A pipe (or tube) mill which receives preformed pipe blanks over an axially fixed mandrel rod and by cold rolling deforms the blanks into super thin walled pipes. The mill has variable speed main and auxiliary drive motors, a main frame, a rolling stand with spring balanced tool rollers with contoured roller tracks having provision for adjustment to accommodate various different diameters of pipe, a rocking lever mechanism for roller stand operation, a mandrel rod clamping mechanism, a floating blank feeding and rotating chuck with associated variable feed and turning gear mechanism, an intermediate blank clamp, a speed reduction gearing with output to the feed and turning mechanism and, via a crank mechanism, to the rolling stand rocking lever mechanism and correlating controls between mandrel clamp and intermediate blank clamp. Emulsion and lubrication is provided.
FIG 1b

FIG 2b

FIG 4

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METHOD AND APPARATUS FOR COLD ROLLING THIN WALL PIPE

RELATED APPLICATIONS

This application includes disclosure of inventive sub-assemblies which constitute subject matter of other related patent applications to be filed.

BACKGROUND OF THE INVENTION

Pipe mills for cold rolling thin wall pipes have been previously known and constructed and some initial constructions and method were disclosed in the text “Cold Rolling Pipe Mills” by Shebakin, Yu. A. et al., Metallurgizdat 1966 published in the Soviet Union. Since that publication, the mills as well as the methods for cold rolling thin walled pipes have undergone considerable development with resultant improvements in the mill structure as well as the methods.

Most cold rolling pipe mills use banks of rolling stands or roll stands with Pilger type rolls with changing working groove profiles which, due to technological reasons, place limits on the finished product. Various mandrel structures are used, some mills using changing profile mandrel heads, stationary mandrels or reciprocating mandrels, some turn the mandrel or blank before a return pass, and most use long mandrel rods dictated because of the need for dual clamping during the blank feed-in stage. Mills of the present type were developed to simplify the mill components, reduce the mill dimensions and weight, and produce better quality finished pipe.

SUMMARY

The primary object of the present invention resides in improved mill construction for cold rolling thin and superthin-wall pipe as well as an improved method for cold rolling pipe blanks to thin and superthin-wall finished pipes. Principle improvements and related benefits from the present invention are as follows:

By making substantial changes in the driving gear of the roll stand operating mechanism has been made more reliable, less expensive and the improvements have made it possible to decrease the dimensions of the mill.

Another improvement in mill construction was the development of a “one-sided mandrel clamping scheme” consisting essentially of the following: 1. The pipe blank enters from a loading train onto the work line of the table. 2. The blank is directed through the end clamping mechanism for the mandrel rod, through the feeding chuck up to the location where the forward end of the blank enters the rolling zone. 3. The mandrel rod clamping mechanism is activated, clamping the mandrel rod, and the feeding chuck operated to grip the pipe blank. 4. The mill is placed in operation, the roll stand receives a reciprocating motion and the feeding chuck periodically feeds the pipe into the rolling zone. 5. After the feeding chuck reaches its extreme forward feed position, the mill is stopped automatically, the mandrel end clamp is opened, an intermediate blank clamp, which protects the substantially rolled pipe blank and the mandrel from axial displacement is actuated to clamped condition, the feeding chuck is then opened and is returned to its rear or start position. A new pipe blank is fed onto the rod and the process of steps 2-5 is repeated.

Such a different and improved mill construction has now made it possible to abandon the previously known and used 2nd mandrel rod clamp of prior art machines, and this is turn results in shortening the length of the mill by one-third, which lowered the weight, and simplified the operation scheme.

Improvements as above reiterated pertain mainly to mill construction, as such, however other inventive developments concern assemblies which have substantial effect on the quality of the rolled product, as well as assemblies which make it possible to expand the technical and technological possibilities of cold rolling mills.

For example, a new chuck which feeds the pipe to the rolling zone has now been developed and makes it possible to carry out the rolling in a “floating” regimen, and this constitutes a decisive role in the satisfactory and efficient rolling of acceptable super thin-walled pipes.

In the mill of the present invention, during rolling, the pipe blank is periodically fed into the rolling zone and simultaneously rotated by a certain angle. The choice of the size of the rotation angle is based on taking into consideration different requirements and data, and the size itself can vary within wide limits. In the new mills according to the present invention the blank pipe feeding and rotating mechanism makes it possible to obtain a whole series of values of the blank feeding and rotation angle quantities, and this allows free selection of a technological regimen for the rolling of superthin-walled, smooth, and, if desired, finned pipes with a different number of fins.

Regarding the economic aspect of the present invention it should be taken into consideration that these mills are used for the rolling of thin-walled, superthin-walled, and finned pipes with a diameter as low as 6 mm, whereas most of the prior art mills previously available are designed for the production of relatively thick-walled pipes no smaller than 16 mm, in diameter.

The economic effectiveness of the present invention resides in two main significant factors:

1. Production of high quality pipes with high tolerances for geometrical dimensions.
2. Economy of metal as a result of a high percentage of product utilization (absence of waste and rejects).

According to the data on mills made in accord with this invention, for this reason alone, it is possible to economize 20 percent of the metal per 1 linear meter of finished pipe.

Further novel features and other objects of this invention will become apparent from the following detailed description, discussion and the appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

A preferred structural embodiment of this invention is disclosed in the accompanying drawings, in which:

FIGS. 1a and 1b, viewed together will be referred to as FIG. 1 which illustrates in side elevation a pipe mill made in accord with this invention and on which the inventive method of rolling thin walled tube can be practiced;

FIGS. 2a and 2b, also viewed together will be referred to as FIG. 2, illustrating in plan view the pipe mill seen in FIGS. 1a and 1b;

FIG. 3 is a diagrammatic representation of the power and drive transmission mechanism in the mill shown in FIGS. 1 and 2;

FIG. 4 (on sheet 2) is an illustrative drawing of the Geneva feed used in the feeding and turning mechanism;

FIG. 5 is a side view of the rear end mandrel rod clamp assembly with the clamp shown in sectional view taken on line 5—5 of FIG. 6. A part of the operating lever is shown in phantom and an arm of the fork is broken away so as not to obscure the sectioned detail;

FIG. 6 is a rear end view of the mandrel rod clamp shown in FIG. 5;

FIG. 7 is a section view taken on line 7—7 of FIG. 6 showing details of the driving pinion used to incrementally turn the mandrel rod;

FIG. 8 is a section view taken on line 8—8 of FIG. 5, illustrating the mandrel rod clamp jaws;

FIG. 9 is a perspective view of one of the mandrel clamp jaws;

FIG. 10 is an enlarged, essentially vertically sectioned view of the “floating” blank feed and rotating chuck;

FIG. 11 is a rear end view of the blank feed chuck shown in FIG. 10;

FIG. 12 is a section view taken on line 12—12 of FIG. 11 showing details of the driving pinion used to incrementally rotate the blank feed chuck;
FIG. 13 is a partially sectioned, enlarged rear view of the intermediate blank clamp and its operating mechanism; FIGS. 14 and 15 are vertical section views taken respectively on lines 14—14 and 15—15 of FIG. 13 illustrating details of the intermediate clamp mounting structure;

FIG. 16 is a sub-assembly side elevation of the roller carriage and attached rocking lever, the lever being partially broken away;

FIG. 17 is a vertical section view taken on line 17—17 of FIG. 18, showing internal details of the rolling stand as well as added details of the operating rocking lever and connecting link;

FIG. 18 is an enlarged, partially sectioned, rear end view of the roller carriage, the rocking lever and operating links;

FIG. 19, drawn to scale slightly smaller than FIG. 18, is a front end view of the roller carriage with one of the carriage support rollers shown in section;

FIG. 20, a vertical section view taken on line 20—20 of FIG. 17, illustrates interior details of the roller carriage;

FIG. 21 is an enlarged detail section of the separator cage, shown in smaller scale in FIG. 17, illustrating the spring balanced roller mounting;

FIGS. 22 and 23 are somewhat diagrammatic views, respectively showing an arrangement using three rollers and an arrangement using five rollers;

FIG. 24 is a pictorial perspective view showing just the three roller and their strap tracks;

FIG. 25 is an exaggerated contour view of the roller track profile on a strap;

FIG. 26, is pictorial side view illustrating the kinematics of the rolling operation;

FIG. 27, is a front view of a roller drawn to scale and used to illustrate the degree of rolling out of the edge of the roller when a 2 mm reduction in diameter from a stainless steel pipe blank to finished pipe is being accomplished; and

FIG. 28 is a graph used in determining rolling out angles for rollers used in cold rolling of stainless steel pipe.

DESCRIPTION OF THE EXEMPLARY EMBODIMENT

With reference to FIGS. 1 and 2, the pipe mill will be generally described in terms of its main mechanisms, details of which will be described hereinafter with reference to FIGS. 5—22, are reproduced from working drawings and can be scaled for relative dimensions. As the general description proceeds, by referring to the diagrammatic illustration of FIG. 3, the functional interrelationship of the mechanisms can be better understood.

The exemplary pipe mill 50 disclosed in the drawings has been used in producing thin-walled pipe with O.D. of from 6—15 mm. The mill is assembled from a number of sub-assemblies supported by the mill floor or foundation 52. The main power is furnished by an electric drive motor 54 which can be located in a well 56 under the other pipe mill components which are supported on several heavy steel I-beams 58 resting on and secured to the mill floor. Reservoirs and drain sumps under cover plates 60 are located between the I-beams and provide space for emulsion and lubrication fluid. A rolling stand 62 is located at the front end (right hand end of the drawings) of the mill and, with the rocking lever assembly 64, is mounted in a front mill housing 66 in a manner enabling the rolling stand to be reciprocated back and forth by the rocking lever, as will be hereinafter described in more detail. The front housing contains heavy structural steel framework secured to the I-beam bed.

At the left-hand end of the mill, a rear housing 68, also secured to the I-beam bed, contains feeding and turning gear mechanism 70, a part of the drive path from motor 54 to the mandrel clamp assembly 84 and the floating blank chuck 80. The front and rear housings 66 and 68 are rigidly secured to and provide end support for the intermediate frame or mill table 72 which includes a heavy cast rear end brace 74 and parallel longitudinal beams 76 to which are fastened parallel channel track slideways 78 forming guide tracks for a "floating" blank feed chuck 80 which travels from a position adjacent the rear housing to a location adjacent the front housing in feeding a pipe blank to the rolling stand.

Seem between the main motor 54 and front housing 66 is a third housing 82, offset to one side but rigidly secured to the I-beam bed. Housing 82 contains reduction and drive transfer gearing from the motor drive to the rocking lever and the blank feed mechanism.

At the extreme rear end of the mill, the input end, is the mandrel rod clamping mechanism 84 which is rigidly fastened to the rear wall of housing 68 by a heavy welded steel cantilever support 86.

