



Sept. 27, 1960

P. W. KLOOZ

2,953,794

PROCESS OF FORGING PRE-WARMED METAL STOCK  
WITHIN RELATIVELY LOW TEMPERATURE LIMITS

Original Filed June 15, 1955

3 Sheets-Sheet 2

Fig. 3

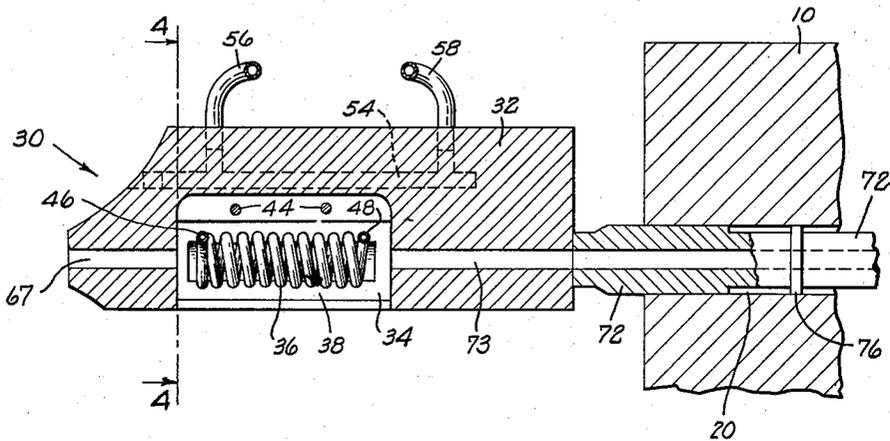


Fig. 4

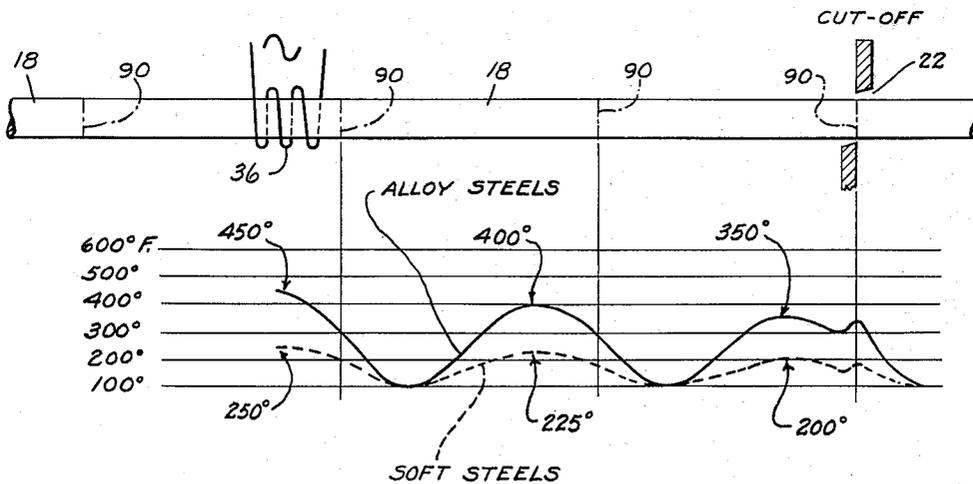
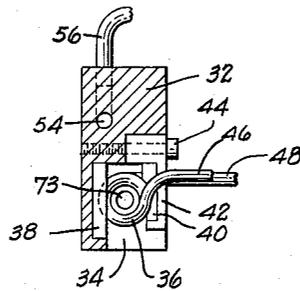


Fig. 5

INVENTOR.  
PAUL W. KLOOZ

BY

Morgan, Finnegan, Durham & Pine  
ATTORNEYS.

