United States Patent

Eibe

[15] **3,665,746**

[45] **May 30, 1972**

[54] COMBINATION ROLLING MILL

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[73] Assignee: **Blaw-Knox Company**

[22] Filed: **Mar. 2, 1970**

[21] Appl. No.: **15,326**

[52] **U.S. Cl.** **72/239**

[51] **Int. Cl.** **B21b 31/08**

[58] **Field of Search** 72/237, 238, 239, 248, 41, 72/42, 43, 44, 201

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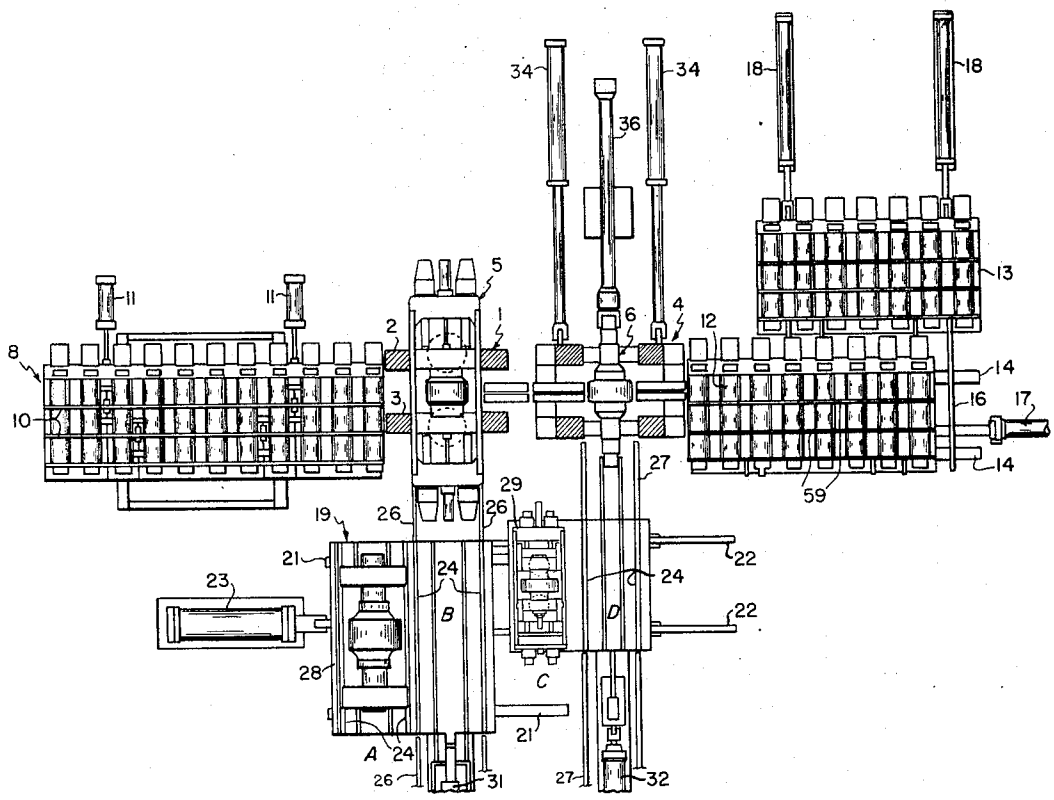
" Combination Mill & Structural Mill" (pamphlet distributed at 1968 AISE convention in Cleveland, Ohio)
Photographs of Combination Mill & Structural Mill which were displayed at the 1968 AISE convention.

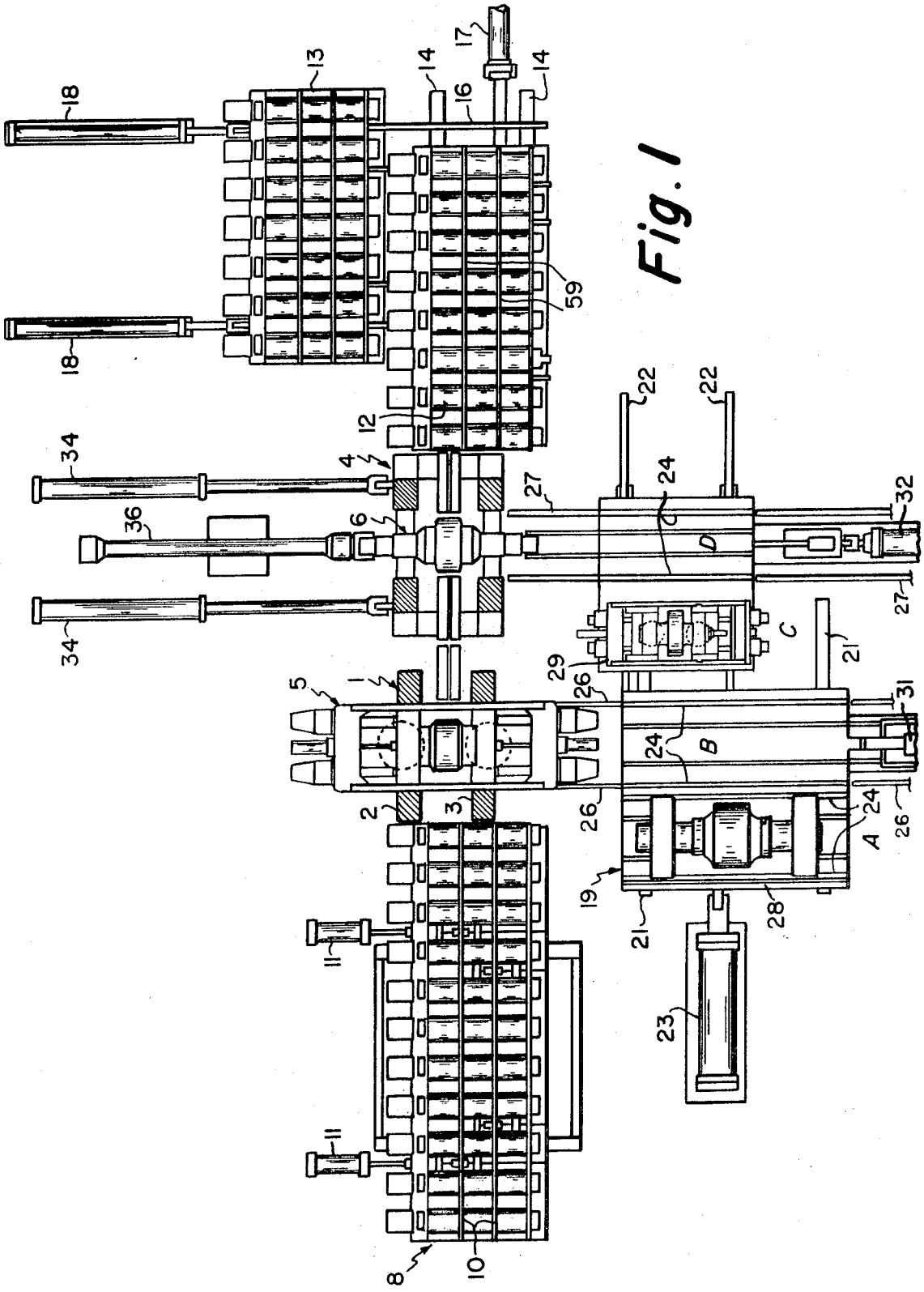
Primary Examiner—Milton S. Mehr
Attorney—Buell, Blenko & Ziesenheim

[57] **ABSTRACT**

A cartridge loadable combination mill for rolling beam, structural or plate products. The combination mill includes a pair of cartridge or cartridge-like loaded mill stands, the first of which has a movable mill housing and the second of which is adaptable to being moved out of the mill line. The cartridges contain a pair of horizontal and vertical rolls that are aligned and adjusted prior to insertion into the mill stands through the mill housing windows. A four station cartridge transfer means having alternative stations simultaneously alignable with both mill stand windows is provided for supporting, positioning, and transferring work roll cartridges to the mill stands for insertion therein. A pair of movable table rolls with side guards adjustable to the maximum width of the first mill stand are movable either along the mill line or out of said line.

16 Claims, 37 Drawing Figures




Fig. 1
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B
C
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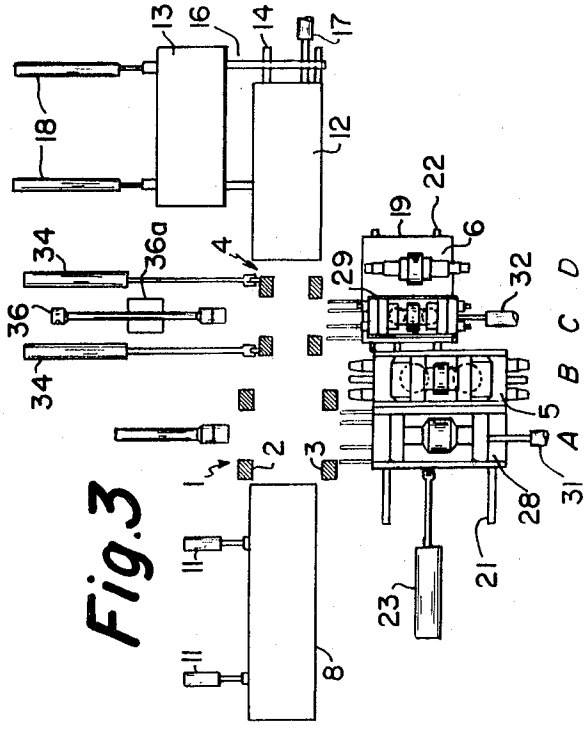


