July 7, 1959 K. F. RUSSELL 2,893,544

APPARATUS FOR DRAWING WIRE

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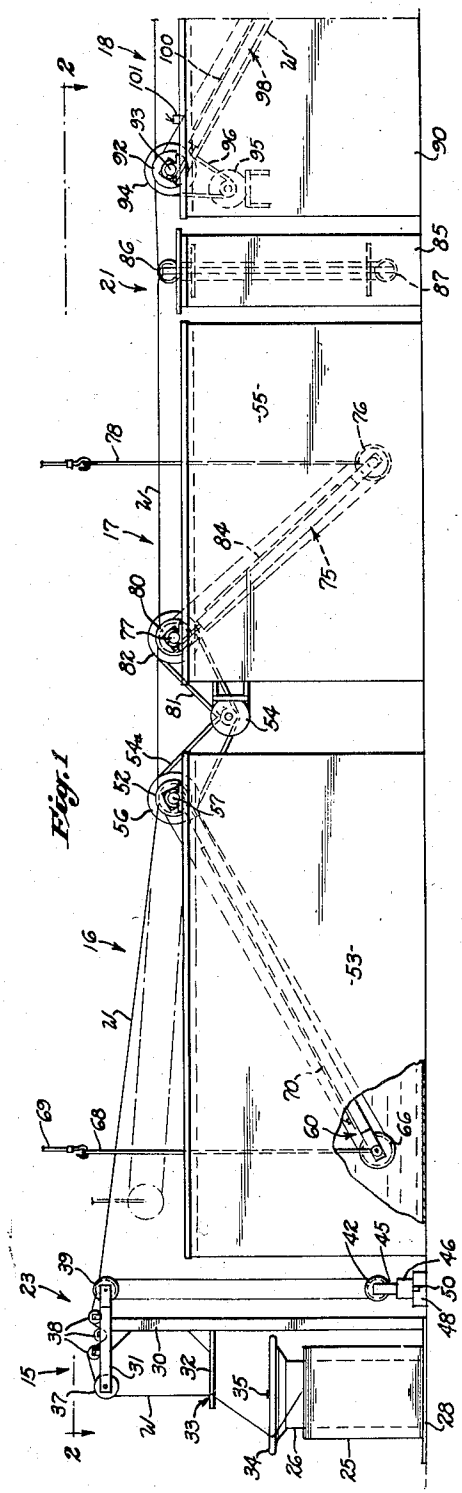


Fig. 1

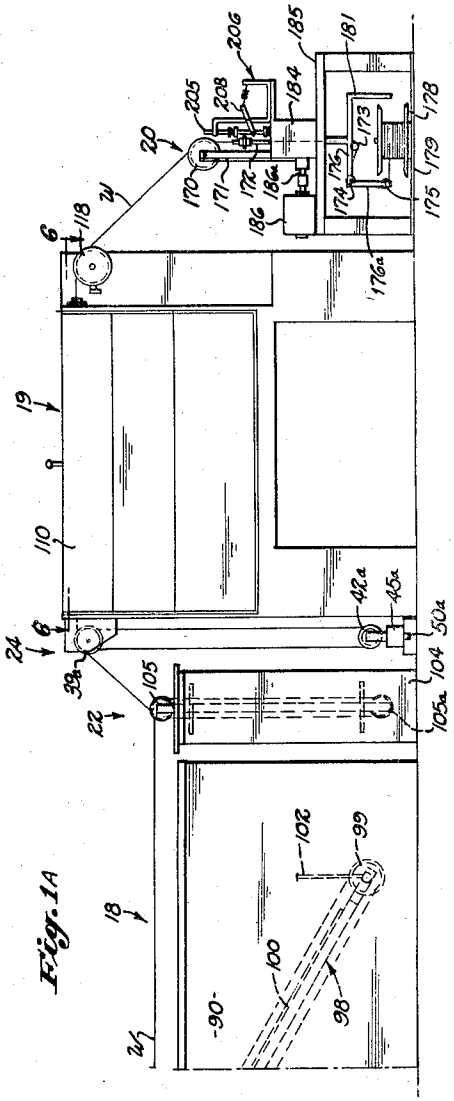


Fig. 1A

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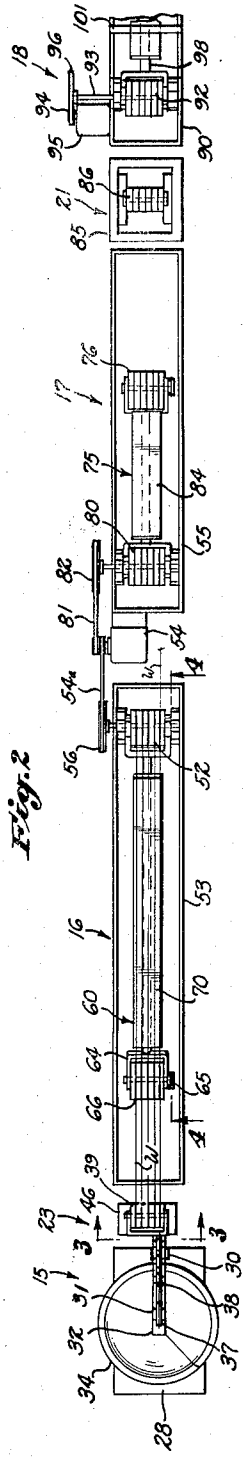


