

Fusee Chain Making

Peter Mower achieves a 'lost' skill



1. Peter Mower with the tools he uses to make fusee chain, inset.

I LIKE TO MAKE as many parts of my clocks as possible but when I said during the South London Branch Clock Project that I would be making my own fusee chain, it was suggested that it was going a bit too far. This article however describes the task. I have now made two complete clock

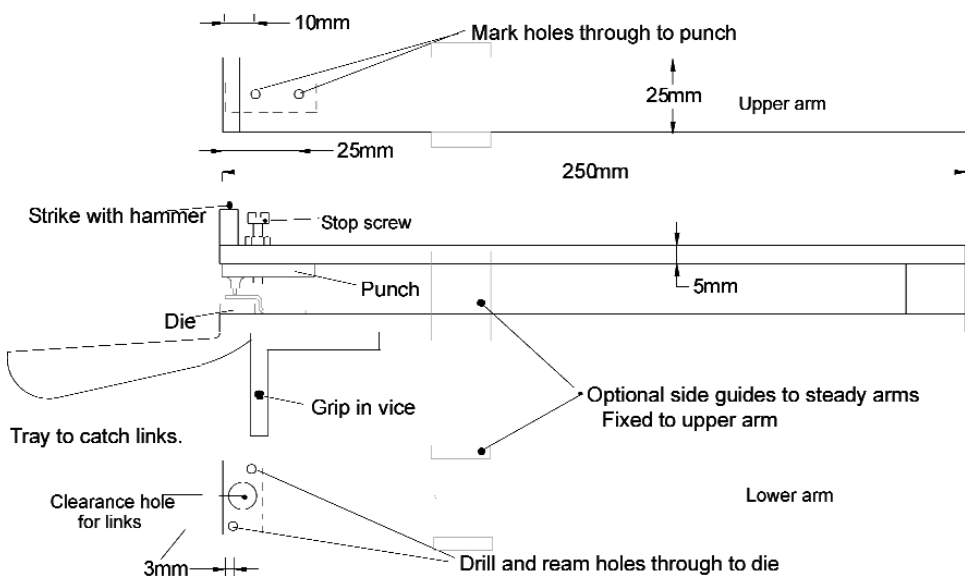
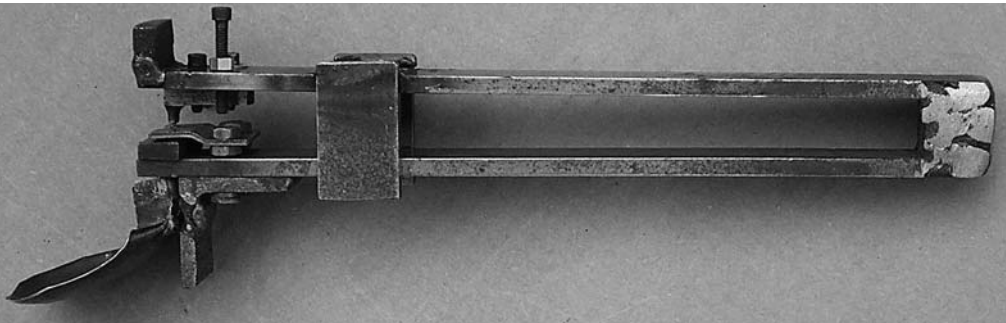
chains plus about 200mm made as a demonstration at this year's LEAP FORWARD SHOW at Upton Hall and 20mm of pocket watch size, 1.

I started out by thoroughly reading the description of chain making in: *Watch-making in England 1760-1820*, by Leonard Weiss, which refers to Diderot's *Cyclopaedia* of 1765.