Sept. 27, 1960

P. W. KLOOZ

2,953,794

PROCESS OF FORGING PRE-WARMED METAL STOCK  
WITHIN RELATIVELY LOW TEMPERATURE LIMITS

Original Filed June 15, 1955

3 Sheets-Sheet 3

Fig. 6

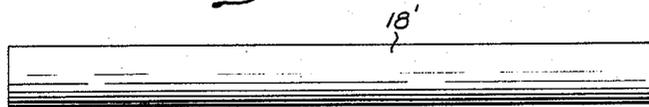


Fig. 12

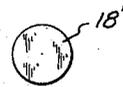


Fig. 7

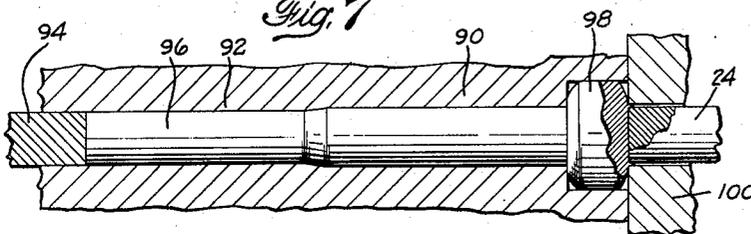


Fig. 13

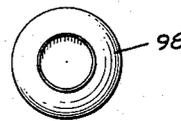


Fig. 8

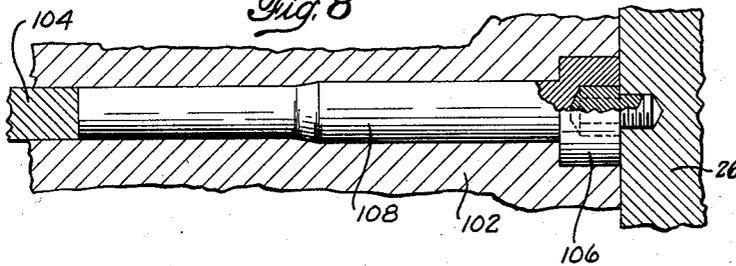


Fig. 14

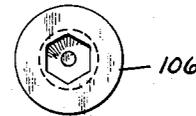


Fig. 9

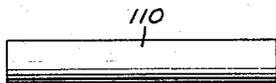


Fig. 15

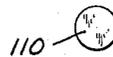


Fig. 10

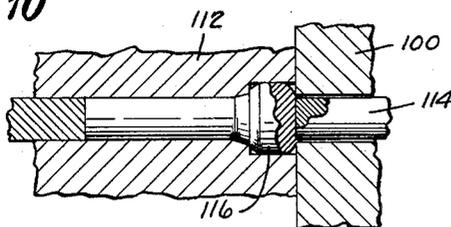


Fig. 16



Fig. 11

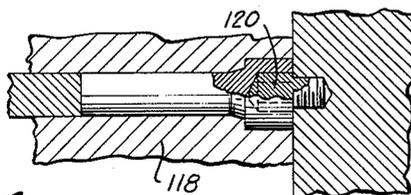


Fig. 17

INVENTOR.  
PAUL W. KLOOZ

BY

Morgan, Finnegan, Durham & Pine  
ATTORNEYS

1

2,953,794

**PROCESS OF FORGING PRE-WARMED METAL STOCK WITHIN RELATIVELY LOW TEMPERATURE LIMITS**

Paul W. Klooz, West Hartford, Conn., c/o The Holo-Krome Screw Corp., Hartford, Conn.

Continuation of abandoned application Ser. No. 515,709, June 15, 1955. This application Sept. 21, 1956, Ser. No. 611,171

4 Claims. (Cl. 10-27)

The present invention relates to a novel and improved process for producing definitely shaped articles of steel metals from bar or wire metal stock on cold forging machines, such as those commonly known as headers, and more particularly to methods for the cold forging of steel articles, such as screws, bolts, rivets, pins and the like, such methods providing for the moderate warming of the stock prior to the heading operation.

This application is a continuation of my prior application Serial No. 515,709, filed June 15, 1955 and now abandoned.

In the commercial practice of forming cold-forged screws and other header articles, considerable difficulty is encountered in forging the screws from alloy and medium and high carbon steels particularly because of rupturing or fracturing of the metal during the heading operation. One conventional practice in the industry when using steels of the type referred to which are difficult to cold-forge is to head the screws in several stages with at least one anneal inbetween; that is to say, the blank is partially cold-forged in several steps on one machine and then is annealed, following which cold-forging is completed in a second machine, often involving four or five blows. Needless to say, such multiple operations are expensive and time-consuming, requiring considerable labor and much equipment, and even then the proportion of rejects may be high, particularly with the more difficult workable steels, and the range of steels which can be cold-forged successfully is very limited. Such a procedure requires the provision of two heading machines for each job as well as several dies, the annealing equipment and considerable manual labor is required, not only to transfer the work from the first machine to the anneal and thence to the second machine, but also to set up the two headers for the particular job. In addition, this method usually requires a minimum of four dies and corresponding punches which frequently entails a prohibitive cost in the case of small orders of special screws.

Attempts have been made to overcome these difficulties by the use of relatively slow and expensive headers incorporating the so-called "progressive" method wherein the screw is headed in four or five gradual stages to avoid rupturing or fracturing of the metal. While progressive headers are an improvement over the older method of forging in two different steps with an anneal between, nonetheless there still is the expense of providing and setting up several dies and often corresponding punches, the range of usable metals is very limited, the rate of output is not high, and the accuracy and quality of the product leaves much to be desired, with failures and rejects being common.

