more uniform heats may be obtained. Place 1½ inches of a mixture of equal parts granulated charred leather and charcoal in the bottom of the box. Place the piece of work on this, cover with the mixture to a depth of an inch or so, put the cover on the box and place in the furnace.

When the piece is of a uniform red heat, the box may be removed from the furnace and the piece of work taken out by grasping it with tongs on opposite sides, as shown in Fig. 64. Place it on a device which consists of a ring having three handles, as represented in Fig. 65. Have the ring (which should be made of iron or machinery steel) considerably thinner than the thickness of the piece to be hardened, but wide enough to screw the handles in as shown. The handles *b b* are threaded on one end and bent; they are then screwed into the ring, as shown. A stud *c* having a tapped hole is screwed in also. The third handle is screwed into this. The object of making it by this method is, the handle may be unscrewed from the stud *c* and the piece to be hardened put in place. The handle may then be screwed into the hole in stud. If the piece of work is very large and heavy, a man may

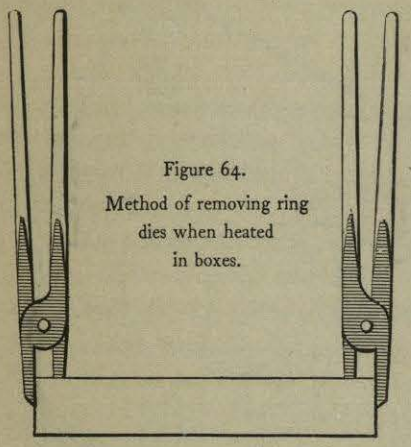


Figure 64.
Method of removing ring dies when heated in boxes.





be stationed at each handle. If not very heavy, two men can handle it all right. The operators should protect their hands and arms in some manner to prevent being burned by the steam generated when the red hot piece comes in contact with the water.

It will be necessary to use a bath having a jet of water coming up from the bottom, so as to cool quickly, when hardening work of this description. Before immersing, the water should be turned on, and at the minute the piece is dipped, a quantity of table salt (about a pint) should be thrown into the water. The ring should be worked up and down in the bath. When the "singing" ceases, the supply valve may be closed. The water in the bath may become somewhat warm, but it will reduce the liability of cracking. As soon as the piece of work is reduced to the temperature of the bath, it may be removed, placed over a fire and heated to prevent cracking from internal strains. If it is necessary to draw the temper, the piece of steel may be brightened while heating and the temper drawn at this time.

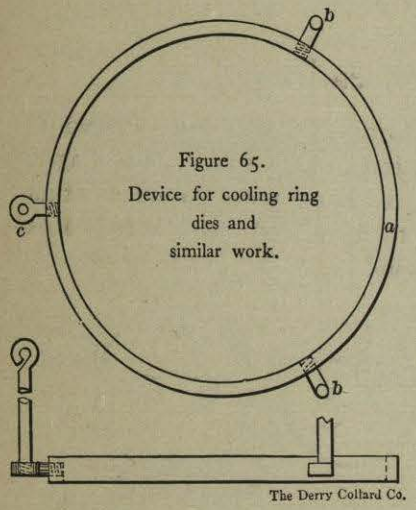


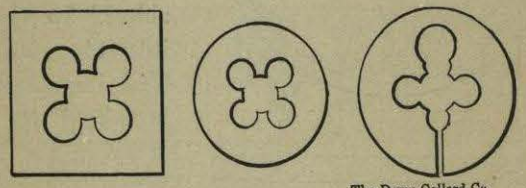

Figure 65.
Device for cooling ring dies and similar work.

It is advisable when drawing the temper of articles

of this description to *heat very slowly*, so as to have all parts of an equal temperature. If possible, have the heat so uniform that it will not be necessary to quench the article when the desired heat is reached. Should the temper colors, however, run so fast that it seems necessary to quench in order to keep it from becoming too soft, it should be dipped in oil or *hot* water, as, if dipped in cold water, it would have a tendency to cause brittleness.

## Screw Threading Dies.

There are several forms of the die under consideration. They are sometimes made square, then again they are made round in shape, with no means of adjustment. They are then termed solid dies. Most square dies are made solid.



The Derry Collard Co.