Fig. 3

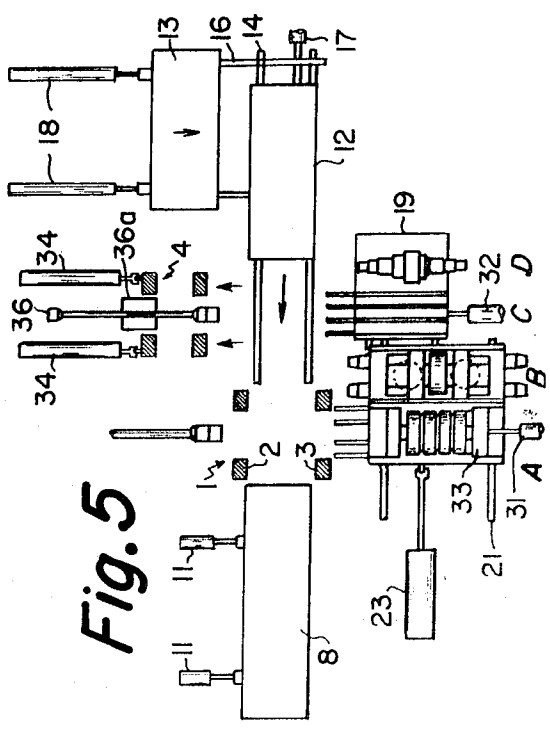


Fig. 5

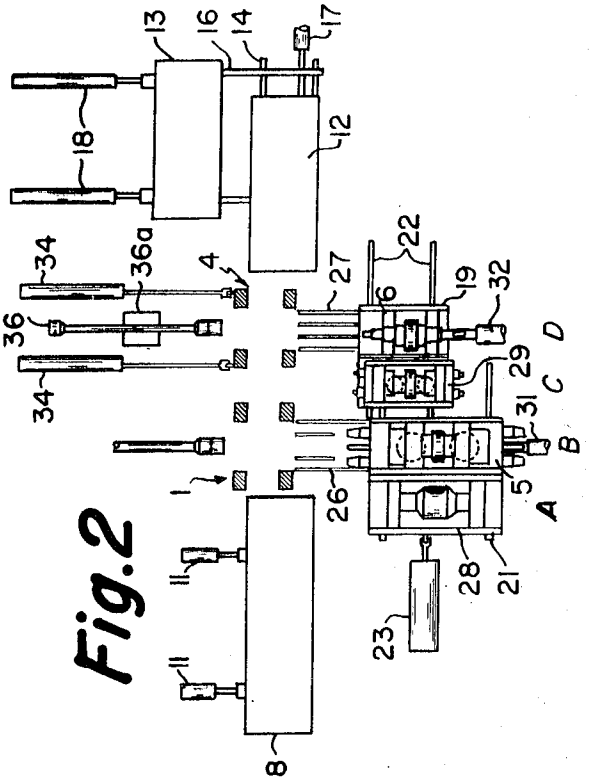


Fig. 2

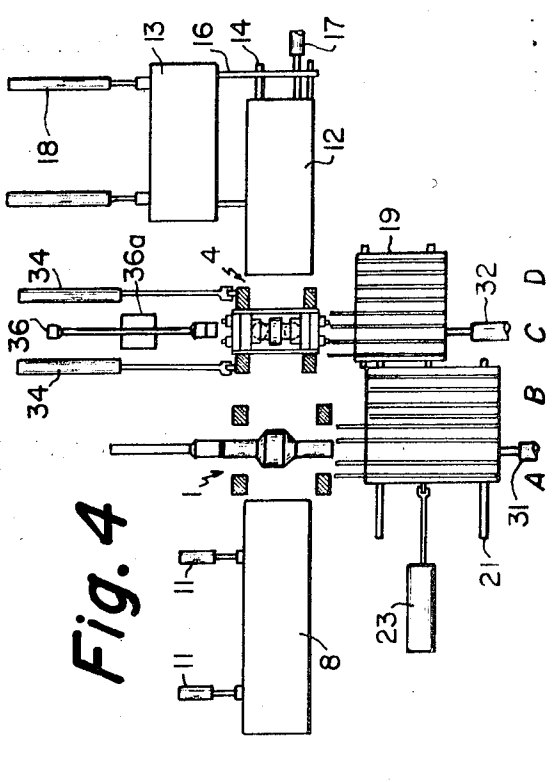


Fig. 4

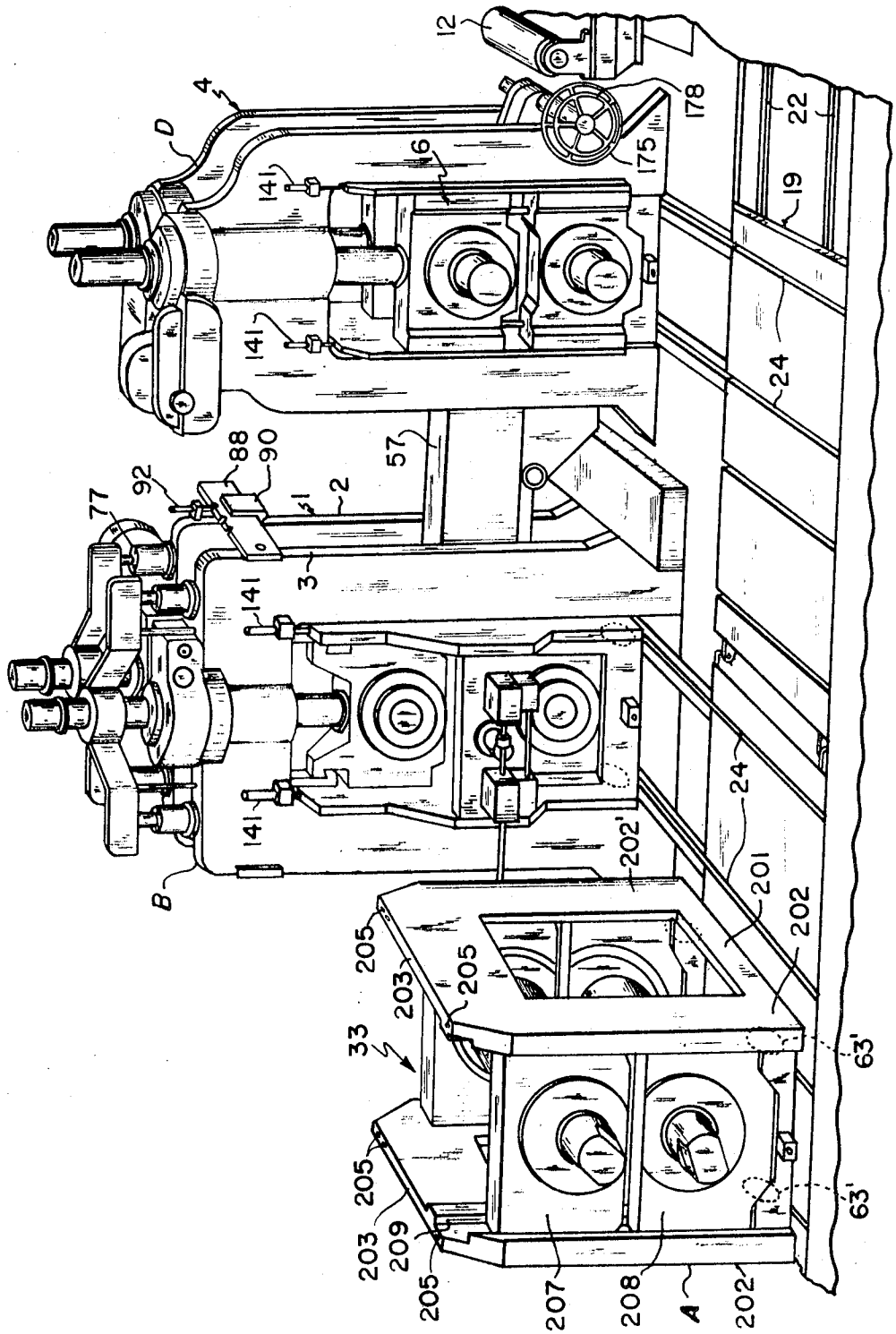

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Fig. 6

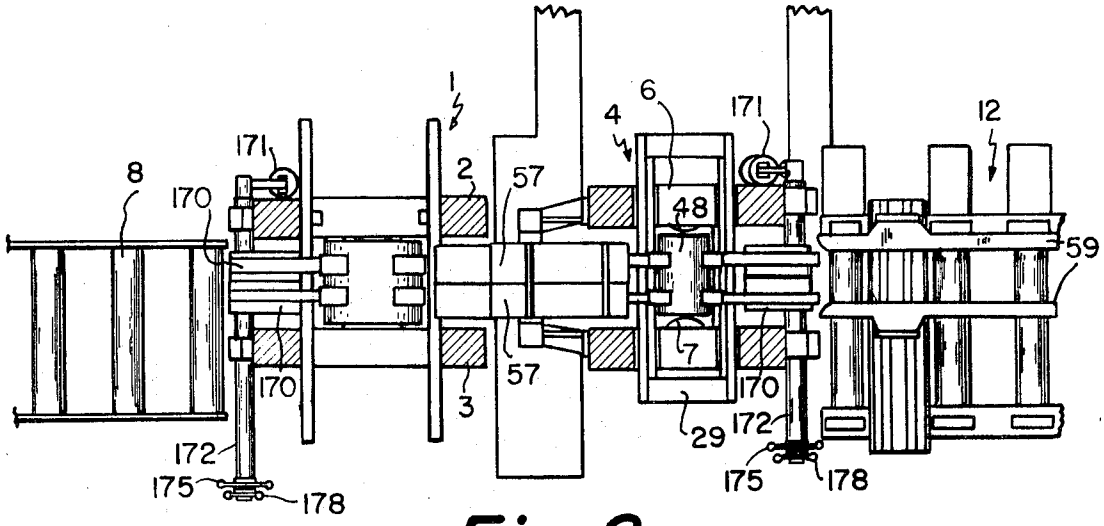

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Fig. 8

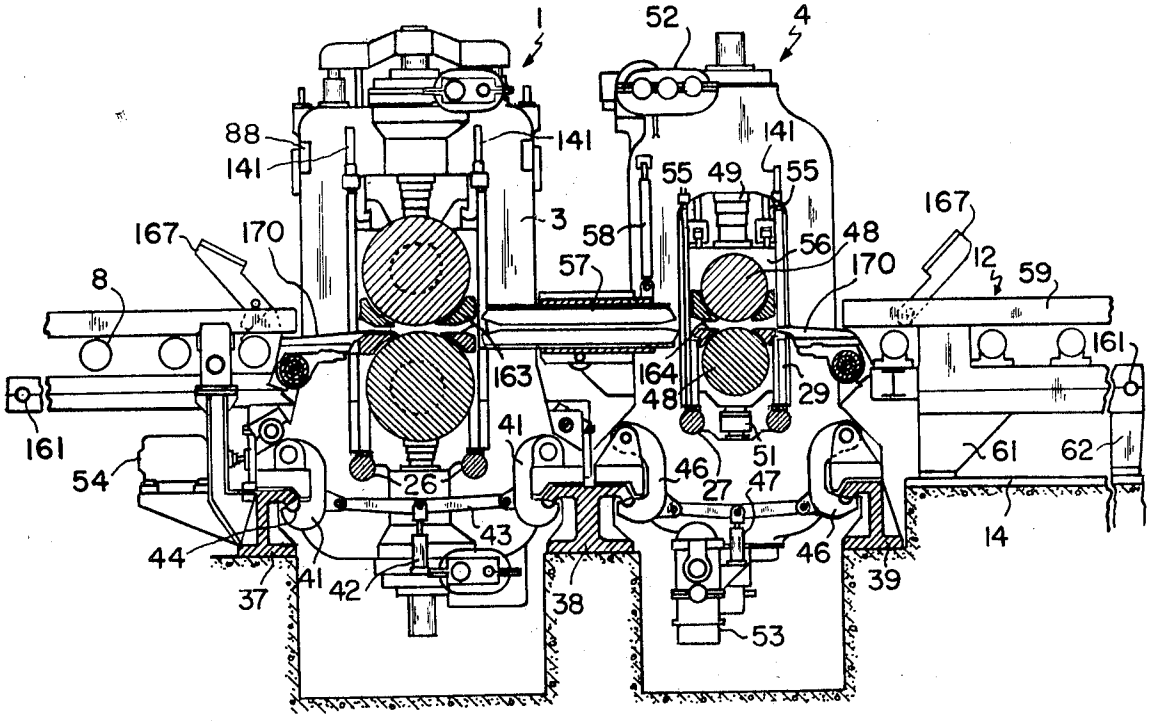