Looking again at the front end of the mill as shown in FIG. 2, an intermediate blank clamp assembly 88 can be seen near the rear end of the rolling stand housing 66. The operating solenoid for the intermediate clamp is located in the box-like housing 90.

Near the left hand side of FIG. 1, a second drive motor 92 is secured under the table on a support frame 94. Auxiliary motor 92 is used for speeded up feed-in and return movement of the blank feed chuck 80.

Suitably located along the length of table 72, one or more welded steel stands 96 provide rigid support for the table, as necessary. Appropriate sheet metal coward 98 can enclose the sides of the intermediate frame or table area. Blank pipe support 100, which can be shifted and removed, are used along the table to help support the mandrel spindle and blank, in a manner well-known in the pipe mill art.

Main and auxiliary mill control panels 102 and 104 are located on the side of the table near the rear and front ends and include various electrical control switches and indicator lights to operate and indicate mill condition.

The drive mechanism is best understood with reference to FIG. 3 with supplemental reference to FIGS. 1 and 2. Drive power is derived from the two electric motors 54 and 92. The main motor 54 is a 3-speed asynchronous electric motor which, with an electromagnetic brake 106, is installed on an adjustable base plate 108 (FIG. 1b) for purposes of adjusting the drive belt tension. A multiple sheave V-belt drive pulley 110 and a brake drum 112 are installed on opposite ends of the electric motor shaft 114. Switching between desired ones of the three speeds of the electric motor 54 is carried out, as required by conventional control circuitry via one of the control panels 102 or 104. By providing variable motor speed, greater versatility is enabled in cold rolling operations, permitting the pipe mill to roll thin-wall pipes made from a number of different metals and alloys.

Drive power is transmitted from main motor 54 through driving pulley 110 and multiple V-belts 116 to a larger diameter multiple sheave driven pulley 118 on an input shaft 120 to the reduction transmission 82. Once the mill is in normal operation, drive power for the rolling is through the input shaft 120 and within the transmission reduction is transferred via gear 122 to a shifting gear cluster 124 (which is splined to a transfer shaft 126) thence via meshed speed reduction gears 128 and 130 to a crankshaft 132. Secured on the end of crankshaft 132 is a crank wheel 134 carrying a crank pin 136 and connected between the crank pin and the rocking lever assembly 64 is a massive connecting rod 138 with its line of thrust being disposed under and in alignment with the pipe feed-in axis.

A second power output shaft 140 is connected to the crankshaft 132 via a set of bevel gears 141, 143 and projects rearwardly from the reduction transmission 82 to provide primary drive power to the blank feeding and turning mechanism 68.

The crank mechanism 134, 136 furnishes the driving power to cause the reciprocal (see-saw) displacement of the rolling stand 62 by means of the swinging lever assembly 64. Inside the reduction gear housing, a pneumatic motor 142 connected to a shift lever 144 is used to shift the gear cluster 124 to mesh with driving gear 146 to furnish a special high speed feed-in drive for moving an initial pipe blank up to the rolling stand.
Drive power for the blank feeding and rotating mechanism 70 is accomplished by means of the main electric motor through its V-belt transmission, reduction gearing 62, and the transmission output shaft 140 which drive in conjunction with a long drive shaft 150 coupled at its rear end to an input shaft 152 for the blank feeding and turning mechanism 70.

The mill rolling operation requires intermittent feeding and turning of the pipe blank, accurately correlated with a specific increment of the rocking cycle of the rolling stand 62 (its extreme rear position). This accurate correlation is enabled by means of a single geneva ("Maltese Cross") drive transfer assembly 154. Geneva drive derives from the continuously rotating input shaft 152 through gear 156, an idler gear 158 and a gear 160 drive connected to the geneva drive input shaft 162. Shaft 162 carries and rotates the geneva crank 164. A 6-slot "Maltese Cross" wheel 166, such as used in the present invention, is shown in FIG. 4 and is subjected to periodic stepped rotation by the crank 164 through its roller cam 168. When not being step driven by the crank the "Maltese Cross" is locked by a conventional locator or blocking plate 170. Crank 164 and locator plate 170 are continuously rotated at a number of revolutions per unit time equal to the number of double passes or cycles of the rolling stand 62. When the rolling stand is approaching its extreme rear position, the geneva crank 164 and roller 168 are free to rotate the cross 166 one step, which with the six slot cross is 60°. The rotation of the cross is terminated at the beginning of the straight rolling pass of the stand.

The geneva output cross 166 is drive connected to a shaft 172, to which is splined an axially fixed gear cluster 174 which provides a selected one of two angular amounts of incremental rotation of the blank rotating drive shaft 176 (58° 10' or 72°) and also causes different numbers of rotations of the feeding screw drive shaft 178. The gear cluster 174 includes three gears 180, 182 and 184 which rotate as a unit and two of the gears, 180 and 182, are used in conjunction with the shifting gear cluster 186 splined to turning shaft 176 to provide the two different increments of rotation (58° 10' or 72°), for reasons which will become apparent as the description proceeds. Gear cluster 186 is shifted by a gear shift lever 188 (FIGS. 1a and 2a) on the top of the rear housing 68.

The blank feed chuck drive is via a step up gearing from gear 184 of the gear cluster 174. Gear 184 meshes with a two gear idler cluster 190 journalled on the feed shaft 178, and drive is transmitted through a shiftable gear cluster 192 splined to transfer shaft 194, thence through a second shiftable three gear cluster 196, also splined to transfer shaft 194, to a selected one of a three gear cluster 198, rotatably mounted on and operable to drive the feed screw shaft 178 as will be described hereinafter. The shiftable two gear cluster 192 is selectively meshed with one of the gears on cluster 190 and the shiftable three gear cluster 196 is selectively meshed with an associated one of the gears on the cluster 198 by means of the two gear shift levers 200 and 202 (FIGS. 1a and 2a) located on the side of the rear housing 68, providing six step-up gear ratios in the drive to the feed screw drive shaft 178 during each cycle of rolling stand reciprocation.

High Speed Feed Screw Operation

Under certain conditions, high speed continuous rotation of feed screw drive shaft 178 is desired, e.g., feed-in of a pipe blank when the first blank is introduced at the start of mill operation and return of the floating chuck assembly 80 to its rear start position when a succeeding pipe blank is fed into the mill. The auxiliary electric motor 92 with conventional reversing controls (not shown) furnishes the drive power for high speed feed shaft rotation. The auxiliary high speed power drive train is via the auxiliary motor shaft 204 which is drive connected through a brake 206 (FIG. 1a) to an input shaft 208 journalled in the rear mill housing 68. From input shaft 208 the auxiliary power is transmitted through a gear 210 on the shaft 208 thence through an idler gear 212 to a friction clutch input gear 214 rotatably journalled on the feed screw drive shaft 178 adjacent the feed screw gear cluster 198. Located on and slidably splined to feed screw shaft 178 is a shiftable coupling member 216. One face 218 of coupling 216 has a jaw clutch tooth which, when the clutch is shifted to one position (normal speed), will positively mesh with the jaw clutch teeth on a clutch face member rigidly secured to the gear cluster 198. This condition enables feed screw drive derived from the main motor through the incremental geneva drive 154. The other face 222 of coupling member 216 is a conical friction surface which can mate with an internal conical surface of a coupling face 224 on the clutch input gear 214.

Coupling member 216 is selectively shifted from one to the other of the two positions by a shifting lever assembly 226 actuated by a pneumatic motor 228 controlled by solenoid operated valves 230, in turn controlled through suitable control circuitry.

The ends of the blank turning shaft 176 project from the front and rear of the mill housing 68, being offset to one side from the axis of the pipe blank path, as seen in FIG. 2a, and it is aligned with and its front end is drive coupled with a long, blank turning shaft 240 extending substantially the length of the mill. Shaft 240 is journaled near its rear end in a bearing block bracket 242 and at its front end in a bearing assembly on the intermediate blank clamp assembly 88, as will be more fully described hereinafter, with reference to FIGS. 13 and 15. The long, blank turning shaft projects through the floating chuck assembly 80 and is slidably drive coupled thereto in a manner to be described hereinafter.

The projected rear end of turning drive shaft 176 is coupled with an aligned mandrel clamp turning shaft 244 enabling an incremental turning of the mandrel clamp (as well as the mandrel spindle) conjointly with turning of the blank, as will be hereinafter more fully described.

The feed screw drive shaft 178 projects from the front side of the rear mill housing and is aligned and drive coupled with a long, feed screw 246 extending substantially the length of the mill and disposed directly under the axis of the pipe blank feed path. The feed screw 246 is journaled against axial movement in tapered roller thrust bearings located in the rear bearing block bracket 242 and, at its front end, in the intermediate blank clamp assembly 88 (see FIG. 15). The feed screw 246, intermediate its front and rear journal portions, is threaded and is turned through a feed nut 442 (see FIGS. 10 and 11) in the base of the floating chuck assembly 80, so that rotation of the feed screw 246 will feed the floating blank chuck assembly forward or backward.

In the cold rolling pipe mill operation being described, a mandrel head 252 (FIG. 5) made from steel and shaped to conform with the desired inner diameter of the finished pipe in axially maintained in a predetermined axial position disposed within the rolling stand 62. A long mandrel spindle or rod 250 (see FIG. 5) extends from the mandrel clamp assembly, which securely clamps the rear end of the rod, along the feed path axis, through the floating blank chuck 80, along the length of the table 72, through the intermediate clamp 88 and into the rolling stand 62 where it carries the mandrel head 252. In this mill, only one mandrel rod clamp is used. In order to keep the mandrel rod 250 from axially shifting when added blanks are fed into the mill, an intermediate blank clamp 88 is used and it is situated directly to the rear of the rolling stand. Using the intermediate clamp 88, the unfinished end of the pipe blank which has been almost completely rolled and formed, is clamped about its outside surface and the blank in turn axially maintains the mandrel rod against movement when the mandrel end clamp 84 is released to permit sliding a new blank onto the mandrel rod. When the new blank clears the mandrel rod clamp, that clamp can be closed, and when the mandrel rod clamp is closed the intermediate clamp will automatically release the leading blank. The blank clamp works when the mandrel rod clamp is open and, vice versa, it is always released and will not work when the mandrel rod clamp is closed.
MANDREL ROD CLAMP

Details of the mandrel rod clamping mechanism 84, seen in FIGS. 1 and 2 at the rear end of the pipe mill, are disclosed and will now be described in detail with reference to FIGS. 5-9.