Figure 66. Various styles of screw threading dies.

When it is necessary to cut a screw to size or to gauge, it is generally considered advisable to make the *finish* die of a form known as an adjustable die. The forms referred to are shown above, in Fig. 66.

The solid square die, being used mostly for threading bolts and similar work where accuracy is not essential, are usually made to cut *small* enough, and no particular pains taken when they are hardened. How-





ever, if a die of this form is hardened all over, the contraction from the outside edges is very unequal, on account of the corner containing more stock than the portion between. Owing to the unequal contraction, the cutting edges do not have an equal amount of work to do, so one cutting edge dulls more rapidly than the other. Every tool maker knows the secret of success in making a screw threading die that will work satisfactory, lays in having each cutting edge cut *its* proportional amount. It will readily be seen that any *unequal* contraction or wear, which causes an upsetting of this equality in cutting, must reduce the usefulness of the tool.

Too often no account is taken of the *amount* of work a tool will do after it is hardened. If it survives the ordeal of going through the fire and water, and will cut, it is considered a successful job of hardening.

From the preceding it will be seen that it is necessary, in order that best results may follow, that the die be in (as near as possible) the same shape, and the location of the cutting edges be the same as before hardening. Now, in order to accomplish this result, it is necessary to treat the die in a manner that will cause the cutting portion to harden *first*. By so doing, the contraction of the outer portion does not seriously affect the cut-

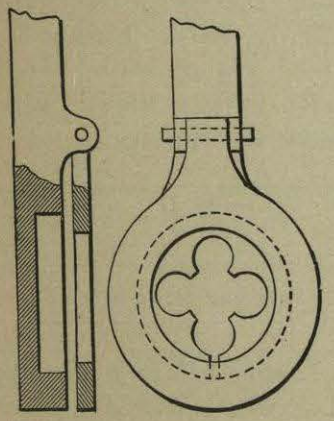


Figure 67. Device for cooling screw threading dies.

ting qualities of the tool. When hardening a square or a solid round die, it is sometimes considered advisable to place the die in a fixture, as shown in Fig. 67. It is then immersed in the bath and swung slowly back and forth in order that the liquid may readily pass through the opening, thus insuring the hardening of the cutting teeth. The portion near the circumference is, of course, soft. This is rather to be desired than otherwise in the form of die under consideration.

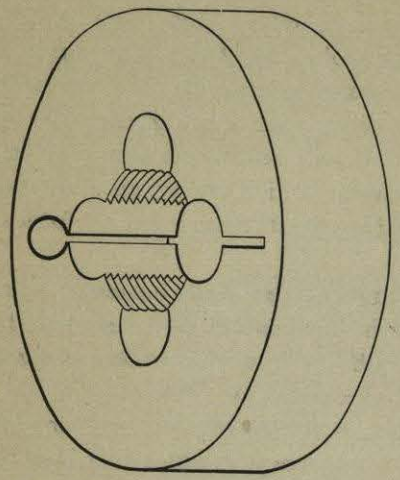


Figure 68. Method of preventing "twist" in screw threading dies.

When adjustable dies are hardened, it is generally considered necessary to harden the outer portion in order to furnish a certain amount of elasticity, in order that the die may open uniformly when expanded. The necessity of this depends on the design of the die. If stock enough is left at the portion where the die is supposed to spring, the stiffness of the stock will give it sufficient tension. Should it be necessary to harden the outer portion somewhat, the fixture may be cut away in a manner

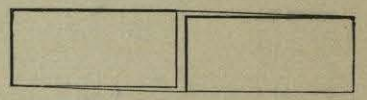


Figure 69. Example of "twist" in screw die.





that allows the contents of the bath to come in contact with the steel nearer the outer edge.