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Fig. 7

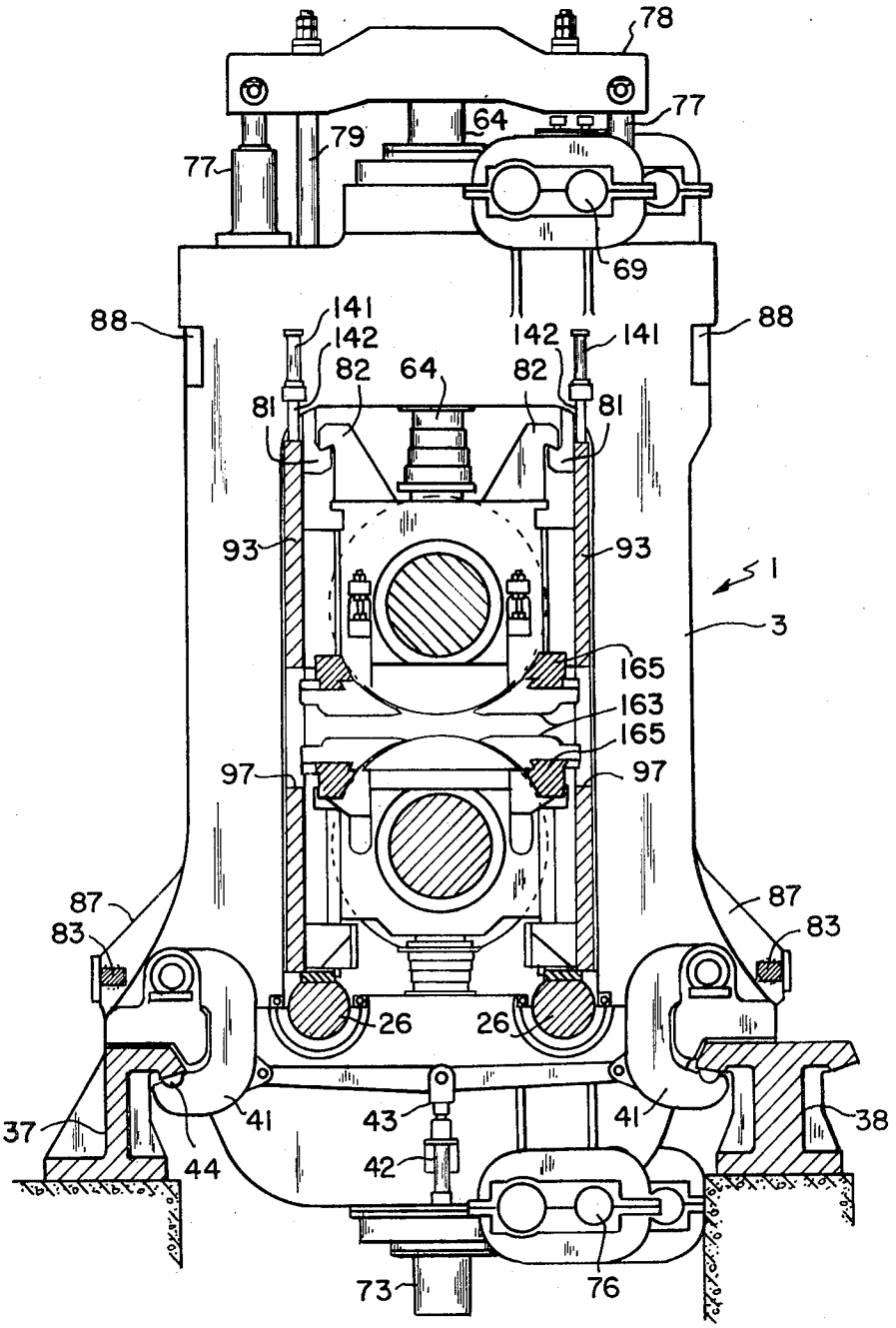

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Fig. 9

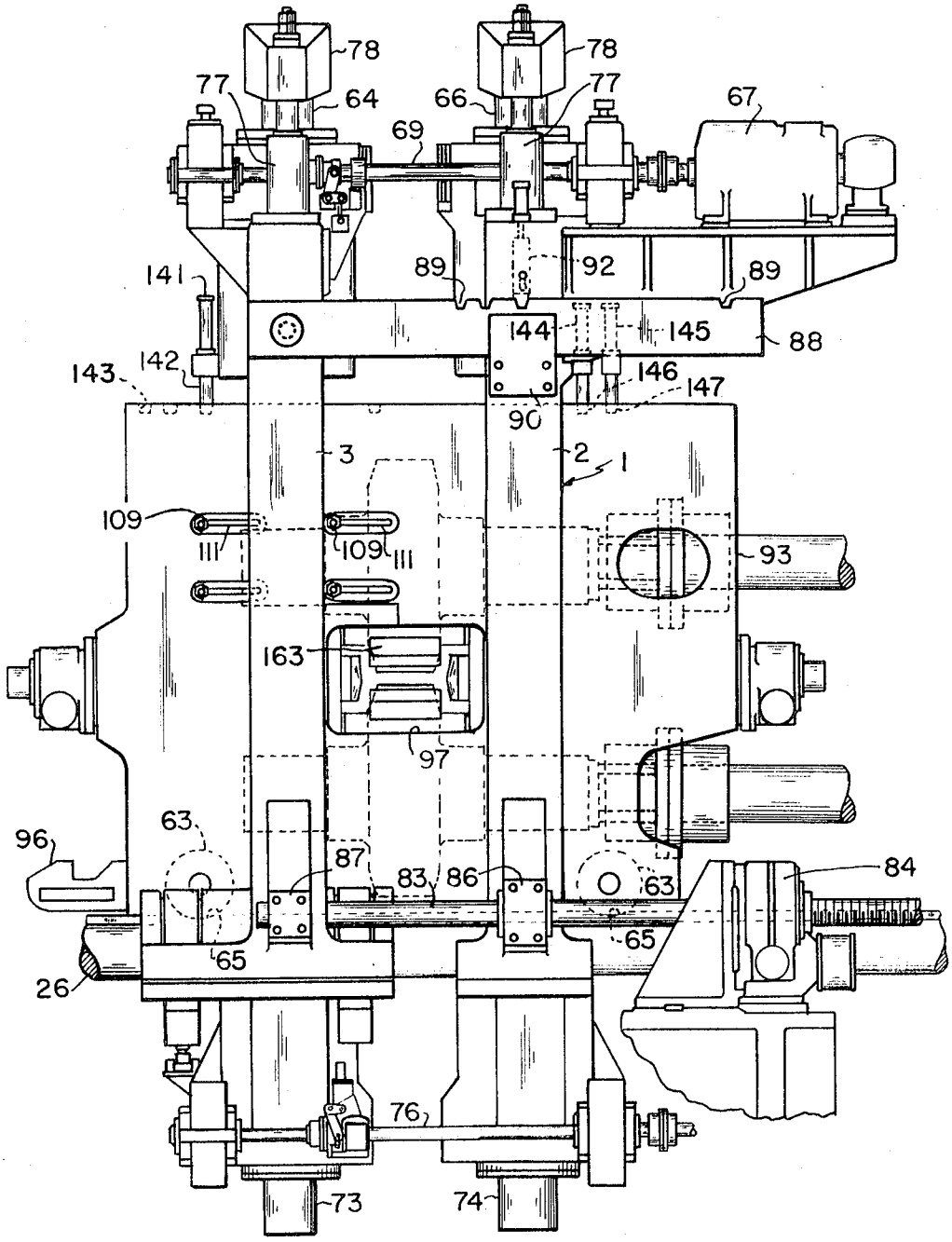

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Fig. 10

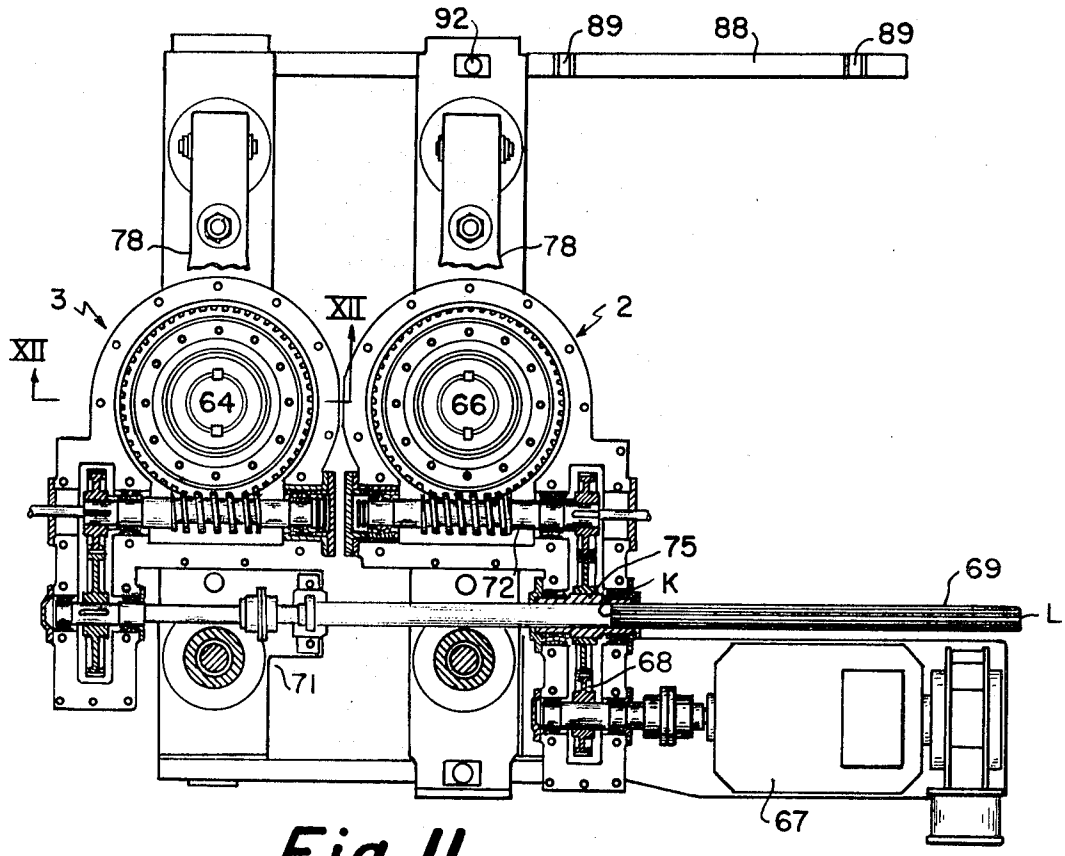


Fig. 11

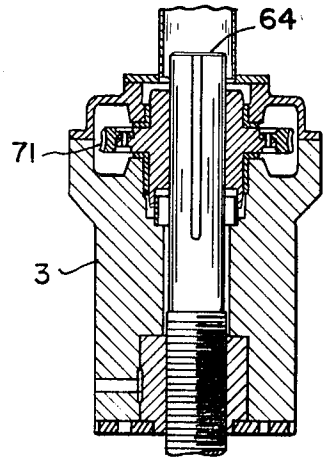
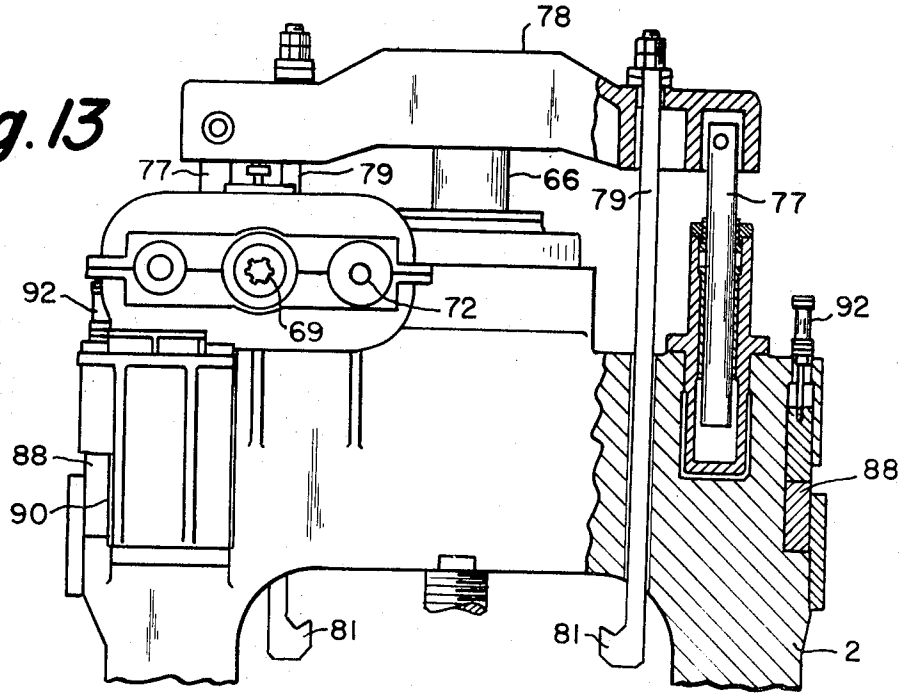


