Oct. 23, 1945. H. C. INSLEE 2,387,515

REDUCING MILL

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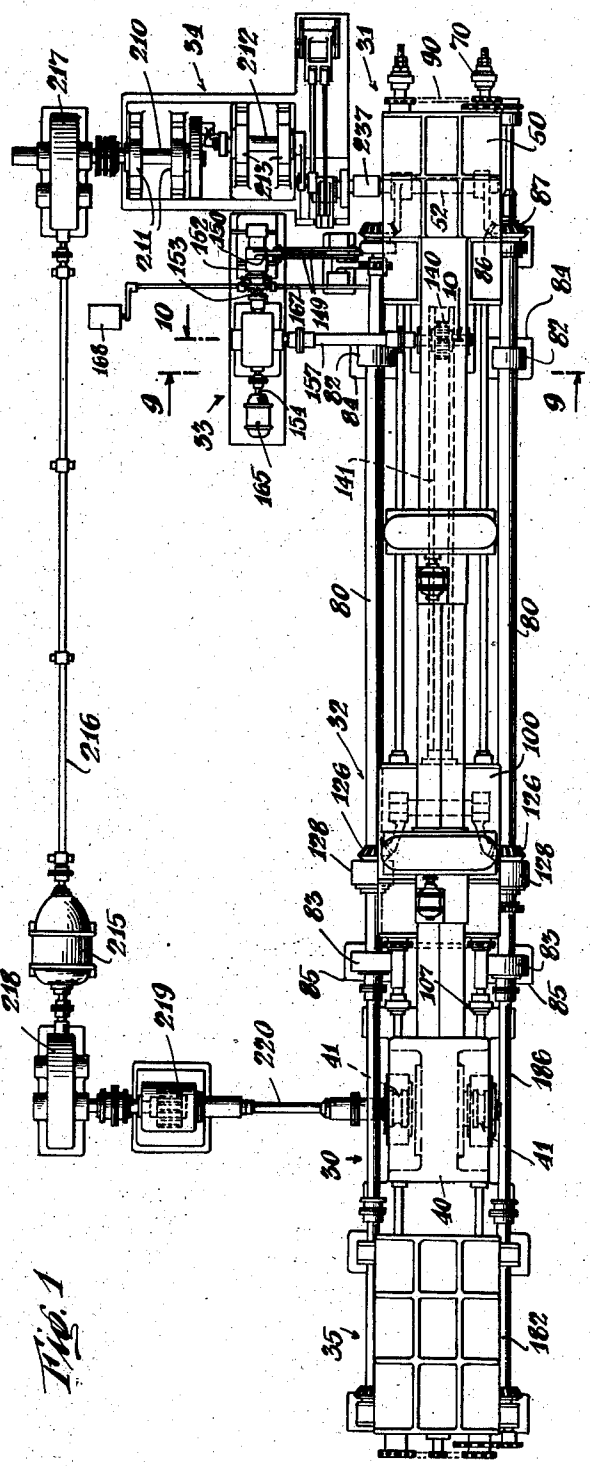


Fig. 1

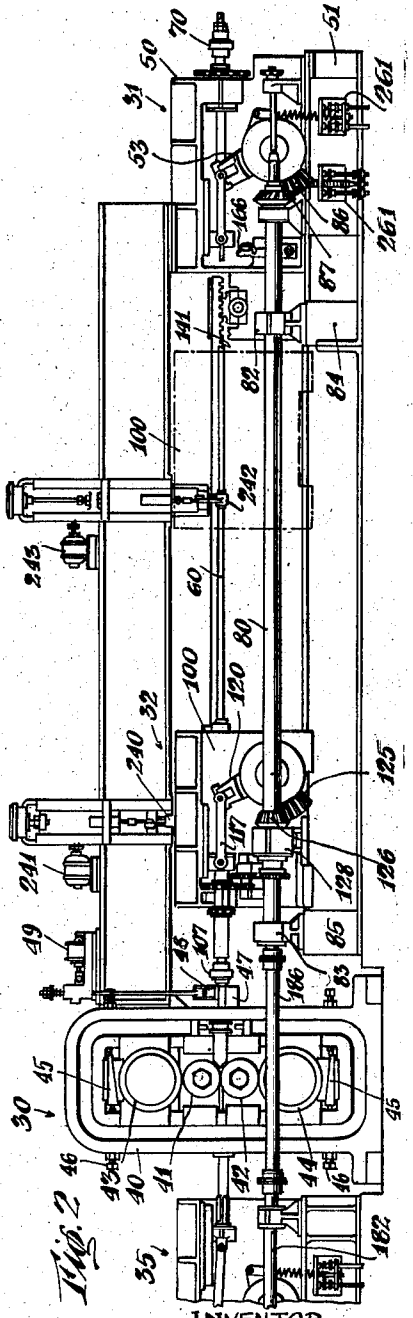


Fig. 2

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REDUCING MILL

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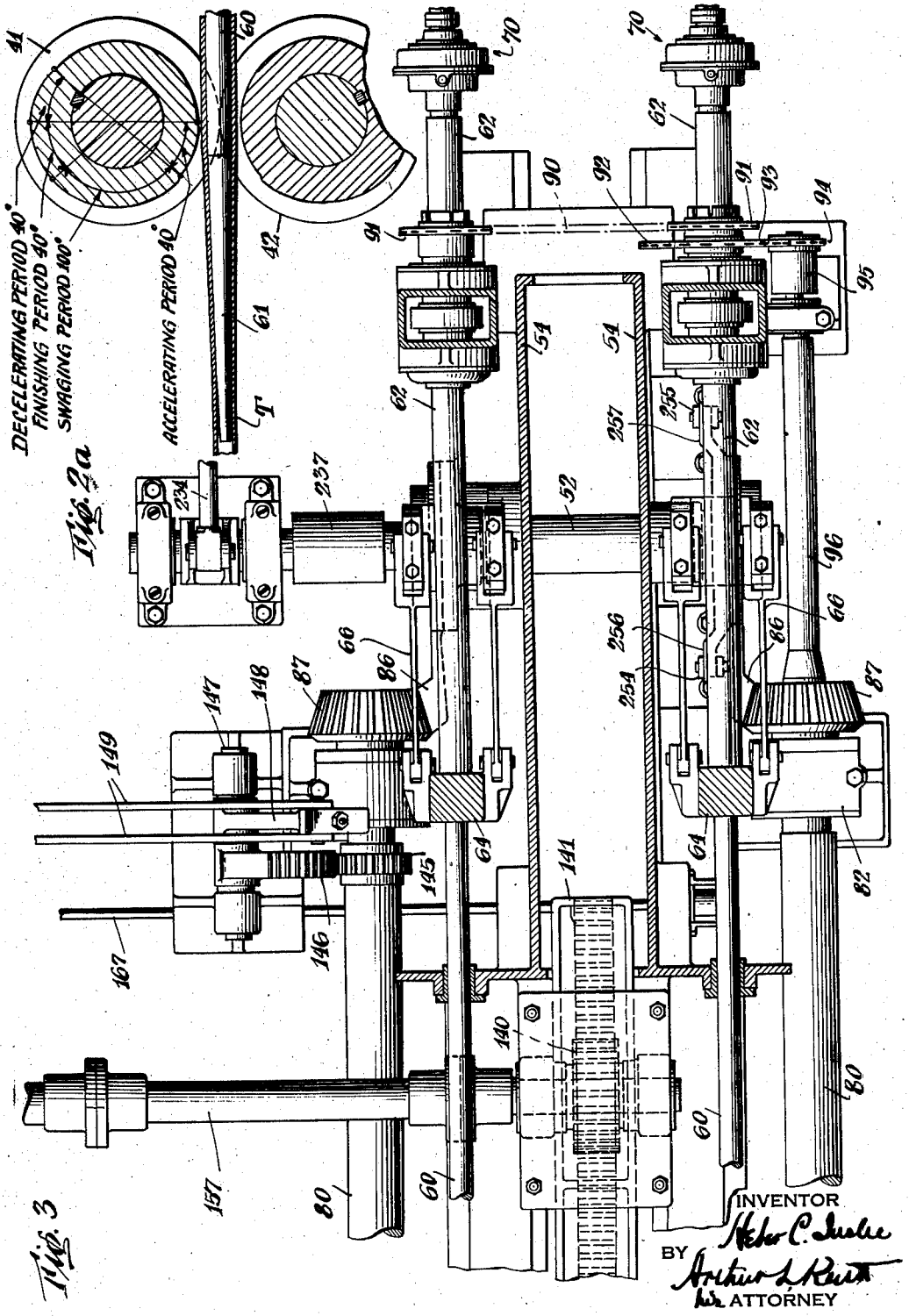


Fig. 2a

Fig. 3

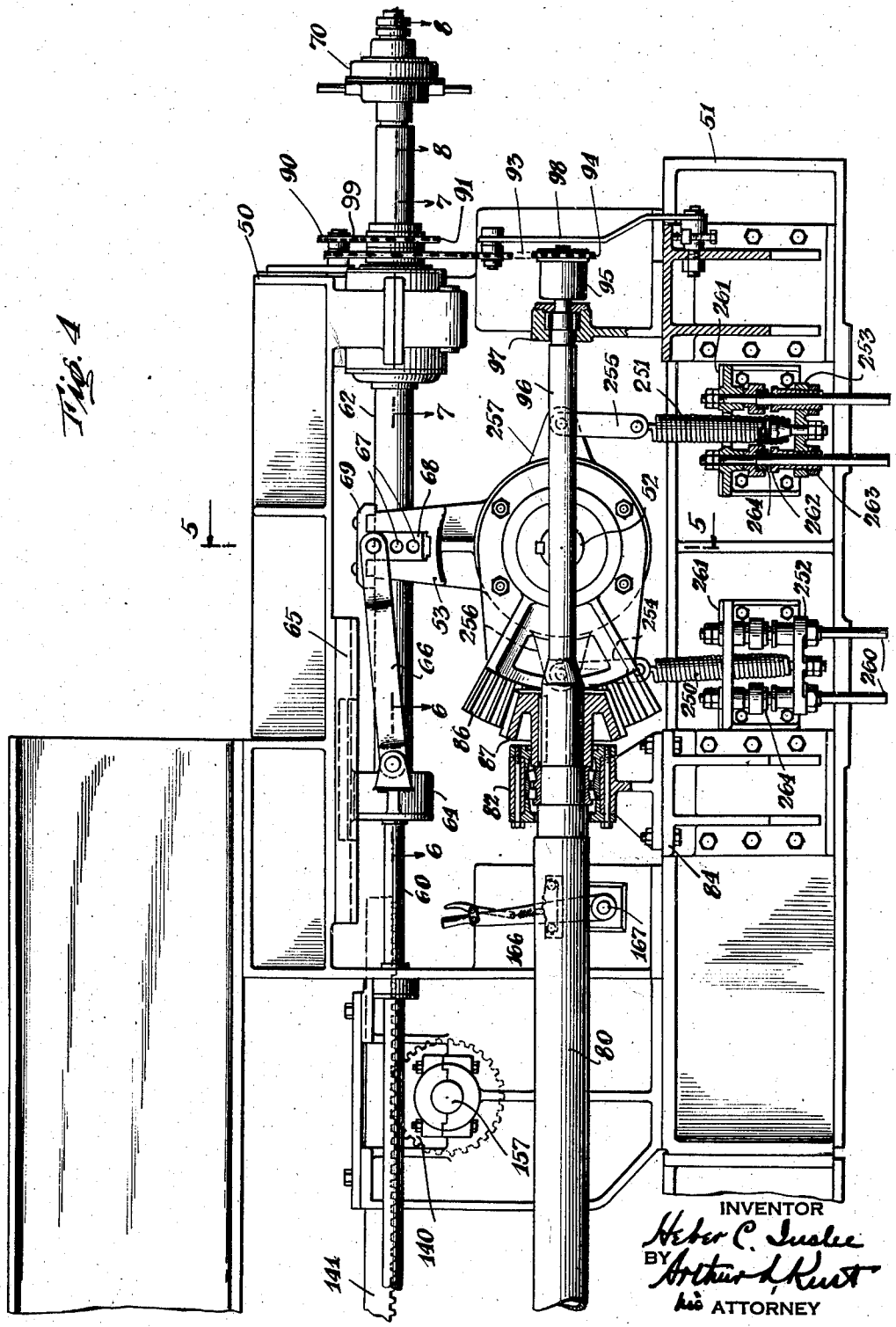
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REDUCING MILL

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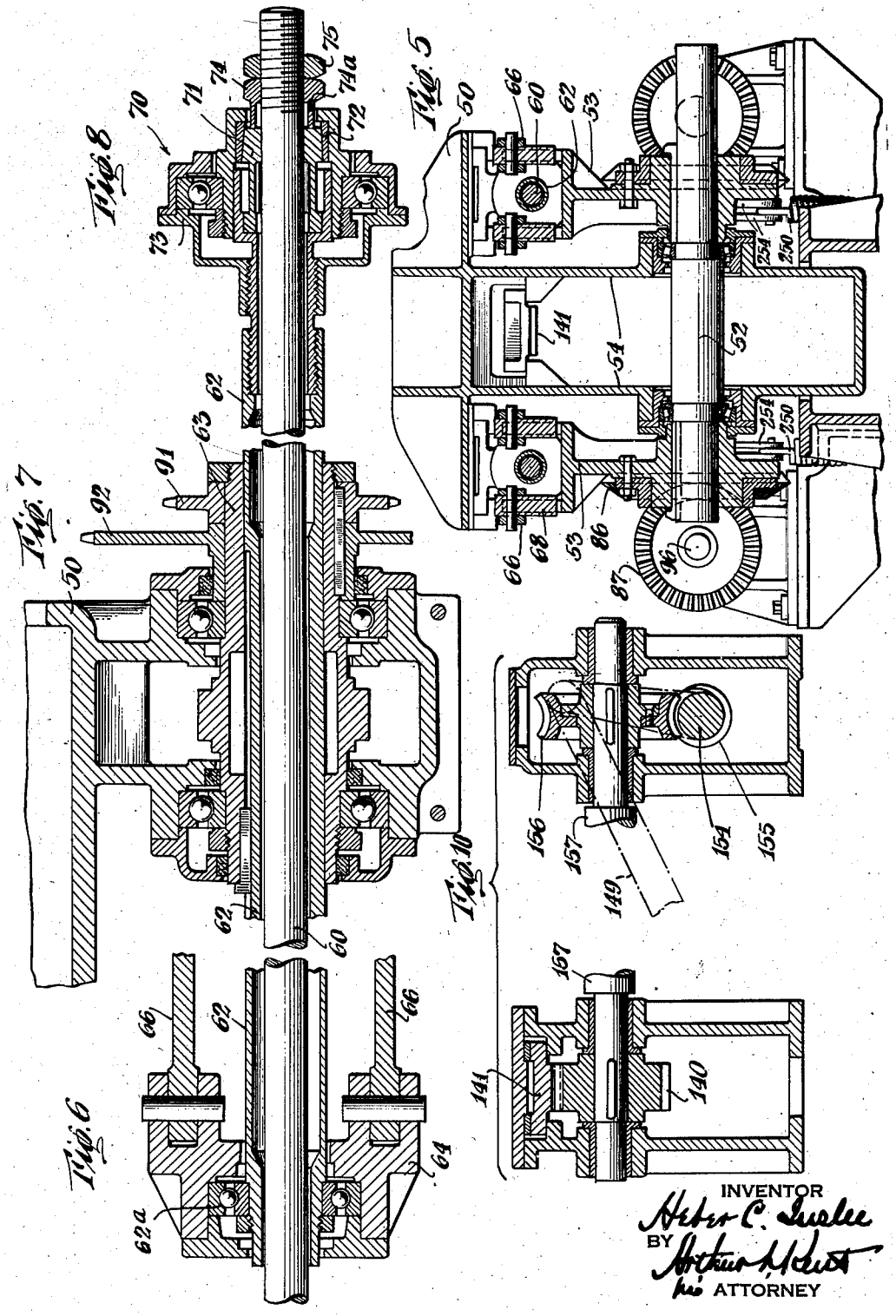
Fig. 4