Adjustable dies of the description shown should not be cut entirely through at the point where pressure is applied to open them, but may be cut nearly through,

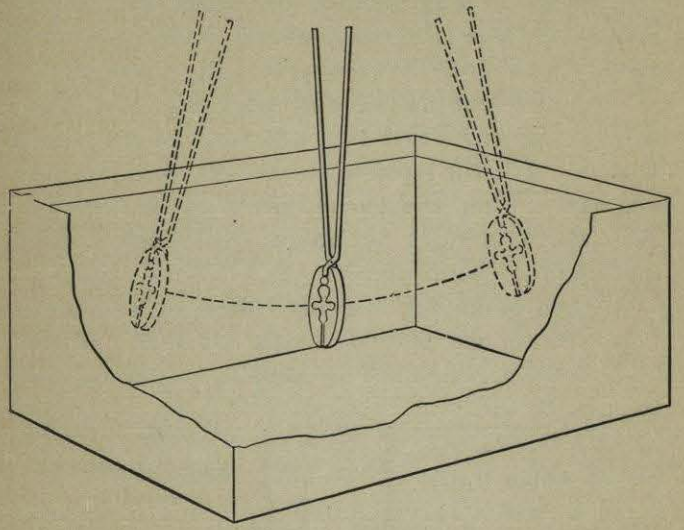


Figure 70. Method of cooling dies for thread cutting.

commencing at the inside and cutting toward the outside, leaving a thin partition, as shown in Fig. 68. This partition holds the die in shape, preventing the tendency to twist, shown in Fig. 69.

When it is not considered advisable to make or use a fixture as described, the die may be grasped, after being heated, with a pair of tongs, as shown in Fig. 70, and quenched in a bath of lukewarm water or brine, swinging it slowly back and forth, as represented. When hardening any tool of this description,

bear in mind the fact that the article should never be heated in a manner that allows the cutting teeth to become oxidized by exposure to the air while heating. Best results are obtained by heating in a muffle or a piece of pipe. If the surface of the teeth become covered with a scale of oxide, this raises, and keeps the contents of the bath from acting, thus causing soft spots, which render the tool practically useless.

An excellent plan consists in heating the dies in an iron box having a half inch of charred leather in the bottom. Fill the opening in the die with the same material. When the die reaches a uniform temperature which is right to produce the desired result, quench in the bath.

When hardening "spring" dies, or, as they are familiarly termed in some shops, "hollow mill dies," best results are obtained by dipping in the bath with the cutting end uppermost, as described under Hardening Hollow Mills.

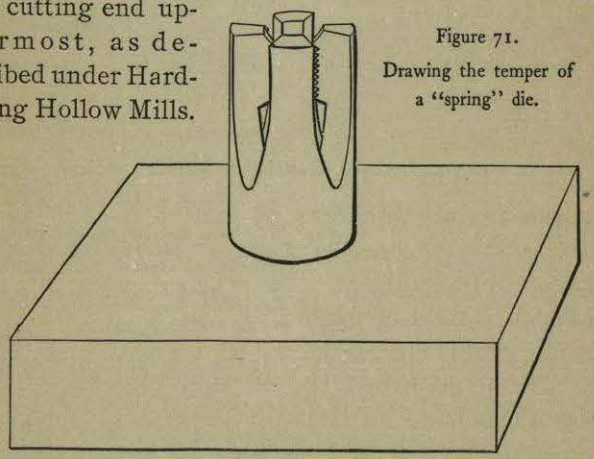


Figure 71.
Drawing the temper of a "spring" die.

Generally speaking, it is not necessary to heat the die much beyond the length of the threads.





The temper may be drawn by placing the die on a hot plate, as shown in Fig. 71, drawing from the back end. On account of the shape of the cutting edge, which makes it stronger than the ordinary form of screw threading die, it is not necessary to draw the temper as much. A faint straw color making them about right, unless the cutting tooth is long and weak, in which case it may be drawn to a full straw color.

If many dies are to be tempered at a time, the cost may be reduced very materially by heating in a kettle of oil, drawing them to a temperature which varies from 460° to 500°, according to the conditions previously mentioned.

When but one or two are to be done, it is advisable to brighten the sides and draw the temper by laying them on a flat plate, moving around on the plate, and turning them over occasionally. The temper color should be from a straw to a brown color. If it is considered advisable to draw the temper of a large batch of dies by the hot plate method, the plate may be placed over a fire, in order to maintain a uniform heat. Quite a number of dies may be placed on the plate at a time. It is necessary to turn them occasionally, as mentioned. As one shows the proper temper color, it may be removed and placed in a dish of *warm* oil. By this method a skillful operator can temper a large batch of dies in a comparatively short space of time, but the results will not be as satisfactory as though heated in oil.

