# PART IV

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The lessons which follow are on more advanced forging and welding, calling for a higher degree of skill. By applying the techniques he has already learned, the knowledge gained by experience and by using common sense the student should have no difficulty in following the exercises.

## BENDS TO DIMENSIONS

In making bends to measurements, allowance has to be made for the amount of metal used in actually forming the bend. The allowance will vary with the type of bend and with the individual smith; no hard and fast rule can be laid down. Experience will show what allowance to make, but the figures given below are a good guide for a start.

**(a) Radius Bends**

Radius bends should have the *inside* radius equal to the thickness of the metal. No preliminary upsetting is required.

To make the **U**-shaped piece from $1\frac{1}{4}'' \times \frac{1}{2}''$ shown in Lesson 26, subtract once the thickness of the metal for each bend from 3″ which is the outside measurement over the bends. The marks will therefore be 2″ apart.

If the two dots are kept in the middle of each bend and the correct radii maintained, the dots will finish up in line with the inside surfaces and the given measurement will be correct.

The same allowances are made for the **Z** bend in 1″ round, also shown in Lesson 26, and again, if the correct inside radii are maintained the dots will finish up in line with the inside edge of each leg.

**(b) Plain Square Corner Bends**

Plain square corner bends have the inside corner forged square and the outside corner left rounded, and no *preliminary* upsetting is required. With light section, square and flat metal the corner can be strengthened by upsetting the material as the bend is made. The inner and outer corners must be forged simultaneously; if the inner one is squared first, it will be galled in forming the outer one.

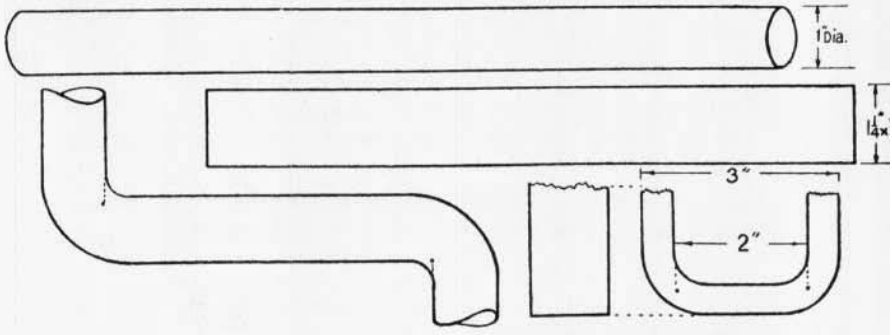
To make the **Z**-shaped piece in $\frac{1}{2}''$ square shown in Lesson 28, *subtract* from the outside measurement half the thickness of the metal for each bend. If the dots are kept on the diagonal line joining the inner and outer corners of each bend, the finished measurement will be correct.

Although the shape is different, the same allowances are made for bending both the shaft staple in Lesson 27 and the **U**-bolt in Lesson 28. Again, the dots should be kept on the diagonal line through the corners of each bend.

### (c) Forged Square Corner Bends

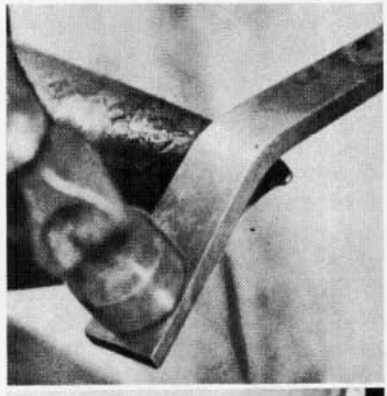
Forged square corner bends are upset before bending starts. The extra metal is then worked into the bend to form a corner square on the outside and with a radius on the inside.

To make the **Z**-shaped piece in Lesson 29 (which has a square corner on the outside and the radius on the inside of each bend) it is first necessary to upset the metal to $1\frac{1}{2}$ times its thickness where each bend will be formed. To the outside measurement, add a quarter of the thickness of the material and mark the bar. Next, upset the bar evenly around the mark using $1\frac{1}{2}$ times the thickness of the material for each upset. The overall length of the bar will now be reduced by three times its thickness. The marks will be $1\frac{1}{4}$ times the thickness of the bar closer together than the outside measurement of the finished bend. If the marks are now kept on a diagonal line through the corner, the outside measurement will again be correct.



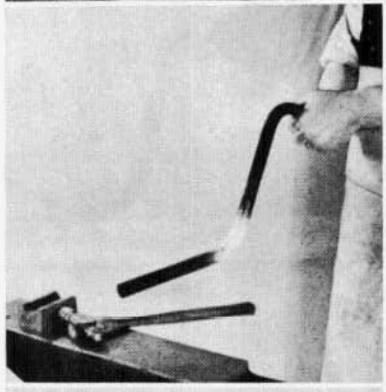

Mark off as described on page 78, paragraph (*a*).

Take a NEAR WELDING heat, adjust the position of the heat if necessary by cooling out with water (Lesson 15, B and C) and bend over the bick. The second bend is made in the same way.



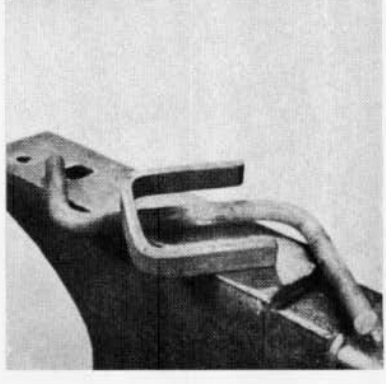
With a heavy job such as a plough axle, it may be more convenient to lay the hammer aside, hold the piece and hit it on the flat of the anvil like this—

The weight of the metal itself will then do the bending.

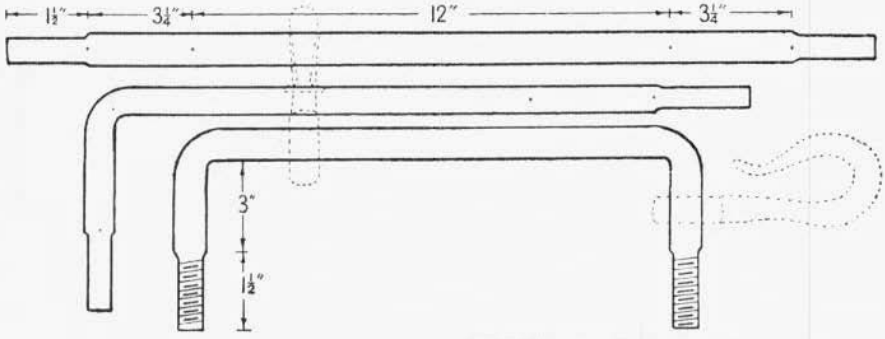


Here are the finished bends—

In the smaller one the punch marks can be seen in the middle of each bend.



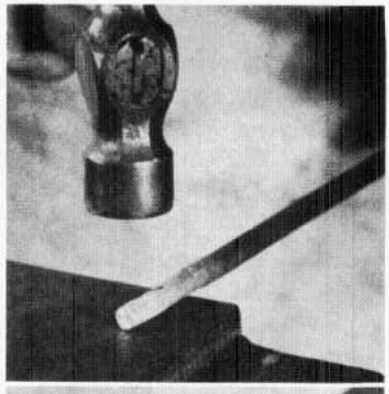
# CART SHAFT STAPLE




Mark off a ½" round bar as shown in the drawing, using the allowances described on page 78, paragraph (*b*).

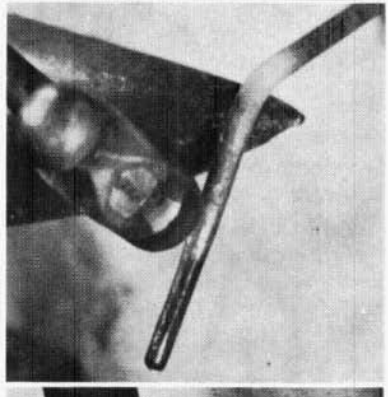
Take a NEAR WELDING heat, and from the mark nearest one end, reduce the diameter to 7/16". There is no need to use a bottom swage for this operation: square it with a hammer, then round up as described in Lesson 1.

Test the diameter in a 7/16" hole.



A

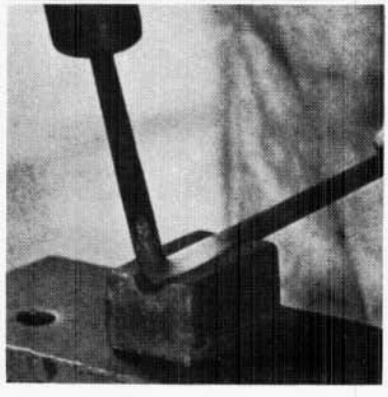
Next, take a BRIGHT RED heat at the second mark and, keeping the mark on one side bend the bar over the bick of the anvil.



