

Feb. 20, 1945.

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2,369,805

WIRE DRAWING PROCESS AND APPARATUS

Filed Feb. 10, 1943

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

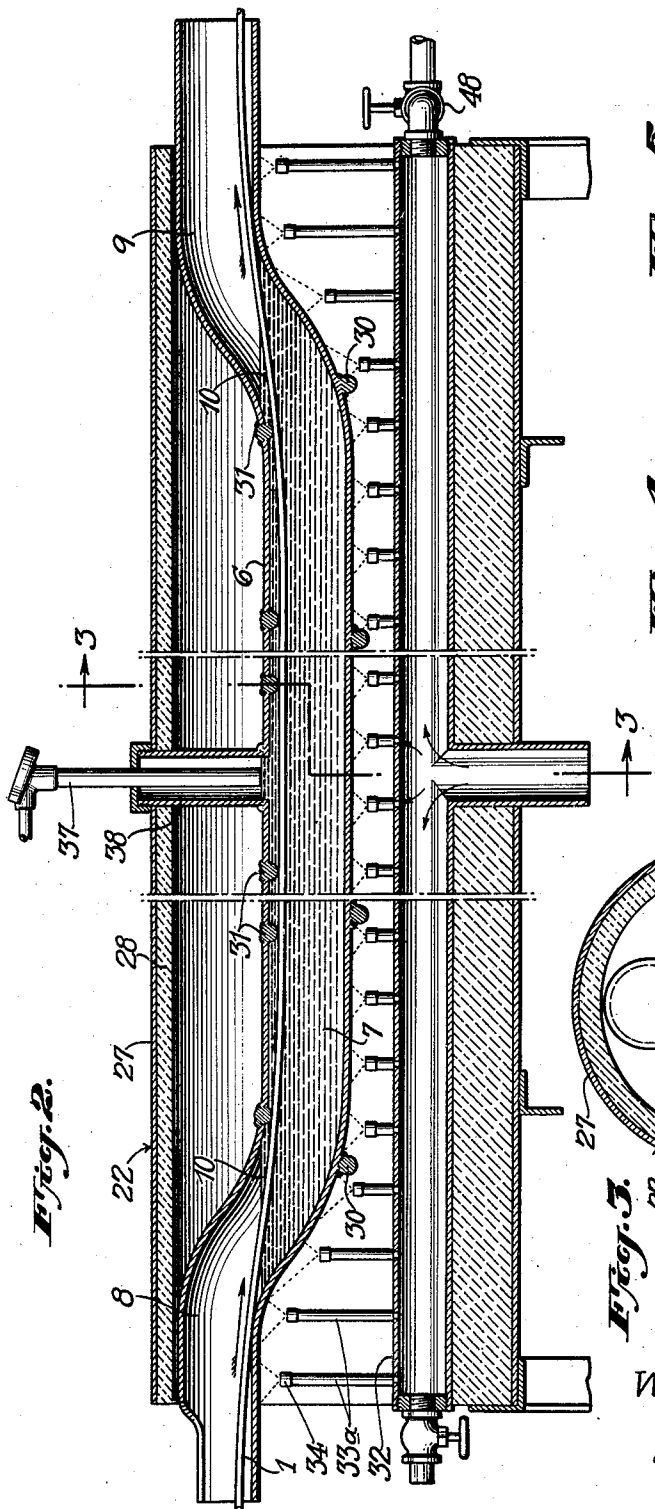


Fig. 3.

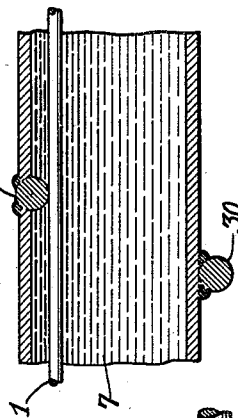


Fig. 4.