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REDUCING MILL

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REDUCING MILL

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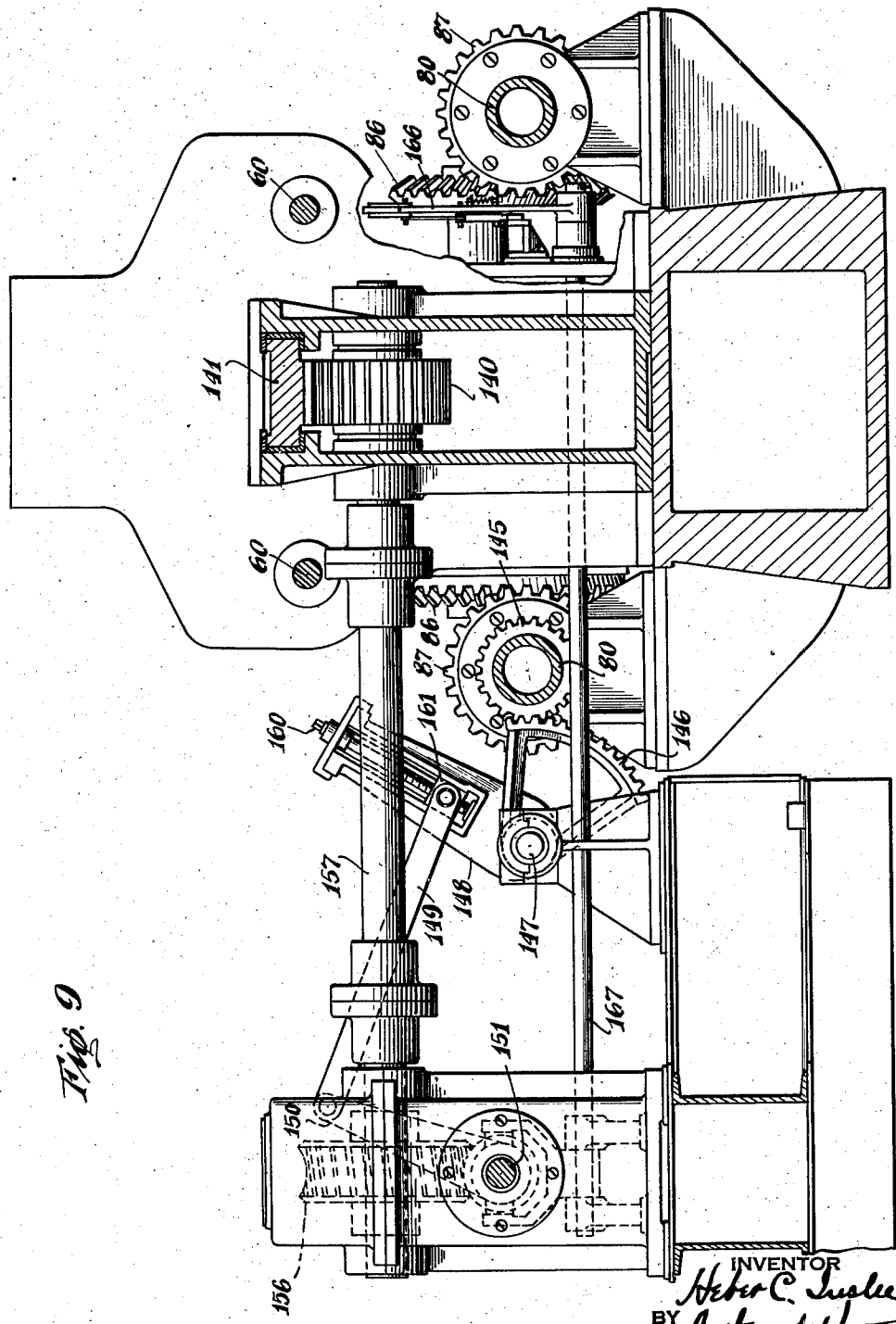


Fig. 9

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REDUCING MILL

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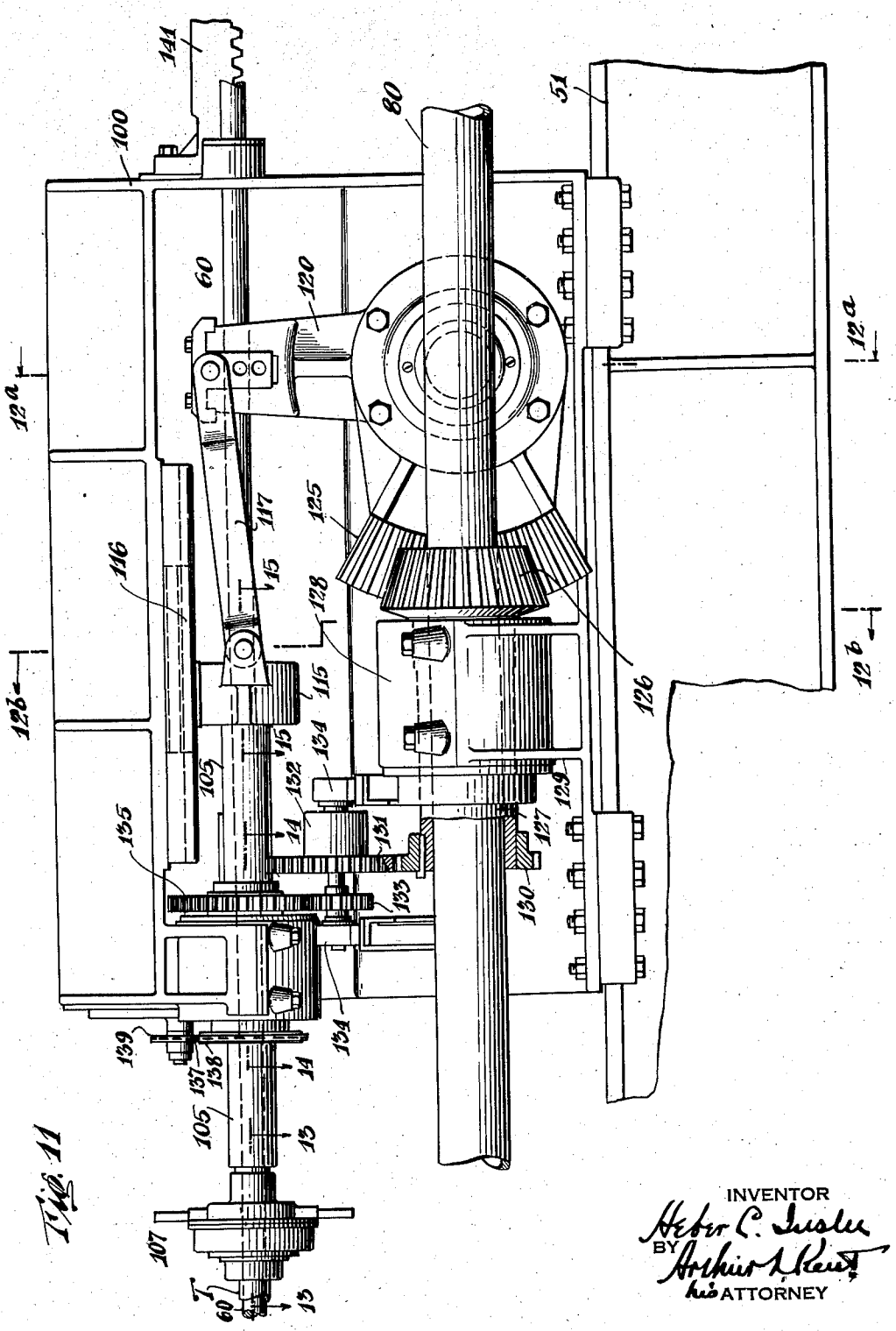