B

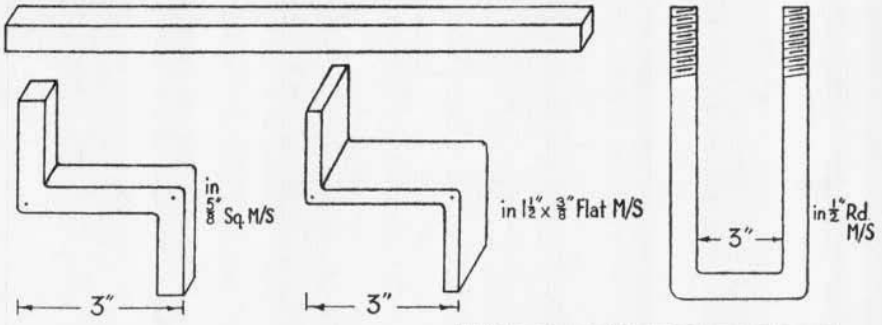
Take a NEAR WELDING heat in the bend, with the long part lying in a bottom swage and the short end upwards, and strike the top with a hammer to drive the bend into the swage. This will upset the metal slightly and produce a sharp bend, with the punch mark exactly in the middle of the side of the thickened corner.

Reduce and bend the other end in the same way; then twist out of alignment for threading as described for the U-bolt in Lesson 2. Twist straight again.



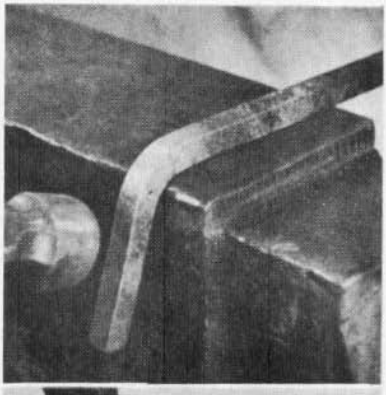
C

# PLAIN SQUARE CORNER BENDS




To make the **Z** or cranked bends, mark the $\frac{5}{8}$″ square and $1\frac{1}{2}$″ × $\frac{3}{8}$″ flat as described on page 78, paragraph (*b*) allowing half the thickness of the metal for each bend.

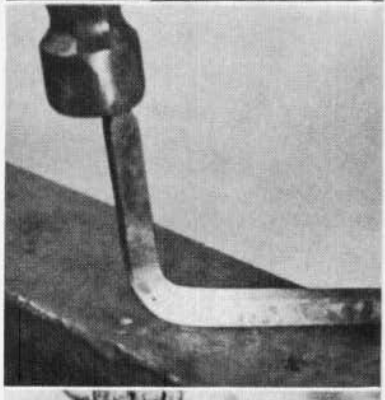
At a NEAR WELDING heat bend the bar over the rounded edge of anvil with the mark on the side of the bar beyond the edge of the anvil, as shown here—



A

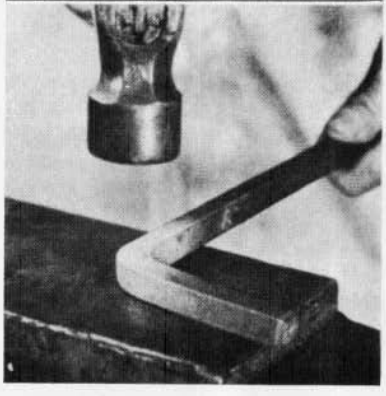
Take another heat, cool out the end and square the corner by laying the long part of the bar on the anvil face and striking the short end, so—

This will upset the metal slightly and produce a sharp bend with the punch mark exactly in the middle of the side of the thickened corner.



B

Keep the metal from thickening by flattening the swelling on the side of the corner as you go.

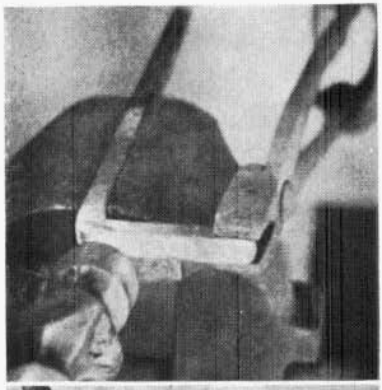


C

Finish off by gripping in the vice with the inside corner about $\frac{3}{16}$″ from the vice jaws and finally square the bend by hammering like this—

*Do not* drive the inside corner hard against the jaws or the sharp edge will cut it.

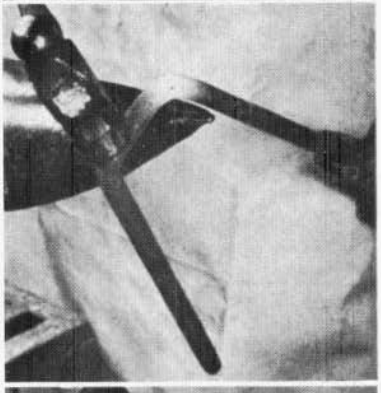
Make the other bend in the same way.



D

To make the U-bolt, mark off the $\frac{1}{2}$″ round, using the same allowances.

Take a NEAR WELDING heat where the bar will be bent, quench to about $\frac{3}{4}$″ on either side of the punch mark and bend with a full radius over the anvil bick.

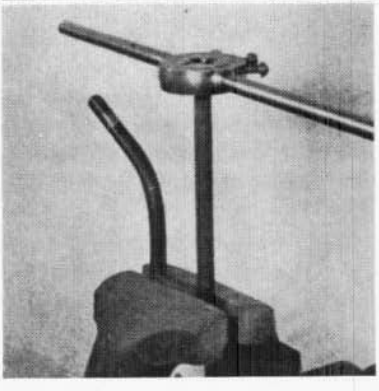


E

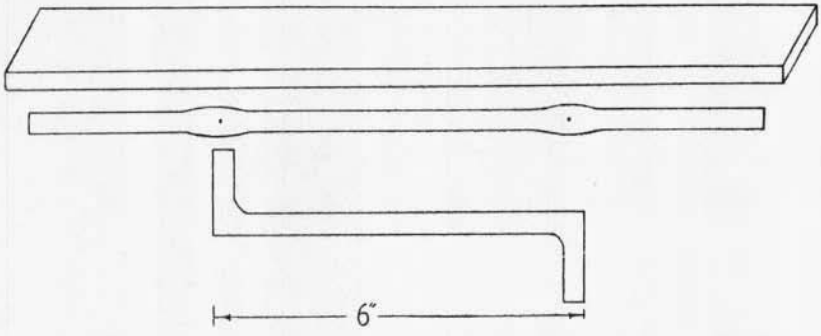
Lay it in a bottom swage and work up the corner like this—

F

In order to screw the ends, bend one side as shown to allow the die-stock to rotate.



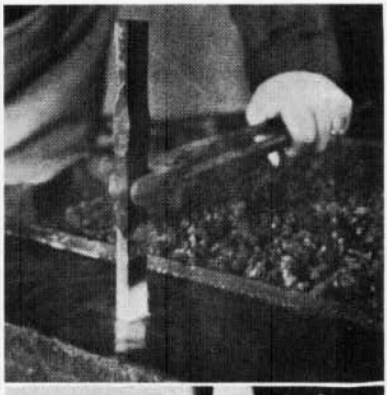
G




Mark a $1\frac{1}{4}'' \times \frac{1}{2}''$ bar using the allowances given on page 78, paragraph (*c*).

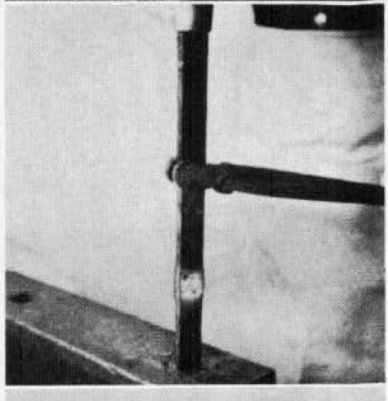
Take a NEAR WELDING heat, keeping the punch mark exactly in the middle of the heat.

Cool out leaving $\frac{3}{4}''$ hot on either side of the mark.



Next, upset the bar evenly each side of the mark until the overall length of the bar is reduced by exactly $1\frac{1}{2}$ times the thickness of the metal.