The mandrel rod clamp serves to immobilize the mandrel via its rod 250 in the axial direction and at the same time to transfer the rod, as a synchronous rotation together with the blank, by the same angle, whenever the blank undergoes an incremental turn during a cycle of rolling stand operation. As has been described, the mandrel clamp mechanism 84 is mounted by means of a welded steel rigid cantilever bracket assembly 86 against the rear wall of the rear mill housing 68 (FIG. 1). Viewing FIG. 5, screws 286 fasten the cantilever bracket base plate 288 to the rear housing, and an upper bracket base plate 290 supports a shim plate 292 and the base flange 293 of a cast steel hollow, mandrel clamp housing 294. The housing base flange 293 and the shim plate are keyed together for accurate fore and aft alignment of the clamp and together are secured on shelf 290 by screws. Front and rear recesses 296 and 298 in housing 294 receive roller thrust bearings 300 and 302 which journal the hollow shank 304 of an enlarged jaw casing 306 made from steel. Apertured cover plates 308 and 310 fastened by screws 312 on the front and rear of clamp housing 294 retain the thrust bearings 300 and 302 in their respective housing recesses.

Rigidity retained between the two bearings 300 and 302 is a spur gear 316, non-rotatably secured to jaw housing shank 304 by a drive key 318. The threaded front end 320 of the hollow shank receives lock nuts 322, which, with a spacer sleeve 324 abutting the inner race of front bearing 300 and a shank shoulder 326 abutting the inner race of rear bearing 302, rotatably mount and maintain the jaw casing 306 against axial shift. The far side of housing 294 has an opening into the space around spur gear 316 and provides spaced apart bearing retainer blocks which retain roller bearings 330 and 332 (FIG. 7) journaling the aforedescribed mandrel turning shaft 244. Between bearings 330 and 332 a spur gear 334 is keyed to the shaft 244 and, in assembly, is meshed with the jaw casing spur gear 316. A combination bearing retainer cap and gear space cover 336 is secured on the side of housing 294 by screws and retains the bearings, the end of shaft 244, gear 334, a grease cap 338 and a flanged shaft seal 340, in assembly. Suitable grease fittings (not shown) enable manual or automatic injection of lubricant into the gear and bearing housing.

Returning to FIG. 5 and with reference to FIG. 8, the jaw casing 306 is a cylindrical steel bossing in the integral forwardly projecting hollow shank 304. Casing 306 has three equi-angularly spaced slots 344 which radiate from a large diameter bore 346, coaxial and coextensive with a bore 345 through the shank 304. The shank 304 has shallow counterbore recesses receiving anti-friction sleeve bushings 350 and 352. Housing slots 344 serve as guide tracks for the jaws 354 and the jaw operating spider 356, extending forward from the rear face 357 of jaw casing 306 to locations closely adjacent the front wall of the casing and radially outward from the bore 346 to axially disposed flat guide surfaces 358 near the outer circumference of the casing.

The rear face 357 of casing 306 serves as an axial abutment surface for the rod, as will be described, and is recessed within an annular, axially extended rear casing flange 360 which receives, and to which, a rear casing wall 362 is secured by screws. The rear wall 362 is apertured and has slotted recesses which match and are coextensive with the casing bore 346 and the three casing slots 344. The wall also has a perforation 364 which, in the angualr casing flange and accurately determines the axial spacing between the front face 366 of the wall and the rear casing face 357 to provide an annular space which slidably receives flanged abutment 378 on the jaws 354.

The mandrel clamp operating spider 356, made from steel, can be seen in FIGS. 5 and 8, and includes a forward projecting sleeve spindle 370 having an inner through passage dimensioned to permit a free fit, through passage of pipe blanks inserted through the rear wall aperture and on completely through the mandrel clamp assembly. Integral with and at the rear end of the spindle 370 are three radially disposed camming arms 372 each outwardly offset, shaped to fit in spaced relationship from the mandrel and dimensioned to permit an axial reciprocation within the casing fork assembly 344. The outer surface of each spider arm 372 slidably engages the outer guide surface 358 in its respective slot 344 and each arm includes two camming slots 374, shaped to cam a jaw pin 376 radially inward and outward between two positions. Clearly illustrated in FIG. 5, the cam slots 374 are shaped at each end to positively maintain the pins 376 in an outward or inward disposition, i.e., at those positions the cam slots are shaped so the pins cannot exert a reversed camming effect on the spider.

Prior to inserting the spider 356 into assembly in the casing, a clamp jaw 354 (see FIG. 9) is assembled to each of the spider arms 372. The jaws are made from hardened steel, are channel shaped to slidably fit on an associated spider arm 372 and to slidably fit within the casing slots 344 as seen in FIGS. 5 and 8. The rear end of each jaw 354 has two integral lateral abutment flanges 378 which are received with a close sliding fit into the space between the casing rear face 366 of the casing rear wall and thereby accurately locate and maintain the axial position of the mandrel clamp and the pipe mill rolling stand. The channel body of each jaw has laterally disposed apertures 380 through both channel flanges and when the jaws are placed on each of the spider arms 372, camming pins 376 are inserted with a force fit through the adjacent jaw apertures 380 and with a freely slidable fit through the spider arm cam slots 344. So assembled, each of the three spider arms 372 carries a clamping jaw and the three jaws can move radially toward or away from each other depending upon the axial relationship of the cam slots to the cam pins. The facing surfaces of each jaw 354 have several (three shown) heavy comb teeth 382 with flat outer faces which, in assembly, are arranged essentially as the sides of an equilateral triangle.

The spider 356, together with the three jaws 354, is inserted into the bore 348 of shank 304 with the jaws radially slidable and the spider arms axially shiftable in the casing slots 344 and the rear casing wall then secured to the casing body. So assembled, the spindle can be shifted forward from the illustrated position and the camming slots will shift the clamp jaws 354 radially outward to an open condition. A rearward shift of the mandrel rod 250 in the radial direction will shift the jaws 354 to a closed condition. In a closed condition, the jaw combs 382 close into a triangular clamping condition, fitting into accurate, correlated mating comb recesses 384 in the end of a mandrel rod 250 to thereby axially locate and clamp the mandrel rod against axial shift and also to secure the mandrel rod against rotation relative to the mandrel clamp. Thus, when the mandrel clamp is rotated, the clamped mandrel rod will rotate coincident with the clamp.

The front end of spider spindle 370 projects beyond the end of the casing shank 304 and is used to selectively reciprocate the spindle. To enable operative reciprocation, a spindle shifting sleeve 388 is secured on the projected end of the spindle, and the arms 390 of shifting fork assembly 391, fixed on a shaft (not shown) which is journalled between the cantilever support brackets 86, fit into the groove of the shifting sleeve. Rigidly keyed to the fork assembly shaft is a gear 392, FIG. 5, and a switch operating arm 394. Fork assembly 391 is operatively rocked by a lever 396 secured on a shaft 398 which is also journaled in the cantilever support 86. A gear (not shown) on the lever shaft 396 meshes with the fork assembly gear 392, so operation of the lever 396 will rock the fork assembly 391 thereby reciprocating the spider spindle 370. Lever 396 has a spring loaded detent or latch pin 400, operated by a thumb button 403, which engages one of two slots 404 and 406, in a latch plate 408 fastened by screws to the side of the cantilever support bracket.
When lever 396 is located in the disclosed position in FIG. 5, the spider 356 is disposed in its rear position, i.e., with the jaws 354 in a clamping condition and when the lever is shifted counterclockwise to its rear latched position, the fork assembly rocks forward, reciprocating the spider forward and the clamping jaws shift radially outward to a release condition, which is open sufficient to pass a pipe blank. As seen in FIG. 12, when the clamp is shifted to a released condition the fork shaft and hence the switch lever 943 are rocked clockwise pressing the actuator button 412 of a terminal switch 410 which controls a circuit that prevents operation of the main motor switch 410 and thereby controls a circuit which enables energizing the operating solenoid for the intermediate blank clamp 88.

The pipe mill uses one mandrel rod clamp, and its jaws 354, spider 356 and cast jaw casing 306 are rotatable as a unit, by means of the gears 334 and 316 driven by the mandrel turning shaft 244, the effective continuation of the blank rotation drive shaft 176. As has been described, when the jaws are closed the flat face jaw teeth enter the flat bottom slots of the rod comb and triangularly clamp the mandrel rod against rotation relative to the clamp as well as rigidly maintain the rod against axial displacement. Accordingly, when the blank turning drive shaft is rotated through a predetermined angle, the mandrel clamp, the mandrel rod and the mandrel head are all turned through a predetermined angle, which is equal to that through which the blank is turned, as will hereinafter be more fully described.

FLOATING CHUCK FOR BLANK FEEDING AND TURNING

The floating chuck assembly 80 is described in detail with reference to FIGS. 10, 11 and 12. As has been hereinbefore generally described, relative to FIGS. 1, 2 and 3, the floating chuck assembly clamps and holds the pipe blank during the rolling process, and, while the blank is clamped, the assembly step feeds and rotates the pipe blank when the rolling stand is in the extreme rear portion of its cycle of operation, during which time period the rollers are not in contact with the rolled pipe. The chuck assembly 80 can travel the length of table 72, guided by channel tracks 78 which assure that the axis of the floating chuck coincides with the centerline of the mandrel axis which is also the feed path axis. Feed movement of the chuck is derived from stepped rotation of the feed screw 246 and rotation or stepped turning of the chuck is derived from the long, chuck turning, grooved shaft 240, both of which have operative engagement with the chuck assembly throughout its path of travel.

Turning to FIGS. 10, 11 and 12, the various components of the floating chuck assembly 80 are shown as assembled on a cast steel housing 430. The bottom part of the assembly housing has two parallel, heavy support flanges 432 and 434 extending fore and aft and spaced laterally from each other. Fastened, as by screws, to the upper and lower outer edges at each corner of both of flanges 432 and 434 are slideway guides 436 made from angle pieces of bearing bronze or the equivalent. The housing is placed in the mill table with the two base flanges received in the sideway channel tracks 78 which cooperate with the sideway guides to securely maintain the chuck assembly 80 against rotation around and deviation from coincidence with the mandrel axis, yet permit its free sliding movement along the mandrel (feed path axis). Suitable manual or automatic lubrication of the slideway guides 436 is provided and can be accomplished by any of many well known expedients.

The hollow upper part 438 of housing 430 is a gear and bearing container and bridges the space between the base flanges, the facing surfaces of which are machined to provide a feed nut retainer 440. A "square" feed nut 442, with end flanges 444, shaped to be slid up into the housing container 440 and prevent axial as well as rotational deviation of the nut relative to the housing is located between the housing flanges.

The aforedescribed feed screw 246 is threaded through the nut 442 so its rotation will move the floating chuck assembly along its feed path.

Received within front and rear recesses of the upper housing body 438 are taper roller bearing sets 448 and 450 which journal and axially maintain a spindle sleeve 452. A spur gear 454 is carried on and keyed to the spindle 452 within housing body 438, the spindle, gear and bearing sets being secured in assembly by apertured housing body end covers 456 and 458 made from steel, which are fastened to the housing by screws. Spindle grease seals 460 and 462 are carried in the cover apertures to retain lubricant within the housing body. The inside surface at each of the gear spindle sleeve 452 is undercut to receive anti-friction bushings 464 and 466. The front end of the gear spindle terminals at the cover 456, but the rear spindle end 468 projects beyond the rear cover 458 and carries a steel, cylindrical, adjustment chuck body 470 which can be suitably secured thereto as by threads and set screws.

