. The slot punch can be made from spring steel while mild steel will do for the U piece.

Take a piece of leaf-spring steel about 16 x 60 x 100 mm or a suitable hand length for the first operations. Mark 25 mm from the end of the bar or piece, placing the mark on a narrow edge (Fig. 229). Heat to yellow, place one end of the slot punch on the mark and start driving it into the work, cooling after every two or three blows. Punch about 8 mm deep on one side, then repeat on the opposite side. After that, work alternately from each side until the hole is made. The width of the metal will be reduced during this operation.

Reheat to bright red heat and introduce the eye drift into the piece, working a little from each side in turn until the eye is formed. The eye can have its sides thinned by hammering on the face of the anvil with the drift in place. Axe eyes do not need any great thickness of metal at the sides of the eye unless used as hammers, for which they are not intended (Fig. 230). During drifting, use is made of the U piece as in Fig. 231.

When the eye is correctly formed, the blade is drawn out at yellow heat using a fuller and finished with a flatter. Excess metal is trimmed off with a hot set. During drawing-down some distortion of the eye might occur. This can be corrected by drifting the eye again and working on the anvil as in Figs 231 and 232. Finishing is carried out by grinding or filing. Hardening and tempering are carried out as described earlier.

All sizes of axe head can be made in this way. Heavier metal and larger drifts will be needed for larger sizes.

