Aug. 25, 1942. A. KULLMAN ET AL 2,294,187

APPARATUS FOR HEAT TREATING

Filed Aug. 30, 1939 2 Sheets-Sheet 1

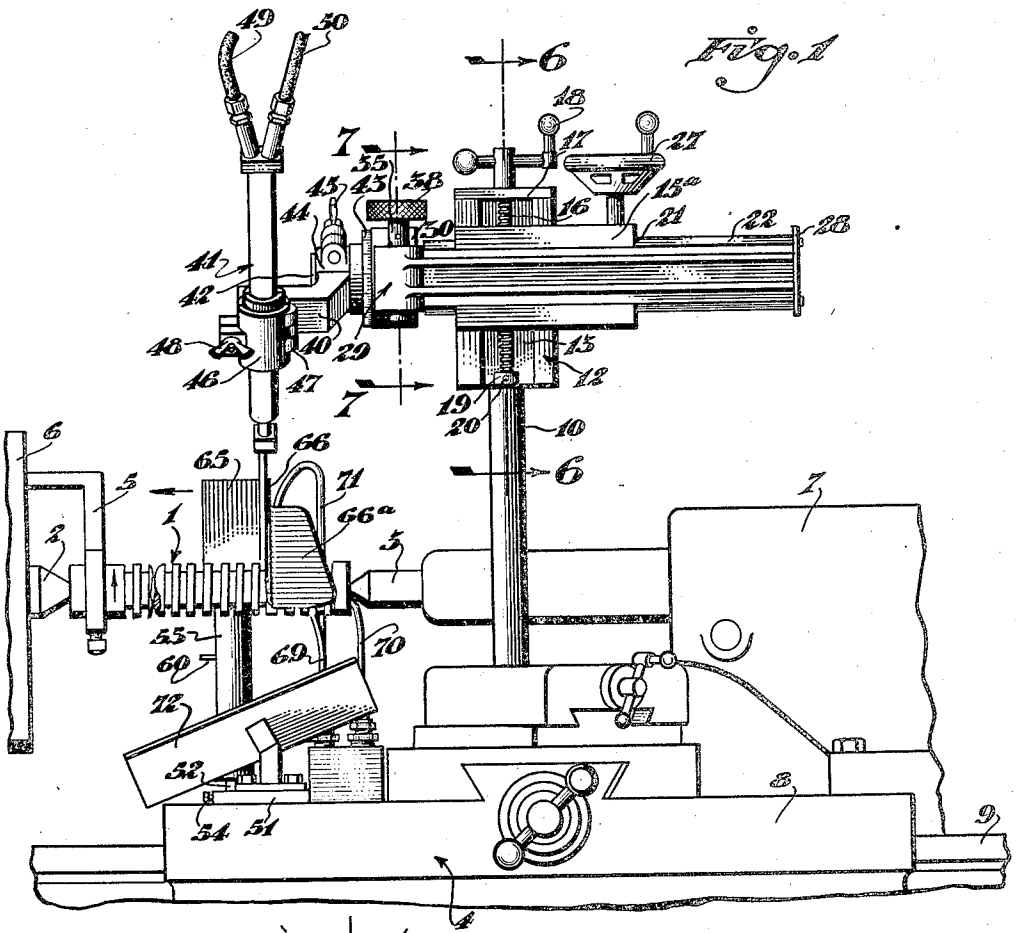


Fig. 1



Fig. 10

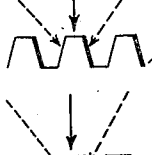


Fig. 11



Fig. 12

Fig. 2

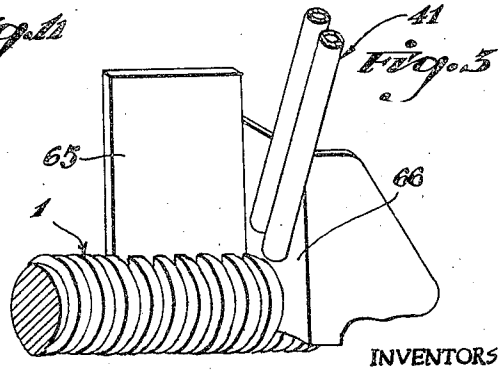


Fig. 5

INVENTORS

BY Alfred Kullman
Thomas A. Walts
Wood & Wood ATTORNEYS

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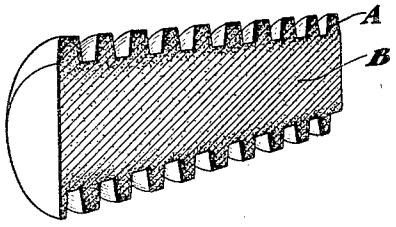


