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EC743 Revised 1952 Simple Forge Hints for Farm Use

W. J. Runnalls

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Nebraska
COOPERATIVE EXTENSION WORK
IN AGRICULTURE AND HOME ECONOMICS
U. of N. Agr. College & U. S. Dept. of Agr. Cooperating
W. V. Lambert, Director, Lincoln

Extension
Circular
743
Revised

SIMPLE FORCE HINTS FOR FARM USE

by
W. J. Runnalls

Farming operations and farm equipment are of the type which require more or less mechanical ability on the part of the farm man or farm boy. Machinery which is kept in good repair and proper adjustment is not only longer lived but does much better work when needed. Occasionally break-downs occur when time can least be spared from farm work. Many times these could be avoided if the owner knew how to make repairs and went over his machines during a slack season.

The purpose of this circular is to give the farmer enough information on some of the fundamentals of forge work so that if he is mechanically inclined he will be able eventually to do at least part of his own repair work and make some of the more simple tools which he may need. To do work of this sort a great deal of practice is needed. It is not possible to turn out a finished product the first time one heats some metal and pounds it with a hammer, but if repeated attempts are made, the quality of work will improve.

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KINDS AND USES OF METALS.

Different kinds of metals are used in different parts of farm machines. For example, plow shares are made of a hard steel which will take on a high polish and cutting edge and will withstand various soil conditions without breaking. The frame work of a plow is made of a much softer and less expensive steel for it does not have to be polished or sharpened. These metals go through different processes in the steel mills before they are made up into machinery. The amount of carbon which a metal contains determines, to a great extent, the hardness of the material. The more carbon a metal contains the greater has been the labor of manufacture and consequently it sells for a higher price than a low carbon steel. Plow share material costs approximately ten times as much per pound as the material from which the frame work is made.

Since the different steels and irons are made differently they must have different treatment. Some can stand intense heat, others not so much and still others must be heated very carefully while there is one which cannot be heated at all. This latter is cast iron and is exactly what the name implies. Articles are formed by pouring the molten metal into moulds. Cast iron cannot be reshaped, bent or pounded while it is either hot or cold as it breaks easily. Cast iron is not used as extensively as it once was and on the present day farm machinery one finds fewer pieces than on machines made a number of years ago.

Improved methods at the foundries created a product called malleable iron. This is cast iron which has been heated by a special process to toughen it and make it stronger. It can be bent while cold, sprung in a vice or heated slightly and then bent. It cannot be welded but must be brazed with brass. Malleable iron is used in many places where cast iron was used heretofore.

Mild steel is considerably stronger than malleable iron and will stand a much greater stress. It can be heated and reshaped, or bent while cold. It can also be welded. It is used in the frame work of a plow where it is subjected to severe and uneven stresses without breaking. Mild steel should never be cooled in water after heating but should be allowed to cool slowly at room temperature.

Crucible steel can be heated and bent in any way desired. It is used for plow shares and can be sharpened to a good cutting edge. However, it will not scour in some soils.

Soft center steel is used in cultivator shovels and plow shares where extra scouring qualities are needed. It might be spoken of as a three ply material whose outer two layers are made from a steel much harder than crucible steel. This steel takes on a much higher polish and much more temper. The center layer is a soft steel which is very tough and which bonds comparatively easy but does not crack or break readily. Cultivator shovels are much thinner than plow shares and there is more danger of breaking them when they are being resharpened or repointed. Since the outside layer of soft center steel will take on a high temper cracks form rather easily. However, the crack will extend only to the soft center where it is stopped. In case, the shovel is made of crucible steel the point will break off entirely after a crack starts. This is the fault of the material and not the fault of the workman.

The first cost of soft center steel is higher than crucible steel but the difference in price is returned many times during the life of the shovel.

Tool steel and spring steel contain more carbon than any of the other metals mentioned. They are harder and will take on much more temper and a high polish. Tool steel is used for chisels, punches, knives and articles of a like nature.

EQUIPMENT NECESSARY FOR FORGE WORK ON THE FARM

Only a few tools are needed in doing such forge work as will be found on the average farm. Of course a forge wherein the metal may be heated is one of the first things to acquire. A handy farmer can build a forge for himself. It may be built in a number of ways but one method is shown by the enclosed drawing. The tuyere and blower are the only parts which cannot be made at home. When these are purchased it pays to get good ones. Without a good fire no one can expect to do good work and the cost of the articles spoiled by improper heating will soon counter-balance the cost of a good tuyere and blower.

An anvil is also a necessity and will have to be purchased. For ordinary use it should weigh from 90 to 100 pounds and should be made of wrought iron. DO NOT BUY A CAST IRON ANVIL as it will soon break. An anvil must be able to withstand considerable punishment and only a wrought iron one will do so.

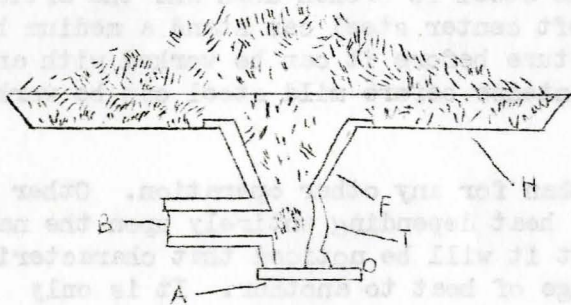
Two hammers will also be needed. A cross pein hammer weighing about three or three and one-half pounds will be used for plow work. A ball pein hammer weighing about two and one-half pounds is often used for other work.

Two pairs of tongs are also needed, flat tongs for holding flat pieces and round tongs for holding round pieces.

THE FORGE FIRE

A good fire correctly built and properly maintained is necessary before metal can be heated to the correct temperature for working. Ordinary coal contains too much sulphur to make a good forge fire. Blacksmiths coal must be used and, if not available locally, it may be purchased from nearby cities. It may be obtained in fifty and one hundred pound sacks. Before building the fire pot around the tuyere should be cleaned of all dirt, cinders and unburned fuel. Small pieces may be blown out by turning on the blast. The tuyere should fit tightly against the fire pot so that there will be no chance for air leakage.

A handful of shavings or some oily waste should be placed over the tuyere and a small amount of coal banked around this in the form of a cone. A small opening should be left at the top so that the pile resembles a volcano with a crater. After lighting the shavings or the waste the blower should be revolved slowly. If the air blast is applied too rapidly there will be a tendency to spread the fire rather than keeping it concentrated in the center. As the coal starts to burn the edges should be built up with wet coal which turns to coke. Coal itself does not give a heat intense enough for forging work. Coke produces a very hot fire and for this reason it is quite necessary to see that it is constantly forming and that a reserve supply is always present. Care should be taken not to cover the fire too closely with wet coal or it may be smothered. The side next to the operator should be left open as shown in Figure I while the other three sides are well banked. This allows the stock to be inserted or taken out of the fire without disturbing the entire cone.



Cross Section of Forge and Fire.
H-hearth; F-fire pot; T-tuyere;
B-blast; A-ash dump.

A fire which is receiving too much air either through too strong a blast or because of too thin a layer of coals is not a hot fire. More oxygen is present than is necessary for the combustion of the fuel and this acts as a cooling agent. It is almost impossible to heat metals in this type of fire to a temperature where they can be worked. A fire of this sort can always be identified by its hollow appearance with only a rim of live coals around

the fire pot and the very thin layer of coals over the tuyere. When there is a heavy compact bed of live coals banked with plenty of green wet coal high temperatures are always sure to be present. Such a fire is one of the most fundamental requirements for good forging and should be watched carefully. It should never be allowed to acquire a hollow appearance.

The scales which fall off of metal as it is being heated bind the burned fuel together and gradually form clinkers. These have to be removed from time to time and if carefully taken out the general structure of the fire will not be injured. Flying sparks and the tendency for the fire to spread usually indicate the presence of clinkers.

The size of the fire will be determined by the size of the piece to be heated. It should be adequate to thoroughly heat that part of the stock which is to be worked but no more. The stock should be placed in the center of the fire in a horizontal position with a bed of live coals completely surrounding it. The air blast should never come in direct contact with the metal and only enough blast should be used to keep the fire burning well.

After the stock has been in the fire for a few minutes it should be removed long enough to see how the heat is progressing. Care must always be taken not to burn a piece of metal since this breaks down the interior structure and when struck with a hammer the whole piece will disintegrate. If two pieces are being heated at the same time, as is done for welding, it is very important that they both have the same heat before they are placed on the anvil. It may be necessary to remove one piece from the fire for a short time to allow the other piece to get to the same heat for successful welding cannot be done if one piece is considerably hotter than the other.

When a piece of stock is so large that it cannot be turned over in the fire the blast should be applied intermittently. By discontinuing the blast for short intervals the heat will have a chance to soak through the piece and in this way uniform heat throughout may be secured.

DIFFERENT HEATS FOR DIFFERENT METALS AND DIFFERENT TYPES OF WORK.