Fig. 12

Fig. 13



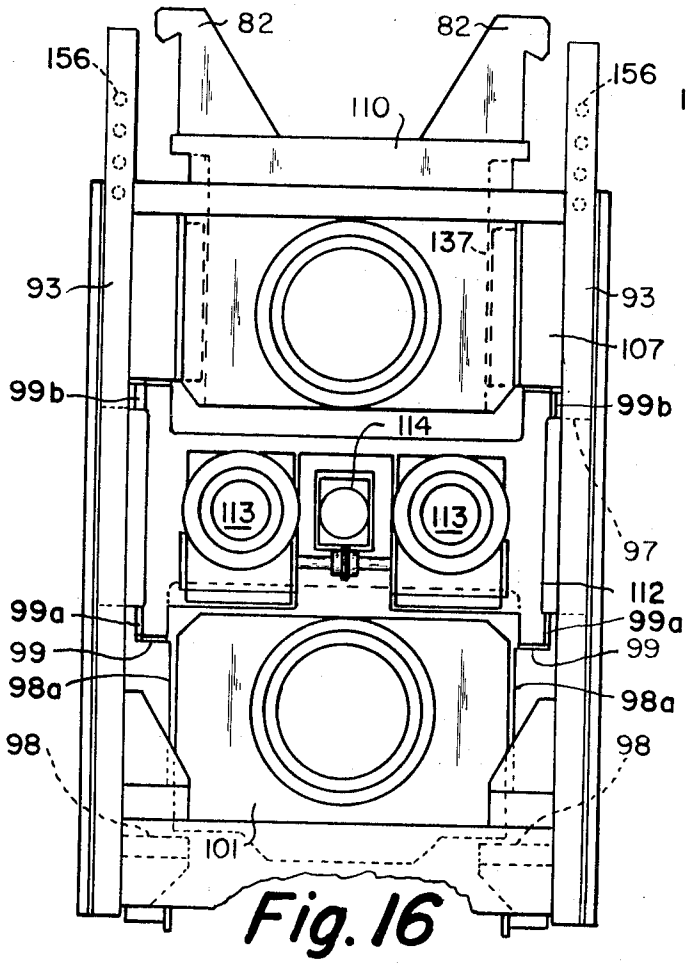


Fig. 16

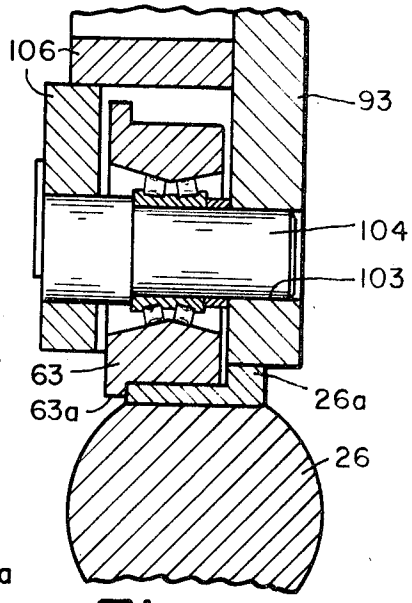


Fig. 14

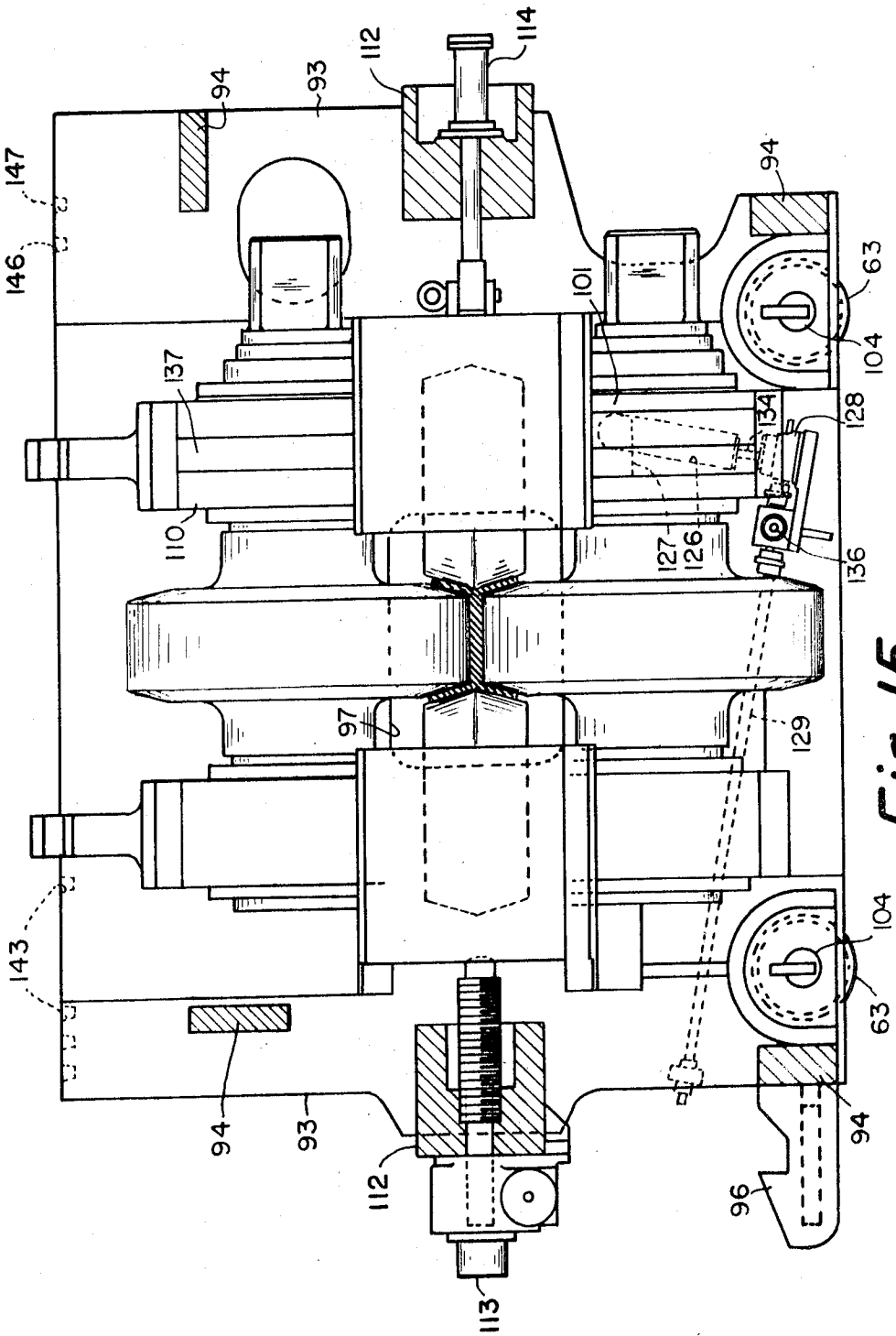

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Fig. 15

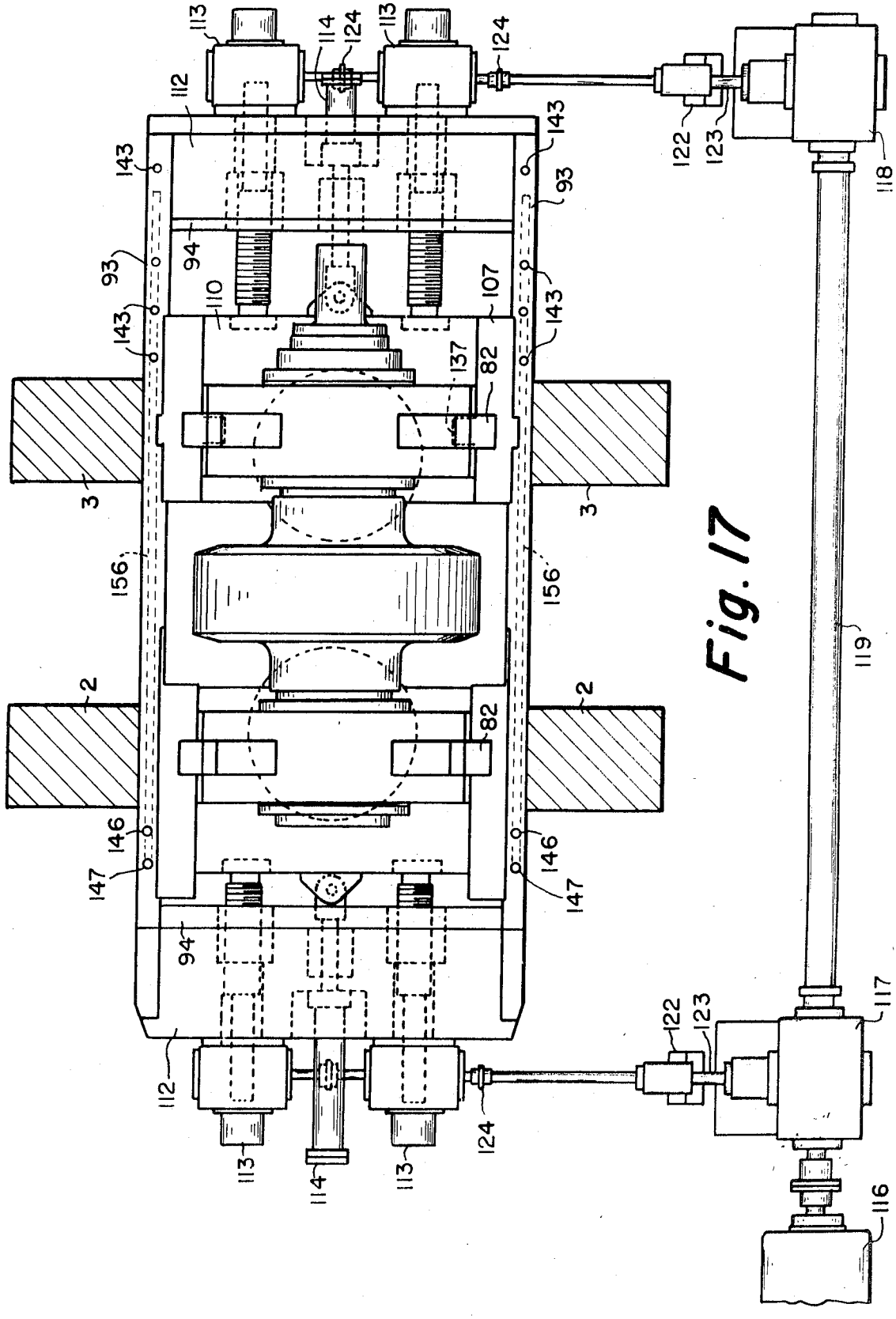

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Fig. 17

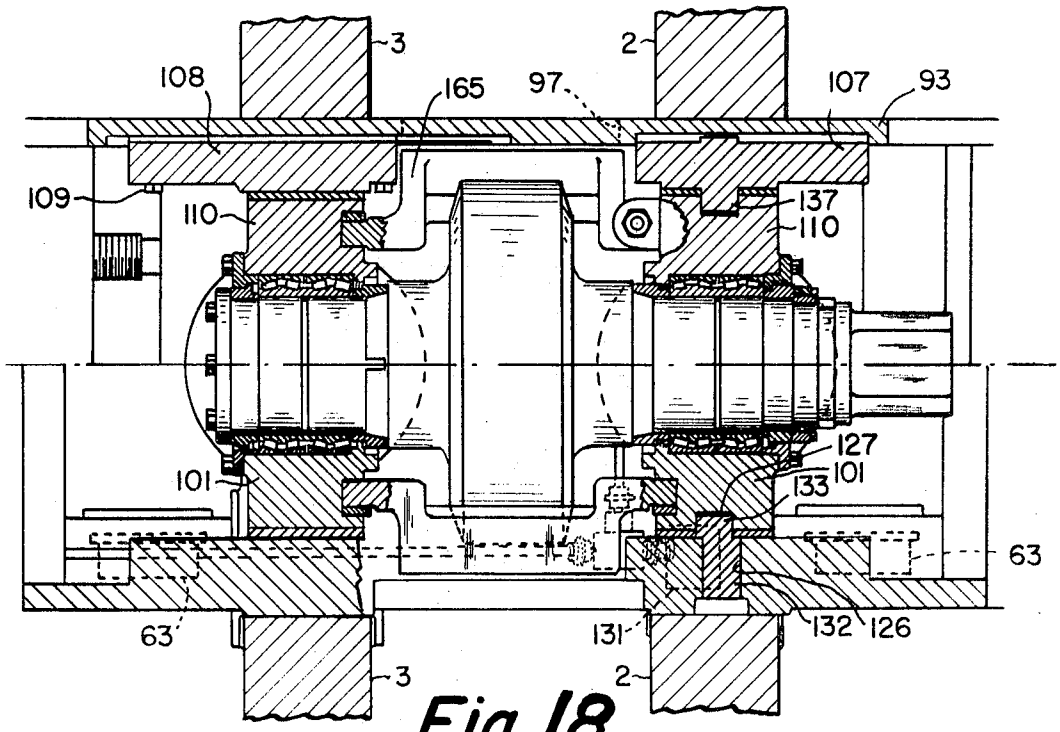

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Fig. 18

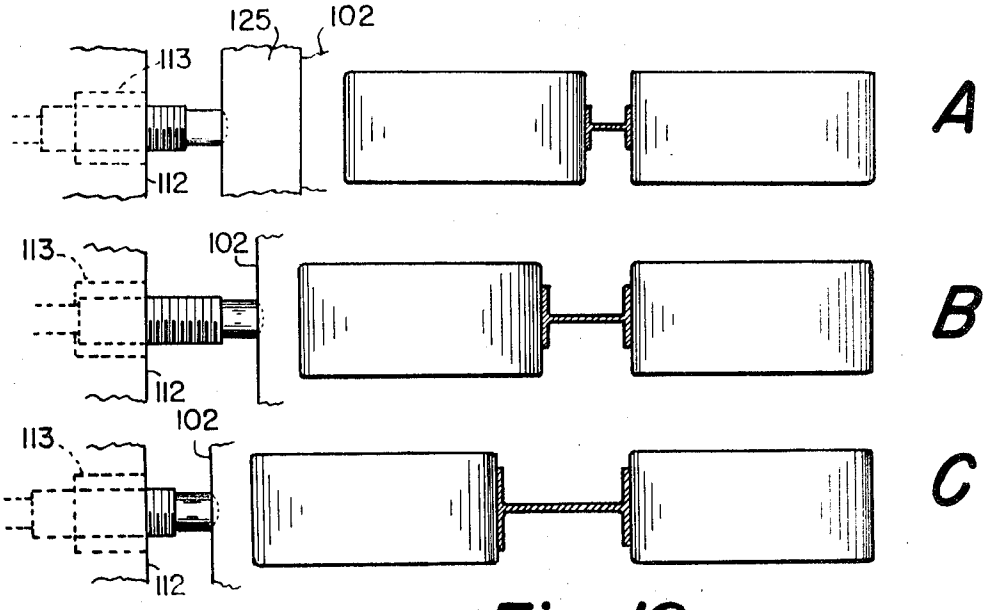

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Fig. 19

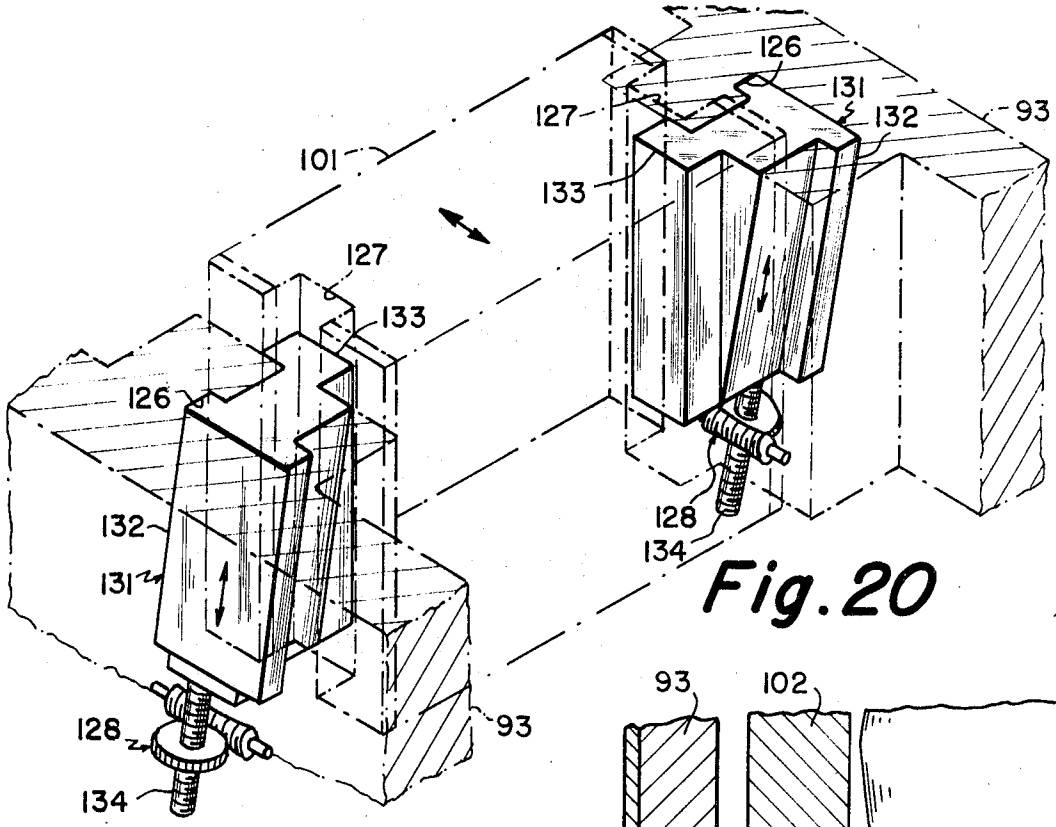


Fig. 20

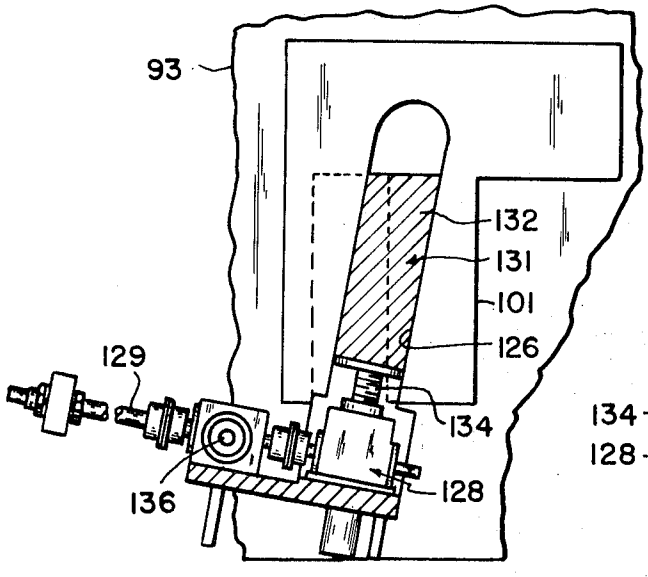


Fig. 21

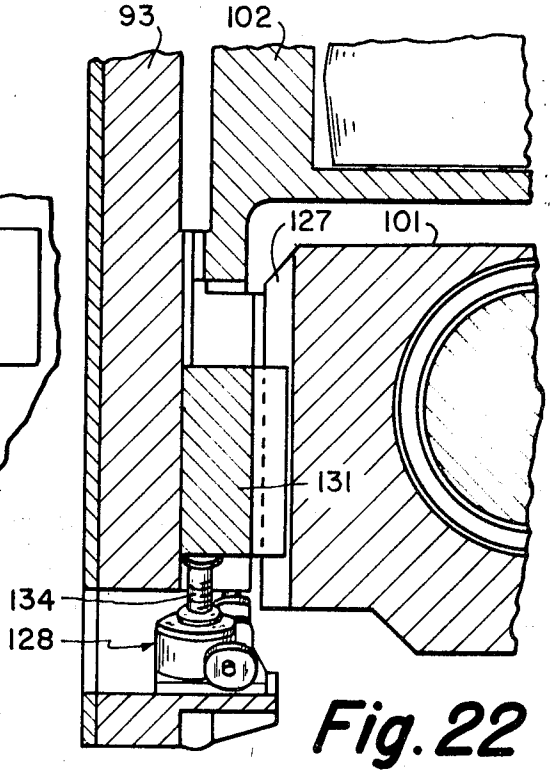


Fig. 22

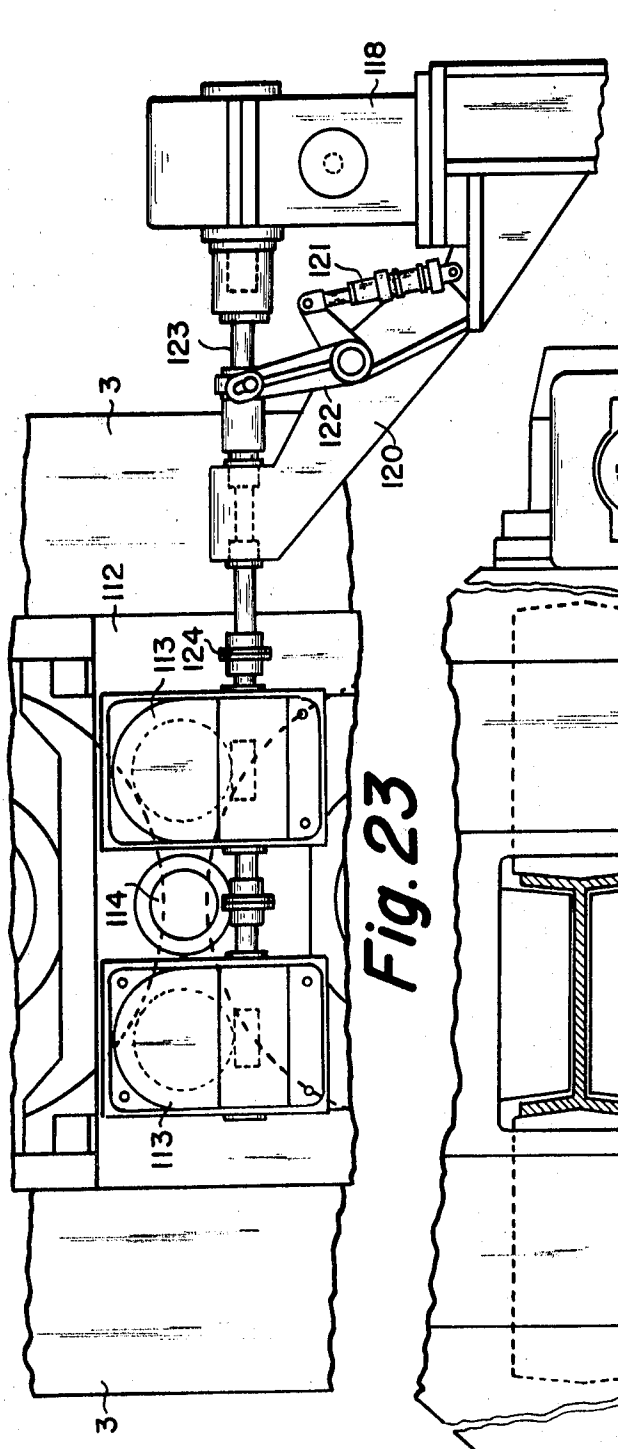

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Fig. 23

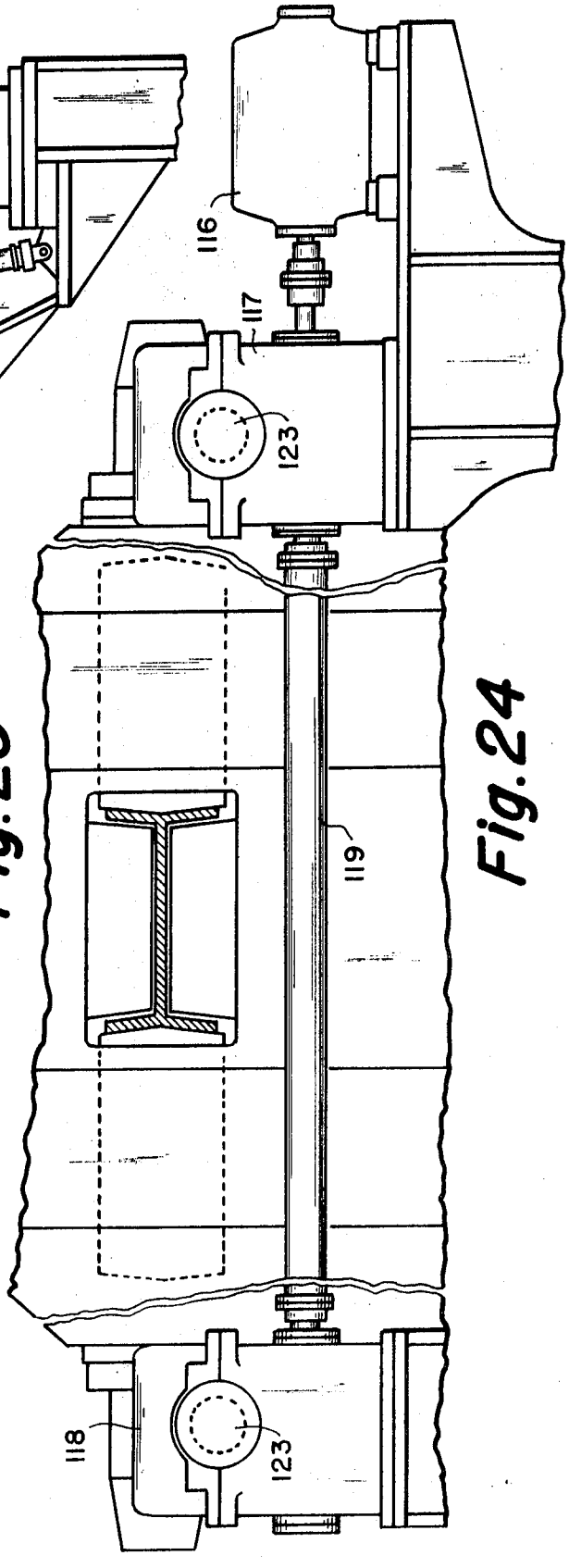