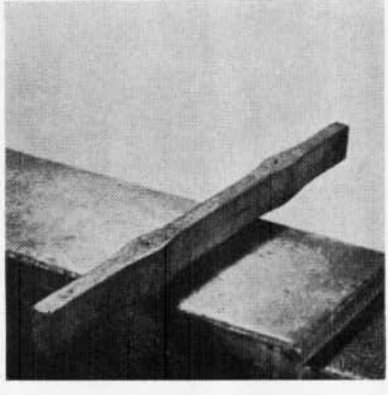
Two or more heats are required to produce this amount of upset and its shape and position can be controlled by suitable quenching.



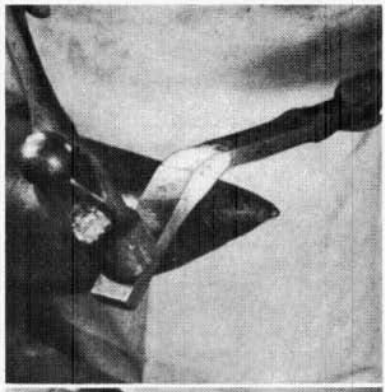
Repeat the upsetting around the second mark, again reducing the overall length of the bar by $1\frac{1}{2}$ times its thickness, so that the total reduction is now three times the thickness.

Here is the bar upset—

Note the evenness of the swellings.

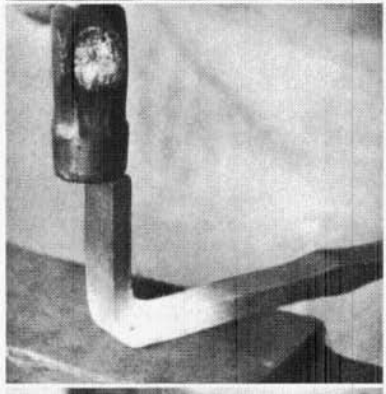


Bend over the anvil bick to form the inside radius. This radius should never be allowed to become too small.



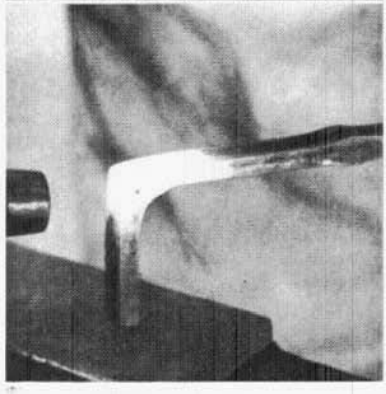
D

Start to work up the bend, as shown here, keeping the punch mark on the diagonal of the corner.



E

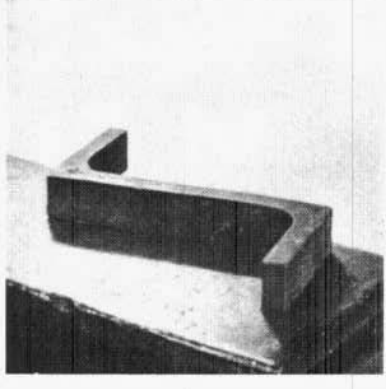
Continue working up the bend like this, keeping a full inside radius and finishing the outside corner to a sharp square edge.



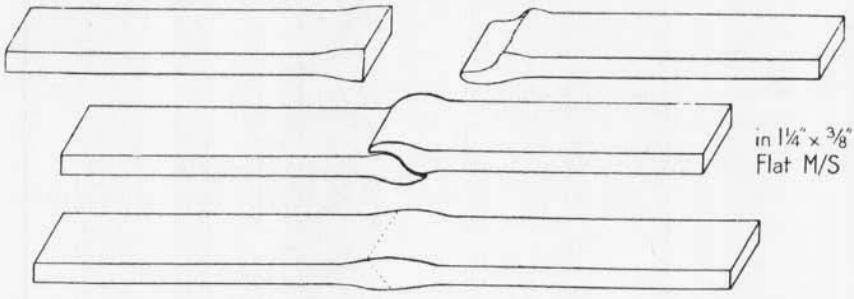
F

Here is the finished piece —

Note the large amount of metal which has been worked into the bends, the sharp outside corners and the perfectly smooth flowing radius on the inside of each bend.

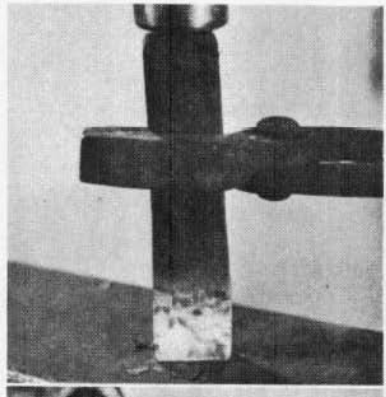


G




Before starting these welding lessons, study carefully the description of fire welding in Chapter 4, page 21.

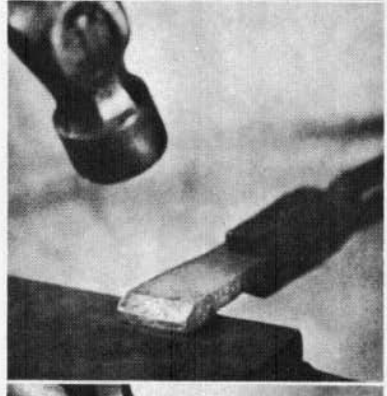
Take a NEAR WELDING heat on each bar in turn and upset the ends which are to be welded to $\frac{1}{2}$" thick, but keep the width the same.



A

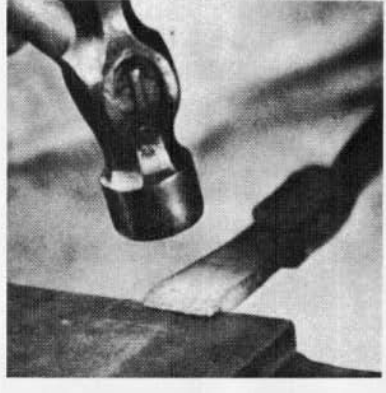
Before starting a large scarf, the upset end of the bar should be forged to a short bevel, leaving the edge about $\frac{3}{16}$" thick like this—

The hammer blows should be delivered at an angle of 45°.



B

Next, with the bevelled edge downwards over the rounded edge of the anvil, forge the scarf as shown here—



C

Before starting to weld, remove any clinker from the fire which must be clean with a good heart.

Lay both pieces side by side in the fire with the scarf lips on top. To ensure they are both heating equally, jockey them about and, as they approach welding heat, draw each in turn to the edge of the fire to judge the heat. If sand is being used as a flux now is the time to sprinkle a little on each piece.

D

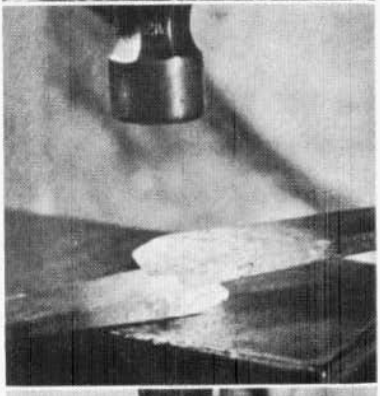
Now work quickly—take both pieces from the fire together, tap them over the edge of the anvil to knock off the dirt, and lay them on the anvil with the scarfs matching and the middles in contact.

The order of the first three blows is important:

**First** on the centre of the top scarf so that any dirt is driven out towards the ends.

**Second** on the thick part of the top scarf so that it welds to the thin end of the under scarf which is being chilled by the anvil face.

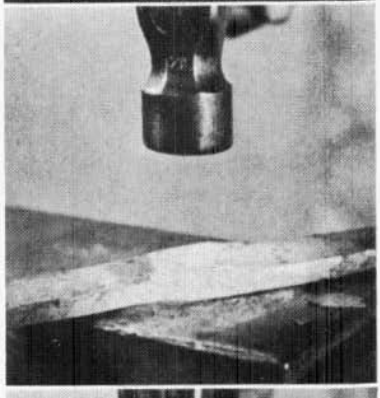
**Third** on the thin end of the top scarf before this cools.



E

If another heat is necessary to complete the weld, take it now.

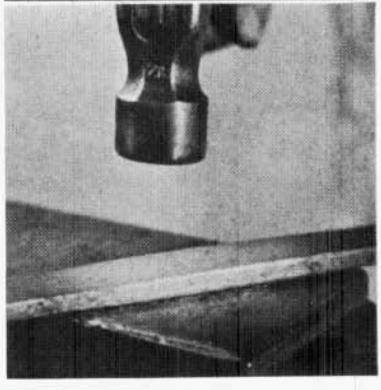
Continue welding by turning the piece to and fro, hammering both sides alternately. Take care not to reduce the section below the size of the original bar.



