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Martin

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[54] **TUBE DRAWING METHOD AND APPARATUS**

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[51] **Int. Cl.** **B21c 1/10,** B21d 3/00

[58] **Field of Search** 72/274, 275, 277, 72/279, 280, 281, 283, 289, 367, 370, 423, 428

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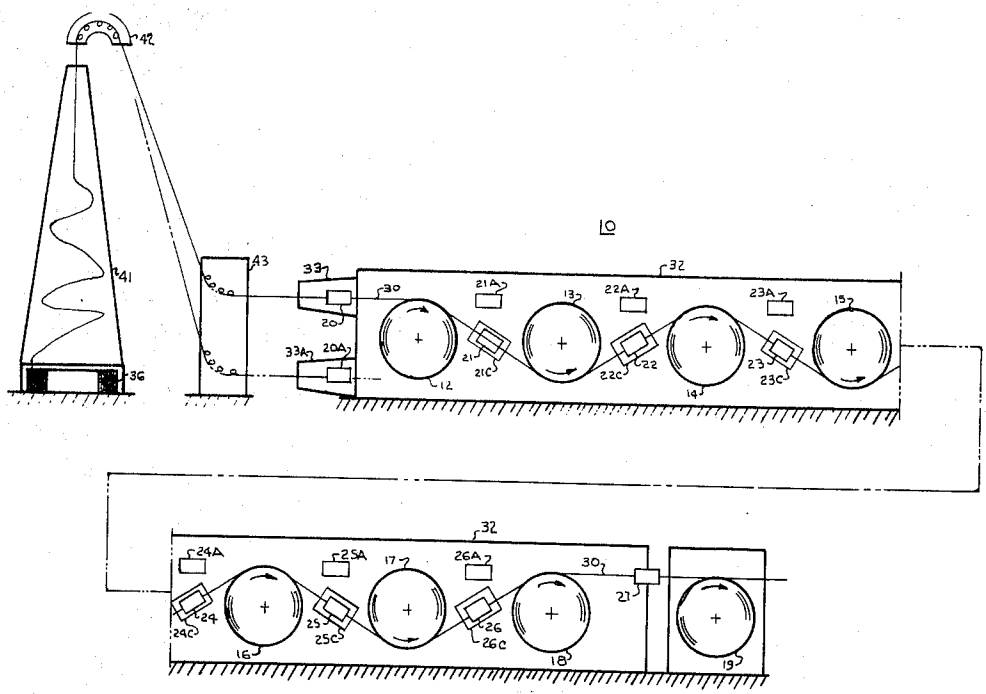
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Assistant Examiner—M. J. Keenan
Attorney—E. Strickland

[57] **ABSTRACT**

A method and apparatus for drawing tubular stock continuously and simultaneously through at least two successive drawing dies having mandrels located in the dies and within the tubular stock. The method comprises the steps of continuously pulling the tubular stock through the first one of the dies by a rotating capstan containing turns of the stock, the capstan simultaneously directing the stock to the second of one of the dies. From the second die, the stock is continuously pulled, the pulling of the stock continuously through the dies effecting a simultaneous reduction of the cross sectional area of the stock, with a single pass of the stock through the dies.