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Fig. 24

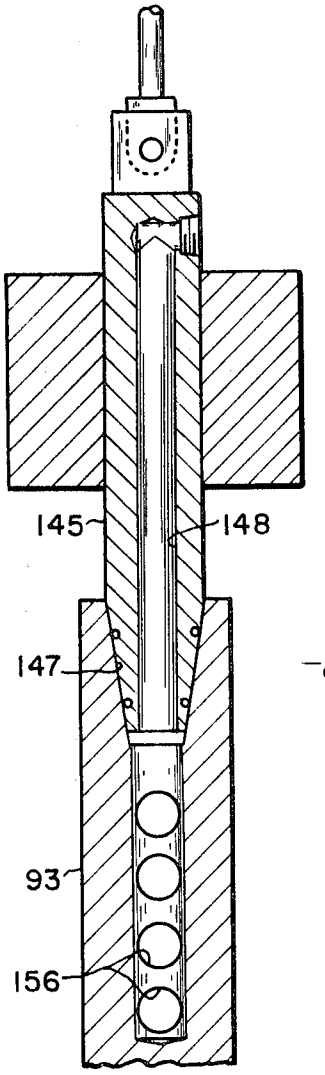


Fig. 25

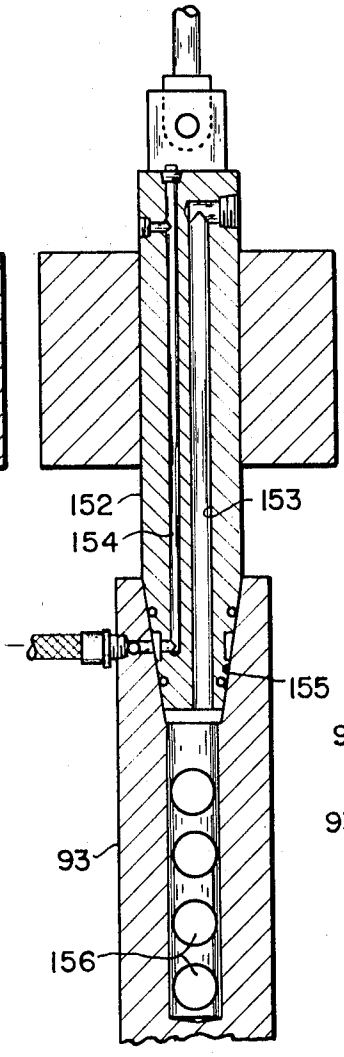


Fig. 28

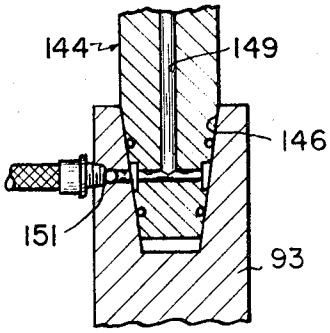


Fig. 27

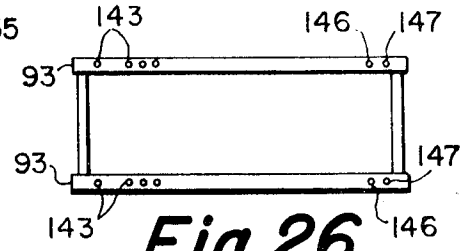


Fig. 26

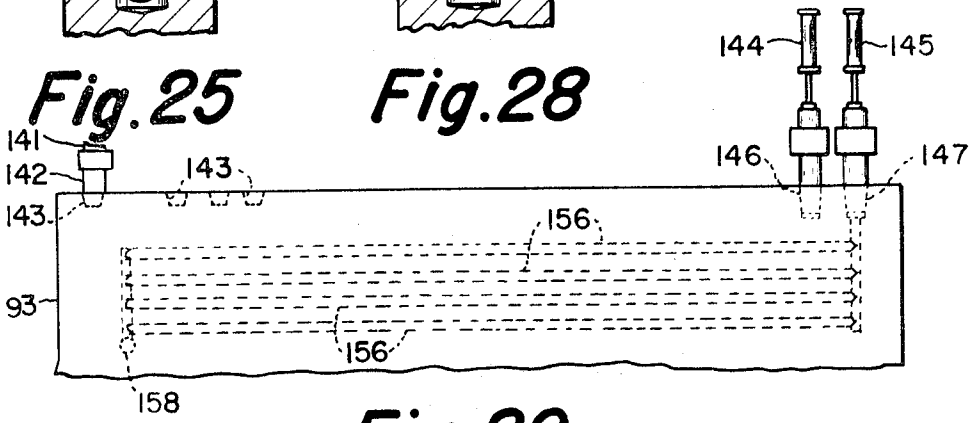


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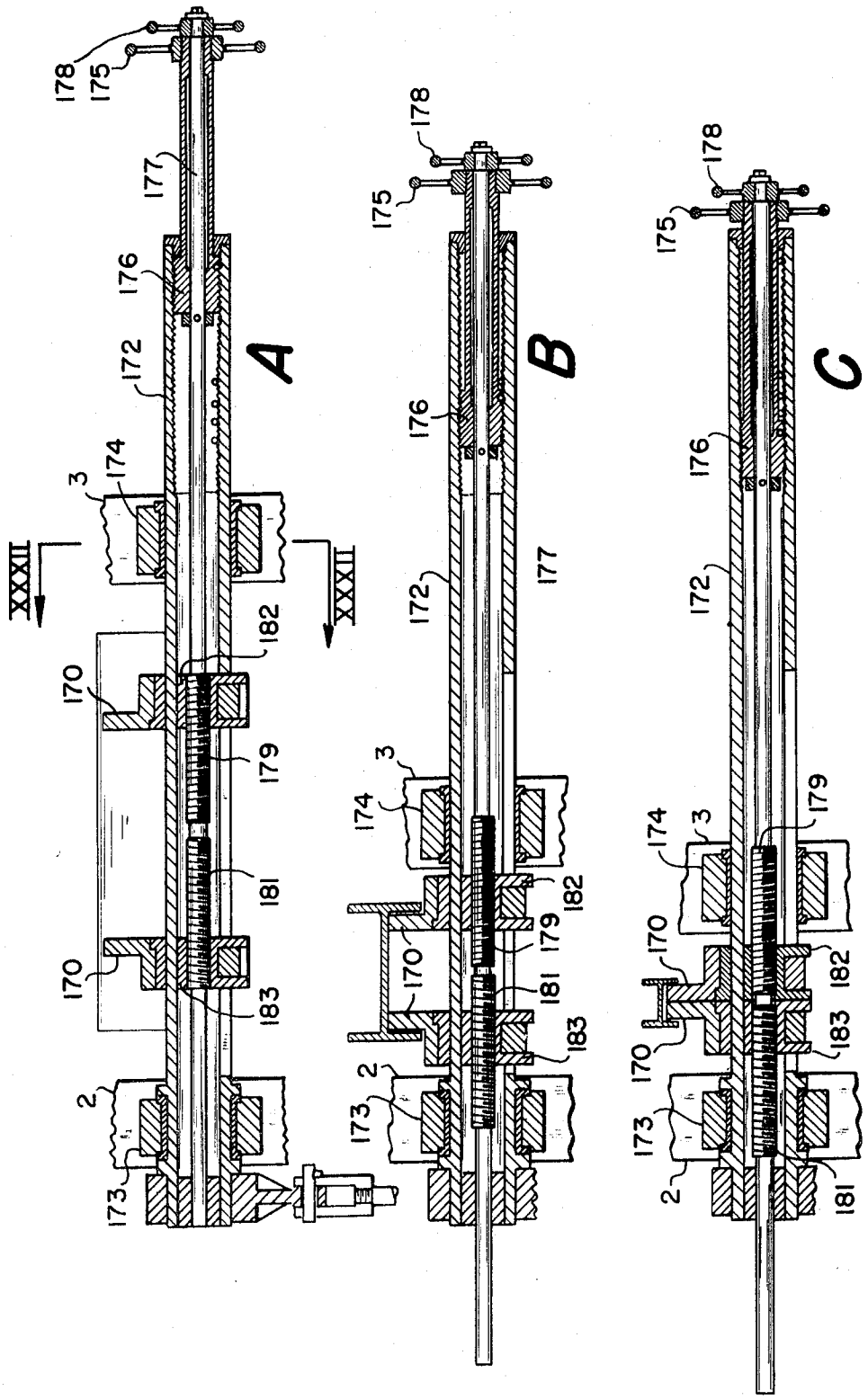

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Fig. 30

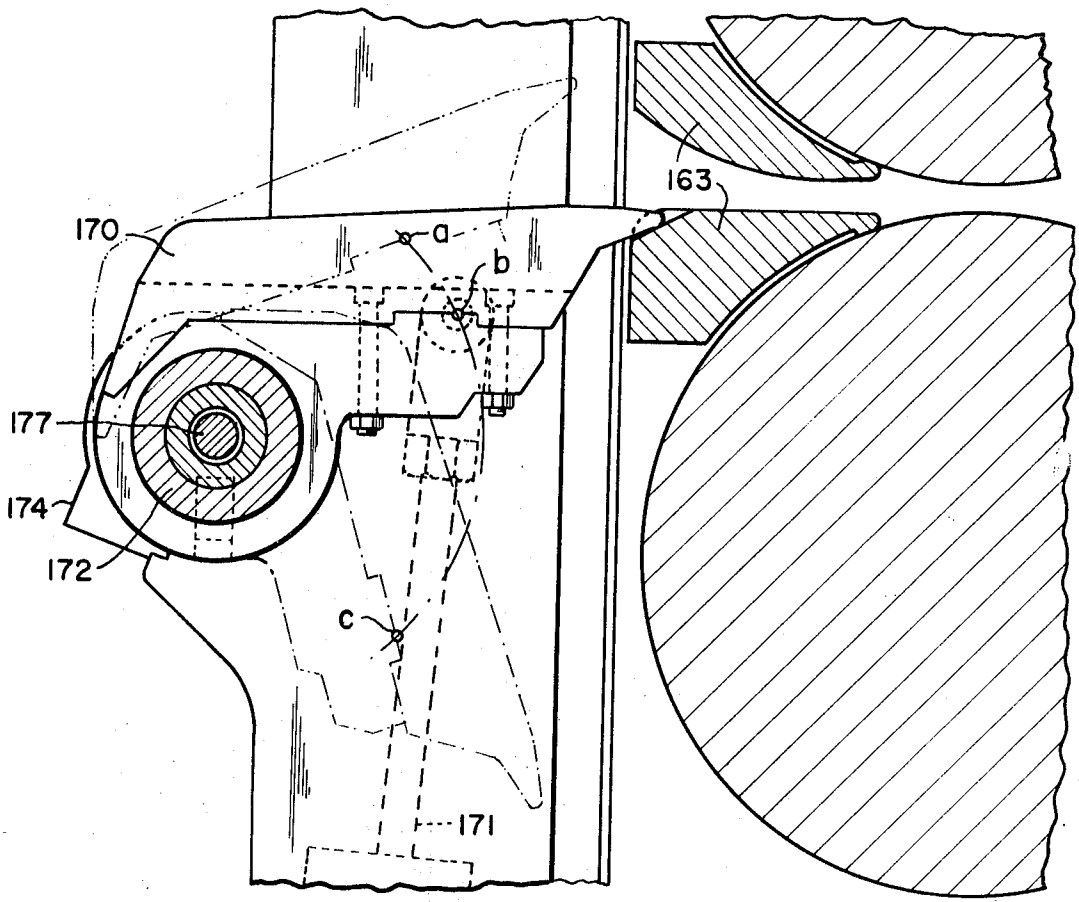


Fig. 33

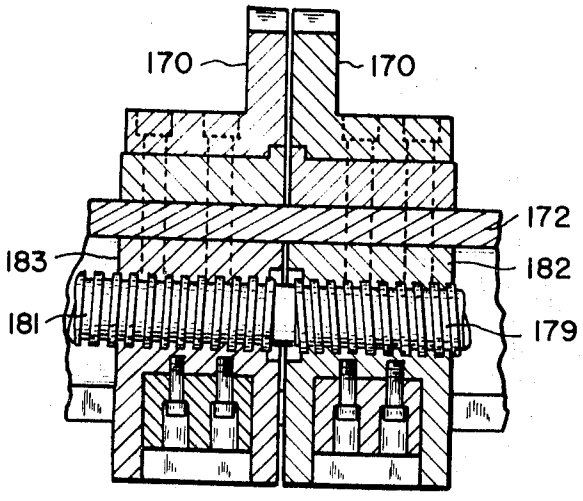


Fig. 31

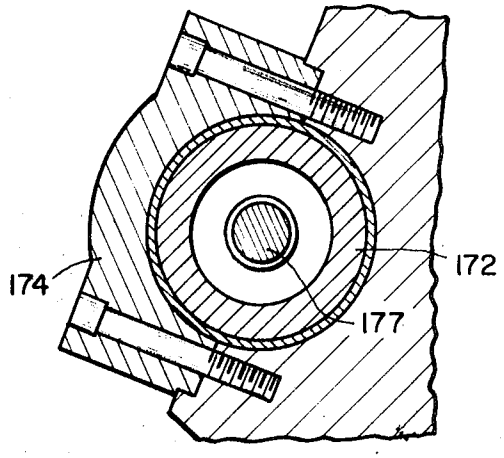


Fig. 32

COMBINATION ROLLING MILL

My invention relates to a new combination mill and, in particular, a cartridge loadable combination mill for rolling beams, structurals, or plates.