F

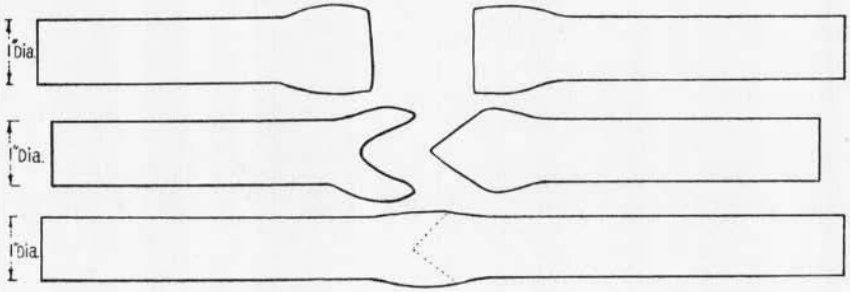
The completed weld should be like this, with no reduction of section and with the corners very slightly chamfered.

The finish of the weld should be smooth, as a rough edge or a hammer mark may cause a fracture to start.



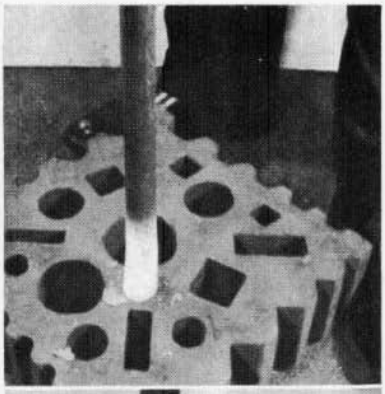
G

# CLEFT WELD




Take a NEAR WELDING heat on the end of one bar and upset to about 1½ times the original size. This can be done by tamping as shown here—

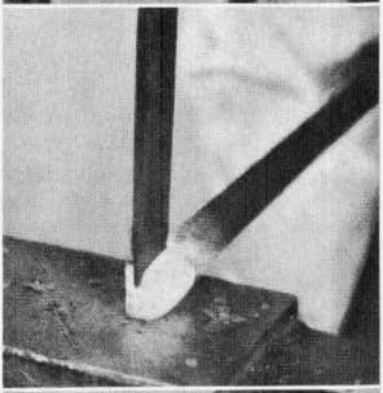
Place the upset end on the anvil face and, holding it at an angle, forge to a blunt chisel end leaving the edge $\frac{5}{16}$" thick.



A

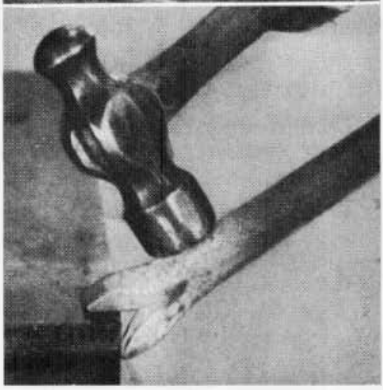
Take a fresh heat and split this end by cutting into each side in turn with the hot chisel.

Force the ends apart as far as possible with the chisel.



B

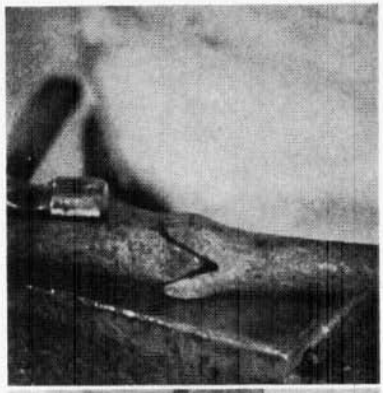
Take a fresh heat and open out the cleft end over the edge of the anvil to a little less than a right angle. Then lay it on one side of the fire to retain the heat while the other piece is being prepared.



C

Take a NEAR WELDING heat on the second bar and upset the end a little less than the first bar.

Forge to an abrupt chisel end which fits into the cleft and then close tightly together at a BRIGHT RED heat, like this—



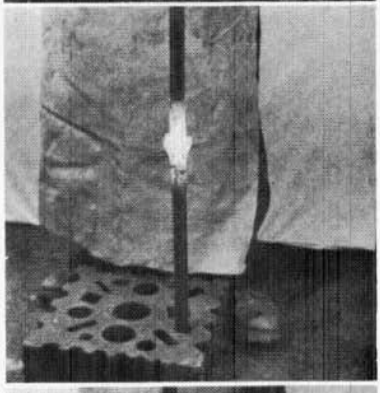
D

The weld can be made in two ways.

**First method. No assistant available**

If no help is available, heat the two pieces side by side as described in Lesson 30.

Take a FULL WELDING heat and drop one piece into a suitable hole in the swage-block with the cleft end uppermost. Place the wedge end in the cleft and drive down hard with a couple of quick hammer blows.



E

Replace the partly-welded bar in the fire, take a fresh welding heat and continue welding by jumping the bar vertically on the swage-block like this—

Weld in the lips on the anvil face and then finish off with a hand hammer in a bottom swage.

F

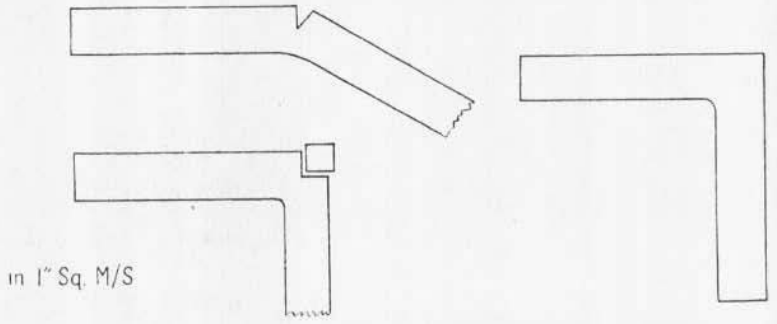
**Second method. With assistance**

If help is available, set the two pieces together as shown in D above and place them carefully in the heart of the fire without disturbing the set-up.

Take a FULL WELDING heat and, without removing the bar from the fire, drive the cleft into the weld until it feels solid while your assistant holds a sledge hammer or heavy weight against the other end of the bar. Lift out of the fire immediately and weld in the lips of the cleft, finishing off between swages.

G

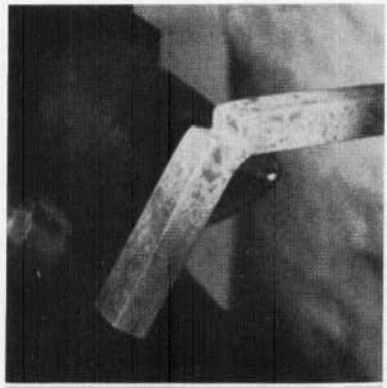
# GLUT WELDED SQUARE CORNER




Mark off where the centre of the bend is required.

Take a NEAR WELDING heat and with the hot chisel on the mark, make a cut nearly halfway through the bar.

Bend the bar over bick to a right angle keeping a good radius on the inside like this—

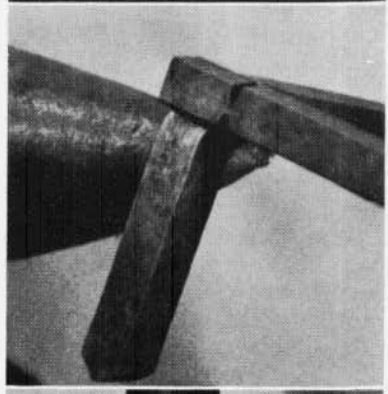


A

The inset is made from a bar of the same thickness and should be about ¼" longer than the width of the metal from which the bend is made.

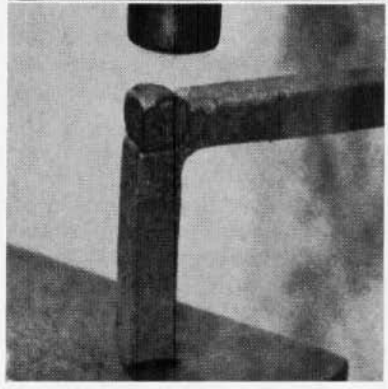
Cut into both sides with a hot chisel and leaving just enough in the middle to support the end when it is being tacked into place.