The difference in the method of manufacture of various metals necessitates a difference in the amount of heat which is required by each for different kinds of work. Mild steel can stand the greatest heat of all while malleable iron must be worked at a relatively low temperature. It should never be allowed to reach a more intense red than a dark cherry and should be worked just as it is beginning to get this color. Tool steel and spring steel can stand slightly more heat than malleable iron and can be welded when heated in a forge fire. Welding should never be attempted on them with an acetylene torch. The torch has to produce so much heat before the welding rod will melt that the structure of the steel is broken down and the article will break again under a very slight blow. Soft center steel can stand a medium heat while crucible steel requires a higher temperature before it can be worked with any degree of ease or success. The heat must be intense before mild steel can be worked at all.

Greater heat is needed for welding than for any other operation. Other types of work require different intensities of heat depending entirely upon the nature of the job. By watching pieces while they heat it will be noticed that characteristic colors appear as the metal passes from one stage of heat to another. It is only through practice that the operator will become proficient in detecting these colors and will know just when a piece should be removed from the fire.

FUNDAMENTAL OPERATIONS OF SIMPLE FORGE WORK.

All forge work is made up of fundamental operations which when combined upon a piece of metal result in a finished article. When these operations are studied separately they do not seem so complicated. The most common of these are drawing, up-setting, scarfing, bending, welding and tempering.

Drawing is usually done while the metal is hot and is a means of increasing the length of the piece by hammering. Naturally the blows which lengthen the piece also make it smaller in cross section. Light blows are not satisfactory as their force is not carried throughout the entire section of the piece and consequently forging strains are set up within the metal which usually results in cracks in the finished article.

The stock should be turned as it is hammered so that the shape may be kept uniform and to avoid one side cooling more rapidly than the other. If the piece is not turned the anvil will pick up considerable heat from the side next to it.

Making a harrow tooth is primarily a drawing operation. Not only is the original piece made longer but in so doing it is brought to a point. On page 5 are shown the steps necessary in making this simple piece of equipment. Harrow teeth may be made from mild steel found in discarded farm machinery provided it is of proper size. Some teeth are from 1/2" material and others are from 9/16" stock.

MAKING HARROW TEETH

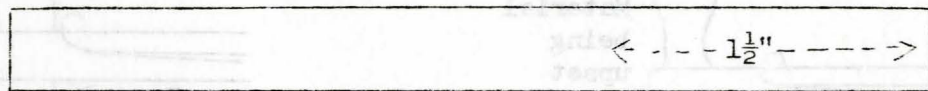
STOCK: 9/16" Mild Steel



WRONG WAY OF DRAWING
ROUND STOCK

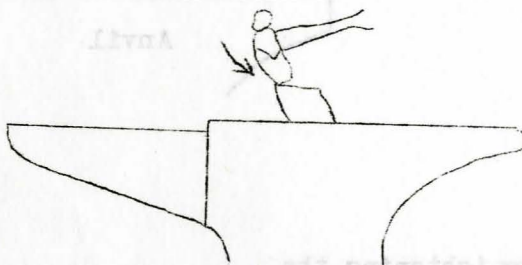


SHOWING RESULTS OF WRONG DRAWING
OUT

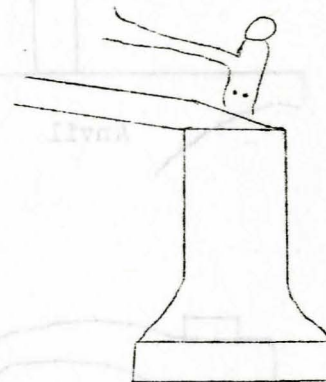


9/16"
Square

6 1/2"

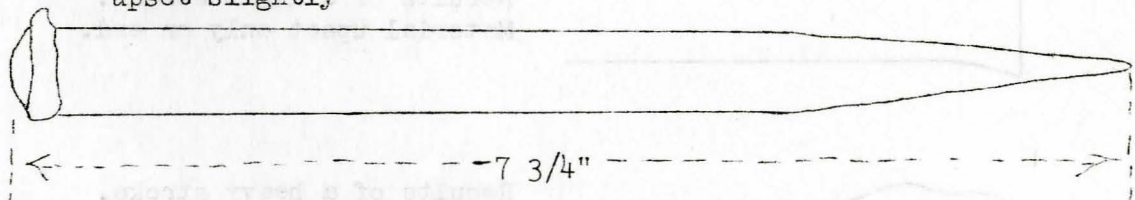


SQUARING UP THE STOCK
IF IT BECOMES DIAMOND SHAPED



MAKING THE POINT

Head of tooth is
upset slightly



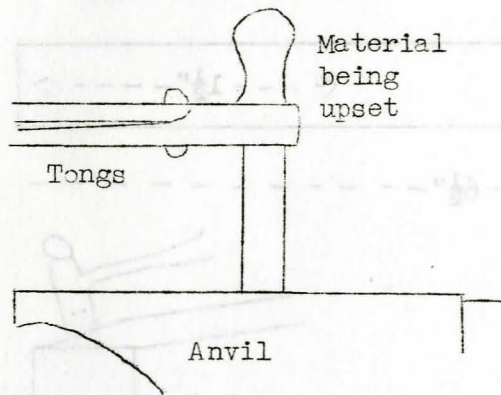
THE FINISHED HARROW TOOTH

Upsetting is the shortening in length and increasing in section of a piece of metal by heating and hammering and is usually done as a preliminary step in welding although not always as has been shown in the case of the harrow tooth. It is not a difficult operation but the kind of material used largely determines the ease with which the result is accomplished. Mild steel upsets readily while common wrought iron and tool steel are prone to give trouble. Tool steel is quite tough and for this reason is hard to upset while wrought iron contains impurities which make it have a tendency to break.

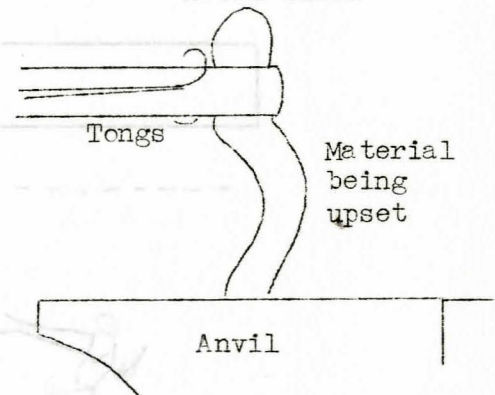
Only that portion of the stock which is to be upset should be heated and the heat should be as great as the material can safely stand. To prevent uneven upsetting uniform heat throughout the piece is necessary. After the stock is removed from the fire and placed on the anvil the strength of the blows should be determined by the size of the piece. If the blows are too hard the piece may bend and if they are too light proper upsetting will not result. The steps in upsetting the end of a rod and notes of some of the mistakes to be avoided are shown below.

UPSETTING

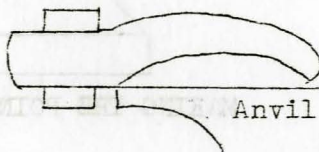
METHOD OF HOLDING THE PIECE WHILE UPSETTING



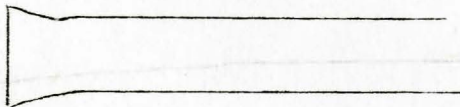
BLOWS ARE TOO HARD Material Bends



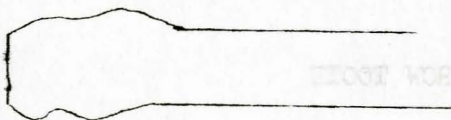
Straightening the piece after bending



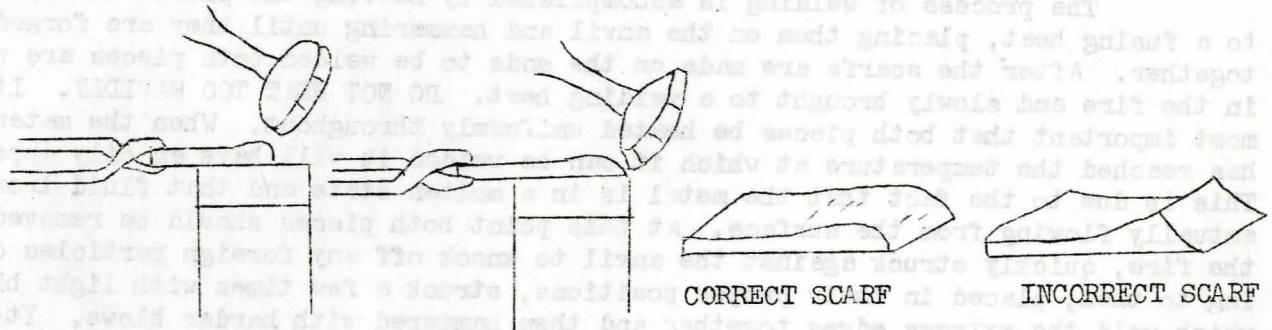
Results of a light stroke. Material upset only on end.



Results of a heavy stroke. Tends to upset through a greater length.



Scarfing is another step preliminary to welding and is merely the act of making an irregular bevel on the ends of both pieces which are to be welded together. A correctly made scarf will result in the end of a piece being about one and one-half times as thick as it was originally. This operation and the necessary steps are shown below.