Fig. 9

Fig. 4

Fig. 8

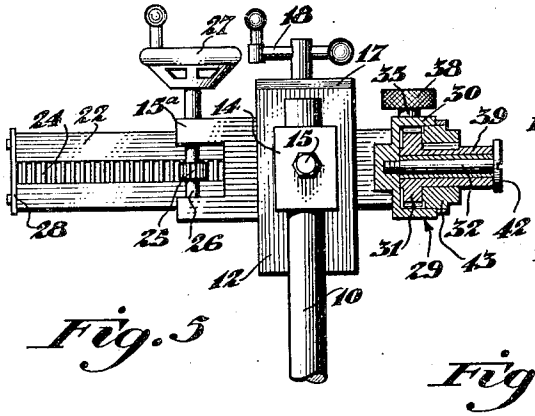


Fig. 5

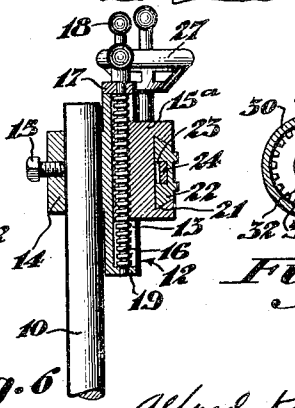


Fig. 6

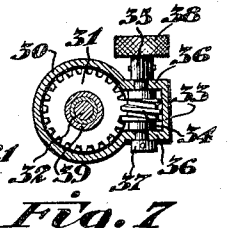


Fig. 7

INVENTORS
Alfred Kullman
Thomas A. Waltz
BY Wood, Wood ATTORNEYS

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APPARATUS FOR HEAT TREATING

Alfred Kullman and Thomas A. Waltz, Cincinnati, Ohio, assignors to The American Tool Works Company, Cincinnati, Ohio, a corporation of Ohio

Application August 30, 1939, Serial No. 292,685

8 Claims. (Cl. 266—4)

This invention relates to apparatus for hardening metal screws. It is adapted particularly for the treatment of screws of relatively large diameter, for instance, lead and feed screws for lathes, other machine tools and similar apparatus. By virtue of the relatively great length of such pieces they tend to become distorted and warped when heated and quenched according to the usual hardening technique.

One of the primary objectives of the invention has been to provide suitable apparatus for hardening such screws without heating them in their entirety, or employing the extensive conventional metallurgical apparatus which is requisite in following the usual practice.

An objective of the invention also has been to provide apparatus for hardening selective portions of a screw or thread thereof, leaving other portions in their unhardened condition.

Briefly, the invention is based upon the concept of heating to hardening temperature, and then quenching, progressive localized portions of the thread of the screw, as distinguished from the method of heating and then quenching the piece in its entirety. The zone of heat and the quenching zone are advanced along the helix of the screw being treated. In this manner the thread or the screw is hardened progressively, starting at the one end and ending at the other, or ending at some intermediate point depending upon how much of the piece is to be treated.

Either the screw may be held stationarily and the local heating and quenching zones advanced spirally to treat the thread, or better still, the screw may be rotated while the heating and quenching zones are moved linearly to follow the thread. In either case metal approaches the treatment area in unhardened condition and leaves it in hardened condition; the process may be termed one of progressive simultaneity, the heating of an advancing portion being accompanied by the quenching of a receding one.

In the present specification the term "heating zone" is intended to designate a zone or section wherein the metal of the screw, or only the metal of the thread, is elevated to hardening temperature. In the quenching area the heated metal is cooled abruptly by a suitable coolant, for instance, a stream of water. The quenching area is separated from the heating area by one or several baffles, in the treatment of screws of relatively small diameter, so that the two operations do not hinder one another. The use of baffles may be omitted in the treatment of screws which are sufficiently large to permit of spacing of the flame and quenching instrumentalities apart from one another.