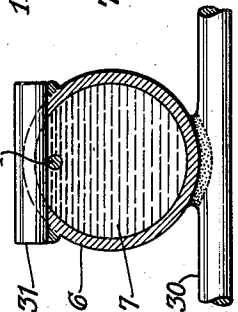
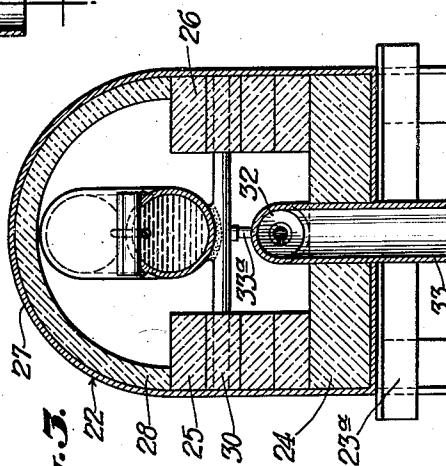


Fig. 5.



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Fig. 6.

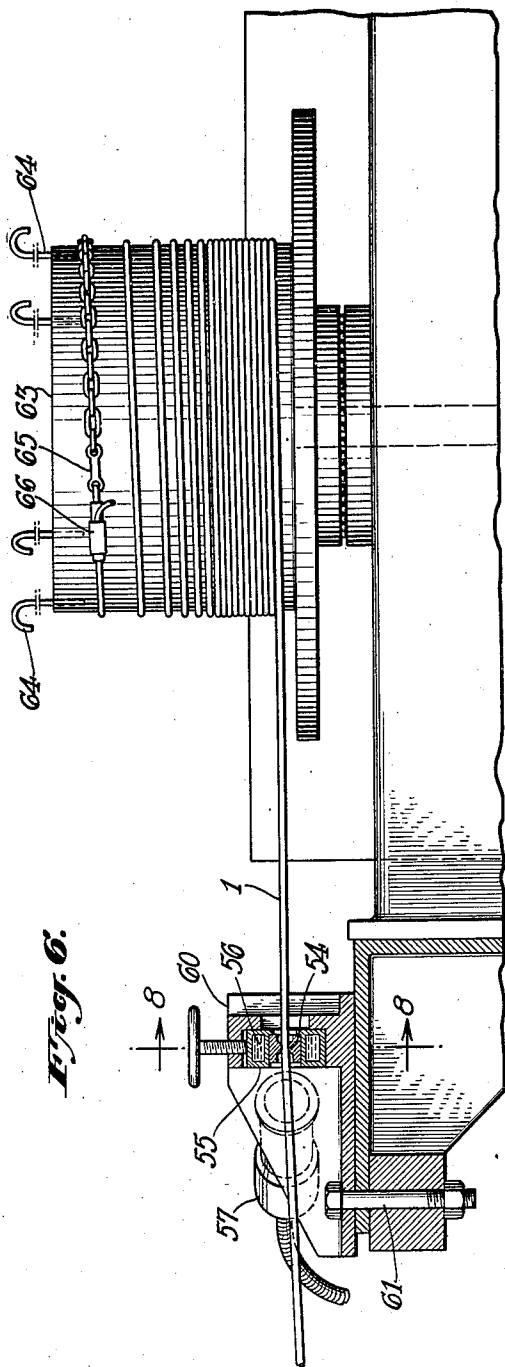


Fig. 8.