The amount of work to be done will always determine the most economical method of doing it, but it is better to err on the side of having too many conveniences. A few spoiled tools will pay for several improvements.

Large pieces of steel are more liable to crack as a result of internal strains than smaller pieces. On account of the weight of the piece there is a tendency on the part of some hardeners to neglect reheating the piece to overcome this tendency to crack, due to various uneven heats the steel may have received.

In order to overcome this tendency, the die should be reheated in a uniform manner to a temperature that allows the various portions to conform to any strains in the piece. This may be accomplished by placing the die in the fire, turning it occasionally, in order that it may be uniformly heated, and heating until moisture applied to the surface forms steam. This method when applied to *large* pieces is not apt to result in the center of the piece being heated as hot as the outside. Consequently *better* results will follow if the die is placed in a kettle or tank of boiling water (212°) and left there until heated uniformly throughout. If the die is large this will necessitate leaving it in the water at the boiling point for several hours, as it takes longer to heat a large piece of steel throughly than we realize. It pays to be very careful about these little points, as these dies are often expensive.

## Hardening Long Articles.

Most hardeners dread hardening long, slender articles, on account of the uncertainty attending the operation, so far as results are concerned. If the article is a reamer or similar tool, having teeth on the outer surface, it will not require as great an amount of heat as though it were a solid piece. In any case, however, do not heat any hotter than is necessary to





accomplish the desired result, always remembering that *even* heats are the *secret* of success when heating steel for hardening. If the tools are hotter on one side than the other, unequal contraction must take place; consequently, the article will be crooked.

When hardening long reamers and similar tools, it is *necessary* that the heat should be *uniform* and as *low* as possible. It must be the same on each side. If one side be a low red and the opposite side a bright red, and it is quenched in the bath, it is sure to come out crooked. A piece of this description must be dipped in the bath in as nearly a vertical position as possible, as shown in Fig. 72, in order to cool both sides uniformly. If it be dipped at very much of an angle, as shown in example marked "wrong," it will surely spring, on account of the uneven contraction of the two opposite sides. It is necessary to work such pieces up and down in the bath, changing the location occasionally in order to avoid the effects of the steam generated.

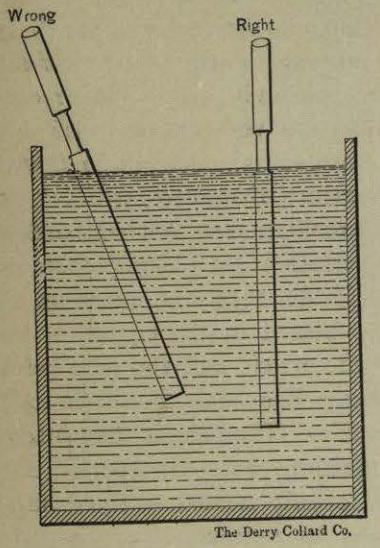



Figure 72. Proper method for dipping long articles.

These may seem like unnecessary precautions, but the results obtained will show that it is worth while

observing them as thoroughly as possible. It's the little things that count in successful hardening and tempering.

## Condition of the Bath.

If the tool is of a design that makes springing a possibility when the article is quenched, it will be necessary to warm the contents of the bath considerably, the degree to which it should be heated depending on the shape of the tool and the temper of the steel used. Excellent results are many times obtained with a bath heated to a temperature of 100° to 150°.

The writer has had excellent results when hardening articles of this description by placing them in tubes one inch larger inside than the piece to be hardened. It should be placed in the center of the tube, the space between the article and the tube being filled with charred leather. The ends should be stopped and sealed with fire-clay. The tube is then placed in the fire and given a uniform heat for a period that insures the article being evenly heated to the desired temperature, when it may be removed from the tube and plunged in a warm bath of brine or the citric acid solution.

## Hardening Taps.

It is necessary to take into consideration the design of the tool, the steel used, and the nature of the work to be done by the tap. If the tool is very long and it is necessary to harden but a small portion of the length, it is not necessary to heat it any farther up than the





length which requires hardening. In such cases it is a comparatively simple job.

