United States Patent

[11] 3,593,553

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[21] Appl. No. **744,366**
[22] Filed **July 12, 1968**
[45] Patented **July 20, 1971**
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Continuation-in-part of application Ser. No. 432,597, Feb. 15, 1965, now Patent No. 3,392,565.

[54] **METHOD AND APPARATUS FOR ROLLING TUBES**
14 Claims, 29 Drawing Figs.

[52] **U.S. Cl.** **72/209**
[51] **Int. Cl.** **B21b 17/10**
[50] **Field of Search** 72/208, 209, 201, 367, 368, 370, 120, 428

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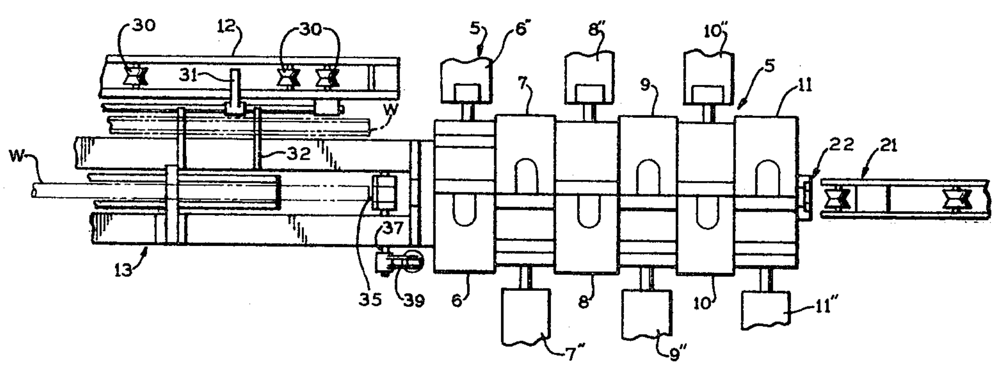
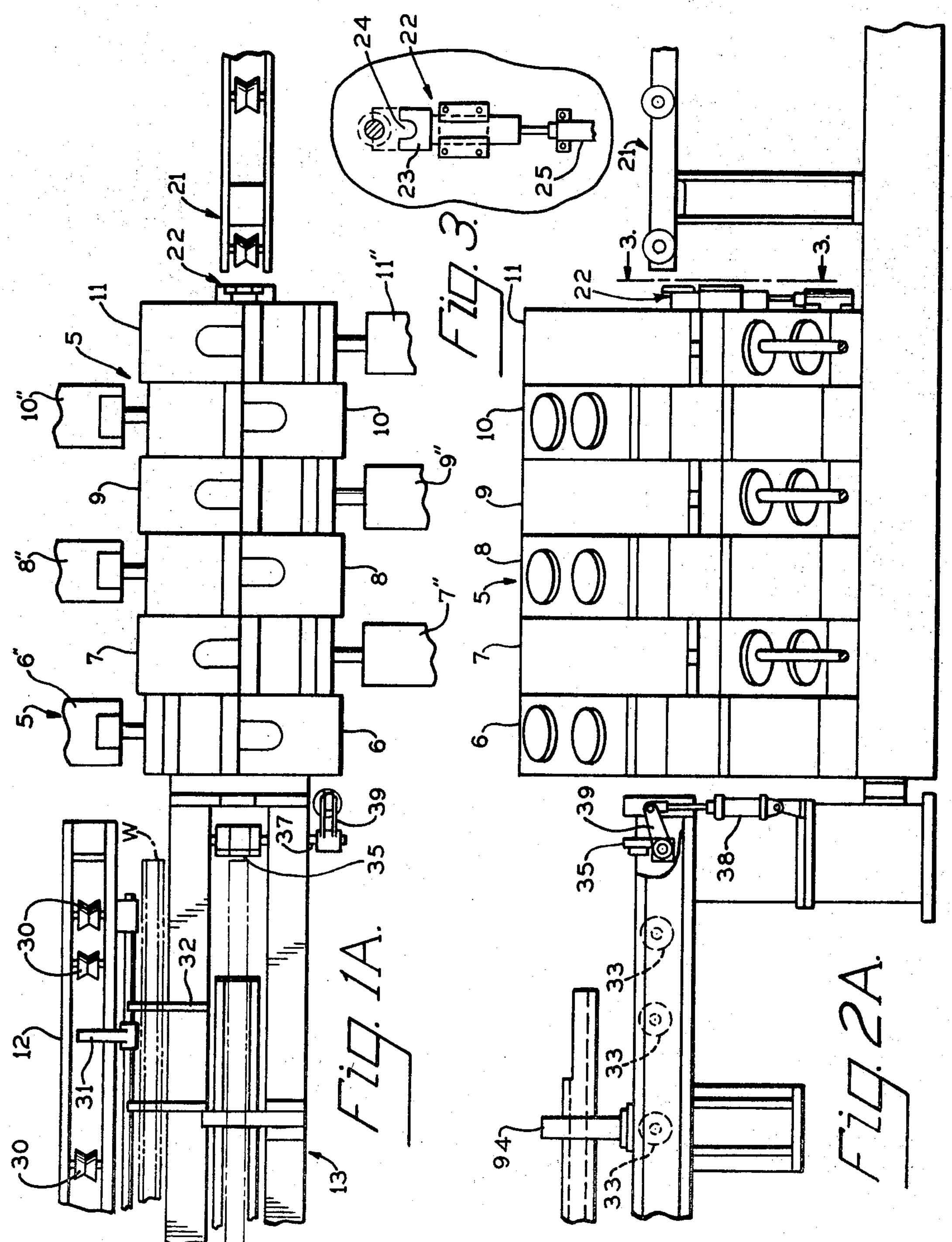
ABSTRACT: A tube mill and a method of rolling tubes in which tubular workpieces are supported by a mandrel as they pass through a series of roll stands that have grooved rolls that reduce the wall thickness and greatly elongate the workpieces during their passage through the mill. The movement of the mandrel is controlled to distribute wear on the mandrel throughout a substantial area and to facilitate entry of the workpieces into the mill. The mandrel is periodically rotated to distribute wear on the mandrel. A construction is provided for quick interchange of mandrels. The positions of the mandrel and the workpiece are indicated to the operator during the rolling operation so that he can change the operation of the mill if that is desirable.





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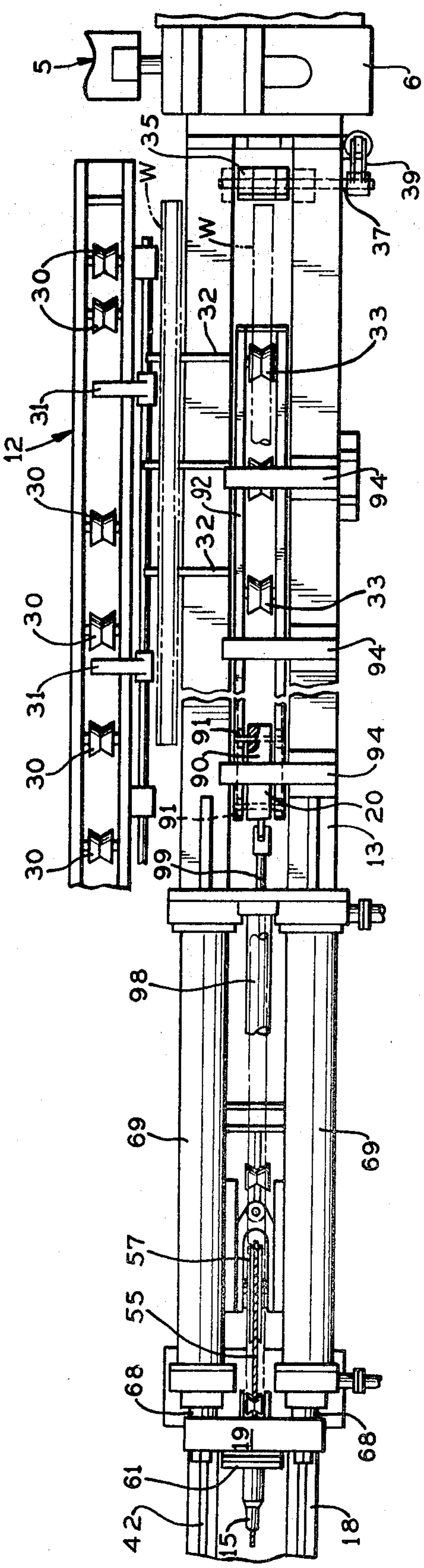

Fig. 1B.

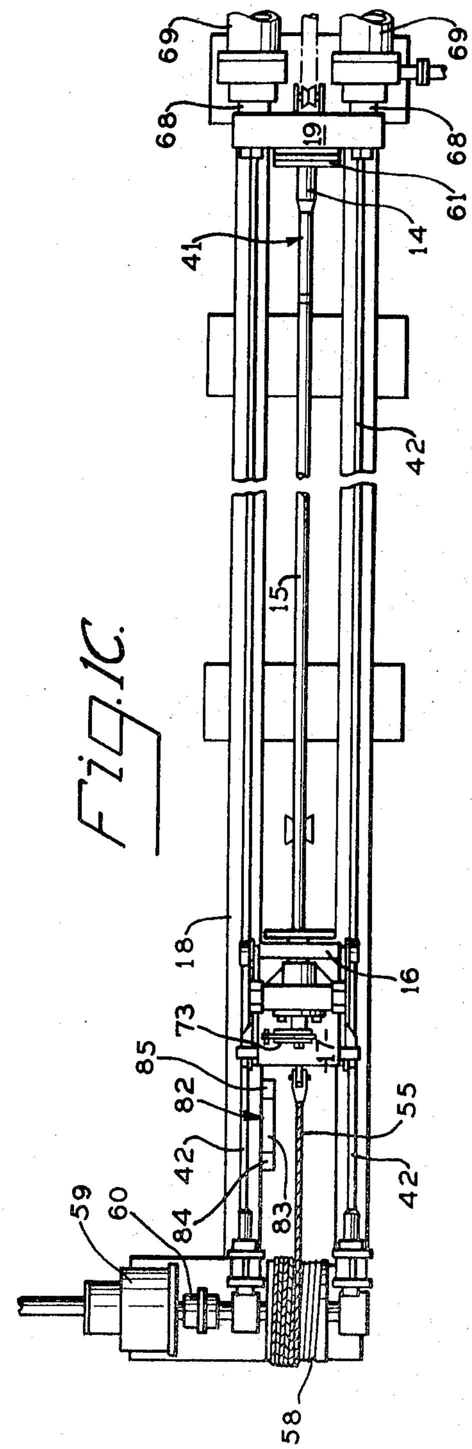

Fig. 1C.