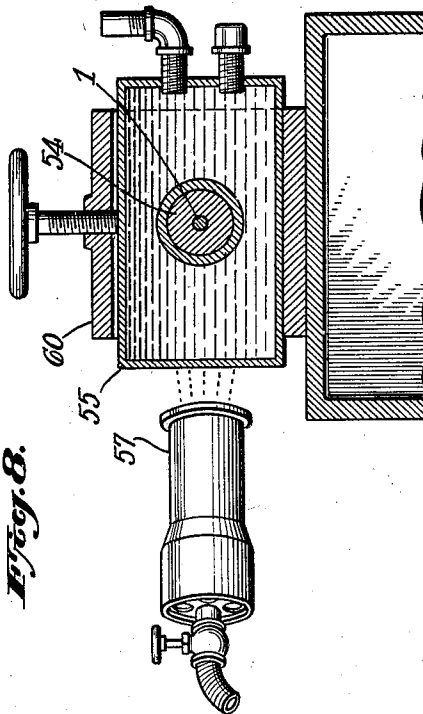
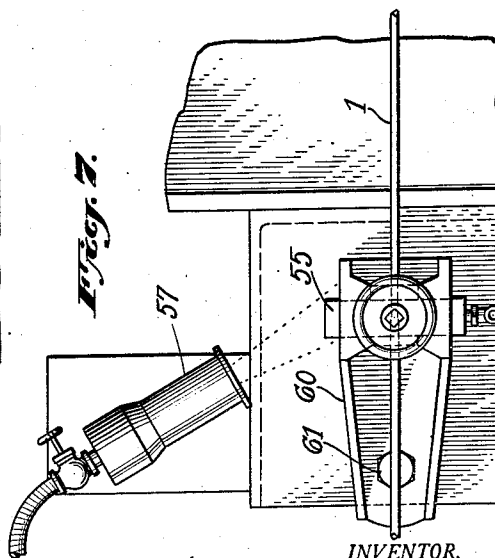


Fig. 7.



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WIRE DRAWING PROCESS AND APPARATUS

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Application February 10, 1943, Serial No. 475,366

12 Claims. (Cl. 205—16)

The invention relates to the art of wire drawing, and especially to the reduction by drawing of hot rolled alloy steels which are so hardened by thermal treatment or mechanical working as to make them difficult or impractical to draw by usual methods. The principles of the invention are also applicable to the reduction of such alloy steel bars to rod form by drawing operations instead of by hot rolling as heretofore, and wire or rod of special shapes other than circular may be produced.

In reducing hot rolled steel rod down to drawn wire, the conventional practice has long been to cold-draw the rod and resulting wire in successive drafts to the gauge desired. An objection to this is that following only relatively small reduction by each drawing step, the wire must be subjected to a heat treatment in the nature of a full anneal to relieve strains, followed successively by pickling to remove scale and oxidation due to the fairly high temperature of the heat treatment, dipping in alkali to neutralize the pickling acid, and baking.

The above operations have long been exceedingly tedious and expensive and the results uncertain, particularly in the case of alloy steels above referred to, as to which the drawing operations have been difficult and impractical.

In a general way the invention aims to provide conditions of operation under which difficult-to-draw alloy steel wire may be successfully drawn in actual practice in such a way as to largely eliminate the objections attendant upon the customary cold drawing practices of the prior art, enabling the difficult-to-draw alloy steels to be satisfactorily and reliably drawn into wire or rod form, at a cost many times less than heretofore, and resulting in the elimination of extra steps and the reduction of excessive strains in the metal such as have been attendant upon the cold drawing operations customarily used for steel wire.

I have discovered that the satisfactory drawing of elongated alloy steel stock of the above character to secure the objectives of the invention may be achieved by subjecting the stock between successive drawing steps, to a sub-critical strain relieving treatment, following which the stock is cooled or quenched to a temperature ranging between about 500 to 700° F. at which latter temperature the stock passes through the drawing die. The sub-critical strain relieving treatment above referred to will be carried out at a temperature somewhat below the critical—i. e. from about 950–1300° F. depending on the particular composition of the steel, which will avoid undue

hardening and relieve the strains sufficiently for the ensuing drawing step to be satisfactorily performed within the temperature range above mentioned. The sub-critical strain relieving treatment above referred to will be sufficient even in respect to the most difficult-to-draw alloy steels such as tungsten or molybdenum high speed steels, martensitic stainless steels, bearing steels, or high carbon, high chromium die steels, and austenitic stainless steels such as 18–8 or 25–20, and likewise as to strain relieving heat treatment if required after the final drawing step, unless a grain structure is desired which requires final heat treatment at a higher temperature. A similar sub-critical strain relieving treatment will be used preliminary to the first drawing step, unless the stock has been previously subjected to a strain relieving or annealing heat treatment.

