PART III

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Having completed the first twelve lessons the student should have sufficient skill to undertake the forging and welding of heavier sectioned metal. The next exercises are designed to develop accuracy in forging to dimensions. He will have learnt for himself that all smithing operations need a great deal of practice and that he cannot expect to complete any of the exercises perfectly the first time. It needs considerable practice to distinguish the various heats, to hit the metal accurately and to deliver the blows at exactly the angle required.

It cannot be stressed too often that the processes described in this book are not the only ones which are used by smiths. Most men evolve their own techniques, others adopt the methods which have been used in their own locality for generations. The techniques described here are considered by the Rural Development Commission the best for the student to learn; and are those used by the Commission's instructors.

Welded rings and chain links are included in this section; the following general instructions on rings and the method of calculating the amount of material required should be carefully studied.

RINGS

Rings which the blacksmith has to make fall roughly into three categories:

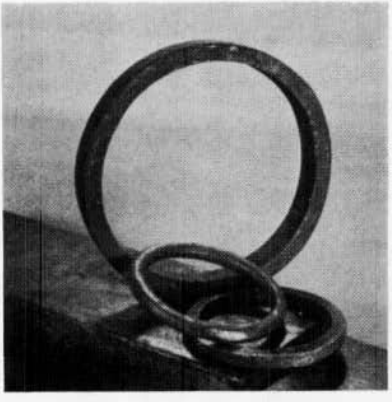


Fig. 37

(1) **Rings bent on the edge,** ranging from washers to waggon sweeps (the rings on which the fore-carriage turns).

(2) **Rings bent on the flat,** ranging from ferrules to cart-wheel tyres.

(3) **Rings of round and square section** of various sizes.

Metal up to $\frac{3}{8}$" round or square need not be upset before scarfing the ends as the welds can be made very quickly without wastage. All flat metal and round and square section above $\frac{3}{8}$" must be upset before scarfing.

Square and round section metal must be scarfed so that the welding begins with the ring flat on the face of the anvil. In the case of a small ring, welding is continued with the ring over the bick, and with a large ring, from the inside with the ring standing upright on the anvil face.

After welding, small rings are rounded up on a hand mandrel (Fig. 23, page 13), and larger ones on a blacksmith's floor mandrel (Fig. 8, page 6).

To Calculate the Amount of Metal Required

When measuring off a bar which is to be bent into a ring, some allowances have to be made for the metal lost—both in the bending and the welding. Most smiths have their own methods of estimating these allowances, but a beginner needs some simple practical system, such as the following, on which to base his calculations.

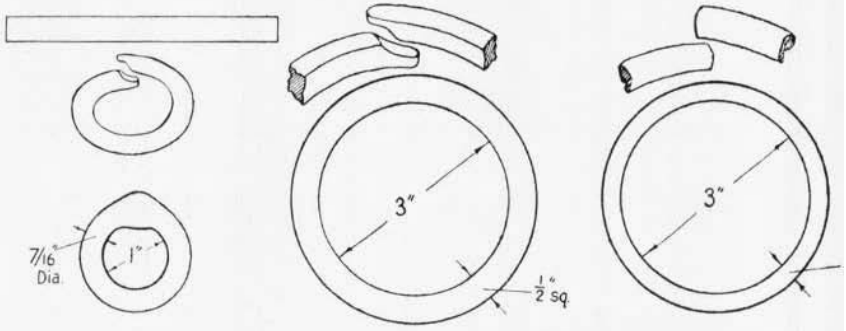
(*a*) To determine the allowance for *bending*, add the thickness of the metal to the *inside* diameter of the finished ring, and multiply this figure by $3\frac{1}{7}$.

(*b*) To determine the allowance for *welding*, take the final figure arrived at above, and add twice the thickness of the metal.

For example

To find the length of the metal required for a ring (shown in Lesson 14) with an *inside* diameter of 6″, made in metal $\frac{1}{2}$″ thick:

A	Inside diameter of ring		6″
	Thickness of metal		$\frac{1}{2}$″
	Total	=	$6\frac{1}{2}$″
	Multiply $6\frac{1}{2}$″ × $3\frac{1}{7}$ (π)	=	$20\frac{3}{8}$″ (approx.)
B	Add twice the thickness		1″
	Amount required	=	$21\frac{3}{8}$″

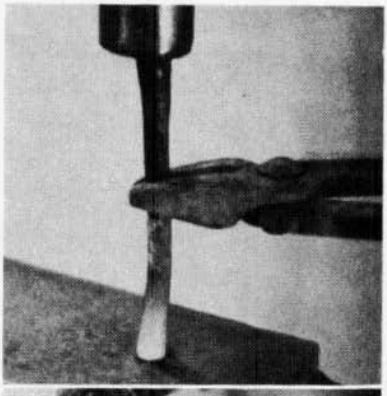


THE SMALL RING

The ring is to be welded on to a shank in Lesson 33, so extra metal must be left in the first weld to form the scarf for the later welding operation.

Using the formula on page 51, calculate and cut off the material required.

Take a NEAR WELDING heat on one end and, holding the bar vertically with the hot end on the anvil face, upset the end by striking the top as shown here—

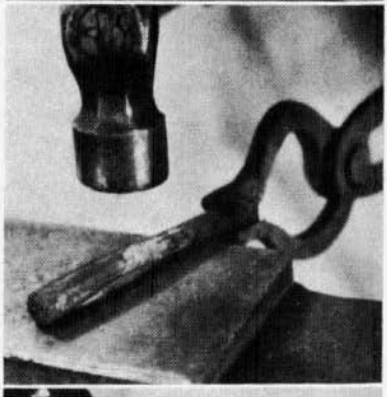


A

The middle of the bar will buckle slightly.

After every two or three upsetting blows on the top, straighten out the buckle in this way—

Heat the other end and upset in the same way.



B

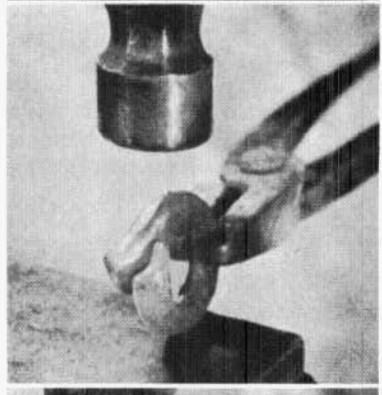
Take a BRIGHT RED heat and form the ring over the bick, leaving the ends for scarfing like this—

C

At a NEAR WELDING heat, using the corner of the anvil to give the required offset, form a scarf at each end on opposite sides so that they pair up when laid over each other.

D

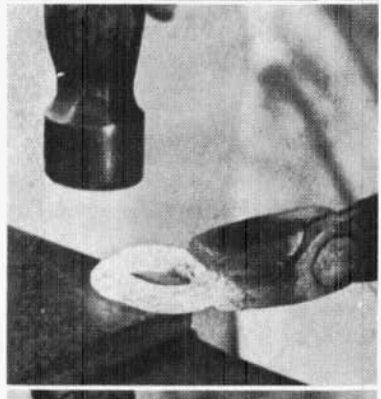
Set the scarfs down tight like this— Then dress up the joint over the bick with light hammer blows.



E

Take a FULL WELDING heat and weld first on the face of the anvil like this—

As soon as the weld feels solid, transfer the ring to the bick of the anvil.

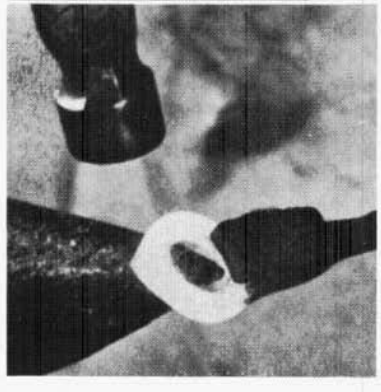


F

Finish the weld over the point of the bick like this—

Note the extra metal left in the weld.

This and the preceding operation must be done in the same heat, so work quickly.



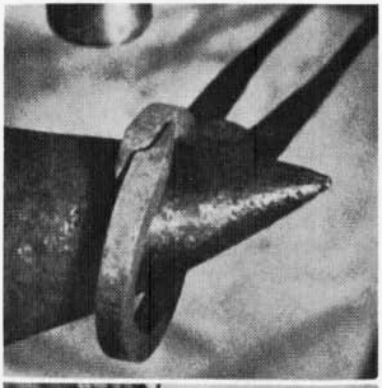
G

THE 3″ DIAMETER RINGS

Cut off the required amount of metal from a $\frac{1}{2}$″ *square* bar.

The ends must be upset before bending and scarfing as described for the small ring made in the first exercise in this lesson.

Set the scarfs together on the anvil face and align the ends on the bick as shown here.