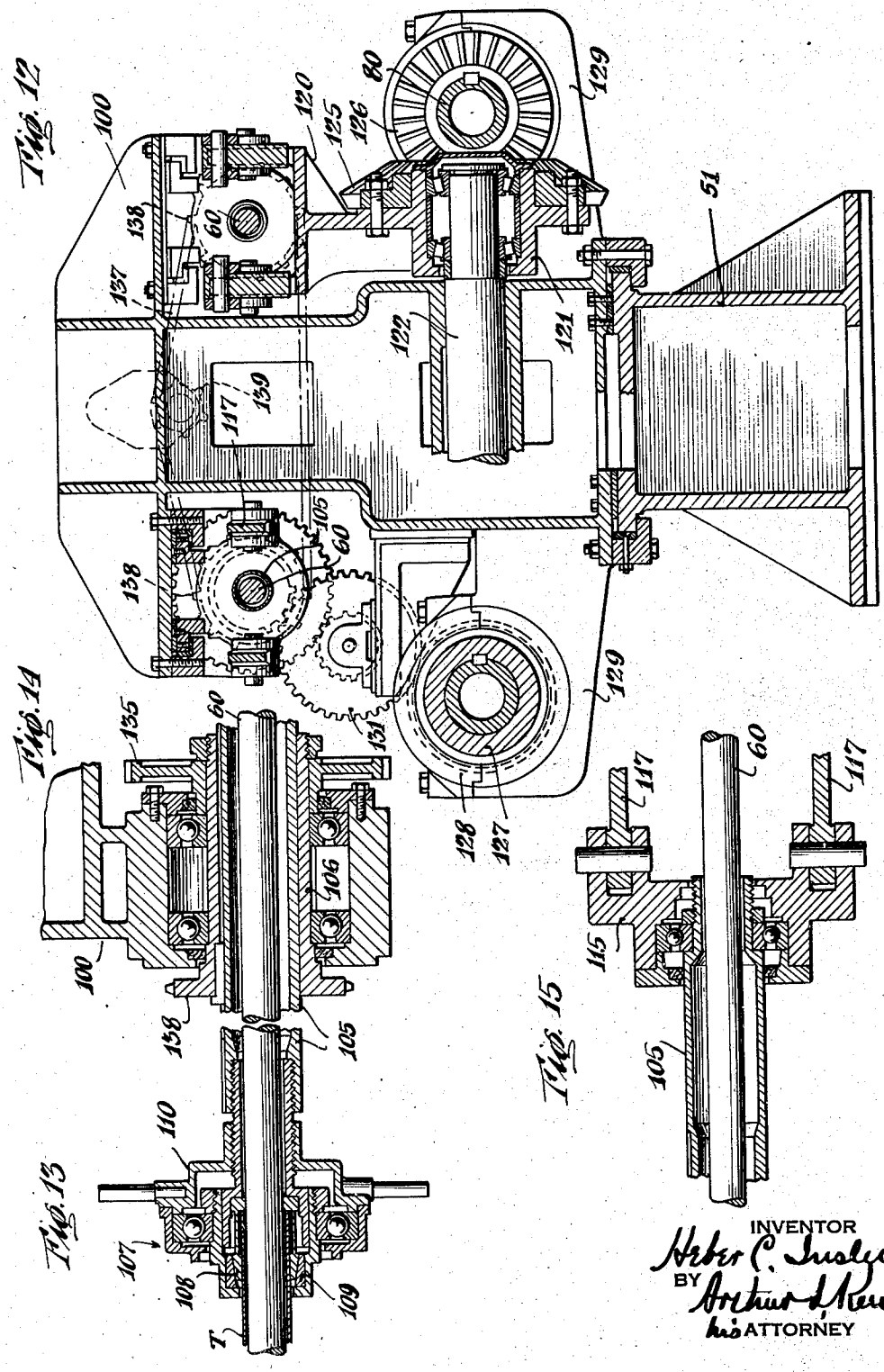
Fig. 11

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REDUCING MILL

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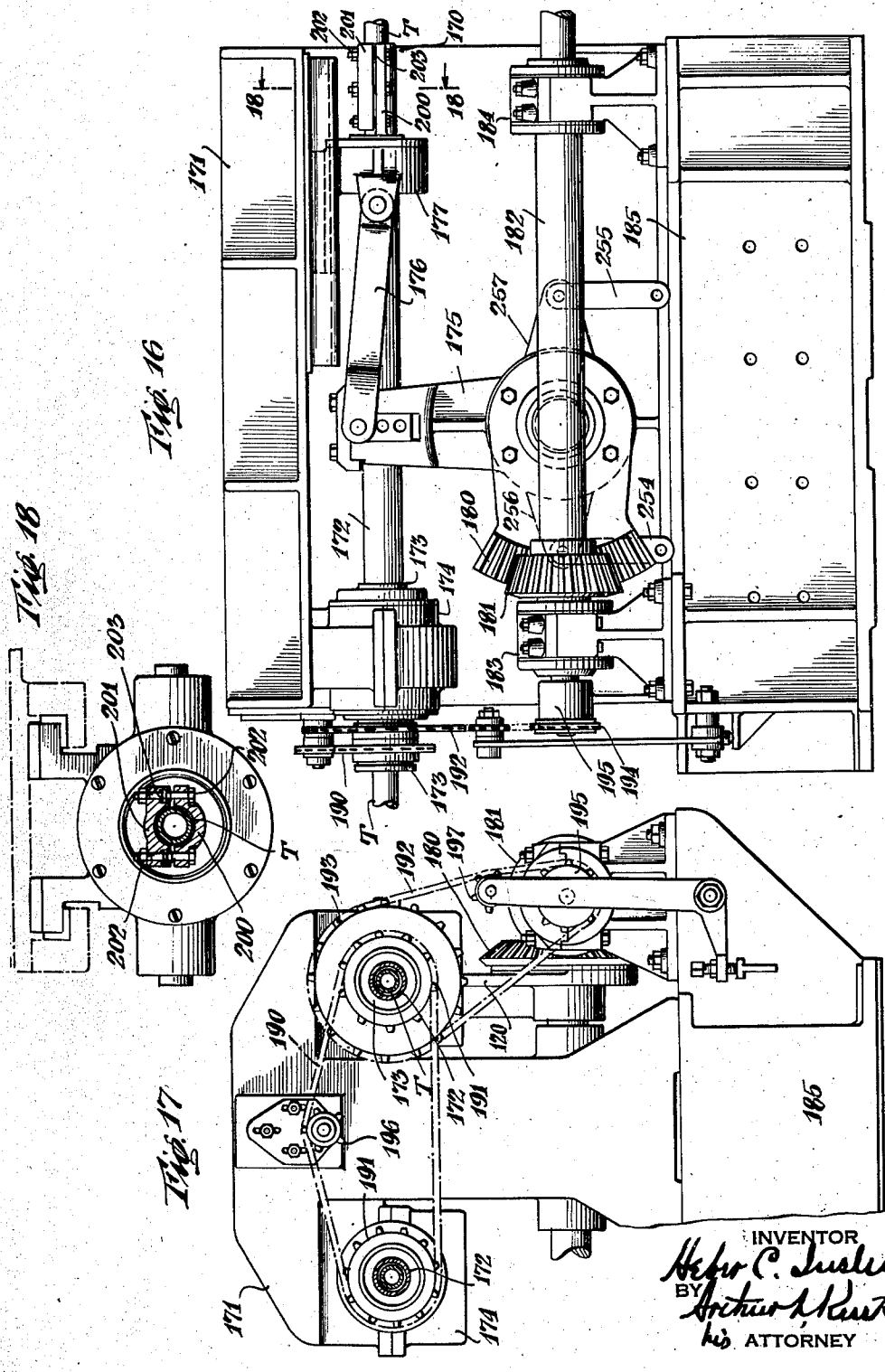


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REDUCING MILL

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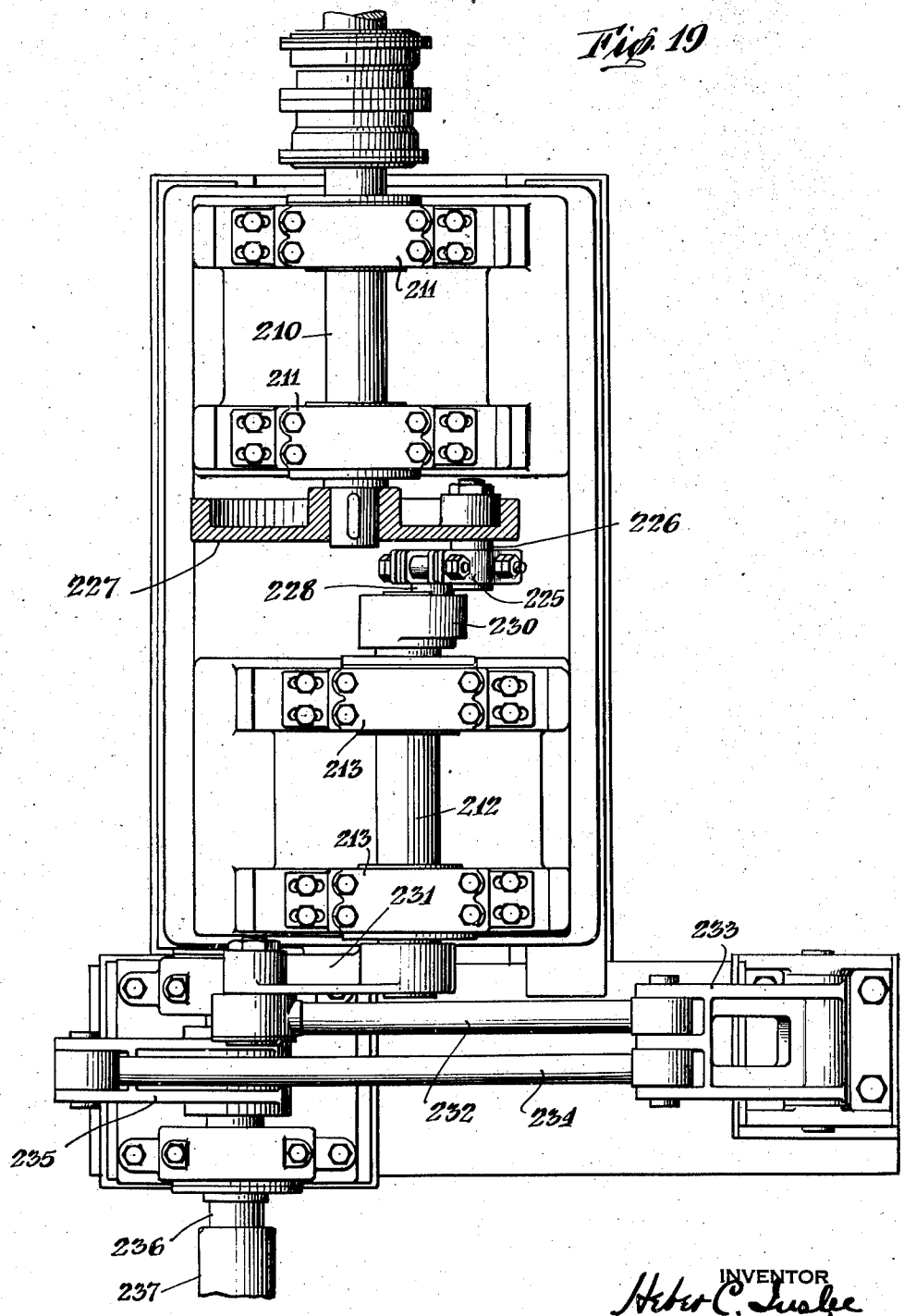
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REDUCING MILL

Filed May 13, 1942 10 Sheets-Sheet 9

Fig. 19



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REDUCING MILL

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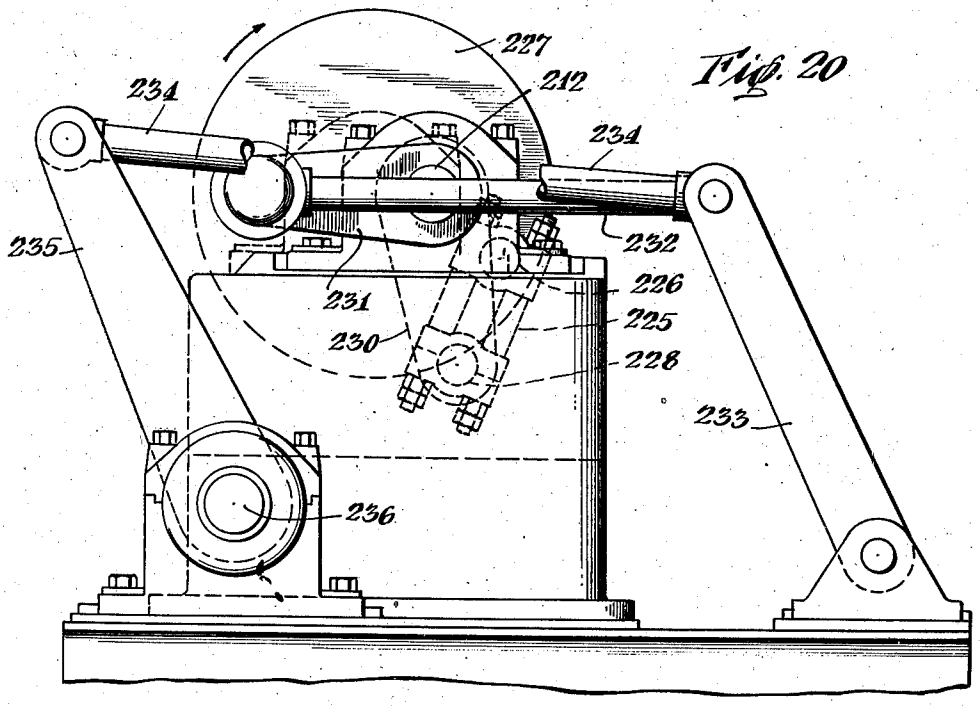


Fig. 20

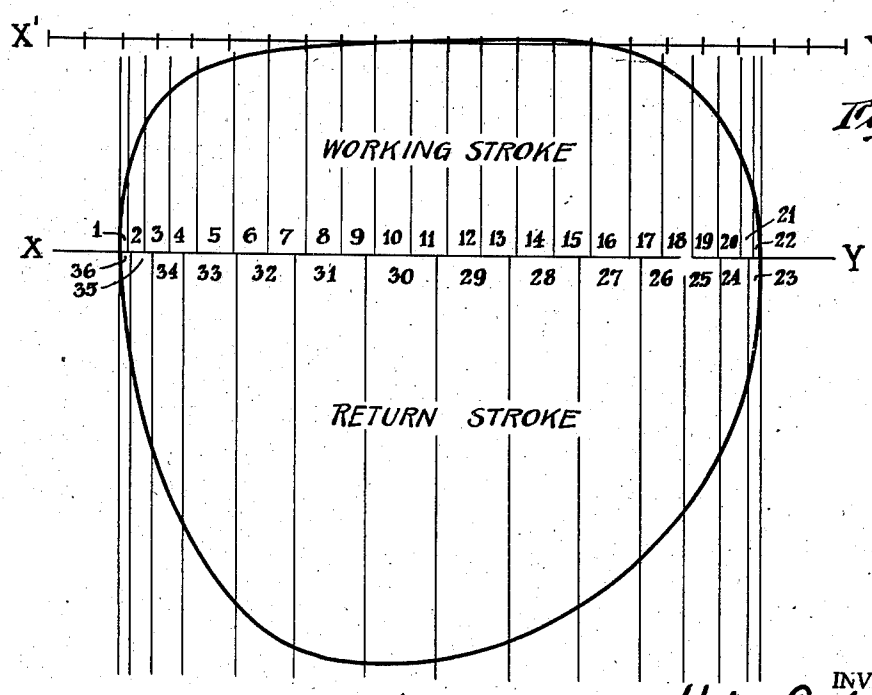


Fig. 21

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Patented Oct. 23, 1945

2,387,515

UNITED STATES PATENT OFFICE

2,387,515

REDUCING MILL

Heber C. Inslee, East Orange, N. J., assignor, by mesne assignments, to Rockrite Processes, Inc., Stamford, Conn., a corporation of Delaware

Application May 13, 1942, Serial No. 442,769

60 Claims. (Cl. 80—14)

This invention relates to apparatus for reducing metal tubes and bars. The invention has been made especially with the idea of providing an improved apparatus for reducing metal tubes in the cold state, but features of the invention may be used also for hot reduction of tubes, and features of the invention are adapted for the hot or cold reduction of bars or rods.

More particularly, the invention relates to a step-by-step reducing mill of the Pilger type, that is, one in which the workpiece, or stock, reciprocates between gapped die rolls which rotate continuously in one direction about fixed axes, the die rolls reducing the workpiece during its successive strokes in one direction and leaving it free during its non-working return strokes, and the workpiece being given an increment of feed and a partial turn for each complete reciprocation; and to a reducing mill of this type in which the movement of the workpiece, and also of the mandrel in a tube-reducing mill, is under positive control during both the reducing and return strokes. Certain features of the invention are adapted for use otherwise than in Pilger mills.

The invention aims generally to provide a Pilger-type reducing mill, and especially one for reducing cold stock, having high efficiency and a high capacity, or rate of output, and to provide such a mill of low capital cost and low operating cost compared to its output, and to provide such a mill which shall produce tubes or bars of high quality with regard both to form and finish, and which shall be convenient to operate, durable, and of low maintenance cost.

The high efficiency and high capacity of mills according to the invention are due in large part to the facts that excessive weight of the reciprocating parts of the mill is avoided, and that the reciprocation of the work-piece and mandrel is effected by means of a driving mechanism whereby a nearly constant linear velocity approximately equal to the pitch line speed of the die grooves of the die rolls is given to the workpiece and mandrel during a major portion of the working stroke, the die grooves of the die rolls extending for a portion of the circumference of the rolls corresponding to such major portion of the working stroke, and acceleration to substantially the pitch line speed of the die grooves being accomplished in the part of the working stroke preceding such major portion and deceleration in the part following such major portion. The driving mechanism disclosed and specifically claimed in this application is a quick-return mechanism whereby the working stroke of the workpiece and mandrel is lengthened to extend over a time during which the die rolls make substantially more than half a rotation and the major portion of the working stroke during which the workpiece and mandrel are driven at approximately the pitch line speed of the die grooves is lengthened and the die portions, or work-engaging portions, of the rolls are correspondingly lengthened. Because of this the amount of work which can be performed on the workpiece during each working stroke is increased or the compressive force required for performing a given amount of work is reduced, while because of the quicker movement of the reciprocating parts during the non-working return stroke there is no loss in the possible speed of operation of the mill. Since the relatively slow working stroke extends over a time during which the die rolls make substantially more than half a rotation, the approximately constant linear velocity during a major portion of the working stroke does not result in an excessively short time for acceleration and deceleration of the reciprocating parts at the beginning and end of the working stroke, there being more time left for such acceleration and deceleration than there would be if the working stroke were limited to the time during which the die rolls rotate only 180°.