When a long tap requires heating and hardening its *entire* length, it is necessary to devise some way of uniformly heating the piece. It is also necessary to quench in such a manner that all portions will cool as uniformly as possible, to avoid unequal contraction, thus preventing springing or cracking.

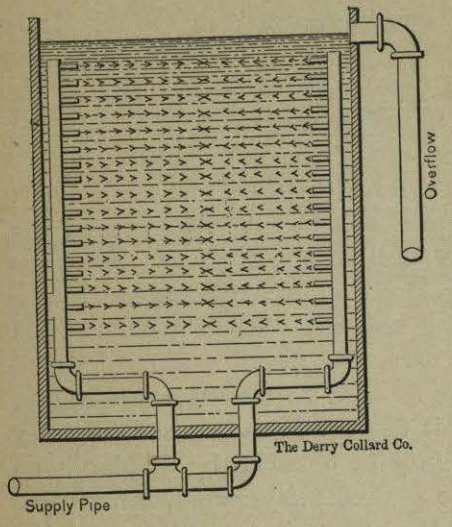



Figure 73. Bath for hardening taps.

When hardening taps, care should be exercised that the teeth are heated no hotter than the refining heat, or they will be brittle. If heated hotter than necessary, it must have the temper drawn very low, or the teeth will snap off when used. If the temper is drawn low, as described, the tap is too soft to perform its full share of work. When hardening tools having teeth or projections, it is essential that the heat be the lowest possible. It is advisable to heat in a muffle furnace or enclosed in some receptacle to remove it from the products of combustion in the furnace and from oxidation by the action of the air. When it

reaches a low, uniform heat, dip in the bath of water or brine, preferably the latter. Work up and down rapidly, to bring the contents of the bath in contact with the teeth; or, better still, use a bath as shown in Fig. 73, having inlet pipes on opposite sides of the tank, these pipes being perforated, as shown. It is advisable to have the piping so designed that the upright perforated pipes may be placed against the side of the tank or moved toward each other, in order that the jets coming out of the holes may strike the object with sufficient force to drive the steam away, thus allowing the liquid to act on the steel.

Long taps give best results if packed in a tube with carbon, in the form of charred leather, as described in hardening reamers. When it has reached the proper uniform hardening heat, it may be hardened by immersing in the form of bath represented in Fig. 73. If a bath of this description is not at hand, very satisfactory results may be obtained by dipping in an ordinary bath of the desired temperature, and revolve the piece rapidly in the bath to insure uniform results. This will in a measure imitate the bath mentioned.

A bath of brine, or the citric acid solution, give excellent satisfaction for hardening tools of this description. Unless the tap is of large diameter, do not use a cold bath.

## Hardening Small Taps, Reamers, Counterbores, Etc.

When small articles of this description are hardened in great quantities, it is necessary to devise means





whereby they may be hardened cheaply, yet the work must be done in a satisfactory manner. Various methods are employed to accomplish this, and one of the most successful methods that has come to the writer's attention consists of a furnace made with a

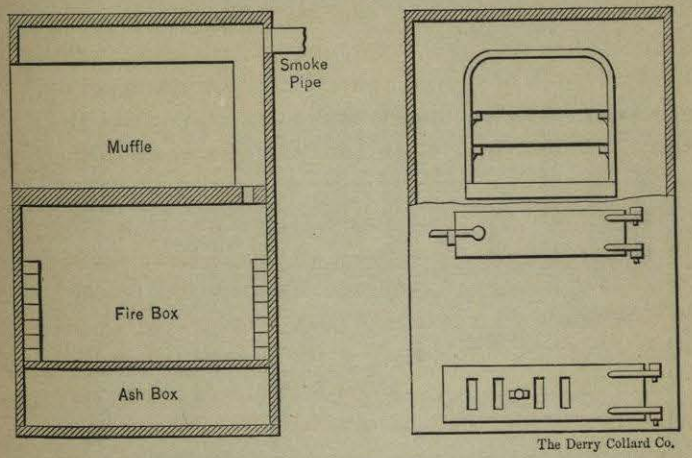



Figure 74. Muffle furnace for heating taps.

muffle. The heat was furnished by burning illuminating gas, or it may be designed to burn coal. The muffle was made as shown in Fig. 74. Cleats are cast on to the walls of the muffle, which in this case was cast iron. On these cleats shelves were placed, and on these shelves the pieces to be hardened were heated. It was necessary to turn the pieces over occasionally to insure uniform results.