Slidably disposed through the gear spindle sleeve 452 and non-rotatably coupled thereto via a long keyway 506 and a key 472, is the sleeve spindle 474 of the blank chuck 476. Key 472 is received in a recess in spindle 474. The front end of chuck spindle 474 is internally threaded at 478 to receive the hollow threaded post 480 of a chuck housing 482 which is fastened, by screws, a manually operated three-jaw chuck head 484, of the conventional lathe type.

At its extreme front end a slightly enlarged portion of the spindle 474 terminates in a radially flanged abutment 486. Force fit on the enlarged spindle end and abutted against the rear shoulder of abutment 486 is a boss 488 having outer peripheral splines 490. A key 492 non-rotatably locks the spindle to the boss. Retained by a round nut 494 and splined to the splines 490, on boss 488 is a cam plate 496 with five equi-angularly spaced, axially facing, camming ratchet teeth 498 on its side which faces the housing cover 456. The facing wall of cover 456 includes five mating ratchet teeth 504. The blank chuck head and its spindle 474 have axial through bores 502 and 504 whose inside diameters enable free passage through the pipe blanks fed into the mill. The chuck spindle 474 with its key 472 is assembled through the front end of the housing and, as has been hereinbefore described, is keyed with a sliding fit between key 472 and the long internal keyway 506 of the gear spindle sleeve 452, and slidably engaged with the bushings 464 and 466. A reduced diameter rear end 508 of chuck spindle 474 projects beyond the rear end 468 of the gear spindle and into the adjustment chuck housing 470 and inside of that housing an abutment ring 510 is secured by set screws 512 at a predetermined position on the chuck spindle end 508. The ring 510 determines the limit of forward axial shift of the blank chuck and prevents the chuck to its ratchet free position as depicted in FIG. 10, yet permits a rearward shift of the chuck and spindle to its ratchet engaged position wherein the teeth 498 on the rotatable chuck spindle mate with the stationary housing teeth 500. The abutment ring set screws 512 are accessible through apertures 514 in the adjustment chuck housing 470.

A compression coil spring 516 located inside within the adjustment chuck housing 470 has one end seated against the abutment ring 510 and the other end against an internal flange 518 in the chuck to provide a strong resilient force biasing the blank chuck and spindle to their forward limit position in which there is clearance between the rotatable part with teeth 498 and the stationary teeth 500.

To eliminate the spring bias floating mode of the blank chuck, i.e., to maintain the chuck head in a rigid axial disposition, the adjustment chuck includes a hollow adjusting nut 520 screw threaded into the rear end of the adjustment chuck housing 470. The nut 520 includes an internally projected sleeve 522 which slides over the end rear 508 of the chuck spindle, provides an abutment end 524 and also pilots into the bores of compression coil spring 516, helping to center the spring. By turning the nut 520 into chuck housing 470 until its inner end 524 abuts the spindle abutment ring 510, the nut can
tightly clamp the ring against the rear end of the gear spindle sleeve 452, thus clamping the spindle 474 with its blank chuck 476 in a fixed axial position relative to the floating chuck housing 430. The outer part of the nut 520 can be knurled or provided with flats for receiving a wrench and is maintained in adjustment by the set screw 526.

Shown in FIGS. 11 and 12, the far side of the upper body 438 of the floating chuck housing has an opening defined by a gear journal pad 528, and receives a pinion gear 530 with integral hollow stub axles 532 and 534. Flanged annular bushings 536 fit over the gear axle stubs and seat in bushing recesses 538 and 540 in the housing journal pad and correlate bushing recesses in a journal cap 542 secured to the housing body 438 by pins and screws 544. A locking key 546, placed in an internal gear keyway 548 is held in place by a retainer end ring 550 fastened on the end of stub shaft 532 by screws. The gear 530 is slidable disposed on the grooved turning shaft 240 and is coupled for rotation thereby by disposition of the gear key 546 in the turning shaft groove 552.

Secured on the side face of the journal cap 542 is an auxiliary support 554 which carries a limit switch operator 556 used to determine the limits of travel of the floating clutch assembly by actuating control circuit limit switches at each end of the table at the limits of the pass of the floating chuck assembly.

The stationary mandrel spindle 250 projects through the aligned spindle and chuck bores 504 and 502 and is axially fixed by the mandrel clamp 841. When a pipe blank is fed in over the mandrel spindle it will be fed through the bores 504 and 502 of the floating blank feed chuck assembly while both the mandrel end clamp 84 and the feed chuck head 476 are open.

The rear end of the pipe blank, after being fed onto the mandrel spindle, is clamped by manual operation of the 3-jaw chuck 476. Displacement of the pipe blank forward of the chuck assembly 80 along the table frame 78 is accomplished by rotation of feed screw 246 cooperating with the feed nut 442 rigidly held in lower part of the blank feed chuck housing. Rotation of the feed chuck spindle 474 by a predetermined angle is accomplished by means of rotation shaft 240 through a pair of pins 530 and 454.

As has been herebefore noted, the blank feeding chuck head 476 can work in a "rigid" or in a "floating" mode. The drawing illustrates the "floating" mode.

**"Rigid" Feed Chuck Operation Mode**

During pipe rolling, when the pipe blank which is to be rolled has a wall thickness from 0.4 mm and greater, there is no danger of the ends of pipe blanks meshing, in other words, deforming and/or nesting where the adjacent pipe blanks are just before reaching the rolling stand. In such a case the floating mode can be omitted so the chuck has no axial spring loading. In such a "rigid" mode, the regulating spring 516 on the chuck spindle is by-passed by turning the nut 520 in tight against ring 510, thereby clamping the spindle 474 and eliminating its axial displacement relative to the chuck housing 430.

**"Floating" Feed Chuck Operation Mode**

The "floating" mode of the chuck is used when thin-walled pipes of the order of 0.08 to 0.15 mm finished thickness and initial wall thickness 0.4 mm and thinner are to be rolled on the mill.

The chuck components are correctly related if, during a straight pass through the rolling stand (after the feeding and turning is completed), the teeth 500 of the stationary jaw 456 will be positioned into the slots between the teeth 498 of reciprocable and rotatable jaw 496. The profile of the matched jaws of the exemplary embodiment was determined, taking into consideration the rotation of the pipe blank by 72°. Therefore, when the floating chuck is operating in the "floating" mode it is necessary to position the handle 188 (FIGS. 1a and 2a) in a position which provides a 72° rotation during each stepped rotation of the feeding and rotation mechanism 70. The other turning angle which can be set by the turning angle shift lever 188 is 58° 10' and in the exemplary embodiment is only used in "rigid" mode of the blank feed chuck.

When changing from the "rigid" to the "floating" mode, it is necessary to assure that the ratchet jaw teeth on the chuck spindle 474 are disposed in such a way that such teeth of the spindle jaw will be directly opposite, axially aligned with the depressions between the teeth of the stationary jaw. When the teeth are properly aligned it is necessary to shift the handle of feed rotation lever 188 to its 72° angle position. Next, the chuck spindle 474 is unlatched by feeding the nut 520 so the regulated spring 516 is rendered operative in order that under a certain load the spindle can be displaced in the axial direction relative to the chuck housing.

"Floating" feeding of a succeeding pipe blank by the chuck through the loading of spring 516 has completely eliminated the meshing of thin wall pipe blanks when the succeeding blank abuts the preceding blank. Once the new blank has abutted the preceding pipe blank and a rolling cycle has occurred, the blank chuck assembly is fed forward a stepped increment and its chuck is rotated. When the chuck rotates its ratchet teeth with cam against the stationary teeth to force the chuck head forward the correct distance. The floating action of the chuck thereafter will enable some of the reaction shock force on the pipe blank as the rolling head starts its cycle of rolling of the pipe blank, as will be more fully described hereinafter.

A speeded up return of feeding chuck assembly 80 is accomplished by using the auxiliary electric motor 92, driving in reverse through the shifted condition of the combination friction jaw clutch (216–224) illustrated in FIG. 3.

The limits of travel of the blank chuck assembly 80 are determined by chuck end switches actuated by the chuck housing operator 555. The switches control conventional circuitry which will shut off power to the main motor 54 and apply its brake 106 at the limit of feed travel and will shut-off reverse condition power to the return motor 92 and apply its brake 206 at the limit of return travel.

In the exemplary mill there are six available increments of pipe blank feed movement per double pass of the stand (1.3; 1.7; 2.5; 4.1; 5.2; and 8 mm) and the maximal pass of the feeding chuck is 4,000 mm. Reverse pass speed of the blank feeding chuck is 0.3 m/sec. The available feed increments can be set by selected positioning of the two gear shift levers 200 and 202, see in FIG. 1a.

**INTERMEDIATE BLANK CLAMP**

In previously known machines, two mandrel rod clamps were used to maintain the axial position of the mandrel rod during recharging of the mill with a fresh pipe blank. The pipe blank was fed through the first open mandrel clamp up to the second mandrel clamp (which would be closed at this stage). Next, the first mandrel clamp was closed and the second clamp opened whereupon the blank is then fed a further distance, usually greater than the length of the blank, to the feeding and rotation chuck.

This invention eliminates the second mandrel clamp and in lieu thereof, an intermediate blank clamp 88 (FIGS. 1b and 2b) has been added at a location just ahead of the entry to the rolling stand 62.

To initially charge the present mill, the mandrel end clamp 84 is opened and a first pipe blank is fed over the mandrel rod 250 clearing the mandrel end clamp 84 and up to the point where the leading end of the blank enters the rolling zone. Then the mandrel end clamp assembly 84 is actuated by hand lever 396 to securely grip the rear end of the mandrel rod. The blank feed chuck 476 (at its rear limit position) is manually operated to grip the rear end of the pipe blank. The mill is then started, and when the roll stand receives the reciprocating motion, and the blank feed chuck assembly 80 periodically feeds the pipe blank into the rolling zone.
After the feed chuck with the first pipe blank reaches its extreme right hand position, which actuates the end-of-feed limit switch, the main motor motor 90 is stopped. At this point in operation the intermediate blank clamp 88 is activated and the blank as well as the mandrel, which has a rather snug fit inside the blank at the rolling zone, are held against axial displacement; the blank feed chuck 476 is manually opened and via auxiliary motor 92 returns to its left hand position. Then mandrel clamp 84 is opened (which assures clamping of the intermediate blank clamp 88) and the new pipe blank fed onto the mandrel rod and the feed and rolling process is repeated. By eliminating the previously existing 2nd mandrel rod clamp, the length of the mill is shortened by one-third, its weight is substantially reduced and the operation simplified.