By practice of the present invention, headed articles, such as screws, can be completely cold-forged from alloy and medium and high carbon steels and other cold-forgable ferrous alloys on a simple two-blow header by warming the stock just prior to forging by means of warming apparatus, preferably of the high frequency type, which is located in close association with the header but ther-

2

mally isolated therefrom and which is controlled to impart only a moderate degree of heat to the stock. The present invention also provides a high production method and apparatus for cold-forging headed articles from alloy and medium and high carbon steels on a single machine, which is substantially foolproof in operation, and which greatly enlarges the range of steels suitable for cold-forging and which produces screws or other header articles of improved structure and appearance.

Other objects will be in part obvious, and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of steps, construction, combination of elements, process and arrangement of parts which will be exemplified in the construction and process hereafter set forth and the scope of the application of which will be indicated in the appended claims.

In the drawings:

Figure 1 is a fragmentary and partially diagrammatic plan view of a header in which the warming apparatus of the present invention has been installed especially adapted for carrying out the process of the present invention;

Figure 2 is a fragmentary enlarged side view of a portion of the header and warming apparatus;

Figure 3 is a further enlarged longitudinal cross-sectional view of the warming apparatus and a portion of the header frame;

Figure 4 is a cross-sectional view taken along the line 4-4 of Figure 3;

Figure 5 is a schematic view showing illustrative and approximate temperatures to which the steel wire or rod stock is heated prior to the cold forging operations of the present invention as used for relatively long pieces, the temperatures along the rod or wire stock being indicated on the graph forming the lower portion of this figure;

Figure 6 is a side elevation of a typical and illustrative steel slug cut to length from bar or rod stock ready for the cold forging operations by the process and apparatus of the present invention.

Figure 7 is a side elevation of the same slug at the end of a first cold forging operation in accordance with the present invention, a broken away portion of the die and punch by which the intermediate blank is forged being shown in section, and a portion of the partially forged blank also being shown in section;

Figure 8 is a similar view of the same blank in the die with the second punch and at the end of its second and final stage of cold forging;

Figure 9 is a side elevation of a different slug, which is adapted to be formed into a forged blank having the same diameter of shank as the slug;

Figure 10 is a view of the same slug at the end of its first cold forging operation in accordance with the process of the present invention, together with a broken-away portion of the dies and punch by which the slug is cold forged, a portion of the head of the partially formed blank being broken away and shown in section;

Figure 11 is a view of the same blank at the end of its second and final stage of cold forging according to the present invention, the surrounding dies and punch being shown in section; and

Figures 12 to 17 are end elevations of the slugs and blanks shown in Figures 6 to 11, respectively.

Referring now in detail to the accompanying drawings, there is shown in Figures 1 to 4 in a diagrammatic manner a typical and illustrative form of apparatus by which the process of the present invention is preferably carried out. In the following detailed description, the apparatus will be described in some detail together with certain features of its operation, and the process of the present invention will then be described with reference to such appa-

ratus although the process may, obviously, be carried out by many other and widely different forms of apparatus.

Figure 1 shows, somewhat diagrammatically, a modified conventional two-blow header of the general type shown in the prior patent to Purtell No. 2,236,733, of 1941, comprising a frame 10 in the form of a large block or casting, a pair of feed rolls 12, 14 mounted on the stanchion 16 for feeding a wire 18, indicated in dotted lines, through a passageway 20 in the frame 10 from a suitable supply (not shown). The steel wire 18 is intermittently fed through the passageway 20 of frame 10 to the combination knife and transfer mechanism indicated diagrammatically at 22, where individual slugs or workpieces are severed from the forward end of the wire and transferred laterally to a suitable forming die (not shown) in the frame 10. After transfer of the severed slugs by the cutting and transfer mechanism 22 the slug is operated on consecutively by the upsetting punch 24 and socketing punch 26, both of which are mounted on the header gate or slide 28. Headers of this type are well known in the art and will operate to form a socketed head in a blank or slug in a continuous high-speed manner. Since the constructional details of the header form no part of the present invention, the details of construction have been omitted for simplicity and brevity of presentation, and may include the structure of the Purtell patent. The header can be any of the commercially available models for forging and heading metallic articles, such as set screws, cap screws, socket head screws, hex head screws, rivets, bolts, wood screws and the like.

Disposed between the feed rolls 12, 14 and the frame 10 and mounted for adjustment longitudinally therebetween is a warming mechanism which, in its illustrative form, is indicated generally at 30. The illustrated warming mechanism 30 comprises a block 32, preferably formed of good heat-conducting material such as copper, brass or aluminum, having a pocket 34 for the reception of a coil 36 preferably formed of copper tubing. The coil 36 is held in the pocket 34 by a non-metallic insulator 38, which may be in the form of a rectangular pad fixed to the block 32 and a similar pad 40 fixed to a removable plate 42, which is held in assembled position on the block 32 by bolts 44.