FIGURE 229

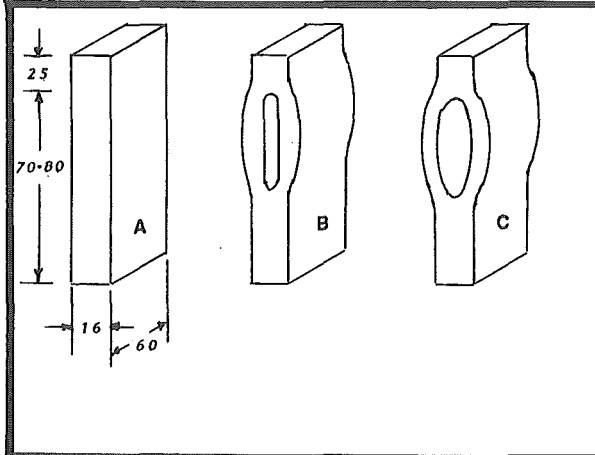


FIGURE 230

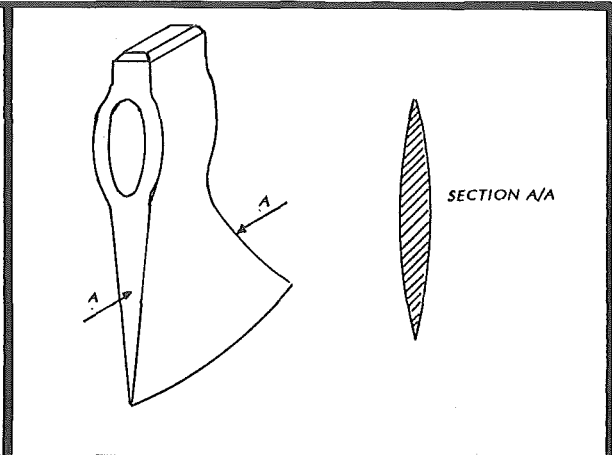


FIGURE 231

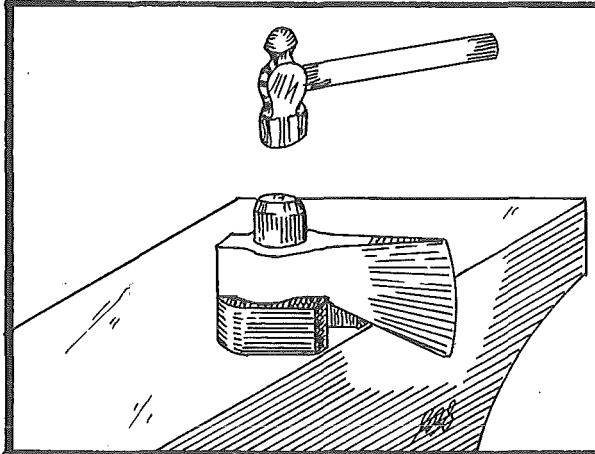
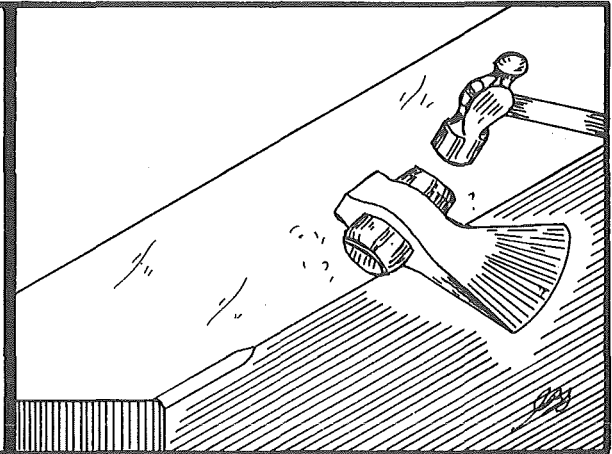


FIGURE 232



30. Making hoe tangs separately from blades

Material. 50 x 50 x 6 mm angle-iron about 120 mm long.

Additional tools. Half-round hot-chisel gouge shaped for 12-mm radius.

METHOD

Hoe-making is introduced in Job 21 of *Basic blacksmithing*. Both types in general use, tanged and eyed, are described. As a result of shortages of materials, many rural smiths make hoe blades from whatever steel is available and rivet the tangs from worn-out hoes on to new blades. This causes a shortage of tangs, which