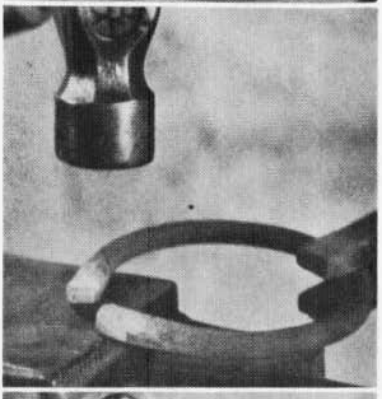


Weld as before.

By this time the student should be practised enough to weld a ring from $\frac{3}{8}$″ round without upsetting the ends.

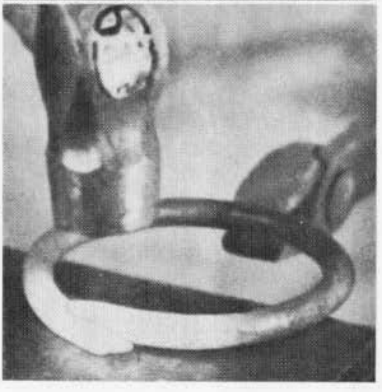
Calculate the amount of metal and cut off the required piece.

Bend the ring into shape and form the scarfs on the plain ends like this—



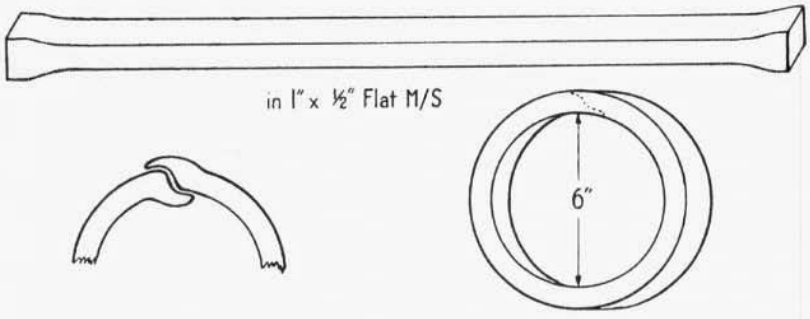
Make sure they are on opposite sides.

Set the scarfs together and align the ends thus—



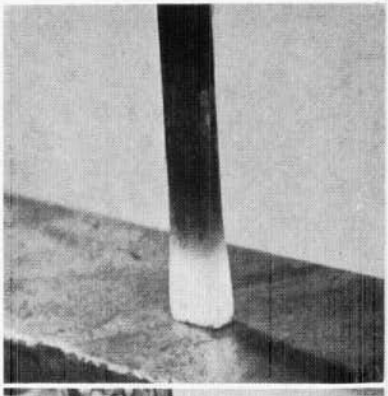
Then weld as in the previous exercises.

TOP SCARF WELDED RING



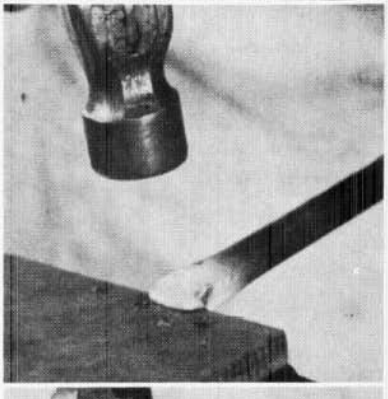
Calculate the length of material required using the formula given on page 51.

A ring made from this size material requires more upset on both ends. This can be done by either 'tamping' or end hammering according to the length of the bar.



A

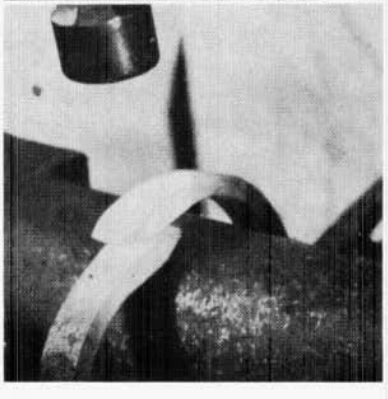
Using the rounded edge of the anvil, scarf the ends on opposite sides so that they pair up when laid together.



B

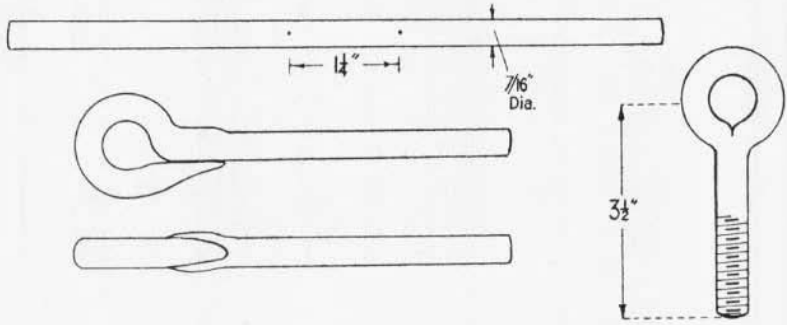
Set the scarfs together over the bick and square up the ends on the face of the anvil before welding.

Take a FULL WELDING heat and start welding on the bick and complete on the flat of the anvil.

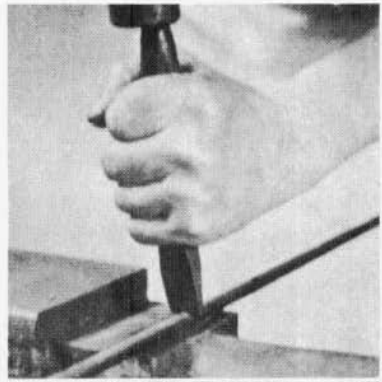


C

TURNED AND WELDED EYE-BOLT



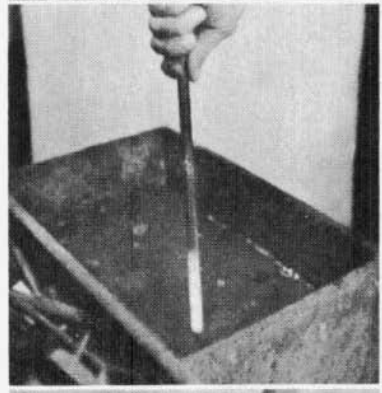
Cut off a piece of $\frac{7}{16}$" bar 6½" long by nicking both sides with a cold chisel to give an even-sided end. A sheared cut is always one-sided, producing an uneven end which would cause the bar to skew and bend when being struck on the top for upsetting. See illustration D on the opposite page.



Make the first mark on the bar 3" from one end, and the second mark 1¼" from the first.

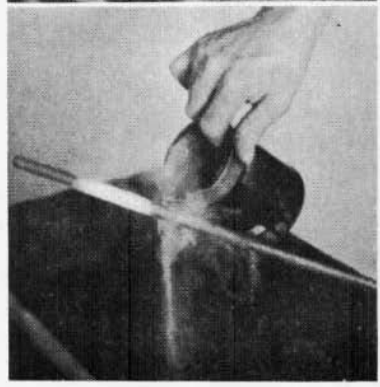
Take a NEAR WELDING heat between the punch marks.

To restrict the heat between the two marks, cool out from the end to the first mark by dipping in water, like this—



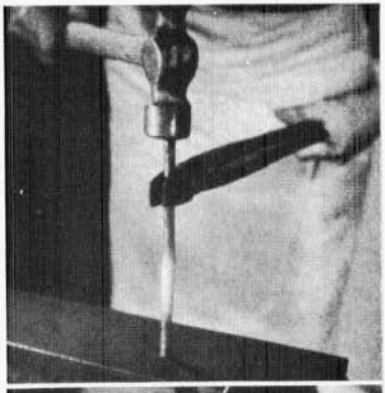
Cool beyond the second mark by pouring water from a tin as shown—

Both cooling operations must be done quickly to keep the maximum heat between the marks.



To upset the hot portion, hold the bar vertically on anvil and strike the top like this—

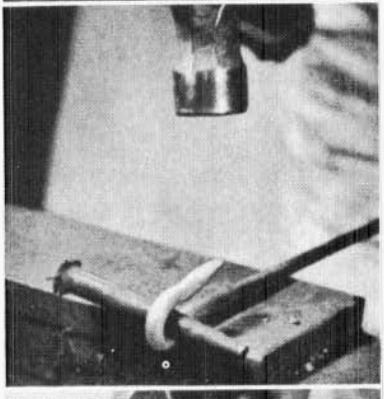
After every two or three blows straighten the resultant buckling on the anvil face and then continue upsetting until the diameter is increased to $\frac{9}{16}$".



D

Take a NEAR WELDING heat on the short end and draw to a blunt point to form a scarf.