SHAPING THE SCARF

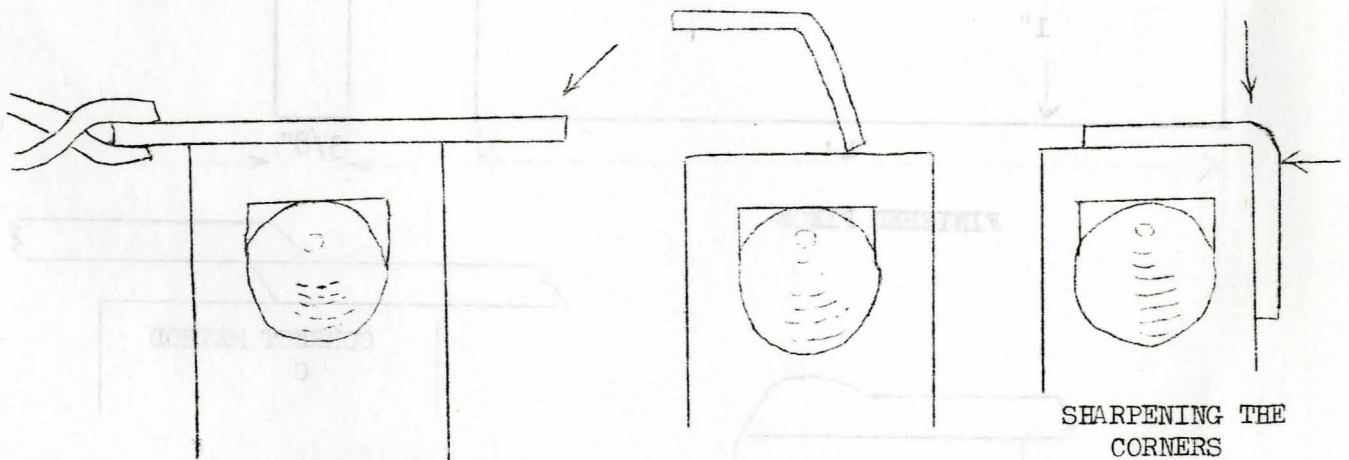
FINISHED SCARF

CORRECT SCARF

INCORRECT SCARF

BENDING

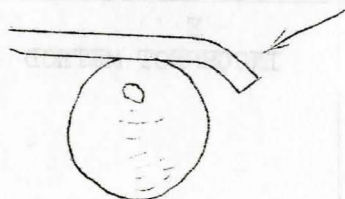
Bending is perhaps one of the most common forge operations and is usually comparatively simple in any article which the farmer attempts to make. Some thin material can be bent while cold but in most cases the stock is heated and usually the higher the heat the easier bending can be done. Articles may be bent over the anvil or around the horn depending upon the kind of bend wanted. In bending over an anvil care must be taken not to strike the metal on the exact edge of the anvil but slightly beyond. If the blow falls on the edge the material may be cut in two. The proper ways of making bends are shown in the following drawings.



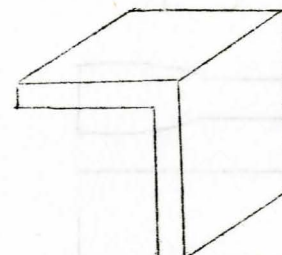
STARTING THE BEND ON ANVIL

UPSETTING A BEND

SHARPENING THE CORNERS



BENDING ON THE ANVIL HORN



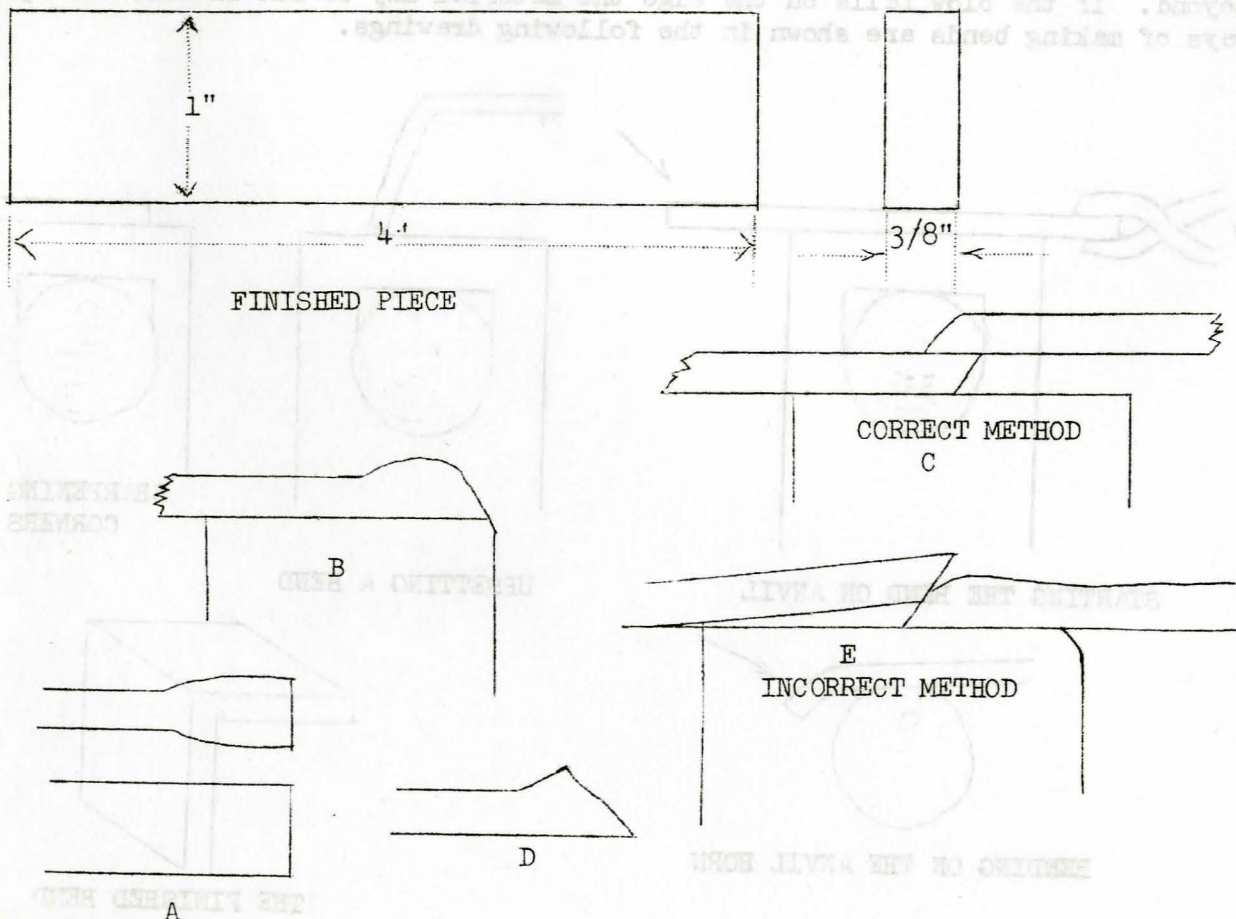
THE FINISHED BEND

Welding is one of the most important of all forge operations and nearly all repair work calls for some type of a weld. Practice is needed before good welds can be made and the beginner should not become discouraged if at first his welds do not hold.

A proper fire is very essential to good welding. It must be clean, deep and hot with sufficient supply of coke on hand to maintain it for some time. Any impurities in the fire tend to adhere to the stock and prevent a secure weld.

The process of welding is accomplished by heating the pieces to be united to a fusing heat, placing them on the anvil and hammering until they are forged together. After the scarfs are made on the ends to be welded both pieces are placed in the fire and slowly brought to a welding heat. DO NOT HEAT TOO RAPIDLY. It is most important that both pieces be heated uniformly throughout. When the material is has reached the temperature at which it can be welded it will have an oily appearance. This is due to the fact that the metal is in a molten state and that fluid iron is actually flowing from the surface. At this point both pieces should be removed from the fire, quickly struck against the anvil to knock off any foreign particles clinging to them, placed in their proper positions, struck a few times with light blows which weld the extreme edges together and then hammered with harder blows. It may be necessary to place the partially made weld back in the fire and reheat as it is useless to continue hammering after the heat has dropped below the point where welding takes place. However it is not advisable to reheat very many times and for that reason the operator works as rapidly as possible once the pieces have been removed from the fire.

The lapped or scarfed weld is the most common one used in repair work on the farm. The proper way of making such a weld is shown below. Note the two incorrect ways and avoid doing work in this manner.



STEP 1--Upset as in A and scarf as in B.

STEP 2--Have a clean fire, grasp the short piece in the tongs and place it in the right hand part of the fire with the scarfed side down. Place the other piece in left part of fire with scarf down.

STEP 3--Bring to a welding heat and see that both pieces reach this heat at the same time.

STEP 4--Take both pieces from fire at the same time, rap them on the edge of hearth and swing to anvil. Lay short piece on anvil with scarf side up, place long piece on top of it as in C. Drop tongs and strike a light blow. Follow with heavier blows.

STEP 5--Finish to size.

NOTE----Do not scarf as in D, scales will catch between pieces. Do not lap as in E.