A flame, for instance an oxyacetylene flame, is best for heating the metal and the zone in which the temperature of the metal is elevated may range from a sector of only a few degrees, to one or even several revolutions of the thread. The range will depend upon the size of the piece or the relative size of the thread upon it, and also upon the time required to impart sufficient heat for proper hardening. As a typical illustration a zone of approximately 30° is suitable for treatment of a ¾ inch 5 pitch screw. Obviously, if a heavy spiral thread is to be treated a larger quantity of heat will be required for the thread to reach hardening temperature, and the zone in which the metal is heated may be increased commensurately.

The range of the quenching zone is relatively unimportant so long as the heat is removed sufficiently rapidly to harden the metal. Those skilled in the art readily will understand the metallurgical conditions requisite for the hardening of various types of metal.

By virtue of the fact that treatment is confined to but a relatively small portion of the whole piece, the metallurgical strains attending the hardening process are localized, and distortion, warpage and similar defects do not occur. For the hardening of lead screws, cross feed screws, elevating screws and the like for machine tools, it is considered the preferable practice to adjust the heating conditions so that the thread only is hardened while the metal in the body of the piece remains unchanged or substantially so. This treatment yields a screw comprised of a hardened thread carried upon a soft base, and it is particularly desirable when both wear resistance and resistance to shock are requisite. Screws hardened in their entirety tend to be brittle even though tempered. If the body of the screw remains substantially soft and the thread is hardened then the body of the screw permits shocks to be absorbed by it while the hardening thread of the screw resists wear.

The resistance to wear which is brought about by the hardening operation is particularly desirable in cross feed screws for lathes. The ordinary cross feed screws in lathes tend to become worn in a central portion due to the fact that the cross slide is moved over this portion much more frequently than over the entire length of the screw. If the nut for the screw be fitted to the worn central portion then it is very tight at the ends. However, if the screw be hardened then there is

little or no wear over the portion which is used most frequently, and consequently the nut is movable freely but without play, over the entire length of the screw.

As typical types of metal suitable for treatment in the present method, we may mention .35 to .55 carbon steels, with or without alloys of steels of the type of SAE 4145 and SAE 1045. Cast iron screws also may be treated by the method. These types of metals are mentioned by way of illustration. There are, of course, many other types and kinds of steel and metal which respond satisfactorily to the treatment, the chemical compositions of which control the physical hardening properties of the metal.

For most purposes, the treatment is controlled, relative to the piece being hardened, so that a scleroscope hardness of 70 to 75 is obtained; the hardness of course, may be greater or less depending upon the usage for which the piece is intended. Moreover, a tempering operation may be employed to alter or modify the hardness of the metal.

In the drawings,

Figure 1 is a front elevation of the apparatus mounted upon the carriage of a lathe and ready to be used for the hardening of a screw.

Figure 2 is a sectional plan view looking down upon the heating and quenching apparatus and the baffle from the rear side of the lathe.

Figure 3 is a perspective view showing the relationship of the baffle to the heating apparatus.

Figure 4 is a cross sectional elevation of the apparatus.

Figure 5 is a top plan view of the adjustable mounting for the torch.

Figure 6 is a cross sectional view taken on the line 6—6 of Figure 1.

Figure 7 is a cross sectional view taken on the line 7—7 of Figure 1.

Figure 8 is a sectional view through the baffle support taken on the line 8—8 of Figure 4.

Figure 9 is a perspective sectional view of a screw having hardened threads and a soft body.

Figures 10, 11 and 12 illustrate diagrammatically the various ways in which flame may be caused to impinge upon the thread of a screw for the hardening operation.

Figure 10 illustrates the treatment of a V thread screw, Figure 11 the treatment of a thread of the Acme type and Figure 12 the treatment of a square thread.