Fig. 2

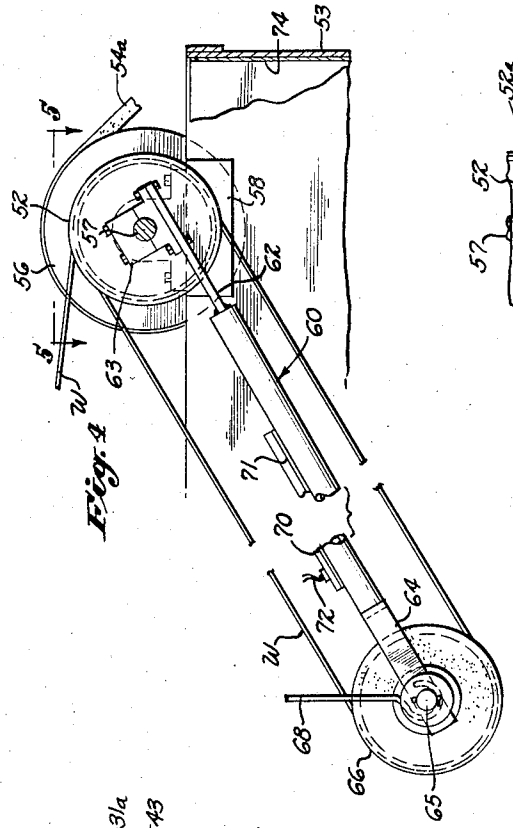


Fig. 4

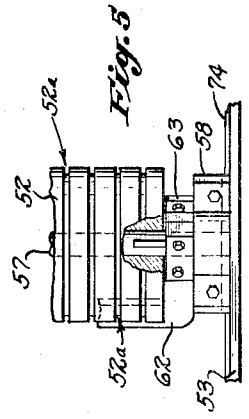


Fig. 5

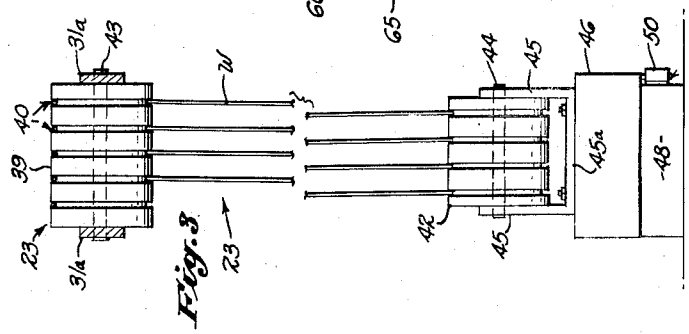


Fig. 3

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Fig. 6

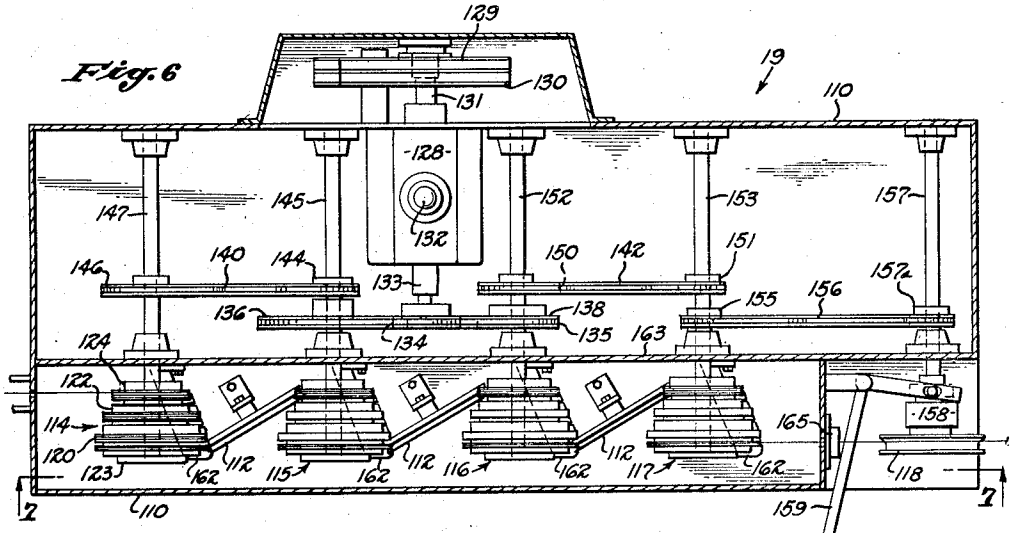


Fig. 7

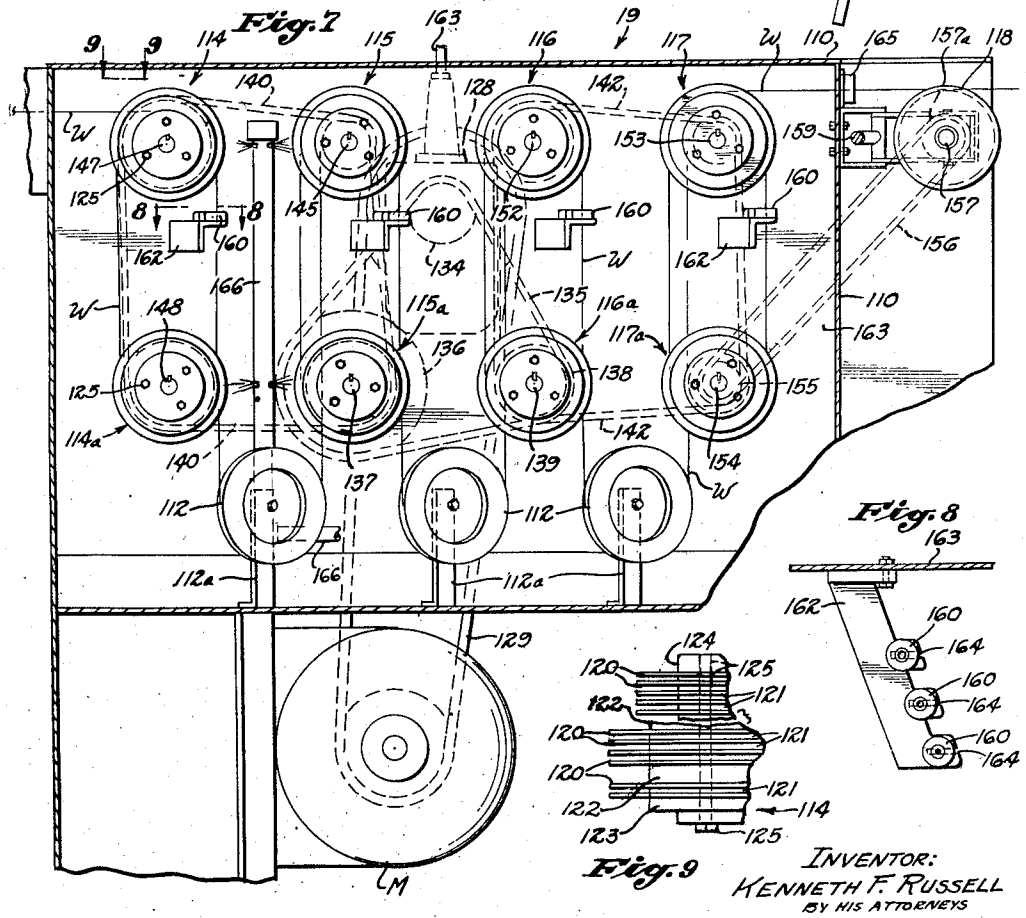


Fig. 8

Fig. 9

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APPARATUS FOR DRAWING WIRE

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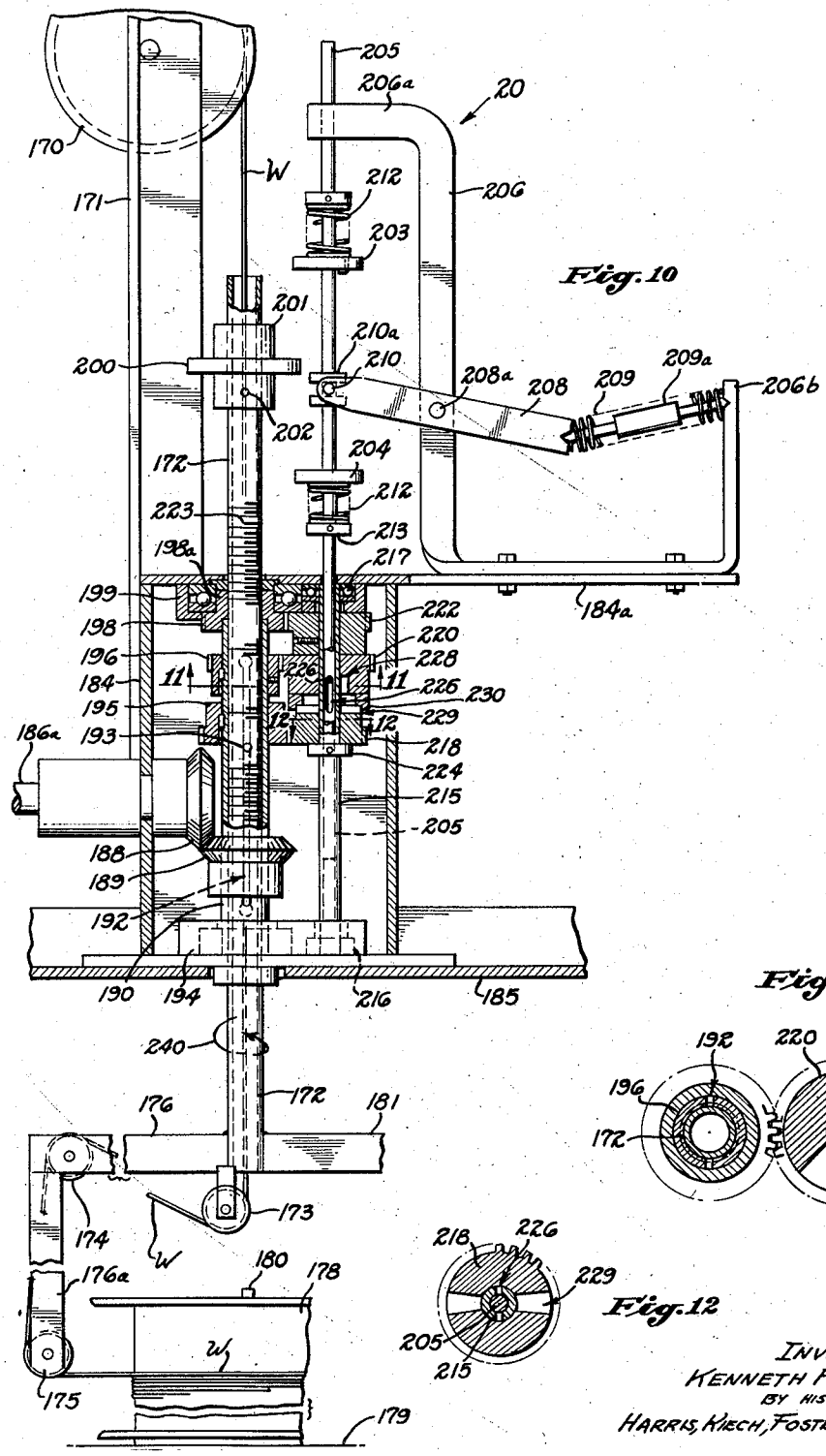


Fig. 10

Fig. 11

Fig. 12

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2,893,544

APPARATUS FOR DRAWING WIRE

Kenneth F. Russell, Claremont, Calif.

Application May 3, 1954, Serial No. 427,088
2 Claims. (Cl. 205—20)

This invention relates to wire drawing and more particularly has to do with methods and apparatus for drawing various types of wire, especially ferrous wire such as is commonly termed steel wire, although other wires such as aluminum wire, copper wire and stainless steel wire may also be processed in accordance with various aspects of the invention.

The present invention is particularly adapted to the drawing of wire of larger diameters to yield wire of much smaller diameters. Thus, wire which has previously been drawn from circular rod, annealed, pickled to remove scale, and coiled according to conventional practices wherein a series of dies is used in the drawing to yield wire in the order of one tenth of an inch in diameter, e.g. 0.09 inch down to 0.04 to 0.05 inch, is drawn to yield wire of 0.020 inch diameter or much smaller diameter such as 0.011 inch wire or even as fine as 0.005 inch. The present method and apparatus have been found particularly efficient in producing hard drawn steel weaving wire having a diameter approximating 0.011 inch, such a wire being economically produced from an annealed wire of 0.041 inch in diameter. Such a reduction of steel wire is not only economical in employing the method and apparatus of the present invention but yields a product that is not excessively brittle while being adequately hard and highly satisfactory.

It is therefore an object of the present invention to produce a drawn wire product of small size (between about 0.005 inch and 0.020 inch) from previously formed steel wire of larger size which is commercially and practically highly valuable and satisfactory.

It is also an object of the present invention to provide a novel procedure for removing previously formed coiled wire from its coil without kinking; also to thoroughly clean and remove scale from such wire; also to prevent the typical drawing dies (which almost universally are tungsten carbide dies) from picking up material from the wire at efficient speeds which otherwise would scratch the wire and eventually result in breaking, such prevention preferably being accomplished by a light metal coating such as a copper coating; and also to provide a highly efficient drawing mechanism as well as highly efficient spooling means, especially one which winds the drawn, fine wire on a heavy stationary spool, whereby to eliminate the necessity for rotating such a spool in the winding operation.