When a piece was heated to the proper temperature, it was taken by means of a pair of tongs and dropped into a bath, which consisted of a tank having

several tube-shaped pieces of wire netting, as shown in Fig. 75. The tubes were slightly larger inside than the diameter of the largest part of the tool being hardened. Tubes of various sizes were used, the size depending on the diameter of the tools to be hardened. The tank had a supply pipe coming up

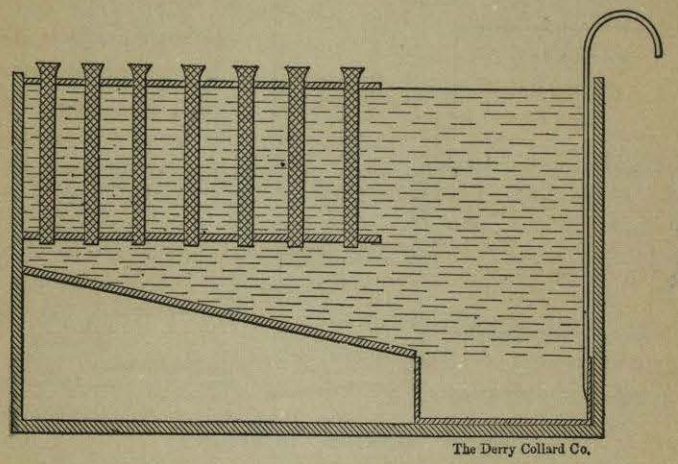



Figure 75. Bath for hardening taps and reamers.

from the bottom. This was connected with a supply tank overhead. A pump was used to force the water into the supply tank. It was possible to use a bath of clear water, brine, or any favorite hardening solution. In this case, the bath consisted of the citric acid solution, described under "Hardening Baths." It was kept at a temperature of about 60°. As fast as the pieces were heated to the desired temperature, they were taken with tongs and dropped into one of the tubes, the cutting end being down. They





passed down through the tubes on to an incline, and then into a catch pan, as shown. The distance the pieces traveled in the bath was considered when designing it. It was found by experiment that the largest piece to be hardened would cool below a red heat in falling a distance of two feet in the bath. To make satisfactory results a certainty, the depth of the part of the tank through which the pieces passed was made 36 inches. If the tools had struck the bottom and

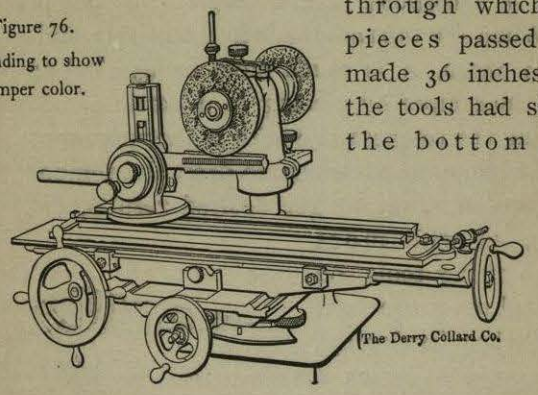



Figure 76. Grinding to show temper color.

turned on their side before the red had disappeared from the surface, they would have, in all probability, sprung; but, as it was, excellent results were obtained.

When taps are brightened, in order that the temper colors may be visible, it is not advisable to use a piece of emery cloth on a stick or round file, as is often done, because unless the operator is *extremely* careful, he is apt to cut away the cutting edge of the teeth, thus rendering the tool unfit for use. If possible, use an emery wheel of the shape of the groove, as shown in Fig. 76. It is not absolutely necessary to use a fixture, as the tap may be held in the hands for brightening.

In this way, not only is the steel brightened, so the colors may be readily seen, but the cutting edges are ground sharp, and any burrs thrown up between the teeth are ground away.

When but a few taps are to be tempered, it is possible to heat them sufficiently in a gas jet or the flame of a Bunsen burner; sometimes the flame of a candle is used when the article is very small, as in Fig. 77. With a blowpipe, a hot flame can be produced.