Take a LIGHT WELDING heat on both pieces and tack the inset into place with the bend over the bick like this (shown cold)—



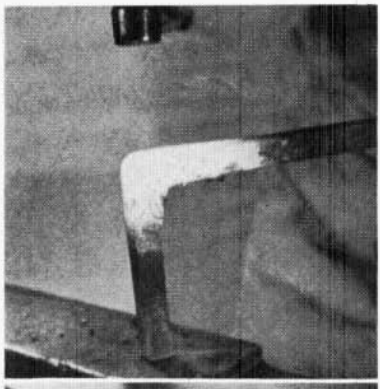
B

When securely in place break the inset of the bar off at the notches and dress the cut face so that it looks like this (shown cold)—



C

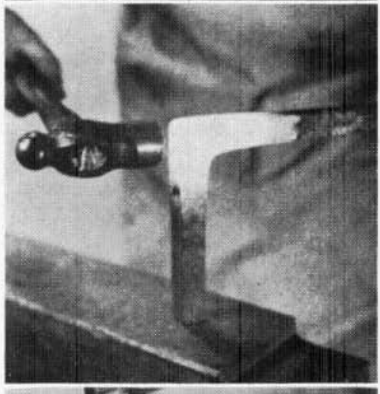
Take a FULL WELDING heat and, to ensure that both sides of the inset are welded right into the corner, strike the first blow downwards on the top of the inset so—



D

Immediately strike the second blow endways like this—

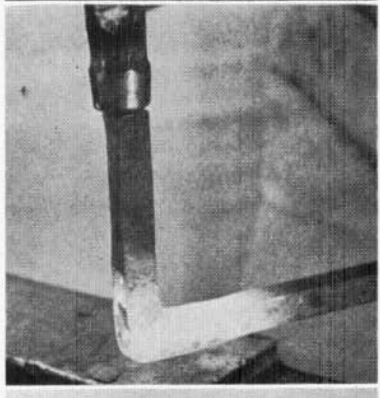
Continue with alternate blows until the weld is solid.



E

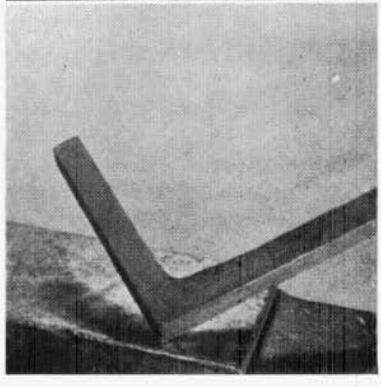
To keep the greatest strength in the bend, work up the corner on the anvil face, like this—

Do not place the inside of the corner over the edge of the anvil or the bick as this will reduce the section of the metal across the corner and so weaken the bend.



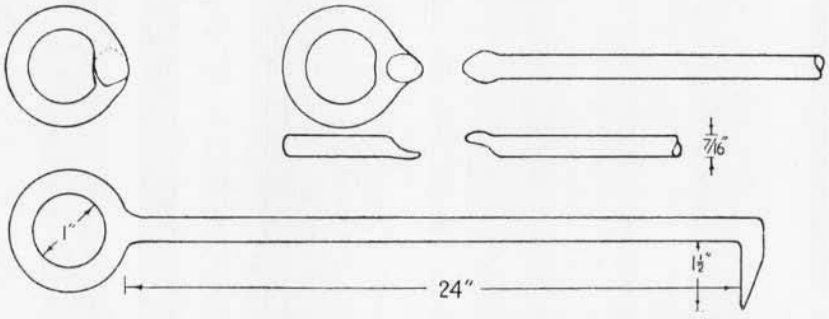
F

The completed bend should have a square outside corner and a good inside radius as shown here.



G

# EYE WELDED TO SHANK




To make the shank cut off 26″ from a $\frac{7}{16}$″ round with a cold chisel.

Bring one end to NEAR WELDING heat and start upsetting by tamping direct on the anvil as shown here—

or by hammer blows on the top with the rod standing upright on the anvil.

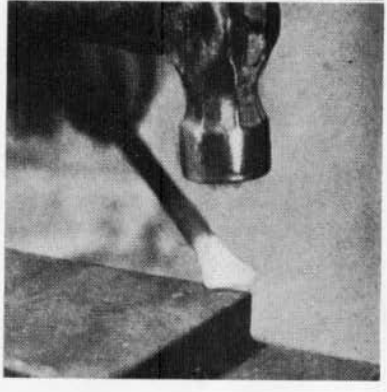
A

Straighten the resultant buckling.

Take another NEAR WELDING heat and finish upsetting by striking the hot end with a hammer like this—

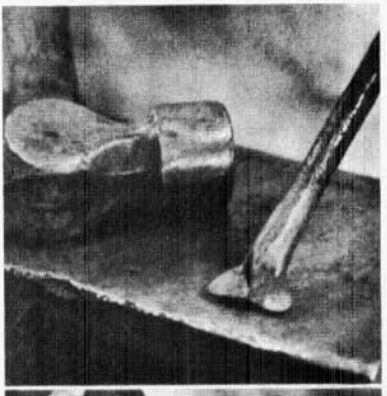
B

Flatten the end a little and make a double wing-shaped scarf by working over the rounded edge of the anvil.



C

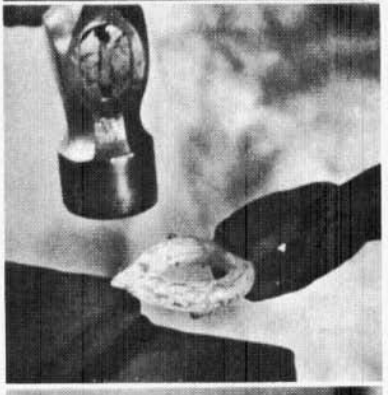
The finished scarf must have a good shoulder between the flattened part and the rod, and must be shaped like this—



D

Make the ring as described in Lesson 13 and while the welded portion is still hot, forge it into a scarf over the corner of the anvil, like this—

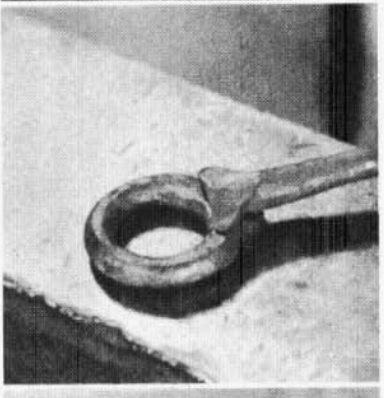
The ring made previously will do, but in this case, bring it to BRIGHT RED heat before making the scarf.



E

The set-up is here shown cold—

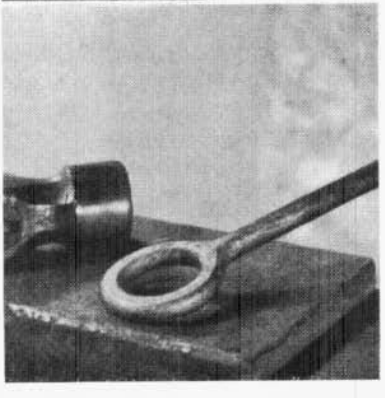
Take a FULL WELDING heat on both pieces together, lay the ring on the anvil with the flat of the scarf downwards. Immediately lay the shank on top with the scarfs matching and start to weld with light blows at first, striking harder as the metal unites.



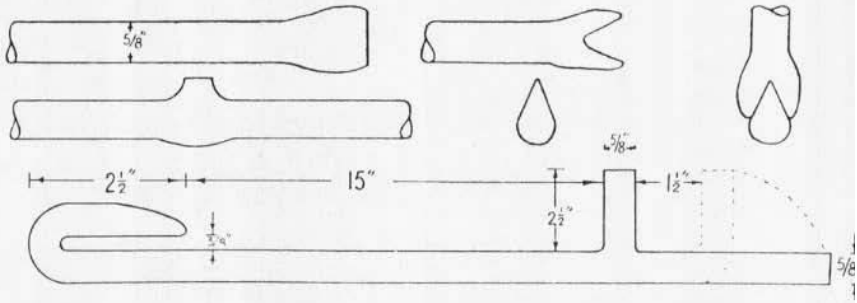
F

While it is still hot, dress up the eye on the bick and then the shank on the anvil face with the shoulder of the eye over the rounded edge.

When finished, it should look like this—



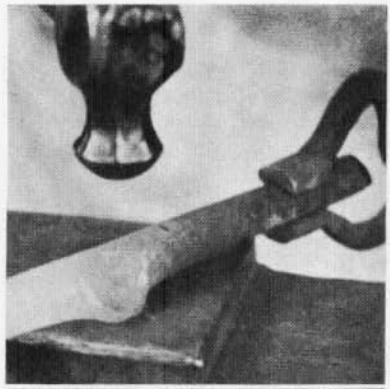
G




Mark off to suit the length of scroll wrench required.

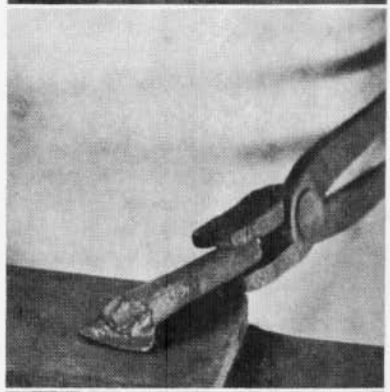
Upset the part forming the top of the **T** around the mark. Then, using the peen of the hammer, forge a *one-sided* scarf, keeping the underlip flat on the anvil face like this—

Place it on the edge of the fire to retain the heat.