The efficiency and capacity of Pilger mills and other metal reducing mills depends primarily on the operating speed of which they are capable without impairment of smooth operation. In mills of the ordinary Pilger type, where the rolls grip the workpiece while the latter is stationary, a considerable shock is produced by each impact of the dies on the metal workpiece. These continuous shocks could not be tolerated in cold working without injury to the workpiece and the rapid impairment of the dies. Consequently, for reducing cold workpieces such a mill would have to run very slowly, too slowly, in fact, to be really practicable for cold working at all. An important result of the driving mechanism of the present invention is that at the beginning of the working stroke the workpiece is started in motion and its speed brought up to approximately the pitch line speed of the die grooves before the workpiece is engaged by the dies, working engagement then continuing during a major portion of the working stroke. Since, in this way, the shock of impact of the dies on the workpiece may be substantially eliminated, there is practi-

cally no limit to the speed of operation of the mill from this cause.

The high capacity of a mill embodying all the features of the invention is also due in part, and the low capital cost and low operating cost of the mill compared to its output are due largely, to the fact that the mill is a duplex mill adapted to operate on two workpieces at the same time. Many features of the invention are, however, suitable for single mills.

The invention consists in various features of construction, arrangement and combination of parts, all of which will be clearly brought out in the following description of a tube-reducing mill embodying the various features of the invention in the form now considered best, and thereafter specifically pointed out in the claims.

In the accompanying drawings:

Fig. 1 is a plan view of a tube-reducing mill embodying the various features of the invention in the form now considered best;

Fig. 2 is a side view of the mill;

Fig. 2*a* is an enlarged detail view showing one pair of the die rolls in section and the mandrel between them, at the end of the forward non-working stroke;

Fig. 3 is an enlarged plan view of the mandrel-reciprocating mechanism and adjacent parts with the mandrel unit housing sectioned;

Fig. 4 is a side view of parts shown in Fig. 3;

Fig. 5 is a section taken on line 5—5 of Fig. 4;

Figs. 6, 7 and 8 are detail sectional views taken, respectively, on lines 6—6, 7—7 and 8—8 of Fig. 4;

Fig. 9 is an enlarged view of the tube feed mechanism taken on line 9—9 of Fig. 1;

Fig. 10 is a broken view of parts of the tube feed mechanism taken on line 10—10 of Fig. 1, Fig. 10 being on the scale of Figs. 3, 4 and 5, and Fig. 9 being on a slightly larger scale;

Fig. 11 is an enlarged side view of the tube-reciprocating mechanism shown in Fig. 2;

Fig. 12 is a section the right hand portion of which is taken on line 12*a*—12*a* of Fig. 11 and the left hand portion on line 12*b*—12*b* of Fig. 11;

Figs. 13, 14 and 15 are sections taken on line 13—13, 14—14 and 15—15 of Fig. 11;

Fig. 16 is an enlarged side view of the tube reciprocating and turning mechanism at the exit side of the roll stand;

Fig. 17 is an end view partly broken away of the mechanism shown in Fig. 19;

Fig. 18 is a section taken on line 18—18 of Fig. 16;

Fig. 19 is an enlarged plan view, and Fig. 20 a corresponding side view, of the drag link quick-return mechanism, shown at the right hand end of Fig. 1, through which the tube and mandrel are reciprocated; and

Fig. 21 is a diagram illustrating the quick return motion imparted to the tubes and mandrels.

The tube reducing mill illustrated is a duplex mill, having two pairs of continuously driven gapped working rolls and means for reciprocating a mandrel and tube between the rolls of each pair, and means whereby the tubes and mandrels are given a partial turn and the tubes are given an increment of feed between successive working strokes, the working rolls having, in the usual manner, tapered die grooves which act on the tubes during the working stroke of the tubes and mandrels, and rotating without contact with the tubes during the non-working return stroke of the tubes and mandrels. In the mill as illustrated, and most desirably, the reducing action takes place during the backward stroke of the tubes and mandrels, the non-working return stroke being in the forward direction, that is, in the direction toward the reduced end of the tube. It will be obvious that many of the features of the invention may be embodied in mills having only one pair of die rolls and means for reciprocating only one mandrel and tube, or in mills differing otherwise from the mill illustrated.

The complete mill illustrated comprises a roll stand 30, a mandrel reciprocating and turning unit 31, a tube reciprocating, turning and feeding unit 32, a tube feeding mechanism 33, a quick-return driving mechanism 34, and an exit tube reciprocating and turning unit 35. The roll stand comprises a massive frame or housing 40 in which are mounted two pairs of overhung die rolls 41 and 42 fast on opposite ends of two shafts journalled within the housing, the upper rolls 41 of the two pairs being held against upward pressure by backing rolls 43, and the lower rolls 42 of the two pairs being supported against downward pressure by backing rolls 44, and wedges 45 and wedge operating screws 46 for adjusting the rolls vertically, permitting die rolls of different diameter within a limited range to be used, and also for applying to both pairs of die rolls a preload aproximately equal to the rolling load on the die rolls. This roll stand forms the subject matter of my copending application Serial No. 442,768, filed May 13, 1942, now Patent No. 2,358,929, issued September 26, 1944, and for further description thereof reference is made to said application. At the entrance side of the housing 40 there are two tube clamping devices, of which one is shown in Fig. 2, one for each pair of die rolls 41 and 42, each comprising a lower stationary member 47 and an upper vertically movable clamping member 48. The clamping members 48 are in raised position during the operation of the mill, and are moved down to clamp the partially reduced tubes against the members 47 by air cylinders 49, of which one is shown in Fig. 2, when the mill is stopped.

Mandrel reciprocating and turning unit

The operating parts of the mandrel reciprocating and turning unit 31 (see Figs. 1 to 8) are mounted in a stationary housing 50 seated on the rear end of a longitudinally extending base 51. The operating parts are driven by a transverse driving shaft 52 which is oscillated by the quick-return mechanism 34 to have a relatively slow movement in one direction and a quick return movement in the other direction. Mounted fast on the oscillating shaft 52 are two lever arms 53, one on each side of the spaced walls 54 of the housing. Each of these lever arms reciprocates one of the two mandrel bars 60. Each mandrel bar has at its forward end a tapered mandrel 61 (see Fig. 2*a*).

Each of the mandrel bars extends through and is removably secured to a longitudinally reciprocable and axially rotable holder formed by a sleeve 62 which is slidably mounted in and keyed to an axially rotatable sleeve 63 mounted and held against endwise movement in a part of the housing 50. The forward end of sleeve 62 is rotatably connected by bearings 62*a* to a cross-head 64 which is mounted to reciprocate on slideways 65 carried by the housing 50 and extending longitudinally of the sleeve, the bearings 62*a* between the sleeve and cross head being formed to prevent

relative longitudinal movement between the two. Cross-head 64 is connected by links 66 to the forked end of one of the lever arms 53 so that as the arm 53 oscillates the mandrel-holding sleeve 62 and the mandrel bar are reciprocated, the mandrel bar making one complete reciprocation backward and forward for each rotation of the die rolls. For changing the length of stroke of the mandrel bar for operating with die rolls of different diameters, the points of pivotal connection of the links 66 to the arm 53 are adjustable for varying the effective radial length of the arm. As shown (Figs. 4 and 5), the connection of the links to the fork ends of the arm may be made at any one of three pivot pin holes 67, and these pivot pin holes are formed in blocks 68 extending into the slotted fork ends of the arm from cap pieces 69 which are bolted to the arm fork ends. By using different blocks with one or more differently positioned pivot pin holes, the throw of the mandrel bar may be adjusted not only for die rolls of the three sizes provided for by the three pivot pin holes of the blocks 68 as shown, but for die rolls of other sizes within the range permitted by the length of the blocks 68.

Each mandrel bar is secured to its sleeve 62 by means of a mandrel clamp 70 at the rear end of the sleeve. This clamp as shown has gripping jaws 71 which are forced against the mandrel bar by a wedging collar 72 which is drawn against the inclined faces of the gripping jaws by the turning of a screw collet 73. The particular construction of this mandrel bar clamp is not of special moment.

In the use of the mill, the mandrel bar must be released from the holding sleeve 62 in order that it may be retracted for the placing of a new tube in the mill, and it is necessary that in returning the mandrel to operative position it should be secured to its sleeve 62 exactly in the right longitudinal relationship thereto. This accurate positioning of the mandrel bar when clamped to the sleeve 62 is assured by a stop 74 on the mandrel bar near its rear end for engaging a part of the mandrel clamp when the mandrel bar has been moved forward to the right position longitudinally with relation to the sleeve, such engagement being with the jaws 71 as shown. This stop 74 is most desirably formed as shown in Fig. 8 by a nut screwed on to the threaded end of the mandrel bar and having a collar 74a for engaging the ends of jaws 71. The stop is thus adjustable on the mandrel bar, providing for adjustment of the tapered mandrel with relation to the die rolls. A lock nut 75 serves to lock the stop nut in adjusted position.

Two longitudinal rock shafts 80 extend forward one from each side of the mandrel unit housing 50, each being journalled in bearings 82 and 83 mounted on lateral extensions 84 and 85 of the base 51 and held by their bearings against longitudinal movement. Each of these longitudinal shafts 80 is oscillated from the drive shaft 52 by a segment gear 86 on the drive shaft meshing with a bevel pinion 87 on the shaft 80. As shown, the segment gear is mounted on the drive shaft by having its hub bolted to the hub of one of the arms 53.

In addition to being reciprocated, the mandrel bars are given a partial rotation during each forward, or non-working stroke. This partial rotation of the mandrel bars is accomplished by turning the rotatably mounted sleeves 63 in which the sleeves 62 to which the mandrel bars are secured are slidably mounted and splined to rotate therewith. For this purpose, the two sleeves 63 are geared together by means of a sprocket chain 90 connecting sprocket wheels 91 fast on the rearward ends of the sleeves, and one of the sleeves 63 has a sprocket wheel 92 fast thereon which is geared by sprocket chain 93 to a small sprocket wheel 94 driven by an overrunning, or one-way, clutch 95 carried at the end of an extension 96 of one of the oscillating shafts 80, this shaft extension 96 being supported near its end by a bearing 97. An idler sprocket carried by a spring tensioned arm 98 bears against the chain 93 to take up any slack in the chain. An idler sprocket 99 serves the same purpose for the chain 90. The two mandrel bars will thus be given a partial rotation during each forward non-working stroke but will not be turned during the rearward, or working, strokes. The size ratio of the sprockets 92 and 94 determines the number of degrees through which the mandrel bars are turned during each forward stroke, and this may be 60 degrees or any other suitable number of degrees, and is adjustable by changing these sprockets.

Tube reciprocating, turning and feeding unit

The tube reciprocating, turning and feeding unit 32 comprises a substantial housing 100 which is mounted to slide on slideways on the base 51 between the position shown by full lines and that indicated by dotted lines in Fig. 2. As in the case of the mandrel unit, this tube unit is a duplex unit comprising duplicate operating parts arranged symmetrically with respect to a central vertical longitudinal plane for reciprocating and turning two tubes sleeved on the two mandrels and mandrel bars.

Referring to Figs. 1, 2 and 11 to 15, each of these tube-reciprocating mechanisms comprises a longitudinally reciprocable and axially rotatable holder formed by a sleeve 105 through which the mandrel bar extends and which is slidably mounted in and keyed to an axially rotatable sleeve 106 mounted and held against endwise movement in a part of the housing 100. At its forward end sleeve 105 carries a tube clamp 107 for gripping the rear end of the tube T. This tube clamp is similar to the mandrel clamp 70, having gripping jaws 108 which are forced against the tube by a wedging collar 109 drawn against the inclined faces of the gripping jaws by the turning of a screw collet 110. The rearward end of sleeve 105 is rotatably connected, as shown in Fig. 15, to a cross-head 115 mounted to slide on longitudinally slideways 116 carried by the housing 100, the bearings between the sleeve and cross-head being formed to lock them against relative longitudinal movement. The cross-head 115 is connected by links 117 to the forked end of a lever arm 120 carried by a hub 121 rotatably mounted on one end of a shaft 122, on the other end of which shaft the corresponding arm 120 of the tube reciprocating mechanism at the other side of the housing is mounted. Extending from the hub of each of the arms 120 is a bevel gear segment 125 which meshes with a bevel pinion 126 carried by a sleeve 127 slidable on one of the shafts 80 and splined thereto so as to be turned thereby. These pinion-carrying sleeves 127 are also held against longitudinal movement with respect to the housing 100 and to move therewith by means of bearings 128 carried by brackets 129 on the housing. By the oscillation of shafts 80, therefore, the arms 120 are oscillated and through links 117 and cross-

heads 115 reciprocate sleeves 105 and the tubes secured thereto.

The arms 120 of the tube unit and the arms 53 of the mandrel unit have the same angular motion and are of the same effective radial length and are driven in unison, so that the tube and mandrel are given equal and synchronous reciprocations. In order to reduce the torsional strain on the spline shafts 80, they are driven at a higher angular velocity than the drive shaft 52, the ratio of the pitch radius of gear segments 86 to that of the pinions 87 stepping up the angular velocity of the spline shafts in, for example, a 3 to 1 ratio. In order that the arms 120 of the tube unit shall have the same angular motion as the arms 53 of the mandrel unit, they are driven by step-down gearing, the ratio of the pinions 126 to the gear segments 125 being the reverse of the ratio of segments 86 to pinions 87. The shafts 80 are most desirably tubular in order that their weight may be as small as possible consistent with the required strength.

The tubes secured to the sleeves 105 are given the same partial turn during each forward or non-working stroke as is given to the mandrels. The sleeve 127 on one side of the mill carries a gear 130 which meshes with a gear 131 from which, through an overrunning, or one-way, clutch 132, a pinion 133 on a shaft mounted in bearings 134 is driven, and pinion 133 meshes with a gear 135 on rotary sleeve 106. The sleeves 106 of the two tube-reciprocating mechanisms of the tube unit are connected by a sprocket chain 137 running on sprockets 138 fast on the two sleeves 106 and held tight by an idler sprocket 139. The sleeves 106 and thereby the sleeves 105 and tubes secured thereto, are thus given a partial rotation during each forward, or non-working, stroke of the holding sleeves and tubes. The number of degrees through which the tubes are turned during each forward stroke depends on the ratio of pinion 133 and gear 135, and is adjustable by changing these gears.