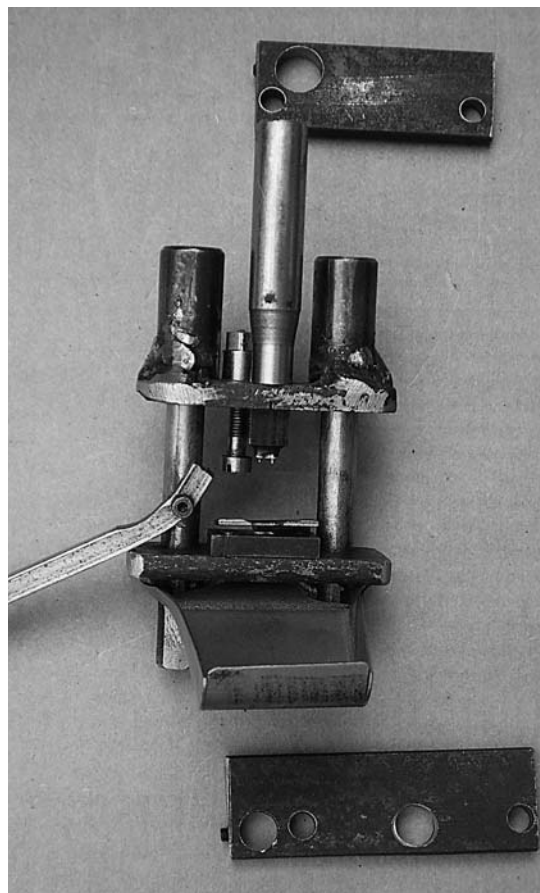
The method described for producing the holes is more suited to watch chains so I decided to punch the holes and also for my small piece of watch chain.

Die Sets

For the holes and the outer shape, the punch needs to be guided so as to slide into the die accurately. For my first chain I used a tool as in 2 and for the second as in 3. I had thought that the guidance was insufficient with the original one leading to burrs; but there was little difference. These tools are referred to as 'die sets' in this article. It is better to make separate die sets for hole and link to save changeovers. There are no critical



2. The press tool used in early attempts.

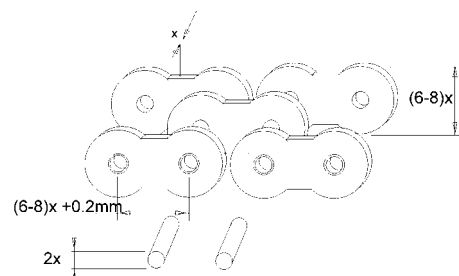


3. A later device. Note the lever, left, to lift the tool from the die after pressing.

dimensions. The first type is the most simple and I assume that two are made.

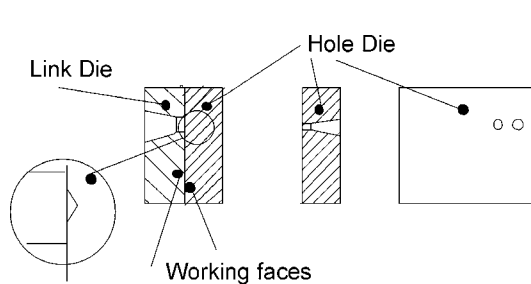
Chain Dimensions

Firstly we must know the size of the chain. The proportions are quoted by Weiss are: *A link is twice as long as it is wide and having a thickness around one eighth to one sixth of its width. The flat faces of a link have the shape of two joined circles, each of which is pierced with a round hole through its centre, 4.*



4. The proportions of the components are based on the thickness of the material, x.

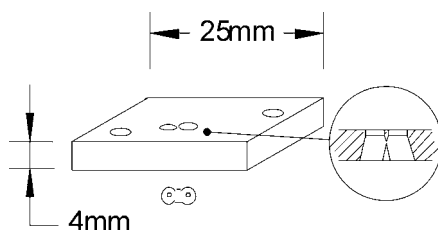
Illustrations and Photographs by the author



6. Detail of link and hole dies.

The thickness of the chain is dictated by width of the fusee and the strength of the chain. For example, 16 turns are usually needed of the fusee for an eight day clock and thus with a length of 32mm. we would have a 2mm pitch. At a wall thickness between grooves of 0.5mm we can have a chain 1.5mm wide, i.e. made of 0.5mm thick material. A convenient size of rivet is around a third the width of the link. Calculations can be made to give us the maximum allowable pull in the chain. The weakest part is the web of the centre link or the section across the hole. This can be checked against the shear of the rivet. However thicker material requires more force to punch the links and produces more wear on the tools.

To assist in assembly and to compensate for any burr on the ends of the links, I added a small amount to the length, 4.



5. Link die. Note tapered profile of hole.

Materials

A convenient source of material for the links is old mainsprings. Modern material can prove unsatisfactory and may not be amenable to hardening and tempering. A sample of the spring and the wire should be checked to make sure it can first be softened for punching and riveting and subsequently hardened and tempered.

(See comments on hardening and tempering the completed chain.)

Link Die

The first part that I made was the blank for the die, 5, to produce the outer shape of the link.