The leads 46, 48 of the coil 36 extend along and are fixed to the outer sides of a pair of conductors 50, 52 and are connected at their far end to a source of cooling liquid such as water (not shown). The coolant liquid supplied through the tubes 46, 48 also is supplied to passageways indicated generally at 54 in the block 32 by means of branch tubes 56, 58 forming a bypass from the tubes 46, 48 at 60 and 62, respectively.

The bus bars 50, 52 are mounted on and connected to a source of high-frequency current indicated generally at 64, as a transformer. The source of high-frequency current may be any suitable conventional converter or generator. I prefer to utilize a variable output high-frequency supply capable of delivering an alternating current of the order of 400 kilocycles and a power output capacity of 10 to 50 or more kilowatts.

The feed wire 18 is guided into the coil 36 by the bore 67 of the block 32. A second bore 73 at the opposite end of the block 32 supports the wire after it passes through the coil 36, thereby insuring that the wire will be adequately supported and guided through the center of the coil 36 without contacting the coil and insuring a consistent, and often localized, warming action. After the passage of the wire 18 through the bore 73, it enters a quill 72 which is disposed in the passageway 20. The quill 72 is an elongated tube of low heat-conductive material such as polished stainless steel and is provided at spaced intervals with peripheral ridges 76 for minimizing contact with the frame 10 and thus minimizing heat transfer from the wire 18 to the frame 10.

The longitudinal position of the warming unit 30 is adjusted relative to the frame 10 so that the distance from

the knife 22 to the coil 36 is a multiple of the length of the slug being severed, thereby insuring that the localized portion of the wire being warmed at any one time will be a uniform part of a complete slug after severance by the knife 22. The length of the warming unit may also be varied, for different blanks, by removal of one and substitution of another coil 36 with its associated parts, so that a longer or shorter portion of the slug may be heated. It will be understood, of course, that the wire 18 is fed intermittently by the feed rolls 12, 14 in accordance with the speed at which the slugs are severed and transferred by the knife mechanism 22.

In the operation of the apparatus, the header preferably is operated at the maximum speed for which the header is designed. Although the wire feed is intermittent, the warming coil 36 may be continuously energized although it is advisable to provide means for automatically de-energizing the coil 36 whenever the machine is stopped. In accordance with the invention, the output of the high-frequency source 64 is adjusted, taking into account the size and rate of feed of the wire, so that the feed wire as it passes through the coil 36 is uniformly or locally warmed to a relatively moderate temperature, as set forth in detail below. The use of high-frequency electrical heating insures that the stock can be heated in a sufficiently rapid manner even at high rates of wire feed and with large wire sizes, and the heating occurs substantially uniformly throughout the cross-section of the wire.

While the temperature ranges are critical from the standpoint of working the ferrous metal, such temperatures are not sufficient to adversely affect the coating on the wire normally provided to improve the feeding of the wire. The exact composition of such coatings may vary widely, and such coatings are frequently of an organic nature and frequently comprise a heat-sensitive material such as aluminum stearate or the equivalent, or may be molybdenum sulfide suspended in oil. The temperature of the slug in the header never approaches any critical limit for the steel of which the wire 18 is composed so that there are no great structural changes in the steel. The resultant headed articles, even when formed from difficultly workable alloy or high carbon steels, are found to be consistently free from fractures or ruptures, and the quality and appearance of the resulting screws, bolts, rivets, pins and the like, is generally superior to that heretofore considered possible.

A further advantage of the apparatus of the present invention is that the transfer of heat to the header and to the supply and feed rolls is substantially avoided. While there will tend to be some transfer of heat rearwardly through the wire 18, this is compensated for by the rapid forward feed of the wire to produce a uniformly warmed wire, or if the heating is localized, the heated portions may be worked, or forged, before the heat has equalized throughout the length of the feed stock. Transfer of the heat to the frame 10 and from there to the dies is substantially prevented by the isolated position of the heating unit 30 and the small area of contact between the frame and fed material.

The lubricating coating on the stock is of prime importance and is maintained on the blank during the forging operation and the removal of the forged blank from the die and any failure of the lubricant is likely to cause scoring or cracking of the forged piece, especially if the piece is headed to a considerably larger diameter. Additional lubricant is preferably supplied as the cut-off piece is transferred to and inserted in the closed die and this may be accomplished by using a stream of lubricant pouring out on the piece, the lubricant exemplarily comprising molybdenum disulfide suspended in lubricating oil.