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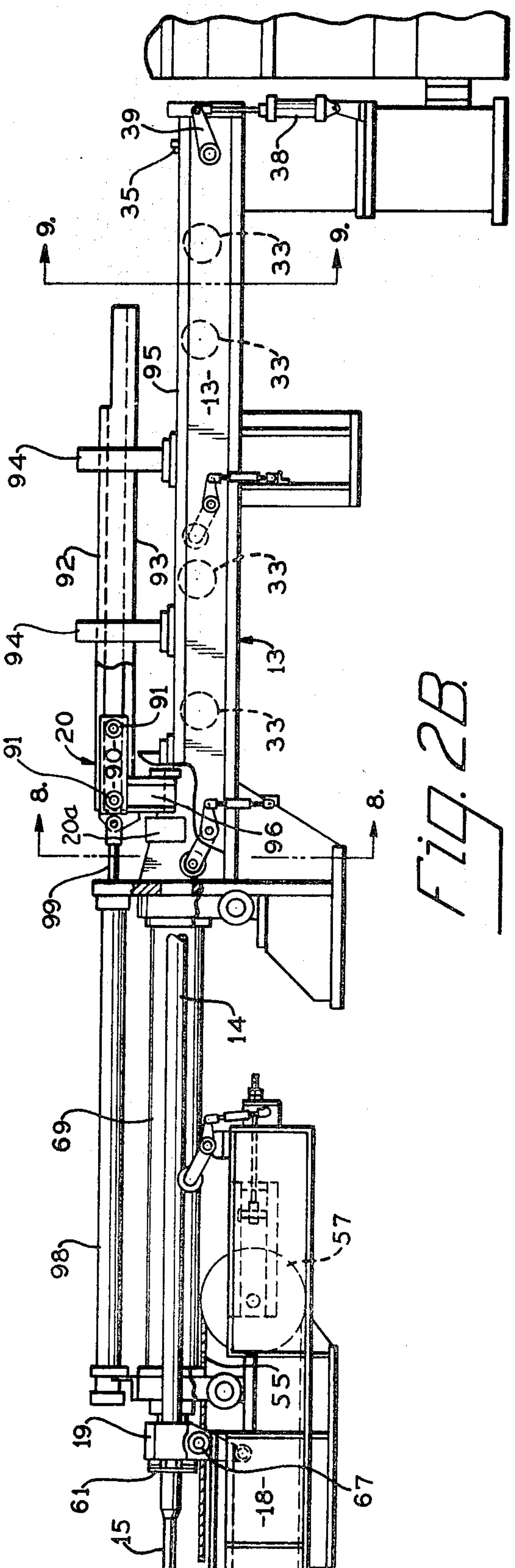

Fig. 2B

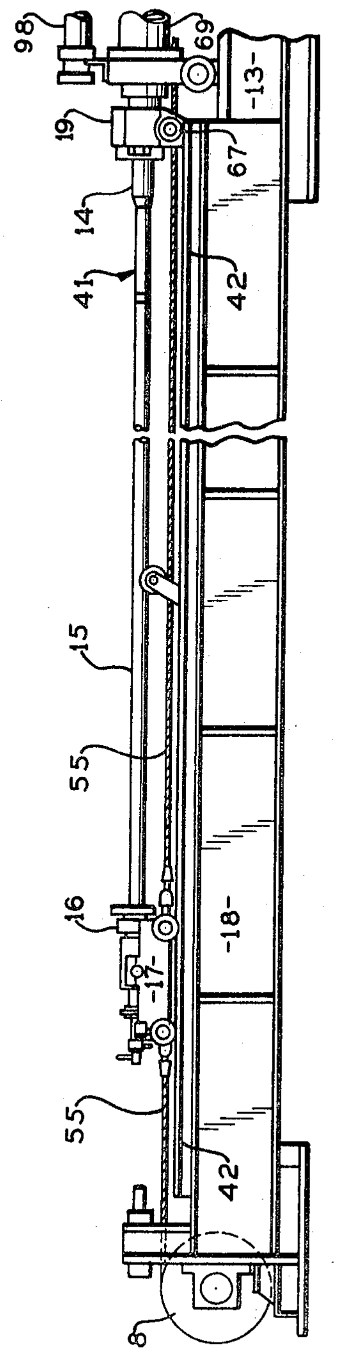

Fig. 2C

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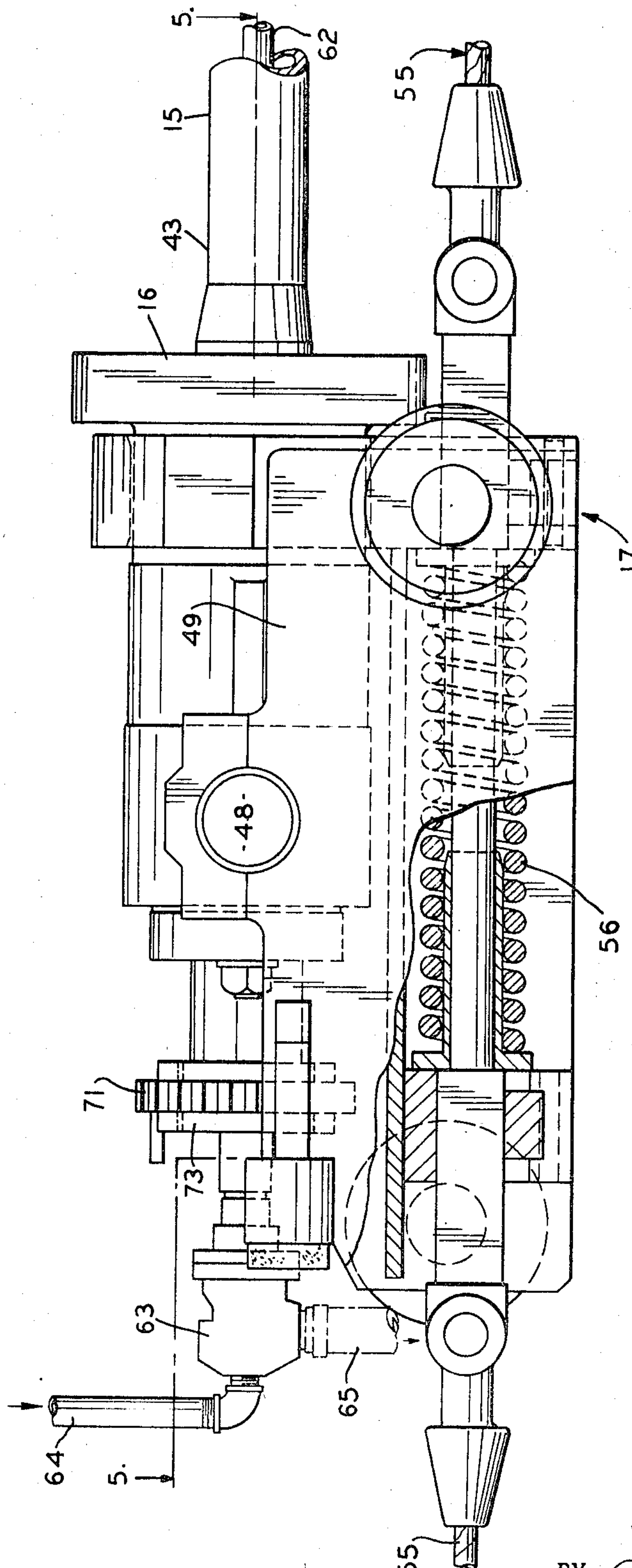

Fig. 4

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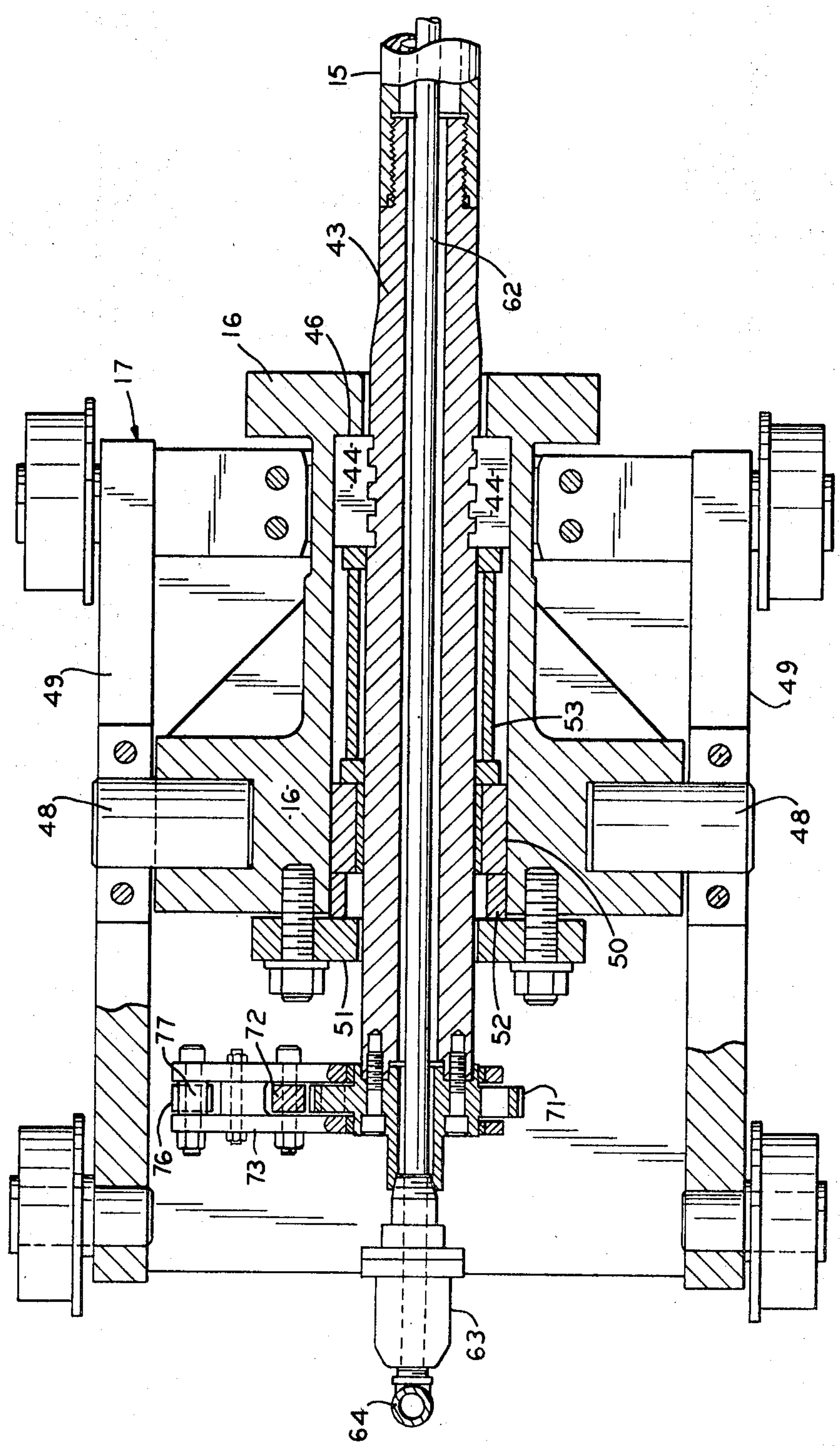

Fig. 5

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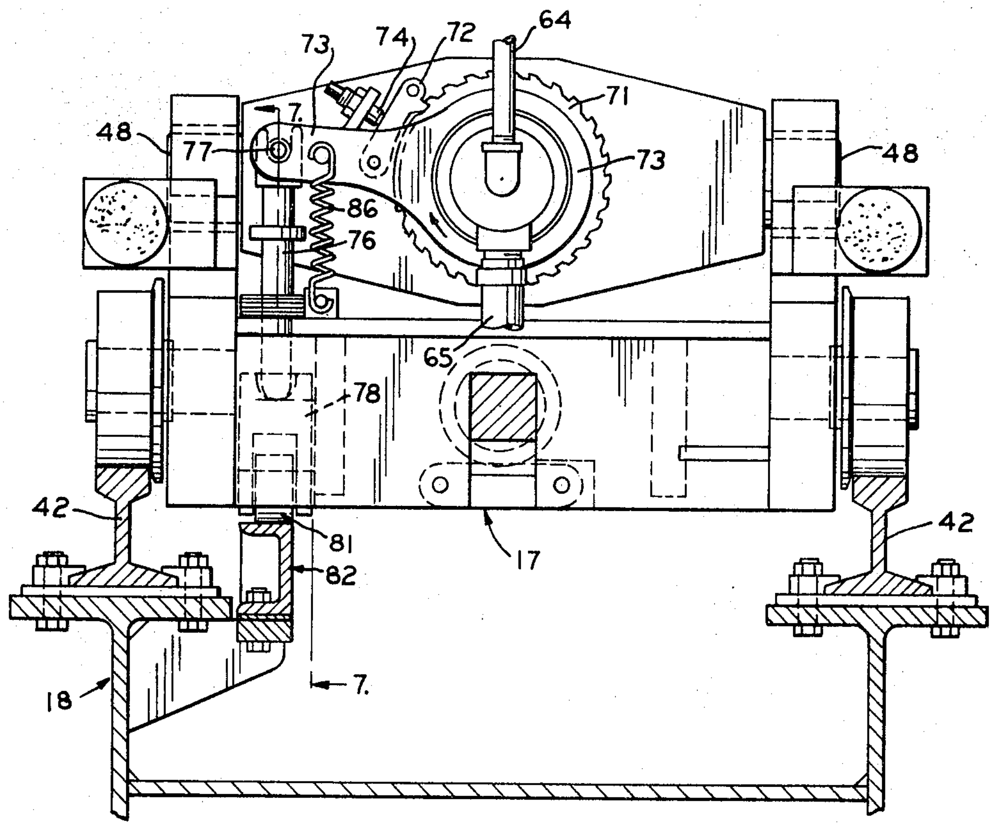

Fig. 6.