10 Claims, 4 Drawing Figures



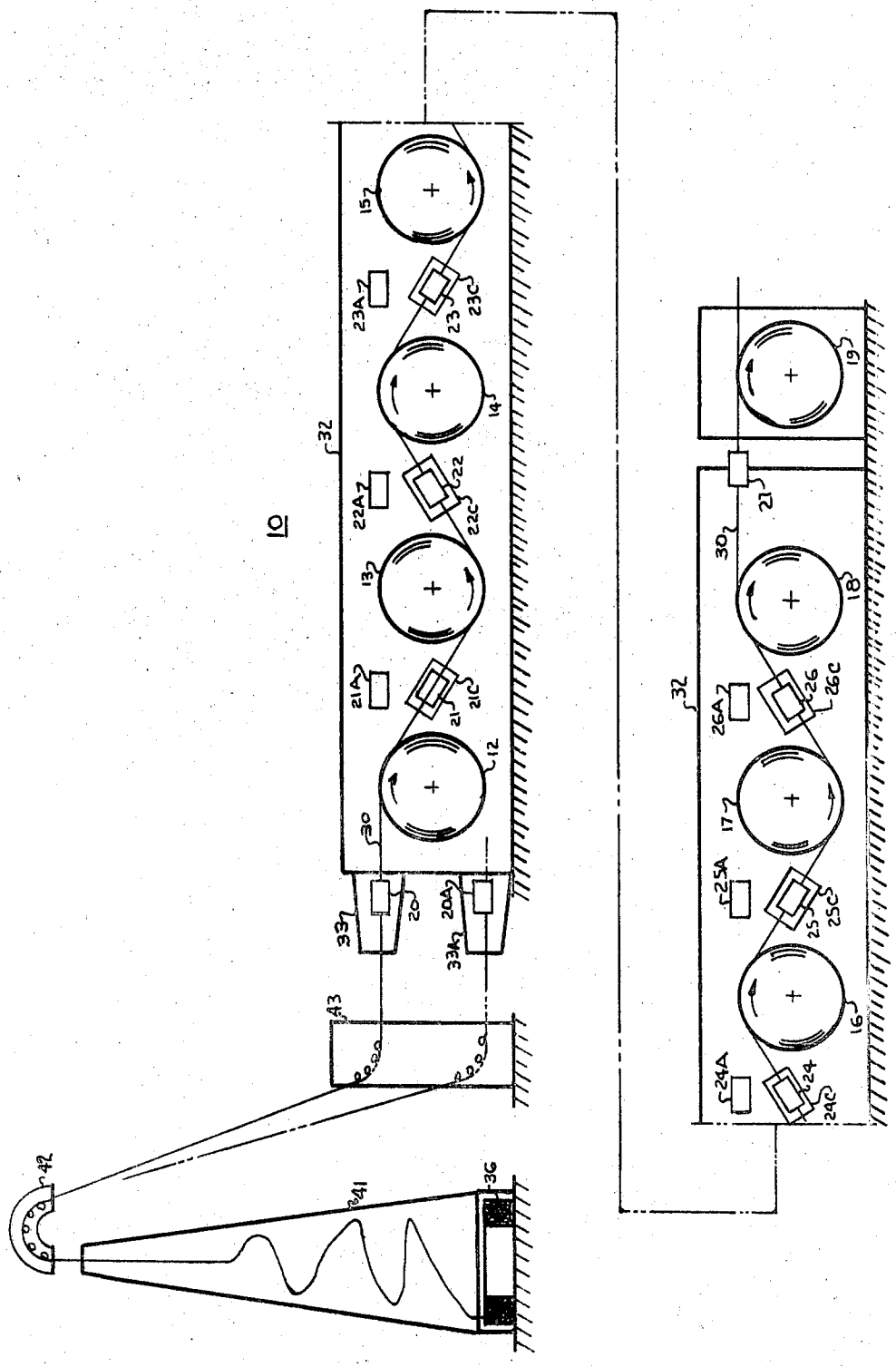

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FIG 1

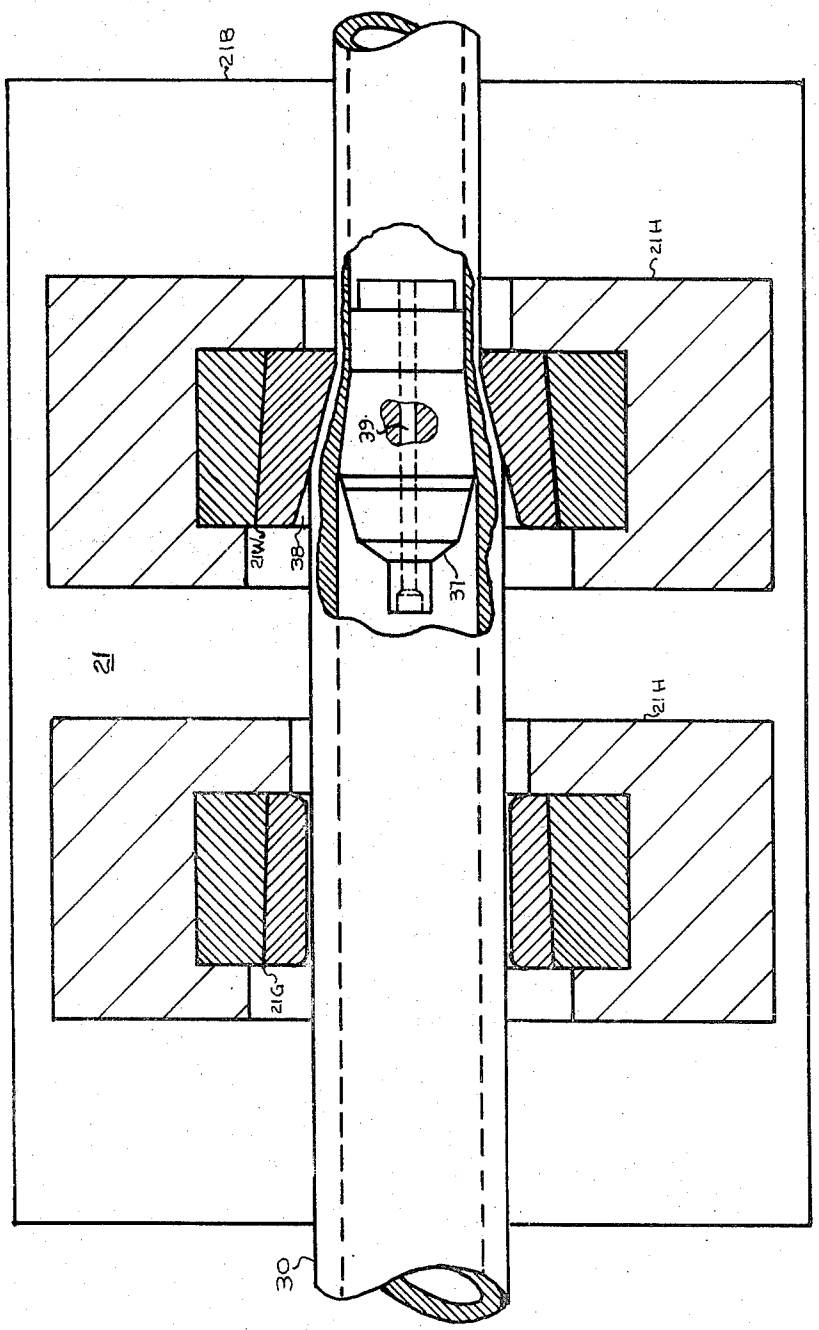


FIG. 2

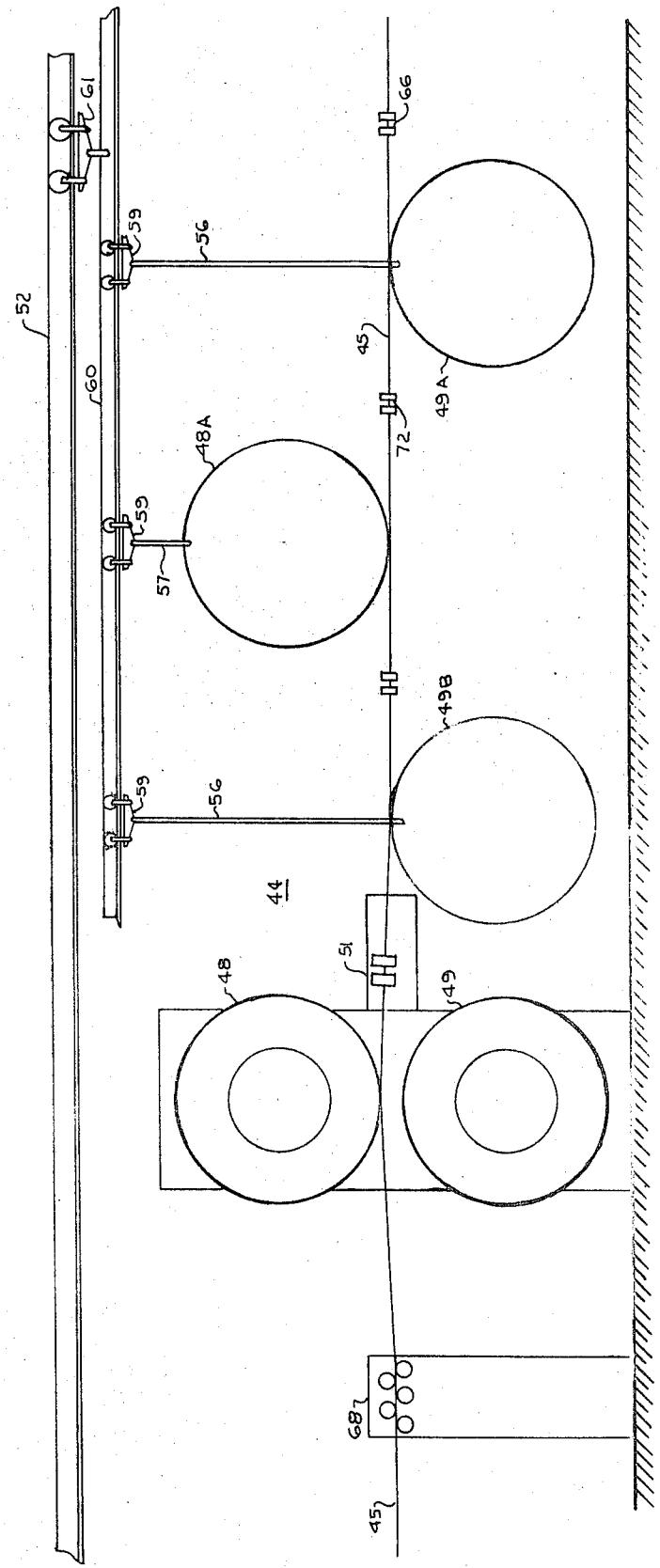


FIG. 3

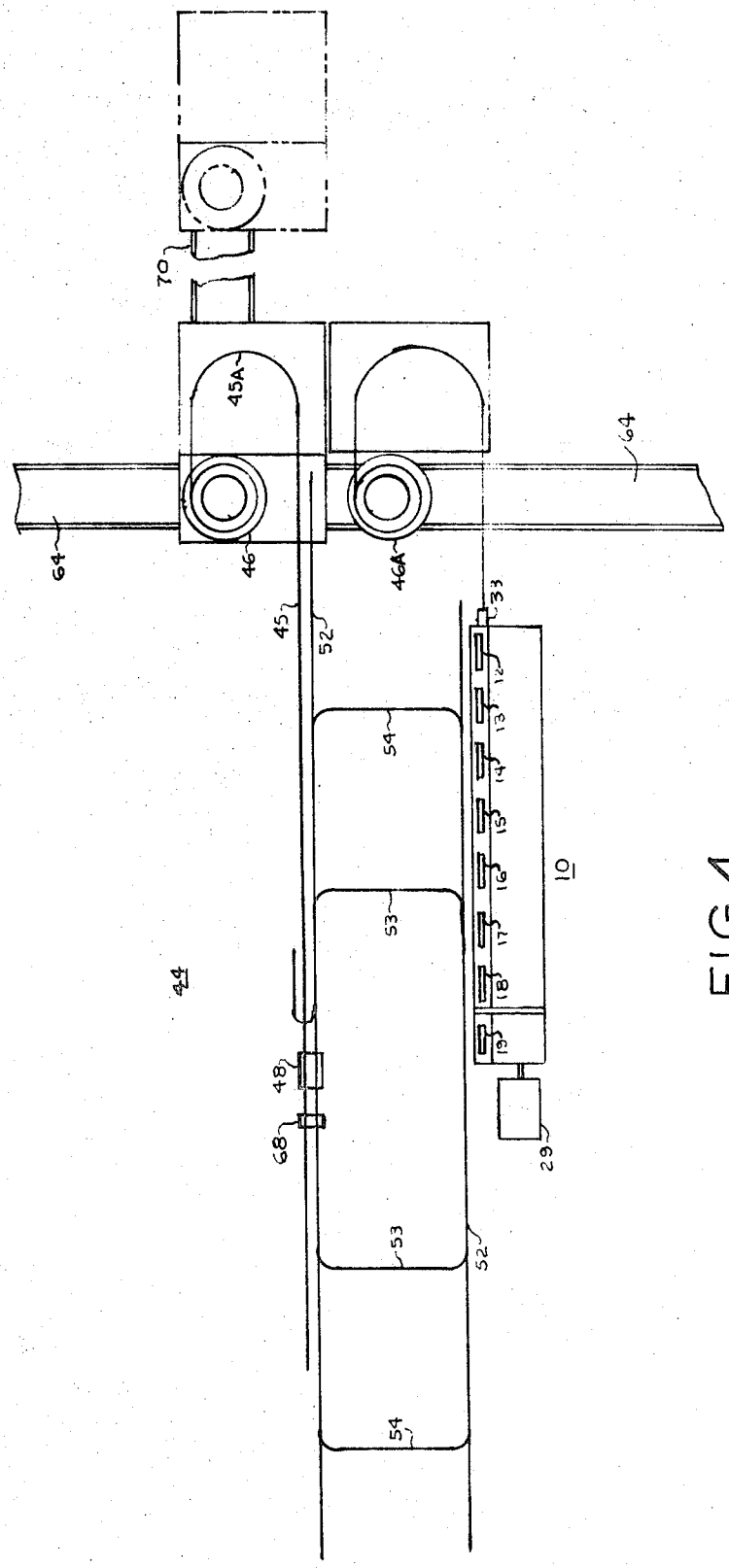

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FIG. 4

TUBE DRAWING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates generally to tube drawing, and particularly to a method of drawing metal tubular stock continuously and simultaneously through at least two successive dies in a rapid, economical manner.

An old and well known means for reducing the wall thickness and diameter of metal tubular stock has been the draw bench. With the draw bench, the practice requires a compliment of tubing to be pulled in a straight-line manner through a first drawing die for the first reduction. After the compliment is reduced, the die is changed for the next reduction or the tube is moved to another draw bench, this process being repeated for each reduction until the tube is reduced to a desired size and wall thickness. Such a drawing operation results in a progressive lengthening of the tube, and consequently draw benches are extremely long requiring large amounts of floor space. In addition, such draw benches produce straight lengths of tubing which are somewhat cumbersome to handle and are frequently damaged in transferring the lengths from one draw bench to another for successive drawing operations.

These space requirements and handling difficulties have led to the utilization of a different type of drawing apparatus commonly referred in the industry as a "bull-block." The bull-block is a large cylindrical drum or "block," as it is called, which is rotated to pull tubing through a drawing die located on the entry side of the block. Such blocks have definite advantages in terms of space requirements, and the tube thus drawn is coiled so that it can be more conveniently handled. However, as explained hereinafter, bull-blocks also have certain disadvantages.