Tube feeding mechanism

During each non-working stroke of the sleeves 105, the tube unit housing 100 is given a short forward feeding movement effecting an increment of feed of the tubes with relation to the mandrels. This step-by-step forward feeding of the tube unit is effected by a pinion 140 driven through a one-way clutch from one of the oscillating spline shafts 80, the pinion meshing with a rack 141 extending backward from the tube unit housing through a guide opening in the stationary housing 50 of the mandrel unit. This pinion and rack serve also for giving a quick return movement to the tube unit when, after being disconnected from the nearly completed tubes, it is to be moved back for the positioning of new tubes, the pinion then being disconnected from the one-way feeding clutch and being motor driven.

The tube feeding mechanism, designated generally by the reference numeral 33, whereby the feeding and return movements of the tube unit are effected, is shown in Figs. 1, 2, 3, 9 and 10. A pinion 145 on one of the shafts 80 meshes with a segment gear 146 to give a reduced rocking movement to a shaft 147 which has fast thereon a lever arm 148 connected by links 149 with lever arm 150 fast on a rock shaft 151 from which, through an overrunning, or one-way, clutch 152 and through a clutch 153, the shaft 154 of a worm 155 is given an intermittent rotation. This worm 155 meshes with a worm gear 156, the worm gear being turned through a small angle by the worm during each non-working stroke, and the worm gear turns the rack pinion 140 through a shaft 157. The tube unit is thus given a small forward feeding movement during each non-working stroke. The amount of such feeding movement may be varied by varying the point of connection of the links 149 to lever arm 148. This variation of the point of connection of the links to the lever arm, that is, of the effective length of the lever arm, is effected as shown by means of an adjusting screw 160, by turning which a block 161 to which the links are pivotally connected may be adjustably positioned lengthwise of the lever arm. The feeding movement will usually be from $\frac{3}{16}$'' to $\frac{3}{8}$'', and as this feed is spread over the return stroke of, for example, about 23'', the feed motion is notably free from shock.

Connected to the worm shaft 154, is a small electric motor 165 by which the rack pinion 140 is driven through worm 155 and worm gear 156 and shaft 157 for causing the quick return movement of the tube unit or for adjustment of its position by movement in either direction. During the step-by-step feeding of the tube unit the motor overhauls, and before the motor is operated the clutch 153 is disengaged. The motor is under push button or other suitable control for either forward or reverse operation. The clutch is engaged and disengaged by means of a hand lever 166 (Figs. 2, 4 and 9) on a clutch-operating shaft 167, and, in order to prevent operation of the mill when the tube unit housing 100 is being moved by motor 165, a switch 168 is operated by the hand lever 166 to open the mill motor circuit when the clutch is disengaged.

Exit tube reciprocating and turning unit

As the reduced portions of the tubes advance beyond the die rolls they are engaged by friction clamps 170 of the exit tube reciprocating and turning unit 35 (see Figs. 16, 17 and 18). This unit comprises a stationary housing 171 in which are mounted, as in the tube unit 32, duplicate tube-reciprocating and turning mechanisms on opposite sides of the central vertical longitudinal plane. Each such mechanism comprises a longitudinally reciprocable and axially rotatable sleeve 172 which is slidably mounted in and keyed to an axially rotatable sleeve 173 mounted in and held against endwise movement in a bearing housing 174 carried by the housing 171. Sleeve 172 is reciprocated in unison with the sleeves 105 of the main tube unit and the sleeves 62 of the mandrel unit by means of an oscillating lever arm 175 connected by links 176 to a cross-head 177 mounted to slide on longitudinal slideways carried by the housing 171 and to which cross-head sleeve 172 is rotatably connected by bearing means which hold the sleeve and cross-head against relative longitudinal movement. The hub of the lever arm 175 carries a bevel gear segment 180 which meshes with a bevel pinion 181 fast on a shaft 182 mounted in bearings 183 and 184 carried by lateral extensions of a base 185 on which the housing 171 is mounted. Shaft 182 is connected by a connecting shaft 186 to one of the oscillating spline shafts 80. Gears 180 and 181 have the same ratio as the tube-reciprocating gears 86 and 87. The arms 175 of the tube-reciprocating mechanisms of this exit unit will therefore have the same angular motion and be operated in unison

with the arms 120 of the tube unit 32 and arms 53 of the mandrel unit. Arms 176 are provided with means for connecting the links 176 to the arms at different points in the length of the arms similar to the means provided on the arms 120 and 53 for varying the effective length of the arms. The adjustment should be such that the effective length of these arms 176 is the same as that of arms 120 and 53.

The two non-reciprocating sleeves 173 are geared to turn together by a sprocket chain 190 running on sprockets 191 fast on the two sleeves, and these sleeves, and by them the reciprocating sleeves 172, are given the same partial turn during each forward, or non-working, stroke as is given to the mandrels and to the tube-reciprocating sleeves 105, this being effected by a chain 192 running on a sprocket 193 fast on one of the sleeves 173 and on a sprocket 194 turned by one of the shafts 185 through an overrunning clutch 195. The chain 190 is shown as held taut by an idler sprocket 196 and the chain 192 by an idler sprocket 197. By changing the ratio of sprockets 193 and 194 the degree of turning may be varied.

Each of the sleeves 172 carries at its end toward the die rolls one of the tube-gripping friction clamps 178. These friction clamps may be simple two-part clamping devices such as shown by Figs. 16 and 18. One part, 200, of each of the clamps is rigidly connected to and extends from one of the cross-heads 177 and has a substantially half-cylindrical tube-engaging face, and the other part, 201, which has a similar half-cylindrical tube-engaging face, is adjustably held to the part 200 by bolts and nuts 202 and spring washers 203.

The function of this exit tube unit is to receive the reduced portion of the tubes and to control the partly reduced tubes during the reduction of the rear end portion thereof and while new tubes are being reciprocated and advanced step-by-step to the die rolls by the tube unit 32, keeping the rear end of the partly reduced tubes against the front end of the new tubes. With the clamps properly adjusted, the exit unit turns and reciprocates the partly reduced tubes in synchronism with the turning and reciprocation of the new tubes by tube unit 32, and also permits slippage through the clamps when the partly reduced tubes are given an increment of feed by the new tubes during each non-working stroke and slippage during the working stroke due to the elongation of the tubes.

Quick-return driving mechanism

While other quick-return mechanisms, such as, for example, the well-known sliding block mechanism, might be used for operating the tube and mandrel reciprocating devices to give relatively slow working strokes to the tube and mandrel with a considerable portion thereof at a linear velocity approximating the peripheral speed of the die rolls, I have found that there are important advantages in using for this purpose a quick-return mechanism of the kind generally known as a drag link mechanism, and the quick-return mechanism 34 shown in Fig. 1 for driving the oscillating drive shaft 52, is of this kind.

This drag link quick-return mechanism, which is shown more in detail in Figs. 19 and 20, comprises a driving shaft 210 mounted in bearings 211, and a driven shaft 212 mounted in bearings 213. The driving shaft 210 is driven by the main mill motor 215 through shaft 216 and reduction gearing 217. This motor also drives the die rolls through reduction gearing 218 and pinion stand 219 from which shafts 220, of which one shows in Fig. 1, extend to the die rolls.

The driving shaft 210 of the drag link mechanism is driven at the same uniform angular velocity as the die rolls. Shaft 212 is driven from shaft 210 by means of a link 225 extending between a crank pin 226 projecting from the face of a disc 227 fast on the end of shaft 210 and a crank pin 228 projecting from crank arm 230 fast on the end of shaft 212. Shaft 212 is mounted eccentrically of shaft 210. The radius of crank arm 230 is greater than the radius of the crank formed by disc 227 and pin 226, and the length of link 225 is greater than the greatest distance between the paths of travel of the crank pins 226 and 228. The result of this arrangement is that by the rotation of shaft 210 at a constant angular velocity shaft 212 is driven at a varying angular velocity.

The driving member of such drag link mechanism may be driven to rotate in either direction, that is, with the driven crank behind the driving crank so that the link pulls the driven crank, or in advance of the driving crank as shown in Fig. 20 so that the link pushes the driven crank. The term "drag link mechanism" is commonly applied to both arrangements.

The other end of shaft 212 has fast thereon a crank arm 231 from which a link 232 extends to a rocking lever arm 233 which is also connected by a link 234 to a lever arm 235 fast on the end of a short shaft 236 in line with and connected to shaft 52 by a coupling 237 (Fig. 1). Shaft 52 is thus given an oscillating movement which is the same as though the crank arm 231 had a suitable link connection directly to lever arm 235, the connection through rocking lever arm 233 being merely a matter of convenience to avoid the necessity of locating the drag link mechanism so far out of line with shaft 52 as it would have to be with a direct connection.

The angular relation between the crank arms 230 and 231 is such that the slower half of each rotation of shaft 212 moves rocking lever arm 233 and through it lever arm 235 in one direction, and the faster half of each rotation of shaft 212 moves these lever arms in opposite direction. Driving shaft 52 is thus given an oscillation which is comparatively slow in one direction during a time during which shaft 210 and the die rolls make more than half a rotation, and comparatively quick in the opposite direction during a time less than the time during which shaft 210 and the die rolls make a half rotation.

And not only does the working stroke correspond to more than 180° of rotation of the die rolls, but with the operative parts of the drag link mechanism and the driving connections therefrom properly proportioned, the linear velocity of the tube and mandrel will be nearly uniform and approximately the same as the pitch velocity of the die grooves of the die rolls during a major part of the working stroke. And, furthermore, during most of this major part of the working stroke the tube and mandrel will move with a slightly increasing velocity which compensates for the increase in pitch velocity of the tapered die grooves.

The dimensions of the operative parts of the drag link mechanism of the mill herein shown, are as follows: The rotational axes of the shafts 210 and 212 are spaced 6¼ inches apart hori-

zontally. The radial length of the driving crank, that is, the radial distance of the axis of crank pin 226 from the axis of shaft 210, is 15 inches, the radius of the driven crank arm 230 is 18 inches, the length of the drag link 225 between the axes of the crank pins is 12 inches, and the radius of crank arm 231 is 18 inches, and it is set 100° angularly in advance of crank arm 230. The length of connecting rod or link 232 is 48 inches between centers, the length of lever arm 233 is 36⅞ inches between centers, and lever arm 235 is 36⅞ inches long between centers. The oscillating lever arms 53, 120 and 175, which reciprocate the sleeves 62, 105 and 172, respectively, have a throw of 52 degrees, and a radial length according to the diameter of the die rolls to give the desired velocity to said sleeves, and to the mandrel and tube connected thereto, during the major portion of the working stroke.

With the operative parts proportioned as stated, the working stroke of the tube and mandrel will extend for a time and distance corresponding to 220 degrees of rotation of the die rolls, and the major portion of the working stroke during which the tube and mandred will have an approximately uniform velocity closely approximating the pitch line speed of the die grooves, will correspond to from about 120 to about 140 degrees of angular motion of the rolls, and acceleration and deceleration of the tube and mandrel on the working stroke will take place each mostly during 40 to 50 degrees of rotation of the rolls; and the quick return stroke will be confined to the remaining 140 degrees of rotation of the rolls. The die rolls may thus have a swaging, or swaging and finishing, arc of from 120 to 140 degrees throughout which the die grooves engage the tube, the rolls being clear of the tube during the balance of each rotation, that is, during from 40 to 50 degrees of rotation at the beginning and during 40 to 50 degrees at the end of the working stroke, and during the whole of the return stroke during which the rolls turn 140 degrees.

Fig. 2a shows the die rolls as having die grooves extending over a swaging and finishing arc of 140 degrees of which 100 degrees is the tapered swaging portion for reducing the workpiece and the following 40 degrees is a concentric, or straight, finishing, or smoothing, portion. The balance of the circumferential groove of each die roll is the gap portion which does not make working engagement with the tube, the tube and mandrel being decelerated while the rolls turn 40 degrees after releasing the tube, then making their forward return movement while the rolls turn 120 degrees and being accelerated at the beginning of the working stroke while the rolls turn 40 degrees before again making working engagement with the tube at the beginning of the swaging arc.

The reciprocating movements given to the tube and mandrel are represented with approximate accuracy by the tube and mandrel velocity curve in the diagram, Fig. 21. In this diagram, the velocity curve above the line X—Y represents the working stroke, and the curve below the X—Y represents the quick return stroke. The distances between the vertical lines represent the distance the tube and mandrel move in successive uniform time intervals during each of which the die rolls and shaft 210 make an angular movement of 10 degrees, the velocity of the tube and mandrel in such time intervals being indicated proportionately by the length of the vertical lines between the velocity curve line and the line X—Y. The diagram shows that the working stroke takes place during the time represented by twenty-two of the spaces, numbered 1 to 22 above the line X—Y, that is, during the time that the die rolls are turning through 220 degrees, and that for as much as fourteen spaces, that is, during the time the die rolls are turning 140 degrees, the tube and mandrel have a substantially constant velocity which during most of this major portion of the working stroke is a slightly increasing velocity. The diagram also shows that most of the acceleration occurs during the first four time intervals of the working stroke during which the die rolls turn 40 degrees, and that most of the deceleration occurs during the last four time intervals of the working stroke; also, that the quick return stroke at variable velocities is accomplished in fourteen of the time intervals, that is, during the time the die rolls are turning through 140 degrees. The straight line X' Y' divided by dots into 22 equal parts represents the uniform angular movement of the die rolls through the 220 degrees during which the tube and mandrel are making their working stroke. By adjustment of the radial length of the lever arms 53 and 120 according to the diameter of the die rolls, the length and speed of the strokes of the tube and mandrel are, as before pointed out, adjusted so that during the major portion of the working stroke the velocity of the tube and mandrel are approximately uniform and approximately equal to the pitch line velocity of the die grooves of the rolls, as the diagram indicates. For die rolls 17 inches in outside diameter having die grooves with a pitch diameter of about 16 inches for reducing 3¼ inch O. D. tubes with a $\frac{5}{8}$'' wall to 2 inches O. D. and .134'' wall, the tube and mandrel will have a working stroke of about 23 inches, and the swaging, or swaging and finishing, arc, if 140 degrees, will have a length of about 19½ inches on the pitch line. For die rolls 15 inches in outside diameter, for reducing a 2½ inch O. D. tube 1½ inches O. D., the working stroke will be about 20 inches, and the length of the swaging, or swaging and finishing, arc, if 140 degrees, will be about 17⅓ inches on the pitch line.

In referring in the preceding paragraph to tube and mandrel velocity during the major portion of the working stroke, the tube velocity referred to is the velocity of the tube as successive portions thereof are engaged by the die rolls. It is especially desirable that the tube and engaging surface of the die rolls move at approximately the same velocity at the time the rolls come into working engagement with the tube at the beginning of each reducing operation.