Details of the intermediate blank clamp 88 are shown in FIGS. 13-15. Clamp 88 is assembled on a machined steel frame 570 which includes base flanges 572 and 574 secured by heavy screws to angled, longitudinal support brackets 576 and 578 rigidly secured to fixed framework between the side walls of the rolling stand housing 66 below the pipe feed path axis. Key plates 580 cooperate with accurately located key recesses in the base flanges 572, 574 and in the support brackets spring sets 578 to accurately locate and maintain the axial position of the blank clamp 88.

The large lower portion 582 of the steel frame 570 is chambered to receive a steel thrust bearing housing 584 which has an outer front end flange 586 and a stepped rear end inside flange 588 which provides a bearing abutment 590 and a recess to receive a shaft grease seal 592. Two tapered roller thrust bearing sets 594 and 596 are received in the bearing housing 588 and journal the end 598 of the feed screw 246. The end of screw 246 is threaded to receive locking nuts 602 which clamp the feed screw and bearing sets within the frame 570. A cover plate 602 is fastened to the frame 570 over the bearing housing 588 by screws and clamps the bearing housing and outer bearing races. Suitable lubricant fittings are provided to inject grease, manually or automatically, into the bearing housing.

The upper part 604 of the intermediate clamp frame 570 is apertured at 606 in a direction normal to the mill axis and serves as a clamp fork fitting as well as providing an integral upper jaw abutment 608. A steel bar, dog leg lever 610, with a short lever arm 612 and a long lever arm 614, projects through the upper frame aperture 606 and is rockably mounted on a headed axle pin 616 which passes through apertures 618 and 620 in the upper frame part 604. A cotter pin or like is used to retain the axle in assembly.

The short arm 612 of the clamp lever 610 constitutes a lower jaw abutment 622 for the clamp. In assembly, the two jaw abutments 608 and 622 are disposed adjacent each other with the pipe blank feed path axis passing between them. Each jaw carries, in semi-cylindrical recesses, a bronze half ring 624 and 626 which have locator flanges 628 fitted in end recesses in the two jaws. The half rings, secured in the jaws by screws 630, are the elements which engage the outer surface of the pipe blank and are shaped to conform the outer circumference of the pipe blank being rolled. Accordingly, different half rings are used as determined by the size of the pipe blank being rolled.

The long lever arm 614 projects beyond the side of the rolling stand housing into the upper end of the solenoid housing 90 (see FIG. 2b), and its end is apertured at 632 enabling a coupled disposition over the shank 634 of an operator rod 636, which has a lower forked end 638 pinned to the plunger 640 of a solenoid 642 secured to the base plate 644 of housing 90.

A spring seat washer 646 and nut 648 on the end of operator rod 634 retain a heavy, coil compression spring 650 on the upper side of the apertured end of lever arm 614. A light compression spring 651 is disposed around the operator rod and under the end of lever arm 614, seating on a spring seat washer 654 which rests on an abutment bracket 656.

FIG. 13 shows the intermediate blank clamp 88 in its clamped condition. When the solenoid 642 is de-energized the heavy spring 650 expands to its full extent and then the light spring 652 expands to lift the lever arm 614, thereby rocking the short lower jaw lever arm 612 to an open condition. The long operating arm 614 and short clamping arm 612 provide a substantial force multiplication from the solenoid operator to the clamp jaws.

Shown in FIGS. 13 through 14, the upper clamp frame body serves as a pillow block which, with bearing cap 658 receives and clamps roller bearing sets 660 to journal the front end of the blank feed chuck turning shaft 240. A shaft seal cover plate 662 and a solid end cover plate 664 are fastened to the ends of the pillow block and, with spacers 666, clamp the bearing sets 660 in the pillow block. As with the lower body part 592, suitable lubricant fittings are provided in the pillow block structure for injecting lubrication into the end bearing chamber.

ROLLING STAND

The rolling stand of the present invention, details of which are shown in FIGS. 16-28, is an improvement over a prior art roller type of rolling stand which has been used in the Soviet Union to roll thin-walled tubes. Most such tubes are produced by cold rolling on special Pilger mills which use rolls having complex working pass grooves of changing profile or by multi-draft drawing over a short or long mandrel. Tubes of 17 to 20 mm minimum diameter can be produced by a cold rolling process providing up to 75-80 per cent reduction per pass. In West European countries it has been regarded inexpedient to roll tubes with wall thicknesses less than 1 mm.

The improvement of the working tool calibration pattern enabled the Soviet Union to effectively roll tubes having walls down to 0.6-mm thick on the Pilger roll-type (called so as to be distinguished from the roller-type mills). Any further reduction in the wall thickness of tubes rolled on the roll-type mills involves great difficulties resulting from excessive plastic contact compression of the working tool with roll diameters specified. As a result, specific roller forces are increased which lead to a much greater degree of sticking of metal particles to the working tool and resultant deterioration of the quality of the finished tubes surface. The reduction of roll diameters in such prior art mills has been limited by the load-carrying capacity of the roll bearings. The complexity involved in accurately machine working the passes of changing profile also makes it difficult if not impossible, to obtain thin-walled tubes on the Pilger roll-type mill due to increased likelihood of transverse non-uniformity of the wall thickness.

In the development of new mills (of which the present is an improved version) for rolling super thin-walled tubes (tubes with wall thicknesses less than 0.02 of the outside diameter), instead of using two complex changing profile former surfaces in large diameter work rolls of the Pilger roll-type tube mill, three or more small diameter rollers are employed, these rollers having grooves of constant profile not changing around the circumference, and either use no axle or use short integral rolling shanks whose diameter approaches that of the bottom of the working groove.

Instead of using back-up rolls as used in some cluster mills, special-type contoured tracks on straps or gibs support the cylindrical stub shank journals of the work rollers. The profile of the strap track provide the amount of reduction movement by the rollers and therefore, function both as bearings and formers for the work rollers. The straps or gibs are mounted in a thick-walled tube of the mill rolling stand carriage, which is reciprocated by the crank-and-like drive of the mill.

The work rollers, held against the straps, are mounted in a separator. With the mill running idle, the separator is moved by a kinematic lever system inside the working carriage at a speed corresponding to the velocity of the rollers as they roll along the tube axis during the rolling process to synchronize the location of the rollers in the rolling head.
Referring initially to FIGS. 16-19, the rolling stand 62, followed by details of the rocking lever assembly ... of the rear wall 692. A peripheral outer flange 734 at the front end (right hand side of FIG. 17) of the head cylinder 688 and 690. The inner surface of saddle 704 is coextensive and coaxial with the upper periphery of the circular openings 700 and 702, respectively, which are aligned and releasably receive and mount the rolling head 680. Immediately adjacent the upper front side of rear wall 692 an arcade saddle 704, made from steel plate, is welded to the rear wall and upper edges of the two side plates 688 and 690. The rolling stand carriage 682 is installed in the mill on eight rollers 706-713, roller bearing mounted on stub axles (see FIG. 19) fixed in each corner of the outer side of the two side plates 688 and 690. The rollers roll along the top and bottom surfaces of two horizontal steel bar tracks 718 and 720 (FIGS. 18 and 19) which are fastened to the rigid support framework of the front mill housing 66, preferably by machine screws. Tracks 718 and 720 are parallel to the mill feed path axis and accurately guide the reciprocation of the rolling stand 62. The four upper rollers support the weight of the rolling stand and the four lower rollers prevent pitching of the stand during operation. Horizontal axle shafts 722 and 724 in the outer surfaces of respective side plates 688 and 690 carry six anti-friction gib 726, made from bearing bronze, which provide a close sliding fit against the opposing faces of the two horizontal tracks 718 and 720 and prevent yaw, or cocking of the rolling stand sideways, during operation.

The rolling head assembly 680 includes a thick walled cylinder 730, which carries the rollers, a roller separator, roller strap tracks or gibs and track adjustment mechanism, and is removable inserted into the carriage through its front wall opening 702. The cylindrical outer surface of the head 680 has a close fit through the front and rear walls of the carriage 682, against the rotational relative to the carriage by a key 732 and cooperating key ways in the head and at the bottom of the rear wall 692. A peripheral outer flange 734 at the front end (right hand side of FIG. 17) of the head cylinder 730 abuts against the front carriage wall 694 to limit insertion of the head and axially locates the head in the carriage. An arcuate cross bar 736 placed in an arcuate groove 738 across the top of cylinder 730, and fastened by screws 740 to the rear of carriage front wall 694, rigidly locks the head to the carriage.

Fixed by screws at equi-angular locations on the inside surface of cylinder 730 are three side plates 742, seen in FIGS. 17 and 26, each of which has an inwardly facing, axially disposed channel track 744. A slide or carrier 746, made from a steel block, having a somewhat triangular cross-section, has three outwardly facing slide boxes 748. Fastened by screws to each slide box 748 is a channel shaped, bearing bronze, gib 750, which enable the slide to slideably fit the channel tracks 744 of the side plates 742, and maintain the slide 746 non-rotatable relative to the head 730, as will be explained hereinafter. An axial through bore 752 in slide 746 is dimensioned to provide passage with a free fit for a pipe blank. Extending back from the rear end of slide 746 at the sides of the bore are two integral, laterally spaced apart arms 754 and 756, with aligned lateral cross bores in their ends. Connected to each of the arms 754 and 756 is an individual axle pin 758, with the forked end 760, 762, of an individual slide operating connecting rod, 764 and 766, respectively. The other ends of the two rods 764 and 766 are connected to the rocking lever assembly, as will be described, hereinafter.

Coextensive with the slide 746 and secured by nuts and studs 760 to its serving end is the body 770 of a unit termed a separator, which keeps the working rollers in proper position in the head when they are not actually performing a rolling operation. The separator body 770, shown in detail in FIG. 21, is essentially triangularly shaped in cross section (see FIG. 19), has a large concentric, axially disposed bore 772 and axially disposed stud bores 774, in each of the arms through which the fastening studs 768 project. Intermediate to its two ends and between its three arms, it has three recesses or windows 776 disposed 120° apart. The ends and sides of each window are accurately shaped to radially receive a working roller 778 and front and rear roller shank bearing inserts 780 and 782. The inserts are channelled to freely bridge the center working groove portion 783 of rollers 778 with their flanges shaped with arcuate surfaces to rotatably fit the two shanks 784 of the associated roller.

Two hard steel cylindrical inserts 786 and 788 are inserted in respective front and rear ends of the coaxial through bore 772 and then are welded to the separator body 770. The inner ends of body cylindrical inserts project slightly into the roller working space formed by the intersection of the three windows 776 and are cut away as at 790 and 792, under the ends of each window, as an extension of the bearing insert walls. The bottom of each bearing insert 780 and 782 has a recessed spring pocket 794 and 796, respectively, which seats a small, coiled compression spring, 798 and 800, respectively. Each working roller 778 with a set of two bearing inserts 780 and 782 and their respective balancing springs 798 and 800 are radially inserted into each of the separator windows 776.