It is additionally an object to provide a rewinding procedure which introduces into the rewound wire a twist for each revolution of the rewinding mechanism with respect to the stationary spool so that, when such wire is later to be removed from such spool in other uses, the wire may be taken off the spool axially, and without rotation, without twisting or kinking the unwound wire removed from such spool.

Thus, it is an over-all object of the invention to assist drawing wire down to fine sizes by adequately cleaning the wire and then applying a suitable metal coating or the like to act like a lubricant (such as a

softer metal than the steel wire itself), whereby to prevent scratching or other injury to the wire as it passes through the usual dies, whereby to yield a high grade, finished, drawn steel wire, or wire of other appropriate metal, it being an additional object as above indicated to spool such wire readily through the production of twists therein while applying it to a stationary spool in a manner to avoid kink formation upon subsequent removal of the wire from such spool while stationary.

Other objects of the invention and the various features of operation and of construction thereof will become apparent to those skilled in the art upon reference to the accompanying drawings wherein certain embodiments are illustrated.

In the drawings, which are very largely diagrammatic:

Fig. 1 is a side elevation of somewhat more than one half of an apparatus embodying the features of this invention, and in which the process of this invention is conducted;

Fig. 1A is a side elevation of the remainder of the apparatus;

Fig. 2 is a top plan view of the construction shown in Fig. 1;

Fig. 3 is a vertical, transverse elevation on an enlarged scale of wire tensioning and safety means at the feed end of Fig. 2 as indicated by line 3—3 of Fig. 2;

Fig. 4 is a side elevation on enlarged scale within a corresponding tank as indicated by the line 4—4 of Fig. 2, intermediate portions being broken away;

Fig. 5 is a fragmentary plan view, a portion being broken away, of one end of the wire feed drum for one of the cleaning tanks, as indicated by the line 5—5 of Fig. 4;

Fig. 6 is a plan view on an enlarged scale, as indicated by the line 6—6 of Fig. 1A, showing the arrangement of the wire advancing capstans with the wire-drawing dies and the drive mechanism therefor;

Fig. 7 is a side elevation taken from the line 7—7 of Fig. 6 showing the capstans and the wire-threading arrangement, and indicating portions of the drive mechanism;

Fig. 8 is a transverse detail in plan, as indicated by the line 8—8 of Fig. 7, to show the relationship of the wire-drawing dies;

Fig. 9 is a fragmentary plan view, as indicated by the line 9—9 of Fig. 7, showing the construction of a portion of each capstan;

Fig. 10 is largely a side elevation, parts, however, being broken away, showing on an enlarged scale the respooling mechanism seen at the right of Fig. 1A;

Fig. 11 is a cross section looking upward, as indicated by the line 11—11 of Fig. 10, to show the cross-sectional construction of certain of the gears; and

Fig. 12 is a similar view indicated by the line 12—12 of Fig. 10 of a co-operating gear.