A piece of gauge plate around 25mm by 12.5mm and 4mm thick had two holes drilled along the longer axis of the die at the pitch of the holes in the link (width of

the chain plus a small amount say 0.2 to 0.3mm). This was achieved either by measurement or indexing in the lathe or milling machine. The diameter of the holes is as the width of the link. After use as a drilling jig for the hole die, these holes were tapered out from the underside leaving a small parallel portion.

In the following description of transferring holes from one plate to another, the 'working' faces should be kept together so that any wandering of the drill is rendered virtually ineffective.

Hole Die

The next requirement is the die for the holes, 7.

The link die has another piece of gauge plate of the same size clamped to it. The centres of the holes are marked using the link die as a drilling jig but only drilling enough to mark the surface. If this is drilled too deeply there will be a chamfer on the cutting face of this second die and the surface will have to be removed to give a sharp edge to the holes. Holes to the diameter of the rivet are drilled through this hole die.

The drill should be checked first to see that it is drilling to size. If there are problems the holes can be drilled slightly smaller and opened up to the correct size. These holes are then tapered from underneath as on the link die.

With the link die and the hole die clamped to the lower arms of the die sets, 2, holes are drilled and reamed to take dowel pins.

The previous holes in the dies are marked out on the lower arms of the die sets and clearance holes drilled through to allow the punched out slugs and links to fall through. The plate with the rivet-sized holes should then be hardened and tempered to a dark straw.

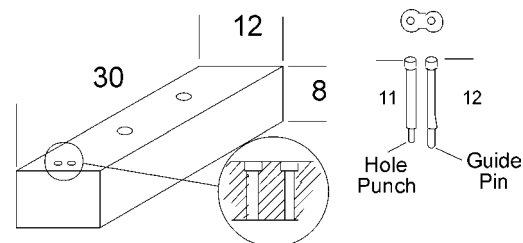
Hole Punch Tool

A piece of mild steel about 7or8mm thick by 12mm wide and 30mm long has two holes marked, this time using the hole die as a drilling jig. These are then drilled to a size about 1mm larger than the rivet. The back side of this block then has these holes opened up by a further 0.5mm by about a millimetre deep. These holes are to take the hole punch and guide pin which are respectively 3mm and 4mm longer than the thickness of the block, 7.

The hole punch and guide pin are turned from untreated pivot steel, which seems far superior to hardened and tempered silver steel – although this can of course be used.

The hole die is fitted to the lower member of the die set and located by its dowels.

The hole punch and guide pin are then



7. Hole punch tool. As each hole is punched it is moved under the guide pin which is inserted to provide the spacing for punching the next hole.

put into the mild steel punch holder and the ends inserted into the holes in the die thus positioning the punch block. The block is clamped to the upper arm and holes are drilled through to mark the block, which is drilled and tapped and then fixed to the upper arm while the punch and guide pin are fully entered in the holes in the die.

A lever is needed to separate the upper and lower arms of the die set after punching holes although a screwdriver can be used.

A stop is needed to limit the penetration into the die of the punch and guide. This can be achieved by a long fixing screw with a locknut to secure the punch or a separate stop.

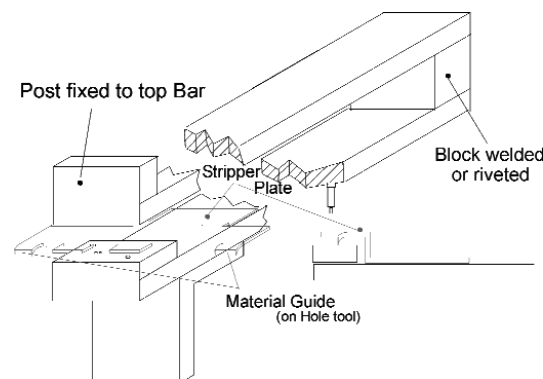
A stripper plate, 8, is also required to disengage the punch from the material.

The alignment of the punches in the die can be checked by operating by hand and if there is a problem the fixing screws can be released and if necessary the holes in the upper arm given slightly more clearance.

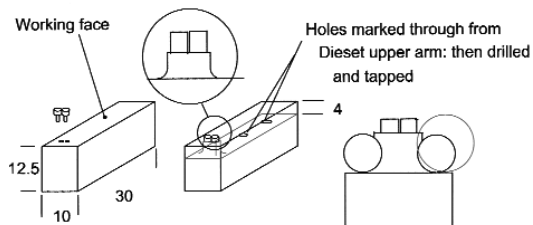
Link Punch and Die

A piece of gauge plate approximately 12.5mm thick 10mm wide and 30mm long then has two holes drilled near one end using the hardened hole die as a drilling jig (afterwards this can be lightly riveted to its arm). These holes are the same diameter as the rivet and will take the guide pins for the link punch.