A

The leg of the **T** is made by first upsetting one end and then forging a double winged scarf.



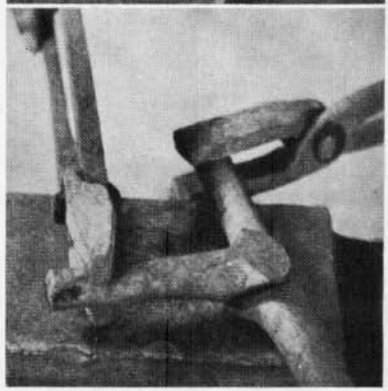
B

Next, take a FULL WELDING heat on both pieces together, lay them on the anvil in this position—

The first blow should be on the thick back of the top scarf so that it welds to the thin end of the under scarf before this is chilled by the anvil.

Continue by hammering towards the top of the **T**.

Dress up over the rounded edge of the anvil.

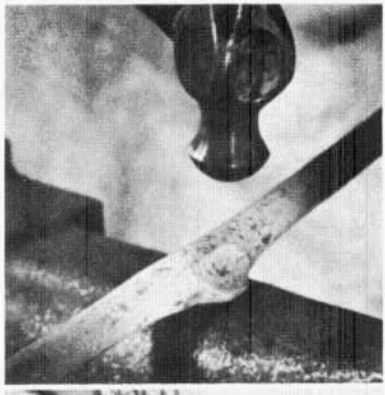


C

**Cleft Weld**

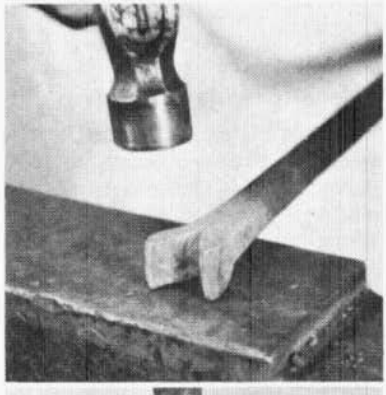
The alternative method of welding a **T** is a little more difficult, but results in a much stronger joint.

Start by forging a *double-sided* scarf on the bar where the leg of the **T** is to be welded. Hammer on both sides and draw out the lip a little longer than in the other method.



D

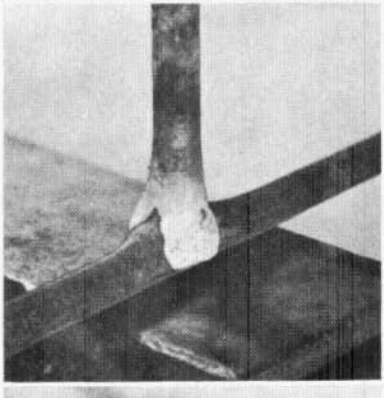
Next make a cleft end on the leg of the **T** by first upsetting and drawing to a blunt chisel end which is split as described in Lesson 31.



E

At a BRIGHT RED heat, set the two pieces together and hammer first on the top of the cleft bar and then on the lips to form a perfect fit.

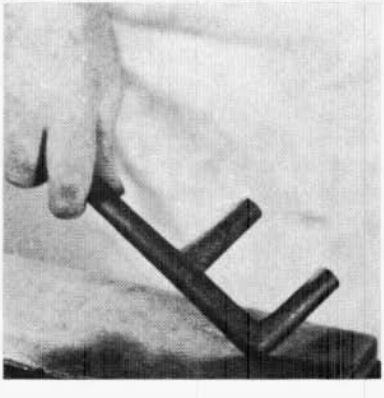
Take a FULL WELDING heat on both pieces together, lay the long bar on the anvil and start welding by driving the cleft portion over the bottom scarf so that the root of the **V** of the weld takes first.



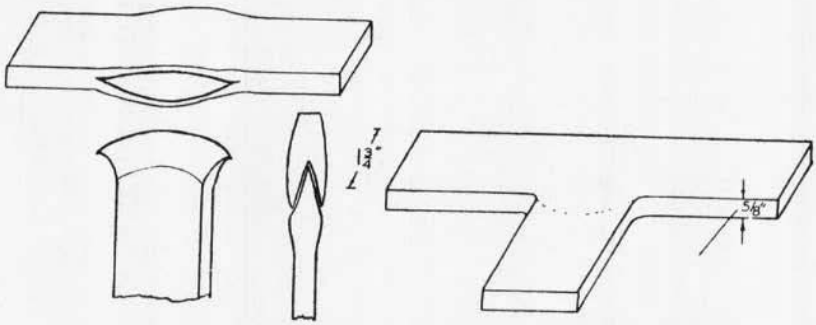
F

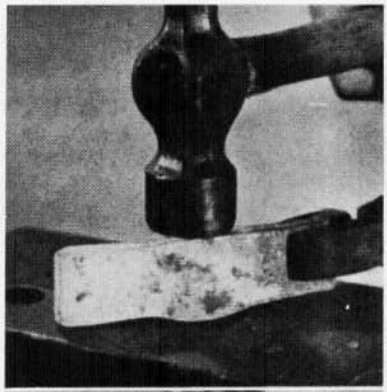
Take another FULL WELDING heat and weld in the lips of the scarfs.

The completed weld is shown here made into a scroll wrench; the end has been bent as in Lesson 27.

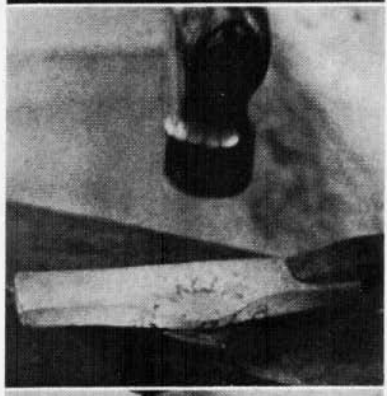


G

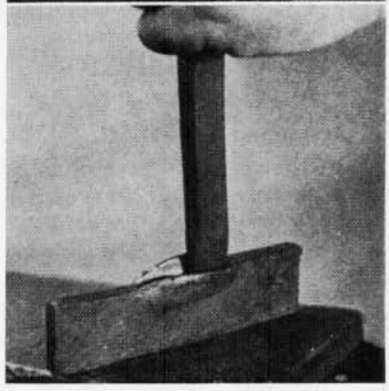


Take a NEAR WELDING heat on the middle of the piece which forms the top of the **T.** Upset to $1\frac{1}{2}$ times the thickness with extra metal on one edge of the bar to form a bulge like this—



Take a fresh heat and draw this side bulge into a lip with a blunt edge about $\frac{3}{16}$" thick as shown here—

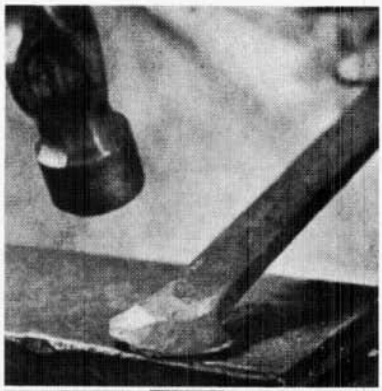


Take a NEAR WELDING heat and split this lip down the middle with a hot chisel to form a semi-circular pocket to receive the fan-shaped scarf on the piece which will be welded in.

Lay on the side of the fire to retain the heat while the next piece is being prepared.

Take a NEAR WELDING heat on the end of the piece which will form the leg of the **T** and upset it for about ½″.

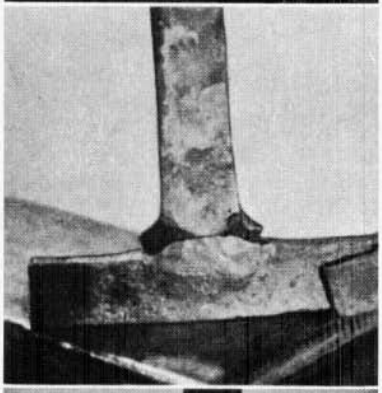
Forge the upset into a fan-shaped chisel end, drawing as much metal as possible to the sides, like this—



D

Take a BRIGHT RED heat and drive the chisel end hard down into the pocket, making sure that it reaches the bottom before closing in the lips, thus—

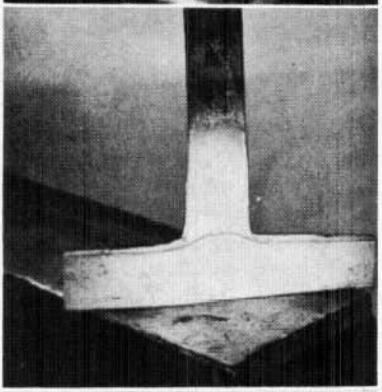
Lay both pieces side by side in the fire. To prevent burning the thin edges of the pocketed piece it must stand on edge with the lips upwards.