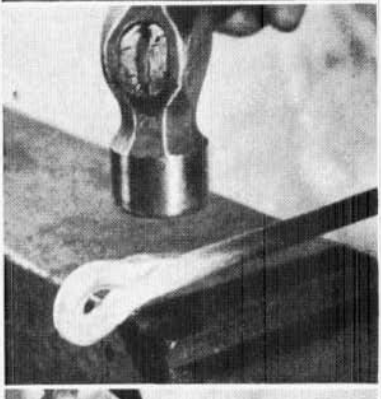
Bend this end from the upset portion over a $\frac{3}{4}$" diameter drift like this—



E

Take a FULL WELDING heat and weld the scarf into the shank with the bend of the eye over the rounded edge of the anvil like this—

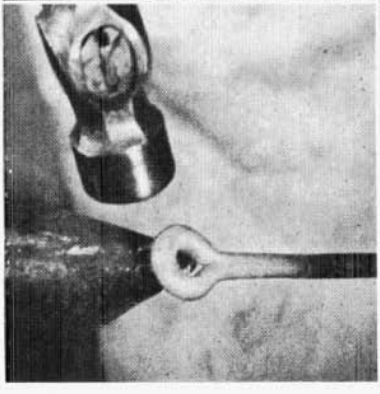
Round up the weld with light hammer blows, leaving a radius where the eye joins the shank.



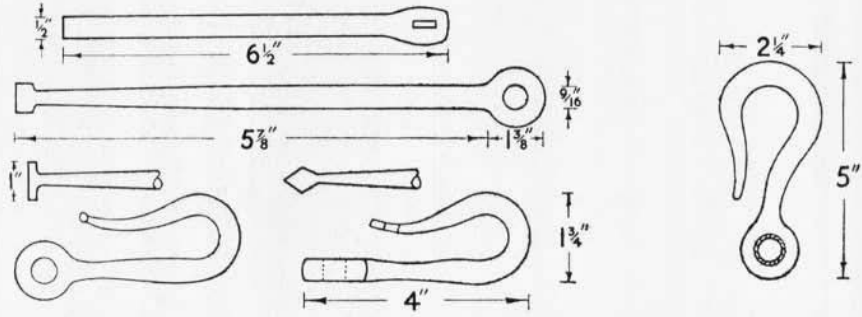
F

Work up the eye on the bick, leaving a slight V in the junction of the weld, like this—

Don't use a swage to round up the weld as this may weaken the eye by cutting into the radius where the ring joins the shank.



G



TO PUNCH THE EYE

Take a NEAR WELDING heat on one end of the bar and upset in the swage until the end is bulb shaped:

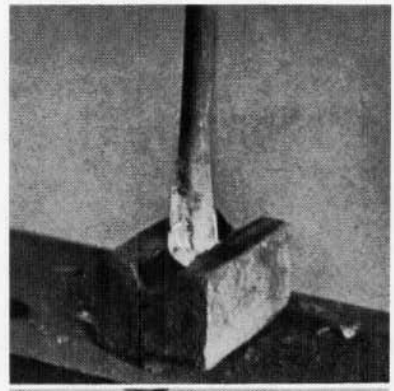
1⅜" long × 1" wide on ½" bar for the harness hook;

1⅜" long × 1¼" wide on ⅝" bar for the trace hook.

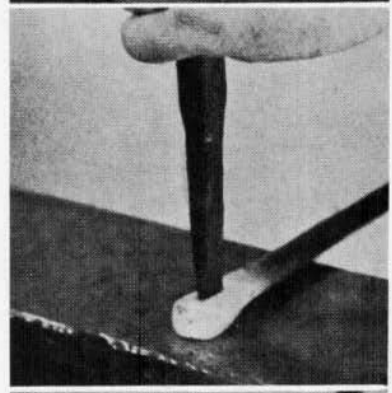
Flatten the bulb on the anvil face to form a flat knob.

9/16" thick on ½" bar.

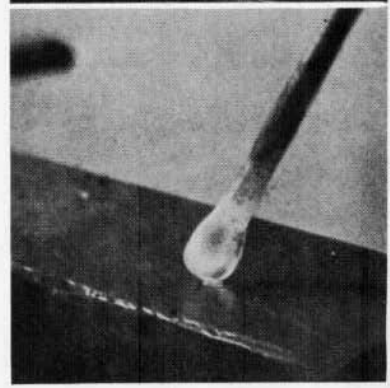
11/16" thick on ⅝" bar.



Next place a slot punch on the knob, in line with the shank but rather nearer the shoulder than the end. Drive it rapidly through the hot metal until the punch stops against the hard, thin layer on the under side which has been compressed and chilled against the anvil face.

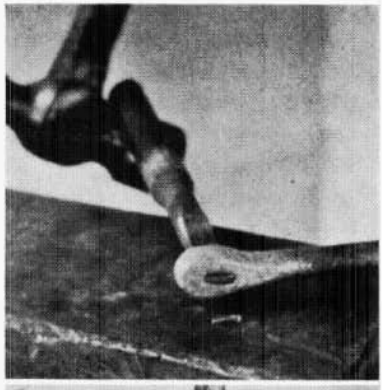


Now, without losing a moment, pull out the punch, and turn the metal over. A black spot will be seen at the blind end of the punch hole. Flick the hot end of the punch immediately into the water trough, and drive it into this black spot until the end breaks through to the other side.



A thin sliver of metal, the size of the hole, will be punched out clean and driven right through.

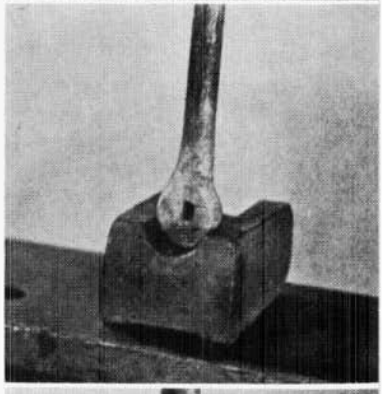
It can be seen just in front of the glowing knob.



D

Next continue upsetting the end in a larger swage.

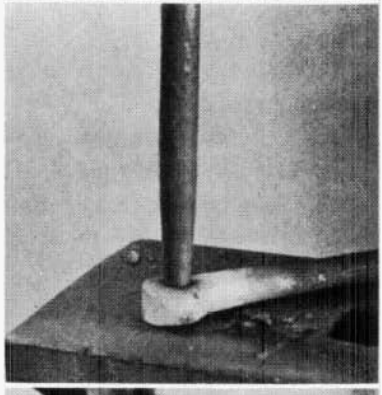
This will increase the diameter of the eye and convert the slot into a square hole.



E

To round up the square hole, place the eye over the round hole in the anvil face and drive a drift through.

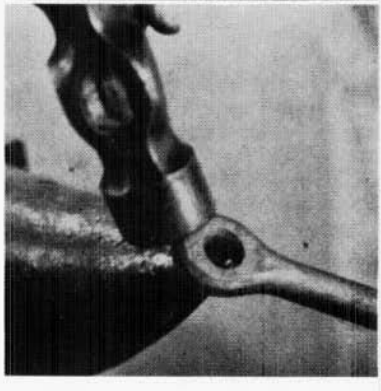
The end is now almost perfect in shape and a little working up over the bick will produce an eye with nicely chamfered edges all round.



F

To prevent the edges from cutting the chain link which passes through the hole of the trace hook both sides of the eye must now be countersunk slightly over the bick of the anvil, like this—

The eyes in the harness hooks must *not* be countersunk or the hooks will ride over the corners of the shaft staple.

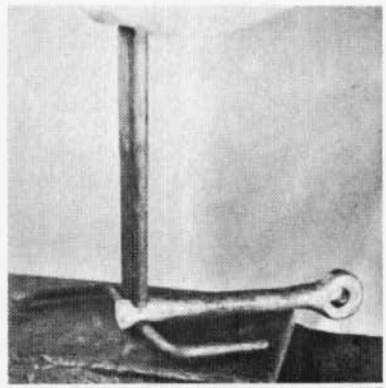


G

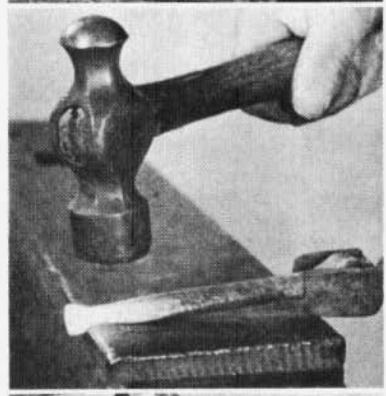
Harness Hooks

The **T** and diamond ends on harness hooks are both started with the same operation.

Take a NEAR WELDING heat and make a groove each side $\frac{1}{4}$" from the end. Use a top hand fuller and a bottom fuller made from $\frac{1}{4}$" round bar cranked as shown to lie flat on the anvil. The resulting knob should be a little shorter than it is wide. Make sure it is in line with the eye like this one—



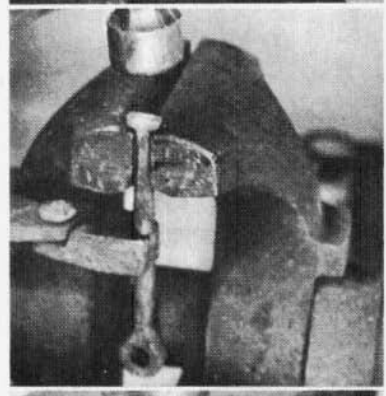
With the groove on the rounded edge of the anvil, forge first to a square and then to a round, easy taper $1\frac{1}{4}$" long. A hammer with a nicely rounded edge to the flat face should be used to avoid damaging the end or breaking it off.