A more modern type of bull-block arrangement presently used to draw long lengths of metal tubing, particularly non-ferrous tubing, includes a bull-block employed with a lazy susan arrangement of large, open baskets with each basket mounted for rotation about its vertical axis, and for movement in a horizontal plane on a carrousel. The carrousel comprises a conveyor means which moves and indexes empty baskets sequentially into place under a bull-block disposed in an upside down manner, while baskets containing tubing or "bloom" to be drawn are indexed into place upstream of a drawing die. To draw tube with this arrangement, a mandrel is inserted in a free end of the tubing contained in the basket indexed into place, and the tube is pointed and then directed through the drawing die and attached to the bull-block. The bull-block is then rotated to pull the tubing through the die and onto the bull-block in the form of turns, the turns, by the force of gravity, falling into an empty, rotating basket. When the draw is completed and the basket containing the "bloom" is emptied, the next basket of undrawn tubing is moved into place by the carrousel for the drawing operation. In this manner, all of the baskets containing tubing to be drawn are sequentially moved into place for the drawing operation. When the tubing in all of the baskets has been drawn, the die is changed for the next reduction, and the above process is repeated.

The bull-block and carrousel arrangement and method of drawing tube, as briefly described above, have critical disadvantages. Probably the most critical disadvantage is the essential slowness of the operation

which affects directly and adversely the cost of producing drawn tube. If, for example, the carrousel has seven baskets containing tube to be drawn, and if eight draws are required to reduce the tube to the desired diameter and wall thickness, 56 (7 × 8) sequential drawing operations are required. This requires eight die and mandrel changes and 56 indexing operations during which no tubing is being produced. In addition, during the drawing operations the tube is exposed in the open baskets so that opportunities are afforded for damaging the tube as well as for foreign matter collecting on the tube surface. Since the drawing dies must be lubricated for the drawing operation, an oil film covers the tube surface which causes foreign matter contacting the surface to adhere thereto. Further, the baskets themselves provide a source of foreign matter. The baskets, which are usually made of steel, are scraped and chipped in the handling thereof so that resulting steel particles and chips often find their way to the tube surface since the tubing is consistently drawn from and returned to the baskets. When the tube is drawn, foreign matter clinging to the tube is carried into the die orifice and thereby forced into the surface of the tube. As the wall of the tube is successively thinned in the drawing process, the foreign matter forms a defect in the tube wall that increases in criticality with each successive reduction. The problem becomes particularly critical with tubing having a wall thickness dimension not substantially larger than that of the particle or chip itself.

To attain high draw speeds with the arrangement just described, precise control of the ratio of block to basket speed is required as well as good packing density in the basket. The long, essentially free floating length of tube between the bull-block and the basket creates a unique speed control problem that is inherent with this arrangement. In contrast with a conventional coiling reel, no physical parameter, such as tube tension, is available to be sensed and fed back to the drive of the receiving basket as a control instruction.

A further disadvantage with the basket collecting method is that at high drawing speeds, thin wall, light weight tubing is difficult to control in that it tends to float above the basket when it leaves the block. This makes recovery and packing of the tube in the basket extremely difficult so that drawing speed and thus tube production are limited in what might otherwise be a more rapid drawing process.

The best control strategy to date, with the open basket, bull-block arrangement, requires preprograming the ratio of block to basket speed in a manner that fills the basket in several stepped zones. A separate program is required for each draw (since each reduction in tube size produces a different set of parameters for the block and basket) and a new program must be developed for each new draw sequence.

A type of drawing arrangement for reducing relatively small amounts of tubing has been used in which two spools or drums, with a drawing die located between them, are employed to pass the tubing back and forth between the drums. In drawing tube with this type of arrangement, one drum functions as a pay-off reel by feeding the tubing wound thereon to the die while the other drum functions to pull the tubing through the die and act as a take-up reel. When the pass is complete, i.e., when the tubing on the pay-off is passed through the die and collected on the take-up drum, the die is changed, for the next reduction, and the tubing then

directed through the new die in a direction opposite to that of the first pass, the take-up drum now functioning as the pay-off drum. This type of arrangement is not highly productive since the amount of tubing drawn is limited to the capacity of the two drums, and the reduction of the tubing is effected by single passes requiring the stopping of the drawing apparatus and rethreading of tubing for each pass.

BRIEF SUMMARY OF THE INVENTION

The present invention is directed to a method and means by which the disadvantages of past and presently used tube drawing techniques, as outlined above, are avoided. More particularly, the invention includes a method by which tubular stock or "bloom" is drawn simultaneously and continuously through two or more successive dies, with a mandrel located in the drawing orifice or opening of each die and within the tubing being drawn. This is accomplished by simultaneously pulling the tubing through the successive dies by the rotation of pulling members, such as capstans containing thereon turns of the tubing, and located downstream of each of the successive dies. As the capstans rotate, the tubing continuously wraps thereon from the die immediately preceding each capstan, and continuously off the capstan as it directs tubing to the succeeding die.

Since all reductions in the tube are simultaneous and continuous with the method and apparatus of the invention, large amounts of tubing can be drawn in a very rapid and economical manner. Further, the apparatus is capable of being strung directly for complete or partial stringing. For example, in the event of a break in the tube being drawn, the drawing apparatus need only be rethreaded downstream of the break.

The invention, however, and in addition, has many other advantages over prior methods of drawing tube. There is at all times full control of the tube since it is always on the capstan or in the dies during the drawing operation, the dies and capstans being preferably enclosed in a drawing chamber. Once the drawing process is started, there is no further handling of the tube outside of the drawing chamber (until the tubing is ready for take-up) thereby providing no opportunities for damage to and for contamination of the tube's surface during the drawing process.

In a preferred, slip drawing embodiment of the invention, the tube, dies and capstans are completely enclosed, and are bathed in a continuous oil spray which washes and cleans the tube, while simultaneously providing lubrication for the dies, and temperature control for the drawing process. In this manner, excellent process control is provided in contrast to the open basket arrangement presently used which requires a substantial amount of rough handling of the baskets (which are quite large and heavy) and provides ample opportunity for damage and settling of foreign matter on the tubing.

Further and substantial economics are effected with a slip drawing process. Slip drawing of the tube permits the use of a single motor and control to drive all of the capstans since tubing is drawn only on demand, i.e., the demand provided by the capstan succeeding each die, as explained in detail hereinafter.

An additional advantage of the present invention includes low pay-off speeds. It can be appreciated that with a single drawing die, in order to increase the production of drawn tube, the input and exit speeds of the tube must be proportionally increased since the input ratio of tube metal (volume and area) to the output ratio of metal is small. In the present invention, with the simultaneous, multiple reduction of the tube, the ratio of metal volume input to metal volume output is quite large thereby providing relatively low payoff speeds while take-up speeds are simultaneously high.