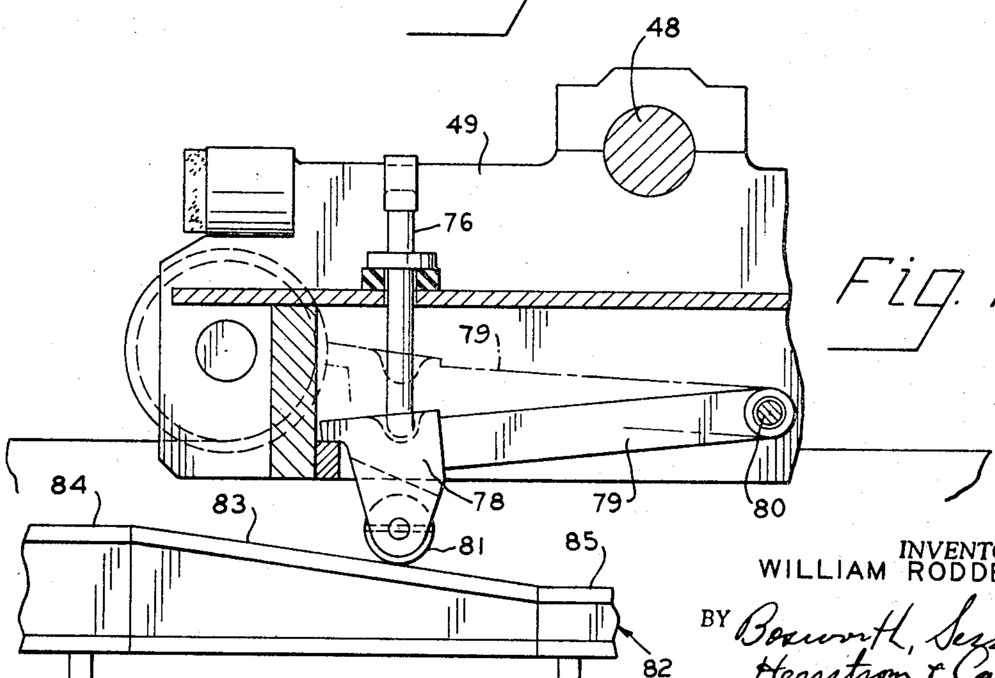

Fig. 7.

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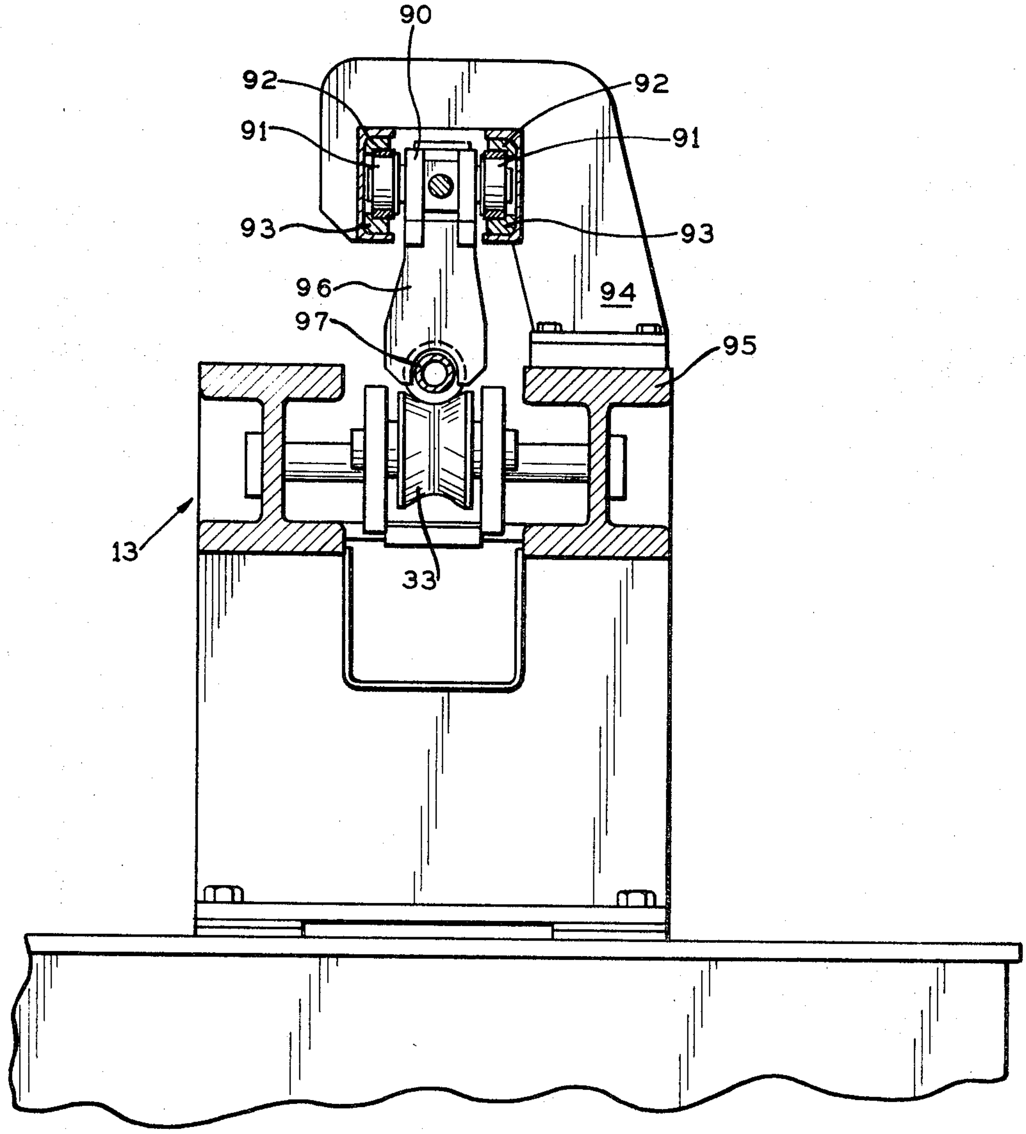

Fig. 8.

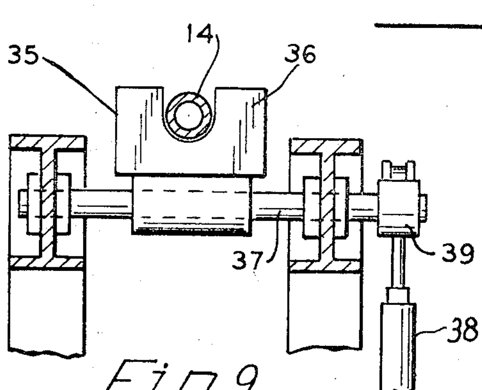

Fig. 9.

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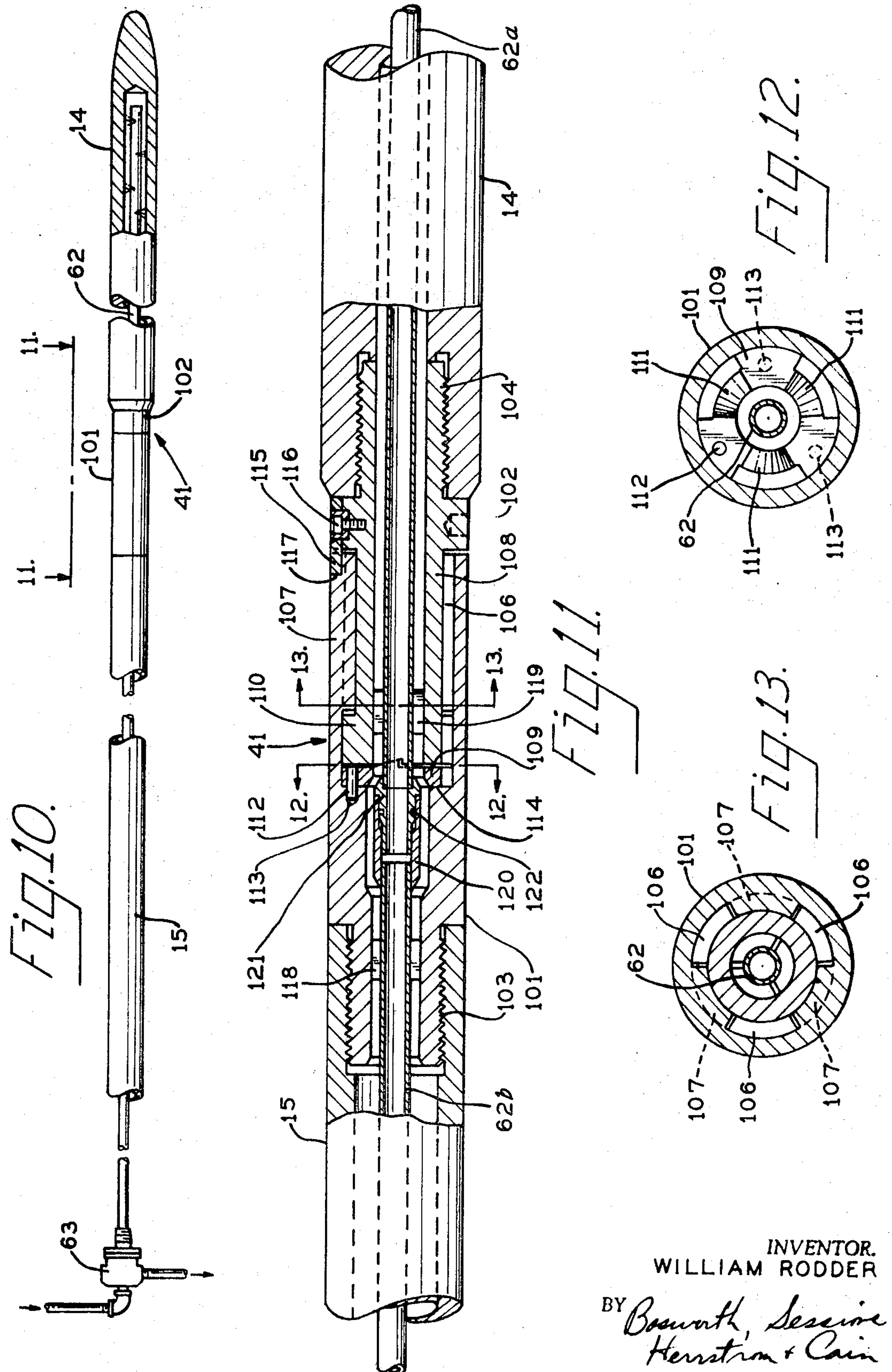