Having reference first to Figs. 1, 1A and 2 particularly of the drawings, the apparatus illustrated comprises several co-operative units arranged in succession and including: a feed-wire take-off and a scale-breaking unit 15; a scale-removing unit 16 providing an electrolytic bath; a second scale-removing, electrolytic unit 17, preferably supplying to the wire a charge opposite from that in the bath of the unit 16; a copper plating unit 18; a drawing unit 19; and a winding or spooling unit 20. In addition there is a rinsing unit 21 ahead of the copper plating unit 18 and a second rinsing unit 22 following the copper plating unit 18. Also, between the scale-cracking unit 15 and the first electrolytic scale-removing unit 16 there is an automatic power shut-off unit 23, and just ahead of the wire-drawing unit 19 there is another power shut-off unit 24, these units 23 and 24 serving automatically as

safety devices to cut off the electric motors used if the wire fails to feed or tangles, and also acting as tensioners.

The wire-feeding or take-off unit and scale breaker **15**, seen at the left of Fig. 1, provides for the positioning of a stationary coil **25** of annealed wire which may be disposed about an upstanding stationary mandrel or core **26** carried, for example, on a base **28** of a standard **30** having a top crossarm **31** and a bracket **32** which projects laterally over the spool **26** and is provided with an aligning guide aperture **33** disposed upon the axis of the wire coil **25**. The strand of wire W which is drawn from the coil **25** and passed through the system moves continuously about the coil axis as it is drawn through the guide opening **33**, and possible kinking of such wire W as it is moved from the coil **25** to the guide opening **33** is prevented by means of a freely rotating wheel **34** which is rotatably mounted about the axis of the spool **26** by a wheel bearing **35** mounted on such axis as by placing in the top of the core or mandrel **26**.

The withdrawn strand of wire W which passes upward through the guide opening **33** thence passes along the spool axis to the periphery of a receiving pulley **37** on the forward end of the crossarm **31**. The wire W is then passed around a series of scale-cracking rolls **38**, preferably three or more in number, and thence to another guide roll or pulley **39** on the opposite end of the cross arm **31** from the pulley **37**. Since the diameter of the freely rotating wheel **34** is somewhat greater than the diameter of the coil **25** or of the spool **26**, the pulling force applied to the wire W has a component transmitted to the periphery of the wheel **34** as a tangential force in the event that the wire being withdrawn from the coil tends to bind on the coil, as a consequence of which kinking or bending or breaking of the wire as it passes from the coil is avoided. This desirable condition might not result if the wheel were stationary, inasmuch as friction of the upwardly moving wire on the wheel periphery might then prevent movement of the unwinding wire about the coil axis. The series of scale-cracking rolls **38** is so disposed that, as the wire passes from one scale-cracking roll to the next, it is bent through a total angle of substantially 90°, each bending operation being substantially the opposite of the preceding bending. With the rolls **38** of relatively small diameters, such to-and-fro bendings insure good scale cracking so that efficient access of cleaning fluids in the succeeding steps is assured.

As shown in Fig. 3, the pulley **39** on the forward end of the crossarm **31** may be in effect a series of two or more pulleys provided by an elongated roller having a plurality of grooves **40** to receive several loops of the wire W, these loops extending downward to an underlying roller **42** which may be correspondingly grooved to receive the bights of the various wire loops. In order to position the pulley or pulleys **39** on the forward end of the crossarm **31**, the latter is provided with bifurcations **31***a* which receive the ends of a shaft or axle **43**. Similarly the roller **42** is provided with an axle **44** whose ends are mounted in upstanding arms **45** of a bracket **45***a* mounted on a block **46** normally carried by an underlying bed member **48** mounted on the floor or other substructure which carries the entire apparatus. The bed **48** is provided with a protective switch **50** at one end thereof and this switch **50** has an upstanding safety plunger **50***a* which is normally held by the weight of the block **46** in a depressed, switch-closing position. However, should draft or strain on the wire W, applied through operating motors as hereinafter described, become excessive, such strain will act to lift the roller **42** and its block **46** so that the plunger **50***a*, which may be a spring-biased plunger, will be actuated upward to break the circuit supplying the switch **50** and the mentioned motors, thereby stopping the entire apparatus until the objectionable condition has been alleviated.

Descaling operation

After the wire W leaves the roller-like pulley **39**, it is passed to a drive drum or roller **52** shown as being mounted at the far or forward end of a solution tank **53**, such roller **52** being provided with a plurality of annular grooves **52***a* (Fig. 5) in which a plurality of loops of the wire W are disposed. The drive roller **52** is driven by an electric motor **54** shown as being carried between the solution tank **53** of the first electrolytic cleaning unit **16** and a solution tank **55** of a second electrolytic cleaning unit **17**. The motor **54** actuates the drive roller **52** through the medium of a drive belt **54***a* and a driven pulley **56**, as illustrated in both Figs. 1 and 4, as well as in the plan view of Fig. 2. The roller **52** is driven through the medium of a drive shaft **57** which is journalled in bearings **58** secured to the opposite side walls of the tank **53**. The drive shaft **57** performs the additional function of journalling the fixed end of a frame **60** through the medium of arms or bifurcations **62** whose forward extremities are provided with bearings **63** disposed about the shaft **57**. The mentioned frame **60** is elongated and normally extends downward into solution in the tank **53** where its lower end is in turn bifurcated to provide arms **64** carrying the ends of a shaft **65** provided with a series of grooved discs or sheaves **66** whose grooves receive the various loops of the wire W. These discs **66** are preferably of insulating material such as rubber. The discs **66** and the corresponding lower or movable end of the frame **60** (which is disposed between the opposite strands of the wire loops W) are adapted to be elevated from the full line position of Fig. 1 to the broken line position thereof by means of a lifting rod **68** or the like which may be hooked around one end of the shaft **65** and may be raised through the medium of any type of elevator **59** (Fig. 1) conected with any overhead structure (not shown).

The discs **66** carried at the lower end of the frame **60** in the cleaning tank **53** of the cleaning unit **16** are idlers preferably made of non-corroding material which may at the same time be insulating material such as rubber, thereby insulating the wire from the frame **60**. The shaft **65** carrying the discs **66** also is of non-corrosive material under the present circumstances whereby to prevent corrosion, such shaft **65** being made of stainless steel, copper or the like.

The wire W receives an electric charge from the upper roller **52** which is metallic, and also if desired through the shaft **57** which is metallic, these parts being insulated from the tank **53** and energized in any suitable manner as by a wiping contact. To provide the required electrolytic condition in the solution in the tank **53**, a metal plate such as a lead plate **70** is mounted on the elongated frame **60** between the runs of the loops of the wire W, the number of such wire loops in practice being around eight or ten. The plate **70** is insulated from the frame **60** as by coating this frame with insulating material or by using a sheet of insulation indicated at **71**, and the plate **70** is energized through the medium of an electric conductor **72**. As presently to be described, the same type of structure is employed in the tank **55** of the cleaning unit **17**, and the charges imposed in the tank **55** are opposite those in the tank **53**. Preferably, and in accordance with the present improvement, the plate **70** in the tank **53** receives a positive charge, with the result that the charge on the wire W is negative and the chemical condition at the wire surface is basic, whereas in the tank **55** the charge on the wire is positive and the condition at the wire surface is acidic. For proper control of the electrical conditions in the tanks **53** and **55**, each of these tanks is provided with an insulating lining as indicated at **74** in Fig. 4; such an insulating lining may be in the form of sheets of appropriate plastic material well known in the arts, or in the form of insulating coating.