FIGURE 233

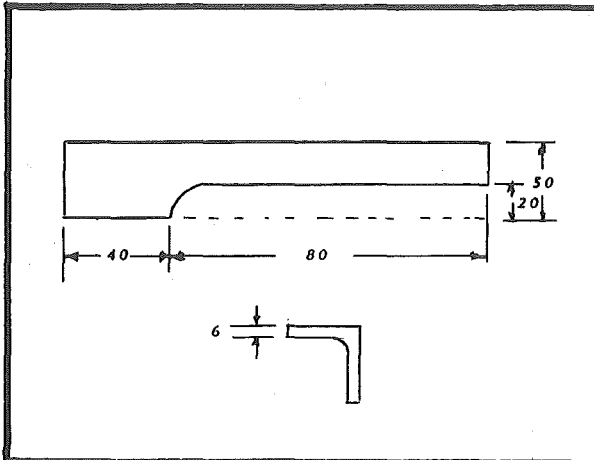


FIGURE 234

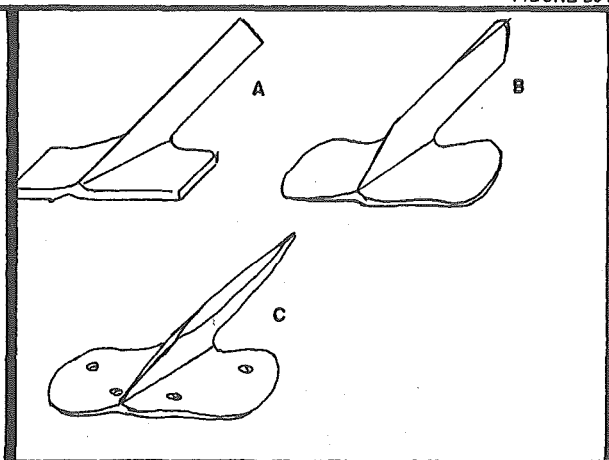


FIGURE 235

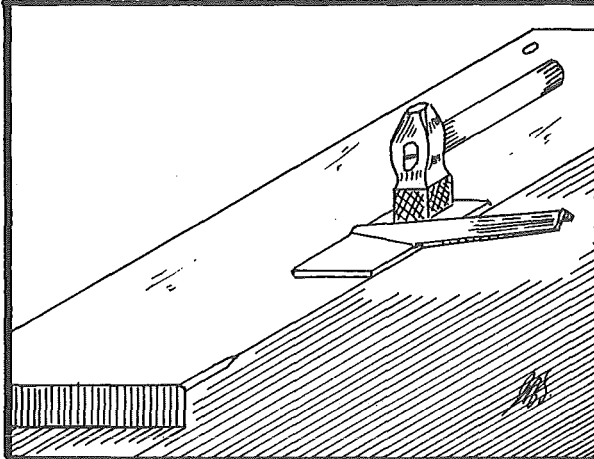
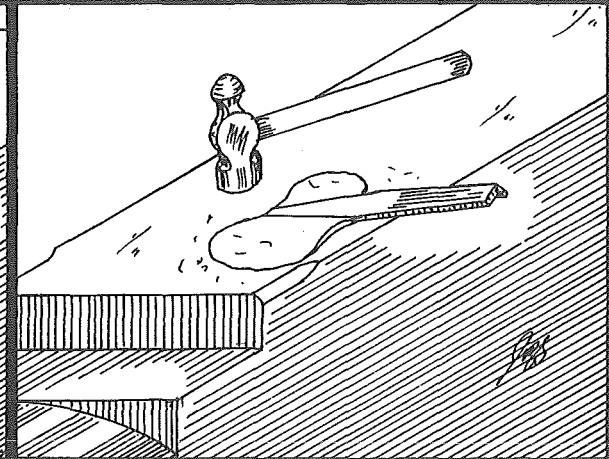


FIGURE 236



then command a relatively high price. Since odd pieces of angle-iron are more common than most other steel sections, a simple method of making hoe tangs from this scrap has been developed.

Angle-iron is particularly suitable because of the extra metal in the corner and the limited work needed to produce such tangs. Here 50 x 50 x 6 mm angle-iron is used but other sizes can be adapted. Take a piece about 120 mm long, and mark out and cut as in Fig. 233. Use the half-round hot chisel to cut the radiused part. Heat to yellow heat and work the wide end as in Figs 234A and 235. Here a set hammer is used but a hand hammer can be applied.

Next, reheat and thin out the flanges now formed, tapering thinner toward the edges (Fig. 236). Take a white heat on the opposite end and close the angle sides together (Fig. 237). Reheat at welding heat and forge the tang to a tapering point as square as possible (Fig. 238).

True up all over and punch rivet holes 6 to 8 mm in diameter. The tang is attached to the blade as in Fig. 239, using short lengths of rod as rivets.