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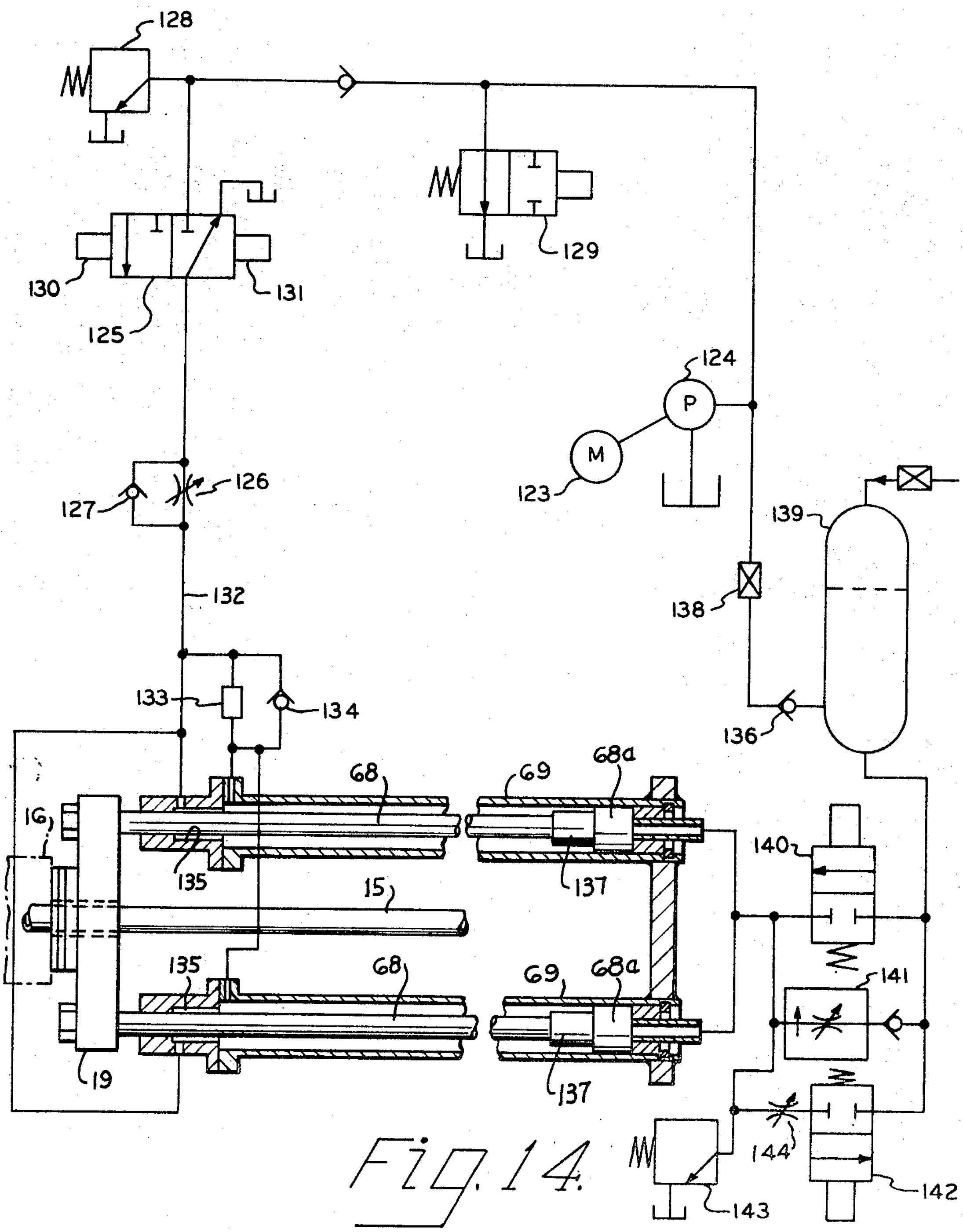

Fig. 14.

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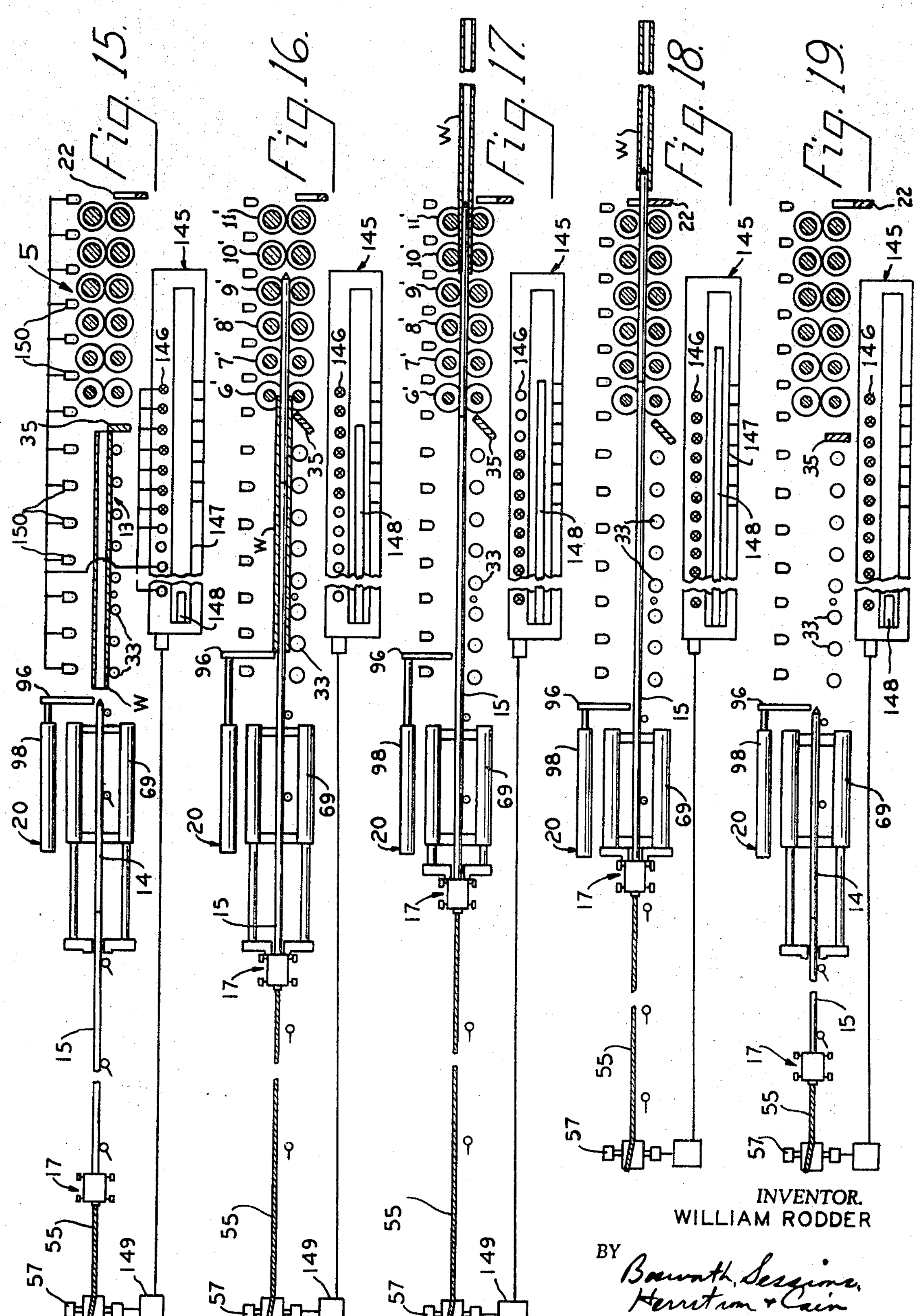

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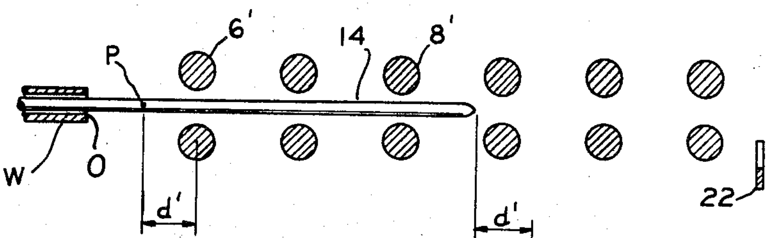

Fig. 20.

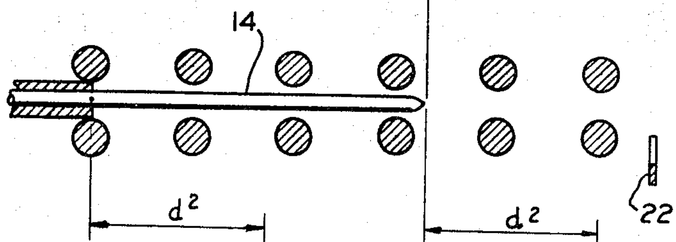

Fig. 21.

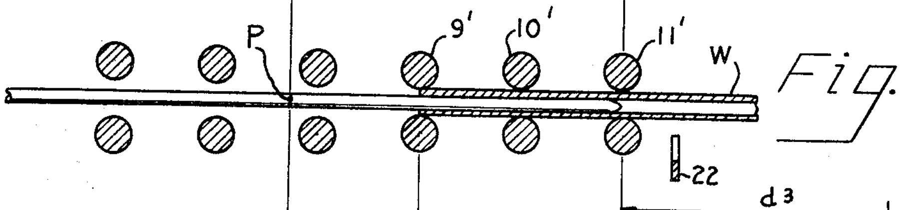

Fig. 22.

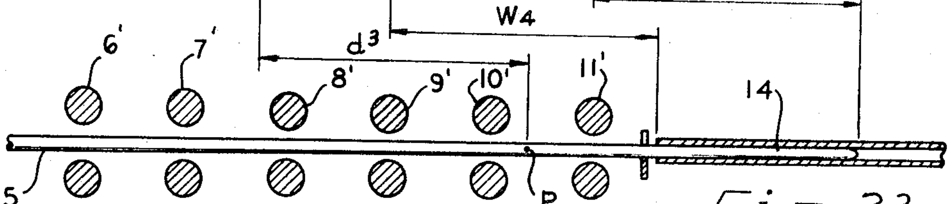

Fig. 23.

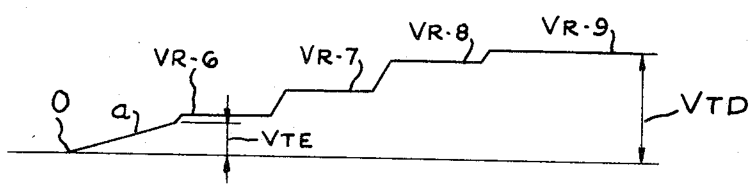

Fig. 24.

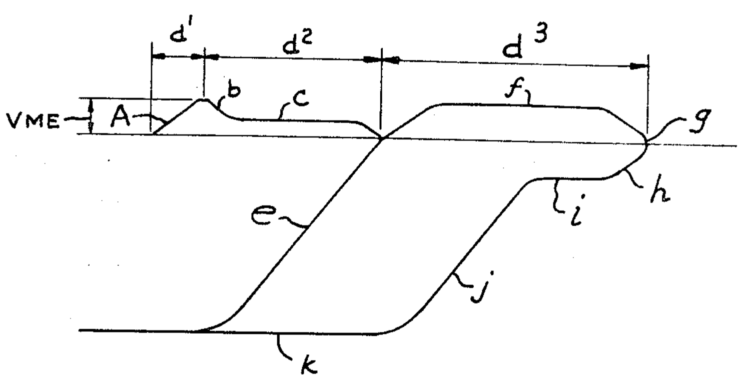

Fig. 25.

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METHOD AND APPARATUS FOR ROLLING TUBES

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of copending application Ser. No. 432,597, filed Feb. 15, 1965, U.S. Pat. No. 3,392,565, issue date July 16, 1968.

BACKGROUND OF THE INVENTION

This invention relates to the manufacture of seamless metal tubing and more particularly to an improvement or further development of the plug or mandrel mill and the method of rolling tubular blanks over a mandrel to reduce their wall thicknesses and diameters and greatly to elongate them that is disclosed and claimed in my aforesaid copending application.

That application discloses a method and apparatus for rolling pierced shells or like workpieces in which many of the problems inherent in the construction and operation of a conventional plug mills and full floating mandrel mills are obviated as explained more fully therein. Briefly, that application discloses a plug or mandrel mill embodying a plurality of roll stands, so that substantial reduction in wall thickness and diameter and consequent substantial elongation of the workpiece can be obtained. An elongated internal plug or mandrel is used in combination with the roll stands, and the motion of the mandrel is controlled so that the mandrel moves with respect to the roll stands and the workpiece. The motion of the mandrel is controlled by a hollow mandrel rod to which the mandrel is secured and through which a cooling fluid is circulated so that the mandrel is maintained at a reasonable temperature and can be used for long periods of time without replacement. The movement of the mandrel distributes the wear throughout a large part of the length of the mandrel, gives lubrication during the rolling operation, and gives a better finish to the interior of the tube than can be obtained in conventional plug and floating mandrel mills.

It has also been proposed to control the movement of mandrels in mandrel mills at the initial stage of the rolling operation as shown in the peters Peters Pat. No. 970,263. A mill in which the mandrel is withdrawn from the tube in a direction opposite to the direction of the movement of the tube through the mill is shown in the Peters U.S. Pat. No. 954,880. Other patents showing efforts to improve the tube rolling mills are French Pat. No. 1,322,304, in which the control of the movement of a mandrel with respect to a mill is suggested, and French Pat. No. 1,224,862, which utilizes a stepped mandrel that may be permitted to advance slightly during rolling. These patents, however, do not present practical solutions to the problems solved in my aforesaid application.