A number of important practical requirements are satisfied by drawing alloy steels of the above type within the temperature range above specified, after the preliminary strain relieving treatment. Within this range the metal is hot enough to assume a workable state which enables a reduction of 25–35%, depending on the size and grade to be obtained without introducing undue stresses in the metal, in contrast with temperatures between the above range and normal, at which intermediate temperatures alloy steels of the type with which the present invention deals are even more difficult to draw than when cold, and which lower temperatures from the standpoint of reduction obtainable in actual practice and from the standpoint of avoiding excessive strains in the metal, afford no advantages as compared to cold drawing. As compared to substantially higher drawing temperatures, the range above referred to avoids the danger of undue loss of diameter enabling the wire to be pulled through at higher speed and with greater reduction.

A drawing temperature within the range above specified also enables effective lubrication to be secured by a simple and inexpensive lubricant such as a graphitic lubricant consisting for example of 60% by weight of graphite and 40% of finely divided clay as a binder. Such a lubricant may be applied by spraying an aqueous suspension thereof on the wire after the stock has been strain relieved and quenched to between about 500–700° F. as above described, and sufficiently ahead of the drawing die to enable the lubricant to dry on the wire before reaching the die. This may be done without reducing the temperature of the stock more than 20 or 30 degrees in passing to the drawing die, but at temperatures materially

higher than the range above specified this type of lubrication becomes impractical, and the matter of providing proper lubrication becomes much more expensive and difficult at higher temperatures.

For successful operation it is important that the temperature to which the stock is heated, both during heat treatment and for the drawing operation, be exceedingly constant as to all portions of the stock passing through, and it is important that accurate and quickly responsive regulation and control of the temperature conditions be provided. For these reasons I prefer to carry out the steps above referred to in successive heating apparatus having certain features of construction as hereinafter described in greater detail, the strain-relieving treatment being carried out preferably in a bath of molten lead or other suitable composition and the stock then passing to a second bath of molten babbitt or the like having a melting point of about 400° F. and acting as a quenching bath to quickly cool the metal fed to it at the hotter temperature of from 950-1300° F. down to a temperature of between 500-700° F. at which latter temperature the quenching bath is constantly maintained. The metal being drawn is thus kept under non-decarburizing and non-oxidizing conditions while passing to the die, which together with the moderate temperatures required, avoids scaling and pitting.

As examples of alloy steels difficult to cold draw, but which may be easily drawn in accordance with the present invention, the following may be referred to:

TABLE III
Analysis of steel

Steel	C	Cr.	V	W	Mo	Ni
18-4-1 high speed.....	.72	4.00	1.00	18.00	—	—
Mo-V high speed.....	.85	4.00	2.00	—	8.00	—
Stainless.....	1.00	18.00	—	—	—	—
Bearing steel.....	1.05	1.25	—	—	—	—
Burr wire.....	1.10	0.70	—	3.50	—	—
W-Mo high speed.....	.80	4.00	1.60	5.25	4.00	—
MoV high speed.....	.78	4.00	1.00	1.50	7.50	—
Austenitic stainless 25-20.....	.10	27.00	—	—	—	21.00
Die steel.....	2.25	12.00	—	—	1.00	—

The invention is thus applicable in general to the hot drawing of alloy steels which are hardenable either thermally or by working, and which it has been difficult and impractical to reduce by the conventional cold drawing practice.

In the drawings—

Figs. 1a and 1b and 1c show in side elevation an assemblage of apparatus for drawing iron or steel rod and wire in accordance with the invention, Fig. 1b being an extension of 1a at X—X, and Fig. 1c an extension of Fig. 1b at Y—Y.