A piece of steel is then turned to the



8. Arrangement of components for punching holes in strip.



9. Link punch.

diameter of the link ends (to fit the link punch plate holes) and then reduced for a short length to the rivet diameter to be a push fit in the link punch (or they can be glued in). The two plugs needed are assembled into the punch block, 9.

The mating face of the link punch is then reduced in height by about 4mm, except for the portion under the plugs, leaving these standing and with a radius to the surface.

The radius in between the raised portion and the flat area is to prevent a stress-producing corner. If the smaller end of a round file is used to initially form the post for the punch, it is possible to closely control the reduction to the size of the plugs by gradually using the thicker part of the file, 9.

The material can be filed away to give the shape of the links but without the 'waisted' centre and slighter larger than the plugs. With the link die fixed to the press tool the link punch is then located by sliding the bosses into this die. The leg of the punch is clamped to the upper arm and holes drilled and tapped for mounting screws.

The link die is then completed by removing most of the web between the two holes. A small rectangular punch just under the width of the waisted portion of the link can be forced through followed by filing. The corners can be blended to the holes or left square. Care must be taken to prevent a negative taper but clearance is needed as is provided in the holes.

This plate is then hardened and tempered.

The link die is then fitted to the die set by lightly riveting the dowels.

The two plugs on the punch are entered into the holes in the die plate and the mounting screws fitted. The die set is then placed in a vice, which is tightened, and it can be seen that the punch sinks into the die slightly. Only a small penetration is required so as not to overload and damage the die.

The swaged out burrs on the punch can now be carefully removed and the 'waist' area cut away with file and graver. Only the swaged chip should be removed. The die set is replaced in the vice and the process repeated, being careful not to file the punch where it has been formed by the die. The formed length of punch needs to

be only about three times the thickness of the links and this can be done in about six or eight passes provided that not too much material has been left.

The plugs are removed and a countersink is then made in the face opposite the punch to take the heads of the guide pins. These are made from two lengths of the rivet wire which have small heads formed to prevent them pulling out when withdrawing the punch from the material and which are rounded at the other end to ease registration into the holes punched in the strip. When fitted they project about 2mm from the face of the punch.

The punch is now hardened and tempered.

The guide pins are inserted and the punch is fitted to the top arm of the tool, the punch being fully entered into the die while tightening the screws, the location being checked as for the hole punch tool.

A screw is fitted in a convenient place as near as possible to the punch to limit the penetration of the punch into the die after punching the links. One of the fixing screws of extended length with a locknut to clamp the punch can conveniently be used as before.

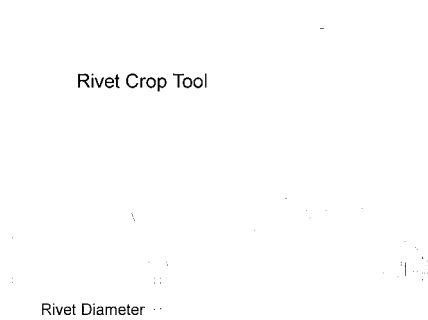
A lever is also required on this tool to strip the material from the punch.

Stripper Plates

Plates need to be provided to remove the punches from the material after punching, 8. These are located one and a half material thicknesses above the dies. A good clearance is needed around the punch with the front cut away completely so that the guide pins can be seen and led into the holes in the strip. A guide is also needed on the hole die tool to guide the material so that the holes are in a straight line equidistant from the edge. To give more control the strip can be guided from both sides. The outer guide then has to be adjustable to compensate for the narrower strip after the first row has been used.

Rivet Crop Tool

For my first chain I used spring wire for the rivets that was slightly larger than the



10. The rivet cutting tool. This is seen in figure 1.

holes in the links and tapered the ends as in the book. After assembly to the links and cropping the rivet to length, the ends had to be filed flat before riveting. This and the tapering took time. During a visit to the Prescott Museum I saw a box of rivets ready for assembly that had been cropped to length and decided to do the same. This had the side effect that the chain did not need so much freeing after assembly. However for the smaller watch chain I found it easier to use the tapered wire to enable handling of rivets and links.