The solution as it is used in the tank **53**, which may be the same electrolyte as used in the tank **55** is, in a preferred form, a magnesium sulfate solution, because it appears that for the present cleaning purpose the SO_4 ion

is most efficient and magnesium sulfate is a very convenient salt to be employed, a salt being preferable to sulfuric acid which is especially objectionable because of its corrosiveness. Unnecessary chemical action and dissipation of electric current are overcome by the use of the previously described insulating material, such as rubber, on the frame and for the discs 66. The sulfate is apparently especially valuable because the combination of sulfate ions with a high concentration of hydrogen ions at the wire surface in the first tank results in loosening the cracked scale particles from the wire surface at a rapid rate. The magnesium sulfate solution used should be, for most efficient results, a rather strong solution which, however, from operating standpoints should not be too highly concentrated and therefore less than a saturated solution. On the other hand, if the solution is too weak, activity and efficiency are too limited. As to exact concentration of the magnesium sulfate, this condition is not critical, for example around 50% to 75% or 80% of the saturation amount would be in order.

Having further reference to the equipment of the unit 17 of Figs. 1 and 2, and the processes carried on within the tank 55 thereof, as previously indicated this tank 55 carries another swinging framework 75 like the framework 60 which has at its lower end a roll or series of sheaves 76 corresponding with the roll structure 60, the upper end of the frame 75 being mounted upon a shaft 77 corresponding with the shaft 57, and the lower end of the frame 75 being elevatable through means 78 similar to the means 68 of the structure in the tank 53. In this instance also, the wire W being cleaned is disposed in a plurality of loops which extend around the roll structure 76 and are driven from a grooved drum or roll 80 corresponding with the drum 52, such drum 80 and its shaft 77 being driven from the previously mentioned motor 54 through a drive belt 81 and a drive pulley 82 mounted on one end of the shaft 77 whereby the wire W is fed around the rolls 76 and 80 as it is being treated in the tank 55, which tank is lined with an insulating material as in the case of the lining 74 of the tank 53, and which tank 55 also contains a magnesium sulfate solution (or the like) as described in connection with the tank 53. The tank 55 and its swinging framework 75 are appreciably shorter than the corresponding tank 53 and the swinging framework 60 of the unit 16. As previously indicated, the charge on the wire W carried by the framework 75 is the opposite of the charge in the tank 53; that is, the wire W receives a positive charge instead of a negative charge. Also a lead plate 84 carried by the framework 75 and insulated therefrom carries a negative charge as distinguished from the positive charge carried by the lead plate 70 in the unit 16.

In passing the wire W from the first cleaning tank 53 where the wire W receives a negative charge through the second cleaning tank 55 where the wire W receives a positive charge, the wire is cleaned of all scale and other extraneous materials and provided with a bright etched surface. Following the scale-breaking operation in the previously described unit 15, the process in the first cleaning tank 53 proceeds as a function of the time and amount of current per foot of length of wire, and for a lower power consumption a relatively long path, that is more loops of wire or a longer tank or both, is desirable. An economical balance between wire speed, space, number of loops and convenience in handling is used. The action in the second cleaning tank 55 is somewhat different, in that below certain current densities (i.e. amperes per foot of exposed wire in the solution) very little cleaning is effected unless the solution itself is very clean, under which circumstances the life of the solution is very short. However, I have discovered that by keeping the current densities relatively high in the second cleaning tank 55, a long solution life can be maintained, and also less time is required for this cleaning action. Therefore, in order to maintain such high current densities in the tank 55 with a minimum total quantity of current used, and also to conserve space, this tank is made appreciably shorter (for example two-thirds the length) than the first tank 53. As a consequence, the current densities in the tank 55 are correspondingly higher, for example 25% to 50% higher than in the tank 53. These higher densities may be in the order of 2 amperes to 4 amperes per foot of .041 inch steel wire exposed in the solution or approximately 1¼ to 2½ amperes per square inch of surface. It is to be noted that to pull wire through the system described, would require such pulling force as normally would be excessive and sufficient to break the wire. Therefore, the motor 54 has been provided for positive actuation of the drive rolls 56 and 30, as above described; with their peripheral speed in excess of the wire speed, these rolls or drums function much as capstans.

Plating operation

The wire W cleaned in the tank 55 is fed from the drive roll 30 to a washing tank 85, containing wash water or other appropriate rinsing solution, the wire being passed into the solution by way of a grooved top roll 86 and a grooved bottom roll 87, around which rolls a plurality of loops of the wire are produced to provide adequate washing contact. The washed, bright, etched wire is then passed to a copper-plating tank 90 (Figs. 1, 1A and 2) in which a light coating of copper or other appropriate soft metal or material is applied as by electrolytic plating, such as coating being readily accepted by the bright etched surface produced as above described, such coating of copper, lead, tin, zinc or the like acting to protect the tungsten carbide or similar drawing dies subsequently used and also to protect the surface of the wire being drawn from scratching or similar injury by the dies themselves. Such a coating is not necessarily a perfect coating and may be incomplete, but it is adequate for the protective function required. The wire W passing to the plating tank 90 is first passed to a drive drum or roll 92 driven from a shaft 93 actuated from a pulley 94 driven by an electric motor 95 through a belt 96 or the like. In order to avoid copper-plating effects upon the drive roll 92, this roll provides at least a rubber surface appropriately grooved to receive several loops of the wire and to avoid metal-to-metal contact between the wire and the roll. This rubber surface is preferably provided by a series of grooved rubber rings adapted to receive the loops of wire and to ride or slip independently of each other upon an inner drum or roll which should be of a material such as stainless steel. Upon the shaft 93 there is swingingly mounted a frame 98 very similar to the frames 60 and 75, which frame has at its lower end another roll 99 which also preferably is of rubber or appropriate material which avoids deposits of copper thereon. The frame 98 must be resistant to corrosion in acid baths and preferably constructed of plastic, wood or similar material, or is coated with resistant material. In order to set up proper conditions for electrolytic plating, the frame 98 has mounted thereon a copper plate 100 (if copper-plating is to be employed), such plate being preferably suitably insulated from the frame 98. The wire W is energized as by means of a brush 101 (Fig. 1) in contact therewith, the plate 100 also having appropriate electrical connections. This frame 98 and associated parts are adapted to be raised out of the conventional acidic bath in the tank 90 by any appropriate rod 102 or other elevating means similar to the means employed with the frames in the tanks 53 and 55.

Several loops of the wire W having been passed over the rolls 92 and 99 to effect the desired copper or other plating on the surface of the wire, the wire is then passed into a wash tank 104 via a grooved roll 105 cooperating with a roll 105*a* in the bottom of the tank 104 of the unit 22 so that several wire loops are provided to insure adequate washing in the bath, which bath may contain a neutralizing agent if desired. The washed wire, with its copper plate, is then passed to a safety control mech-

anism of the unit **24** which is like the safety control mechanism of the unit **23** and includes an identical top roll **39***a*, bottom roll **42***a* with block **45***a*, and switch **50***a*.

From the tank **104** of the washing unit **22** and the wire tensioning and safety mechanism of the unit **24**, the wire then passes to the wire-drawing mechanism of the unit **19** (Figs. 1, 6 and 7) which is contained within a housing **110** required especially because of the employment of lubricant sprayed over the wire-drawing mechanism.

Wire drawing mechanism

The wire drawing mechanism within the housing **110** is disclosed particularly in Figs. 6, 7, 8 and 9.