HINTS ON REPAIRING BROKEN SICKLE BAR

When repairing a broken sickle bar do not try to weld the two pieces of the bar together. When sickle bars are repaired in this manner it is impossible to do so without shortening the bar at least $1/8$ " and perhaps $1/4$ ". There are two other methods which may be used in repairing a broken sickle bar. Either will give a much stronger job and the bar can be made exactly the same length as it was originally. One method is to butt the broken pieces together and weld a third piece on top of the two. This piece should be about four inches long and since bars usually break through a rivet hole, this would allow the new piece to extend far enough to cover two additional rivet holes as well as the one where the break occurred. In this way the strength of the rivets is added to the strength of the weld. The other method can be used when a short piece breaks off one end of the bar. An entire new end is welded on the remaining part and after the weld is completed is cut to the proper length and holes are then drilled. Either of these two methods will give a bar that is the exact length it should be and which will be strong.

TEMPERING

Tempering is an operation necessary in making chisels and punches and one with which the farmer needs to be familiar. The processes of hardening and tempering are closely related and are both used to obtain the proper degree of temper in a desired article. The hardness of an article depends upon the amount of carbon it contains and the rapidity with which it is cooled after heating. If cooled quickly it becomes very hard but also quite brittle. Tempering involves the removal of sufficient hardness and brittleness to make a tool which can be used without breaking.

Tool steel must be used for cold chisels. It is a waste of time and materials to attempt to make them from old metal found on farm machinery.

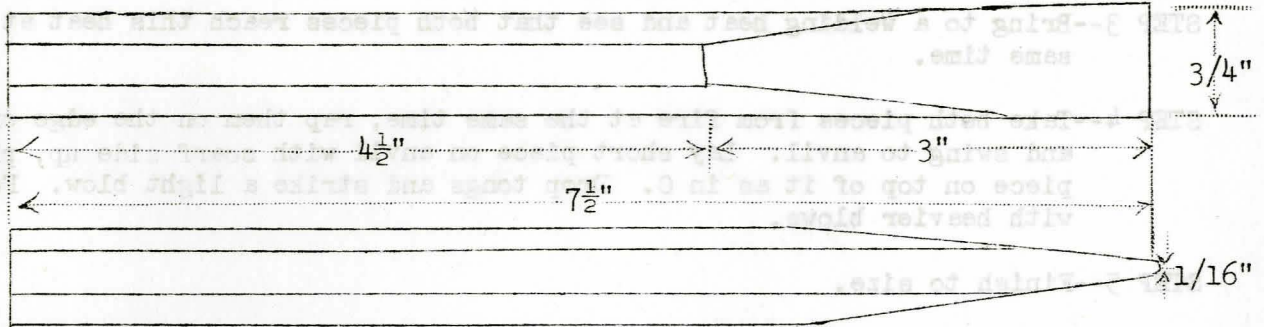
For small work of this sort the hardening and tempering processes can be done with one heating. Tempering a cold chisel is a particular job and needs to be done carefully. Dipping the hot metal in the water only to the specified depth and watching the colors are perhaps the two most important phases of this operation. The main thing to remember is that TOO RAPID COOLING RESULTS IN TOO MUCH HARDNESS AND ITS ACCOMPANYING BRITTLENESS.

WARNING: The article to be tempered must be completely finished and polished before tempering is started. It must have its final shape and size since no change can be made in a tool after it is tempered without destroying the temper.

The accompanying drawings and notes outline the steps needed in making a cold chisel and a rivet punch. Follow each step carefully and WATCH THE COLORS CLOSELY.

MAKING A COLD CHISEL

Stock: 5/8" x 7" Octagonal Tool Steel

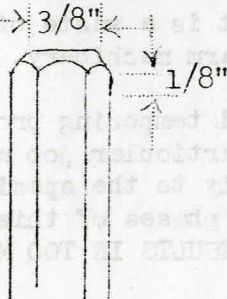


- STEP 1 Forge the piece to the form shown above, being careful not to heat the piece above a cherry red. Do not work the piece below a dull red heat.
- STEP 2 Sharpen and finish the chisel according to the illustrations given below. A templet can be made by filing a notch in a piece of thin galvanized iron with an ordinary three-cornered file.
- STEP 3 Polish the point the full length of the bevel.

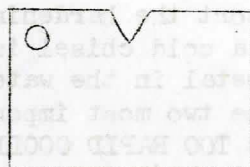
HARDENING AND TEMPERING

- STEP 1 Heat the piece to a cherry red, through a distance of about 2" from point.
- STEP 2 Hold the piece vertically, and dip the point in cold water, chilling it about 3/4" back. The point will thus be cold and hardened, while at some distance back from the point the piece will still be quite hot.
- STEP 3 Immediately brighten the surface of the point with emery cloth or a piece of sandstone.
- STEP 4 Now watch the bright surface very closely. Colors will gradually move down from the heated portion. First will be seen a light straw, then a dark straw, then a light brown, followed by a dark brown. When the dark brown has reached the end of the piece, quickly place the cutting edge 1/8" back in cold water and the required temper will have been secured. Keep the point cool until the entire piece has come to a black heat, when it may be cooled slowly by dipping it in water. Never cool it rapidly until the body of the chisel is above a black heat.

NOTE: The above method may be followed in tempering center punches, drills, etc. The colors after brown are: purple, light blue, full blue, dark blue, and then a sort of a grey black which fades into the original color of the steel. The point should be the hardest part of the chisel for if there are harder portions farther back, the chisel is liable to break at that point.



Head



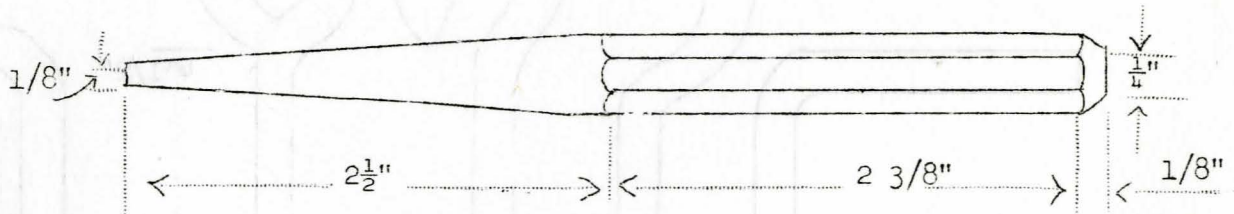
Templet



Point

A RIVET PUNCH

Rivet punches made from tool steel are not tempered. Only center punches are tempered, following the same procedure as given for tempering cold chisels.



Forge and finish the piece to the form shown above, drawing out the point, first square and then round, being careful not to heat the piece above a cherry red.

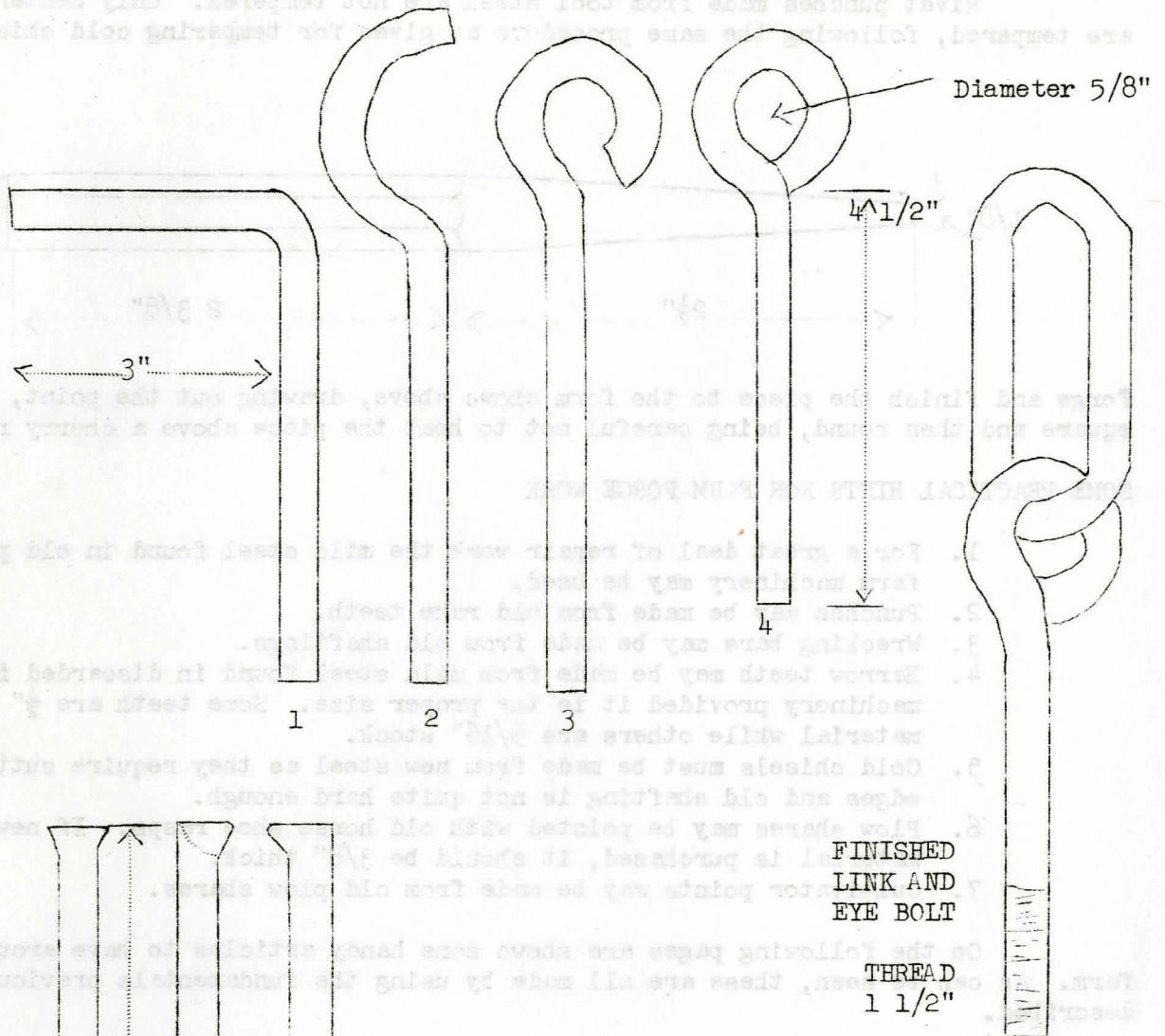
SOME PRACTICAL HINTS FOR FARM FORGE WORK