When the taps are made in quantities sufficiently large, it is much more economical to draw the temper by placing in a kettle of oil, gauging the temperature with a thermometer.

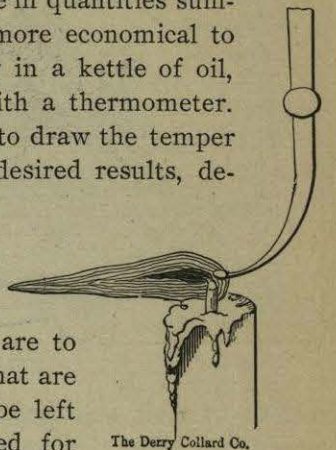



Figure 77. One way to heat small taps.

The amount necessary to draw the temper of a tap in order to get desired results, depends, as with most other cutting tools, on the steel used, the heat given when hardening, and the use to which they are to be put. Very small taps that are to be used by hand may be left harder than those intended for use in a screw machine. Taps used by hand should be drawn to deep straw or brown color, while those used on screw machine work need drawing to a deep brown, and in some cases to a purple.

## Half Round Reamers.

These should be heated very carefully in a pipe or muffle furnace to the lowest heat possible to harden.





When dipping in the bath, the reamer should be inclined somewhat from a perpendicular position, the heavier portion being on the lower side, as shown in Fig. 78, to avoid a tendency to spring. The contents of the bath should be heated as warm as is consistent with good results, as this will help keep it straight.

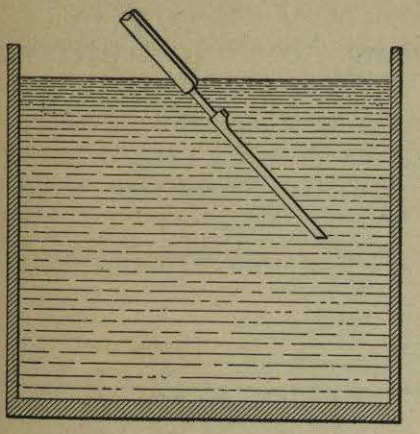


Figure 78. Proper method for cooling half-round reamers.

Should the reamer spring somewhat in hardening, it may be straightened by reheating and exerting a pressure on the convex side.

If the projection has been left on the end, as shown in Fig. 79, the reamer may be placed between centers and straightened, as represented elsewhere.

Should it be a reamer having *no* center at the small end, it may be placed on two V blocks, as shown in Fig. 80. Apply heat by means of a gas jet, spirit lamp, or any other means to the lower side, heat until oil placed on the surface commences to smoke. Now apply pressure at P, on top side. When it has been sprung the proper amount, cool by means of wet waste.

The possibility of straightening reamers and similar work means such a saving in many shops that it

will pay to have special attention paid to it, as crooked tools of any kind cannot do accurate work. It will pay to rig up fixtures especially for this, as the saving is far greater than the cost.

Small, half-round reamers should be drawn to a full straw, or a brown color for most work.

## Hardening Milling Machine Cutters.

As most shops have at least one milling machine, and many shops hundreds, there are probably more cutters hardened for this class of work than for any other.

In hardening this class of tools, it is necessary to


Figure 79. Half-round reamer.

have them hard enough to cut the metal being machined, yet tough enough to stand up under the strain to which it must be subjected.

Milling machine cutters should be hardened at a lower heat than a solid piece of the same size. The teeth, being slender and projecting from the solid body, take heat very readily. When possible, tools of this description should be annealed after a hole somewhat smaller than the finished size has been drilled and the tool blocked out to shape in order to overcome the tendency to crack from internal strains. If it has not been possible to do this, or if for any reason it has





not been considered advisable, the cutter may be heated to a low red and laid to one side and allowed to cool until the red has disappeared, when it may be reheated and quenched. It is always better, however, to anneal after blocking out if it can be planned so as to take the time necessary to do this. The results are more satisfactory in every way.