The inserts slidably fit the walls of their windows and in turn hold the working roller by their cylindrical shanks. The inserts with the rollers are prevented from moving radially out from within the window by a special locking plate 802 secured by a screw to the separator body 770. The two balancing springs 798 and 800 seat on the cutout flats 790 and resiliently bias their inserts and retained roller 778 outwardly to the limit position dictated by the lock plate 802.

During the rolling operation the working rollers 778 are supported (by means of their shanks 784) and roll on the contour surfaces of the support planks or straps 810, as will be hereinafter described. The spring balancing of each working roller 778 considerably softens their working conditions during the moment of pipe blank feeding and rotating which occurs at the beginning of the rolling process. The spring balancing also provides gradual speed increase after reversal of the stand into its forward pass and prevents slippage of the roller shanks 784 along the support planks 810, as well as eliminating lashing of the pipe by the rollers during the clamping moment (grubbling).

Balancing of the working rollers is also necessary during the rolling of the forward end of the pipe onto the mandrel. The two cylindrical front and rear inserts 786 and 788 have inside diameters permitting free passage of a pipe blank. A threaded end 804 of the front insert 786 projects beyond the front face of the separator 770 and receives spacers washers and gaskets 806 secured by a nut 808. The studs 768 project through the washers and gaskets 806 and the nuts screwed on the studs transfer clamping force through the washers to the face of the separator body 770 to fasten it securely on the slide 746. Thus the separator with the working rollers will reciprocate as a unit with the carriage.

The perspective side view of FIG. 24 clearly illustrates how three working rollers and their track strap groupings are arranged. The straps 810 are hard steel channels, with upper edges 812 and 814 of the flanges carefully contoured to provide inclined roller track formers. The bottom 816 of each strap as shown in FIG. 28, is flat but inclined up in a direction toward the front end of the strap. FIG. 25 is a distorted view showing the track edge contour 812 substantially exaggerated for illustration.
The actual contour change is quite small. The grooved working surface 783 of the roller rides with a sliding fit between the three flanges 874 of the roller track straps 810, each of which is disposed in a guideway between adjacent faces 818 of the sides 742 of the working surface 730 of the roller rides with a sliding fit against an abutment part 820 of a roller rear cover plate 822 fastened on the thick-walled cylinder body 730 by screws. An inner front housing cover plate 824 is held on the front of the cylindrical body 730 by screws and provides a front retaining abutment for axially holding the strips against the rear abutments with a snug but sliding fit.

Under each strap 810 is a flat wedge shaped adjusting gib 826 extending the length of the strap and having an inclined face which matches and engages the bottom inclined surface 816 of the associated strip 810. The front end of each wedge gib 826 is fastened to a common ring 828 which in turn is fastened by screws to a bushing ring 830 which has screw threads 836 on its outer periphery and is threaded on the screw threads 832 of the bushing ring 830 and journalled adjacent the front end of cylindrical body 730 by two ring bushings 838 and 840 held in place by a gear cover 842. At the top of the housing and meshed with the ring gear 834 is a small pinion gear 836 keyed on an operating shaft 846 journaled in bushings mounted in the top wall of the gear cover 842. The pinion shaft 846 projects through to the front of gear cover 842 and secured thereto is a hand wheel 848. Rotation of wheel 848 will rotate the ring gear 834 and, via its threaded connection with ring bushing 830, will shift the wedge gib forwards or backwards to adjust the strap tracks 810 radially inward or outward. The screw thread connection between ring gear 834 and ring bushing 830 constitutes an irreversible connection so that once a wedge adjustment is made by the hand wheel, it is self-maintaining, although a locking pin 849 can be provided to engage the pinion teeth. The purpose of adjusting the radial disposition of track straps 810 is described in a following section of this description.

Track straps 810 are held outwardly against the wedge gibs 826 by spring loaded studs 850 projecting through free fitting apertures in the cylinder body 730, slotted apertures 852 in the wedge gibs 826 and screwed into a threaded hold 854 (FIG. 24) in the bottom of a track strap 810. A cupped washer 856 and a coil spring 858 are held over the outer end of each stud by a nut with the washer and spring recessed into the wall of the cylinder body 730 and provide the bias force on the track straps 810.

Rocking lever assembly

The rocking lever assembly 64 is actually two spaced apart heavy levers 870 and 872 (FIG. 18) assembled on a rock shaft 874 intermediate the lever ends. Each lever has a collar 876 welded to its side face at the rocking axis and with a spacer sleeve 878 between the collars are fixed on shaft 874 by suitable set screws. The ends of rocking shaft 874 project beyond the outer sides of each lever and are journaled in roller bearing sets 880 secured in pillow blocks 882 bolted to heavy angle brackets 884 and 886 fixed to the rigid internal frame of the roller stand housing 66.

The lower ends of the spaced levers 870 and 872 constitute a fork coupling into which fits the front end of the aforesaid connecting rod 138 (FIG. 16). A connecting pin 888, placed through apertures in the lower ends of the levers and the front end of connecting rod 138 couple the rod and lever. Lock plates 890, fastened by screws hold the pin 888 in position and a grease fitting 892 is included in the connecting pin 888. The lower ends of levers 870 and 872 are reinforced by a brace rod 894 and spacer sleeve 896.

The spaced apart upper arms 898 and 900 extend up on either side of the pipe blank feed path axis with their ends located above the largest diameter of the rolling load, bearing on and rolling along the contoured edges 812 and 814 of the strap flanges during the fore and aft passes of the roll stand.

Returning to FIGS. 17 and 20, the side faces 818, of fixed slideways 742 are spaced from and are parallel with adjacent slideway side faces 818 to constitute three guideways for the three roller track straps 810, each of which is disposed in a guideway between adjacent faces 818 of the sides 742 of the slideways 742 fitting with a snug sliding fit against an abutment part 820 of a rear cover plate 822 fastened on the thick-walled cylinder body 730 by screws. An inner front housing cover plate 824 is held on the front of the cylindrical body 730 by screws and provides a front retaining abutment for axially holding the strips against the rear abutments with a snug but sliding fit.
The decrease of the pipe blank diameter to a finished pipe diameter during the cold rolling on the thin-wall mills is quite small, due to the fact that the radius of the pass groove which is constant along the perimeter of the roller is equal to the radius of the finished pipe. In the case of considerable difference between the diameter of the blank and the finished pipes the rollers will cut into the blank. This leads to the intensive flow of metal into the spaces between the rollers and to the spoiling of the pipe surface. During the comparatively small reduction of the pipe during the rolling process the clearance between the inner surface of the blank and the mandrel usually does not exceed 1.0–1.5 mm. Therefore, the length of the reduction section B can be selected within the 10–12 mm limit.

The contour of the track segment A, corresponding to the blank feeding and pipe rotation jaw opening, must guarantee impossibility of contact of the rollers with the pipe blank during the feeding and rotation operations.

ROLLING STAND OPERATION

The cold rolling mill rolling stand 62 works on reciprocating motion principle. The rolling of the pipes is carried out on a stationary cylindrical mandrel head 252 with the help of three or more (depending on the adopted scheme) working rollers 778. At the end of a straight forward pass of the stand 62 the rollers 778 have been moved together to form a closed round groove in cross section, essentially as seen in FIG. 22.

The working rollers are supported by large diameter shanks 784 or, alternatively their work surface (groove surface), by means of contoured tracks such as 810 which provide the regulation of the ring space between the roller groove and mandrel 252 along the work pass of the stand. The ring groove formed by the three rollers at the beginning of the working pass of the stand is larger than it is at the end of the pass.

The roll stand 62 consists of the thick walled sleeve 730 inside which are installed three or more support tracks 810 along which the working rollers 778 roll. Synchronism of the longitudinal displacement of the rollers is provided by a separator 770 fastened to the slide block 746. The position of the slide block 746 in relation to the sleeve 730 is fixed by the yoke 942. The rolls with the separator, support tracks, and thick-walled sleeve are installed in the welded carriage 682 of the roll stand, and can be quickly and simply removed and replaced with minimum effort. The roll stand is connected with the crank and rotation mechanism 82 by rocking lever assembly 64 which imparts the reciprocal motion to the stand.

In order to compensate for the elastic deformation of the working instruments (tools) and the cylindrical head, the possible inaccuracies in the manufacture of the instruments, and the adjustment of the mill, the special wedge gib 826, provided with adjustment via the hand wheel 848, enable regulation of the strap track height.

During the operation of the separator (retainer) and the strap tracks the possibility of insignificant displacement of the rolls along the working surfaces of the support tracks in the transverse direction was incorporated. This allows the self-adjustment of the rollers along the rolled pipe and decreases considerably the uneveness of the deformation along the perimeter of the pipe, thus improving its quality.

The spring balancing of the roll and stand rollers considerably softens their operation conditions during the moment of feeding and rotation of the blank and at the beginning of the rolling. The balancing provides a gradual increase in roller rotation speed after the carriage has been reversed, precludes the slippage of the shanks along the support tracks, and at point of impact of the rollers on the pipe during the seizure moment.

The components of the mill are quite simple in form and are simple to manufacture. The work profile of the strap support tracks are a combination of sloping planes. The groove of the roller corresponds to the size of the finished pipe and is maintained along the entire perimeter of the roller. When switching from the rolling of pipes of one diameter to the rolling of pipes of another diameter the rollers and mandrel are changed and the lever system of the carriage is re-adjusted.

In the exemplary machine the following conditions exist keeping in mind that the main motor is a 3 speed electric motor.

1. Transmission ratio number from motor to the crank gear
2. Transmission ratio from the motor to crank gear at feed-in speed.
3. Transmission ratio of reducer
4. Crank gear radius 100mm
5. Length of connecting rod
6. Power
7. Number of revolutions
8. Number of double passes of the rolling stand
9. Length of the rolling stand pass

ROLLING MILL OPERATION

In the exemplary mill, loading of the pipe blanks is carried out manually. During the work process the mill can be operated by one operator and allows the rolling of measured blanks 4 meters in length as well as unmeasured ones less than 4 meters in length.

A rod 250 with a required diameter and length of mandrel head 252 is placed into the mill. The blank feeding chuck 80 is placed into extreme rear position.

The feed chuck is opened and the coupling of the feeding and rotating mechanism is placed into working position. The mandrel rod clamp 84 is just closed manually on the mandrel rod end grooves to locate the mandrel and then the electromagnetic blank clamp 88 is closed on the front part of the mandrel through a terminal switch and electric solenoid 642. The mandrel clamp is then opened.

The pipe blank, coated internally with a lubricant emulsion, is pushed over the mandrel through the mandrel end clamp and into the sector between the mandrel end clamp and intermediate blank clamp, after which the mandrel rod end clamp is closed manually. When that is done, via its terminal switch 410, which is actuated by closing the mandrel rod end clamp, the electromagnetic intermediate blank clamp 88 opens automatically.

The pipe blank is next manually clamped in the lathe type feeding chuck head. When rolling pipes with a "rigid" chuck the angle regulating handle on the feeding and turning mechanism is placed into position corresponding to the blank rotation angle of 58° 10', and when rolling is done with "-"
floating" chuck the handle is placed into position corresponding to the angle of rotation of 72°. The necessary blank feeding value is chosen by shifting of the feeding speed shift handles.