1. For a great deal of repair work the mild steel found in old pieces of farm machinery may be used.
2. Punches may be made from old rake teeth.
3. Wrecking bars may be made from old shaftings.
4. Harrow teeth may be made from mild steel found in discarded farm machinery provided it is the proper size. Some teeth are $\frac{1}{2}$ " material while others are $\frac{9}{16}$ " stock.
5. Cold chisels must be made from new steel as they require cutting edges and old shafting is not quite hard enough.
6. Plow shares may be pointed with old horse shoe rasps. If new material is purchased, it should be $\frac{3}{8}$ " thick.
7. Cultivator points may be made from old plow shares.

On the following pages are shown some handy articles to have around the farm. As can be seen, these are all made by using the fundamentals previously described.

EYE BOLT AND LINK

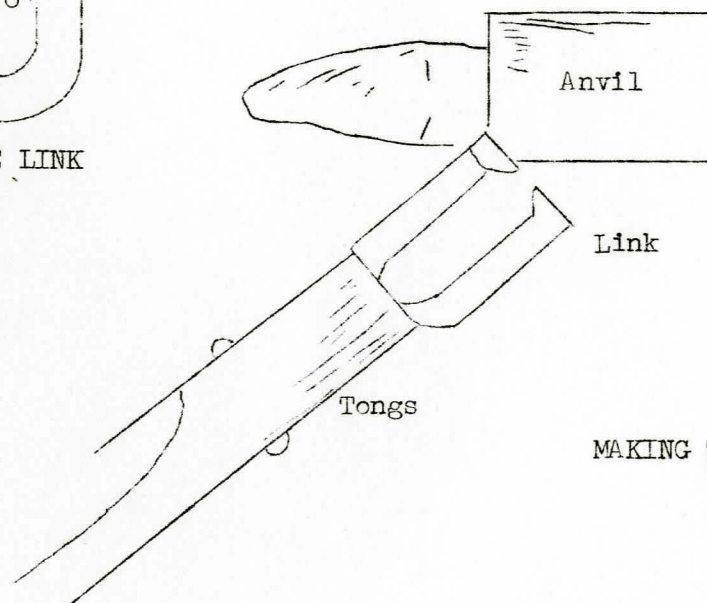
STOCK 7/16" MILD STEEL



FINISHED
LINK AND
EYE BOLT

THREAD
1 1/2"

THE LINK



MAKING THE SCARF

GATE HOOK

Stock: $3/8"$ x $3/8"$
Mild steel

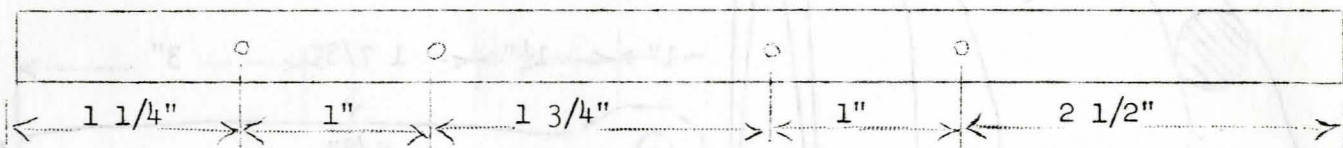
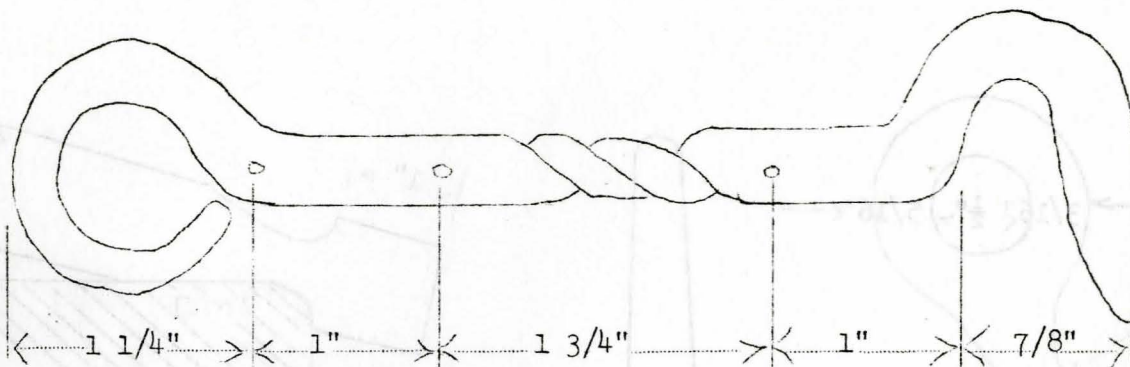


FIGURE 1

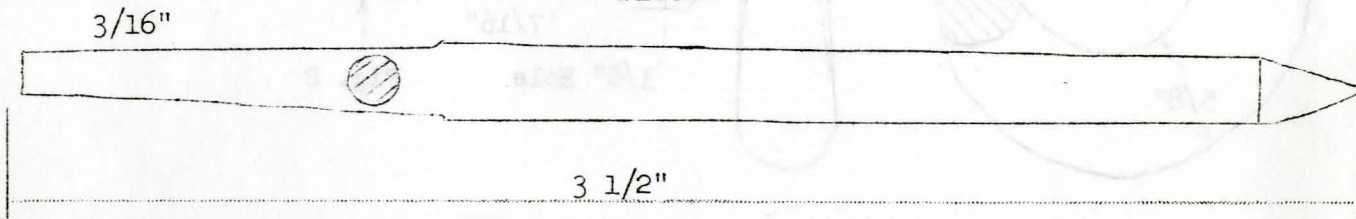


FIGURE 2

STEP 1--Lay off piece as shown in Fig. 1.

STEP 2--Point one end, draw and round the other, Fig. 2.

STEP 3--Form the eye as shown in Fig. 3.

STEP 4--To form hook bend back as shown in Fig. 4, cool up to the bend then turn back.

STEP 5--Heat piece to a dull cherry red and place in vise as in Fig. 5 and twist one full turn.

NOTE----Iron is softer at a dull cherry than at a bright cherry so have heat uniform