SUMMARY OF THE INVENTION

A general object of the present invention is the provision of a mill for rolling tubular workpieces such as pierced shells and a method of operating the mill in which many of the problems inherent in the construction and operation of conventional plug mills and mandrel mills of the type heretofore known are obviated. More specific objects are to provide a mandrel mill embodying a plurality of roll stands (a "multistand" mill) and a method of operating the same wherein the movement of the mandrel is controlled to facilitate the entry of the pierced shell into the mill; the provision of a multistand mandrel mill in which the mandrel is rotated as well as moved longitudinally to distribute the wear on the mandrel and increase the life of the mandrel; the provision of a multistand mandrel mill in which mandrels can be changed with comparative rapidity when necessary because of wear or in order to accommodate different sizes of tubing; the provision of a multistand mandrel mill in which the operator is given an indication of the position of the mandrel with respect to the mill during the operation of the mill, and the provision of a multistand mandrel mill in which the operator receives an indication of both the position of the mandrel and the position of the workpiece during the operation of the mill.

Briefly, the above and other objects of the invention are attained by (1) the provision of a mechanism for controlling the movement of the mandrel that is arranged to advance the mandrel, preferably at approximately the same speed as the speed of the tube leaving the first roll stand, at the instant that the shell is entered into the first roll stand, thereby facilitating entry of the shell into the roll stand and reducing shock on the mechanism; (2) the provision of a mechanism that rotates the mandrel a fraction of a turn between successive rolling operations, thereby to distribute circumferentially the wear on the mandrel; (3) the provision of a quickly detachable connection between the mandrel proper and the mandrel supporting bar so that mandrel or plugs can be interchanged with rapidity and the connections for cooling fluid and lubricant, if any, being made automatically at the time that the mandrels are interchanged, and (4) the provision of an indicator disposed at the operator's station or console and actuated by the mandrel advancing and retracting mechanism that shows the position of the mandrel with respect to the mill at all times. Preferably, the position of the shell in the mill is also indicated on the operator's console. These indications make it possible for the operator to vary the rate of movement of the mandrel with respect to the mill if that should appear to be desirable.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which illustrate a preferred form of the invention:

FIGS. 1A, 1B and 1C taken together constitute a top plan view somewhat diagrammatically showing an apparatus embodying the present invention;

FIGS. 2A, 2B and 2C taken together constitute a somewhat diagrammatic side elevational view of the apparatus of FIG. 1;

FIG. 3 is an end elevational detail showing a stripping mechanism, the view being taken generally as indicated by the line 3–3 on FIG. 2A;

FIG. 4 is a side elevational view on an enlarged scale illustrating the carriage that supports the rear end of the mandrel bar;

FIG. 5 is a horizontal sectional view taken as indicated by line 5–5 of FIG. 4;

FIG. 6 is an end view of the carriage that supports the rear end of the mandrel bar showing the mechanism for rotating the mandrel bar;

FIG. 7 is a partial sectional view taken as indicated by line 7–7 of FIG. 6;

FIG. 8 is a partial sectional view on an enlarged scale taken on line 8–8 of FIG. 2B and illustrating the pusher for pushing a workpiece into the mill;

FIG. 9 is a fragmentary sectional view taken along line 9–9 of FIG. 2B and illustrating a stop for restraining a shell against movement toward the mill while the mandrel is being passed through it;

FIG. 10 illustrates the mandrel and its supporting mandrel bar;

FIG. 11 is a sectional detail showing the quick disconnect connection between the mandrel and the mandrel bar;

FIGS. 12 and 13 are sectional views on an enlarged scale taken on lines 12–12 and 13–13 of FIG. 11, respectively;

FIG. 14 is a hydraulic circuit diagram showing a hydraulic system for controlling the mandrel movement;

FIGS. 15, 16, 17, 18 and 19 are diagrams illustrating successive steps in the rolling of a tubular blank on the apparatus and according to the preferred method;

FIGS. 20, 21, 22 and 23 are diagrams showing the relative positions of the shell and mandrel during the rolling sequence, starting with the shell and ready to enter the first roll stand as shown in FIG. 20 and concluding with the rolling operation having been completed as shown in FIG. 23;

FIG. 24 is a velocity diagram indicating the speed of the shell at various stages in its passage through the mill; and

FIG. 25 is a velocity diagram illustrating the speed of movement of the mandrel at corresponding times during the rolling operation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

General Arrangement: As shown particularly in FIGS. 1A, 1B, 1C, 2A, 2B and 2C, an apparatus embodying the present invention is generally similar to the apparatus illustrated and described in my copending application aforesaid and comprises a mill indicated in general at 5 and having roll stands 6, 7, 8, 9, 10 and 11 in which the actual reduction and elongation of the workpieces W takes place. The workpieces are ordinarily in the form of pierced shells that are produced by a piercing mill (not shown). They are deposited on a receiving table indicated at 12 and from this are transferred to an inlet table 13 which supports the workpieces W in alignment with and immediately adjacent the inlet end of the mill 5. A shell or workpiece W, which is broken away to permit illustration of the receiving table, is shown in position on the receiving table in FIGS. 1A and 1B. A portion of the mandrel over which the workpiece W are rolled is shown at 14 in FIGS. 1C, 2B and 2C, but has been omitted from other figures for convenience of illustrating other components. The mandrel 14 is supported by a mandrel bar 15 and is advanced and retracted by a mandrel thrust block 16 that is supported by a carriage 17 on extension 18 of the inlet table. The carriage is moved toward and away from the mill on tracks 42 to advance and retract the mandrel. The mandrel 14 is movable from a position in which its forward end projects entirely through the mill to a position in which the forward end is retracted far enough from the entry end of the mill to permit the inlet table to receive a shell to be rolled.

During the actual rolling operation the mandrel thrust block 16 engages a mandrel movement control beam 19 that is also mounted for movement on the table extension 18, and which controls the motion of the mandrel within the mill immediately before and during the rolling operation. A tube pusher mechanism indicated generally at 20 is utilized to engage the rear end of a shell W that is in position on the inlet table 13 and to push the front end of the shell W into the first roll stand 6 of the mill 5. Lubricant may be sprayed on the exterior of the mandrel by a spray box 20*a* located between the pusher and the front end of the mandrel when the mandrel is in extreme retracted position. The pusher 20 is of different construction from the pusher shown in my copending application and is described below. Thereafter the tube is drawn through the mill by the action of the rolls; the friction of the tube on the mandrel 14 tends to draw the mandrel bar and associated mechanism along with the tube. This motion, however, is controlled by the mandrel movement control beam 19, as described below. After passing through the mill, the workpiece, which has been much elongated is discharged onto an outlet table 21, only a fragment of which is shown in the drawings.

In order to prevent rolled workpieces that stick to the mandrel from being drawn back toward the mill when the mandrel is withdrawn, a stripper mechanism 22, shown in FIG. 3, is disposed between the last roll stand 11 and the outlet table 21. This comprises a stripper plate 23 having a U-shaped recess 24 in its upper edge, the recess being large enough to receive the mandrel 14 but small enough to block movement of a rolled tubular workpiece through it. The plate 23 is raised and lowered by a fluid pressure cylinder 25 and is supported and guided by its movement by a guide 26. In use, if it appears that a rolled workpiece has stuck to the mandrel, the operator actuates the cylinder 25 to raise the stripper plate 23 to the position shown in broken lines in FIG. 3 after the trailing end of the workpiece has passed beyond the plate 23. The mandrel is then withdrawn by mechanism described below. The plate 23 blocks rearward movement of the workpiece and continued movement of the mandrel in the rearward or withdrawing direction results in the release and stripping of the workpiece from the mandrel. The plate 23 is then lowered preparatory to the rolling of the next workpiece.

The Mill: The mill proper is shown as being made up of six independently driven roll stands 6, 7, 8, 9, 10 and 11. The roll stands themselves may be of conventional construction, each embodying a pair of rolls 6′, 7′, 8′, 9′, 10′ and 11′, as shown in FIGS. 15 to 19. The rolls are grooved as shown, but for convenience of illustration the rolls are shown in these figures in elevation and as being disposed on horizontal axes; however, as illustrated in my copending application, aforesaid, the axes of the rolls are preferably at angles of 45° to the horizontal and the aces of the rolls in successive stands are at 90° to each other as is the usual practice in tube rolling mills of various types.

The rolls and the roll stands are driven by drive mechanisms 6″, 7″, 8″, 9″, 10″ and 11″ which are indicated diagrammatically inasmuch as they may be of conventional construction. The mill is described in somewhat greater detail in my aforesaid copending application and this description will not be repeated herein. It is pointed out, however, that the peripheral speed of the rolls must progressively increase from roll stand 6 through roll stand 9 because of the progressive elongation of the workpiece as it passes through the mill; as in any continuous rolling process the product of the cross-sectional area of tube and tube velocity must have the same value in each roll stand. The last two roll stands round up the work and, in the usual operation of the mill, strip the work from the mandrel.

Receiving, Inlet and Outlet Tables: Except for the manual control and tube pushing mechanism which are described in greater detail below the receiving, inlet and outlet tables (12, 13, and 21, respectively) are of simple and more or less conventional construction. They are, in general, similar to the corresponding parts disclosed in my said copending application and their operation is as described therein. Workpieces W are deposited upon the rollers 30 of the receiving table 12 and are transferred from the receiving table 12 to the inlet table 13 by a series of kick-out arms and bars 32. While on the inlet table the workpieces are supported by rolls 33.

The inlet table is also provided with a shell stop 35 (see FIGS. 1A, 1B, 2A, 2B and 9) that consists of a transversely extending member 36 having a U-shaped groove in it dimensioned to surround the mandrel 14 as shown in FIG. 9 but to engage the end of a workpiece that is resting on the rolls 33 of the inlet table 13. The member 36 is supported on a transverse shaft 37 and holds the tubular workpiece against movement toward the mill during the time that the mandrel is being passed through the workpiece and into the mill. The shaft 37 is rotated by a fluid pressure cylinder and piston mechanism 38 and crank arm 39 to move the member 36 out of the way when it is desired to advance a workpiece into the mill, and is rotated in the opposite direction to return the member into the position shown in the drawings before the mandrel is advanced through another workpiece.

Mandrel Bar, Thrust Block and Carriage: As mentioned above, mandrel 14 is positioned by the elongated mandrel bar 15 to which it is connected by a coupling as indicated at 41 in FIGS. 1C and 2C. Coupling 41 is shown in detail in FIGS. 10 to 13 and is described below. The rear end of the mandrel bar 15 is carried by the mandrel thrust block 16 which is mounted on carriage 17 that operates of tracks 42 on the table extension 18. The rolling forces exerted by the operation of the mill tend to draw the mandrel 14 through the mill. Since the rear end of the mandrel bar 15 is secured to the mandrel thrust block 16, the substantial forces exerted by the mandrel during rolling subject the mandrel bar only to stresses in tension. In order to transmit the tension forces from the mandrel bar 15 to the mandrel thrust block 16, the end of the mandrel bar 15 is threaded to a coupling member 43 as shown particularly in FIG. 5. This member is retained against longitudinal movement by a split sleeve 44 that in turn engages an internal flange 46 on the mandrel thrust block 16 that is supported by trunnions 48 in the side members 49 of the carriage 17.

The coupling member 43 extends rearwardly through the central opening of the mandrel thrust block 16 and is supported for rotation with respect to the mandrel thrust block not only by the split sleeve 44 by also by a bearing 50. The bearing 50 is secured in place and the coupling member 43 is held against rearward (away from the mill) longitudinal movement with respect to the mandrel thrust block **16** by a plate **51** that is bolted to the mandrel thrust block and by spacer sleeves **52** and **53**.

In order to move the carriage **17** toward and away from the mill and correspondingly to advance and retract the mandrel bar **15** and mandrel **14**, a cable drive mechanism for the carriage as shown in FIGS. **1B**, **1C** and **2B** and **2C** is preferably provided. This mechanism comprises a cable **55**, the ends of which are secured to opposite ends of the carriage **17**, as shown, in FIG. **4**, a spring **56** being interposed in the connection to reduce shocks. The cable passes over an idler pulley **57** at the forward end of the inlet table extension **18** and several turns of the cable are wrapped around a driving drum **57** at the rear end of the table extension.