FIGURE 237

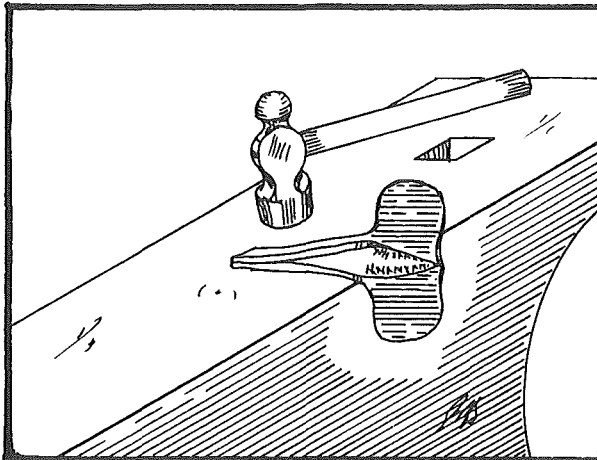


FIGURE 238

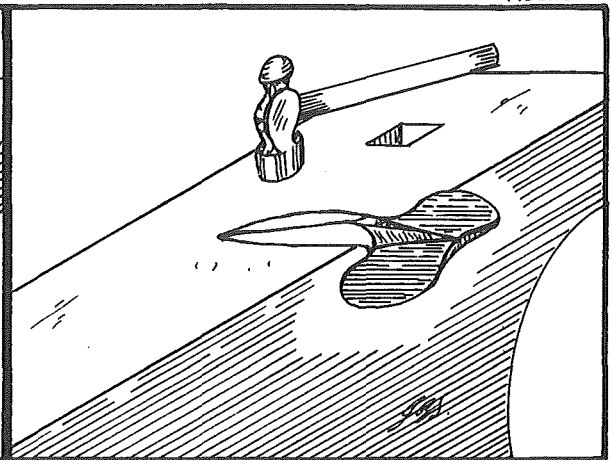
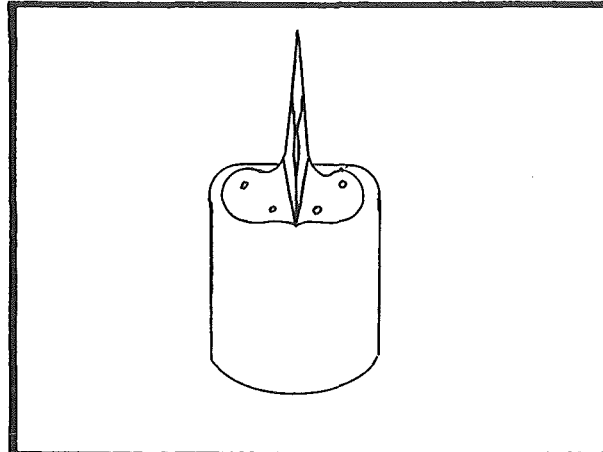


FIGURE 239



Appendixes

Appendix I

Notes on charcoal use

For blacksmiths' work using open fires, a supply of clean fuel of high calorific value is essential. Without the ability to heat metals quickly to high temperature, the work carried out by smiths is very limited.

Tools, equipment and skill are of little value if heating requirements are not met. High-density fuels such as coal and coke are, in general, most effective. In many countries, however, only charcoal is available. Charcoal is a clean fuel capable of giving high temperatures when supplied with an air blast. However, because of its low density, more charcoal must be burnt to provide smithing requirements than coal or coke. The large amounts of white ash produced, if not frequently removed from the fire, inhibit the heating effect of the burning fuel. Charcoal made from hardwoods is almost as good as coke, while the more common softwood charcoal is very difficult to use at high temperatures. Slower heating causes large buildups of oxide to appear on the surface of steels, making working difficult and welding almost impossible.

Some improvements can be made by simple modifications to the blacksmith's hearth and fire. To enable a greater mass of fuel to be burnt, a deeper fire is needed. Simply piling fuel on top of a workpiece is ineffective. Heat escapes through the fuel mass, reducing the heat available in the fire and creating great mounds of ash. Considerable improvements are noticed if fires

are 100 to 140 mm deep and confined at the sides. Figure 240 is of a hearth made of brick, but the same rules apply to steel hearths or fire built in the ground. In this figure, A is a water-cooled blast pipe and B is a metal plate separating the fuel reserve at C from the fire; E is a foundation built of stones, soil and general rubble; and F is the bed of the fire made of packed soil and ash. The fire is confined to the depression in this bed. Some experimenting with the depth of the fire is worthwhile, but sufficient fuel must always be between air blast and workpiece (D in Figs 240 and 241). Small jobs might do with a shallower fire while large work will need more depth.

Figure 241 illustrates a fire made in the floor of a workshop. Even here the same rules of depth and size of fire apply. A simple mound of fuel on top of the ground is not effective. Where charcoal must be used, the hardwood type is preferable.