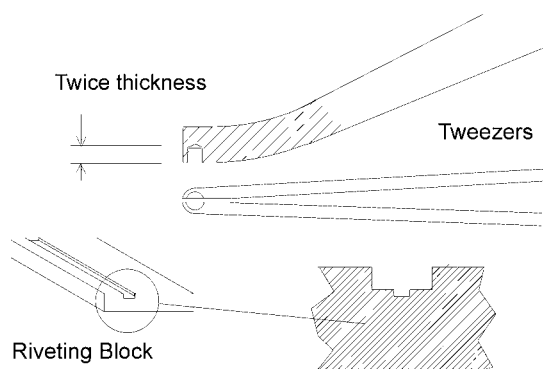
To make a rivet crop tool, 10, a piece of angle iron approximately 100mm long had a hole drilled to take a handle 200mm long. About 60mm from the pivot, a piece of spring steel (or gauge plate) thinner than the final length of the rivet is screwed to the side of the handle with its end projecting by 15mm. This end is squared off.

The handle is then bolted to the angle iron with a washer between and adjusted to be a free fit. A piece of silver steel 10mm by 10mm by 25mm has a hole of the rivet diameter drilled through its centre. Holes are then drilled at right angles for mounting to the angle iron. The block is then screwed to the angle iron so that the plate mounted to the handle passes across the hole for the rivet wire. A short piece of this plate is sandwiched between the block and another piece of gauge plate and screwed together leaving a slot for the blade on the handle to work in. The steel mounted on the handle is thus controlled and prevented from flexing. A hole is drilled in the base to allow rivets to fall through. The block with the cross hole and the blade on the handle are hardened and tempered.

In line with the cross hole in the block a hole is drilled in the vertical flange of the angle iron and tapped to take a screw to control the length of wire for the rivet. The length is determined on assembly of the first links from the tools.

Assembly Tool

For the assembly tool, 11, a piece of gauge



11. Riveting block and tweezers used to handle rivets.

plate about 25mm by 50mm by 5mm has a slot machined along its length 10mm in from the edge. The width of the slot is to give a free fit to the links. The depth is two and a half times the link material thickness. Along the centre of this groove is another groove slightly wider than the diameter of the rivet. The depth of this groove is about 0.3mm. This groove is to allow the rivet to project from the underside of the chain when the first riveting is done. A hole is drilled through this groove at a convenient position to allow for rivets to be punched out if required.

This plate is hardened and tempered before use.

Tweezers

A pair of tweezers, **11**, with a square end about 4 to 5mm wide, has a hole formed parallel to the end with half the hole in each leg. This hole was drilled with a piece of shim between the legs to give less than half a hole in each. The diameter of the hole is as the rivet. The length of the hole is twice the thickness of the link. The ends of the tweezers are radiused to leave a thin wall. Rivets can be picked up and inserted firmly into the links.

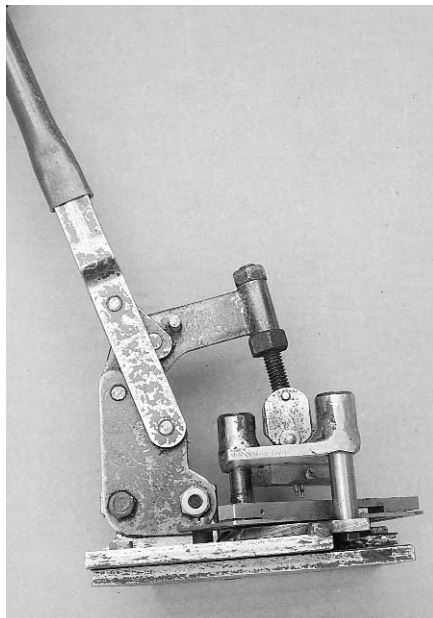
Making the Parts

A piece of mainspring of the correct thickness is cut to approximately 300mm. long and softened by bringing it to red heat and slowly allowing it to return to room temperature. Several pieces can be done at the same time also some lengths of spring wire.

If fitted, the hole punch material guide is adjusted to give the material a free movement, otherwise the material is pushed to the back material guides and the first hole is punched in the end of the material with the guide pin kissing the end of the strip. The top half of the die set is then moved up and the strip advanced and the guide pin entered into the hole just punched. The second hole is punched and so on until there is a row of holes down one side of the strip.

The under side of the strip is then smoothed to remove the burrs.