The drum **58** is arranged to be driven in either direction by a motor **59** through a coupling **60**. The motor, which is of a known type, is controllable to operate at continuously variable speeds in either direction so that the carriage **17** can be advanced rapidly toward the mill to pass the mandrel **14** through the workpiece and into proper position for rolling and slowed down just before the mandrel thrust block **16** engages the mandrel movement control beam **19** to reduce shock. The motor **59** can also be operated to withdraw the mandrel **14** rapidly from the rolled shell and the mill and back to a position wherein a new workpiece can be positioned between the forward end of the mandrel and the mill on the inlet table **13**. The motor **59** can also be operated in the forward direction to exert a constant or substantially constant torque so as to retain the mandrel thrust block **16** firmly in engagement with the mandrel movement control beam **19** when the mandrel movement control beam **19** is stationary or is being advanced and before the workpiece is engaged with the first coil stand. This is described below in the summary of the operation of the apparatus.

Cooling liquid is supplied to the interior of the mandrel **14** through a conduit **62** (FIGS. **4** and **5**) that extends from a swivel fitting **63** at the rear end of the coupling member **43** to a position adjacent the forward end of the mandrel **14**. As in the case of my copending application, fluid is discharged through conduit **62** and into the interior of the mandrel near the forward end thereof a flows rearwardly through the mandrel **14**, coupling **41**, mandrel bar **15** and coupling member **43** to also be discharged through the fitting **63**. Fluid such as water is supplied to the swivel fitting **63** through a conduit **64** and fluid is discharged through a conduit **65**. Both of these are preferably flexible or are connected to flexible members so that the carriage can move along its path without disturbing the fluid connections. While only the cooling fluid connection is shown in the drawings, it will be evident that a lubricant can also be supplied through an appropriate conduit as in my copending application, aforesaid. Preferably, the lubricant conduit is disposed within the cooling liquid conduit as disclosed in that application.

Mandrel Movement Control: As noted above, the movement of the mandrel during the actual rolling operation is controlled and substantial tension forces exerted on the mandrel bar **15** and thence the carriage **16** are taken by the mandrel movement control beam **19** because the forward end of the carriage **16** engages the shock absorbing pads **61** on the rear side of the mandrel movement control beam **19** during the rolling operation. As shown particularly in FIGS. **1B**, **1C**, **2B** and **2C**, the mandrel movement control beam **19** is a massive member that is supported by rollers **67** that operate on the tracks **42** of the inlet table extension **18**. The beam **19** has a central aperture through which the mandrel **14** and the mandrel bar **15** can pass and the ends of the beam on the front side are engaged by the piston rods **68** of the pistons within the massive hydraulic cylinders **69**, these being suitably supported immediately to the rear of the inlet table **13**. The operation of the hydraulic cylinders is described below in the conjunction with the hydraulic circuit diagram as shown in FIG. **14**. It will be evident, however, that by controlling the flow of fluid to and from the cylinders **69** the speed of movement of the mandrel **14** and mandrel bar **15** can be controlled and the forces exerted on the mandrel during the rolling operation can be transmitted through the piston rods and the cylinder mechanism to the frame of the machine. The arrangement is such that the mandrel can be advanced or retracted and the speed in either direction controlled both during each rolling operation and between successive rolling operations so long as the mandrel thrust block **16** is in contact with the mandrel movement control beam **19**.

Mandrel Rotating Mechanism: As in my copending application and as described below, the movement of the mandrel during the rolling operation is controlled to distribute the zones of wear longitudinally throughout a substantial area of the mandrel. In order to eliminate concentration of wear and high stress in circumferentially spaced zones, according to the present invention the mandrel is rotated, preferably after each rolling operation. A preferred mechanism for accomplishing this is associated with the carriage **17** and is illustrated in FIGS. **4** to **7**.

As there shown, a ratchet wheel **71** is rigidly secured to the rear end of coupling member **43** of the carriage **17**. The teeth of the wheel are engaged by a pawl **72** pivotally mounted on a ratchet lever or arm **73** that is mounted for oscillatory movement concentric with the ratchet wheel **71**. The pawl **72** is urged toward the center of ratchet wheel **71** by a spring-pressed plunger **74** that is also carried by the ratchet arm or lever **73**.

In order to rotate the ratchet wheel **71** and thus the mandrel bar **15** and mandrel **14** in the direction shown by the arrow in FIG. **6**, a plunger **76** that engages a pin **77** also carried by the ratchet arm **73** is provided. The plunger **76** is suitably guided in the carriage **17** and the lower end of the plunger **76** is engaged by a cam follower **78** that is supported by an arm **79** pivotally mounted on the carriage as at **80**. The cam follower **78** has a roller **81** that rides upon a track **82** having a cam portion **83**, the track **82** being positioned adjacent one of the tracks **42** of the inlet table extension **18**. It will be evident that when the carriage moves in a rearward direction, the plunger **76** is raised by the cam follower **78** to the dotted line position as shown in FIG. **7** when the roller **81** rides on the cam portion **83** of the track **82**, and then the pawl **72** rotates the ratchet wheel **71**, mandrel bar and mandrel a fraction of a turn. When the carriage moves forwardly again toward the mill, the roller **81** rides from the elevated portion **84** of the track **82** down the cam portion **83** to the lower portion **85**. As this takes place, the weight of the arm **73**, assisted by a spring **86**, rotates the arm **73** in the direction opposite to the direction of the arrow in FIG. **6**, placing the ratchet mechanism in condition for another fractional rotation of the ratchet wheel **71**, mandrel bar **15** and mandrel **14** when the carriage **17** is again retracted and the wheel **81** rides upwardly on the cam portion **83**.

The cam portion **83** is positioned near the rearward limit of the movement of the carriage **17** as indicated in FIG. **1C** so that the mandrel will be completely withdrawn from the mill and the workpiece at the time that it is rotated. The amount of rotation can be varied by varying the difference in elevation between the portions **84** and **85** of the track **82** so that, for example, the amount of rotation can be varied between the spacing of **1**, **2** or **3** teeth of the ratchet wheel **71**.

By this simple and reliable mechanism that requires no attention on the part of the operator, the mandrel is automatically rotated after every workpiece is passed through the mill. This rotation distributes the wear and stress circumferentially around the mandrel, distributes the heating effects on the mandrel and results in longer mandrel life and improved rolling conditions.

Tube Pusher: In order to feed the workpieces W into the rolls **6'** of the first roll stand **6** of the mill **5**, a tube pusher indicated in general at **20** is disposed adjacent the inlet table **13** as shown in FIGS. **1B**, **2B** and **8**. The mechanism comprises a carriage **90** supported by two pairs of rollers **91** that operate between upper tracks **92** and lower tracks **93** that extend parallel to the inlet table above the axis of the workpiece disposed on the table and are supported by brackets **94** which are in turn supported by the longitudinal member **95** of the inlet table **13**.

The pusher itself is shown at **96** and comprises a rigid structure fabricated from plates welded together that extends downwardly from the carriage **90** to a region adjacent the centerline of the apparatus as shown in FIG. **8**. As there indicated, the lower end of the pusher **96** has an arcuate recess **97** in it that is large enough to receive the mandrel **14** and the mandrel bar **15** and permit longitudinal movements of these parts without interference. The aperture, however, is such that it will engage the end of a workpiece supported on the inlet table **13** and thus the workpiece can be moved or pushed into the bite of the rolls **6'** by actuating the pusher from its retracted position toward the mill.

Movement of the pusher is accomplished by means of a hydraulic cylinder and piston mechanism **98** disposed above the hydraulic cylinders **69** that control the movement of the mandrel movement control beam **19** and have a piston rod **99** that is secured to the carriage **90**. By means of appropriate conventional controls, hydraulic fluid is supplied to cylinder **98** to urge the carriage **90** to the right, as shown in FIG. **2B** so that the pusher **96** engages the rear end of a tubular blank or workpiece to feed the leading end of the blank into the bite of the rolls **6'** of the mill. After this is accomplished the hydraulic connections are reversed and the pusher **20** is returned to its retracted position substantially as shown in FIG. **1B** where it is ready for the next operation after the mandrel has been retracted and a new pierced shell or workpiece deposited on the inlet table **13**.

Quick Change Mandrel: The mandrels used with the mill are subject to wear and must periodically be replaced for this reason. Also, the mandrels control the internal diameter of the tube rolled on the mill and therefore whenever it is desired to roll tubing of different wall thicknesses or different internal diameters, replacement of the mandrel is required. Therefore, it is important that changing of the mandrels be affected in the shortest period of time to reduce downtime of the apparatus A preferred form of construction for quickly connecting or disconnecting the mandrel **14** to the mandrel rod **15** is shown at **41** and illustrated in FIGS. **10**, **11**, **12** and **13**.

As there shown this is a connection of the bayonet type with a female coupling member **101** threaded to the mandrel bar **1** and a male coupling member **102** threaded to the mandrel **14** as shown at **103** and **104**, respectively. The coupling member **101** has the same external diameter as the mandrel rod **15** and this diameter is preferably equal to the external diameter of the smallest mandrel **14** to be used in the apparatus. Each mandrel is provided with its own coupling member **102** and the coupling member **101** remains permanently affixed to the mandrel bar **15**. The coupling **101** is slotted as shown at **106** in FIG. **13** and is provided with intervening lugs **107**. The coupling **102** has a sleeve portion **108** and spaced end lugs **110** which lie behind the lugs **107** of the female coupling **101** when the parts are assembled as shown in FIG. **11**. The coupling members are made of high-strength steel that is much stronger than the less expensive steels utilized in the mandrel and mandrel bar. The use of the high-strength steel makes possible the employment of a bayonet-type joint.

In order to eliminate lost motion or play in the coupling, a wedge member **109** is provided which has sloping surfaces **111** as shown in FIG. **12** that engage corresponding sloping surfaces on the ends of the lugs **110** of the male coupling **102**. The wedge member **109** is held against rotation by a pin **112** engaged within an aperture **113** in the base **114** of the recess in the female coupling member **101**. Three different openings **113** are provided in the base **114** so that the angular position of the wedge member **109** can be varied. The parts are assembled in the usual manner of a bayonet coupling by inserting the member **102** into the member **101** and then turning the members relative to each other to bring the lugs **110** in back of the lugs **107** as shown. When this is done the end surfaces of the lugs **110** ride on the sloping surface **111** of the wedge member **109** and with the wedge member properly positioned take up all longitudinal play between the two coupling members **101** and **102**. If the adjustment provided by the pins **112** and apertures **113** is insufficient shims can be employed between the wedge member and the base **114**. After assembling, the parts are held against accidental rotation by means of a key **115** that is secured to the coupling member **102** by a screw **116** and engages within a recess **117** in the external surface of the coupling member **101**.

As previously explained, there is a cooling fluid conduit **62** within the mandrel bar and mandrel. This is made up of a portion **62a** carried by the mandrel **14** and a portion **62b** carried by the mandrel bar **15**. The ends of these conduit portions are centered accurately within the coupling members **101** and **102** by spacers **118** and **119**, respectively. A female coupling member or fluid connector **120** is secured to the end of conduit **62b** as by welding or brazing and a male coupling member **121** is similarly secured to the end of the conduit section **62a**. These parts interfit as shown in FIG. **11** when the mandrel is coupled to the mandrel rod, a seal automatically being provided by an O-ring or similar sealing member **122**. Since there is not substantial pressure in the returning fluid flowing around the exterior of the conduit **62** no external seal is provided between the coupling members **101** and **102** but, if desired, O-rings can be incorporated in these connections also.

It will be evident that with the foregoing arrangement the mandrel **14** can be disconnected from the mandrel bar **15** simply by removing the key **115**, rotating the parts with respect to each other about 60° and withdrawing the mandrel and its coupling **102** from the mandrel bar coupling member **101**. This automatically disconnects the cooling fluid conduit sections **62a** and **62b**. The mandrel is then removed from the mill or the apparatus, a new mandrel placed in position and the assembly completed by inserting the coupling **102** of the new mandrel into the coupling **101** of the mandrel bar and rotating the parts 60° in the opposite direction to complete the bayonet coupling. The wedge member having been properly positioned to eliminate play and then the key **115** is replaced to lock the parts securely together. By this means mandrels can be interchanged in a comparatively short period of time, for example, a matter of a few minutes. This makes an important contribution to the efficient operation of the apparatus and to the operation of the entire tube manufacturing facility by the reduction of downtime.