For a mill to provide a diversity of rolled products, it has been customary to convert a particular mill line from one product to another by changing either the mill stands as well as the work rolls contained therein or by providing means that make the mill adaptable to hold various different product work rolls. As an alternative to a convertible mill line, various product mill lines can be provided. However, both methods of providing a diversity of rolled products have disadvantages. In changing a line from one rolled product to another, losses in production and man hours are caused by the down time or inoperability of the mill during the conversion. To have a number of product lines requires an initially high capital outlay but overcomes the serious problem of down time losses.

I provide an improved solution to the problem of rolled product diversification without the high initial cost required for a number of product lines and without high down time requirements to convert a single mill line. I provide a cartridge loadable combination mill that is adaptable to rolling beams, structurals, or plates without costly conversion down time and with a minimum of labor required. Not only does my mill substantially reduce conversion down time, but my novel cartridge and mill arrangement reduces the work roll cost by certain size reductions in the work rolls and by the elimination of strains and undue work loads placed upon the rolls. My combination mill is adaptable to being converted automatically from one product to another in approximately 75 percent less time than is now ordinarily possible.

I provide a combination rolling mill line comprising a pair of mill stands. In rolling beams, for example, one of the stands is a universal-type mill stand and the other is an edging-type mill stand. In rolling structural products, the edging mill stand is movable out of the mill line towards the drive side; the spindles for the edging mill are positioned through the drive window to rest within the stand after the cartridge is removed. Both stands are cartridge or cartridge-like loaded with a universal-type cartridge containing a pair of horizontal and vertical rolls and the cartridge-like assembly containing a pair of horizontal rolls. In the production of both structural and plate products, the universal mill stand is loaded with a cartridge-like assembly for holding the twohigh horizontal structural and plate rolls. Production of a plate product involves the use of a universal-type cartridge in the edging mill stand as edging and pinch rolls. The universal mill stand incorporates a movable housing on the operator's side of the mill line which is positionable at preselected settings conforming to various widths of the product to be rolled. The movable housing is securely retained on the shoe plates by means of a toggle operated clamping mechanism.

The universal-cartridge and cartridge-like assemblies are supported and aligned with respect to the mill prior to insertion into the stands by means of a four station transfer table which is movable on a line parallel to the mill line. Alternative stations of the transfer table are simultaneously alignable with the mill housings for simultaneous extraction and insertion of the cartridges into and out of their respective stands. The cartridge assemblies ride on guideways that extend from the transfer means to and into the mill stands. The universal stand's guideway permits unrestricted movement of the movable housing, and the edging mill has a guideway supported between the mill housings and movable therewith. The cartridges are pushed into the mill stands from the transfer table by means of hydraulic cylinders. Great time savings are accomplished in part because the cartridges are preassembled in the work roll shop or set up area prior to conversion of the mill line and are positioned on the transfer means in a nonaligned position to await alignment after ejection of an existing cartridge or cartridge-like assembly from the mill. The cartridges have one discrete position within the mill and are secured therein by means of hydraulic cylinders.

I provide table rolls that have a width equal to the maximum width of the universal stand to accommodate all sizes of rolled products. At least two of the table roll assemblies are positioned behind the edging mill stand and are movable. One of the table roll assemblies is movable along the mill line to occupy the space left when the edging mill is moved out of the line during the production of structural products; the other one is movable into and out of the mill line to occupy the space vacated by the first table roll assembly.

Since the work roll cartridges are preassembled and adjusted prior to conversion and since their actual movement into and out of the mill stands requires very little time, the actual conversion from one rolled product to another is extremely short and a minimum down time is required. Further advantages and features of my invention will become apparent from a perusal of the following description of a presently preferred embodiment of my invention taken in connection with the accompanying drawings of which:

FIG. 1 is a diagrammatic plan view of my combination mill in position to convert from a beam to a plate product;

FIGS. 2–4 are partial sequential block diagrams of the conversion steps from a beam to a plate product;

FIG. 5 is a block diagram of one of the conversion steps from a beam or plate product to a structural product;

FIG. 6 is an isometric view of my mill in beam rolling position with a structural cartridge-like assembly prior to or after conversion;

FIG. 7 is a side elevation in partial section from the operator's side of my mill in plate rolling position;

FIG. 8 is a plan view of the mill shown in FIG. 7;

FIG. 9 is a side elevation in partial section of the movable housing of the first mill stand with a cartridge;

FIG. 10 is front elevation of the cartridge loaded first mill stand;

FIG. 11 is a plan view in partial section of the screw-down assembly of the first mill stand;

FIG. 12 is a section of the screw-down taken along line XII—XII of FIG. 11;

FIG. 13 is a side elevation and partial section of the balancing cylinder, hanging rods and notched bar of the first mill stand;

FIG. 14 is a sectional elevation of the cartridge wheel assembly;

FIG. 15 is a front side cut-away elevation, in partial section, of the cartridge for beam products;

FIG. 16 is an end elevation of the cartridge shown in FIG. 15;

FIG. 17 is a plan view of the cartridge shown in FIGS. 15 and 16 inserted in the first mill stand and screw-in drive-coupling arrangement shown in FIGS. 23 and 24;

FIG. 18 is a split section of the cartridge showing on one half the bottom work roll and chocks and on the other half the top work roll and chocks;

FIG. 19 A–B–C diagrammatically shows various size wide flanged beams between the vertical rolls and a filler block for the screw-in;

FIG. 20 is an isometric partial section of the longitudinal adjusting means for the lower work roll;

FIG. 21 is a front section of the adjusting means shown in FIG. 20;

FIG. 22 is an end section of the adjusting means shown in FIGS. 20 and 21;

FIGS. 23 and 24 show the vertical screw-in drive-clutch means;

FIG. 25 is a section of the cooling fluid coupling means;

FIG. 26 is a diagrammatic view of the top cartridge sidewalls showing the bores for rapid coupling means;

FIG. 27 is a section of a grease/or oil rapid coupling means;

FIG. 28 is a section of a combination cooling fluid and oil or grease rapid coupling means;

FIG. 29 is a partial front elevation of the cartridge sidewalls showing the cooling passageways and rapid service coupling means;

FIG. 30 A,B,C are sections of the cross-over/carryover guide adjusting means at various center lines for differing rolled products;

FIG. 31 is a section of the opposing threaded means for positioning the spacing between the guides;

FIG. 32 is a section of the guide adjusting means mounting member and sleeve; and

FIG. 33 shows the guide in various positions for rolling, roll changing, and out of the line.

Referring to FIG. 1, I have shown my combination mill in beam rolling position just prior to a change over to a plate product. The combination mill includes a universal mill stand 1 having a fixed housing 2 on the drive side of the mill line and a movable housing 3 on the operator's side of the mill line. The combination mill also includes an edging mill stand 4 having housings fixed in relation to each other. Universal mill stand 1 is designed to hold a universal-type cartridge 5 (more fully described hereinafter) that includes a pair of horizontal and vertical rolls. Edging mill stand 4 includes a cartridge-like assembly 6 containing a pair of edging rolls 7.

My mill line includes table roll assembly 8 positioned in front of universal mill stand 1 and having adjustable sideguards 10 movable by means of hydraulic cylinders 11 to coordinate the center line of the tables with the product being rolled as well as the movable housing 3. Table roll assemblies 12 and 13, behind mill stands 1 and 4, are movable along tracks 14 and 16 by means of hydraulic cylinders 17 and 18 respectively. Tracks 14 are flanged or channeled so as to cooperatively retain the table supports that ride within the channel. Table roll assemblies 8, 12 and 13 are, preferably, as wide as the widest separation between housings 2 and 3 of stand 1. To accommodate various roll products, the product center line moves across the table as stand 1 is increased in size to accommodate increasingly larger rolled products.

A cartridge transfer means 19 is positioned to move in a line parallel to the mill line. Transfer means 19 has four tracked stations, A–D; alternative stations, A and C, and B and D, are simultaneously alignable with the housing windows in stands 1 and 4. Transfer means 19 rides in a pair of parallel guideways 21 and 22, and is moved by hydraulic cylinder 23, which is shown in its fully retracted position in FIG. 1. As shown in FIG. 1, stations B and D are aligned with the windows in stands 1 and 4 respectively. When cylinder 23 is actuated and fully extended, stations A and C are aligned with housing 1 and 4 respectively. Each station includes a set of tracks 24 that are alignable with tracks 26 and 27 of the respective mill stands 1 and 4, and which extend over cylinder 31 and 32 and lead to the roll shop or set up area.

Prior to converting the combination mill from one rolled product to another, replacement or conversion roll assemblies in the form of a cartridge are placed on the "ready" position of transfer means 19. The universal-type cartridge and cartridge-like assemblies are made up in the roll shop including the replacement of all chocks, rest bars and guides, internal hydraulic, lubrication, and cooling connections and alignment of the work rolls. The cartridge is then moved from the work shop area to the transfer means by utilizing either an overhead crane or by rolling it on its wheels. Building up the cartridge and aligning its work rolls in the work shop area as well as transporting it from the work shop area to the transfer means next to the mill line is accomplished without shutting down the mill line. For example, positioned on station A is a previously assembled cartridge-like assembly 28 containing two horizontal rolls for rolling a desired plate product. Positioned on station C is cartridge 29 which is the same as cartridge 5 except that it is of a somewhat smaller size. Both of these cartridges are placed in their respective mills for rolling a plate product.

FIGS. 2 through 4 diagrammatically show the steps involved in converting from a beam-type product to a rolled plate product. Generally, the first step involves the removal of beam cartridge 5 from stand 1 by means of hydraulic cylinder 31, which is positioned under the tracks leading from the transfer means to the roll shop, and which is connectable to the cartridge by a hook latching means. Cartridge 5 is pulled along tracks 26 and 24 and placed on station B of transfer means 19. Simultaneously therewith, the edging roll cartridge-like assembly 6 is withdrawn from stand 4 along tracks 27 and 24 and positioned on station D of transfer means 19 by means of hydraulic cylinder 32, which is also positioned beneath the tracks to the roll shop. Hydraulic cylinder 23 is then fully extended to position transfer means 19 to a second position to align stations A and C with the windows in stand 1 and 4 respectively. Simultaneously with the movement of the transfer means 19, housing 3 of stand 1 is moved from one of its narrower beam rolling positions to a wider plate rolling position. In order to reduce stand deflection, the mill housing separation is kept to the minimum width consistent with the product width rolled. Cartridge-like assembly 28, containing horizontal plate rolls and cartridge 29 containing pinch rolls and vertical edging rolls, are pushed into stands 1 and 4 by hydraulic cylinders 31 and 32 respectively. Hydraulic clamping means securely position the cartridges within the stand and at the same time function as utility service connections for a hydraulic fluid, oil or grease, and water for cooling. Hydraulic balancing means both horizontal and vertical as well as the screw-downs and screw-ups are positioned and adjusted. After these fittings have been made and the table roll side guards adjusted for the width of the product to be rolled, and the crossover guides adjusted, the mill is ready for production of plate. At a convenient time, cartridges 5 and 6 are taken back to the roll shop for either a partial or a complete interchange of newly dressed work rolls. Transfer means 19 is then placed in its ready position by retraction of hydraulic cylinder 23. Essentially the same procedure would be utilized from one size of beam to another, except that different sized rolls would be contained in the cartridges rather than types.

Converting from either a plate or a beam-type rolled product to a structural product involves the same procedure as described above, except that: First, the previously prepared cartridge-like assembly containing the horizontal structural rolls 33, FIGS. 5 and 6, is positioned on station A of transfer means 19. The cartridges of stands 1 and 4 are removed by hydraulic cylinders 31 and 32 respectively and positioned on stations B and D of transfer means 19. After extraction of the cartridges from the mill stands, mill stand 1 is widened by moving housing 3. As shown in FIG. 5, the combination mill is converted from a beam product having a narrow setting which requires that the mill stand be widened. Mill stand 4 is not necessary and is, therefore, moved out of the mill line by hydraulic cylinders 34. Mill stand 4 rides on its shoe plates in a manner similar to that of housing 3 of mill stand 1. Spindles 36 for driving the plate and beam rolls of stand 4 are supported by support 36a which is positioned between the mill stand and the motor (not shown). Spindles 36 enter the drive side of the housing window of stand 4 as it is moved from the mill line to the drive side. Table roll assembly 12 is moved along rails 14 and positioned in the space vacated by stand 4 by hydraulic cylinders 17. The full extension of cylinder 17 pushes table 12 and securely holds it in position. Hydraulic cylinders 18 are then fully extended to push filler roll table assembly 13 into a position vacated by table rolls 12.

Simultaneously with these operations, and after the positioning of housing 3, transfer means 19 is positioned to align the structural work rolls contained in cartridge-like assembly 33 with the window in housing 3 of stand 1. Assembly 33 is then inserted into the mill and the necessary connections and adjustments are made and the mill is ready for operation. A reverse operation of that heretofore described will convert the structural back to a plate or beam product.

When my combination mill has been arranged to roll a plate product, the edging mill stand is transformed into a small universal-type of mill by the use of cartridge 29 FIG. 7. Since stand 1 is connected to a larger drive or power unit, it carries out the primary reduction.

Stand 4, on the other hand, is generally connected to a smaller drive unit and is utilized as an edging mill with the

horizontal rolls acting as pinch rolls for the nondriven vertical edging rolls. Since edging forces on small to medium sized plate or strip are small, the pinch roll power is considered sufficient to do the driving work. Eventual marking on the plate or strip by the somewhat narrower-than-plate pinch rolls is flattened out by rolling the last pass through only the reduction rolls of stand **1**.

Referring to FIGS. **7** through **10**, stand **1** is supported on shoe plates **37** and **38**, and stand **4** is supported by shoe plates **38** and **39**, all of which are securely fastened or mounted to the foundation of the mill. Shoe plate **38** is designed to support one half of each of stands **1** and **4** to keep the distance between the stands to a practical working minimum. Stand **1** includes a movable housing **3** which is secured to shoe plates **37** and **38** by a pair of clamping means **41**, and a fixed housing **2** permanently bolted to the plates. Clamping means **41** is operated by means of hydraulic cylinder **42** connected at toggle joint arm **43**. The jaws of clamp **41** rigidly hold housing **3** to shoe plates **37** and **38**. The toggle joint arms **43** in combination with the retracted position of the cylinder **42** maintain a fail safe clamping means to prevent the mill house from separating during rolling in the case of a hydraulic or other type of power failure. Self aligning pads **44** provide excellent contact with the shoe plates for maximum clamping of the housing. Mill housing **2** is fixed and is used to position the mill equipment, such as the cartridge, to the center of the mill line. It, therefore, must be securely anchored to the shoe plates or foundation.