An apparatus which is suitable for the practice of the present invention is disclosed in the accompanying drawings. This apparatus is characterized by a baffle plate delineating one portion of the thread of a screw from an adjacent portion. On the one side of the baffle a flame is played upon the thread. The rate at which the thread moves past the baffle is so adjusted that each portion of the thread remains in the zone of heating for a period sufficiently long for it to be elevated to a hardening temperature.

On the other side of the baffle a stream of water or other suitable coolant is projected upon the heated metal so as to cool it rapidly and harden it. The apparatus includes a suitable carriage for supporting the torch or heating elements. This torch is supported adjustably, so that screws of different diameter and pitch can be treated.

In the preferred embodiment which is disclosed in the drawings the apparatus is arranged for disposition upon the carriage of a lathe. The screw to be treated is mounted between the centers of the lathe and is rotated. The carriage of the lathe is moved along the bed at a rate proportioned to the pitch of the screw and the rate of rotation, so that the flame of the torch follows the thread. The torch producing the flame is so adjusted that the tip of the flame is in heating proximity with the thread being treated. Several torches, or a plurality of them, may be used if a relatively large sector of the screw is to be heated.

Referring to the drawings, the screw piece being treated is indicated generally at 1. This screw piece is mounted between a live center 2 and a dead center 3 of a lathe indicated generally at 4. A dog 5 is attached to the screw piece and drives it in the usual manner from the face plate 6 of the lathe. The tailstock of the lathe carrying the dead center 3 is indicated at 7, and the carriage 8 of the lathe is movable along the ways 9 of the lathe bed, through the usual lead screw driven through the headstock of the lathe. The dead center is preferably the axially yieldable type so as to accommodate expansion of the screw during the treating process. The details of such structure are well known and need not be described here in detail.

The post 10, at its upper end, carries a vertical slide member 12. This member is comprised of a grooved slide plate portion 13 and a boss 14 bored to receive the post 10. A set screw 15 is carried by the boss to clamp the slide plate upon the post.

A block 15a is provided to slide within the ways 13 of the vertical slide plate 12. This block is bored and threaded to receive an adjusting screw 16 which is journalled in a plate 17 fixed to the upper end of the vertical slide plate. The upper end of the screw 17 carries a handle 18, and the lower end of the screw is journalled in a boss 19 provided at the lower extremity of the ways of the plate. The portion of the screw within the journal of the boss 19 is grooved and a pin keeper 20 is carried by the boss in engagement with the annular groove of the screw, to keep the screw axially stationary.

A dovetail groove 21 is provided in the cross slide block 15a transversely relative to post 10, and a cross slide member 22 is fitted to slide within the groove. The inward face of the cross slide is grooved as at 23 (see Figures 5 and 6) for the reception of a rack 24. A pinion 25 for driving the rack is carried on a shaft 26 journalled in the cross slide block 15a. The cross slide block is slotted to provide clearance for the pinion and the pinion shaft 26 is driven through a handle 27, for adjusting the cross slide back and forth in the block. A plate 28, limits the movement of the slide within the groove.

Cross slide block 15a carries a compound head indicated generally at 29 at the end opposite the stop plate. This head is comprised of an annular casing 30 which is integral with the slide itself, and a worm wheel 31 is housed and journalled within the casing, upon a shaft 32. The casing 30 includes an integral casing portion 33 in which a worm 34 is mounted for engagement with the worm wheel 31. The worm 34 is carried upon a shaft 35 which is journalled in the upper and lower faces 36—36 of the casing portion. A washer 37 is pinned to the shaft 35 at the one end and an adjustment knob 38 is pinned to the shaft at the other end. Rotation of the adjustment knob, drives the worm to rotate the worm wheel 31.

Worm wheel 31 carries a hub 39 extending be-

yond the casing 30 to carry an arm 40 by which the torch, indicated generally at 41, is supported.

The shaft 32 extends centrally within the housand it threadedly engages a bore in the rear face thereof. The shaft 32 is provided with a cap 42 for keeping the hub in position on the shaft, and hub 39 also carries a graduated collar 43 for indicating the extent of rotation of the hub; this collar is keyed to the shaft and serves as a cover for the casing 30.