The mill is provided with suitable guides, or steadiers, for centering and supporting the tubes when the tube unit is in a retracted position and means for moving the guides to clear the tube unit as the unit advances, and with guides, or steadiers, for supporting and steadying the mandrel bar when the tube unit is in a forward position, and means for moving such mandrel guides clear of the tube unit as the unit is retracted. The mill illustrated has one set of tube guides 240, of which one appears in Fig. 2 in upper position, and an operating motor 241 therefor, and one set of mandrel bar guides 242, of which one is shown in Fig. 2 in its lowered guiding position, and an operating motor 243 therefor, of a kind fully described and claimed in my co-pending application Serial No. 501,104, filed September 3, 1943.

In the operation of the mill, throughout the major portion of each working stroke of the tubes and mandrels, during which they move at substantially constant velocity, a length of tube is pressed between the swaging portions, or swaging and finishing portions, of the grooves of the die rolls, and thereby progressively reduced from the original O. D. and wall thickness at the beginning of the stroke to the final O. D. and wall thickness at the end of the stroke. The tubes are then released by the die rolls, and after deceleration the tubes and mandrels make a quick forward return stroke during which they are given a partial turn and the tube unit **32** is moved forward to give an increment of feed to the tubes. This short feeding movement of from $\frac{3}{8}$ inch to $\frac{3}{8}$ inch of the tube unit is a very slow movement spread over the entire length of the return stroke and is consequently performed without shock. During the working stroke the tube unit housing is held against movement. The partial turning of the tubes and mandrels is also spread over the entire return stroke.

When the tube unit **32** has been advanced to its extreme forward position, as shown by full lines in Figs. 1 and 2, at which time an unreduced rear end portion of the tubes will project from the rear side of the roll stand housing **40**, the mill is stopped and the unreduced ends of the tubes are clamped between the clamping members **47** and **48**. The tubes are then disconnected from the sleeves **105** of the tube unit **32** and the mandrel bar is disconnected from mandrel unit **31**. Clutch **153** of the tube feed mechanism having been disconnected, motor **165** is then operated to move tube unit **32** backward to its extreme retracted position indicated by dotted lines in Fig. 2, and the mandrel bar is drawn back, by any suitable means not shown in the drawings, until the forward end of the mandrel is back of the tube clamp **107** of tube unit **32**. Two new tubes are then brought into position in the mill and moved backward and their rear ends are entered into and secured in the clamps **107**, and the tube guides **240** are moved down into position to support the tubes. The mandrel bar is then moved forward back to its original position as determined by the stop **74**. Then, clutch **153** having been again engaged and tube clamping members **48** having been raised, the mill may be again started in operation, or, before engaging clutch **153** and raising clamping members **48**, motor **165** may be operated to move tube unit **32** forward to move the new tubes up to the partially reduced tubes. Until the new tubes have been advanced to bring their front ends into engagement with the rear ends of the previous partially reduced tubes, the partially reduced tubes are merely reciprocated backward and forward and given their partial turns by exit tube unit **35**, and during this time these partially reduced tubes are not fed forward and unreduced portions thereof are not brought into reducing contact with the die grooves of the die rolls. When, however, the new tubes have been advanced so that their front ends engage the rear ends of the previous tubes, then the previous partly reduced tubes are on each return stroke pushed by the new tubes and given the same increment of feed as is given to the new tubes by the forward feeding movement of the tube unit **32**. The reduction of the previous tubes is thus completed, and the reduction of the new tubes then proceeds by continued operation of the mill until the tube unit **32** again reaches its forward position shown by full lines in Figs. 1 and 2.

Instead of operating as a duplex mill, reducing two tubes at the same time, the mill may be operated to reduce only one tube at a time, either side of the mill being used for such single tube operation, and many features of the duplex mill illustrated may be embodied in single reducing mills for operating on only one tube or other workpiece at a time.

The mill is most desirably, though not necessarily, provided with counterbalancing means for reducing inertia forces of reciprocating parts by cushioning the decelerating forces and absorbing energy during deceleration of the parts and returning energy to the reciprocating parts during acceleration. As the motion of the reciprocating parts of the mill shown is not harmonic motion, complete balancing is not obtainable, but the degree of balancing obtained is important in its advantageous results. The counterbalancing means may be applied to different reciprocating parts of the mill. In the mill shown by the drawings, springs are used as the resilient members of the counterbalancing means. Most desirably, and as shown, the mill is provided with four sets, or pairs, of these springs, the springs of two of the sets being connected to the oscillating levers **53** of the mandrel unit **31**, and the springs of the other two sets being connected to the oscillating levers **175** of the exit tube unit **35**, as indicated in Figs. 2 and 16. The construction is the same for both units, and Figs. 2, 3, 4 and 5 may be considered as showing the construction for one of the sets of either unit, the two sets of each unit being on opposite sides of the mill.

Referring now to Figs. 2, 3, 4 and 5, two helical tension springs **250** and **251** extend vertically upward from cross-heads **252** and **253** and have their upper ends connected by links **254** and **255** each to one of two arms **256** and **257** extending from diametrically opposite sides of the hub of one of the oscillating levers **53** in a diameter normal to the lever. The cross-heads **252** and **253** are each mounted to slide on a pair of vertical rods **260** extending downward from a bracket **261** secured to the base **51**. Each cross-head is mounted on its rods **260** by means of exteriorly threaded sleeves **262** adjustable in threaded openings in the cross-head and locked in adjusted position by lock nuts **263**. Upward movement of the cross-head is limited by engagement of the upper ends of sleeves **262** with buffer rings **264** of rubber or other suitable cushioning material on the rods **260**.

When the oscillating lever **53** is in its midway position as shown in Fig. 4 with the arms **256** and **257** horizontal, both of the cross-heads will be in upper position with neither of the springs under tension. During the last half of the working stroke, spring **250** will be fully extended, and in being extended it will resist the inertia forces during deceleration of lever **53** and the reciprocating and oscillating parts connected to move therewith. And during this last half of the working stroke spring **251** will remain unextended, the spring and cross-head moving downward. During the first half of the following forward non-working stroke, acceleration will be aided by the tension of spring **250**, and cross-head **253** will be returned to its upper position without extension of spring **251**. Then during the last half of the non-working stroke, spring **251** will be extended, resisting deceleration, and spring **250** will remain unextended moving downward with its cross-head **252**. In the first half of the succeeding working stroke, acceleration will be aided

by spring 251, and cross-head 252 will be returned to its upper position without extension of spring 250.

Although, as stated, complete balancing is not obtainable since the mass energy of the reciprocating and oscillating parts varies on the working and non-working strokes, the results obtained by the use of suitable counter-balancing means, such as the springs shown, the springs being of proper strength, are of great advantage in obtaining smoother operation of the mill at the comparatively high speed at which it operates and reduction of shock on the machine frame, in reducing the effort required of the quick return mechanism and other parts in driving the reciprocating and oscillating parts of the mill, in reducing the power required for operating the mill, and in maintaining close registration between the tapered mandrels and the tapered die grooves during the working strokes by reducing the inertia effect of the reciprocating mandrel rods.

As will be apparent from the foregoing description, the new mill has many features of construction contributing to the high efficiency and production capacity of the mill and the quality of its product. The mass of reciprocating parts is largely reduced by having the mandrel bars and the tubes secured to relatively light reciprocating parts mounted in non-reciprocating housings and reciprocated by means of lever arms oscillating on axes fixed in the housings, the mandrel unit housing being stationary and the tube unit housing being moved only with a small slow step-by-step movement for feeding the tubes relatively to the mandrels during the non-working strokes. The mandrels and tubes are positively reciprocated, and synchronous movement between the mandrels and tubes and the swaging portions of the die rolls is secured by reciprocating the mandrels and tubes by means of a drag-link quick-return driving mechanism whereby at the beginning of each working stroke the movement of the mandrels and tubes is accelerated to approximately the pitch line speed of the die grooves of the rolls before the rolls make working engagement with the tubes, and whereby during a major portion of each relatively slow working stroke the mandrels and tubes are moved at a substantially constant but slightly increasing speed corresponding to the die groove pitch line speed of the rolls. The mandrels and tubes are reciprocated independently but in unison except for the slightly greater movement of the tubes during the forward non-working strokes due to the forward feed movement of the tube unit housing on which the tube reciprocating oscillating lever arms have their axis. The inertia effect of the oscillating shafts by which these oscillating lever arms, or rocker arms, are actuated is much less than that of reciprocating parts of much less weight. These and other contributing features will be specifically defined in the claims. The operating speed of the mill with die rolls 15" to 18" in diameter is from 60 R. P. M. upward of the die rolls, depending on the diameter of the die rolls.

It is to be understood that the invention is not limited to the exact construction, arrangement and combinations of parts shown by the drawings and to which the foregoing description has been largely confined, but that it includes changes and modifications thereof within the claims. It will also be understood that certain features of the invention as claimed may be employed independently of other features thereof and in machines differing otherwise from that shown by the drawings. As stated, many features of the invention may be embodied in single reducing mills adapted for operating on only one tube or other workpiece at a time.

What is claimed is:

1. In a Pilger mill of the type wherein a pair of gapped die rolls mounted to rotate continuously in one direction about fixed axes work on successive portions of a reciprocating workpiece on successive reciprocations, the improvement which consists in providing workpiece-reciprocating means mechanically geared with and positively timed with the rolls and mechanically connected with a workpiece-gripping member and constructed and arranged to accelerate the movement of the workpiece from its position of rest at the beginning of each working stroke to approximately the pitch-line speed of the die portion of the rolls before working engagement between the workpiece and the rolls occurs, and positively-operated step-by-step feeding means whereby the workpiece is given an increment of feed during each return stroke.

2. In a Pilger mill of the type wherein a pair of gapped die rolls mounted to rotate continuously in one direction about fixed axes work on successive portions of a reciprocating workpiece on successive reciprocations, the improvement which consists in providing workpiece-reciprocating means mechanically geared with and positively timed with the rolls and mechanically connected with a workpiece-gripping member and constructed and arranged to accelerate the movement of the workpiece from its position of rest at the beginning of each working stroke to approximately the pitch-line speed of the die portion of the rolls before working engagement between the workpiece and the rolls occurs and then to maintain the speed of the workpiece constant during a major portion of the working stroke, and positively-operated step-by-step feeding means whereby the workpiece is given an increment of feed during each return stroke.

3. In a tube reducing Pilger mill of the type wherein a pair of gapped die rolls mounted to rotate continuously in one direction about fixed axes work on successive portions of a reciprocating tube on successive reciprocations, the improvement which consists in providing tube and mandrel - reciprocating means mechanically geared with and positively timed with the rolls and mechanically connected with a tube-gripping member and a mandrel rod gripping member and constructed and arranged to accelerate the movement of the tube and mandrel from their positions of rest at the beginning of each working stroke to approximately the pitch-line speed of the die portion of the rolls before working engagement between the tube and the rolls occurs and then to maintain the speed of the mandrel and tube constant during a major portion of the working stroke, and positively-operated step-by-step feeding means whereby the tube is given an increment of feed during each return stroke.

4. In a Pilger mill of the type wherein a pair of gapped die rolls mounted to rotate continuously about fixed axes in one direction work on successive portions of a reciprocating workpiece on successive reciprocations, the improvement which consists in providing a drag-link quick-return driving mechanism for reciprocating the workpiece with a relatively slow working stroke which extends over a time during which the die rolls make substantially more than half a rota-

tion, said mechanism operating to accelerate the speed of the workpiece during the first part of the working stroke before working engagement occurs from rest to approximately that of the pitch line speed of the the die portions of the rolls, to move the workpiece at approximately such speed during a major portion of the working stroke, to decelerate the speed of the workpiece to rest during the last part of the working stroke after the rolls have released their grip on the workpiece, and then to move the workpiece forward through the gap portions of the rolls into position for the next working stroke.

5. In a Pilger mill having a pair of gapped rolls mounted to rotate continuously about fixed axes and providing working surfaces having a tapered portion for reducing the workpiece followed by a straight portion for smoothing the reduced workpiece and then by a gap portion, the improvement which consists in providing workpiece-reciprocating means mechanically geared with and positively timed with the rolls and mechanically connected with a workpiece-gripping member and constructed and arranged so that during each operating cycle the workpiece is moved through the gap portion of the rolls from rest to approximately the peripheral speed of the working surfaces of the rolls, then is engaged by the tapered portion and straight portion of the rolls in succession, and then is brought to rest again and returned through the gap portion of the rolls into position to begin a new cycle, and positively operated step-by-step feeding means whereby the workpiece is given an increment of feed during each return stroke.

6. In a Pilger mill having a pair of gapped rolls mounted to rotate continuously about fixed axes and providing working surfaces having a tapered portion for reducing the workpiece followed by a straight portion for smoothing the reduced workpiece and then by a gap portion, the improvement which consists in providing workpiece-reciprocating means mechanically geared with and positively timed with the rolls and mechanically connected with a workpiece-gripping member and constructed and arranged so that during the first part of each working stroke the workpiece is moved through the gap portion of the rolls from rest to approximately the peripheral speed of the working surfaces of the rolls, then during the major portion of the working stroke corresponding to 120 or more degrees of the cycle is engaged by the tapered portion and straight portion of the rolls in succession, then during the balance of the working stroke is brought to rest again, and during the remainder of the cycle is returned through the gap portion of the rolls into position to begin a new cycle, and positively operated step-by-step feeding means whereby the workpiece is given an increment of feed during each return stroke.

7. A tube reducing mill, comprising in combination a pair of gapped die rolls mounted to rotate about fixed axes, means for continuously rotating said rolls, a mandrel co-operating with the die grooves of said rolls, a mandrel-reciprocating member, a tube reciprocating member, and a quick-return driving mechanism mechanically connected with the rolls and with the mandrel-reciprocating and tube-reciprocating members for reciprocating the mandrel-reciprocating member and the tube-reciprocating member with a relatively slow working stroke and a quick return stroke, said driving mechanism moving the mandrel-reciprocating member and the tube-reciprocating member from their positions of rest at the beginning of each working stroke to approximately the pitch-line speed of the die portions of the rolls before working engagement occurs and then during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, and means for giving an increment of feed to the tube-reciprocating member during each return stroke.

8. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, means for continuously rotating said rolls, a tapered mandrel cooperating with the die grooves of said rolls, a mandrel-reciprocating member, a tube-reciprocating member, and a quick-return driving mechanism mechanically connected with the rolls and with the mandrel-reciprocating and tube-reciprocating members for reciprocating the mandrel-reciprocating member and the tube-reciprocating member with a relatively slow working stroke and a quick return stroke, said driving mechanism moving the mandrel-reciprocating member and the tube-reciprocating member from their positions of rest at the beginning of each working stroke to approximately the pitch-line speed of the die portions of the rolls before working engagement occurs and then during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, and means for giving an increment of feed to the tube-reciprocating member during each return stroke.

9. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, means for continuously rotating said rolls, a tapered mandrel cooperating with the die grooves of said rolls, and a drag-link quick-return driving mechanism for reciprocating the mandrel with a relatively slow working stroke and a quick-return stroke, said driving mechanism driving the mandrel during the major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls and during most of such major portion at a slightly increasing speed.

10. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, means for continuously rotating said rolls, a tapered mandrel cooperating with the die grooves of said rolls, a mandrel-reciprocating member, a tube-reciprocating member, a quick-return driving mechanism for reciprocating the mandrel-reciprocating member and the tube-reciprocating member with a relatively slow working stroke and a quick return stroke and for moving them during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, and means for giving an increment of feed to the tube-reciprocating member during each return stroke.

11. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, means for continuously rotating said rolls, a tapered mandrel cooperating with the die grooves of said rolls, a positively acting quick-return driving mechanism, a rock shaft operated by said driving mechanism to have a relatively slow turn in one direction and a quick turn in the other direction, and a lever arm on said shaft for reciprocating the mandrel.

12. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, means for continuously rotating said rolls, a tapered mandrel cooperating with the die grooves of said rolls, a mandrel-reciprocating member to which the mandrel rod is secured, a tube-reciprocating member to which the tube is secured, a longitudinally movable housing in which said tube-reciprocating member is mounted, a drive shaft, driving mechanism for oscillating said shaft, a lever arm receiving oscillatory movements from said drive shaft for reciprocating the mandrel-reciprocating member, a longitudinally extending rock shaft operated by said drive shaft, a sleeve on said rock shaft splined thereto to be turned thereby and mounted for oscillation in said housing, a lever arm pivotally mounted in said housing and geared to said sleeve to be oscillated thereby for reciprocating the tube-reciprocating member, and means for giving an increment of feed to said housing during each return stroke.

13. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, means for continuously rotating said rolls, a tapered mandrel cooperating with the die grooves of said rolls, a mandrel-reciprocating member to which the mandrel rod is secured, a tube-reciprocating member to which the tube is secured, a longitudinally movable housing in which said tube-reciprocating member is mounted, a drive shaft, driving mechanism for oscillating said shaft, a lever arm on said shaft for reciprocating the mandrel-reciprocating member, a longitudinally extending rock shaft operated by said drive shaft at a higher angular velocity than the drive shaft, a sleeve on said rock shaft splined thereto to be turned thereby and mounted for oscillation in said housing, a lever arm pivotally mounted in said housing and geared to said sleeve to be oscillated thereby at the same angular velocity as the first-mentioned lever arm for reciprocating the tube-reciprocating member, and means for giving an increment of feed to said housing during each return stroke.

14. A tube reducing mill, comprising in combination a pair of die members having tapered die grooves mounted to turn about fixed axes, a tapered mandrel cooperating with the die grooves of said members, a mandrel-reciprocating member to which the mandrel rod is secured, a tube-reciprocating member to which the tube is secured, a longitudinally movable housing in which said tube reciprocating member is mounted, a drive shaft, driving mechanism for oscillating said shaft, a lever arm receiving oscillatory movements from said shaft for reciprocating the mandrel-reciprocating member, a longitudinally extending rock shaft operated by said drive shaft, a sleeve on said rock shaft splined thereto to be turned thereby and mounted for oscillation in said housing, a lever arm pivotally mounted in said housing and geared to said sleeve to be oscillated thereby for reciprocating the tube-reciprocating member, and means for giving an increment of feed to said housing during each return stroke.

15. A tube reducing mill as claimed in claim 14, in which the longitudinally extending rock shaft is driven by the drive shaft through speed-up gears and the second mentioned lever arm is operated by the rock shaft through speed-down gears.

16. A tube reducing mill, comprising in combination a pair of die members having tapered die grooves mounted to turn about fixed axes, a tapered mandrel cooperating with the die grooves of said members, a rotatable mandrel-reciprocating member to which the mandrel rod is secured, a rotatable tube-reciprocating member to which the tube is secured, a longitudinally movable housing in which said tube-reciprocating member is mounted, a drive shaft, driving mechanism for oscillating said shaft, a lever arm receiving oscillatory movements from the drive shaft for reciprocating the mandrel-reciprocating member, a longitudinally extending rock shaft operated by said drive shaft, a sleeve on said rock shaft splined thereto to be turned thereby and mounted for oscillation in said housing, a lever arm pivotally mounted in said housing and geared to said sleeve to be oscillated thereby for reciprocating the tube-reciprocating member, means for giving an increment of feed to said housing during each return stroke, means including a one-way clutch operated by said rock shaft for turning the mandrel-reciprocating member during each return stroke, and means including a one-way clutch operated by said rock shaft for turning the tube-reciprocating member during each return stroke.

17. A tube reducing mill, comprising in combination a pair of die members having tapered die grooves mounted to turn about fixed axes, a tapered mandrel cooperating with the die grooves of said members, a rotatable mandrel-reciprocating member to which the mandrel rod is secured, a rotatable tube-reciprocating member to which the tube is secured, a longitudinally extending rock shaft, means for oscillating said shaft in time with the rotation of the die rolls, means operated by said shaft for reciprocating the tube-reciprocating member, means for reciprocating the mandrel-reciprocating member, and means whereby the tube-reciprocating member and the mandrel-reciprocating member are turned in unison by said shaft during its oscillations in one direction.

18. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel cooperating with the die grooves of said rolls, a rotatably mounted mandrel-reciprocating member to which the mandrel rod is secured, a rotatably mounted tube-reciprocating member to which the tube is secured, driving mechanism for the mandrel-reciprocating member and the tube-reciprocating member for moving them from rest at the beginning of each working stroke to approximately the pitch line speed of the die grooves of the rolls before working engagement occurs and during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, and means for turning said members during each return stroke.

19. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel cooperating with the die grooves of said rolls, a rotatably mounted mandrel-reciprocating member to which the mandrel rod is secured, a rotatably mounted tube-reciprocating member to which the tube is secured, a drag-link quick-return driving mechanism for reciprocating the mandrel-reciprocating member and the tube-reciprocating member with a relatively slow working stroke and quick return

stroke, whereby during the major portion of the working stroke said members are moved at a speed approximating the pitch line speed of the die grooves of the rolls and during most of such major portion at a slightly increasing speed, and means for turning said members during each return stroke.

20. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel cooperating with the die grooves of said rolls, a fixed housing, a mandrel-reciprocating member to which the mandrel rod is secured mounted to rotate and to reciprocate in said housing, driving mechanism for reciprocating the mandrel-reciprocating member and for moving it from rest at the beginning of each working stroke to approximately the pitch line speed of the die grooves of the rolls before working engagement occurs and during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, and means for turning said member during each return stroke.

21. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel cooperating with the die grooves of said rolls, a fixed housing, a mandrel-gripping member mounted to rotate and to reciprocate in said housing, a longitudinally movable housing, a tube-gripping member mounted to rotate and to reciprocate in said movable housing, driving mechanism for reciprocating said mandrel-gripping and tube-gripping members and for moving them during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, means for turning said members during their movement in one direction, and means for giving an increment of feed to said movable housing for each complete reciprocation of said members.

22. A tube reducing mill, comprising in combination a pair of gapped die rolls mounted to rotate about fixed axes, a mandrel cooperating with the die grooves of said rolls, a fixed housing, a mandrel-gripping member mounted to rotate and to reciprocate in said housing, a longitudinally movable housing, a tube-gripping member mounted to rotate and to reciprocate in said movable housing, driving mechanism for reciprocating said mandrel-gripping and tube-gripping members and for moving them during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, means for turning said members during their movement in one direction, and means for giving an increment of feed to said movable housing for each complete reciprocation of said members.

23. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel cooperating with the die grooves of said rolls, a rotatably mounted mandrel-reciprocating member to which the mandrel rod is secured, a rotatably mounted tube-reciprocating member to which the tube is secured, means for reciprocating the mandrel-reciprocating member and the tube-reciprocating member, said means including a longitudinally extending rock shaft by the rocking of which the tube-reciprocating member is reciprocated, and means operated by said rock shaft for turning the mandrel-reciprocating member and the tube-reciprocating member during each return stroke.

24. In a tube reducing mill, a pair of gapped die rolls mounted to rotate about fixed axes, a fixed housing, a mandrel-reciprocating member mounted to rotate and to reciprocate in said housing, means for securing the mandrel rod to said member, and positively acting quick-return driving mechanism for reciprocating said member and for moving it from rest at the beginning of each working stroke to approximately the pitch line speed of the die grooves of the rolls before working engagement occurs and during a major portion of the working stroke at an approximately constant speed.

25. In a tube reducing mill, a pair of gapped die rolls mounted to rotate about fixed axes, a mandrel-reciprocating member, means for securing the mandrel rod to said member, and a drag-link quick-return driving mechanism for reciprocating said member with a relatively slow working stroke and a quick-return stroke and for moving it during a major portion of the working stroke at an approximately constant speed.

26. In a reducing mill, a pair of reducing rolls mounted to rotate about fixed axes, a longitudinally movable housing, a workpiece-reciprocating member mounted to rotate and to reciprocate in said housing, means for securing the workpiece to said member, and positively acting quick-return driving mechanism for reciprocating said member and for moving it from rest at the beginning of each working stroke to approximately the speed of the working surfaces of the rolls before working engagement occurs and during a major portion of the working stroke at an approximately contant speed, and means for giving an increment of feed to said housing during each return stroke.

27. In a reducing mill, a pair of reducing rolls mounted to rotate about fixed axes, a workpiece-reciprocating member, means for securing the workpiece to said member, and a drag-link quick-return driving mechanism for reciprocating said member with a relatively slow working stroke and a quick-return stroke and for moving it during a major portion of the working stroke at an approximately constant speed.

28. In a tube reducing mill having a tapered mandrel, a mandrel reciprocating and turning unit, comprising a fixed housing, a sleeve for receiving the mandrel rod mounted to reciprocate and to rotate in the housing, a clamp on said sleeve for gripping the mandrel rod, driving means for reciprocating said sleeve, and means operated by said driving means for turning said sleeve during the reciprocation thereof in one direction.

29. In a tube-reducing mill having a tapered mandrel, a mandrel reciprocating and turning unit, comprising a fixed housing, a sleeve mounted to rotate in said housing and held against axial movement, a sleeve for receiving the mandrel rod mounted to reciprocate in the first said sleeve and to rotate therewith, a clamp on the second said sleeve for gripping the mandrel rod, driving means for reciprocating the second said sleeve, and means operated by said driving means for turning the first said sleeve during movement of the second said sleeve in one direction.

30. In a tube reducing mill having a tapered mandrel, a mandrel reciprocating and turning

unit, comprising a fixed housing, a sleeve mounted to rotate in said housing and held against axial movement, a sleeve for receiving the mandrel rod mounted to reciprocate in the first said sleeve and to rotate therewith, a clamp on the second said sleeve for gripping the mandrel rod, a cross-head to which the second said sleeve is rotatably connected by means preventing relative longitudinal movement between the sleeve and cross-head, a pivotally mounted lever arm connected to said cross-head, means for oscillating said lever arm to reciprocate the cross-head, and means for turning the first said sleeve during the movement of the cross-head and the second said sleeve in one direction.

31. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel cooperating with the die grooves of said rolls, a rotatably mounted mandrel reciprocating member, means for reciprocating and turning said member, means for securing the mandrel rod to said member and for releasing the mandrel rod to permit the mandrel rod and mandrel to be withdrawn endwise for the placing of a new tube and to be returned to operating position, and position determining means for limiting the return movement of the mandrel rod and mandrel to operative position relatively to the mandrel reciprocating member, said position-determining means including a part adjustable for adjusting the position of the mandrel with relation to the die rolls.

32. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel for cooperating with the die grooves of said rolls, a fixed housing, a mandrel reciprocating sleeve mounted to rotate and to reciprocate in said housing, means for reciprocating and turning said sleeve, means for securing the mandrel rod to said sleeve and for releasing the mandrel rod to permit the mandrel rod and mandrel to be withdrawn endwise for the placing of a new tube and to be returned to operating position, and a stop member on the mandrel rod for engaging a part carried by the mandrel reciprocating sleeve for limiting the return movement of the mandrel rod and mandrel to operative position relatively to the mandrel-reciprocating sleeve.

33. A tube reducing mill, comprising in combination a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a tapered mandrel for cooperating with the die grooves of said rolls, a rotatably mounted mandrel reciprocating member, means for reciprocating and turning said member, means for securing the mandrel rod to said member and for releasing the mandrel rod to permit the mandrel rod and mandrel to be withdrawn endwise for the placing of a new tube and to be returned to operating position, and a stop member on the mandrel rod for engaging a part carried by the mandrel reciprocating member for limiting the return movement of the mandrel rod and mandrel to operative position relatively to the mandrel reciprocating member, said stop member being adjustable on the mandrel rod for adjusting the position of the mandrel with relation to the die rolls.

34. In a tube reducing mill, in combination with a pair of gapped rolls mounted to rotate about fixed axes, a tube reciprocating, turning and feeding unit, comprising a longitudinally movable housing, a tube-gripping tube-reciprocating member mounted to reciprocate and to rotate in the housing, means mechanically geared with and positively timed with the rolls for reciprocating said member, means for turning said member during its return stroke, and means for holding said housing stationary during the working stroke of said member and for giving an increment of feed to said housing during the return stroke of said member.

35. A reducing mill, comprising a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a longitudinally movable housing, a member mounted to reciprocate and to rotate in said housing, a clamp on said member for gripping the end of the workpiece, driving mechanism for reciprocating said member and for moving it during a major portion of the working stroke at a speed approximating the pitch line speed of the die grooves of the rolls, means for turning said member at a time when the workpiece is not engaged by the rolls, and means for holding said housing stationary during the engagement of the workpiece by the rolls and for giving an increment of feed to said housing for each complete reciprocation of said member.