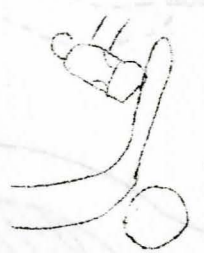


FIG. 3

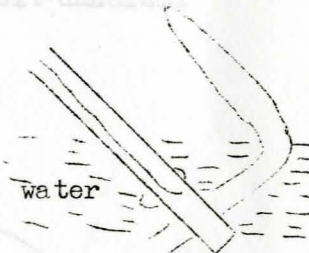


FIG. 4

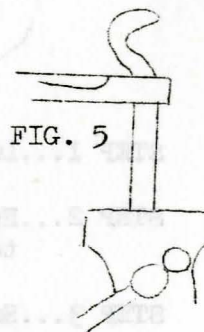
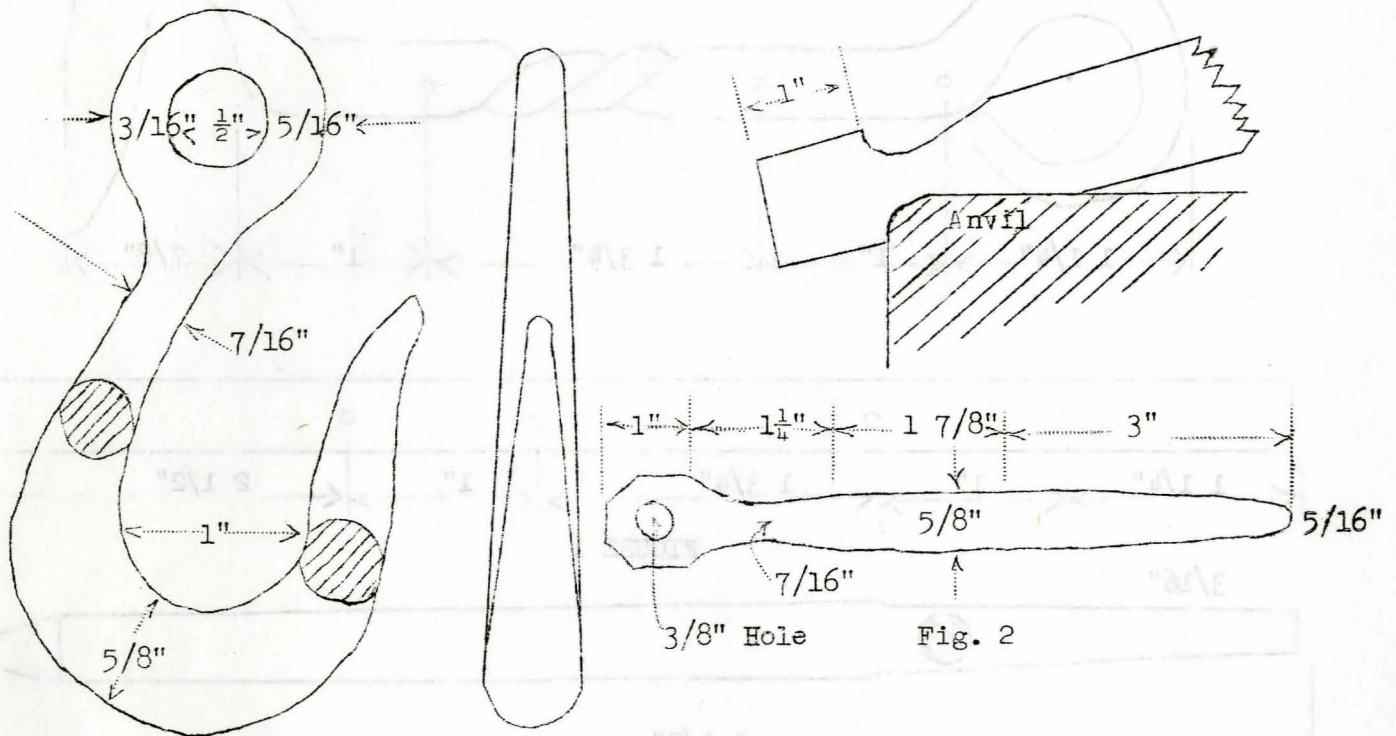


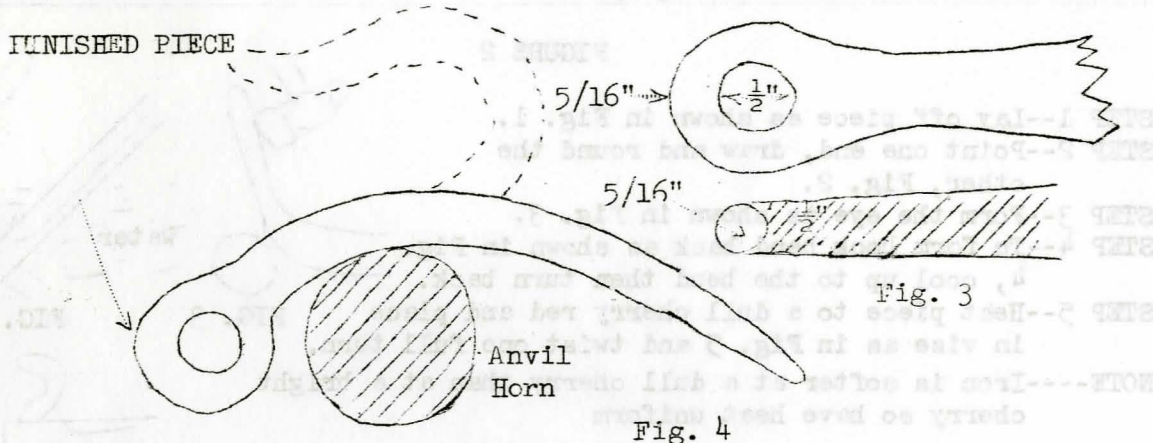
FIG. 5

Stock: $3/8"$ x $4\frac{1}{2}"$ Mild Steel

FORGING HOOK



FINISHED PIECE



STEP 1...Lay off a punch mark 1" from one end of the stock.

STEP 2...Heat and draw the piece to the form shown in Fig. 1 and then to the form shown in Fig. 2

STEP 3...Hammer down the corners of the large end of the piece, and bend the small end of the piece as shown by the dotted lines, then punch a $3/8"$ hole.

STEP 4...Make the eye round, and also round in section as in Fig. 3.

STEP 5...Bend as shown in Fig. 4 and produce the finished piece.

Belt Making

Stock: $\frac{1}{2}$ " rod of Mild Steel
 $\frac{7}{16}$ " rod of Mild Steel

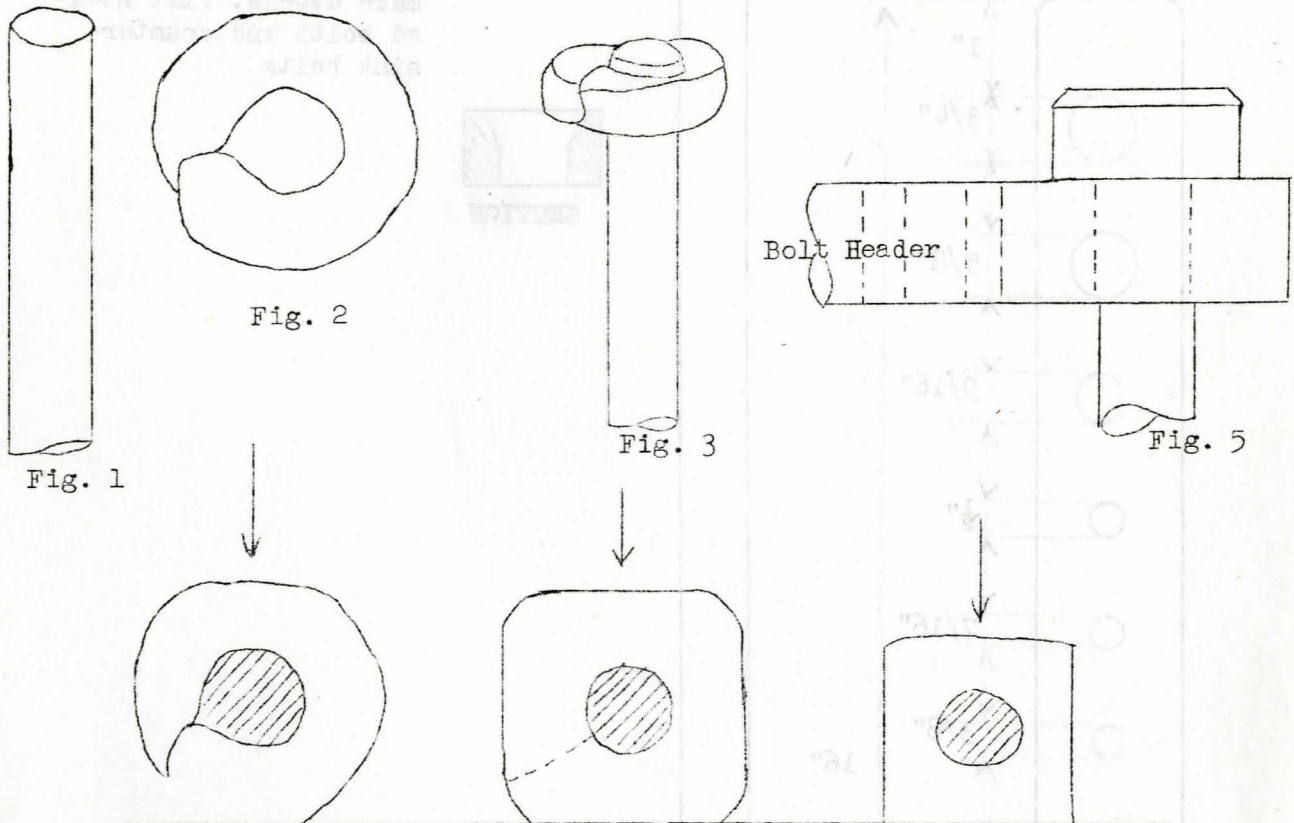


FIGURE 4.

STEP 1 - Bend $\frac{7}{16}$ inch rod into shape shown in Figure 2.