Hydraulic Circuit for Mandrel Movement Control Beam: It will be evident that by appropriate control of the flow of hydraulic fluid to and from the opposite ends of the double-acting cylinders **69** the movement of the mandrel control beam **19** and hence movement of the mandrel at all times that the mandrel thrust block **16** is in engagement with the beam **19** can be readily affected. A simplified hydraulic circuit for obtaining such control is shown in FIG. **14**.

As there indicated the cylinders **69** are double-acting, each containing a piston **68a** that is connected to its associated piston rod **68** rigidly secured to the mandrel movement control beam **19**. The hydraulic system comprises a motor **123** that drives a pump **124** that supplies fluid under pressure, preferably water, for operating the system. The pump **124** is connected through suitable lines as shown, a two-way solenoid valve **125**, an adjustable flow control valve **126** and line **132** to the rearward ends of the cylinders **69**. A pressure relief valve **128** and a solenoid unloading valve **129** are interposed in the line between the pump **124** and the solenoid valve **125**. The pump **124** is also connected to an accumulator **139** through lines as shown, a shutoff valve **138** and a check valve **136**.

The accumulator **139** is also connected to the forward ends of the cylinders **69** by suitable lines as shown, a solenoid valve **140**, an adjustable flow control valve **141**, another solenoid valve **142**, and another flow control valve **144**. A pressure relief valve **143** is also connected to the lines between the accumulator **139** and the forward ends of the cylinders **69**.

At the start of the rolling cycle suitable control devices such as a limit switch energizes solenoid **130** of solenoid valve **125** to connect the pump **124** to the rearward ends of the cylinders **69** wherein the pistons **68***a* are in their rearward positions opposite that shown in FIG. **14**. Solenoid valve **129** is energized to prevent flow to its sump and solenoid valve **142** is also energized to permit flow of fluid out of the forward ends of the cylinders **69** through the appropriate lines to the accumulator **139**. This supplies pressure to the rod ends of the cylinders to accelerate the mandrel control beam **19** and mandrel **14** to the appropriate starting velocity which velocity can be controlled by the flow control valve **144** between the forward ends of the cylinders **69** and the solenoid valve **142**. As soon as the workpiece W is gripped by the mill stand **6**, appropriate controls such as relays initiate the deenergizing of solenoid **130** of solenoid valve **125** and energize solenoid **131** of valve **125** to release the supply pressure from the pump **124** to the rearward or rod ends of the cylinders **69**, the fluid then being opened to the sump of valve **125**. At the same time the solenoid valve No. **129** is deenergized to unload the pump **124**. Solenoid valve **142** is deenergized thereby forcing all of the fluid from the hydraulic cylinders **69** through the flow control valve **141** which controls the movement of fluid from the forward ends of the cylinders **69** to the accumulator **139** thereby controlling the movement and velocity of the mandrel. During this operation the solenoid valve **140** is deenergized. Other means, such as a variable displacement hydraulic pump or motor can be utilized for metering the flow of fluid from the cylinders, thereby to control the speed of the mandrel.

Pressure relief valves **128** and **143** are provided on appropriate sides of the hydraulic cylinders **69** to relive pressure in the event of undesired pressure buildup within the lines. As the pistons **68***a* approach their positions as shown in FIG. **14**, pressure builds up in the gas-charged accumulator **139** which is charged with air at its upper end from a suitable source of supply.

At the end of the rolling cycle suitable controls such as a heat-sensing switch will initiate the return of the piston rod **68** and associated structure to the appropriate position to receive a second workpiece for start up of a second cycle. The appropriate control energizes the solenoid valve **140** to supply pressure from the charged accumulator **139** to the forward ends of the cylinders **69** for rapid return to the startup position. The velocity of the return is controlled by the adjustable control valve **126** connected by lines **132** to the rearward ends of the cylinders **69**. An appropriate control is energized by the cylinders piston rods **68** upon their return to the substantial reset position which deenergizes the solenoid valve **140** thereby blocking further flow of fluid from the accumulator **139**. At the same time the appropriate device actuates the flow restrictor valve **134**.

If a stripping cycle is indicated because the workpiece has stuck to the mandrel **14**, suitable controls deenergize solenoid **131** and energize solenoid **130** of valve **125**, solenoid valve **129** and solenoid valve **142**. This prevents rearward movement of the piston rods **68** and mandrel control beam **19** and mandrel **14** until the workpiece has cleared the stripper plate **22** at which time the solenoid **130**, the solenoid valve **129** and **142** are deenergized thereby permitting rearward movement of the piston rods **68** thereby withdrawing the mandrel from within the workpiece whose rearward motion is restricted by the stripper plate **22**.

At the rear end of the cylinders **69**, cushioning chambers **135** are provided, these cooperate with the projections **137** on the pistons **68***a* to cushion the end of the return stroke of the pistons **68***a*. The normal flow of fluid out of the cylinders **69** is through the line **132** directly to an adjustable remotely controlled flow control valve **126** while after the projections **137** have reached the recesses or chambers **135** the flow must take place through the flow restrictor **133**, there being a check valve **134** in parallel with the restrictor **133** so that flow of fluid into the cylinder at the rear ends thereof can taken place freely.

It will be evident that with an arrangement of this sort the movement of the beam **19** and hence the mandrel **14** and the mandrel bar **15** can be controlled in either direction. Thus, the mandrel can be advanced before it is in the mill and after the mandrel thrust block **16** has come into contact with the mandrel control beam **19** by admitting fluid under pressure to the rear end of the cylinders **69** and controlling the rate of discharge of the fluid from the forward ends of the cylinders through the flow control valve **144**, the cable mechanism associated with the mandrel carriage **17** maintaining the mandrel thrust block **16** in engagement with the beam **19** during this time.

After the rolling operation has been initiated the frictional engagement between the rapidly advancing shell and the mandrel exerts a strong advancing force on the mandrel and hence on the mandrel bar **15**, thrust block **16** and beam **19**. The rate of advance then is controlled by the adjustable flow control valve **141**. The rate of retraction is controlled by the fluid flow control valve **126**. This movement is also useful in the event that a tubular shell should stick to the mandrel and it becomes necessary to strip the shell from the mandrel using the stripper **22**. Thus, the hydraulic system can be employed to give great flexibility of operation and control over the movement of the mandrel whenever the mandrel thrust block is in engagement with the mandrel movement control beam **19**. This flexibility of operation will become more apparent upon consideration of the description of the operation of the apparatus that follows.

Operation and Control: A typical sequence of operations of the apparatus is shown in FIGS. **15** to **19** and these figures also illustrate preferred instrumentation to give the operator at the control console accurate knowledge of the relative positions of the workpiece W and mandrel **14** at all times. FIGS. **20** to **23** show particular stages of the rolling cycle and the velocity diagrams, FIGS. **24** and **25**, show the relative speeds or velocities of the workpiece and the mandrel of plug during the rolling operation.

In FIGS. **15** to **19** the operator's instrument panel is indicated diagrammatically at **145**. This is positioned on the console at which the controls for the various instrumentalities are located and includes a housing having a series of lights **146** which are illuminated to show the position of the workpiece, and a window **147** behind which an indicator **148** showing the position of the mandrel **14** is disposed. The indicator moves across the window in response to movement of the mandrel, the movement of the indicator being controlled by an appropriate servomechanism diagrammatically indicated at **149** and driven by, for example, the drum **57** around which the cable **55** is wrapped. The indicator lights **146** are controlled by a series of heat-sensing devices **150**, the first of which is disposed shortly in advance of the mill and adjacent the shell stop **35**. The next is immediately in advance of the first roll stand **6** and thereafter the sensing devices are disposed between roll stands with one being positioned after the last roll stand **11** and adjacent the stripper plate **22**. These are connected through appropriate electrical circuits and amplifiers so that a corresponding light **146** is illuminated whenever a heated shell is opposite its associated heat-sensing device **150**. Thus, the lights **146** light up progressively as the shell is advanced toward and through the mill. In the drawing lighted lamps are indicated by clear circles, unlighted lamps have an *x* in their centers. It is to be understood, of course, that the instrument **145** is drawn to an entirely different scale from the diagrams constituting FIGS. **15** to **19**.

It is also to be noted that in FIGS. **15** to **19** while most of the elements of the machine are indicated in plan, some parts such as the roll stands, the pusher and the supporting idler rolls are indicated in elevation for convenience of illustration.

A typical sequence of operation is as follows: In FIG. **15** a workpiece W in the form of a pierced billet has been deposited on the inlet table **13** between the mill **5** and the pusher **20** with the forward end of the workpiece against the shell stop **35**. The heat-sensing devices **150** that are opposite the inlet table indicate the presence of the workpiece or shell in position as will be seen by the illumination of the corresponding lights **146**. The mandrel **14** is retracted to a position about opposite the tube pusher **20** to make room for the depositing of the workpiece W on the inlet table **13** and the end of the mandrel is shown by the indicator **148** as being in its retracted position. In FIG. **16** the mandrel stop **35** has been moved out of the way and the workpiece W has been pushed into the bite of the first roll stand **6** as shown, this being indicated by the lighting of the light **146** immediately in advance of the first roll stand **6** and the extinguishing of the first light **146**, showing the movement of the trailing end of the workpiece toward the mill. The mandrel thrust block **16** is in engagement with the mandrel movement control beam **19** and the mandrel itself has been projected until its end is just beyond the fourth roll stand **9**. The lines on the window of the instrument **145** indicate the centerlines of the roll stands and thus the operator can see at a glance the position of the mandrel **14** with respect to the mill and also the location of the workpiece. In FIG. **17** the mandrel has been advanced to a point just beyond the last roll stand **11**, in which the tube is rounded up, again as indicated by the indicator **148**, while the last three lights **146** are illuminated to show the presence of the trailing end of the workpiece near the delivery end of the mill. The first several lights have been extinguished indicating that the trailing end of the workpiece has passed beyond these stations. The lights are successively extinguished as the trailing end of the workpiece advances.

In FIG. **18** the mandrel has been advanced to the full limit of its travel which is ordinarily done only in the case of a sticking workpiece and the indicator shows that the point of the mandrel is beyond the stripper **22**, while all of the lights are extinguished indicating that the workpiece is beyond the mill. Under these circumstances the operator actuates the stripper to position it as shown in FIG. **18** to block retracting movement of the workpiece toward the mill and then fluid under pressure is admitted to the cylinders **69** to withdraw the mandrel from the workpiece. Normally this is not required, the mandrel is advanced only to the position shown in FIG. **17** and then is retracted as soon as the workpiece has passed the last working roll stand **9**.

The apparatus is placed in position for another operation by retracting the mandrel to its initial position as shown in FIG. **19** and as indicated by the position of the indicator **148**. The inlet table is then ready to receive another workpiece with the shell stop **35** in position. The absence of a workpiece on the inlet table **13** is indicated by the fact that all of the lights **146** are extinguished.

FIGS. **20**, **21**, **22** and **23** show in greater detail the relative positions of the workpiece and mandrel during a typical rolling operation including stripping of the workpiece from the mandrel **14** and FIG. **24** shows the speed of the workpiece at various positions in the mill while FIG. **25** shows the location of a point on the mandrel and the speed of and direction of movement of the mandrel when the point is located as shown.

In FIG. **20** the leading end of the workpiece is at point **0** in advance of the first roll stand. The workpiece is accelerated by the pusher **20** through the segment *a* of the curve constituting FIG. **24** to an entering speed VTE which is just a little less and could be the same as the surface speed VR–6 which is the surface speed of the rolls **6'** of the first roll stand **6**. The workpiece entering the first roll stand **6** is rapidly accelerated so that its speed equals the speed of the roll stand but because of the elongation that takes place in the roll stand the workpiece leaving the roll stand is accelerated to a speed VR–7 which corresponds quite closely to the speed of the rolls **7'** in the second roll stand **7**. The rolls being designed so that the rolls in each succeeding stand have a surface speed that is approximately equal to the calculated speed of the leading end of the workpiece as it enters the rolls thus to minimize shock on the equipment.

The workpiece is again elongated as it passes through the rolls **7'** and the speed again increases to the speed indicated at VR–8. As shown by the diagrams, the speed again increases as the workpiece passes through rolls **9'**. There is no substantial change in velocity as the workpiece passes through the rolls **10'** and **11'** inasmuch as they simply round up the work and in ordinary circumstances free it from the mandrel **14**; thus the last part of the curve of FIG. **24** indicates the deliver speed of the work VTD.