Due to technological reasons, the start of rolling of the forward end of the first blank is carried out at a fast feed-in speed.

The feeding and turning operations are actually a combined operation performed when the working carriage is in its extreme rear position and the work rollers are set apart at a maximum distance from the axis of the tube rolled.

Viewing FIG. 26, upon start of the forward travel of the carriage and contoured track 810, a part of the tubular pipe blank stock 966b which has already been fed is gripped by the work rolls 778. Being brought together radially, the rollers "float" in the direction of the carriage movement, and periodically reducing this part of the stock, they roll it over a cylindrical mandrel 252 to the desired diameter and wall thickness. During the return stroke of the carriage, some reduction of the part of the tube still on the mandrel head also takes place owing to elastic compression of the "working tool-working carriage" system.

For purposes of visual demonstration, the kinematics of the process of tube rolling by rollers may be compared to rolling a pencil held down by a palm over a table, the palm moving in the longitudinal direction. In this case the palm will correspond to the thick-walled tube of the working carriage accommodating the shaped track straps; the pencil, to the work rollers; and the table surface, to a tube being rolled on a stationary mandrel.

The advantage of the process of tube rolling by rollers is as follows:

a. Small diameter of work rollers and corresponding reduction in the specific roll force and in the contact surface between the metal, the roller and the mandrel.

b. Some decrease in elastic compression of the rollers and the mandrel and the possibility for producing tubes with much thinner walls.

c. It is possible to roll tubes of much smaller diameters as compared to the Pilger roll-type mills.

d. The working tool may be manufactured with an accuracy of ±0.01 mm.

e. There are no expensive work roll bearings having low service life.

f. Sliding of the roller pass surfaces over the tube rolled is sharply reduced owing to a greater number of rollers and the constant cross-section of their grooves.

g. Metal sticking to the working tool is minimized due to some reduction in the specific roll force and sliding.

h. Self-aligning of the rollers over the tube which minimizes the possibility of rolling marks formation on the tube.

i. It is possible to roll the so-called "non-scratched" tubes, having outside and inside surfaces of high quality finish, which, apart from other factors involved, is aided by the use of a cylindrical mandrel rotated synchronously with the tube being rolled.

THE EMULSION-LUBRICATION EQUIPMENT

The mill is provided with emulsion-lubrication equipment to supply lubricant to the friction surfaces of the mill mechanisms and enable the cooling flow of emulsion over the blank at the pipe rolling zone.

The majority of the lubricated points are provided with liquid or grease lubricant through centralized means.

The centralized liquid lubrication of the feeding and turning mechanism is carried out from reservoirs and pumps situated within the main frame of the mill. A pumping installation may be installed to feed the lubricant. The return of the lubricant and emulsion to the reservoirs takes place through drain pipes by gravity. Reducer lubricant is grease and a number of bearing assemblies have packed grease lubrication.

ROLLING OF STAINLESS STEEL THIN-WALL PIPES

Although the following special process steps and conditions for rolling thin-walled pipes made from stainless steel is the subject matter of a method invention to be submitted in a separate application it is herein set forth by way of an example showing a method which can be carried out on the hereinbefore described mill structure.

To cold roll finished pipes with wall thickness variation with a desired tolerance, it is imperative that the relative wall thickness variation of the blank not exceed that tolerance.

The blanks made from stainless steels or alloys thereof destined for pipe rolling must pass the following technological operations:

a. Thermal processing for removal of the work hardening and impartation of ductility to the metal.

b. Pipe Straightening

c. Pickling

d. Washing

e. Drying

f. Deposition of lubricant onto the inside surface of the blank.

The peculiarities of rolling stainless steels and their alloys consists of the fact, that during deformation they have a predilection to considerable densification. And this factor leads to increased pressure of the metal on the rollers during the rolling process.

The rolling regimen is considered to be normal, when the degree of deformation reaches 65–70 percent. In order to guarantee a mill output of 30–40 meters per hour, the rolling is done at 1st and 2nd speeds of the mill, i.e., 70 and 95 double passes of the roll stand per minute during feeding of 1.8–2.5 mm/pass.

The following conditions apply to the dimensions of the blanks:

a. Clearance of 0.3–0.5 mm must be provided between the outside diameter of the mandrel and the inside diameter of the blank. The clearance is necessary for the passage of the lubricant onto the mandrel.

b. Reduction of the outside diameter of the blank to that of the finished pipe must be no greater than 2 mm. Taking into account that the rolling of pipes is done by the rollers with groove profiles having a constant radius, in order to provide the mentioned reduction, the rollers must be rolled out according to the graph shown in FIG. 28.

In addition, the contours on the strap tracks (for rollers) are correlated to preselected pipe blank sizes. The mandrel must correlate to the inside diameter of finished pipe and the following substance, or other special lubricants can serve as mandrel lubricant: castor oil — 8.0 percent, graphite powder — 20 percent. Oil, as a cooling medium is fed over the pipe blank in the deformation zone in order to cool the pipe.

As shown in FIG. 27, the peripheries of a roller for a three roller stand are beveled at their edges on angles of 120° so that the three rollers will meet and mate with a true ring cross-section when they reach the finishing segment of the tracks. The bevel angle limits the permissible shank width and diameter. In rolling out of the rollers, the sharp bevel R₁ is rolled off until the angle of the tangent to the peripheral edge zone of the profile groove rolling zone of the roller is smaller than the normal 60° angle normally formed by a sharp bevel edge. The amount of necessary rolling out of such roller edges depends upon the amount of diametral reduction between the pipe blank and that of the finished pipe. The chart shown in FIG. 28 provides the correct rolling out angle for the diametral reduction.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.
What is claimed and desired to be secured by Letters Patent is:

1. A pipe mill for rolling and reducing the wall thickness of pipe blanks comprising: front, rear and intermediate frame structure fixed rigidly along a pipe blank feed path, whereby a removable mandrel rod with a mandrel head on the front end may be disposed from said rear frame structure to said front frame structure along the pipe blank feed path; rolling stand means on said front frame structure for accomplishing a step-by-step incremental rolling reduction of the wall of a pipe blank over and forward along a mandrel head zone; the length of frame structure which will be occupied by a mandrel rod being greater than, but substantially less than twice, the maximum length of pipe blanks to be rolled; clamping means, rigidly fastened at the rear of said frame structure, adapted to selectively clamp the rear end of the mandrel rod and axially position the mandrel head in the rolling reduction zone; pipe blank feed means, including means, adapted to surround the mandrel rod, releasably clamping a pipe blank placed over the mandrel rod, reciprocally mounted on said intermediate frame structure for travel back and forth from positions adjacent the front and rear frame structures along the pipe blank feed path; intermediate clamping means located on said frame structure between said front and rolling reduction means and the front of said pipe blank feed means selectively operable to clamp the outer surface of a pipe blank; and drive means connected to reciprocate said rolling reduction means and also connected to incrementally step feed said pipe blank feed means in synchronization with a predetermined stage of a reciprocation cycle of said rolling means.

2. A pipe mill, as defined in claim 1, wherein said drive means includes: a main electric motor, a reduction gearing including a vertical rocking lever connecting said motor and said rolling stand means; a speed change transmission drive including intermittent input drive gearing connected to said reduction gearing; and a feeding drive connection from said speed change transmission coupled to feed said pipe blank feed means.

3. A pipe mill, as defined in claim 2, wherein means rotatably mount both of said mandrel clamping means and said pipe blank feed means for rotation about the feed path axis; and a turning drive means from said speed change mechanism is coupled to and adapted to conjointly rotate both of said mandrel clamp and said pipe blank feed means at the same angular rate.

4. A pipe mill, as defined in claim 3, wherein said electric motor is a multi-speed, asynchronous motor and said change speed transmission includes means selectively enabling at least six different rates of feed between its input and said feeding drive connection.

5. A pipe mill, as defined in claim 3, wherein said change speed transmission includes means selectively enabling at least two angular values of step rotation of said turning drive means.

6. A pipe mill, as defined in claim 2, wherein said pipe blank feed means includes a feed shifting body and a resiliently biased, limited shift, axially floating connecting means between said pipe blank clamping means and said body.

7. A pipe mill, as defined in claim 6, wherein said limited shift, floating connecting means rotatably mounted said floating, pipe blank clamping means for rotation in said body and said turning drive means from said speed change mechanism is coupled to rotate said floating pipe blank clamping means.

8. A pipe mill, as defined in claim 7, wherein means rotatably mounted said mandrel clamping means, and said turning drive means is coupled to rotate said mandrel clamp conjointly with said floating pipe blank clamping means and at the same angular rate.

9. A pipe mill, as defined in claim 8, wherein a positive axial feed drive between said body and said floating pipe blank clamping means intermittently over-rides said floating shift of said floating clamp to assure an increment of feed movement during each intermittent angular rotation of said floating pipe blank clamp, and said intermittent angular rotation occurs during when said rolling stand is at end of its back stroke and the beginning of its working pass.

10. A pipe mill, as defined in claim 2, wherein said drive means includes: an auxiliary reversible electric motor; selectively shiftable coupling means, drive coupling said auxiliary motor to said speed change transmission and simultaneously disconnecting said intermittent drive gearing to permit said high speed continuous forward and reverse feed feeding of said pipe blank feed means.

11. A pipe mill, as defined in claim 1, wherein said intermediate clamping means is a solenoid operated jaw clamp.

12. A pipe mill, as defined in claim 11, wherein operating means for said mandrel end clamp includes a component shifting between two limit positions upon selective clamping and unclamping of said mandrel end clamp; a terminal switch is mounted on said rear frame structure adjacent and actuable by said shifting component; and safety circuits connect said terminal switch to both the main motor energizing circuit and the energizing circuit to the operating solenoid for said intermediate clamping means whereby the main motor circuit is rendered inoperative when said mandrel end clamp is opened and said solenoid circuit is rendered inoperative when said mandrel end clamp is closed.

13. A pipe mill for rolling and reducing the wall thickness of pipe blanks comprising: front, rear and intermediate frame structure fixed rigidly along a pipe blank feed path, whereby a removable mandrel rod with a mandrel head on the front end may be disposed to extend at least from said rear frame structure to said front frame structure along the pipe blank feed path; rolling stand means on said front frame structure for accomplishing a step-by-step incremental rolling reduction of the wall of a pipe blank over and forward along a mandrel head zone; the length of frame structure between said front and rear frame structure which will be occupied by a mandrel rod being greater than, but substantially less than twice, the maximum length of pipe blanks to be rolled; clamping means rigidly fastened relative to the rear of said frame structure adapted to selectively clamp the rear end of the mandrel rod and axial position the mandrel head in the rolling reduction zone encompassed in the front frame structure; pipe blank feed means having means to grip a pipe blank and mounted for feed movement in a path parallel to said mandrel rod to and from positions adjacent the front and rear frame structures, said pipe blank feed means adapted to continuously grip a pipe blank while feeding said pipe blank a distance equal to its length; and solenoid actuated intermediate clamping means located adjacent said frame front end rolling reduction means and the front limit position of said blank feed means selectively operable to clamp the outer surface of a pipe blank.