It may be well to again caution the reader in regard to the heats. The teeth of this form of tool being thin, are apt to absorb heat faster than one realizes, and as a consequence, they become too hot. If a cutter is

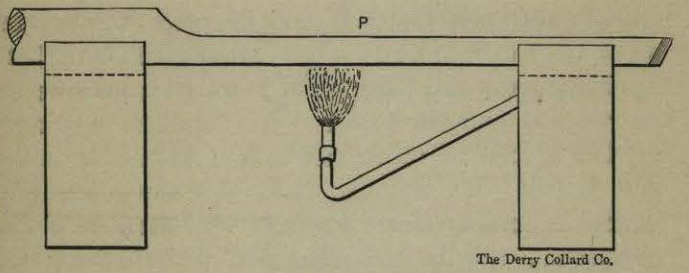



Figure 80. Straightening a half-round reamer.

overheated, it will not do as much nor as satisfactory work as though properly heated; but should the teeth by any carelessness become overheated, do not quench at that heat, thinking no one will know the difference. While it is possible to misrepresent the condition of the heat when describing it, the texture of the steel always tells the truth in regard to what the operator has done with it when in the fire. Neither is it a good plan to hold it in the air and let it cool until the color shows about right, because it is hotter inside than on the outside; and then again, the grain will be as coarse

as though it were dipped at the higher heat. It should be allowed to cool off and then heated to the refining heat and quenched.

When this form of tool is ready to harden, place it on a wire, bent as shown in Fig. 81. The wire should be large enough to hold the cutter without bending, but not much larger, as it should not impede the circulation of the fluid through the hole of the cutter. Neither should any considerable sized piece of steel rest against the side of the cutter, as the action of the bath would not be uniform if it were kept away from some portions of the piece. The cutter should be worked around well in the bath until the teeth are hard, when it may be removed and plunged in oil and left until cold. It should then be taken and held over a fire and heated sufficiently to remove any tendency to crack from internal strains. The temper may now be drawn the required amount.

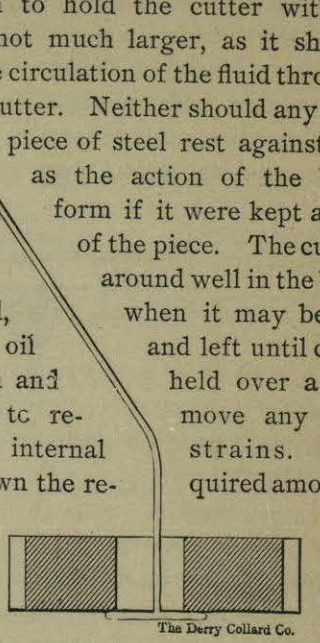



Figure 81. Proper way to cool milling cutters.

A method in use in many shops, consists in dipping the cutter in a bath of water having one or two inches of oil on the surface. The cutter is passed down through the oil into the water. Fig. 82 shows a bath of this description. The oil does away with the first sudden shock, which results when hot steel is plunged into cold water, and as a small portion of the oil adheres to the teeth, especially in the corners where the teeth join the body of the material,





the action of the water is not as "rank" as would otherwise be the case. Where the teeth are long or the mill is of irregular contour, it is advisable to heat the water somewhat. Water or brine, heated lukewarm, works fully as well as though cold on tools of this description and is not as likely to crack them. When the outline is very irregular and the tool is made of high carbon steel, the writer has had excellent success using a bath of brine heated to 80° Fahr. The idea that a bath must be as cold as possible has probably ruined more steel than we realize.

## Drawing Temper of Milling Machine Cutters.

A method in very general use for drawing temper of milling machine cutters, consists in placing the hardened cutter on an iron plug of the form shown in Fig. 83, the plug having been previously heated sufficiently to draw the temper of the cutter.

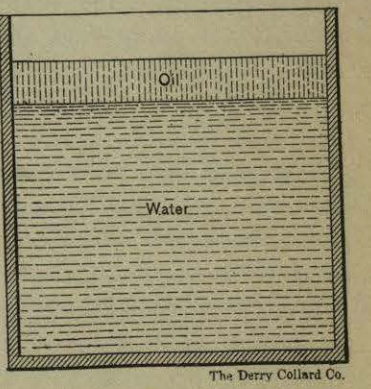



Figure 82. Oil and water bath for milling cutters.

The plug, when heated, should not fill the hole in the cutter. In order to heat the cutter uniformly, it should be turned constantly on the plug.

It is, of course, necessary to brighten the backs