FIG. **25** shows a preferred mode of operation with respect to control of the speed of the mandrel **14**. In FIG. **20** the mandrel has entered to the point shown with its leading end beyond the third roll stand **8**. A point P on the mandrel is selected for reference in this discussion. The mandrel is stationary and the work is stationary. As the workpiece is pushed into the first roll stand **6** by the pusher **20** the hydraulic control apparatus of FIG. **14** is operated to advance the mandrel by a distance d_1 which brings the point P to a point approximately even with the leading end of the workpiece as shown in FIG. **21**, and with the mandrel moving at a velocity VME which is substantially equal to the entering velocity VTE of the workpiece into the first roll pass which preferably is substantially equal or slightly below the speed VR–6 which is the lineal speed of the rolls in the first roll pass. In either event, the entry of the workpiece into the first roll pass is greatly facilitated and shock on the mandrel **14** on the mill and on the mechanism of the entire apparatus is greatly reduced. The acceleration of the mandrel is shown by the sloping portion A of the curve of FIG. **25**.

After the workpiece has entered the first roll stand the mandrel is slowed down as shown by the sloping portion *b* of the curve of FIG. **25** and then continued at a substantially uniform velocity as indicated by *c* through a major portion of the rolling period of the tube whereupon the mandrel is stopped after having been move through a distance d_2 to the position shown in FIG. **22**. The velocity *c* is determined by the length of the workpiece the length of the mandrel and the amount of elongation taking place in the mill being calculated so that the mandrel will always be present to support the workpiece wherever reduction and elongation of the workpiece takes place. Withdrawing movement of the mandrel is then started immediately as shown by the curve *e*, the presence of the mandrel not being required in the last roll stands **10** and **11** since their function is primarily to round up the work and strip it from the mandrel. If the workpiece does not stick to the mandrel, retraction as shown by the curve *e* is continued and the mandrel is withdrawn to its original position as shown in FIGS. **15** and **19**.

However, if the tube sticks to the mandrel in the position shown in FIG. **22**, then the mandrel is advanced through the distance d_3 while the trailing end of the workpiece is advanced through a corresponding distance w_4 as shown in FIG. **23** so that the trailing end of the workpiece is beyond the stripper plate **22**. This operation is shown by the portion *f* of the curve in FIG. **25** which indicates movement of the mandrel in the forward direction along with the blank and reduction of movement of the forward motion to 0 at point *g*. The mandrel is then accelerated in the rearward direction as at *h* with continued movement in a rearward direction at a fairly low velocity *i* until the mandrel is released from the sticking tube. Then acceleration in the reverse direction is as shown at *j* and continued high-speed retraction at a fairly high velocity *k* until the original position indicated in FIGS. **15** and **19** is reached.

The foregoing description of operation is given as an example of the preferred operation that is possible with the present construction and in which the mandrel is advanced at approximately the entry speed of the first roll stand, at the moment that the workpiece is entered into the first roll stand. This is highly advantageous because of the reduction in shock to the apparatus. However, it will be understood that because of the nature of the controls, different modes of operation can be utilized with the apparatus to conform to working conditions and the materials being rolled. It will be evident that the knowledge given to the operator of the location of the shell or workpiece and the location of the mandrel with respect to it gives him an important tool in properly controlling the workpiece and the rolling operation. By observation at his console he can determine these positions with a sufficient degree of accuracy to enable him to vary the control of and direction of movement of the mandrel if that seems advisable. This can be accomplished through the hydraulic control system even though the relative positions of the workpiece and the mandrel would be invisible to him otherwise, because the leading end of the mandrel, is, of course, concealed within the workpiece while the portion of the workpiece itself that is within the mill cannot be accurately observed.

Various changes and modifications in the method and apparatus may be made without departing from the spirit and scope of the invention, a preferred form of which has been described herein. The essential characteristics of the invention are defined in the appended claims.

I claim:

1. The method of rolling a tubular blank to elongate it and reduce its diameter which includes the steps of disposing the blank on the entry side of a mill having a plurality of roll stands having grooved rolls providing passes of progressively reduced diameter, passing an elongated mandrel through the blank and into the pass of the mill, feeding the blank into the first roll stand of the mill, rolling the blank continuously through the mill over the mandrel, moving the mandrel in a axial direction with respect to both the mill and the blank during substantially the entire rolling operation, discharging the rolled blank on the exit side of the mill, and withdrawing the mandrel to the inlet side of the mill a distance sufficient to permit another blank to be positioned between the forward end of the mandrel and the mill, the improvement which comprises moving the blank into the first roll stand independently of the mandrel at a speed equal to or slightly less than the lineal speed of the rolls in the first roll stand, and moving the mandrel in the same direction as the blank and at a speed that, at the instant that the blank enters the first roll stand, is also equal to or slightly less than the lineal speed of the rolls in the first roll stand, thereby to reduce shock on the mandrel at the time that the blank enters the mill, and substantially reducing the speed of movement of the mandrel immediately after the blank has entered the first roll stand.

2. Apparatus for rolling tubular blanks comprising a mill embodying a plurality of aligned rolls stands adapted to reduce the tubular blank passing therethrough, an inlet table at the entry end of the mill for supporting a tubular blank to be rolled, an elongated mandrel adapted to support a blank being rolled in the mill, a mandrel bar extending rearwardly from the mandrel for controlling the position and movement of the mandrel, means for controlling the speed and direction of movement of the mandrel bar during the rolling operation, a pusher operable independently of the mandrel bar for pushing a tubular blank disposed on said inlet table into the first of the plurality of roll stands and means independent of the pusher for advancing the mandrel bar and mandrel at the time that the leading end of the tubular blank is pushed into the first roll stand of the mill.

3. An apparatus for rolling tubular blanks comprising a continuous mill embodying a plurality of aligned roll stands, each roll stand having at least two rolls defining a roll pass, an inlet table at the entry end of the mill for supporting a tubular blank to be rolled in alignment with the working pass of the mill, a mandrel adapted to support the interior of a blank being rolled, said mandrel being movable from a retracted position spaced from the mill sufficiently to permit a blank to be rolled to be deposited on said inlet table between the forward end of the mandrel and the mill and a position in which the forward end of the mandrel projects through the mill, a mandrel bar secured to and extending rearwardly from the mandrel for controlling the position and movement of the mandrel, power means for positively controlling the position and movement of said mandrel bar, said power means being under control of the operator, and indicating means visible to the operator for indicating the position of the mandrel with respect to the mill at all times during the operation of the apparatus.

4. Apparatus according to claim 3 in which the mandrel bar is supported by a carriage that operates toward and away from the mill and the indicating means is controlled by a servomechanism interconnecting the carriage and the indicating means.

5. Apparatus according to claim 3 having means for indicating the position of a tubular blank with respect to the mill during the operation of the apparatus.

6. Apparatus according to claim 5 in which the means for indicating the position of the tubular blank and the means for indicating the position of the mandrel are displayed on the same panel whereby the relative positions of the mandrel and blank are exhibited to the operator during the operation of the apparatus.

7. Apparatus according to claim 5 wherein a series of heat-sensing devices are employed to control the means for indicating the position of the tubular blank.

8. In an apparatus for rolling tubular blanks on a continuous rolling mill embodying a plurality of aligned rolls stands and having a mandrel adapted to support the interior of a blank being rolled in the mill and a mandrel bar for controlling the position and movement of the mandrel, the mandrel being subjected to tension during the rolling operation, the improvement which comprises the provision of means for effecting rapid interchange of one mandrel for another without changing the mandrel bar which comprises a fitting secured to the rear end of the mandrel and a fitting secured to the forward end of the mandrel bar, said fittings having diameters not in excess of the diameters of the smallest mandrel to be used on the mill, and said fittings being provided with interengaging mating parts to provide a bayonet-type joint whereby the fittings can be quickly connected and disconnected from each other, thereby to correspondingly disconnect and connect a mandrel from the mandrel bar, there being a wedge member having inclined faces disposed within one of said fittings and the end of the other of said fittings having corresponding inclined faces adapted to engage the inclined faces of the wedge member, whereby when the mandrel bar and mandrel are rotated with respect to each other to complete the locking of the bayonet joint the engagement of said inclined surfaces eliminates longitudinal play from the joint.

9. Apparatus according to claim 8 in which the mandrel bar and mandrel are tubular and in which there is a fluid conduit disposed coaxially with the mandrel bar and mandrel, said fluid conduit being divided into two parts, one part carried by the mandrel bar and the other part carried by the mandrel, there being fittings on the adjacent ends of the two parts whereby a fluidtight connection is automatically made when the bayonet connection between the fitting on the mandrel and the fitting on the mandrel bar is completed.

10. Apparatus according to claim 9 in which one part of said conduit is provided with a male fitting and the other part of the conduit is provided with a female fitting, the said fittings being disposed one within the other when the mandrel and mandrel bar are connected together, there being a seal between said fittings when the mandrel and mandrel bar are connected together.

11. Apparatus as defined in claim 10 in which the seal is an O-ring disposed in a groove in one of said fittings and engaging a cylindrical surface on the other of said fittings.

12. An apparatus for rolling tubular blanks comprising a continuous mill embodying a plurality of aligned roll stands, each roll stand having grooves defining a roll pass adapted to reduce a blank passing therethrough, an inlet tube disposed at the entry end of the mill for supporting a tubular blank to be rolled in alignment with the working pass of the mill, a mandrel adapted to support the interior of a blank rolled in the mill, a mandrel bar for controlling the position and movement of the mandrel, the forward end of the mandrel bar being secured to the rear end of the mandrel, a mandrel thrust block secured to the rear end of the mandrel bar, a carriage supporting the mandrel thrust block and supported on tracks on an inlet table extension for movement in directions toward and away from the mill parallel to the pass line of the mill, drive

means for operating said carriage toward and away from the mill on said tracks, said means comprising a flexible element supported adjacent said tracks and having its ends secured to said carriage, a motor for driving said flexible element in either direction, said drive means including means adapted to exert a substantial torque urging the carriage, mandrel bar and mandrel in a direction toward the mill even through there be no movement of the carriage, said mandrel thrust block, mandrel bar and mandrel being retracted to permit a blank to be rolled to be deposited on the inlet table between the forward end of the mandrel and the mill, said carriage being movable toward said mill to move said mandrel through a blank positioned on said inlet table and to project said mandrel into the working pass of the mill, means associated with the carriage for rotating the mandrel bar and mandrel a fraction of a turn each time the mandrel is moved to its retracted position, a mandrel movement control beam engageable with the mandrel thrust block whereby the mandrel movement control beam can apply forces to the mandrel thrust block in opposition to the forces exerted on the mandrel during the rolling operation, hydraulic cylinder means for controlling the movement of said mandrel movement control beam comprising at least one double-acting hydraulic cylinder secured to said mandrel movement control beam, a source of hydraulic fluid under pressure, a hydraulic circuit controllable to selectively supply fluid under pressure to either end of said cylinder thereby to apply forces to move said mandrel movement control beam toward the mill or away from said mill selectively, fluid flow control means associated with each end of said cylinder adapted to control the discharge of hydraulic fluid from each end of said cylinder and thereby to control the rate of movement of said mandrel movement control beam in either direction, a movable stop adapted to engage the forward end of a tubular blank disposed on said inlet table and restrain movement of the blank toward the mill during the time that the mandrel is advanced through the blank into the mill, said stop being movable out of the path of the blank to permit the blank to enter the mill, a pusher adapted to engage the rear end of the tubular blank disposed on the mill and push the blank into the bite of the rolls of the first roll stand of the mill, and a hydraulic cylinder mechanism for advancing and retracting said pusher.

13. Apparatus according to claim **12** having a stripper plate disposed beyond the exit end of the mill, said stripper plate being movable from an inactive position where it permits passage of a blank from the mill to a support disposed beyond the mill to an active position in which it will block movement of a blank on said outlet table toward the mill while permitting movement of the mandrel toward the mill whereby the mandrel may be withdrawn from a blank by operation of the mandrel movement control beam in the direction away from the mill.

14. Apparatus according to claim **12** having indicating means visible to the operator for indicating the position of the mandrel with respect to the inlet table and the mill and indicating means also visible to the operator for indicating the position of a tubular blank with respect to the mill during the operation of the apparatus.