Arm 40 comprises a clamp ring 44 for engagement over the hub 39, and a lock screw 45 is provided for clamping the ring upon the hub. The other end of the arm 40 includes a journal 46 located transversely of the arm and suited for slidably receiving the torch 41.

Journal 46 is comprised of separable members hinged together as at 47, and a clamp screw 48 is provided for clamping the members together to hold the torch rigidly in position within the arm. The arm preferably is bent, as shown in Figure 1, to extend forwardly of the rotatable head 28 of the apparatus.

Oxygen and acetylene are fed to the torch through the hose connections 49 and 50. In place of oxygen and acetylene other suitable heating gases may be employed if desirable.

The tips of the torch extend forwardly of its shank and into proximity with the thread to be treated. This is shown best in Figure 4. The apparatus illustrated in the drawings is set up for the flame to impinge upon the periphery of the square thread of the screw 1. In this type of set-up the heat travels down through the thread to elevate it to hardening temperature. However, the torch may be adjusted so that the flame impinges upon the metal in the groove of the thread, so that the heat is applied from the sides. The torch also may be adjusted so that the flame impinges upon the thread angularly.

Various modifications of the arrangement are shown in Figures 10, 11 and 12. According to Figure 10, the arrow indicates the direction of impingement of the flame upon a V thread; here the flame is applied at the side of the thread so as to avoid burning of the sharp V at the thread periphery. In the treatment of an Acme thread as shown in Figure 11, the flame either may be applied as shown by the solid arrow upon the thread periphery, or it may be applied at one side or at both sides of the thread as shown by the dotted arrows. Whether or not the flame is applied to one side or both sides of the thread will depend, of course, upon the proportions of the thread or the portions of it which are to be hardened. Likewise, in the hardening of a square thread the flame may be applied directly to the periphery or angularly so as to impinge upon one or both sides of the thread.

For the purpose of localizing the heating action to a predetermined portion of the thread being treated the torch may be adjusted relative to the pipes for applying quenching fluid, so that the quenching fluid does not splash upon the metal being heated to hinder the heating operation. Moreover, baffles may be employed to sequester the relative operations, and baffles also preferably are employed so that the heat which is being applied to one thread does not impinge upon an adjacent portion of the thread which already has been hardened, for in this instance the heating of the hardened thread would tend to temper it.

For supporting the baffles a bracket plate 51 is mounted transversely upon the carriage. The bracket plate is bored to receive a stud 52 extending from a baffle support 53 and a set screw 54 is employed for locking the stud relative to the bracket plate. Post 53 is bored longitudinally as at 55 to carry a compression spring 56 and a shaft 57 in cooperation therewith, as shown in Figure 8. The post 53 also is slotted as at 59 and a keeper pin 60 extending from the shaft 57 rides within the slot so as to limit the movement of the shaft under the influence of the spring. A locking screw 61 threadedly engages the post for locking the shaft in any predetermined position relative to the post. When the lock screw is released the spring 56 throws the shaft 57 upwardly until the keeper pin strikes the end of the slot 59. Shaft 57 at its upper end is provided with a bracket 62 containing an aperture for the reception of a baffle support arm 63. The arm is adjustable in the bracket and a lock screw 64 is employed for fastening it in any given position.

The post 53 preferably is mounted upon the bracket plate 51 at the side of the screw 1, opposite the side upon which the torch is mounted. The baffle support arm 63 extends forwardly of the post to carry the baffle 65. The lower edge of baffle 65 is notched to fit the contour of the thread for localization of the flame relative to the thread.

For treating threads of various types various baffles are employed. The configurations of the lower edges of these conform to the contours of the various types of threads to be treated. Baffle 66 extends forwardly from baffle 65 and its lower edge is fashioned to fit partially around the thread. This baffle is positioned relative to the torch or flame, as shown in Figure 2, so as to prevent the flame heating the portion *a* of the thread from impinging upon the portion *b* of the thread which already has been hardened. This baffle, in other words, segregates the hardened portion from the unhardened portion and prevents the flame impinging upon the unhardened portion from spreading to temper the hardened portion.