As a result of the process of the present invention, it is possible to form headed articles, such as screws, bolts, rivets, pins and the like, cut from rod stock of alloy and medium and high carbon steels which heretofore could

5

not be completely cold forged in two-blow headers. By "alloy steels" I mean steels to which characterizing amounts of alloying components have been added such as nickel steels, chromium steels, molybdenum steels, stainless steels, and the like. By "medium and high carbon steels" I mean steel having a carbon content of at least .3 percent carbon and including steels having a carbon content of the order of .6 percent carbon and approaching the tool steel class. It also is possible to cold forge large wire sizes so that a wide range of screw sizes blanks, even up to several inches in diameter, can be made available in headed articles formed of alloy and medium and high carbon steels. The provision of low cost parts formed of alloy and medium and high carbon steel opens up an entirely new field of use for cold forged parts in installations where conventional cold forged parts of low tensile strength have been unsuitable and those of better strength have been too costly.

The process of the present invention not only permits the use of a wider range of steels but, in addition, its output capacity is usually at least 50 percent greater than that of previous apparatus, and the accuracy and quality is superior. At the same time the costs are lowered inasmuch as the complete cold forging operation can usually be attained by the use of one die instead of several dies and the set up time and down time is less. For example, the die cost in practicing the present invention may amount to only approximately \$250 at present-day prices, whereas the die cost for a similar job on a progressive machine would be in the neighborhood of \$1,000. This is a particularly important factor in the production of small orders of special parts where, previously, the die cost would greatly exceed the total of the remaining items of cost.

The process of the present invention depends upon rather precise temperature control of the blanks as they are cold forged and invariably requires that the blank be initially heated prior to any work being performed thereon, and further requires that the work be carried out at such a rate, considering the amount of metal to be displaced in a given time and the rates of heat transfer from the metal work piece, that the work piece does not exceed an average temperature in its worked portion of 650° F., and preferably not in excess of 600° F. The temperature of the socketing punch, in operations involving the formation of a cold forged socket, are also of importance, and best results, especially with respect to punch life are found when the punch is operated in the neighborhood of 600° F., i.e., from 550° to 650° F., the heat of the punch being derived from the work which it performs.

The precise temperatures to which the stock or blanks are warmed and at which they are delivered from the cut-off mechanism to the heading or cold forging portion of the header are dependent upon several different factors, such as the type of steel being worked, the extent to which the steel is to be worked or cold forged in one, two or more stages, the rapidity with which the steel is cold forged, and to a lesser extent, the shape of the head or formed portion to be produced on the blank.

The specific examples given below are illustrative of specific applications of the process of the present invention, but in its broadest aspect, the processes of the present invention are carried out completely in the cold forging or heading operations without exceeding a temperature of 650° F., as the average temperature of the worked or headed portion of the piece, and most preferably in the range of 500° to 600° F. as the final temperature of the head portion of the work piece. In some cases, the temperature may be as low as 450°, although the punch life is markedly better when the temperature attained by the head is in the range of 500° to 600° F. To attain this temperature, the heat input into the stock is carefully controlled and varied with respect to the amount of cold forging to which the metal is to be sub-

6

jected, the rapidity with which the work is carried out, the number of heading steps used, and the heat lost to the machine during the heading operation.

The reason that punch life is increased is not yet subject to a satisfactory explanation but such greatly increased punch life is readily observed in actual operations carried out and resulting in a final temperature of the head of 450° to 650° F., and most desirably from 500° to 600° F.

Operating at these final temperatures, the heading machines may produce larger sizes of headed objects than is otherwise possible on a given machine, the parts so produced are more accurately sized and the heading machines operate more quietly than otherwise.

To attain these final temperatures and with the usual size of work pieces and where a normal amount of working of the metal is to be done on the head portion of the blank, the head portion or the entire blank is preliminarily heated to an initial temperature by high frequency heating, of at least 150° F., and more usually at least 200° F., the working of the metal in the heading operations raising the temperature into the range of 450° to 650° F., or more desirably 500° to 600° F.

Where the heading or cold forging operation is to be done in a single stage, the initial temperature of the stock will be between 250° and 400° F., and the working of the metal will raise the temperature into the range of 450° to 650° F., and preferably from 500° to 600° F.

Where the heading or forming operation comprises a two stage operation including a first coning operation (Figure 7) and a final punch and socketing operation (Figure 8), the work is preliminarily heated to about 150° or 200° and sufficiently so that at the end of the coning operation the average temperature of the head is in the range of 250° to 450° F. and more preferably 325° to 400° F., which is followed immediately by the socketing operation and produces an ultimate average head temperature of 450° to 650° and most preferably 500° to 600° F.

Where more than two cold forging operations are involved and the headed portion of the work is to be formed in three or more stages, the work is initially heated to a temperature of at least 150° F. and more preferably 200° F., and in the final stage of working, usually involving a punching operation, the cold forging is carried out at a temperature above 450° F., or less desirably 400° F., and the temperature reached by the head portion at the end of the work does not exceed 600° F., or less desirably 650° F.