E

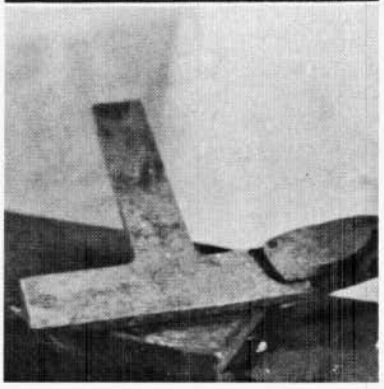
Take a FULL WELDING heat and start the weld by driving the long end right down to the bottom of the pocket.

Concentrate on getting the full width of the fan solidly welded into the bottom and ends of the pocket, leaving the lips till the next heat.

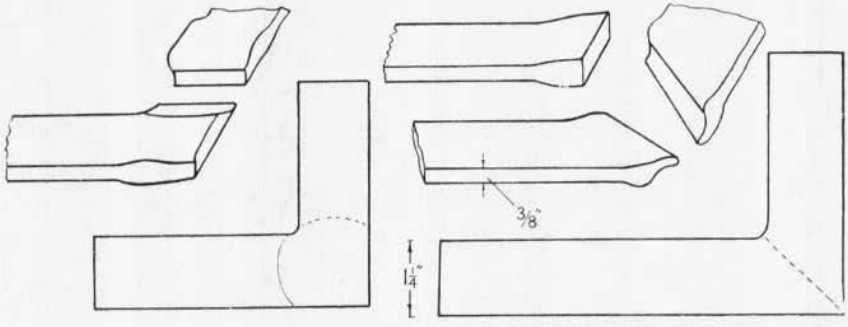


F

Take another FULL WELDING heat and complete the weld by closing in the lips, leaving a small radius in the corners of the **T.**



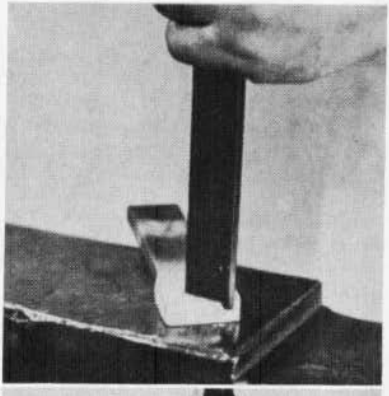
G



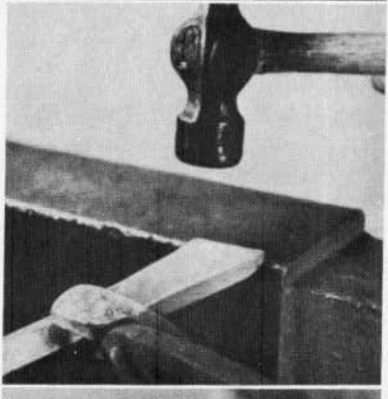

### Diagonal Scarf Weld

The quickest way to weld a square corner is to use diagonal scarfs, but the resulting joint is not so strong as the straight scarf method.

Take a NEAR WELDING heat on each piece in turn and after upsetting the ends cut them off at an angle of 45°, leaving a blunt corner, like this—


A

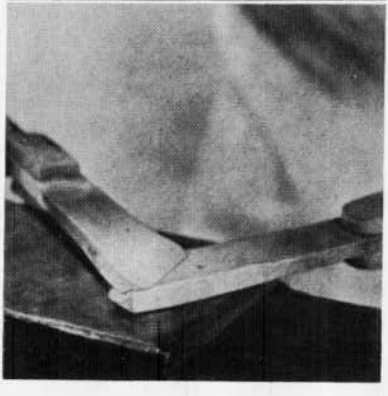
Take another heat and, using the rounded edge of the anvil, forge a scarf on the same side of each piece, so that they pair up when laid on top of each other at a right angle with the scarfs matching as shown in the next illustration.


B

Take a FULL WELDING heat on both pieces together and lay them on the anvil as shown.

Strike the first blow on the thick part of the top scarf so that it welds to the thin part of the under scarf which is being chilled by the anvil face.

Finish off with a minimum of blows so as not to reduce the thickness, because a diagonal scarf has no surplus metal in the finished weld.

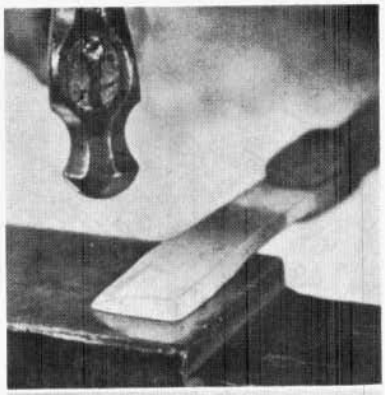

C

**Straight Scarf Weld**

A straight scarf corner weld has greater strength than a diagonal scarf weld, but it takes longer to prepare and make.

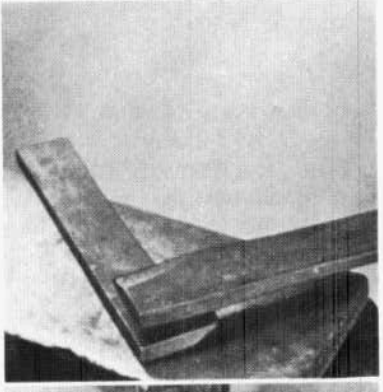
Take a NEAR WELDING heat on each piece in turn and upset, first quenching the tip so that the swelling starts about $\frac{3}{4}$" from the end.

After upsetting take another heat and form a scarf on the edge of one side of the bar from the end to the middle of the upset.



D

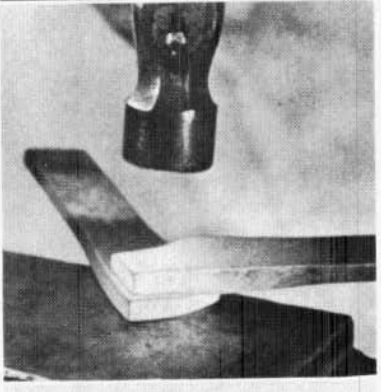
Each bar is scarfed on the same side so that when one piece is turned over and laid under the other at right angles as shown here, the side scarf on each piece must be in contact with the upset part of the other piece.



E

Take a FULL WELDING heat and deliver the first blow on the thick part of the top piece to weld the thin under scarf before it is chilled by the anvil face. Continue hammering across the thin part of the top scarf making sure that the inside corner is welded at this heat.

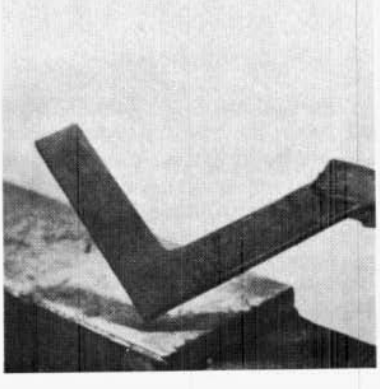
Take another FULL WELDING heat and finish by hammering from the inside to the outside of the corner.



F

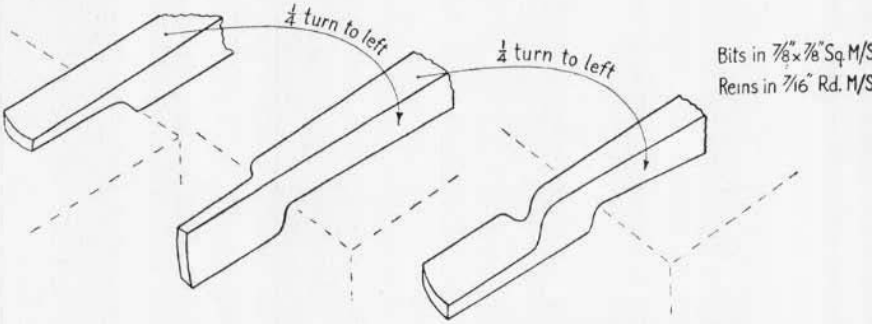
There is no need to forge in the superfluous metal, so trim it off with a hot chisel; ample has been allowed for the strength of the joint.

The finished welds should look like this with no reduction in section, and a small radius on the inside corner.