The next operation varies according to the type of end required.

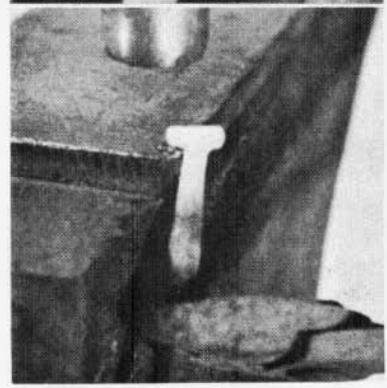
To make the T end

Grip the tapered part in the vice with the knob on the jaws and form a **T** like this—



Make sure that the sharp edge of the vice jaw does not cut into the shoulders of the **T** and weaken the corners.

Take a fresh heat and work the **T** to a neat round section on the rounded edge of the anvil.

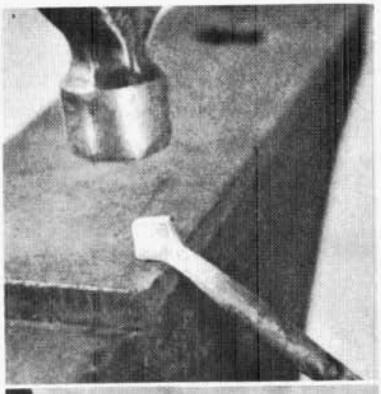


Great care must be taken with both this and the previous forging in the vice; otherwise the **T** will break off or be weakened by nicking under the head.

To make the Diamond End

Start the diamond end by fullering and then forging the taper in the same way as for the **T**. *Do not* upset in the vice but forge the end on the anvil to a diamond shape like this—

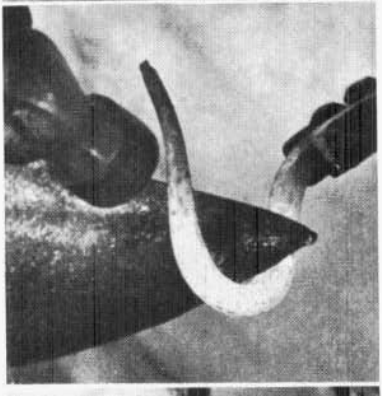
Keep the flat of the diamond at right angles to the eye and leave a nice curve to the tapered part.



M

Trace Hook

The trace hook with the countersunk eye has a long tapered end which is drawn down and given a slight curve outward as shown here—



N

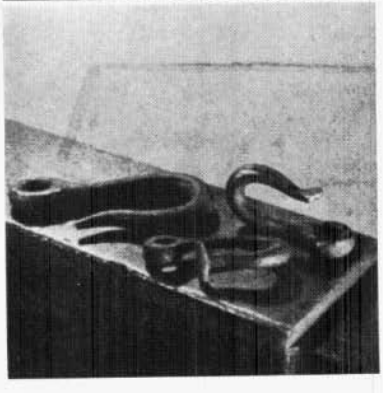
Then flatten the centre of the bend slightly to increase the strength.

Give the trace hook a little more flattening round the curve than the others.

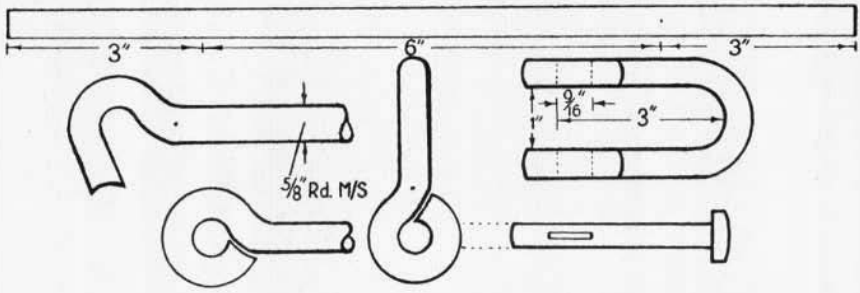
All hooks are bent round the bick of the anvil.

O

Compare the measurements on the drawing with the hooks, which should look like this—



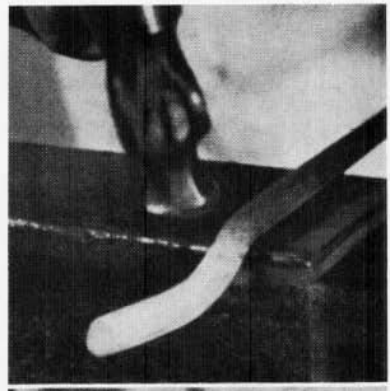
P



Cut off 12" from a $\frac{5}{8}$" round bar and mark off as shown in the drawing.

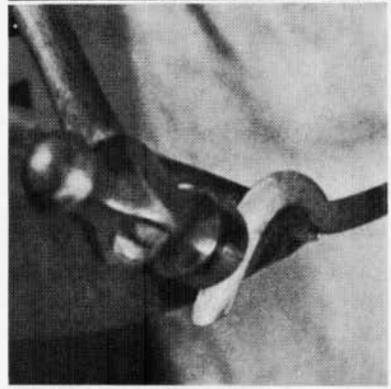
Take a NEAR WELDING heat and lay the bar with the punch mark over the rounded edge of anvil. As this will be a small eye in thick metal, use the ball-peen of the hammer to make the first bend at the shoulder of the eye.

The free end will jerk upwards as described in Lesson 4.



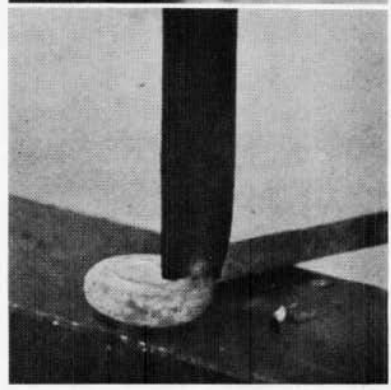
Take another NEAR WELDING heat and cool out the bar at the first bend.

Continue turning the eye around the bick—first over the top, then from the underside as in Lesson 4 C.



Next trim the end of the eye with a curved hot chisel to form a radius which will fit snugly against the curve of the first bend.

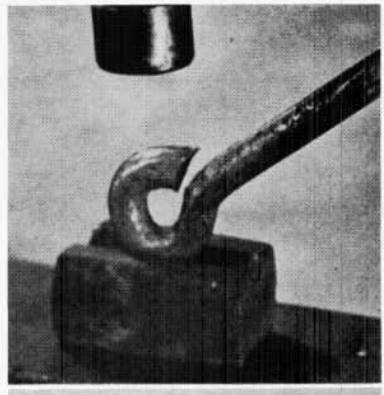
The finished shackle can be seen in the illustration E on the opposite page.



With the eye in the bottom swage, close the end of eye down to the first bend by hammering it like this—

The hole should be $\frac{9}{16}''$ in diameter when finished.

Next turn the other eye in the opposite direction, but keep them both in alignment on the bar.

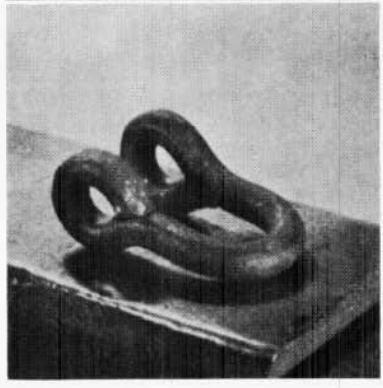


D

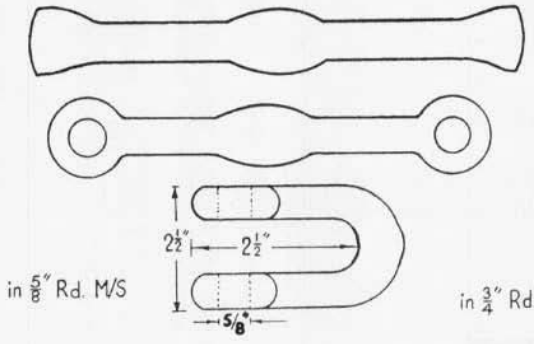
Bend the middle of bar round the bick to an even semi-circle to form a **D**, keeping the eyes in alignment as shown in this finished shackle—

The advantage of trimming the ends of the eyes is very plain.

The mushroom-headed pin for this shackle is made in Lesson 19.



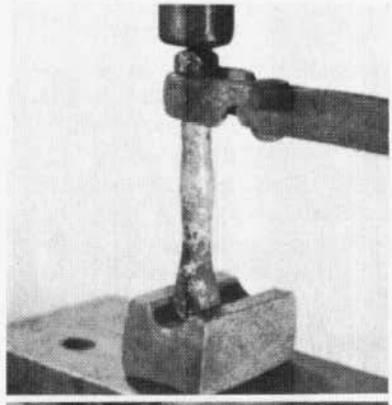
E



Cut off 9″ of ⅝″ round for the **D** shackle and 14″ of ¾″ round for the bow shackle.