In the final stage of a two or more stage cold forging operation, where the final shape of the head is determined, operating as to produce a final temperature of 450° F. to 650° F. or 500° F. to 600° F. has the further advantage of operating with less spring back in the heading machine, a factor which probably contributed to longer tool life and quieter operation in this temperature range.

In accordance with the preferred manner of carrying out the process of the present invention for the cold forging of slugs or blanks of steel having some ductility at relatively cool temperatures, the slugs or blanks may be forged without being heated to initial temperatures well above 1000° F. (as contrasted with those processes which require that the metal blank or slug be heated to temperatures approximately red heat, or those processes which require that the metal blank be normalized, annealed or subjected to further heat treatment during or immediately after the cold-forging operation to correct for the structure formed by working of the metal blank during the cold forging operation).

The blank or slug of steel wire or rod stock usually has a diameter approximating the general diameter of the finished object to be produced, which may be as small as 0.1" or smaller, or alternatively may be as large as one or more inches in diameter, depending upon the ca-

capacity of the heading machine in which the cut-off slug or blank is to be shaped by heavy pressure between a succession of operations.

While the process of the present invention is generally applicable to a wide variety of steels which are sufficiently ductile to be cold forged in one or more stages, the process finds its greater effective application in the two or three stage cold forging of ferrous metals, especially alloy steels, including stainless steels and tool steels, which cannot otherwise be cold forged in any practical manner.

In carrying out the process of the present invention, the steel slugs or blanks of the desired diameter are warmed and cut from the stock supplied and are intermittently fed from the supply to the heading machine. The heating is preferably accomplished in an extremely short period of time and only shortly prior to the cutting and heading operations, so that in almost every case, the stock is warmed within a period of less than one, and always less than two or three seconds, times in excess of one second being required only when dealing with relatively heavy stock such as rod stock in excess of  $\frac{3}{4}$ " diameter. The heating may be accomplished adjacent the cut-off station, and when the wire or rod stock is not heated to a uniform temperature, the heating means may be so adjusted that the cut-off point on the wire or rod stock is relatively cool with respect to the warmest portion of the stock, thereby insuring a sharper or cleaner cut-off than would result if the metal stock were hotter at the point of cut-off.

Thus, according to the present invention, the steel stock is heated at one position and is fed therefrom intermittently to a cut-off station and thence to a heading station, and the heading station is positioned close to the heating station. In this way, the wire or rod stock may be selectively and locally heated to a moderate temperature, may be cut-off while the cut-off points are still relatively cool, and may then be fed to the heading station while the head is still locally heated to a higher temperature than the remainder of the feed stock. Preferably, not more than a few lengths of stock intervene between the cut-off station and the heading station, so that when the apparatus is operating at an overall speed of from 60 to 250 or more units per minute, depending upon the size of blanks being produced, no more than several seconds, and sometimes less than one second will elapse between the heating operation and the initial heading or cold forging operation. In this way, the slugs or blanks may be heated so that certain portions of the blank are rendered more plastic than in the normal cold forging operation, while relatively long slugs or blanks may retain certain portions substantially at ambient temperature so that none of the compressive strength of the steel is lost prior to the cold forging operation, thereby enabling the slug or blank to be pushed into and shaped by a reducing die at the same time and at the same station as the slug or blank is subjected to a heading operation.

Relatively short slugs and those which are not to be substantially reduced in diameter, as well as those in which the head is not to be abnormally large may be heated with substantial uniformity, and this is preferably accomplished by heating a unit length of the wire or rod stock as it is fed intermittently, the heating being substantially uniform over the entire length of the slug or blank to be cut from the stock.

Figure 5 of the drawings illustrates typical non-uniform temperatures which may be used on a length of feed stock to be cut into relatively long slugs or blanks prior to the cold forging operations. As shown, the optimum temperatures lengthwise of the slug or blank are given with respect to a rod or wire which is eventually to be cut to form a blank or slug  $\frac{3}{4}$ " by  $7\frac{1}{2}$ ", one end of which is to be reduced in diameter throughout a substantial portion of its length and the other end of which is to be formed into a definite, accurately shaped head, the area of the head being approximately twice the area of

the stock from which it was formed, as shown in Figures 6 to 8.

As is seen in Figure 5, the length of rod 18 which is intermittently fed is locally heated by means of the high frequency coil 36, and the coil 36 is relatively short with respect to the length of the rod between those points 90 where it is to be cut off by the cut-off mechanism 22.

In the lower portion of the Figure 5 are shown typical temperatures along the intermittently fed stock after it has been locally heated. These temperatures will vary widely depending upon the type of steel or other metal being fed and used in the process, but typical values are given for a relatively soft steel, such as SAE 1320, as well as for a more refractory alloy steel, such as SAE 6150.