Fig. 2 is a vertical section taken through a molten metal bath apparatus appropriate to be used in carrying out the heating treating and drawing operations of Figs. 1b and 1c.

Fig. 3 is a section on line 3—3 of Fig. 2 looking in the direction of the arrows.

Fig. 4 is an enlarged detail section through the tubular retort of Fig. 3, and

Fig. 5 is a similar section taken at right angles to the section of Fig. 4.

Fig. 6 is an enlarged side view partly in section of the drawing die and pulling mechanism.

Fig. 7 is a plan view of the drawing die and immediately associated parts shown detached.

Fig. 8 is a section on line 8—8 of Fig. 6 looking in the direction of the arrows.

Referring to the drawings, the rod or wire 1 to be drawn, is mounted in the form of a coil on reel 2 on an unwinding drum 3 which is freely rotatable on a spindle 4. The rod 1 is fed from the reel through a guide stand 5 consisting of an eyelet mounted on a support as shown. From the guide stand 5, the rod passes into the tubular retort or pipe-like container 6, which is filled with molten lead as indicated at 7, Fig. 2, this container being provided with upwardly extending goosenecked ends at the entrance and exit, as indicated at 8 and 9, to prevent the lead from flowing out, the lead rising to about the level 10 in the goosenecked portions as shown.

The lead bath retort 6 is housed in a tubular furnace 22 consisting of a metal base 23a, Fig. 3, built up of angle members as shown, supporting a hearth or floor 24 and lateral walls 25, 26 of refractory brick, the walls being surmounted by a semi-circular metal shell 27 lined with refractory brick 28. The retort 6 is supported at spaced intervals upon transversely extending bars 30 welded thereto, which in turn extend into the side walls 25, 26. Also the upper portion of the retort 6 is slotted at intervals for reception of rounded bars 31 for submerging the rod or wire 1 beneath the level of the lead bath in its passing therethrough.

Extending longitudinally of the furnace and resting on the hearth 24 is a fuel pipe or gas header 32 provided with uniformly spaced upstanding nipples, such as 33a, provided with burner tips, as at 34, these burners being disposed beneath the retort 6 as shown.

For supplying the fuel mixture to the header or manifold 32, an injector valve 33 extends through the hearth and opens into the manifold. The injector valve 33 is fed from a source (not shown) over a supply line 34a, in which is interposed a motorized valve 35 operated by a thermostatically controlled motor 36 for automatically regulating the burners in accordance with the temperature desired for the bath. This automatic regulation is effected by means including a thermo-couple pyrometer 37 mounted in a protective tube 38 extending through the roof of the furnace and welded onto the retort 6 to provide an opening therinto for exposing the thermo-couple pyrometer to the temperature of the lead bath. From the pyrometer 37, appropriate electrical connections 38a extend to a potentiometric indicating recorder 39, from whence in turn other appropriate electrical connections 40 extend to the motor 36 controlling the valve 35, in a well-known manner, for operating the valve in accordance with the temperature at which the lead bath is to be regulated.

For the purpose of accurately controlling the temperature of the rod or wire 1, it is important that the thermo-responsive element 37 project in through the upper wall of the retort 6 into contact with the molten lead which is immediately in contact with the wire 1, and it is important that the wire be held spaced from the upper wall of the retort, otherwise the temperature of different portions of the wire will not be uniform and the thermo element 37 will not respond accurately to temperature conditions in different parts of the wire.

The furnace 22 performs the sub-critical strain-relieving step previously described, and the wire or rod thus heated to a temperature of 950°-1300° F. then passes to a heating appa-

ratus 41 (Fig. 1c) which may be understood as exactly similar to the apparatus 22 previously described in connection with Figs. 2 to 5, except that this heating apparatus 41 contains a bath of molten Babbitt metal or the like, maintained at a constant temperature between about 500°-700° F. Accordingly the specific parts making up this heating apparatus 41 need not be described in detail.