First upset each end as in Lesson 16 to a little over twice the thickness of the bar.

Next take a NEAR WELDING heat in the middle of the bar and, with the bottom end in the swage, upset to about 1½ times the original diameter.



A

Flatten the ends into bosses:

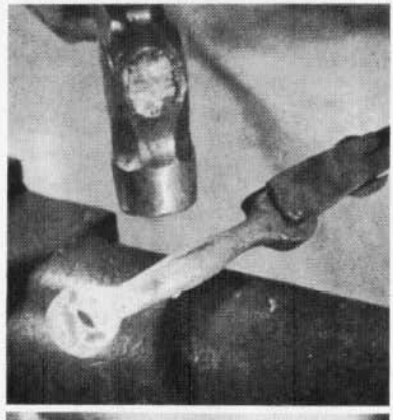
1¼″ long × 1⅛″ wide × 11/16″ thick on the ⅝″ round.

1½″ long × 1¼″ wide × 13/16″ thick on the ¾″ round.

Next slot punch and drift the holes to:

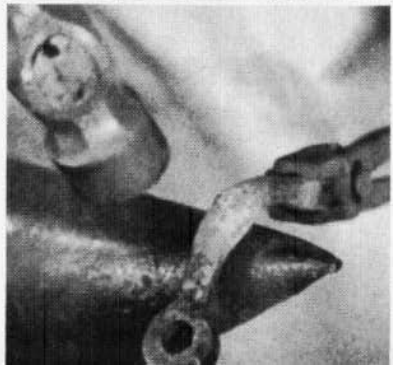
⅝″ dia. on the ⅝″ round.

13/16″ dia. on ¾″ round.



B

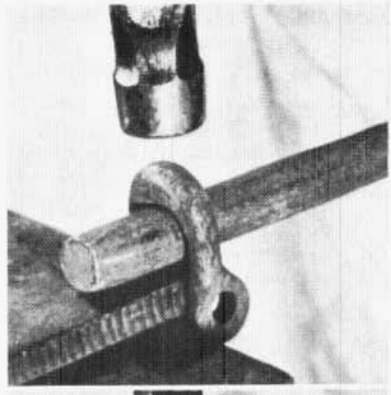
Start bending the **D** shackle over the anvil back, keeping both ends even and the holes in alignment.



C

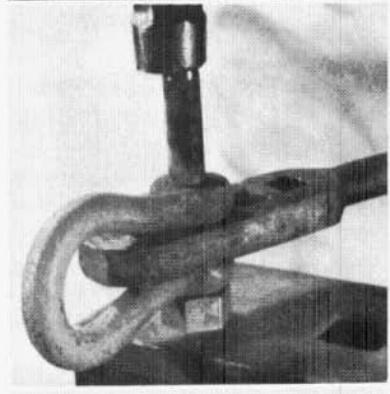
Complete the bend over a suitable size round bar or mandrel, and then line up the holes with a drift.

Note the extra metal surrounding the holes on the shackle in comparison with the trace hook.



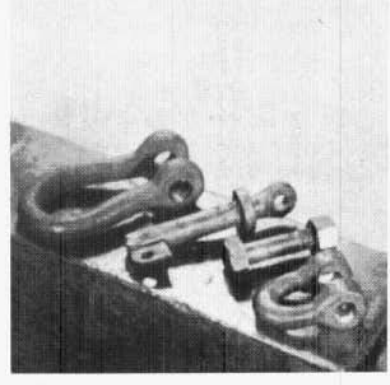
D

The bow shackle is made in the same way. The ends are brought parallel and the holes aligned by driving a drift through with a spacer between. A large nut is placed between the anvil and the end of the shackle to prevent any distortion of the bow.



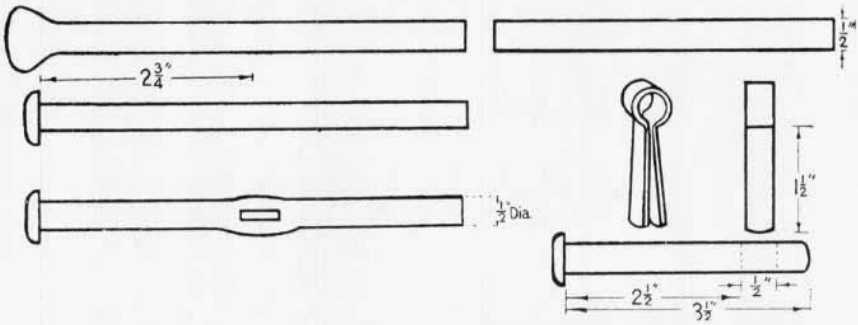
E

Here are the bow shackle; the shouldered pin and cotter made in Lessons 21 and 22; the hexagon-headed bolt made in Lesson 20; and the **D** shackle.



F

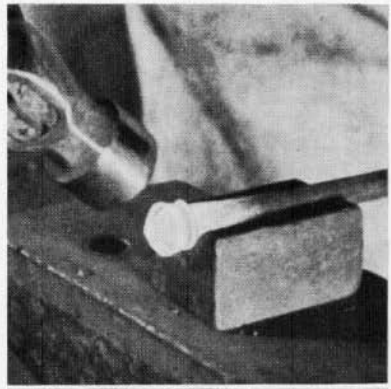
Lesson 19 MUSHROOM-HEADED SHACKLE PIN and COTTER



Take a NEAR WELDING heat on one end of a piece of ½" diameter bar 18" long, and upset one end as described in Lesson 13 A and B until the end is about twice the size of the bar.

Do not mark off for the slot until the head is formed.

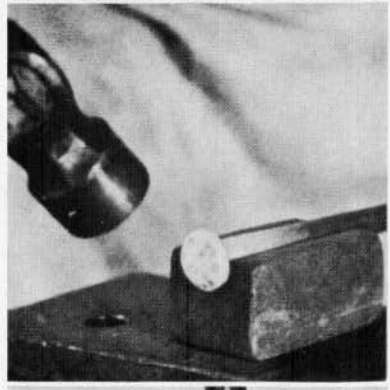
Re-heat the upset end and lay it in the swage. Forge the head by striking at an angle of about 45°. Turn the bar a little between each blow to keep the head even.



A

Take a second heat and, keeping the head central on the bar, continue working it up until it is an even mushroom shape.

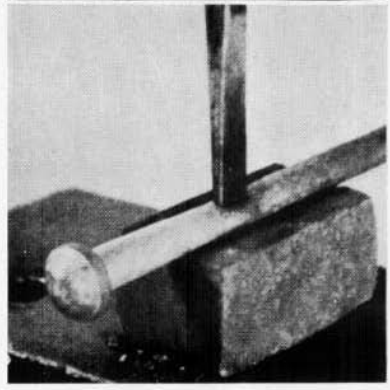
Keep the bar the original diameter, with a clean square shoulder underneath.



B

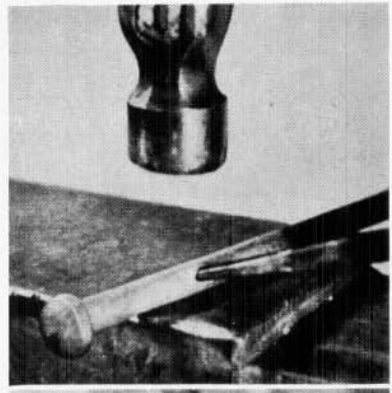
Now mark off and centre punch the slot.

To punch the slot, take a NEAR WELDING heat over the mark, lay the bar in the swage and, with the end of the slot punch on the dot, make a slot as in Lesson 16.



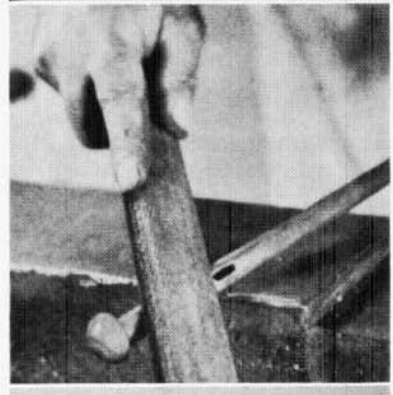
C

Dip the end of the punch in water, replace it in the hole and then forge in the swelling as much as possible to save the labour of filing it to size later.



D

At a BRIGHT RED heat finish shaping to size and clean up and roughness with a bastard file.