THE DRAWINGS

The objectives and advantages of the invention will be more apparent after consideration of the following detailed description and the accompanying drawings in which:

FIG. **1** is a diagrammatic representation of tube drawing apparatus in which the principles of the present invention are employed:

FIG. **2** is a longitudinal section of die tooling used in one embodiment of the invention;

FIG. **3** is a side elevation view of an apparatus employed to prestring tubing to be drawn in the apparatus of FIG. **1** as seen from the operating side thereof; and

FIG. **4** is a plan view of the apparatus of FIG. **3.**

PREFERRED EMBODIMENTS OF THE INVENTION

Referring now to the drawings, FIG. **1** shows diagrammatically a tube drawing machine or apparatus **10** comprising a plurality of successive tube pulling members or capstans, generally designated by numerals **12** through **19,** and a similar plurality of successive drawing die units **20** through **27,** the number of capstans and die units being given by way of example only. The capstans are mounted for rotation about their horizontal axes, (extending into the plane of the paper) and are driven preferably by a single motor **29** (FIG. **4**) through suitable shafts and gearing (not shown) located behind the capstans. The capstan **19** comprises the final pulling unit of the apparatus **10** and thus sets the speed of the drawing process in a preferred embodiment of the invention as explained hereinafter.

Each of the die units of the plurality (**20** through **27**) are located upstream from a related capstan, with the die units **21** through **26** being alternately located with the capstans, and alternately angled with respect thereto to direct tubular stock **30,** being drawn by the apparatus, alternately in a downwardly and upwardly direction to the capstans, as shown in FIG. **1,** for purposes explained hereinafter. The invention, however, is not limited to the die and capstan arrangement shown in FIG. **1.** For example, in addition to the angled die units **21** through **26,** or in place thereof, a second set of die units **21A** through **26A** can be provided in the drawing apparatus **10,** as indicated diagrammatically in FIG. **1,** with the orifices of the dies in essentially horizontal alignment with each other and with the upper periphery of the capstans **12** through **19.**

Each of the drawing die units **20** through **27** comprises a guide die and a working die, as indicated in FIG. **2,** by numerals **21G** and **21W** respectively. The guide and working dies of each unit are held in die holders **21H** which, in turn, are preferably mounted on an adjustable base **21B,** except for the first and last die units **20** and **27.** The adjustable base **21B** can, in turn, be mounted on a second adjustable base **21C** as shown in FIG. **1.** The first or entrance die unit **20** is located in a separate, outside die box **33** suitably attached to the left end wall (in FIG. **1**) of a housing **32** while the last

or exit die unit 27 is shown mounted in the right end wall of the housing 32.

The drawing apparatus, as depicted in FIG. 1, may have an additional entrance die unit 20A located in a second outside die box 33A mounted on the left wall of the housing 32 beneath the upper die box 33.

The dies and capstans of the apparatus 10, with the exception of the first die 20 and the last capstan 19, are preferably completely enclosed by the housing 32, though, for purposes of illustration, the front wall of the housing is removed in FIG. 1 to expose the dies and capstans, as well as the length of tubing 30 traversing the apparatus.

As best seen in FIG. 1, the tubing 30 extends through the successive dies and around the successive capstans from a supply 36 thereof located to the left of the die box 33 (in FIG. 1). The supply of the tubing is preferably contained in a non-rotating basket for reasons explained hereinafter. As explained in detail hereinafter, the tubular product to be drawn can be directly threaded on and through the drawing apparatus 10, or the tubing can be prestrung on means separate from the drawing apparatus, and then easily and quickly disposed in the drawing apparatus.

FIG. 2 of the drawing shows the die tooling employed in the invention in partial horizontal section. In order to reduce the wall thickness of a tube, the tube must contain a mandrel, and the mandrel must seat in the orifice of the die when the tube is pulled therethrough. In FIG. 2, a die unit 21 is shown in which the working die portion 21W thereof has a mandrel 37 seated in the orifice 38 thereof and in a tube 30 extending through the guide and working portions of the die 21.

The mandrel is shown provided with an opening 39 extending longitudinally through the mandrel for the purpose of directing a lubricant therethrough when the tube 30 is pulled through the die in a drawing process. In such a case, however, the last one of the successive dies operable with a mandrel would preferably employ a solid mandrel (not shown). For reasons that will become apparent, all of the dies may operate with solid mandrels if the tubing to be drawn is prestrung or threaded through the drawing apparatus in a manner presently to be explained.

If each of the dies 20 through 27 are employed to reduce the wall thickness of the tubing 30, (one or more of the dies may be used without a mandrel) the orifice 38 of each die, and the tubing at each die location would contain a mandrel 37, as shown in FIG. 2, with the mandrel in the last die 27 preferably being solid.

To draw tube in the drawing apparatus 10 in the continuous drawing process of the invention, a length of tubing from a supply thereof to be drawn (tubing 30 from supply 36, for example) must first be located in the drawing dies and around the capstans. To locate the length of tubing directly in the apparatus 10, the following procedure is employed. The length of tubing is unwound from the supply thereof, and a lubricant suitable for lubricating a first mandrel (37, for example) is disposed in the free end of the length of tubing. The first mandrel is next inserted in the end of the tube, the diameters of the first mandrel and of the orifice of the first and largest die operative with a mandrel being selected to effect a predetermined reduction in the cross sectional area of the tube. In the case where all the dies are employed with a mandrel, the first mandrel disposed in the end of the tubing would be of a size suitable for the first and largest die of the apparatus 10, namely, die 20. In the case where the first die is operated without a mandrel, the lubricant and mandrel, of course, would not be inserted.

The mandrel is temporarily fixed in the tube at a location removed from the end thereof so that the end of the tube can be swaged or otherwise reduced to the diameter of the orifice of the first die. Fixing of the mandrel may be accomplished by simply dimpling the tube at locations immediately before and after the mandrel.

The tube is next directed through the die 20 and to the first capstan 12. The capstan is provided with means (not shown) for suitably gripping the end of the tube so that with rotation of the capstan, the tube is pulled through the die 20 and around the capstan. The capstan is rotated, and as the tube moves through the die, the mandrel is carried therealong until it seats in the die orifice 37, as shown in FIG. 2. Preferably, several wraps or turns of the tubing are wound on the capstan, and the end of the tubing is then released therefrom for preparation for threading through the next die.