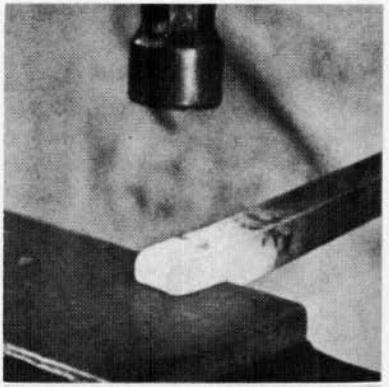
G

# BLACKSMITH'S TONGS

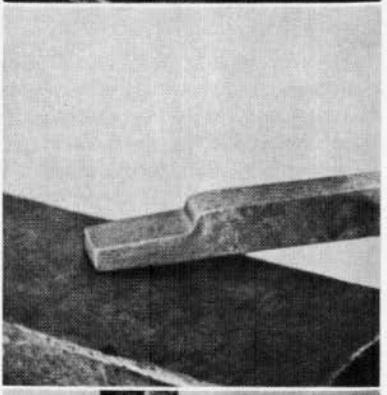



To forge a pair of tongs, cut off a piece 12″ long from a ⅞″ square bar.

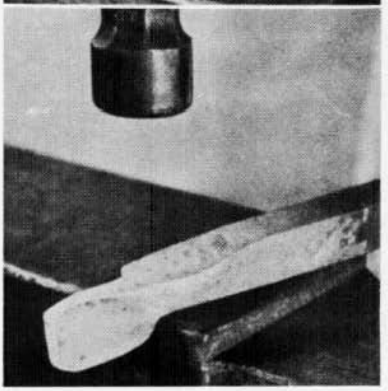
Take a LIGHT WELDING heat and, with the end over the rounded edge of the anvil like this, forge a shoulder, leaving the end ⅜″ thick × 1¾″ long × 1″ wide.



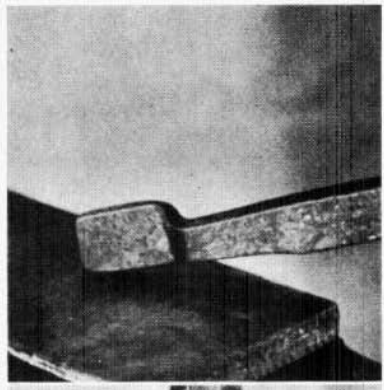
There should be a good radius at the base of the shoulder and the end should look like this—



Take another LIGHT WELDING heat and from the position shown in A above give the bar a quarter turn to the *left* and place it over the rounded edge of the far side of the anvil. Move the left hand slightly to the *left* and forge a second shoulder to form a boss.



The end should now look like this—

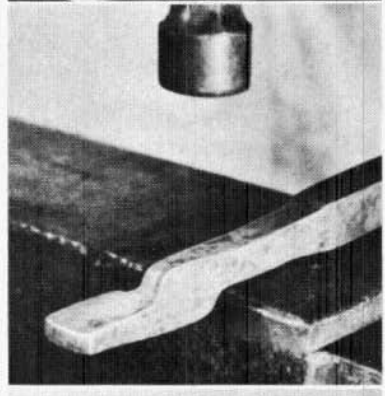


D

Take another LIGHT WELDING heat and, from the position shown in C, give the bar another quarter turn to the *left* and, again using the far edge of the anvil, forge a third shoulder.

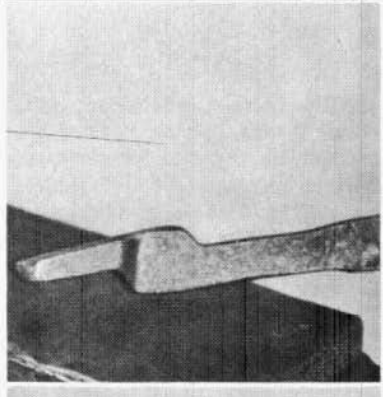
The bar behind the boss is reduced to a $\frac{5}{8}$" square section.

The completed jaw is shown here—



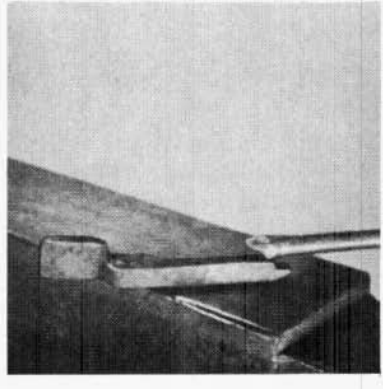
E

The second jaw is made on the other end of the bar in exactly the same way. Remember to turn the bar to the *left* each time. The two finished jaws are alike, not opposites.



F

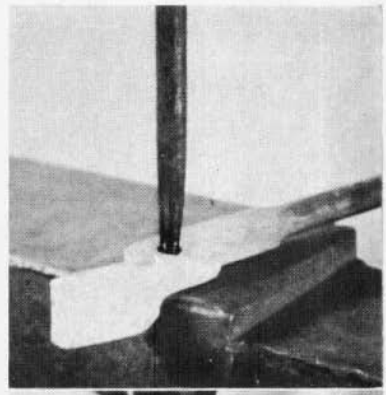
Cut the jaws apart and scarf the cut ends of the reduced square sections. Weld a piece of $\frac{7}{16}$" round to each jaw to form the reins.



G

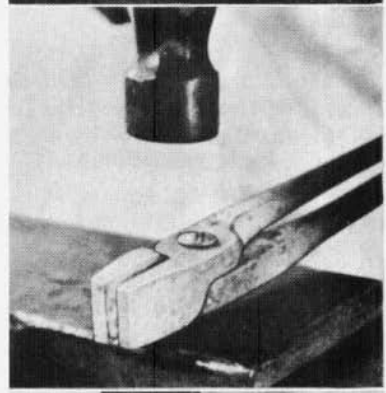
To retain the maximum strength in the boss the rivet holes should be punched, not drilled. Start to punch as shown with the shoulder downwards over the edge of the anvil.

Turn over on to the flat side and complete punching over the anvil hole.

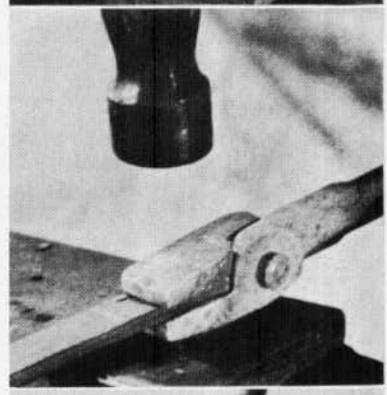


The method of making a rivet for a pair of tongs is described on the next page.

The tong jaws and the rivet are put together cold and all made hot together before riveting up.



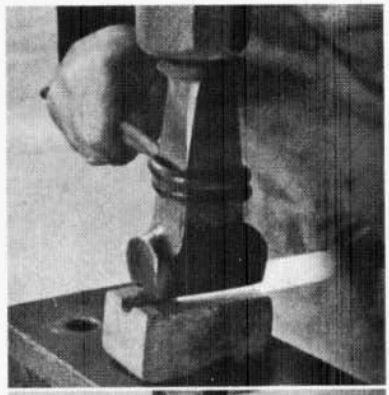
After the rivet is clenched and while the jaws are still hot, they should be set to the size of material it is intended to hold. The spacing of the reins should be adjusted at the same time, so that they are comfortable to grip.



Dip the tongs in the water trough, opening and closing them as they cool to ease them.

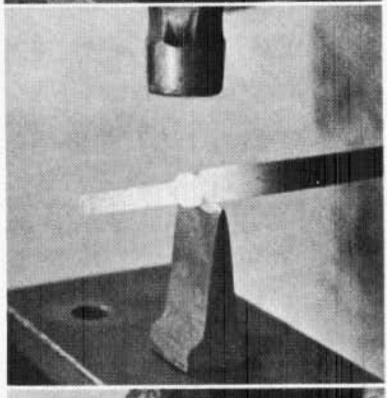
**Rivet for Tongs**

The rivet is made from $\frac{5}{8}$" round metal, the shank being reduced between top and bottom swages like this—



M

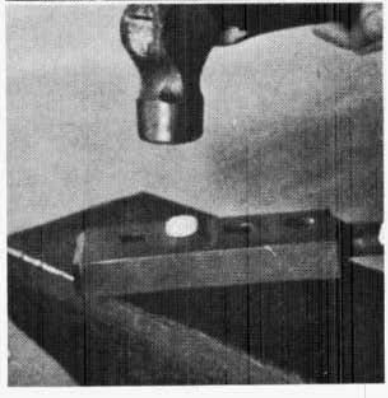
Cut off as shown, allowing sufficient length of the full-size section to form the head.



N

The head is then formed by setting the piece down in bolster, thus—

and is worked up either on the anvil face or by using a rivet snap.



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