A small counter-sinking cutter is then



12. The hole press tool can be activated using a toggle clamp.

used to give a tiny impression in the top face for the spring wire to be riveted into; this can be controlled by eye. The actual depth should be determined by making and assembling several links.

The links are now punched from the strip by registering the two pegs projecting from the link punch into the first two holes in the strip. A sharp tap with a hammer on the post will make the link. The strip is advanced to the next pair of holes and the process repeated. It will be found that several links will remain in the die. The number depends on how deep the parallel section left when making the die is.

At this stage it is advantageous to make a sufficient number of links to be able to make a 50mm length of chain to check the depth of the countersink for riveting, the

length of the rivet and cleaning up the sides of the chain. The least possible length of rivet means the least amount to be removed by filing after assembly.

The links are now transferred to the assembly plate and flattened.

After the first row of links has been made the strip is filed parallel ready for a second row.

A slightly more sophisticated method of creating parts was to use a toggle clamp, **12**, to operate the hole making punch, dummy jaws fitted to the die set and a vice to open and close the link punch.

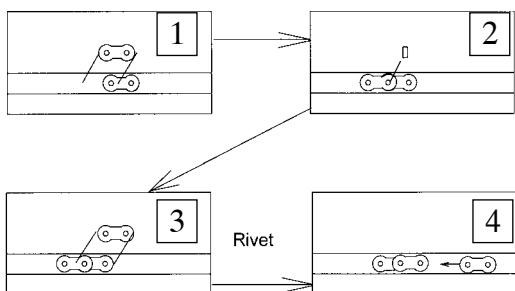
The dummy jaws can be seen at the extremes of the die set in **3**

End Hooks

The end hooks are made. For just one or two chains it is obviously not necessary to make a press tool and single holes can be punched in the strip in the same way as starting the line of holes and the hooks filed to shape. The shape of these is quite standard.

Assembly

Steps in the assembly are shown, **13**. A link is taken and laid countersink side down in the groove in the assembly tool, **14**. Another link is placed on to the first to extend the length. A rivet is gripped in the tweezers and inserted into the hole to tie these two together. A third link countersink side up is placed over the rivet to be in line with the first. The rivet is then swaged over. It is convenient to use a pin punch rather than hitting directly with a hammer. The chain is turned over on to a flat portion of the tool and the other end of the rivet formed. The next link is placed between the outer links so that the ends abut and placed in the groove. A rivet is inserted into the hole and the riveting carried out. It can be seen that the holes



13. Sequence of chain assembly.



14. Assembling the links in the groove in the assembly tool.



15. To finish the chain, smoothing, deburring and freeing the links, it is lubricated and drawn successively back and forth over a file, a graver and a smooth bar.

are aligned by the groove and the lengthwise abutment of the links.

The next link is placed in the groove countersink down and one of the chain ends placed over it. The rivet is next inserted and then another link countersink up and riveted. The

procedure is repeated until the chain feels unmanageable. A light tap on the edges of the chain is sometimes required to allow easy insertion in the slot. Several short lengths are made and subsequently joined together.

A spare short length should be made for testing after heat treatment.

Occasionally the links do not settle together properly and this can be rectified by use of a hollow punch.

A light tapping along the length of the chain on the faces will settle any less than firmly formed rivets.

Finishing

Some oil is applied to the chain to prevent galling during the following procedure. A small handle is attached to each end and the chain is run backwards and forwards over a round file held in a vice, 15. The diameter of this file is about three or four times the width of the links. This is followed by two or three light passes over the sides of a graver, also held in the vice. This is to remove burrs on the sides of the chain.

The faces of the chain are the next part to clean up. The chain is settled into the groove of the assembly tool and the ends of the rivets filed off. Only the minimum

should be removed as, apart from the swelling in the holes the rivet is only held by the small countersinks. The file should be used at an angle to the groove to reduce the tendency to tip. After smoothing with the file the sides can be polished with emery paper.

Hardening and Tempering

The chain and test piece are coated with softened soap and placed in a small tin or specially made container. This is to keep scaling to a minimum and prevent burning. The lid needs to be loose. The container with chain is heated to a cherry red and the chain inspected to ensure that the heat has penetrated. Then the chain and test piece are tipped into oil. They are then returned to the tin together with a small amount of oil and the tin reheated until the oil burns. They are then tipped again into oil.

The short piece of chain should be tested to make sure it is not brittle.

Finishing

The sides of the chain can be polished or left black. If the chain is too stiff it should be run several times over a former held in the vice in the same way as done earlier over a file. □

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