Mill stand **4** includes a pair of mill housings that are not movable relative to each other. However, the mill stand must be movable along shoe plates **38** and **39** when the line is converted to a structural product. Stand **4** is movable along the plates into and out of the mill line by hydraulic cylinders **34**. Stand **4** is aligned and secured to the shoe plates by the full extension of cylinder **34** and clamping means **46**. Clamping means **46** includes the same arrangement as that used in stand **1**, including a pair of jaws and toggle joint arm actuated by hydraulic cylinder **47**. Within stand **4** are a pair of rails **27** for carrying and supporting cartridge **29** which contains horizontal rolls **48** and vertical edging rolls. A pair of screw-downs **49** and screw-ups **51** operated by the respective drive assemblies **52** and **53** provide the mill stand **4** with accurate roll adjustment for rolling both plate and beam products. The stand is also provided with hydraulic balancing cylinders (not shown) and hanging rods **55** to relieve any slack between the screw-downs and the upper chocks **56** of roll **48**. Stand **4** includes a set of crossover guides **57** which can be pivoted by hydraulic cylinder **58** attached to the mill housing to free the guides from stand **1** when stand **4** is moved from the mill line. A pair of guides **170** are mounted to stands **1** and **4**. These guides can be rendered ineffective for structural rolling and replaced by carryover guides **167** mounted to the table roll assemblies. Guides **170** are quickly adjustable both as to width and center line when changing beam widths or plate products. The adjustment can be either manually or motor actuated, and either center line or width can be changed without disturbing the other setting. Accordingly, there is no need for laborious inserting, bolting or wedging down any guides after new rolls have been inserted into the mills. The stripper guides **163** and **164** are premounted on the chocks or cartridge in a set up area prior to mill conversion. Set at the proper width, the housing mounted guides **170** and **57** serve as a continuation of chock or cartridge mounted stripper guides **163** and **164**. Because of unique operation of our guide arrangement, this aspect of mill changeover is dramatically reduced.

Table rolls **12** include adjustable side guards **59** and at least 3 supports, two of which, **61** and **62**, are spaced apart a distance equal to the separation between shoe plates **38** and **39** upon which they rest when table **12** is moved into the space vacated by stand **4** during the rolling of the structural product. Supports for table **12** are interlocked with flanges on rail **14** to prevent the tables from pivoting when it is extended across the shoe plates. The table roll assemblies also are pivotable about points **161** between the upper and lower portions of the table and are actuated by wedges, etc., not shown. The tables are tiltable a few degrees to make up for the differences in flange height of various products.

Referring to FIGS. **9–13**, mill stand **1** includes a set of rails **26** extending the width of the stand. Rails **26** are preferably made of a solid rod having on its top a flattened portion along which the wheels **63** (FIG. **14**) ride. Rails **26** are preferably of a shaft design to provide better weight distribution and minimize stress concentration in the mill stand. The stop position for the cartridge when inserted into the mill housing are small depressions **65** into which wheels **63** drop so that the entire unit rests on the sides of the cartridge.

Mill stand **1** includes a pair of screw-downs **64** and **66** which are driven by motor **67**. Motor **67** is operably connected to the screw-downs through drive gear **68** and drive shaft **69**. Drive shaft **69** is splined from K to L a length, preferably, at least equal to the width of the widest separation of mill housings **2** and **3**. Shaft **69** is fixedly mounted to housing **3** and in gear train drive with gear and support unit **71** and slidably mounted through gear means **75**. Gear means **75** is adapted to a gear train relation with shaft **69** through its length K through L and in gear train drive with gear **68** and gear train **72** which is operably connected to screw-down **66**. Screw-down **64** is operably connected through gear and support unit **71**. Shaft **69** is slidably moved through gear means **75** when housing **3** is moved. Because the splined portion of the shaft is maintained in gear train relation with gear means **75**, screw-downs **64** and **66** are always mechanically synchronized through the various positions of housing **3**. A pair of screw-ups **73** and **74** are provided for the lower work roll chocks which are of the same configuration and operation as screw-downs **64** and **66** respectively. Synchronizing power shaft **76** includes a portion splined the same manner as synchronizing power shaft **69** for the screw-downs which operates in the same way when the housing is moved. The motors for operating both the screw-downs and screw-ups are electrically synchronized.

Mill stand **1** also includes a pair of hydraulic balancing units each having a pair of hydraulic cylinders **77** connected together by balancing arms **78** from which depend a pair of hanging rods **79** having at their bottom portions jaws **81** that coact with the upper chock legs **82** of the horizontal rolls.

Housing **3** is moved along the shoe plates by means of a pair of motor driven shafts **83** mounted on both sides of the housing. Both shafts are driven by the same power unit **54** (FIG. **7**) and are connected and driven through a hollow shaft speed reducer **84**. Shaft **83** is movable through and supported by support unit **86** mounted at the base of housing **2**. Shaft **83** is secured to the movable housing **3** by support member **87**. The shaft **83** is free to rotate within member **87** so that shaft **83** may be screwed through unit **84** to provide the translatory motion required to move housing **3**. At the upper portion of the mill stand and spanning the two housings are a pair of notched bars **88** having a plurality of notches **89**. Each bar **88** is securely positioned and mounted to movable housing **3** and is adapted to slide through guideway **90** mounted on housing **2**. To add stability and rigidity to the upper portion of mill stand **1** a pair of hydraulically actuated cylinders **92** attached to either side of the upper part of mill housing **2** are engageable in notches **89**. Each notch represents a preselected mill width for rolling a preselected or predetermined size of rolled product. For example, the notch representing the widest separation between housings **2** and **3** could be utilized in the production of structurals. The narrowest, on the other hand, may be used for a 6 to 12 inch wide flange beam.

My mill is uniquely adapted to quick roll change from one size product to another or to different products without costly down time because the most laborious tasks can be done while the mill is operating. In the past, conversion from one product to another or to a different sized product required excessive down time because of work roll changeover. With my mill almost all of the changeover is done prior to shutting down the mill. I have been able to accomplish this with a unique car-

tridge or cartridge-like assembly which contains the work rolls.

The cartridge and cartridge-like assemblies are pre-assembled in the roll shop or set up area prior to the time when they would be needed. The cartridge as made up, with the work rolls in substantial adjustment, stripper guides in place, hydraulic and cooling connections made, is rolled or carried to the transfer means to await insertion into the mill stand.

Cartridges **5** and **29** are essentially self-contained and comprise a pair of sidewalls and yokes with positioning members for initially supporting the work roll chocks. The cartridges include a pair of horizontal work rolls and a pair of vertical work rolls. All internal cooling hydraulic and grease connections are made in the set up area and are connected to distribution points on the cartridge. Essentially all that remains to be done after preassembly to make the cartridge "operational" is to insert it into the mill, connect the rolls to the spindles, engage the screw-downs and -ups, make the proper service utility connections and adjust the pass line setting. Many of these steps are accomplished simultaneously and as with the guide adjustments including carry-over guides, and table roll assembly sideguards, the entire changeover is adapted to an automated operation.

Referring to FIGS. **15** through **22**, our cartridge comprises a pair of sidewalls **93** that extend substantially the length of the horizontal rolls and their necks and have a height which is preferably just less than the height of the mill housing windows. The sidewalls are preferably made of a relatively heavy gauge plate and are provided with a universal pass window **97**. The window is sized so that any type of beam size will pass through and is positioned to have its center line on the center line of the pass line. The window of smaller cartridge **29**, used in the edging mill stand for the rolling of a plate or strip product is, preferably, a relatively larger window than cartridge **5** in order to accommodate the wider product.

Sidewalls **93** are joined together by a pair of stiffeners **94** at each end of the cartridge. Preferably, the stiffeners are located at the upper and lower extremities of each end and are designed to add rigidity and stability to the cartridge. Basic strength and rigidity is obtained by the integrated yoke **112**. Preferably the yoke is positioned approximately midway between the top and bottom of the cartridge with the center line of the yoke being on the plane of the pass line. Yoke **112** is also convenient for mounting the vertical roll screw-ins **113** and hydraulic balancing cylinder **114**.

The sidewalls at the drive end of the cartridge are preferably champered 30° to aid in inserting the unit into the stand. Alternatively, the cartridge can be made smaller than the window in the mill housing. To assure that there is relatively no motion between the cartridge and the stand during rolling, liners can be placed along the outside of the sidewall to abut the housing.

To aid in the removal from and insertion into the mill stand, we have included a hook or latch coupling means **96** which is secured to the lower stiffener **94** on the operator's end of the cartridge unit. Coupling means **96** is adaptable to connect with hydraulic cylinders **31** and **32** positioned below the tracks. To further facilitate and speed conversion, the cartridge is provided with a set of wheels. At each end of the cartridge are a pair of openings **103** in sidewalls **93** for positioning axles **104**. The opposite end of axles **104** are secured in an arcuate member and flange **106**. Member **106** is rigidly secured to the inside of sidewall **93** and to the lower stiffener **94**. Alternatively, it is also possible to mount axle **104** within lower shelf extension **98** used to support the lower work roll chock. Wheels **63** are carried by axles **104** and include a flange **63***a* that extends over the flat portion of rail **26**. The riding surface of rail **26** is preferably flat and includes an upright flange which is in nearly abutting relationship to the bottom of sidewall **93**. The upstanding flange aids in positioning and guiding the cartridge during injection and withdrawal from the mill. Further, rails **26** include small recesses **65** into which the cartridge wheels are positioned during rolling. The depth of the recess is made approximately equal to the distance between the upstanding flange **26***a* and the lower portion of sidewall **93**. Thus, when wheels **63** are positioned in the recesses, the entire weight of the cartridge is distributed along the sidewalls. However, since there are no mill forces or separating forces on the wheels, it is possible to rest the full load of the cartridge on the wheels and minimize the power necessary to move the unit by eliminating the recesses altogether.

The sidewalls of my cartridge are constructed to carry the work roll chocks by means of inwardly extending shelves. A lower shelf **98** is positioned at the bottom of the sidewall near each end corner. The two shelves **98** on the drive end of the cartridge run the length of fixed mill housing **2** and are bounded by imaginary lines bisecting the outside and inside of the housing window. Lower shelves **98** on the operator's end of the cartridge preferably extend the full length of the area bounded by the movable housing including the maximum and minimum settings. To support the vertical roll chocks **102**, shelves **99** are provided. Shelves **99** are above and offset from shelves **98**. Shelves **99** are coextensive in length with shelves **98** and both can be constructed by building up a number of relatively heavy plates. Lower work roll chock **101** initially rests on shelves **98** when assembled in the set up area and inserted into the mill stand. Roll pass clearance is established, once in the mill, by means of the screw-ups **73** and **74**. Lateral movement is restrained by wall **98**a extending between shelves **98** and **99** and which comprises shelves **99**.

Vertical roll chock **102** rests on shelves **99** and constrained in lateral movement by upstanding wall **99***a*. Since wall **99***a* cannot extend past the window **97** in the sidewall, flanges **99***b* are welded to the sidewalls to prevent lateral movement of the upper portion of the vertical chock. Accordingly, the lower work roll chock and the vertical work roll chock are prevented from any lateral movement by their nested relationship with the vertical riser portion of the shelves.

To support the upper work roll chocks **110** against lateral movement between the sidewalls, a pair of removable filler supports **107** and **108** are provided above an imaginary line that runs across the top of the window **97**. Filler supports **107** are mounted on the drive end of the cartridge after the lower horizontal and vertical work roll chocks have been dropped into place. Fillers **107** are coextensive in length with shelves **98** and **99** on the drive end of the cartridge. Fillers **108** are mounted on the operator's end of the cartridge and are adjustable along their length by means of adjustment screws **109** that fit through counter sunk elongated openings **111** which keep the screws from extending past wall **93** and interfering with the cartridge movement into the housing. Fillers **108** are adjustable to accommodate and provide lateral support for various sized upper work rolls and chocks **110** by maintaining the center line of the chocks and filler support since the center line of the fixed housing and the chocks on the drive end are fixed, no adjustment with center line of housing **3** is needed. Both fillers **107** and **108** as well as the shelves **98** and **99** on the drive side include vertical alignment guides that are described in more detail below.

For in-mill correction of the longitudinal center line of the lower work roll chocks, we provide an adjustment mechanism that can either be hand operated or motor driven for automatic control. Within the vertical risers between shelves **98** and **99** on the drive end of the cartridge we provide inclined passageways **126**. See FIGS. **20** and **22**.

Vertical guideways **127** are formed in the lower horizontal chock **101**, and passageways **126** and guideways **127** communicate with one another through a substantial portion of their vertical length. At the bottom of passageways **126**, jack assemblies **128** are connected to the operator's end of the cartridge by shaft **129** which can be either hand turned or power driven. Jack **128** is operably connected, at approximately a right angle, to member **131** having an inclined leg **132** and a vertical leg **133** which extend into passageway **126** and guideway **127** respectively. By causing jack **128** to move its screw **134** up-

wardly in passageway **126** member **131** and leg **132**, in particular, is moved through the passageway, leg **133** is moved longitudinally and upwardly in guideway **127**. Such movement by leg **133** causes a rearward movement of the lower work roll chock; that is, the chock is moved to the drive end without any vertical movement. It is also clear that vertical alignment of the lower chock will not effect the longitudinal alignment since vertical guideway **127** and vertical leg **133** permit free vertical movement of the chock by means of the screw-ups. The jack on the side not directly connected with shaft **129** is connected thereto through shaft **136**.

The lower chocks on the operator's side of the cartridge are "free floating," that is, they are free to move longitudinally and vertically by means of the screw-ups and jack assembly of the drive side. The upper chocks are not longitudinally movable but are movable vertically by means of the combination of the screw-downs and balancing cylinder. To assume accuracy in the vertical direction without effecting longitudinal alignment, upper chock **110** include vertical guideways **137** on the drive end of the cartridge. Conforming guidearms **138** are provided on filler supports **107** that extend within the length of guideway **137**. The upper roll chock on the operator's end of the cartridge is freely movable in longitudinal and vertical direction as is the lower work roll chock on that side.

As in the case with the lower work roll and chocks and the vertical rolls and chocks, the upper work roll is positioned in the cartridge in the set up area by being dropped into the cartridge. The upper chocks are positioned after filler supports **107** and **108** have been secured on top of the vertical chocks. Initially, the upper chocks rest upon the vertical chock and then it is supported by the hanging rods **81** legs **82** and the screw-down when it is inserted into the mill stand.