36. A reducing mill, comprising a pair of gapped rolls mounted to rotate about fixed axes, a longitudinally movable housing, a member mounted to reciprocate and to rotate in said housing, a clamp on said member for gripping the end of the workpiece, driving mechanism mechanically geared with and positively timed with the rolls and mechanically connected with said clamp for reciprocating said member, means for turning said member at a time when the workpiece is not engaged by the rolls, and means for holding said housing stationary during engagement of the workpiece by the rolls and for giving an increment of feed to said housing for each complete reciprocation of said member.

37. A reducing mill, comprising a pair of grooved rolls mounted to rotate about fixed axes, a longitudinally movable housing, a member mounted to reciprocate and to rotate in said housing, a clamp on said member for gripping the end of the workpiece, a longitudinally extending rock shaft, a sleeve on said rock shaft splined thereto to be turned thereby and rotatably mounted in said housing, a rigid lever arm pivotally mounted in said housing and geared to said sleeve to be oscillated thereby for reciprocating said member, and means including a one-way clutch by which said member is turned by said rock shaft.

38. A reducing mill, comprising a pair of gapped rolls mounted to rotate about fixed axes, a longitudinally movable housing, a member mounted to reciprocate and to rotate in said housing, a clamp on said member for gripping the end of the workpiece, a longitudinally extending rock shaft, a sleeve on said rock shaft splined thereto to be turned thereby and rotatably mounted in said housing, a lever arm pivotally mounted in said housing and geared to said sleeve to be oscillated thereby for reciprocating said member, means including a one-way clutch by which said member is turned by said rock shaft, and means operated by said rock shaft for giving a step-by-step feeding movement to said housing.

39. In a Pilger mill, in combination with the reducing rolls, workpiece-reciprocating, turning and feeding means, comprising a longitudinally movable housing, a workpiece-reciprocating member mounted to rotate and to reciprocate in said housing, means for reciprocating said member

comprising a longitudinally extending rockshaft and a lever arm oscillated by a gear splined on said rockshaft and by which lever arm said member is reciprocated, means including a one-way clutch by which said member is turned by said rockshaft, and means operated by said rockshaft for giving a step-by-step feeding movement to said housing.

40. In a tube reducing mill, a tube reciprocating, turning and feeding unit, comprising a longitudinally movable housing, a sleeve through which the mandrel rod extends mounted to reciprocate and to rotate in the housing, a clamp-on said sleeve for gripping the end of the tube, means for reciprocating said sleeve, means for turning said sleeve during the return stroke thereof, means for holding said housing stationary during the working stroke of said sleeve, and means for giving an increment of feed to said housing during the return stroke of said sleeve.

41. In a tube reducing mill, a tube reciprocating, turning and feeding unit, comprising a longitudinally movable housing, a sleeve rotatably mounted in said housing and held against longitudinal movement therein, a second sleeve through which the mandrel rod extends mounted to rotate within the first said sleeve and held to rotate therewith, a clamp on the second said sleeve for gripping the tube, means for reciprocating the second said sleeve, means for turning the first said sleeve to turn the second said sleeve during its movement in one direction, and means for giving an increment of feed to said housing for each complete reciprocation of the second said sleeve.

42. A tube reducing mill, comprising a pair of gapped die rolls mounted to rotate about fixed axes, a mandrel cooperating with said rolls, means for reciprocating the mandrel, a longitudinally movable housing, a tube-reciprocating member mounted to rotate and to reciprocate in said housing, a longitudinally extending rock shaft, means including a gear carried by a part rotatably mounted in said housing and splined on said rock shaft for reciprocating the tube-reciprocating member, means including a one-way clutch by which the tube reciprocating member is turned by said rock shaft, and means operated by said rock shaft for giving a step-by-step feeding movement to said housing.

43. A reducing mill, comprising a pair of gapped die rolls mounted to rotate about fixed axes, a longitudinally movable housing, a tube-reciprocating member mounted to rotate and to reciprocate in said housing, a longitudinally extending rock shaft, means rotatably mounted in said housing and splined on said rock shaft for reciprocating the tube-reciprocating member, means including a one-way clutch by which the tube reciprocating member is turned by said rock shaft, a rack bar extending longitudinally from said housing, a gear engaging said rack bar, and means including a one-way clutch operated by said rock shaft for operating said gear to give a step-by-step forward movement to said housing.

44. A reducing mill, comprising a pair of gapped die rolls mounted to rotate about fixed axes, a longitudinally movable housing, a tube-reciprocating member mounted to rotate and reciprocate in said housing, a longitudinally extending rock shaft, means operated by said rock shaft for reciprocating the tube-reciprocating member and for turning said member, and means for moving said housing longitudinally, said last mentioned means comprising a rack bar extending longitudinally from said housing, a gear engaging said rack bar, means including a one-way clutch operated by said rock shaft, driving connections between said clutch and said gear for giving a step-by-step forward movement to said housing, said driving connections including an engageable and disengageable clutch, means for engaging and disengaging said clutch, and driving means operative when said clutch is disengaged for operating said gear to give a rapid backward movement to said housing.

45. A reducing mill, comprising a pair of gapped die rolls mounted to rotate about fixed axes, a longitudinally movable housing, a tube-reciprocating member mounted to rotate and reciprocate in said housing, a longitudinally extending rock shaft, means operated by said rock shaft for reciprocating the tube-reciprocating member and for turning said member, and means for giving said housing a step-by-step forward movement, said last mentioned means comprising a rack bar extending longitudinally from said housing, a gear engaging said rack bar, and driving connections between said rock shaft and said gear including a one-way clutch the oscillating member of which is oscillated by said rock shaft through means adjustable for varying the amount of feed.

46. In a Pilger mill, a workpiece-reciprocating, turning and feeding unit, comprising a longitudinally movable housing, a member mounted to reciprocate and to rotate in the housing, a clamp on said member for gripping the end of the workpiece, means for reciprocating said member, means for turning said member during the forward movement thereof, and means for moving said housing longitudinally, said last mentioned means comprising a rack bar extending longitudinally from the housing, a gear engaging said rack bar, means operating through a clutch device for turning said gear to give a step-by-step forward movement to the housing, means for engaging and disengaging said clutch device, and reversible driving means other than the step-by-step moving means for operating said gear to move the housing backward or forward when said clutch device is disengaged.

47. In a tube reducing mill, the combination with a mandrel-reciprocating member to which the mandrel rod is secured, and positively operated means for reciprocating said member mechanically connected therewith, of cushioning means to absorb energy from said reciprocating member during deceleration thereof and for returning energy thereto in each direction during acceleration thereof in each direction.

48. A tube reducing mill, comprising in combination a pair of gapped die rolls mounted to rotate about fixed axes, a mandrel cooperating with said rolls, a mandrel-reciprocating member, a drive shaft, means for oscillating said shaft, a lever arm on said shaft for reciprocating said mandrel-reciprocating means, and cushioning means comprising a pair of springs connected to act in opposite directions on the oscillating drive shaft to absorb energy from the reciprocating parts of the mill during deceleration thereof in each direction and to return energy thereto during acceleration thereof in each direction.

49. A tube reducing mill, comprising in combination a pair of gapped die rolls mounted to rotate about fixed axes, means for continuously rotating said rolls, a mandrel cooperating with said rolls, a mandrel-reciprocating member, a drive shaft, means for oscillating said shaft, a lever arm on said shaft for reciprocating said mandrel-reciprocating means, and cushioning means to

absorb energy from the reciprocating parts of the mill during deceleration thereof and for returning energy thereto during acceleration thereof, said cushioning means comprising a pair of oppositely acting tension springs connected to be extended by the turning of said drive shaft, one spring being extended during deceleration in one direction and the other spring being extended during deceleration in the opposite direction.

50. A reducing mill, comprising in combination a pair of gapped rolls mounted to rotate about fixed axes, a reciprocating member to which the workpiece is secured, positively operated means for reciprocating said member mechanically connected therewith, means for imparting an increment of feed to said member for each complete reciprocation thereof, and cushioning means to absorb energy from said reciprocating member during deceleration thereof in each direction and for returning energy thereto during acceleration thereof in each direction.

51. A duplex reducing mill, comprising two axially spaced pairs of gapped die rolls mounted to rotate about fixed axes, means for continuously rotating said rolls, a mandrel cooperating with each pair of die rolls, two laterally spaced mandrel-reciprocating members each adapted to grip one of the mandrel rods, two laterally spaced tube-reciprocating members each adapted to grip a tube to be reduced, a longitudinally movable housing in which the said tube-reciprocating members are mounted, a transversely extending drive shaft, means for oscillating said drive shaft, two laterally spaced lever arms receiving oscillatory movement from said drive shaft for reciprocating the two mandrel reciprocating members, two laterally spaced longitudinally extending rock shafts operated by said drive shaft, a sleeve on each of said rock shafts splined thereto to be turned thereby and rotatably mounted in said housing, two lever arms pivotally mounted in said housing one geared to each of said sleeves to be oscillated thereby for reciprocating one of the tube-reciprocating members, and means for giving an increment of feed to said housing during each return stroke.

52. A duplex reducing mill, comprising two axially spaced pairs of gapped rolls mounted to rotate about fixed axes, means for continuously rotating said rolls, two laterally spaced workpiece-reciprocating members each adapted to grip a workpiece to be reduced, a longitudinally movable housing in which said workpiece-reciprocating members are mounted, two laterally spaced longitudinally extending rock shafts, means for oscillating said shafts, a sleeve on each of said shafts splined thereto to be turned thereby and rotatably mounted in said housing, two lever arms pivotally mounted in said housing one geared to each of said sleeves to be oscillated thereby for reciprocating one of the workpiece-reciprocating members, means operated by one of said shafts for turning the workpiece-reciprocating members during each return stroke, and means for giving an increment of feed to said housing during each return stroke.

53. A duplex reducing mill, comprising a roll housing, two pairs of gapped rolls overhung on opposite sides of the housing, an overhung backing roll for each die roll, a longitudinally movable housing, two laterally spaced workpiece-reciprocating members mounted to reciprocate and to rotate on opposite sides of said movable housing, means for reciprocating and turning said members, and means for giving a step-by-step feeding movement to said housing.

54. A duplex tube reducing mill, comprising a roll housing, two pairs of gapped die rolls overhung on opposite sides of the housing, an overhung backing roll for each die roll, a longitudinally movable housing, two laterally spaced tube-reciprocating members mounted to reciprocate and to rotate on opposite sides of said movable housing, two oscillating lever arms mounted in said housing for reciprocating the tube-reciprocating members, two laterally spaced reciprocable and rotatable mandrel-gripping members, means for reciprocating said mandrel-gripping members and actuating said lever arms, said means including two laterally spaced longitudinally extending rock shafts on opposite sides of said movable housing by which said lever arms are actuated, means operated by one of said rock shafts for turning the tube-reciprocating members and the mandrel-gripping members during each return stroke, and means for giving a step-by-step feeding movement to said movable housing.

55. In a Pilger mill, a workpiece-reciprocating, turning and feeding unit, comprising a longitudinally movable housing, a workpiece-reciprocating member mounted to reciprocate and to rotate in the housing, a clamp on said member for gripping the end of the workpiece, means for reciprocating said member, means for turning said member during its non-working stroke, and means for giving an increment of feed to said housing during the non-working stroke of said member; and an exit workpiece-reciprocating and turning unit, comprising a member mounted to reciprocate and to rotate in a fixed housing, a friction clamp carried by said member for frictionally gripping the workpiece as it advances from the die rolls, and means for reciprocating and turning said member in unison with the first mentioned workpiece-reciprocating member.

56. A tube reducing mill, comprising a pair of gapped die rolls mounted to rotate about fixed axes, a mandrel cooperating with said rolls, means for reciprocating the mandrel, a longitudinally movable housing, a tube-reciprocating member mounted to rotate and to reciprocate in said housing, a longitudinally extending rock shaft, means operated by said rock shaft for reciprocating and turning said tube-reciprocating member, means for giving a step-by-step feeding movement to said housing, a tube-reciprocating member mounted to rotate and reciprocate in a stationary housing at the exit side of the die rolls, a friction clamp carried by the second said tube-reciprocating member for frictionally gripping the tube as it advances from the die rolls, and means operated by said rock shaft for reciprocating and turning the second said tube-reciprocating member.

57. A reducing mill, comprising a pair of gapped rolls mounted to rotate about fixed axes, a longitudinally movable housing, a workpiece-reciprocating member mounted to rotate and reciprocate in said housing, means for reciprocating and turning said member, means for giving a step-by-step feeding movement to said housing, a workpiece reciprocating member mounted to rotate and reciprocate in a stationary housing at the exit side of the die rolls, a friction clamp carried by the second said workpiece-reciprocating member for frictionally gripping the workpiece as it advances from the die rolls, and means

for reciprocating and turning the second said workpiece-reciprocating member in unison with the first said workpiece-reciprocating member.

58. A reducing mill, comprising a pair of gapped rolls mounted to rotate about fixed axes, a longitudinally movable housing, a member mounted to reciprocate and to rotate in said housing, a clamp on said member for gripping the end of the workpiece, means for reciprocating said member, means for turning said member during its movement in one direction, means giving a step-by-step feeding movement to said housing and for feeding said housing backward to its starting position after the workpiece has been partially reduced, and a clamp for holding the partially reduced workpiece when released from said member and during the backward movement of said housing.

59. A tube reducing mill, comprising a pair of gapped die rolls having tapered die grooves mounted to rotate about fixed axes, a mandrel cooperating with said rolls, means for reciprocating the mandrel, a longitudinally movable housing, a tube-reciprocating member mounted to reciprocate and to rotate in said housing, means for reciprocating said member, means for feeding said housing forward step-by-step, means for moving said housing backward to its starting position when a tube has been partially reduced, and a clamp for holding the partially reduced tube to permit the mandrel to be withdrawn and during the backward movement of said housing.

60. A duplex reducing mill, comprising a roll housing, two axially spaced pairs of overhung gapped die rolls on opposite sides of the housing fast on two shafts journalled within the housing, means for applying to both pairs of die rolls a preload approximately equal to the rolling load on the rolls, two laterally spaced workpiece-reciprocating members, driving means for rotating the die rolls and for reciprocating and turning said members, and means for giving a step-by-step feeding movement to said members.

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