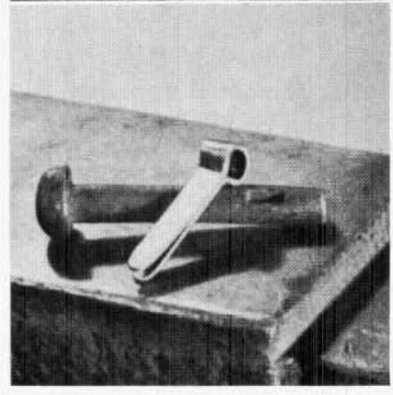


E

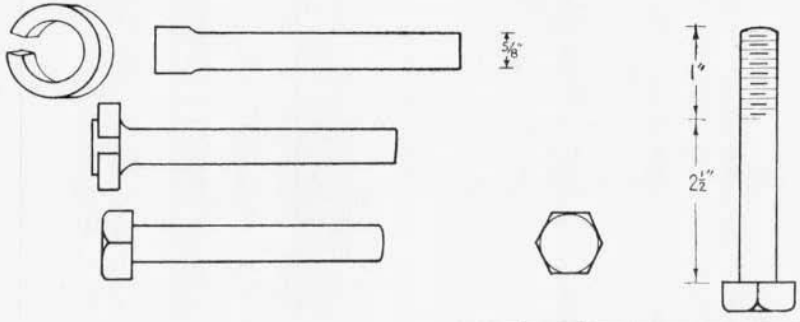
A 4″ length of $\frac{1}{2}$″ × 16 s.w.g. is needed for the cotter.

It is made by folding the strip over a piece of $\frac{1}{4}$″ round then squeezing to shape between the vice jaws.

This is the finished cotter and pin for the shackle with turned eyes made in Lesson 17.



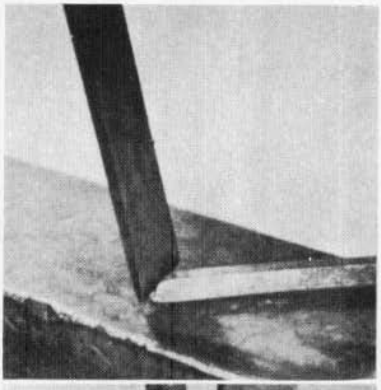
F



First upset one end of the $\frac{5}{8}$" round bar to a diameter of about $\frac{3}{4}$".

The head of the bolt is made by welding on a collar made from $\frac{3}{8}$" square. This is a tricky weld, so it is better to use wrought iron for the collar as this gets hot quicker than the bolt. (Wrought iron, remember, will stand a higher temperature than mild steel).

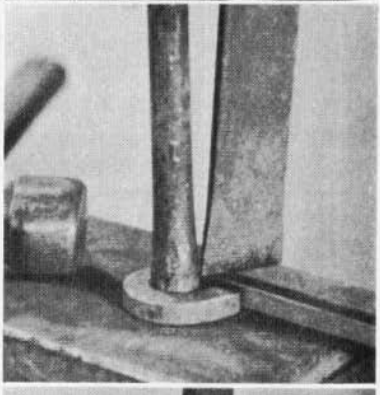
Next, cut the end of the $\frac{3}{8}$" square to an angle of 45° so—



A

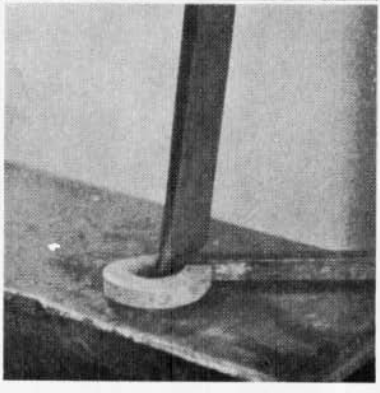
Hold the square bar over the tip of the bick with the point upwards and bend it into a tight circle. The metal will stretch while this is being done bringing the oblique end about square with the side of the bar.

Fit the collar over the upset end of the round bar and after allowing for a gap equal to the width of square metal, make a chisel mark like this—



B

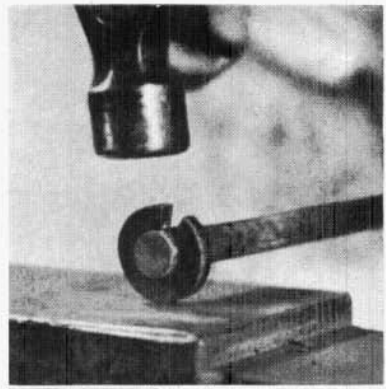
Take a BRIGHT RED heat, cut off the bar at the chisel mark and fit the collar over the upset end of the $\frac{5}{8}$" bar.



C

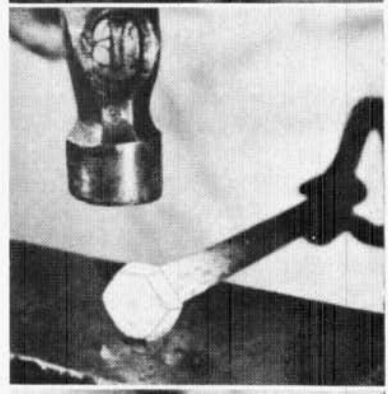
Close the collar tightly around the bar and return to the fire.

Take a FULL WELDING heat very slowly so that the heat penetrates to the centre of the bar without burning the collar.



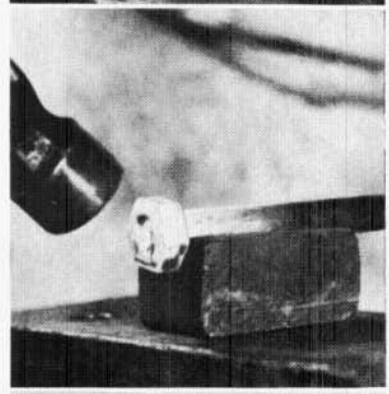
D

The ends of the collar must join at one corner of the hexagon. To close the ends and at the same time form the hexagon, *the order of the first three blows is most important*. Strike the first blow a little back from one end of the collar. This will partly close the gap. Before each of the next two blows, give the bar one-sixth of a turn. This will close the gap and the hexagon will form automatically between the hammer and the anvil. To complete the welding take a further heat. All subsequent blows must be delivered on the flats of the hexagon.



E

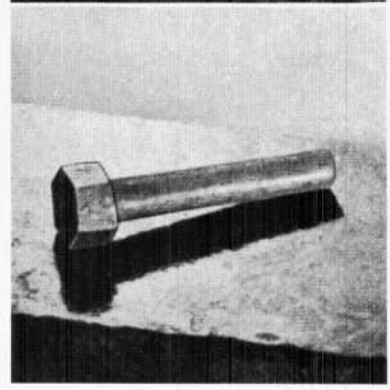
Before cleaning up the body of the bolt, true up the hexagon on the anvil face. Then lay the shank in the swage, and true up the diameter. Keep the head central and at right angles to the shank.



F

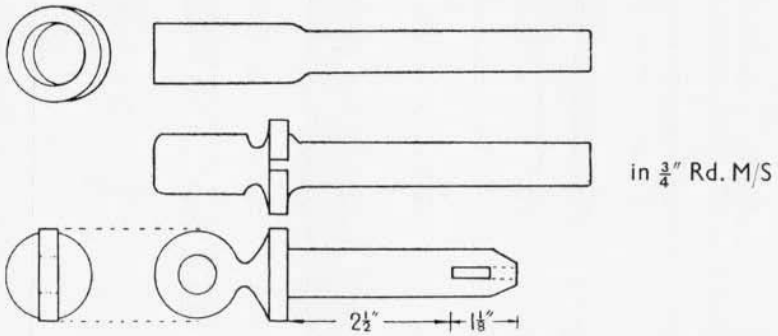
On all bolts the thickness of the collar should be half the diameter of the bolt or a little more according to the sizes of metal available.

In each case, the gap left is equal to the width of the square metal used for the collar.



G

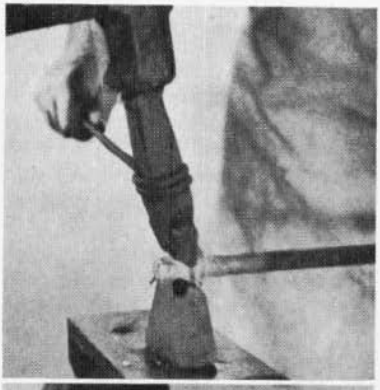
SHOULDERED SHACKLE PIN



The shoulder under the eye of this shackle pin is formed by welding on a collar made as in Lesson 20.

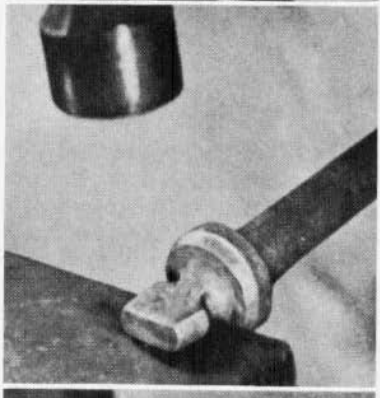
Take a NEAR WELDING heat on one end of a ¾″ bar 18″ long and make an upset 2″ long. Weld on the collar at the base of the upset.

While still hot, fuller a groove all round like this—



A

Take a NEAR WELDING heat, flatten the end, shape roughly on the rounded edge of the anvil, then punch the hole.