FIGURE 240

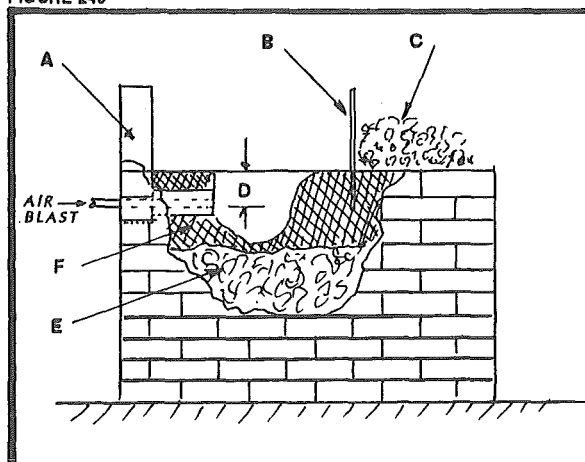
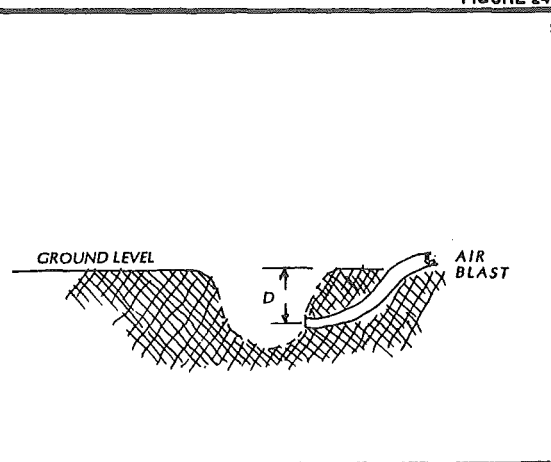


FIGURE 241



Recommended tools and equipment

Blacksmiths should be capable of making most of their own tools. The making of tools as and when needed is one of the most important parts of a smith's work. Given basic equipment and tools, producing others should be part of any training programme.

Below are lists of essential and desirable equipment. An asterisk indicates that the tool can be locally made.

ESSENTIAL EQUIPMENT

Hearth. Hand-powered or electric blower, preferably side blast with water-cooled blast pipe; hearth area at least 1 000 x 1 000 mm.

Anvil. The heavier the better, it should not be less than 70 to 80 kg. Design is not important, but London pattern is very versatile. Anvil stand of angle-iron, cast iron or heavy block of timber.

Cooling tank. Any suitable container will do, preferably metal. It should hold at least 100 litres of water.

Hand hammer. Ball- or cross-peen, 750 g to 1 kg, wooden handle.

Sledgehammer. Double-faced, full-length wooden handle, 4 to 6 kg.

Top and bottom fullers.* To fit tool hole of anvil, wooden or steel-rod handles. Sizes include 8, 10, 12, 16, 20 and 25 mm (having two or three assorted sizes eases work initially).

Top and bottom half-round swages.* To fit tool hole of anvil. Tops should have wooden or steel-rod handles. Sizes include 8, 10, 12, 16, 20 and 25 mm.

Set hammer.* Face 25 to 30 mm square with wooden or steel-rod handle.

Flatter.* About 50 x 50 mm face with wooden or steel-rod handle.

Cold set.* With wooden or steel-rod handle, for cutting cold metal.

Hot set.* With wooden or steel-rod handle, for cutting hot metal.

Hardy (anvil cutter).* Cutting tool to fit tool hole of anvil.

Punches, assorted.* With and without handles; usually made as required.

Tongs.* Four to 6 pairs needed initially, others made as required; close bits, flat hollow bits, flat-angle bits, combination hollow bits, etc.

DESIRABLE EQUIPMENT

Swage block. About 80 kg, cast iron.

Floor mandrel. About 1 to 1.5 m high, cast iron, tapered.

Vice. Heavy-duty, leg-type preferred.

ADDITIONAL BENCH TOOLS

Drilling machine. Hand-powered for rural areas.

Grinding machine. With 150- to 200-mm wheels, hand- or foot-powered for rural areas.

Set of taps and dies.* For cutting screw threads, 6 to 16 mm.

Set of drill bits.* Five to 15 mm.

Files.* Flat, square, round and half-round.

Folding steel rule. About 600 mm.

Blacksmith's square

Callipers. About 150 mm.

Glossary

Alloy

mixture of two or more metals

Anneal

to heat and then cool to achieve maximum softness

Antimony

element alloyed with lead and tin to produce soft solder

Anvil

shaped iron or steel block with hardened face upon which metal is forged

Ash

residue after fuel has been burnt

Ash

wood often used for tool handles, particularly in Europe

Beak

the cone-shaped end of the anvil

Bellows

air pump used for supplying air blast to the forge fire

Bend

angle or curve formed in metal

Blast

air supplied to the forge fire by bellows or by other means

Blast pipe

pipe conducting air blast to fire (also called tuyere)