It will be noted that as thus far described no lubricant has been applied to the traveling wire. As one specific feature of the invention in its preferred form, the lubricant may be applied after the wire has been quenched at 500°-700° F. in heating apparatus 41, and while the wire is passing from thence to the drawing die. As shown in Fig. 1c, the lubricant may be applied to the wire in a lubricating chamber 42 having apertured guides 43 for the wire or rod, and as the latter passes through chamber 42 it receives a coating of the lubricant which is sprayed thereon as at 44, by nozzles 45 to which an aqueous mix of the lubricant is supplied under pressure by pipe lines 46 leading from a pump 47 connected to a reservoir 48 containing a supply of the lubricant. The lubricating chamber 42 may be shaped as shown so that excess lubricant will drain back to reservoir 48 through a return pipe 49. As previously stated the lubricant preferably consists of a mixture of 60% graphite with 40% comminuted clay as a binder in aqueous suspension.

The stock need not be materially cooled by spraying of the lubricant thereon as above described, and sufficient space is left between the chamber 42 and the drawing die hereinafter described, to afford time for the lubricant to dry on the surface of the stock before reaching the die.

The rod or wire then passes to the drawing die 54 which is shown as mounted in a die-box 55 filled with Babbitt metal 56 which is maintained in molten condition by means of a burner 57 fed from the injector valve 52 by means of a fuel feed pipe 58, a suitable control valve 59 being provided to regulate the heat and thus keep the die 54 at substantially the same temperature as the rod or wire passing through it. This matter of heating the die to substantially the same temperature as the wire passing through it, is important to the success of the drawing operation. The die-box is shown as mounted in a holding frame 60, in which it is clamped by a suitable screw 61.

As shown in Figs. 1c and 6, the wind-up drum 63 is provided with a series of hooks 64 which are axially slidable with respect to the drum for the purpose of receiving the overflow of the wire being reeled up on the drum. Fastened to one end of a chain 65 having its opposite end secured to the drum, is a clamp 66 which grips the wire being fed through the die.

It should be understood that successive drawing operations, each involving a reduction of 25-35% as above described, may be performed until the stock has been reduced to the desired diameter or other dimensions, the strain-relieving and quenching operations being carried out as above described preliminary to each successive drawing step. The process thus lends itself to the production of wire in successive and continuous drawing steps. Reference is here made to my earlier copending application Serial No. 457,154 filed Sept. 3, 1942, and also to my earlier

application Serial Number 419,822, filed November 21, 1941.

While the invention has been disclosed as carried out by apparatus of the above described specific construction, it should be understood that many changes may be made therein without departing from the invention in its broader aspects, within the scope of the appended claims.

I claim:

1. The method of treating elongated alloy steel stock of the difficult-to-draw types which are hardenable thermally, or by mechanical working, which includes progressively passing the same through a bath heated to a temperature near the critical, thereafter progressively quenching said stock by passing same through a bath of lower temperature to reduce the temperature of the stock to a value between about 500°-700° F., and drawing said stock through a die substantially at said last mentioned temperature.

2. The method of treating elongated alloy steel stock of the difficult-to-draw types which are hardenable thermally, or by mechanical working, which includes progressively subjecting the same to a strain relieving heat treatment, thereafter quenching said stock by passing same through a liquid heated to a temperature between about 500°-700° F., and thereafter progressively drawing said stock through a die while said stock is substantially at the temperature of said liquid.

3. The method of treating elongated alloy steel stock of the difficult-to-draw types which are hardenable thermally, or by mechanical working, which includes passing the same through a bath prior to the application of lubricant thereto, regulating the temperature of said bath to maintain same between about 500°-700° F., applying lubricant to such stock after passing through said bath, and drawing the lubricated stock through a die at substantially the temperature of said bath.

4. The method of treating elongated alloy steel stock of the difficult-to-draw types which are hardenable thermally, or by mechanical working, which includes subjecting the same to a strain-relieving heat treatment, thereafter passing said stock progressively through a fluid medium which is heated to a temperature between about 500°-700° F. to cool said stock substantially to said last mentioned temperature, and drawing said stock through a die while said stock is substantially at the temperature of said fluid medium.