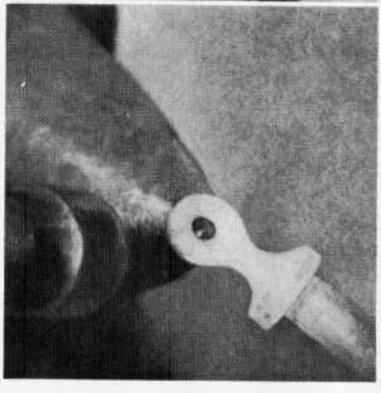


B

Take a fresh heat and work up the eye to shape with the point of the bick through the hole like this.

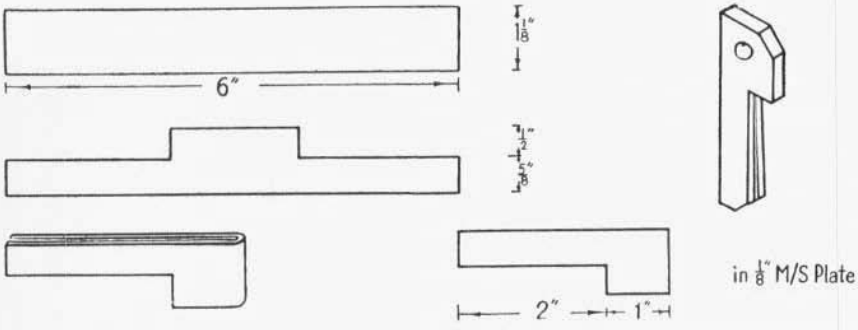
Complete the pin by slot punching the hole so that it is ⅝″ × 3/16″, and cut off to length.

The finished pin is shown in Lesson 22 C.

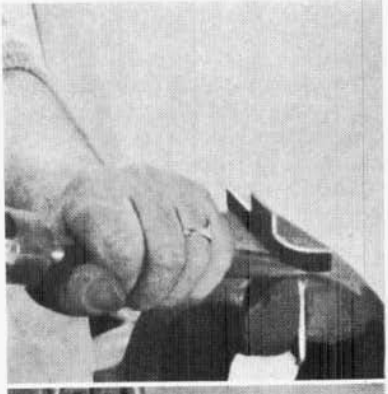


C

WELDED COTTER



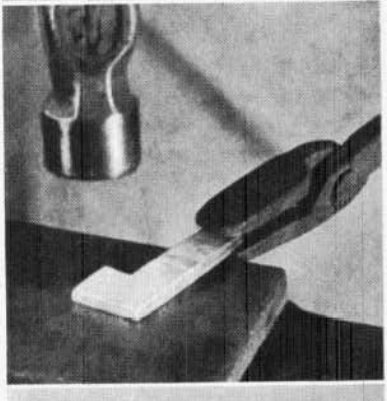
Mark off a piece of ⅛" plate to the sizes given in the drawing. Using a cold chisel, cut the piece to the correct shape in the vice.



A

Take a BRIGHT RED heat and fold over flat. Then take a LIGHT WELDING heat on the head to about half way down and weld with light and rapid hammer blows without thinning the metal unduly.

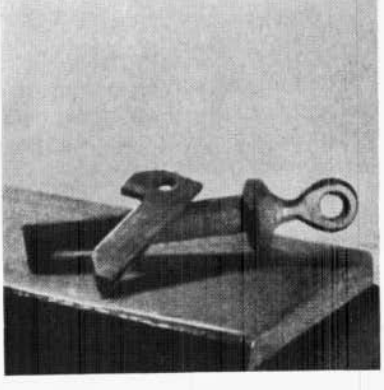
Punch the hole with a round punch while hot.



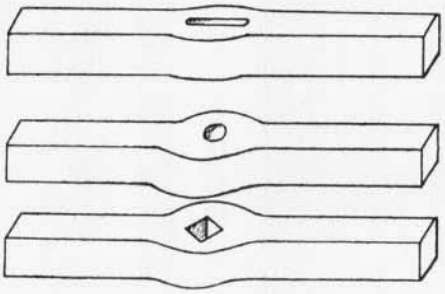
B

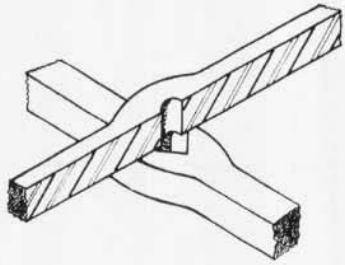
File the cotter to fit the slot in the pin.

This is the finished pin and cotter for the bow shackle made in Lesson 18.



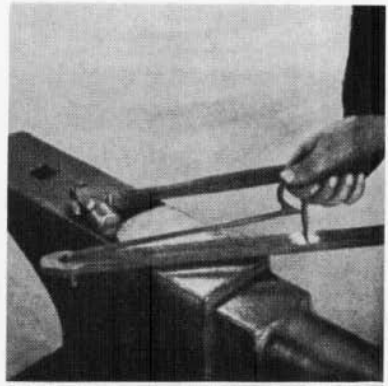
C





The position of the first hole in a harrow bar is marked with a centre punch. Each hole thereafter is marked from the previous one using the gauge or scriber made in Lesson 5.

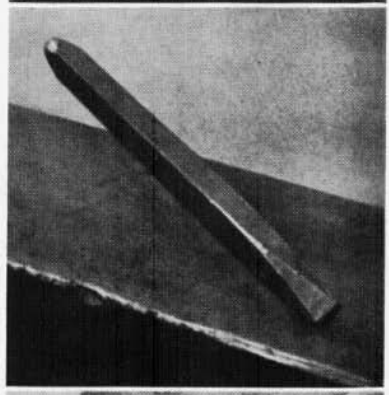
Do not try to mark all the holes before starting to punch them.



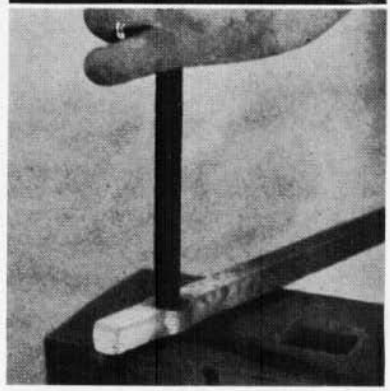
The holes in *light* harrow frames are slotted and punched to the finished size and shape in one operation.

This is the special punch used for punching square holes in light harrow frames—

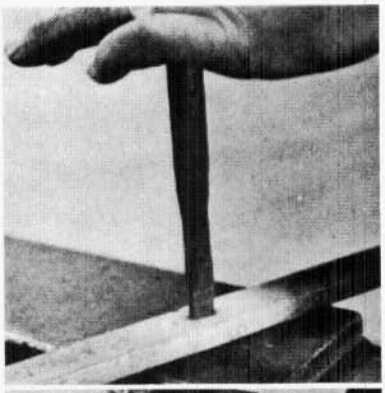
It combines the action of a slot punch with that of a square drift.



Do not attempt to punch the hole right through from one side, but use the punch as described in Lesson 16. As there is no upset, make sure that the slot is started exactly in the middle of the bar. It is important to keep as much metal as possible either side of the hole.

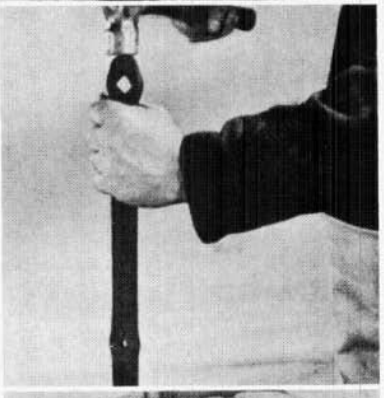


Round holes in light bars are made with a combined punch, similar to that shown in B on the opposite page, but it is of round instead of square section, like this—



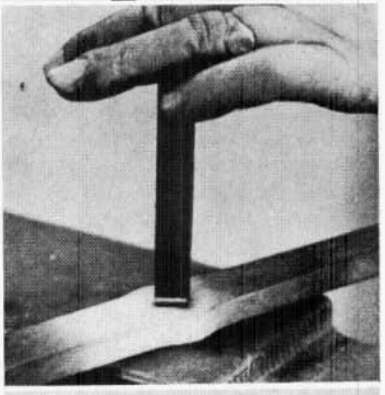
D

Heavy flat bars are first slot-punched and then the hole is opened out by upsetting. This is being done here to the lower hole which is hot. The upper one is complete.



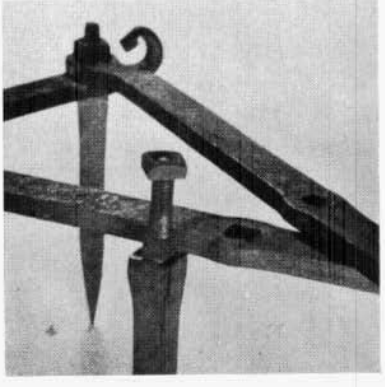
E

The hole is finished off with a special stubby drift, which is marked at three-quarters of the thickness of bar. It is driven in from each side in turn almost as far as the mark. This is done on the flat of the anvil and not over a hole. The use of the special drift prevents burrs forming on either edge of the hole.