14. A pipe mill, as defined in claim 13, wherein operating means for said mandrel end clamp includes a component shifting between two limit positions upon selective clamping and unclamping of said mandrel end clamp; a terminal switch is mounted on said rear frame structure adjacent and actuable by said shifting component; and safety circuits connect said terminal switch to both the main motor energizing circuit and the energizing circuit to the operating solenoid for said intermediate clamping means whereby the main motor circuit is rendered inoperative when said mandrel end clamp is opened and said solenoid circuit is rendered inoperative when said mandrel end clamp is closed.

15. A pipe mill for rolling and reducing the wall thickness of pipe blanks comprising: front, rear and intermediate frame structure fixed rigidly along a pipe blank feed path, whereby a removable mandrel rod with a mandrel head on the front end may be disposed from said rear frame structure to said front frame structure along the pipe blank feed path; rolling stand means on said front frame structure for accomplishing a step-by-step incremental rolling reduction of the wall of a pipe blank over and forward along a mandrel head zone; clamping means fastened on said frame structure, adapted to selectively hold the mandrel rod and axially position the mandrel head in the rolling reduction zone; a pipe blank feed means recipro-
cally mounted on said intermediate frame structure for travel between the front and rear frame structure along the pipe blank feed path including means, adapted to surround the mandrel rod, for releasably clamping a pipe blank placed over the mandrel rod; and drive means connected to reciprocate said rolling reduction means and to incrementally step feed said pipe blank feed means in synchronization with a predetermined stage of a reciprocation cycle of said rolling means, said drive means including: an output crank means, a vertically disposed rocking lever with its rocking axis intermediate its arms, a connecting rod connected between said crank means and a lower arm of said rocking lever, and connecting rod means connecting an upper arm of said rocking lever to said rolling stand means; means on said frame structure mounting said crank means with its axis normal to and below the feed path axis; and means on said frame structure mounting said rocking lever with its axis normal to and below the feed path axis, the upper rocking lever arm projecting above the feed path axis and the connection between said upper lever arm and said connecting rod means to said rolling stand means disposed above the feed path axis.

16. A pipe mill, as defined in claim 15, wherein said connecting rod is so disposed below the feed path that its path of movement is in alignment with a vertical plane through the feed path axis.

17. A pipe mill, as defined in claim 15, wherein the rocking lever structure has means providing a feed path space between its rocking axis and the end of the upper arm so a pipe blank can pass through the upper lever arm into the rolling reduction zone.

18. A pipe mill, as defined in claim 17, wherein said rocking lever includes a lever body equally balanced on opposite sides of a vertical plane through the feed path axis.

19. A pipe mill, as defined in claim 15, wherein said connecting rod means includes adjustable parallel links connected at different positions on said upper lever arm and to said rolling stand means and to a roller separator located within said rolling stand means to provide reciprocation of said rolling stand means and of said roller separator synchronized at the proper ratio.

20. A pipe mill, as defined in claim 15, wherein said upper lever arm is longer than said lower lever arm.

21. A pipe mill, as defined in claim 15, wherein said drive means further includes: a main three speed electric motor, a reduction gearing including said crank means; a speed change transmission drive including an intermittent input drive gearing connected to said reduction gearing; and a feeding drive connection from said speed change transmission coupled to feed said pipe blank feed means in synchronization with reciprocation of said rolling stand means.

22. The method of reducing wall thickness of pipe, as defined in claim 24, including the further steps of: stopping the mill drive when the blank feeding means reaches the end of its feed path; secondarily clamping the exterior surface of the pipe blank on the feed-in side of the rolling zone and thereby maintaining the axial position of the mandrel; unclamping the mandrel rear end and the blank feeding chuck; returning the blank feeding drive to its start of feed location; feeding a new pipe blank over the rear end of the mandrel and into abutment with the rear end of the new blank; and secondarily clamping the blank over the mandrel head and the rear end of the blank clears a rear end mandrel rod clamp; axially securing the rear end of the mandrel rod to render the mandrel head stationary; secondarily clamping the rear end of the pipe blank in a combination blank feeding and rolling chuck at a location anywhere from adjacent the mandrel end clamp to adjacent the reducing zone of the pipe mill, such location depending upon the length of the pipe blank; providing a power driven roll stand cycle with a double rolling pass along a mandrel head synchronized with a combined forward feed step and simultaneous partial rotation of the pipe blank occurring at the beginning of the roll stand working pass; removing all rolling engagement with the pipe blank during the feed and turning step; providing said blank feed steps in increments approximately 10 mm or less correlated with a rolling reduction pass at least twelve times longer than said feed step; stopping the mill drive when the blank feeding means reaches the end of its feed path; secondarily clamping the exterior surface of the pipe blank on the feed-in side of the rolling zone and thereby maintaining the axial position of the mandrel; unclamping the mandrel rear end and the blank feeding chuck; returning the blank feeding device to its start of feed location; feeding a new pipe blank over the rear end of the mandrel and into abutment with the rear end of the new blank; and secondarily clamping the blank over the mandrel head and the rear end of the blank clears a rear end mandrel rod clamp; axially securing the rear end of the mandrel rod to render the mandrel head stationary; clamping the rear end of the pipe blank in a combination blank feeding and turning chuck; rendering the mill drive operative to provide a power driven roll stand cycle with a double rolling pass along the mandrel head synchronized with a combined forward feed step and simultaneous partial rotation of the pipe blank occurring during the period when said rolling stand is at the end of its back stroke and the beginning of its working pass; removing all rolling engagement with the pipe blank during the feed and turning step; providing said pipe blank feed steps in increments approximating 10 mm or less correlated with a rolling reduction pass and said feed step; and maintaining said pipe blank under a resiliently biased axial float condition subject to a limited increment of feedback shifting of said pipe blank.

24. The method of reducing wall thickness of pipe, step-by-step comprising: pre-conditioning a pipe blank with an internal coating of lubricant; feeding the blank over a mandrel rod from its rear end until the front end of the blank reaches a rolling zone disposed along the mandrel head and the rear end of the blank clears a rear end mandrel rod clamp; axially securing the rear end of the mandrel rod to render the mandrel head stationary: secondarily clamping the rear end of the pipe blank in a combination blank feeding and rolling chuck at a location anywhere from adjacent the mandrel end clamp to adjacent the reducing zone of the pipe mill, such location depending upon the length of the pipe blank; providing a power driven roll stand cycle with a double rolling pass along a mandrel head synchronized with a combined forward feed step and simultaneous partial rotation of the pipe blank occurring at the beginning of the roll stand working pass; removing all rolling engagement with the pipe blank during the feed and turning step; providing said blank feed steps in increments approximately 10 mm or less correlated with a rolling reduction pass at least twelve times longer than said feed step; stopping the mill drive when the blank feeding means reaches the end of its feed path; secondarily clamping the exterior surface of the pipe blank on the feed-in side of the rolling zone and thereby maintaining the axial position of the mandrel; unclamping the mandrel rear end and the blank feeding chuck; returning the blank feeding device to its start of feed location; feeding a new pipe blank over the rear end of the mandrel and into abutment with the rear end of the new blank; and secondarily clamping the blank over the mandrel head and the rear end of the blank clears a rear end mandrel rod clamp; axially securing the rear end of the mandrel rod to render the mandrel head stationary; clamping the rear end of the pipe blank in a combination blank feeding and turning chuck; rendering the mill drive operative to provide a power driven roll stand cycle with a double rolling pass along the mandrel head synchronized with a combined forward feed step and simultaneous partial rotation of the pipe blank occurring during the period when said rolling stand is at the end of its back stroke and the beginning of its working pass; removing all rolling engagement with the pipe blank during the feed and turning step; providing said pipe blank feed steps in increments approximating 10 mm or less correlated with a rolling reduction pass and said feed step; and maintaining said pipe blank under a resiliently biased axial float condition subject to a limited increment of feedback shifting of said pipe blank.
including means, adapted to surrounding the mandrel rod, for releasably clamping a pipe blank placed over the mandrel rod; and drive means connected to reciprocate said rolling reduction means and to incrementally step feed said pipe blank feed means in synchronization with a predetermined stage of a reciprocation cycle of said roll stand, said drive means including: an output crank means, a vertically disposed rocking lever with its rocking axis intermediate its arms, a connecting rod connected between said crank means and a lower arm of said rocking lever, and connecting rod means connecting an upper arm of said rocking lever to said roll stand; means on said frame structure mounting said crank means with its axis normal to and below the feed path axis; means on said frame structure mounting said rocking lever with its axis normal to and below the feed path axis, the upper rocking lever arm projecting above the feed path axis and the connection between said upper lever arm and said connecting rod means to said roll stand disposed above the feed path axis; and said front frame structure including opposed, spaced apart tracks, disposed parallel to the feed path axis; and said roll stand comprising a carriage with bearing means adapted to engage the tracks and reciprocally mount said stand on the tracks, a thick walled roller mounting head rigidly fastened in said carriage coaxial with the feed path axis, a roller separator slidably mounted within said head for reciprocation along said feed path axis relative to said head, working rollers in said separator spaced at equi-angular locations around said axis, and means on said carriage enabling attachment of said connecting rod means.

27. A pipe mill, as defined in claim 26, wherein the rocking lever structure has means providing a feed path space between its rocking axis and the end of the upper arm so a pipe blank can pass through the upper lever arm into the rolling reduction zone.

28. A pipe mill, as defined in claim 27, wherein said rocking lever upper arm includes a dual member lever body equally balanced on opposite sides of a vertical plane through the feed path axis.

29. A pipe mill, as defined in claim 26, wherein said connecting rod means includes adjustable differential motion linkage connected to said roll stand and to said roller separator to provide reciprocation of said roll stand and of said roller separator synchronized at the proper ratio.

30. A pipe mill, as defined in claim 26, wherein said upper lever arm is longer than said lower lever arm.

31. A pipe mill, as defined in claim 26, wherein said drive means further includes: a main three speed electric motor, a reduction gearing including said crank means; a speed change transmission drive including an intermittent input drive gearing connected to said reduction gearing; and a feeding drive connection from said speed change transmission coupled to feed said pipe blank feed means in synchronization with reciprocation of said roll stand.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,670,549 Dated June 20, 1972

Inventor(s) Alexandr Ivanovich Tselikov et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 20, in the chart at #1 insert --10-- in right column.
Column 20, in the chart at #4 insert --100 mm-- in right column.

Signed and sealed this 7th day of November 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR. ROBERT GOTTSCALCH
Attesting Officer Commissioner of Patents