To prepare the tube end for the next die, the end portion reduced for the first die is severed from the remainder of the tubing, and the above steps are again repeated. Depending upon the parameters of a particular tubular stock, and the amount of reduction desired in the stock, the number of the dies 20 through 27 operable with a die mandrel with vary accordingly.

When the tubing is threaded through a selected schedule of dies and capstans, the end of the tube is extended from the last capstan 19 to a suitable take-up system (not shown).

With the tubing threaded through the apparatus 10, as described above, the capstans and the take-up system are simultaneously rotated (at suitable speeds) to continuously pull the stock from the basket 36 and through the dies to effect simultaneous reductions in the cross sectional area of the tubing, the reduced tubing being collected by the take-up system. In this manner, substantial amounts of tubing can be drawn in a very short period of time since all drawing operations are simultaneously and continuously effected with a single pass of the tubing through the apparatus 10.

In drawing tube in the apparatus 10, as mentioned above, the orifices of the dies 21 through 26 may be alternately angled in the manner shown in FIG. 1, or the orifices may be disposed in horizontal alignment with each other and with the dies 20 and 27, as indicated by numerals 21A through 26A. Where tube wall "thin-out" is not a problem, horizontal alignment of the die orifices is preferable since stringing the dies is simpler. On the other hand, with the die orifices alternately angled, the direction of tube bending and working is changed after each draw thereof, which change tends to prevent "thin-out," "thin-out" referring to the thinning of the tube wall on one side of the tube that may occur when the tube is consistently worked in one direction. With wall "thin-out" of essentially round tubular stock, the inner and outer diameters thereof would not be concentric. In the arrangement in FIG. 1, the change in direction is 180°, with the alternate capstans 13, 15 and 17 rotating in a counterclockwise direction. Where tube wall "thin-out" is a problem, any change in direction of tube bending will tend to alleviate the problem, i.e., 180° changes in the direction of tube

bending, as shown in FIG. 1, are not necessary to control the "thin-out" phenomenon.

All of the capstans, as mentioned earlier, are preferably rotated by a single motor 29 (FIG. 4), and in such a manner that the capstans slip within the turns of the tubing 30 wound thereon, with the exception of the last capstan 19 which operates at zero slip. This is accomplished by rotating each capstan at a slightly greater speed than the speed at which the tubing issues from the die immediately preceding each capstan. In such an operation, all of the capstans being used, with the exception of the last capstan 19, are operated in a spray bath of oil which serves (1) to lubricate the tube engaging surface of the capstan, (2) to lubricate the external surface of the tube being drawn, and thus the drawing orifice of each die, (3) to control and thereby provide an optimum drawing and working temperature for the tube, and (4) to clean the surface of the tube of any foreign matter and thereby prevent the embedding of foreign matter in the tube wall via subsequent draws of the tube. By control of tube temperature and by cleaning the tube surface, the oil bath tends to insure a high quality, drawn tubular product.

Further, such a high quality product is economical to produce with a slip operation. In such an operation, tubular stock is drawn only on the demand provided by the capstan pulling the stock through the die. For this reason, precise control of the relative speeds of the capstans is not necessary.

Substantial quantities of tubing have been successively drawn by the process of the invention as described above. More particularly, coils of F temper 3003 aluminum bloom have been drawn and reduced to a 0.250 inch diameter and 0.025 inch wall thickness in a slip drawing operation using a four-draw schedule. As can be appreciated, such a simultaneous reduction of tubing in a rapid manner provides economies that are unobtainable by the prior art tube drawing methods described earlier.

The supply 36 of the tubing to be drawn by the process of the invention is preferably a non-rotating pay-off means, as explained earlier, such as the basket 36 shown in FIG. 1. By directing the tubing upwardly from the basket through a cone-shaped tower 41 and over an upper guide unit 42, located above the basket, before the tubing is pulled into the die box 33 around a lower, two position, guide unit 43 in line with the die box 33 (or 33A), the tubing unwinds without kinking or knotting. By providing such a pay-off, the tail end of tubing within the basket is stationary so that it can be welded to the leading end of the next, adjacent supply of tubing to be drawn, and, in this manner, provides a drawing operation without the necessity of stringing the apparatus 10 anew for each supply of tubing to be drawn. Substantial amounts of tubing can thus be drawn before the apparatus 10 need be stopped for such maintenance as the replacement of worn dies and/or mandrels, for example.

With the use of such a serially welded tube supply, the die mandrel 37 (FIG. 2) with the central opening 39 becomes important. As explained earlier, when the apparatus was initially strung with the tubing 30, a quantity of lubricant was disposed in the end of the tubing before each mandrel was inserted in the tube. Because such an opportunity is presented for locating the lubricant, this procedure can be followed each time the apparatus is strung, or each time a prestringing process is performed as explained hereinafter. Because this lubricating opportunity is presented each time a supply of tubing is readied for drawing, there is a quantity of lubricant upstream of each mandrel in the tubing for lubricating each mandrel when the tubing is drawn. Thus, the longitudinal opening 39 in each die mandrel, as shown in FIG. 2, is not necessary when each supply of tubing to be drawn is independently strung.

When supplies of the tubular stock are serially welded together, as explained above, the drawing apparatus 10 is then continuously supplied with tubing so that the opportunity for disposing lubricant in the stock ahead of each drawing die is no longer available after the initial string-up of the apparatus. To provide lubricant for the die mandrels when supplies of the stock are serially welded together, before the tail end of a first supply is welded to the leading end of a next supply, a quantity of lubricant sufficient to lubricate all of the die mandrels is disposed in the leading end of tubing of the next supply. The ends of the two supplies are then welded together for the drawing process, and this can be accomplished while the first supply is being drawn since the supply 36 is stationary. When the weld connection between the two supplies reaches the first die 20 of the drawing apparatus, the lubricant, being carried along with the tubing, is there to lubricate the mandrel, with the major portion of the lubricant being directed through the mandrel opening 39 to the next mandrel. As the tube continues its travel through the dies, the lubricant is carried along to lubricate each mandrel as the lubricant is directed through the opening 39 in each mandrel to the last mandrel which is preferably solid. The solid mandrel functions to prevent loss of lubricant, other than that carried over from the system in lubricating the last mandrel.