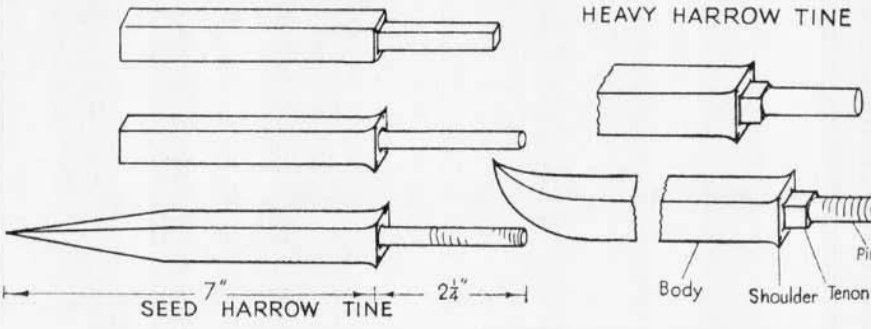
F

Harrow tines must be a push fit in the holes. The holes must be spaced exactly so that the harrow frame can be assembled correctly. It is therefore essential to use a scriber to mark off each hole as the previous one is punched.

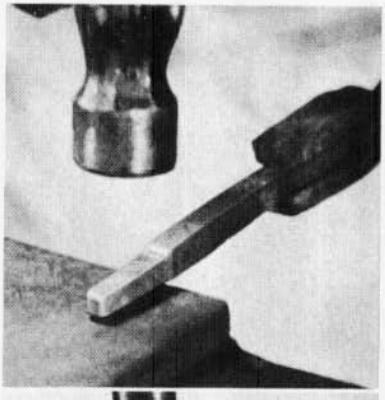


G

HARROW TINES

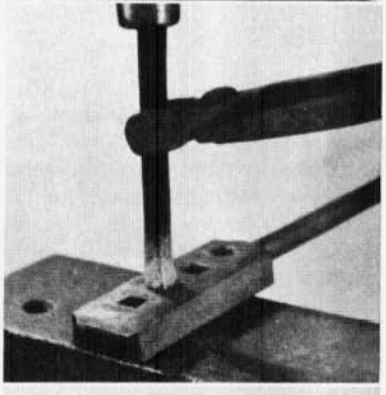


A shoulder on a seed harrow tine has a parallel round shank without a square tenon. Only a very slight reduction in section is needed to form a shoulder. Neither fullering nor swaging is necessary as the drawing down can be done by hammering the bar on the flat of the anvil and using the rounded edge of the anvil to form the shoulder.

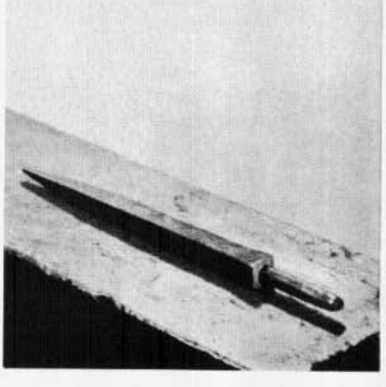


Next drive the reduced portion of the tine into the countersunk side of the small round hole in the bolster. Withdraw the tine, reverse the bolster so that the square edged holes are uppermost, and drive the tine into the same hole. This completes the shoulder and forms the upset.

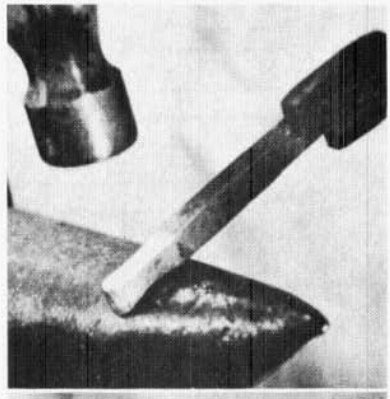
The special bolster used for forming the shoulders on tines is described in Chapter 2 and shown in Figs. 24 and 25 on pages 13 and 14.



This is the seed harrow tine as forged. The rounded pin, which will be threaded, continues right up to the shoulder without a square tenon.



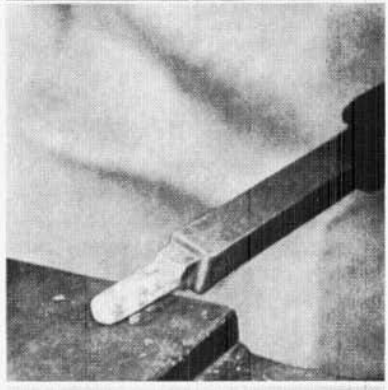
Medium and heavy tines have a square tenon between the shoulder and the threaded portion. More reduction is required on these tines and the drawing down should be started over the bick of the anvil and completed on the flat, leaving both the tenon and the pin square.



D

To square and upset the shoulder take a NEAR WELDING heat and drive the tine into the square hole in the bolster.

The pin, which is to be threaded, must now be rounded on the face of the anvil to the required size. It is then driven into the special round hole in the bolster; this will form the shoulder between the pin and the tenon and leave the tenon the required length.

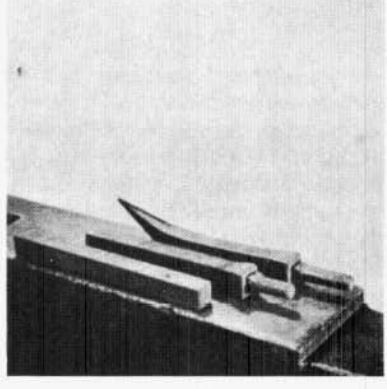


E

Here a medium harrow tine is shown in three stages:

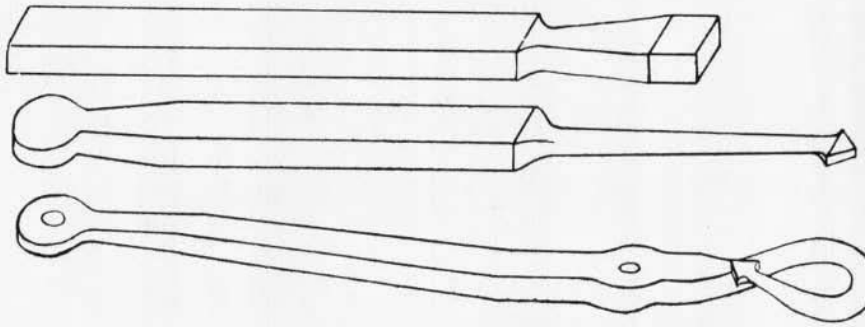
(1) cut and marked,
(2) the pin and tenon formed,
(3) the tine pointed and set.

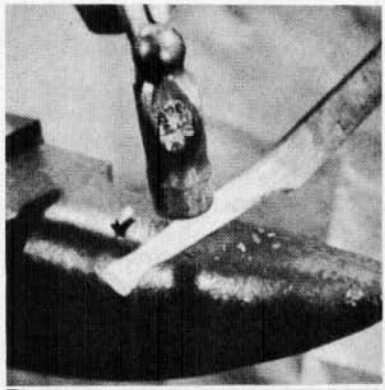
The square upset shoulder between the tine and the tenon, and the reduced shoulder between the tenon and the pin can be clearly seen.



F

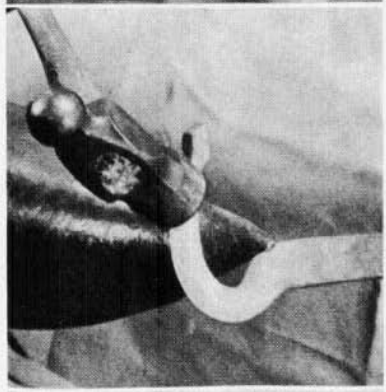
HARROW DRAUGHT HOOK



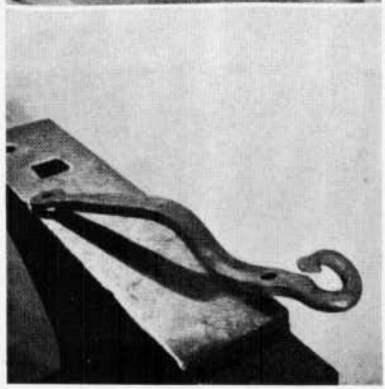


Approximately 18″ of $1\frac{1}{8}″ \times \frac{1}{2}″$ bar is used for the harrow draught hook.

Bring one end, which will form the hook, to a NEAR WELDING heat. Drawing down should be started on the anvil bick and finished off on the anvil face. The diamond head is formed as described in Lesson 16.



In forming the hook, the first bend is made on the top of the anvil bick as shown in Lesson 2. A harrow needs one right-handed and one left-handed hook. So, at the second stage of bending shown here, the point of one hook is turned to right and the point of the other hook to the left of the bar.



One completed hook for a diamond harrow frame should look like this—

The other should have the hook bent in the opposite direction, as shown in the drawing.