When the pitch of the thread is quite steep it is desirable to cant the baffles 65 and 66 so that the baffle 65 is normal to the thread and the baffle 66 parallel to it. This enables the notches in the lower edge of the thread to fit accurately the contour of it. The baffle 66 also may include a splash wing 66*a*.

For the purpose of cooling the metal, water is led through a hose line 67 to a distributor block which is mounted upon the carriage of the lathe. From this block flexible pipe connections 69, 70 and 71 lead the quenching fluid to the heated portion of the screw for hardening and to adjoining portions for keeping the metal cool. Lead 69 projects a stream of water upon the thread directly behind the torch flame for quenching. Lead 70 is spaced therefrom to play upon an adjacent portion of the thread which has already been hardened, and the pipe 71 projects a stream of quenching fluid upon the hardened portion (*b*) of the thread (Figure 2), so as to keep this portion cool. Fluid from the ducts also is splashed upon the baffles for cooling them.

A trough 72 is mounted upon the carriage beneath the screw so as to convey the cooling fluid down to the pan of the machine.

The arrows shown in the drawings illustrate the relative rotation and movement of the parts.

In a typical hardening operation upon a conventional lead screw with tap water as coolant,

the entire hardening procedure takes place within a localized zone extending approximately a few inches along the length of the screw. In an ordinary operation, the metal receding from this hardening zone is practically at room temperature. If air hardening metals are employed for treatment the quenching fluid may be constituted by a stream of air led upon the metal through the appropriate ducts.

A typical screw hardened in accordance with the method of the present invention is illustrated in Figure 8. In a piece of this type the thread portion A is hard and wear resistant. The base portion B is soft and unchanged or substantially unchanged relative to its original condition. The screw, otherwise expressed, is characterized in that it is comprised of a hardened thread carried upon an unhardened base or shaft. In a screw of the type shown in the drawings the relatively soft base is capable of absorbing the localized strains incidental to the heating and quenching operation and, therefore, the hardening process takes place without distortion or warpage of the piece. Lead screws of great length have been hardened in this manner. Moreover, by virtue of the fact that the heating of the metal to hardening temperature takes place very promptly, and the metal is not subjected to elevated temperature for an extended period, the formation of scale upon the metal is negligible. The screws may be used with or without further heat treatment and also may be ground or lapped if desired, although these supplemental operations are not requisite.

Having described our invention, we claim:

1. Apparatus for hardening the thread of a screw comprised of baffle means comprised of a portion adapted to be disposed substantially longitudinally of such screw and transversely of the threads thereon and a second portion adapted to reside transversely of the screw and substantially parallel to the threads thereon with an edge of the said first baffle portion being configurated to fit the thread profile and with a part of the said second baffle portion being cut away to permit it to fit within a thread groove and extend partly around the body of the screw, a torch positioned to cause impingement of a flame therefrom upon the metal of such screw at the one side of the first portion of the baffle, cooling fluid means arranged to cool the metal of the screw at the other side of said baffle portion, means for rotating the screw, and means for advancing the torch member, quenching member, and the baffle linearly relative to the screw, as the screw is rotated.

2. An apparatus for heat treating the thread of a screw which apparatus comprises a torch for providing a jet of flame adapted to be impringed upon the thread of said screw to be hardened, means for rotating the screw to be hardened, means for advancing the torch upon rotation of the screw for maintaining a predetermined relationship between the jet of flame and the thread of the screw, substantially L-shaped baffle means adapted to be arranged upon the screw to localize the heat of the flame, the said baffle means comprising one portion adapted to reside longitudinally of the screw and which has an edgewise portion configurated to fit the thread profile of the screw and another portion which is adapted to reside transversely of the screw and which is cut away in part to permit an edgewise portion thereof to fit within a thread groove of the screw, and partly around the screw body, the said torch being located to impinge a jet of flame from it upon a screw-thread portion adjacent to both baffles, and a jet positioned to supply quenching fluid to the heated portion of the thread of the screw as it passes the longitudinal portion of said baffle, with means provided for advancing the baffle and the quenching fluid jet along the screw as the thread of it is advanced during its rotation.