Blow

to supply fire with air or to hit with a hammer

Bolster

steel plate with variously shaped holes to aid in the forging of shoulders

Bolt tongs

specially shaped tongs to hold bolts and rivets

Borax

chemical used as a fluxing agent when welding

Bosh

blacksmith's tank that supplies water to cool work or the blast pipe

Carburize

to heat iron in the presence of a carbon-rich material with air excluded to increase the surface carbon of the iron

Case harden

to harden surface of steel by carbonizing

Charcoal

black residue of wood after smothered burning, used as forge fuel

Cleft

cut or slot in metal often used as a weld preparation

Clinker

the residue of burnt fuel in the blacksmith's fire

Coal

fossil fuel used in blacksmith's fire

Coke

coal processed to remove gas and used as forge fuel

Dies shaped blocks of metal between which metal is forged, as well as tools for cutting external screw threads	Gouge chisel-like tool with a curved cutting blade	Mild mild steel is that which is soft and malleable
Dog mechanical device for holding or gripping something	Grind to remove metal with an abrasive such as a grinding wheel	Monkey tool block with holes used in forging shoulders
Drift short metal rod used to size or shape punched holes	Haft shaft or handle of tool	Normalize heat-treat to remove stresses and to bring the metal to its normal condition
Eye-bolt bolt with a looped head	Hammer shafted tool for striking metal and tools	Notch prominent nick or groove in metal
Fan mechanical device used to produce air blast	Hand length length of metal that can be handled without tongs	Oxide metal combined with oxygen; it forms rapidly at high temperatures
Felloe section of a wheel rim	Harden to heat-treat steel to achieve maximum hardness	Peen face of hammer other than flat, such as cross-peen
Flatter flat-faced swage	Hardness ability of one metal to scratch another	Pintle hinge peg
Flux chemical agent used to dissolve oxides on metal to be welded	Hardy cutting tool fitted to tool hole of anvil	Plastic capable of being moulded or shaped
Forge (n.) blacksmith's workplace	Heat to make hot or the degree of hotness, i.e. red, yellow or white heat	Pritchel punch for opening holes in horseshoes; also describes anvil hole used for punching
Forge (v.) to shape hot metal by hammering, by hand or machine	Helper blacksmith's assistant	Punch shaped steel tool for making holes in metal
Former device for bending sheet metal; also template around which an article is formed	Incandescent glowing with heat, giving off light	Reins the handles of blacksmith's tongs
Fuller shaped bottom tool or shafted top tool used to produce grooves in metal	Iron silvery grey metallic element; when mixed with carbon, it changes to steel	Rivet (n.) metal pin passing through holes with a head formed on ends
Glow to give off light, i.e. red, yellow or white heat	Mandrel shaft to which work is fixed while being turned	Rivet (v.) to fasten parts together with a rivet
	Metal metallic elements: iron, copper, tin, etc. or mixtures of such	Scale oxide on surface of metal after heating

Scarf (n.)

metal notched as a preparation for welding

Scarf (v.)

to notch; to unite by a scarf joint

Set

tool to be hit with a hammer

Shaft

length of bar or a handle for a tool

Shears

level-operated tool for cutting metal

Shoulder

angle forged in metal resembling human shoulder

Snap

tool for forming rivet heads

Soften

to remove hardness by heat treatment

Steel

combination of iron and carbon

Stocks

supporting framework

Strike

to hit with a hammer

Swage

shaped top or bottom tool, usually with half-round groove, to form metal

Swage block

heavy cast-iron block with shaped holes and grooves

Tang

projecting point by which a blade is held firm in handle

Temper

to reduce the degree of hardness by heat treatment

Tenon

end of bar drawn-down to a square or rectangular section

Tommy-bar

short bar for use with box-spanner

Tongs

pincers for holding metal during forging and other operations

Tuyere

pipe to conduct air blast to fire

Upset

to make metal shorter and thicker

Vernier

small movable graduated scale for indicating parts of divisions on a graduated instrument

Vice

device with two jaws that is fixed to a bench to hold workpieces

Weld

in blacksmithing, to join metals by heat and pressure or by fusion

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