With such an operation, the drawing apparatus 10 is continuously supplied with tubing so that if the tubing breaks during its pass through the apparatus, or if one or more of the dies and/or mandrels needs replacing, only that portion of the apparatus beyond the break or worn die need be rethreaded.

FIGS. 3 and 4 of the drawings show an apparatus 44 for prestringing a length of tubing 45 from a supply 46 thereof to be drawn. Prestringing is desirable when it is not possible to serially weld supplies of tubing as described above, and when the drawing apparatus 10 is already in the process of drawing a supply of tube. By stringing on an apparatus separate from the drawing apparatus 10, the drawing apparatus need be stopped only for the time it takes to receive the prestrung length of tubing (with dies and mandrels) as compared to the substantially longer time required for stringing the tubing directly on the apparatus in the manner described above.

As best seen in the elevational view of FIG. 3, the prestringing apparatus 44 comprises upper and lower capstans 48 and 49, a die holder 51, a monorail arrangement 52, with divided portions 53 and 54 (FIG. 4), and eight hangers 56 and 57, only three of which are shown in FIG.3. (For the eight capstan apparatus of FIGS. 1 and 4, eight hangers are required for the prestringing apparatus 44 as will become apparent hereinafter. Four of the hangers, i.e. hangers 56, are long while the other four (57) are relatively short, as shown in FIG. 3). Each hanger is suspended from a vehicle 59 movably mounted on a carrier beam 60, as shown in FIG. 3. The beam 60 is, in turn, suspended from two ve-

hicles 61 (only one of which is shown in FIG. 3) mounted on the monorail 52.

The divided portions 53 and 54, as seen in FIG. 4 (which is on a much smaller scale than FIG. 3), form a generally rectangular shaped, endless rail arrangement which extends laterally between the prestringing apparatus 44, as thus far described, and the drawing apparatus 10. As shown, the rail portions are spaced apart between the prestringing and drawing apparatus but come together to form the single rail arrangement 52 adjacent the prestringing and drawing apparatus.

Still referring to FIG. 4, the monorail 52 extends (to the right) to the vicinity of the tube supply 46 in substantial alignment with the tube 45.

To prestring the apparatus 44, and thereby prepare a series of spaced groups of loops of tubing (with dies and mandrels) to be disposed in the drawing apparatus, a supply of tubing (supply 46, for example) is moved to a location that permits a length of tubing 45 to be removed from the supply sufficient to reach the capstans 48, 49 and the die holder 51, with a loop 45A off the supply as shown in FIG. 4. The supply of tubing 46 may be held in an open basket (such as 36 in FIG. 1), and may be moved into place on a powered conveyor, generally indicated in FIG. 4 by numeral 64, though the invention is not limited thereto.

A lubricant is next disposed in the end of the tube length removed from the supply 46, and a first mandrel is then inserted in the end of the tube, the diameters of the mandrel and the cooperating orifice of the first die (die 66 in FIG. 3) being selected to effect the first predetermined tube reduction in the drawing process of the invention. The cooperating die 66 is shown in FIG. 3 disposed on the tube 45 to the far right of the die holder 51, whereas for the prestringing method of the invention, each die, as will become apparent hereinafter, is initially located and secured in the die holder 51.

The end of the tube is next swaged or otherwise reduced in diameter to the size of the orifice of the first die 66. After the tube end is swaged, it is directed through the die 66 (which now is in the die holder 51), and at least one, but preferably three wraps or loops of tubing 45 are pulled on the lower capstan 49. From the capstan 49, the tube may be directed to and through the rolls of a powered straightening device 68. The straightening device, if used, provides tension to enable the capstan 49 to pull an amount of tubing through the die 66 (still in the die holder 51) sufficient to provide a volume of metal to string seven additional capstans (for an eight capstan drawing apparatus).

With the tubing 45 extending through the straightening device 68, as shown in FIG. 3, the hanger 56 is moved into place adjacent the capstan 48, via the rail vehicle 59, and the wraps or loops of tubing on the capstan 49 are removed therefrom and hung on a hook (not shown) at the lower end of the hanger 56, the loops being designated diagrammatically in FIG. 3 by a single circle 49A. When the loops 49A, which form the first group of a plurality corresponding to the number of capstans of the drawing apparatus, are removed from the capstan 49, the die 66, with a mandrel therein and in the tube, is removed from the die holder 51 so that the loops with the dies are free to move from the vicinity of the capstan 49 and the die holder 51.

With the rolls of the straightening device 68 opened so that the tube is free to move, the carrier beam 60 is moved to the right (in FIGS. 3 and 4) along the monorail 52 extension, with moves the loops 49A and the tubing 45 to the right until the end of the tubing is returned to a location upstream of the die holder 51. A die 72, having an orifice sized for effecting the next reduction in tube size, is disposed in the die holder 51 for the next step in the prestringing method, though, in FIG. 3, the die 72 is shown removed from the die holder and disposed on the tube between upper and lower loop groups 48A and 49A.

The tube lubricating, mandrel inserting, and swaging steps are again repeated, and turns of the tubing are pulled on the upper capstan 48 through the die 72 (located at this time in the die holder 51). As with the first die 66, the die 72 is removed from the die holder 51, and the turns of the tubing wound on the capstan 48 are removed therefrom, as indicated diagrammatically at 48A, and hung on the lower end of a second hanger 57, as shown in FIG. 3.

With the upper loops 48A on the second hanger 57, and the die 72 removed from the die holder 51, the beam 60 is again moved to the right to place the end of the tubing 45 ahead of the die holder and capstans for the preparation of a third group of loops 49B in the manner explained above, the third group being formed on the lower capstan 49. This process is continued until eight groups of loops are suspended, in a spaced apart manner, from eight hangers 56 and 57 with eight dies alternately located between the loop groups.

At the completion of the process, as thus far described, the eight groups of loops of tubular stock hang from the carrier 60 in substantial horizontal alignment beneath the monorail 52 on the side of the rail portions 53, 54 (FIG. 4) opposite to that of the drawing apparatus 10. With the loops so disposed, the two vehicles 61, supporting the carrier 60 and the hangers 56, 57 are then simply moved along the monorail 52 and switched respectively onto rail portions 53 and 54 (via rail switches not shown), to present the eight groups of loops to the eight capstans (12 to 19) of the drawing apparatus, the eight vehicles 59 aligning the first four groups with the first four capstans 12 to 15 of the drawing apparatus, and the last four groups with the last four capstans 16 to 19. With the loop groups aligned with the capstans, and dies aligned with their respective die holders, the loops are removed from the hangers and placed on their corresponding capstans, the upper group of loops (as seen in FIG. 3) being moved down in horizontal alignment with the lower group of loops. Similarly, the dies located on the tubing are disposed and secured in the die holders 21H to 26H, (FIG. 1) with the first and last dies being located and secured respectively in the die box 33 and in the right end wall of the housing 32.