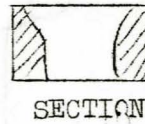
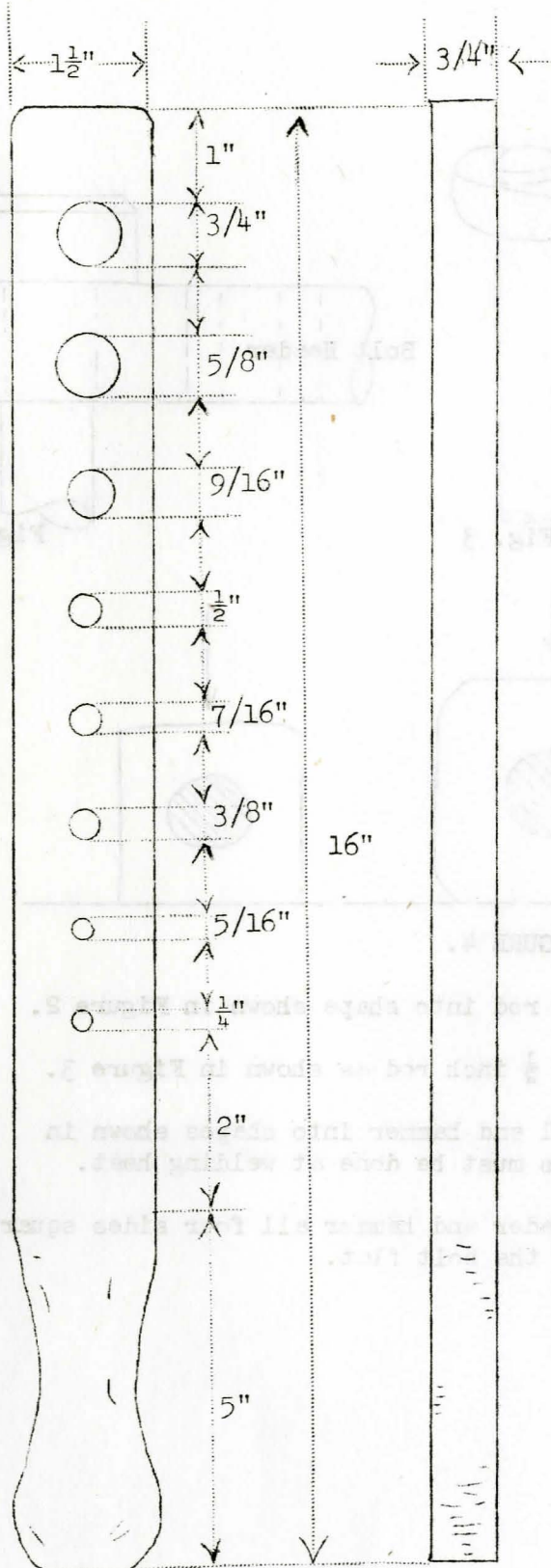
STEP 2 - Slip on end of $\frac{1}{2}$ inch rod as shown in Figure 3.

STEP 3 - Put on an anvil and hammer into shapes shown in Figure 4. This must be done at welding heat.

STEP 4 - Put in bolt header and hammer all four sides square and the top of the bolt flat.

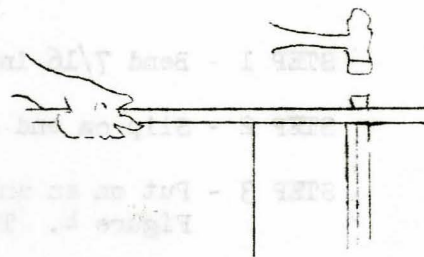
Stock: $1\frac{1}{2}$ " x $\frac{3}{4}$ " x 16"
Mild Steel

BOLT HEADING TOOL



Cut and Drill as Shown

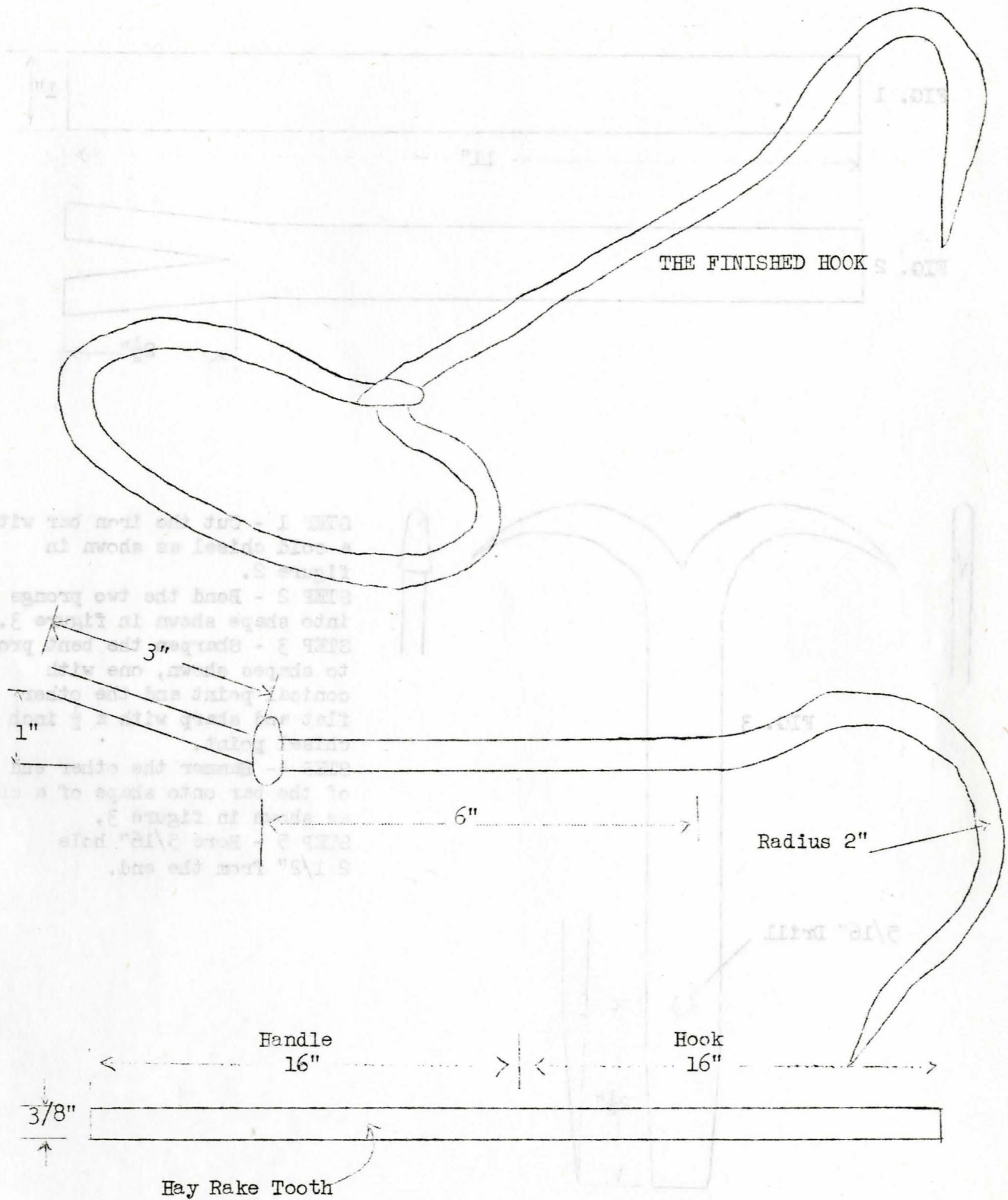
Tool may be used to
make dowels, flat head-
ed bolts and counter-
sink belts



Countersink
header in
use.

HAY HOOK

Stock: 3/8" Hay Rake Tooth



HORSES HOOF CLEANER

STOCK: 5/16" x 1" Mild Steel

FIG. 1

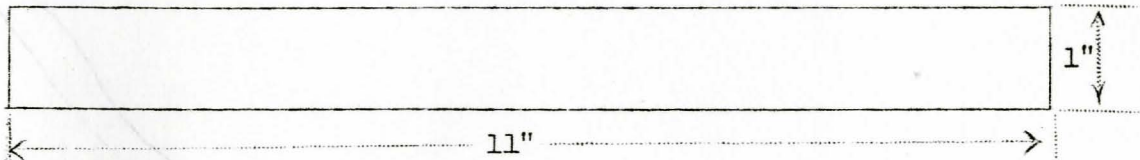


FIG. 2

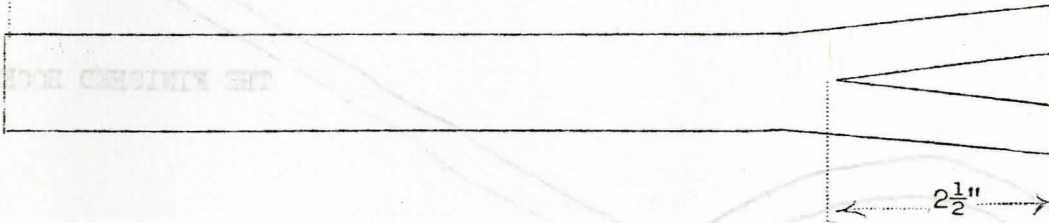
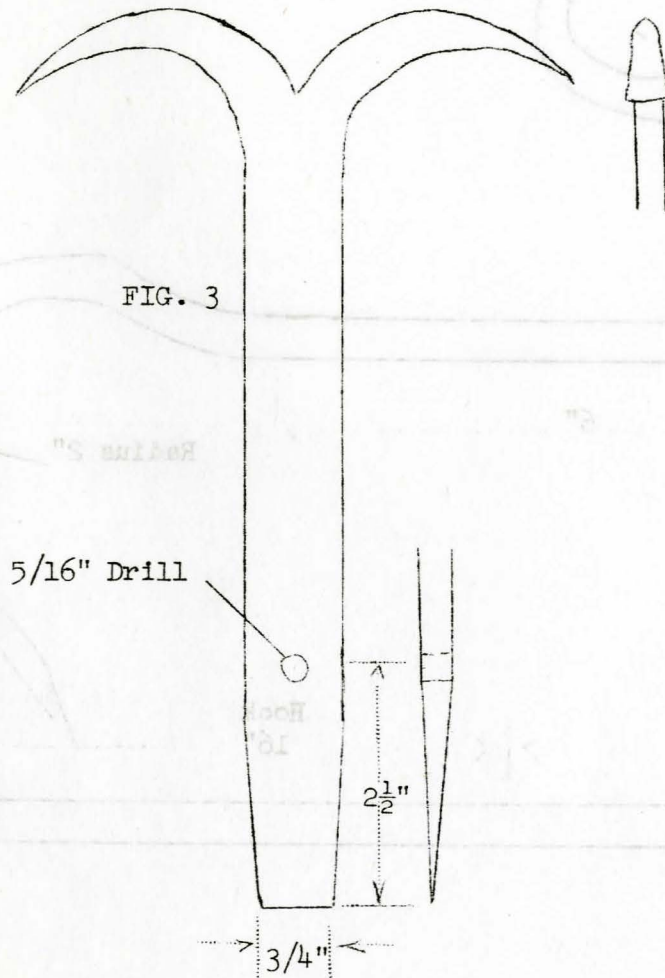


FIG. 3



STEP 1 - Cut the iron bar with a cold chisel as shown in figure 2.