For positioning the vertical work roll and its associated chock, we provide vertical chock screw-ins **113** and a balancing cylinder **114**, FIGS. **17**, **23–24**. Preferably, both the screw-ins and balancing cylinder are mounted on yoke **112** that extends between the two sidewalls at the ends of the cartridge. I prefer that there be one pair of screw-ins at each end of the cartridge and one hydraulic balancing cylinder per pair of screw-ins. Both pairs of screw-ins are mechanically synchronized and driven by a single motor preferably mounted on the mill housing support to save both space and weight on the cartridge. A motor **116** is mounted on the drive side of the mill on the mill house foundation. Motor **116** is directly connected to right angle gear drive **117**, and to right angle gear drive **118** through housing **117** by means of shaft **119** which is positioned below the pass line. A coupling mechanism for coupling the drive of the screw-ins with gear drives **117** and **118** includes a hydraulic cylinder **121** and a pivot arm **122** which is connected to slidable drive shaft **123**. Drive shaft **123** is supported by arm **120** mounted to the stand foundation. Drive shaft **123** is slidable into and out of engagement with clutch **124** mounted on yoke **112**. Clutch **124** is operably connected in gear train relation to the screw-ins.

Since the motor **116** for driving the screw-ins is mounted on the foundation rather than on the cartridge itself, the weight of the cartridge can be kept to a minimum. Furthermore, maintaining a mechanical synchronization permits a high degree of accuracy in aligning or adjusting the vertical rolls, which is very important for accurate flange tolerance of the rolled beam, while in the mill stand without consuming a lot of time. The coupling can be made automatically when the cartridge is inserted in the mill and at its rest position.

Since all accommodations for size variations made by the movable housing and different sized work rolls, it is preferable to keep the reach of the vertical screw-ins as short as possible. The effective length of the screw-ins on the operator's end of the cartridge have the greatest strains and stress when a narrow webbed beam is rolled. FIG. **19** A–C. In order to relieve these stresses and strains on the screw-ins, we provide for a filler block **125** between screw-in **113** and vertical chock **102**. Filler block **125** is generally U-shaped with upright legs adapted to receive the ends of the screws and to rest against the vertical chock. The bottom of the block is supported by shelves **99** which also supports the vertical chock. The space between the legs permits the hydraulic balancing cylinder **114** to reach the chock. The utilization of a filler block reduces the effective length of the screw required to reach the vertical chock and reduces certain bending and compressive deflective forces placed on them. The filler block maintains the screw projection on the operator's side approximately equal to the drive side resulting in even flange tolerances. FIG. **19** diagrammatically shows the use of filler block **125** to effectively shorten the length of the screw-ins **113**. FIG. **19A** shows the utilization of block **125** for rolling a narrow webbed beam. Depending upon the web size, it is also possible to effectively utilize the block in FIG. **19B**. However, FIG. **19C** is shown with the largest beam rolled on the mill and the screw-ins are set with an effective length equal to those on the drive end. As can readily be seen, all accommodations for size variations are made on the operator's end of the cartridge. The center line of the vertical roll on the drive end moves only enough to do the reduction work on the drive side beam flange, but is not greatly affected by the size changes of the product.

To further reduce the time necessary to connect from one product to another or to change from one size to another, I provide novel utility or service connections that simultaneously act to secure the cartridge within the mill stand. I provide on the outside of the mill stands at least one set of hydraulic cylinders. A pair of hydraulic cylinders **141** are provided on the operator's side of the housings. For example, see FIGS. **7** and **9** and FIGS. **25–29**. Cylinders **141** are connected to engageable extensions **142** that are adapted to pressure fit within bores **143** in the top portion of side walls **93**. Bores **143** are spaced to conform to the preselected housing setting for housing **3**; that is they conform to the spacing of notches **89**. Alternatively, a channel can be formed to provide a continuous receptacle for the extender. Hydraulic cylinders **141** provide a pressure clamping to the cartridge to secure it within the stand.

On the drive end of the cartridge I provide two pairs of hydraulic cylinders **144** and **145** and their associated extensions. Both pairs are mounted to the fixed housing or drive side housing and their extenders sealingly engage within bores **146** and **147** respectively on the top end of both sidewalls. Both cylinders and their associated extenders provide a clamping force to secure the cartridge as well as providing service connections to the cartridge. The extender associated with cylinder **145**, for example, is provided with an inlet bore **148** connected to a source of water for cooling. Bore **148** is adapted for communication with the receiving bore **147** which includes a passageway that is connected to a water output distribution connection which is linked to the roll cooling device during preassembly.

Cylinder **144**, FIG. **27**, and its associated extender is provided with an inlet bore **149** which is connected to a source of grease or hydraulic fluid. The inlet bore **149** is adapted to communicate with coupling **151** which, during preassembly of the cartridge, is connected with either the grease of hydraulic coupling of the work roll or hydraulic cylinders. If the cylinder extension **144** in the front side of the mill is connected to hydraulic fluid, then the rear side cylinder is provided with the grease connection.

Alternatively, only one pair of cylinders and extension **152** need be provided for utilities and clamping. FIG. **28**. Cylinder extension **152** includes two passageways **153** and **154**. Passageway **153** is connected to a water inlet source on the mill stand and exits into bore **155** which sealingly engages extension **152**. The passageway **154**, of somewhat smaller diameter, is used for either the hydraulic fluid or grease. A small diameter passageway can be used for this service connection since pressure, not volume is the functional parameter for these services. The use of the alternative system reduces the overall cost somewhat and the number of hydraulic cylinders. This is preferably where the extra pressure of an additional pair of cylinders is not required, for example, when

recesses **65** are provided in the rails to aid in securing the cartridge. Further, it is possible to eliminate the pressure-clamping feature of the cylinders altogether by making the cartridge with minimum tolerances.

While it is possible to make the water connections from the end of the extension to the roll cooling device similar to the hydraulic fluid and grease connection, that is by connecting a hose at the bore, I prefer to use the incoming water to cool the cartridge. Connected with bore **147** or **155** and in communication with passageway **153** and **148** are a plurality of passageways **156** which extend longitudinally across the top of both sidewalls **93** of the cartridge. A water outlet **158** is provided on the operator's end of the cartridge which is connected to the roll cooling devices. Water passing through passageways **156** provides cooling for the upper portion of the cartridge prior to entering the roll cooling device. This permits a more uniform expansion of the cartridge during rolling so that a parallel beam flange can be rolled. Control valves (not shown) can be included in each passageway to regulate the amount of water flowing through as required by the cartridge expansion and rolls.

In the rolling of plate and structural products, mill stand **1** is equipped with a cartridge-like assembly **28**, or **33** FIG. **6**. Cartridge-like assembly **33** includes a carriage frame **201** which has a set of wheels **63'** similar to the cartridge described above. Mounted on the carriage frame at the operator's end are angled corner supports **202** which extend from the frame to longitudinal stiffeners **203** on the top of the cartridge and form slots **209**. Mounted at the corners on stiffeners are bores **205** for receiving the various hydraulic clamping and service cylinder extensions **141**, **142**, **144**, **145**, or **152**. End supports **202'** on the drive side are not provided with slots as **202** so that chocks and work rolls are free to expand. A pair of horizontal work roll chocks **207** and **208** nest on the carriage and within the supports.

As can readily be seen, both the cartridge and cartridge-like assemblies greatly reduce the time required to change or convert the mill line product. The final adjustments of the screw-downs and balancing cylinders are rapidly effectuated once the cartridge is inserted into the mill stand. The center line adjustment of the table roll assembly sideguards and the guides are the final steps prior to operation, and these can be accomplished simultaneously with other operations once the cartridge has been inserted. Stripper guides **163** and **164** are mounted on rest bars **165** in the roll shop or assembly set up area. Rest bars **165** are mounted on the upper and lower horizontal chocks prior to or shortly after their respective placements within the cartridge.

To further reduce conversion or down time, I provide adjustable and replaceable guides between the table roll assemblies and the mill stands, and carryover guides between the mill stands. Referring to FIGS. **30–33**, I provide a pair of guides, **170** connected to a hydraulic actuated piston **171**. Guides **170** are positionable at three positions: (FIG. **33**) (a) roll changing position, (b) rolling position, beam or plate, and (c) out of the pass line and nonfunctional during structural rolling. Guides **170** are supported by support sleeve **172** which is securely mounted to fixed housing by brace **173** and to movable housing by brace **174** having a sliding fit. Sleeve **172** is threaded at the operator's side of the mill to receive adjustment screw wheel **175** and screw assemblies **176**. Assembly **176** is threaded to engage the threads of sleeve **172** and to move along said threaded length when wheel **175** is turned. Assembly **176** is adapted to rotatably mount shaft **177** having a wheel **178** secured at the operator's side of the mill. Shaft **177** is also provided with a set of opposingly threaded members **179** and **181**. One guide **170** is attached to member **179** through support **182** which is in threaded engagement with member **179**. The other guide is secured to member **181** through support **183** which is in threaded engagement with member **179**.

By turning wheel **178**, members **179** and **181** are rotated causing supports **182** and **183** to move along the threaded portions in opposite directions. The split guide halves mounted on the respective supports also are caused to move in opposite directions. Accordingly, the width of the split guide can be accurately adjusted. See FIG. **30** (A–C). On the other hand, by turning wheel **175**, assembly **176** is caused to move along the threaded portion of sleeve **172** carrying along with it shaft **177** and split guide **170**. Accordingly, wheel **175** provides a center line adjustment for the guide without disturbing the guide width setting. The same device is also utilized with crossover guides **57**. This provides for a reduced down time after cartridge injection which can be further reduced automating and motor driving the wheels.

It is clear from the above description of my presently preferred embodiment, that a conversion from one rolled product to another can be quickly and efficiently made without the need for high capital expenditures.

While I have shown one presently preferred embodiment of my invention, it may otherwise be embodied within the scope of the appended claims.

I claim:

1. A combination rolling mill for rolling beam, structural and plate products comprising:

A. first and second cartridge loadable mill stands, said first stand including a movable housing on the operator's side and said second stand being movable to the drive side out of the mill line and adapted to support its spindles when out of the line;

B. at least one cartridge movable into and out of said stands and having at least one set of work rolls;

C. a transfer means movable along a line parallel to the mill line for supporting and transferring cartridges and including four stations, alternate stations being simultaneously alignable with the windows in said stands;

D. means for moving said cartridge from the transfer means into a mill and from a mill onto the transfer means;

E. means for moving the transfer means to one of two positions; and

F. at least two table roll assemblies positioned behind said second stand, one of said tables being movable along the mill line and adapted to occupy the space vacated by the second stand when moved out of the mill line and said other table being movable into and out of the line to occupy the space vacated by the table filling the vacated mill stand space.

2. A combination mill as set forth in claim **1** wherein said first mill stand includes a motor operated screw means for moving said movable mill housing.

3. A combination mill as set forth in claim **1** wherein said first and second mill stands include hydraulic clamping means adapted to engage said cartridge and having at least one utility service connection for hydraulic fluid, grease and water, and wherein said cartridge includes means for receiving said clamping means.

4. A combination mill as set forth in claim **3** wherein said first mill stand includes a notched bar mounted on the top of movable housing having preselected openings engageable with cooperating means on the fixed housing for setting the width of said mill housing in relation to the preselected openings.

5. A combination mill as set forth in claim **1** wherein said cartridge includes an upper and lower horizontal work roll and associated chocks and a pair of vertical rolls and associated chocks, said upper work roll chocks including legs to cooperate with hanging rods of the mill stand and landings for the mill stand screw-downs, said lower roll chocks including landings for screw-ups of said mill stand, said cartridge also including at least one pair of screw-ins and a balancing cylinder for said vertical work roll.

6. A combination mill as set forth in claim **1** wherein said table rolls assemblies are vertically adjustable about a pivot point for accommodating various sized rolled products.

7. A combination mill as set forth in claim **1** wherein carryover guides are provided between said first and second mill stand, said guides including means for independently adjusting

the width of said guide and means for independently positioning said guide on the center line of pass line.

8. A rolling mill stand adaptable to cartridge loading of work rolls comprising:

A. first and second mill housings, said first mill housing being movably mounted on the operator's side of the line and having a window therein, said second stand being securely mounted;

B. means for moving said first mill housing;

C. a pair of screw-ups and screw-downs, one of each pair associated with each housing;

D. means for synchronously operating each pair independently of the other pair;

E. a pair of hydraulic balancing cylinders associated with each housing;

F. guideways extending through each housing and extending through a window in said first housing for guiding a cartridge; and

G. means for selectively positioning the first housing and extending between said housings.

9. A rolling mill stand as set forth in claim 8 wherein said means for moving the first housing includes a motor and a screw drive member, said drive member being rotatably mounted to the first housing and operably engaged with said motor, said motor being securely mounted to cause said drive members to be driven therethrough.

10. A rolling mill stand as set forth in claim 8 wherein said means for synchronously driving each pair of screw members includes a gear associated with and operably connected to each screw, a motor, and a shaft connected to said motor and in operable engagement with said gears, said shaft being splined a portion of its length for sliding engagement with one of said gears throughout the length of said splined portion.

11. A rolling mill stand as set forth in claim 8 wherein said means for selectively positioning said first housing comprises an elongated member securely positioned to the upper portion of said first housing and slideably mounted to said second housing, said member having preselected openings therein, and a hydraulically actuated engaging element mounted on said second housing for engaging said openings to securely and selectively position said first housing.

12. A rolling mill stand as set forth in claim 8 including a pair of hydraulically actuated service coupling mounted on the second housing and adapted to cooperatively and sealingly engage a cartridge, said service members comprising an elongated member having at least one passageway therethrough adapted to communicate with a passageway in the cartridge when cooperatively engaged therewith, said passageway being connected to a source of at least one of grease, oil and water.

13. A pair of service couplings as set forth in claim 12 wherein said member includes first and second passageways therethrough, said first passageway adapted to communicate with a first passageway in said cartridge and said second passageway being adapted to communicate with a second passageway in said cartridge when said member is cooperatively and sealingly engaged with said cartridge, said first passageways of said pair being connected to a source of water, one of said second passageways being connected to a source of grease and said other second passageway being connected to a source of hydraulic fluid.

14. A pair of service couplings as set forth in claim 12 including hydraulic actuating means provide a pressure greater than that required for sealing engagement of said member thereby effecting a clamping between the stand and a cartridge.

15. A plate mill comprising:

A. first and second cartridge loadable mill stands, said first stand having one movable and one rigid housing, said movable housing being on the operator's side;

B. first and second cartridges movable into and out of said first and second mill stands respectively, said first cartridge having a pair of horizontal work rolls and said second cartridge having a pair of horizontal and vertical work rolls;

C. means for moving said first and second cartridge into and out of their respective mill stands; and

D. means for driving said pairs of horizontal rolls.

16. A beam mill comprising:

A. first and second cartridge loadable mill stands, said first stand having one movable and one rigid housing, said movable housing being on the operator's side;

B. first and second cartridges movable into and out of said first and second mill stands respectively, said first cartridge having a pair of horizontal and vertical work rolls and said second cartridge having a pair of horizontal work rolls;

C. means for moving said first and second cartridges into and out of their respective mill stands; and

D. means for driving said pairs of horizontal rolls.

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