As the steel leaves the point of heating it has been locally heated to a temperature which approximates  $250^{\circ}$  to  $400^{\circ}$  F. for alloy steel or about  $150^{\circ}$  to  $400^{\circ}$  F. for soft steel. The major portion of the stock, however, has not been substantially heated, except by conduction along the stock, and at the time of cut-off one to three seconds later at most, the hottest part of the rod may vary from  $150^{\circ}$  F. to  $400^{\circ}$  F., while the point of cut-off will be appreciably cooler, and the intermediate portions of the rod will be substantially at their initial ambient temperature. As the rod or wire stock is cut by the cut-off means, these ends become heated somewhat by the cutting action, and the portions of the rod adjacent the cut-off ends become more plastic, thereby facilitating the forging operations which follow immediately.

Thus, where relatively long pieces are to be cold forged and especially where one end is to be substantially reduced in diameter for a substantial part of its length, the cut-off slug or blank is heated at its ends, leaving the intermediate portion of the slug or blank substantially unheated. The end of the slug or blank which is to be reduced in diameter is only slightly warmed by the heat applied at the warming station, to which is added the minor quantity of heating generated by the act of cutting the stock, while the other end of the unit slug or blank has been heated at a distance slightly spaced from the end so that that end is heated to a sufficient extent to enable it to be formed by two or more rapidly delivered forging blows which forge the steel into its final desired form without raising the temperature above  $650^{\circ}$  and preferably not above  $600^{\circ}$  F.

Using the steel slug or blank at the temperatures indicated in Figure 5 of the drawing to form the finished blank by the stages shown in Figures 6 to 8, the long blank or slug 18' is at a temperature of about  $150^{\circ}$  or  $200^{\circ}$  F. to  $400^{\circ}$  F. at its forward end which is to be formed into the enlarged head. The other end of the blank is at a temperature of about  $125^{\circ}$  to  $300^{\circ}$  F. for a short distance which temperature falls rapidly to about  $100^{\circ}$  along the length of cut-off piece of stock, thereby providing a somewhat plastic end immediately adjacent a cool length of the rod which has lost substantially none of its compressive strength. The warmer end of the slug or blank forms a portion which can be initially deformed as the blank or slug is pushed into the reducing die, which action generates enough additional heat to cause the surface of the metal to yield sufficiently to allow it to assume the desired final shape.

In accordance with the preferred manner of carrying out the process of the present invention, as illustrated in the cold forging of a relatively long steel screw blank shown in Figure 6, and in which the headed portion is larger than has been possible using conventional cold forging techniques, the head being formed by upsetting from  $4\frac{1}{2}$  to 5 times the diameter of the wire, and even larger heads can be achieved by the process of the present invention.

The temperature to which the cut-off blank is warmed will depend to a large extent upon the heading operation to be performed and upon the composition of the steel from which the blank is formed. With carbon and

low alloy steels in small sizes up to 1/4" or 3/8" in diameter, the blank need be locally heated only to temperatures ranging from 200° to 250° F., while larger sizes may require temperatures as high as 350° F. Certain grades of alloy steels, stainless steels, and tool steels may require temperatures as high as 350° to 400° F.

Using a steel alloy, such as 4037, and to form the screw blank shown in Figure 6, the cut-off length of steel wire 18' has been locally heated near its end to a temperature of about 300° F., some of the heat being transferred by conduction from the next blank length heated prior to cutting, thereby slightly warming the other end of the blank to a temperature of about 200° F. The speed of operation, and the short time interval between the heating, cutting and cold forging operations is so short that the temperatures along the length of the wire stock do not have time to equalize, as there are only a few stages between the point of heating and the forging, and the cutting and feed of blanks takes place usually at a rate of several cycles per second. Thus, the central portion of the blank remains substantially at its initial temperature until the cold forging is carried out.

Figure 7 is a sectional view showing the heated blank after the first forging operation of the blank or slug has taken place. In this first stage of the operation, the left hand end of the blank 18' which is slightly warm and is at a temperature of about 200° F. is pushed into the generally tubular portion of the forging die 90, and is forced into the narrower cylindrical portion 92 of the die until the end of the blank engages the stop and ejecting member 94 filling the end of the die portion 92. During this portion of the operation, the warm end of the blank is reduced accurately to size and the work of the cold forging causes the end and the reduced portion to become heated to a temperature not exceeding 650° F. and preferably below 550° to 600° F., thereby accurately sizing the end portion 96 of the blank 18' in accordance with the size and shape of the die portion 92. As the upsetting die and punch 24 continue to move towards the stop member 94, the other end of the blank is upset to form the head 98 thereon in accordance with the shape of the die 24 and the enlarged die opening 100, and simultaneously by this working of the steel, the head portion becomes further heated, above its initial temperature of 250° F. but below the temperature of 650° F. and preferably below 550° to 600° F.