STEP 2 - Bend the two prongs into shape shown in figure 3.

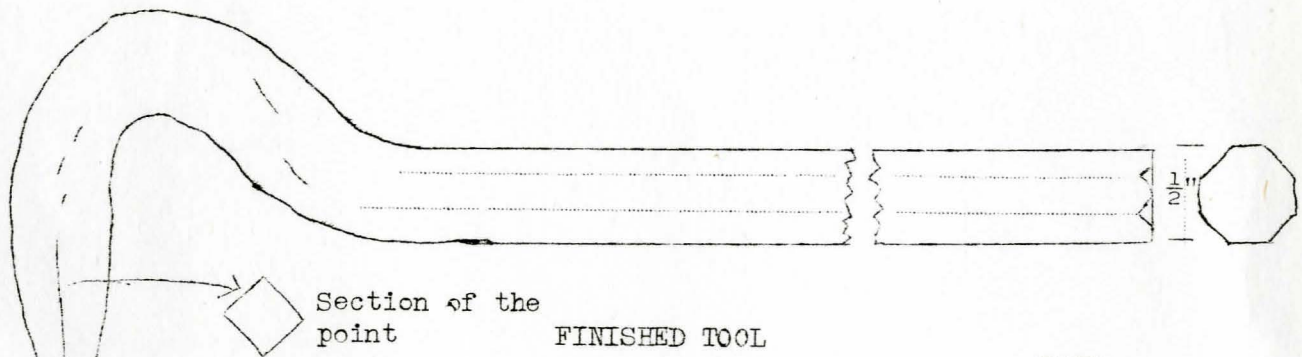
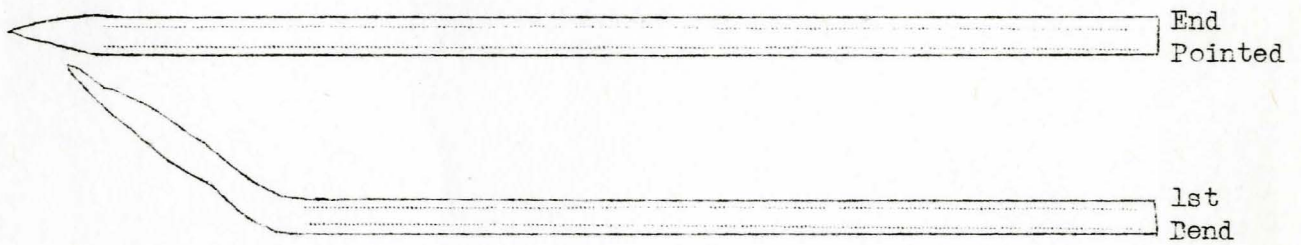
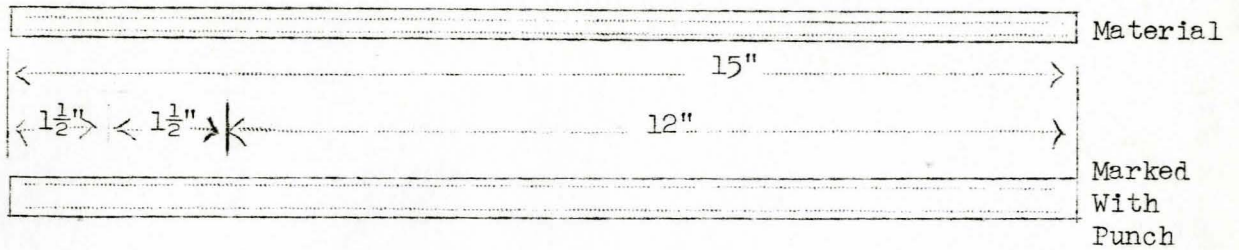
STEP 3 - Sharpen the bent prongs to shapes shown, one with conical point and the other flat and sharp with a 1/2 inch chisel point.

STEP 4 - Hammer the other end of the bar onto shape of a chisel as shown in figure 3.

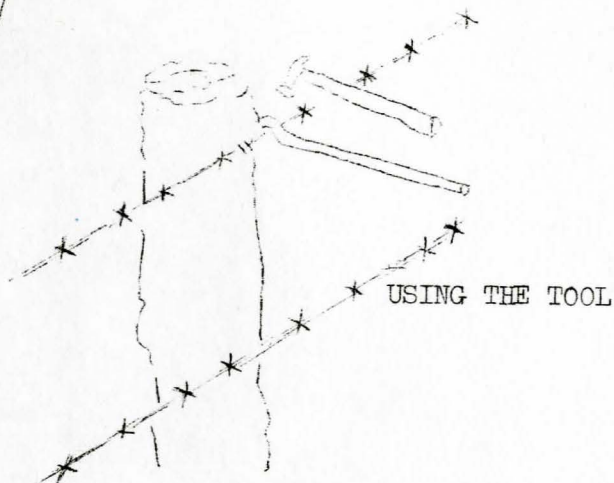
STEP 5 - Bore 5/16" hole 2 1/2" from the end.

STAPLE PULLER

1/2" Tool steel



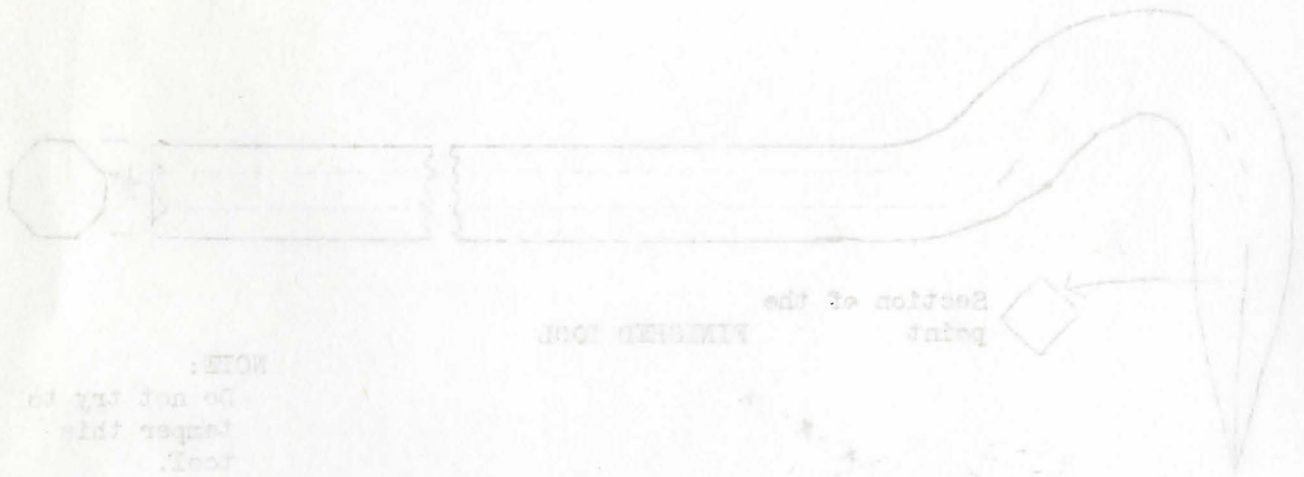
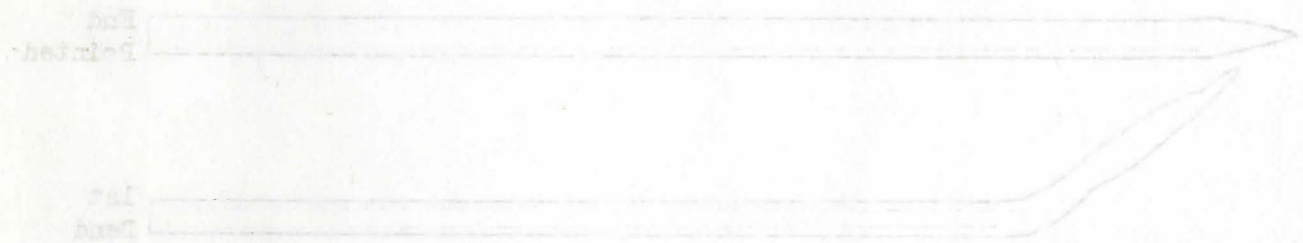
NOTE:
Do not try to temper this tool.



1 1/2" Tool steel

STAPLE PUNCH

Material	
Length	12"
Width	1 1/2"
Thickness	1/8"



Section of the
point

NOTE:
Do not try to
bore this
tool.

* BRING THE TOOL