5. The method of treating elongated alloy steel stock of the difficult-to-draw types which are hardenable thermally, or by mechanical working, which includes passing the same progressively through a fluid medium while regulating the temperature of the latter to maintain the same to about 500°-700° F., thereby to cause said stock to assume substantially the temperature of said fluid medium, and then passing said stock through a die while said stock is substantially at the temperature of said fluid medium.

6. Apparatus of the class described for producing drawn elongated wire and like purposes, said apparatus including means for maintaining a liquid treating bath at a temperature near the critical point of said stock, a drawing die, means interposed between said first mentioned bath and said die for maintaining a second fluid medium at a temperature substantially lower than the first bath, thereby to produce a temperature be-

tween about 500°-700° F. in the stock passing through said second mentioned fluid medium, and means for drawing the stock successively through said bath, fluid medium, and said die.

7. Apparatus of the class described, for producing drawn elongated wire and like purposes, said apparatus including means for maintaining a liquid treating bath at a temperature near the critical point of said stock, a drawing die, means interposed between said first mentioned bath and said die for maintaining a second treating bath at a temperature substantially lower than the first, to produce a temperature between about 500°-700° F. in the stock leaving said second mentioned bath, and means for drawing the stock successively through said baths and said die, means being interposed between said second mentioned bath and said die for applying lubricant to the stock before it passes to the die.

8. Apparatus of the class described for producing drawn elongated wire and like purposes, said apparatus including a chamber having means associated therewith for heating the stock to a temperature near its critical point, a drawing die, means interposed between said chamber and said die for quenching the stock to a temperature between about 500°-700° F. and mechanism for drawing the stock successively through said chamber, said quenching means and said die.

9. The method of treating elongated alloy steel stock of the difficult-to-draw types, which are hardenable thermally or by mechanical working, which includes progressively subjecting the stock to a heat treatment near the critical point of said stock, thereafter suddenly cooling the stock from a temperature near the critical to a temperature several hundred degrees F. lower but above about 500° F., said heat treating and cooling operations being conducted without intervening drawing operations, and then progressively drawing the cooled stock through a die while said stock is still at a temperature above about 500° F.

10. The method of treating elongated alloy steel stock of the difficult-to-draw types, which are hardenable thermally or by mechanical working, which includes progressively subjecting

the stock to a heat treatment near the critical point of said stock, thereafter suddenly cooling the stock from a temperature near the critical to a temperature several hundred degrees F. lower but above about 500° F., said heat treating and cooling operations being conducted without intervening drawing operations, and then progressively drawing the cooled stock through a die while said stock is still at a temperature above about 500° F., the aforesaid method including the step of applying lubricant to said stock between the above mentioned heat treating and drawing operations.

11. Apparatus of the class described for producing drawn elongated wire and like purposes, said apparatus including a chamber having means associated therewith for heating the stock to a temperature near its critical point, a drawing die, means interposed between said chamber and said die for suddenly cooling the stock from a temperature near the critical to a temperature several hundred degrees F. lower but above about 500° F. and mechanism for drawing the stock successively through said chamber, said cooling means and said die, said apparatus being constructed and arranged to maintain said stock at a temperature above about 500° F. when passing to said die.

12. Apparatus of the class described for producing drawn elongated wire and like purposes, said apparatus including a chamber having means associated therewith for heating the stock to a temperature near its critical point, a drawing die, means interposed between said chamber and said die for suddenly cooling the stock from a temperature near the critical to a temperature several hundred degrees F. lower but above about 500° F., and mechanism for drawing the stock successively through said chamber, said cooling means and said die, said apparatus being constructed and arranged to maintain said stock at a temperature above about 500° F. when passing to said die and said apparatus including means interposed between said chamber and said die for applying lubricant to said stock.

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