It includes a plurality of capstans arranged in vertical pairs as indicated in Fig. 7, cross-over pulleys **112** being disposed on brackets **112***a* between the lowermost capstans of adjacent pairs as best indicated in Figs. 6 and 7. The mentioned pairs of capstans seen in Fig. 7 are successively designated, reading from left to right as pair **114**, **114***a*, pair **115**, **115***a*, pair **116**, **116***a*, and pair **117**, **117***a*; the uppermost capstans of the respective pairs being capstans **114**, **115**, **116**, and **117**. In this figure, the wire W is shown as entering from the left and passing over the first top capstan **114** and passing thence downward on the right side of the capstan to the lower capstan **114***a* of the respective pair, whence the wire passes up on the left side and again over the upper capstan **114**, the descending wire eventually passing around the under side of the cross-over pulley **112** and thence upward along the left side of the pair **115**, **115***a* to the top capstan **115** around which it passes to the lower capstan **115***a*. Thus the wire W progresses through the system of four pairs of capstans and the three cross-over pulleys **112**, the wire W eventually leaving the wire-drawing equipment over a so-called finishing "block" or roll **118**. This finishing block and the various capstans are power driven through a system presently to be described from an A.C. constant speed electric motor M positioned beneath the housing **110**.

The various capstans, of which the first capstan **114** is typical, are constructed so as to provide for contact of a given strand of wire at only one annular location or narrow track on a capstan surface. As indicated in the detailed showing of Fig. 9, each such track is in the form effectively of a narrow groove provided by opposing steel discs **120** which are appropriately spaced by intervening steel discs **121** of lesser diameter than the corresponding discs **120**. As seen in both Fig. 6 and Fig. 9, the discs **120**, forming the respective grooves and the respective spacer discs **121** forming tracks also designated as **121**, are arranged in stepped series, each series comprising several groove-forming discs **120** and spacer disc **121**, such stepping forming, in effect, what may be termed "lands" indicated at **122** and produced by thick spacer discs. At the outer end of each capstan there is provided a relatively thicker end disc **123**, and all of the discs **120**, **121**, **123** are assembled, by means of central openings, upon the core of a hub **124** of each capstan, the discs **120** and **121** being bound to the head or collar of the hub **124** as by means of plural bolts **125** passing through the hub and the discs **120** and **121**, and being secured to the thick end disc **123**. A drive shaft is secured in a center bore of each hub **124** and its core in any appropriate manner.

With the described construction of capstan, only one strand of the wire W is passed into each track or groove formed between the respective pairs of discs **120**. Thus, the capstans need not be replaced frequently because relatively deep grooves may be worn into the capstan surfaces without an adjacent turn of wire riding upon the wire strand in the worn groove and thereby causing breakage of the wire.

In fact, with the present construction, not only is the positioning of more than one strand in each groove avoided, but at the same time the peripheries of separate relatively thin discs form the capstan surfaces, these being economically produced of high-carbon wear-resistant steel or similar hard steel, suitably ground or otherwise finished, or being formed from low-carbon steel appropriately hardened and ground or treated with a wear-resisting metal such as hard chromium.

As previously indicated, the various capstans are powered by the electric motor M, and this leads to a standard transmission, such as a four-speed transmission **128**, by way of a pair of V-belts **129** and corresponding pulleys **130** on a power shaft **131** entering the transmission **128**. A typical gear shift handle **132** is shown as extending upward from the transmission **128** whereby to energize a driven shaft **133** as required. This transmission may or may not include any conventional clutch as may seem necessary or desirable. The driven shaft **133** carries a gear **134** over which passes a drive chain **135** which drives a larger gear **136** on a shaft **137** of the capstan **115***a* and also drives a smaller gear **138** on a shaft **139** of the capstan **116***a*. In this manner the capstan **116***a* is rotated at the required faster rate than the rate of rotation of the capstan **115***a*. The wire W, of course, slips somewhat on the various disc tracks **121** of the various capstans, due to the relatively faster driving of the successive capstans in the system, of which the relatively faster driving of the capstan **116***a* as just described is representative of the entire system.

To effect drive of the upper capstans **115** and **116** and of the other two pairs **114**, **114***a* and **117**, **117***a*, the shafts **137** and **139** are provided with additional gears so that a common drive chain **140** drives the capstans **114**, **114***a* and **115**, and so that an additional chain **142** drives the capstans **116**, **117** and **117***a*. Thus, the shaft **137** of the capstan **115***a* is provided with a smaller gear than the gear **136**, such smaller gear conforming with a gear **144** on a shaft **145** of the capstan **115**, a larger gear **146** being similarly provided on a shaft **147** of the capstan **114** directly above a corresponding gear on the shaft **148** of the lower capstan **114***a*. Similarly, the chain **142** passes over a gear **150** and a smaller gear **151** on the shafts **152** and **153** respectively of the capstans **116** and **117** which overlie corresponding gears on the shaft **139** of the capstan **116***a* and on the shaft **154** of the capstan **117***a*.

Thus, all the capstans are individually power driven at successively faster rates as the wire passes through the system, so as to be in conformity with the increase in the length of the wire being drawn, the various gears mentioned being of the required sizes to produce such stepped up speed of rotation of the various capstans.

In addition to the means just described for advancing the wire W, the shaft **154** of the capstan **117***a* is provided with an additional gear **155** to drive a chain **156** which drives a shaft **157** having a gear **157***a* receiving the chain **156** whereby to drive the finishing block **118** with which driving connection may be made through the medium of a clutch **158** actuable through a hand lever **159**. In operating the finishing block **118**, the wire is wrapped a sufficient number of times about the block **118** so that it will not slip circumferentially and so that the wire assumes the same speed as that of the surface of the finishing block **118**. Thus, this finishing block controls the flow of wire through the machine when the clutch **158** is engaged, whereas there is a certain amount of slippage of the wire on all of the capstans.

The actual drawing of the wire traveling through the described system of capstans is effected through the medium of a series of dies **160** (Figs. 7 and 8), a set of plural dies **160** for each pair of capstans being mounted on a supporting bracket **162** carried by an upstanding longitudinally extending partition wall **163** carried within the housing **110**, each die, which may be of more or less conventional tungsten carbide structure, being fixed in a receiving slot **164** in the respective bracket **162**. In the form shown there is a die for the descending strand between each set of capstans as it descends from the last

track 121 of the various capstan units separated by the lands 122. Thus, the last wire strand passing from one diameter of a capstan unit downward to that unit (of the underlying capstan) of the next larger diameter passes through a drawing die 160. In other words, in the form shown with four pairs of capstans, each capstan having three units of different diameters, there are twelve dies, the wire diameter being reduced in each die, and the wire length being correspondingly increased and compensated for by the increased rotation speeds of the various capstans, as previously described. The wire W having passed through the last set of the dies then passes around the largest unit of the lower capstan 117*a*, then up over the largest unit of the upper capstan 117, thence through a final die and guide 165 (Fig. 7) and around the finishing block 118 several times as above mentioned, whence it passes to the final spooling unit 20 of the apparatus.