In the prestringing apparatus, the distance between the die holder 51 and the two capstans 48 and 49 corresponds to that of the die holders and capstans of the drawing apparatus 10 so that when the dies on the prestrung tubing are presented to the drawing apparatus, the dies will align substantially with the die holders of the drawing apparatus.

When the loops of tubing are moved from the prestringing apparatus 44 to the drawing apparatus 10, the supply of rough drawn tubing is moved along the conveyor 64 to the position of 46A as shown in FIG. 4. In this manner the supply is aligned with the drawing apparatus which is now ready to draw the tubing from a rotary payoff. After the supply is drawn, the supply

container is moved out of the way on the conveyor to make room for the next supply of rough drawn tubing, the leading end portion of which has been prestrung in the manner described above.

By employment of such a prestringing process, the drawing apparatus **10** is allowed to perform a drawing operation or operations during the prestringing process thereby effecting maximum utilization of the drawing apparatus. As explained above, the time required to place the prestrung tubing on the drawing apparatus **10** is substantially shorter than that required for stringing the drawing apparatus itself.

From the foregoing description it should now be apparent that a new and useful tube drawing process has been disclosed, the process providing simultaneous, continuous tube drawing with a single pass of the tube through an apparatus comprised of a series of drawing dies and tube pulling capstans. The economy of the process and apparatus is enhanced by using a slip-drawing arrangement, and a process of prestringing the tube to be drawn provides economies by maximizing utilization of drawing apparatus.

While the invention has been described in terms of preferred embodiments, the claims appended hereto are intended to encompass all embodiments which fall within the spirit of the invention.

Having thus described my invention and certain embodiments thereof, I claim:

1. A method of drawing tubular stock simultaneously through at least two successive drawing dies, the method comprising the steps of

pulling the tubular stock through the first one of said dies by rotating a pulling member capable of winding the tubular stock thereon at a location intermediate of said dies while simultaneously directing the tubular stock to the second one of said dies from said pulling member, and

simultaneously, continuously pulling said tubular stock through the second one of said dies,

said dies simultaneously reducing the cross sectional area of the tubular stock being pulled therethrough.

2. The method of claim **1** in which at least one of the drawing dies is operative with a mandrel located therein and within the tubular stock being drawn.

3. The method of claim **1** in which the first pulling step includes rotating the pulling member at a rate of speed greater than the rate at which the tubular stock is pulled from the first die to cause the pulling member to slip within at least one turn of tubular stock.

4. The method of claim **3** including the step of continuously winding the tubular stock being pulled from the second die onto a second pulling member at an angle different from the angle at which the stock was directed from the first pulling member.

5. Apparatus for performing simultaneous drawing operations on tubular stock in a single pass of the stock through the apparatus, comprising

at least two successive drawing dies and mandrels disposed in the orifices of the dies, and located within the tubular stock,

a rotatable pulling member located intermediate of said dies for continuously pulling tubular stock through the first one of said dies and for directing the tubular stock from the pulling member to the second one of said dies, said pulling member having wound thereon at least one turn of said stock,

a rotatable second pulling member for simultaneously and continuously pulling the tubular stock through the second one of said dies, said dies in cooperation with their respective mandrels being adapted to effect simultaneous reduction of the cross sectional area of the tubular stock pulled therethrough.

6. The apparatus of claim **5** in which the mandrel in the first one of the dies is provided with an opening extending longitudinally therethrough, said opening being adapted to pass lubricant therethrough when the tubular stock is drawn through the dies.

7. Apparatus for performing simultaneous multiple drawing operations with a single pass of tubular stock through the apparatus, comprising

a plurality of successive drawing dies and die associated mandrels operative with at least a portion of said dies,

a plurality of capstans mounted for rotation and alternately arranged with said dies, and

means for rotating the capstans, with each capstan being capable of pulling the tubular stock through the die immediately preceding it and onto itself when rotated while simultaneously directing the tubular stock from the capstan to the die immediately succeeding the capstan.

8. A method of threading tubular stock through the orifices of successive drawing dies, at least a portion of which is operative with mandrels located in the die orifices and within the tubular stock, the method comprising the steps of

inserting and temporarily fixing a mandrel in a free end of a length of tubular stock to be drawn,

reducing the diameter of the free end of said tubular stock substantially to the size of the orifice of the first die of said successive drawing dies,

directing the reduced end of said tubular stock through said orifice and onto a capstan,

rotating the capstan to pull said tubular stock through the die and onto the capstan to provide at least one complete turn of the stock on the capstan,

severing the reduced end of said tubular stock from the remainder thereof, and

repeating the above steps with each of the remaining successive dies operative with a mandrel.

9. The method of claim **8** including the step of disposing a lubricant in the free end of the tubular stock before the mandrel is inserted in the stock.

10. A method of prestringing tubular stock for a tube drawing apparatus having a plurality of alternately disposed successive dies and capstans, the method comprising the steps of

1. disposing a lubricant in a free end of a length of tubular stock,
2. inserting and temporarily fixing a mandrel in said tubular stock adjacent the free end thereof,
3. reducing the free end of the tubular stock substantially to the size of an orifice of a die secured in a die holder,
4. directing the reduced end into and through the orifice,
5. pulling the tubular stock from the orifice and around a pulling member to provide a first group of loops of the tubular stock,
6. pulling the free end of the tubular stock from the pulling member for a distance sufficient to provide a volume of tubular stock capable of extending

through the dies and around the capstans of the drawing apparatus,

7. removing the group of loops of tubular stock from the pulling member, and the die from the die holder,
8. disposing the group of loops on a movable suspension means,
9. returning the free end of the tubular stock to a location adjacent the die holder,
10. disposing a die in the die holder,
11. repeating steps one to five, seven, eight and 10 to provide spaced groups of loops of the tubular stock, with dies attached to the stock at locations intermediate of the loop groups,
12. moving the suspension means from the prestringing apparatus to the tube drawing apparatus to thereby present the groups of loops and dies to corresponding capstans and die holders of the drawing apparatus, and
13. placing the group of loops on the corresponding capstans, and the dies in the corresponding die holders of the drawing apparatus.

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