3. An apparatus for hardening the thread of a screw comprised of a pair of baffles, one extending in a direction transverse the axis of a screw and having an edge configurated to fit within a thread groove thereof partly around the body of the screw, and the other positioned relative to the first to extend substantially longitudinally of the screw and having an edge configurated to fit the sectional contour of the screw threads, a torch positioned to provide a jet of flame upon a screw thread portion located adjacent both baffles, means for rotating the screw, means for advancing the said baffles and the torch along the screw as the thread of it advances during rotation and means located at the sides of the baffles opposite the torch for providing a supply of quenching fluid to the portion of the screw which is heated by the flame.

4. Apparatus for hardening the thread of a screw comprising, a baffle member which includes a portion adapted to be disposed substantially longitudinally of a screw and transversely of the threads thereon, and a second portion adapted to reside transversely of the screw and substantially parallel to the threads thereon with an edge of the said first baffle portion being configurated to fit the thread profile and with a part of the second baffle portion being cut away to permit the second baffle portion to fit within a thread groove and partly around the body of the screw, a torch positioned to cause impingement of a flame therefrom upon the metal of the screw to one side of the first portion of the baffle, cooling fluid means arranged to cool the metal of the screw at the other side of said baffle portion and at the side of said second baffle portion opposite the torch, means for rotating the screw, and means for advancing the torch member, cooling fluid means, and baffle member linearly relative to the screw as the screw is rotated.

5. An apparatus for heat treating the thread of a screw, said apparatus comprising means for supporting said screw for rotation, a torch adapted to provide a jet of flame, a quenching jet adapted to deliver a quenching medium, a carriage supporting said torch and quenching jet in tandem, means for feeding said carriage and rotating said screw in synchronized relation so that the torch and quenching jet follow the convolutions of the thread, said torch positioned symmetrically relative to the thread width so as to heat any cross section of any convolution of the thread over its entire effective surface at the same time, said torch and quenching jet impinging upon the screw at isolated zones and means for cooling the hardened thread convolution adjacent the thread convolution being heat treated.

6. An apparatus for heat treating the thread of a screw, said apparatus comprising means for supporting said screw for rotation, a torch adapted to provide a jet of flame, a quenching jet adapted to deliver a quenching medium, a carriage supporting said torch and quenching jet in tandem, means for feeding said carriage and rotating said screw in synchronized relation so that the torch and quenching jet follow the con-

volutions of the thread, said torch positioned symmetrically relative to the thread width so as to heat any cross section of the thread convolution over its entire effective surface at the same time, and a baffle lying adjacent the torch between the thread convolution being heated and the thread convolution previously hardened so as to isolate the mentioned thread convolutions.

7. An apparatus for heat treating the thread of a screw, said apparatus comprising means for supporting said screw for rotation, a torch adapted to provide a jet of flame, a quenching jet adapted to deliver a quenching medium, a carriage supporting said torch and quenching jet in tandem, means for feeding said carriage and rotating said screw in synchronized relation so that the torch and quenching jet follow the convolutions of the thread, said torch positioned symmetrically relative to the thread width so as to heat any cross section of the thread convolution over its entire effective surface at the same time, and a baffle having a portion interposed between the torch and the quenching jet so as to isolate the heating and quenching zones, and another portion lying laterally adjacent the torch between the thread convolution being heated and the thread convolution previously hardened so as to isolate the mentioned thread convolutions.

8. An apparatus for heat treating the thread of a screw, said apparatus comprising spindles for supporting and rotating the screw, a carriage, a torch adapted to provide a jet of flame, said torch supported upon said carriage and having its jet disposed symmetrically relative to the width of the thread so as to be directed upon the entire effective surface of any cross section of the thread of the screw to be hardened, means for feeding the carriage and rotating the screw for maintaining a predetermined relationship between the jet of flame and the thread of the screw so that the jet follows the screw thread, a water supply jet supported by the carriage and positioned to supply a quenching medium to the heated portion of the thread of the screw, and a baffle carried by the carriage disposed relative to the screw and interposed between the jet of flame and the jet of quenching medium for localizing the heat of the flame and causing progressive convolutions of the thread to be heat treated without affecting the convolutions of the thread which have been heat treated.

ALFRED KULLMAN.
THOMAS A. WALTZ.