In operating the wire drawing machine just described, it is apparent that one strand of wire never contacts another strand inasmuch as each strand lies on its own track 121 between adjacent groove-forming discs 120. Thus, there is no axial sliding of wire on a capstan surface. This provision of an individual track for each wire strand on a capstan is a great advantage in facilitating the effective drawing action on the wire by a capstan surface which is always traveling at a speed greater than that of the wire at any given contact position, because adjacent wires cannot pile up, even when relatively deep grooves are worn in the capstan surface. By this arrangement wire breakage common in other forms of drawing apparatus is avoided. In starting up the present wire drawing machine, the clutch 158 is disengaged. The entire machine is then brought up to speed by merely starting the alternating current motor M with the transmission 128 in a preselected gear. The clutch 158 is then engaged, and this brings the finishing block 118, and consequently the wire, up to the desired speed at a controlled rate of acceleration. Inasmuch as, before the clutch 158 is let in, the wire remains stationary although the capstans rotate at proper speed, the wire is gradually brought up to speed by the finishing block 118 as the clutch 158 is let in, and this gradually developed movement avoids dangerously higs stresses tending to break the wire, as in the case where the wire must be broken loose from various capstan surfaces in effecting the required slippage. This avoids the necessity for a variable speed motor. In addition to the function of the clutch 158 as just described, this clutch also assists in coordinating the speed of the wire leaving the drawing machine with the speed of the spooling machine constituting the last unit 20 of the present apparatus, as both of these machines approach their normal operating speeds. In practice, during the wire drawing operation, the capstan surfaces and the dies 160 are lubricated as by means of a sprayed lubricant introduced from one or more upstanding spray pipes such as indicated by the spray pipe 166 seen at the left of Fig. 7, and jets supplying the dies 160, which liquid lubrication is in addition to the protecting or lubricating effect of the soft plated metal on the wire.

Wire spooling mechanism

After the wire W leaves the finishing block 118 of the wire drawing mechanism 19 in the housing 110, it passes to a guide roller or a pulley 170 (Figs. 1*a* and 10) at the top of a standard 171 of the wire spooling mechanism. From the pulley 170 the wire W passes downward through a vertically disposed hollow shaft 172 which is both rotatable and vertically shiftable. The wire upon leaving the lower end of the hollow shaft 172 then passes immediately around the first of a series of small guide pulleys 173, 174 and 175 carried by a transversely disposed rotating spooling arm 176 fixed on the lower end of the rotating hollow shaft 172. The arm 176 has at its outer end a depending portion 176*a* fixedly mounted thereon, the guide pulley 174 being mounted adjacent the joint between the two portions and the pulley 175 being mounted at the lower end of the portion 176*a* in position to travel vertically opposite a stationary spool 178 resting upon the floor or other convenient support 179 in alignment with the axis of the hollow shaft 172 for wrapping of the wire W upon the spool 178 by rotation of the arm 176 with its hollow shaft 172. The stationary spool 178 may be centered as by means of an upstanding stud 180 anchored in the support 179, and the spooling arm 176, 176*a* is desirably balanced in its rotation by means of an oppositely extending balancing arm 181.

The spooling mechanism is principally contained in a housing 184 resting upon a table or similar support 185 and is driven by a motor 186 also resting upon the table 185 and having a shaft 186*a* extending into the housing 184 and appropriately borne by one of the walls of such housing.

The spooling mechanism of this unit 20 includes not only means for rotating the hollow shaft 172 and the spooling or winding arm 176 but also includes means for vertically reciprocating such shaft 172 and arm 176 automatically in order to cause the lowermost guide roller or pulley 175 to feed the wire progressively up and down along the spool 178.

Rotation of the hollow shaft 172 by the motor 186 is effected through the medium of a beveled gear 188 fixed on the motor shaft 186*a* and a beveled gear 189 fixed on a sleeve 190 within which the hollow shaft 172 is disposed for reciprocating movement of the shaft. Such reciprocating movement is permitted by reason of slots 192 in opposite sides of the sleeve 190 and a drive pin 193 extending transversely through the hollow shaft 172 and having its ends working in the slots 192, the ends of the slots defining the limits of movement of the shaft 172 in opposite directions. The lower end of the sleeve 190 is suitably borne adjacent the bottom of the housing 184 by appropriate bearing means such as indicated at 94.

To effect reciprocation of the hollow shaft 172, a portion of the sleeve 190 above the beveled gear 188 has fixed thereon a lower gear 195 and an upper gear 196, and at its upper extremity it is nested in another gear 198 which is stepped and has its upper collar portion 198*a* carried within any appropriate bearing indicated at 199.

For the purpose of effecting the incidental necessary reversing of the movements of the hollow shaft 172, the upper end of such shaft 172 has secured thereon a trip 200 in the form of an annular flange shown as being secured between nuts or hub portions 201 and 202 adjustably fixed on the hollow shaft 172. The flange 200 always has a circumferential portion lying between an upper stop 203 and a lower stop 204 on a reversing rod 205 which parallels the hollow shaft 172 and projects downward into the housing 184 where its lower portions are suitably borne. The upper end of the reversing rod 205 is borne conveniently in an overhanging portion 206*a* of a bracket member 206 which is anchored to the top plate 184*a* of the housing 184. A spring-controlled throw arm 208 is pivoted at 208*a* on the bracket 206 and operates as a snap arm under the influence of a compression spring 209 conveniently disposed about a conventional compressible positioning stem 209*a* whose ends are respectively borne in notches in the end of the arm 208 and in the upstanding portion 206*b* of the bracket 206, so that when the arm 208 is swung to either position, it is maintained in such position by the compression spring 209. The opposite end of the arm 208 is provided with a laterally extending stud 210 which projects into an annular groove in a collar 210*a* fixed on the reversing rod 205, at a position intermediate the two stops 203 and 204. Each of the stops 203 and 204 is approximately cushioned by a spring 212 whose opposite end bears against a collar 213 adjustably fixed on the reversing rod 205. The portion of the rod 205 depending into the housing 184 alongside the reciprocating hol-

low shaft 172 is received within a non-reciprocating sleeve 215 whose ends are non-reciprocatingly borne within the housing 184, as by a bearing 216 at the bottom and a bearing 217 at the top. This sleeve 215 carries a driven gear 218 in a lower position to mesh with and be driven by the lower gear 195 on the hollow shaft 172, an overlying gear 220 meshing with and being driven by the gear 196 on the hollow shaft 172, and an upper gear 222 which is fixed on the sleeve 215 in position against the upper bearing 217 and in meshing engagement with the upper gear 198 on the hollow shaft 172, whereby this fixed gear 222 drives the gear 198. The gear 198, which lies above the upper end of the sleeve 190 on the hollow shaft 172 is internally threaded to engage upon external threads on the upper portion of the hollow shaft 172 as indicated at 223. The gear 198 being borne at its under side on the top of the non-reciprocating sleeve 190 and being borne at its upper side against an appropriate bearing part at the top of the cover 184a of the housing 184, causes the hollow shaft 172 to be moved up or down within the gear 198 in accordance with the relative speeds of rotation of the gear 198 and the hollow shaft 172 as driven by the rotating sleeve 190 and its beveled gear 189.

The sleeve 190 is continuously rotated at a desired speed inasmuch as the motor 186 is essentially a constant torque motor (as one of adjustable resistance and variable speed), and as a consequence the hollow shaft 172 is rotated at the necessary speed by reason of the driving connection of the through pin 193 with the shaft 172 and the sliding engagement of the ends of such pin in the slots 192 of the sleeve 190, whereby to take wire from the wire drawing machine as required.