In actual practice the size and shape of the headed end 98 of the blank 18' may vary widely and the diameter of the head may even be as much as 2 to 2.5 times the initial diameter of the blank.

Upon completion of the upsetting operation shown in Figure 7, the partially forged blank is then subjected to the second forging position in the same die and by a second die and punch. The blank is still in the cylindrical die member 92, is backed up by stop member 94 and is subjected while still warmed to the powerful cold forging action of the socketing die and punch 26 which form the desired cavity in the end of the upset head 98 and force the steel of the upset head 98 into substantially exact conformity with the enlarged heading portion 100 of the die 92 further heating the head portion 109 but without exceeding the maximum temperature of 650° F. and preferably not above 550° to 600° F.

The ejecting stop 94 then ejects the finished blank 108 from the die and it is then allowed to cool, after which it may be subjected to such further threading, finish-machining, and heat treating operations as are desired.

When the blanks are not to be reduced in diameter, and especially where the blanks are relatively short, the blanks cut from the rod or wire stock may be warmed throughout their length. As shown in Figure 9, the steel blank 110 is warmed to a temperature of at least 200° F., and preferably not exceeding 450° F. after which the blank is transferred to the cold forging dies 112, 114 to upset the head end of the blank forming the upset head 116, after

which the upset blank is further forged by the punch 120 to finish the cold forging operations of punching, socketing and final forging of the head portion between the die member 112 and 120. The work of forging in these two steps generally causes a temperature rise in the steel of from 100° to 150° F. but is so controlled that the temperature of the blank never exceeds 650° F. and is preferably kept below 550° to 600° F.

Other forms of cold forged headed steel articles can obviously be formed by using appropriate forging and heading dies and punches, and by following the procedures and steps set forth above.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A method of heading definitely shaped steel articles from lubricated wire or bar stock which comprises positively and intermittently forwardly feeding said stock, warming the stock, in advance of the point at which the stock is fed, to a temperature of approximately 200° F., the speed at which said stock is fed forward being in excess of the rate at which the heat travels rearwardly along said stock, whereby said stock at the point of feeding remains relatively cool, cutting a blank from said stock, slidably supporting said stock between the points of heating and cutting, said stock being otherwise unsupported between the points of feeding and cutting, laterally transferring the cut blanks and longitudinally inserting the blanks separately into the open end of a closed die, rapidly forging the outer end of the blank to materially alter the shape thereof while the blank is supported within the die and removing the blank from the die, and maintaining the temperature of the cut-off blank above 150° and below 650° F. subsequent to said warming during the cutting, transferring, and forging operations.

2. A method of warm heading definitely shaped steel articles from lubricated steel wire or bar stock with a succession of header punches and a single open-ended die of a smaller cross section than the stock, which comprises axially forcing a steel blank warmed to a temperature of at least 150° F. and not exceeding 400° F. into the smaller die by means of one of the header punches and while said blank remains at a minimum temperature of at least 150°, continuing the longitudinal movement of the blank in the die until its forward end engages a stop within the die and the header punch enters and forges the rearward end of the blank, again forging the rearward end of the blank with a different one of the header punches whereby the shape of said rearward end is materially altered, and controlling the rate of forging with respect to the initial temperature of the blank and the extent of the forging so that the maximum temperature of the forged blank does not exceed 650° F. whereby destruction of the lubricant is avoided.

3. A method as claimed in claim 2 in which the blank is cut from the stock after the stock has been warmed to a temperature between 150° and 400° F.

4. A method as claimed in claim 2 in which the stock is intermittently fed through a localized high frequency field to warm the stock from 150° to 400° F. by engagement of feeding means with the stock at a point prior to the localized heating field, the stock is slidably supported beyond the feeding means and heating field, and blanks are cut from the warmed stock prior to forging.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

1,333,081	Kobert	Mar. 9, 1920
1,341,626	Kobert	May 25, 1920
1,671,484	Pilling	May 29, 1928

(Other references on following page)

## 11

## UNITED STATES PATENTS

2,172,533	Freeman -----	Sept. 12, 1939
2,276,521	Stark -----	Mar. 17, 1942
2,288,643	Purtell -----	July 7, 1942
2,621,344	Friedman -----	Dec. 16, 1952
2,788,301	Moore -----	Apr. 9, 1957

## 12

## FOREIGN PATENTS

249,013	Germany -----	July 8, 1912
---------	---------------	--------------

## OTHER REFERENCES

Mechanical Engineer's Handbook, 4th edition, Lionel S. Marks, p. 588.