It will be apparent that, by rotating the gear 198 on the threads 223 of the hollow shaft 172 at a faster rate than the rotation of the shaft 172 (and in the same direction) the shaft 172 will be lowered, and by rotating the gear 198 at a slower speed than the shaft 172 is rotated, the latter will rise. The speed of rotation of the gear 198 is determined by whichever of the gears 218 and 220 is automatically selected for driving the sleeve 215 about the reversing rod 205 and hence driving the upper gear 222 of this series which is fixed on the sleeve 215, as by a set screw as indicated, and meshes with the gear 198 working on the threads 223. Selection as between the gears 218 and 220, both of which are held in the position shown by means of a collar 224 fixed on the sleeve 215, is accomplished through the medium of a round pin 225 (Figs. 10 and 11) fixed in the rod 205 and extending through oppositely disposed slots 226 in the sleeve 215 and beyond the sleeve 215 into position to engage either in flared slots 228 in the gear 220 or into flared slots 229 in the underlying gear 218. Thus, the flared slots 228 and 229 are opposed, as indicated in Fig. 10, so that the pin 225, as the reversing rod 205 moves up or down, passes from one gear to the other. The flaring of the slots facilitates entering of the pin 225 into such slots as the parts rotate, the bottoms of the slots being appreciably wider than the diameter of the pin in order further to facilitate entry. Desirably, a spacing washer 230 is disposed between the gears 218 and 220 and is stepped to overhang the slotted upper portion of the lower gear 218 which is of correspondingly reduced diameter. The central portion of the washer 230 is provided with an opening adequate to pass the drive pin 225 as it moves from one gear to the other in the slots 226 of the sleeve 215, and the thickness of such central portion of the washer being greater than the thickness of the pin 225 so that such pin must disengage one of the gears 218 and 220 before engaging the other gear. The depth of the slots 226, of course, measures the amount of throw of the reversing rod 205 and of the reversing pin 210 in the actuating end of the snap arm 208 working in the annular groove of the trip collar 210a fixed on the rod 205. It will be appreciated that the action of the compression spring 209 maintains the rod 205 in the respective upper and lower tripped positions.

In the operation of this tripping and reversing mechanism, the movement of the trip flange 200 up and down is effected through the ascending and descending movement of the hollow shaft 172 under the action of the gear 198 mounted on the threads 223 thereof, as previously described. The amount of reciprocation of the trip flange 200 is a measure of the amount of reciprocation of the rotating spooling arm 176 and its lowermost guide pulley 175 to move the wire W back and forth between the flanges of the spool 178. Assuming that the shaft 172 and spooling arm 176 are moving downward in Fig. 10, this motion will continue until the trip flange 200 strikes the lower stop 204 and compresses the cushioning spring 212 sufficiently to move the reversing rod 205 downward from its elevated position shown and against the power of the compression spring 209 to trip the snap arm 208. Each spring 212 must be sufficiently strong, when compressed as described, to move the rod 205 and the pin 225 through the space provided in the spacing washer 230 and into engagement with the respective gear slot. Under that action, the reversing rod 205 will have been moved from its uppermost position to its lowermost position, thereby moving the drive pin 225 in the rod 205 downward through the slots 226 of the sleeve 215 and from the flared slots 228 of the gear 220 to the flared slots 229 of the lower gear 218. Thus, the gear 218, which is driven by the gear 195 fixed on the sleeve 190, now acts to drive the sleeve 215 with the reversing rod 205 and change the speed of rotation of the upper drive gear 222 and hence the speed of rotation of the threaded gear 198 actuating the hollow shaft 172. As a consequence of this change, the shaft 172 and the trip flange 200 thereon begin to move upward, thereby reversing the direction of winding on the spool 178, which continues until the trip flange 200 engages the upper stop 203 on the reversing rod 205 and reversal of operations is thereby effected. Variation in the amount of reciprocation of the spooling arm 176 to accommodate the length of any given spool 178 is accomplished by changing the setting of the stops 203 and 204 on the reversing rod 205, so that the excursion of the trip flange 200 is thereby decreased or increased.

As will be apparent from an inspection of the relative sizes of the gears 195 and 218 constituting a lower pair and of the meshing gears 196 and 220 constituting an upper pair, the larger gear 195 of the lower pair rotates its smaller engaged companion gear 218 at a faster rate than the smaller gear 196 rotates its engaged larger companion gear 220. Thus, when the drive pin 225 in the reversing rod 205 and its sleeve 215 engages the upper and larger gear 220, the sleeve 215 and the top fixed gear 222 are driven at a slower rate, thereby driving the feed gear 198 upon the threads 223 of the hollow shaft 172 at a slower rate than when the drive pin 225 is engaged with the flared slots 229 of the bottom gear 218. These gear relationships are such that, when the gear 220 is engaged the feed gear 198 rotates more slowly than the constant-speed hollow shaft 172 rotates; whereas, when the smaller gear 218 is engaged by the pin 225, the feed gear 198 is driven at a faster rate of rotation than that of the hollow shaft 172. By the above described means the wire W is progressively wrapped around the spool 178 by rotation of the spooling arm 176 in a clockwise direction (as viewed from above and as indicated by the arrow 240), the reciprocating movement of the arm 176 and the hollow shaft 172 on which it is supported being automatically reversed at the upper and lower ends of the spool through the operation of the trip flange 200 against the stops 203 and 204 on the reversing rod 205. By this rotational action, one twist is necessarily produced in the wire W itself for each turn about the spool 178. As a consequence, when the wire is subsequentially axially unwound from the spool, the spool

may remain stationary, as it was during the spooling operation just described, the twists being automatically eliminated as the unspooling operation progresses, thereby avoiding all tendency of the wire to kink as is normally the case where wire is drawn endwise off a non-rotating spool.

From the preceding description of the machine in its entirety, it is apparent that wire of relatively large diameter taken from the supply coil **25** at the beginning of the system, after having scale thereon cracked by passage through the series of rolls **38**, is completely descaled by the electrolytic descaling operations in the tanks **53** and **55** of the descaling units **16** and **17**, wherein opposite charges are successively applied to the wire undergoing treatment; that the wire is easily given a light copper or other suitable metal plating in the tank **90** of the unit **18**; that the wire is then efficiently drawn to the required smaller diameter in the drawing apparatus of Figs. 6 to 9 contained in the housing **110**; and that the drawn steel wire is then readily spooled by the rotating mechanism of the unit **20** to place a twist therein for each revolution of the spooling arm **176** through the means of Figs. 10, 11 and 12. In this manner a very fine, drawn steel wire, adequately cleaned and plated, is provided in properly spooled condition ready for subsequent use such as for the making of small steel springs, the weaving of fly screen, and the like.

Since various modifications within the scope of the generic invention herein disclosed will be apparent to those skilled in this art, it is intended to cover all such variations as fall within the scope of the patent claims.

I claim as my invention.

1. In wire-drawing apparatus: a unitary wire-receiving capstan having a plurality of cylindrical steps of different diameters, each of said steps being provided with a plurality of separate circumferential tracks, each track being adapted to receive only a single strand of wire, and track-separating means between adjacent tracks on each step.

2. Apparatus as defined in claim 1 wherein said capstan comprises a plurality of track-forming discs, the outer peripheries of which define said tracks, and intervening spacer discs of greater diameter than the track-forming discs and constituting said track-separating means.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,893,544 July 7, 1959

Kenneth F. Russell

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 33, for "elevator 59" read -- elevator 69 --; column 6, line 28, after "such" strike out "as"; column 7, line 52, for "spacer disc" read -- spacer discs --; column 10, line 72, for "approximately" read -- appropriately --.

Signed and sealed this 15th day of December 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents