United States Patent [19]

Miller et al.

[11] **3,916,976**

[45] **Nov. 4, 1975**

[54] **PROCESS FOR PRODUCING FOUNDRY SAND MOLDS**

[75] Inventors: **Leon F. Miller**, Rocky River; **Henry J. Herbruggen**, Westlake; **Robert G. Shields**, Chagrin Falls, all of Ohio

[73] Assignee: **The Sherwin-Williams Company**, Cleveland, Ohio

[22] Filed: **Jan. 3, 1974**

[21] Appl. No.: **430,473**

Related U.S. Application Data

[62] Division of Ser. No. 131,528, April 5, 1971, Pat. No. 3,815,662, which is a division of Ser. No. 672,063, Oct. 2, 1967, Pat. No. 3,589,432.

[52] **U.S. Cl.** **164/37**

[51] **Int. Cl.²** **B22C 15/30**

[58] **Field of Search** 164/27, 29, 37, 38, 39, 164/40, 181, 182, 183, 213, 214

[56] **References Cited**

UNITED STATES PATENTS

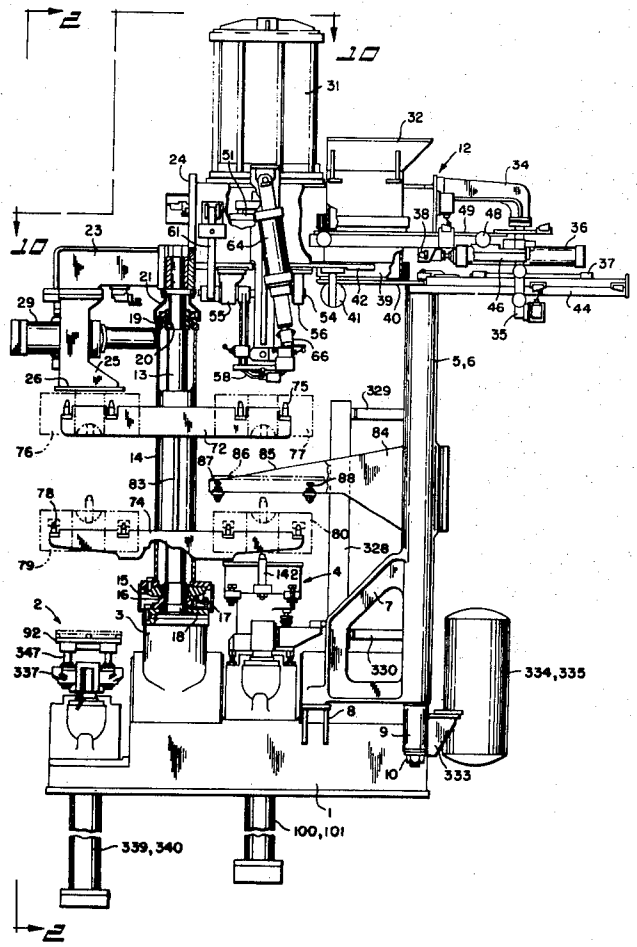
1,561,500	11/1925	Wood	164/29
2,013,278	9/1935	Luton	164/37 X
3,506,058	4/1970	Hunter	164/37

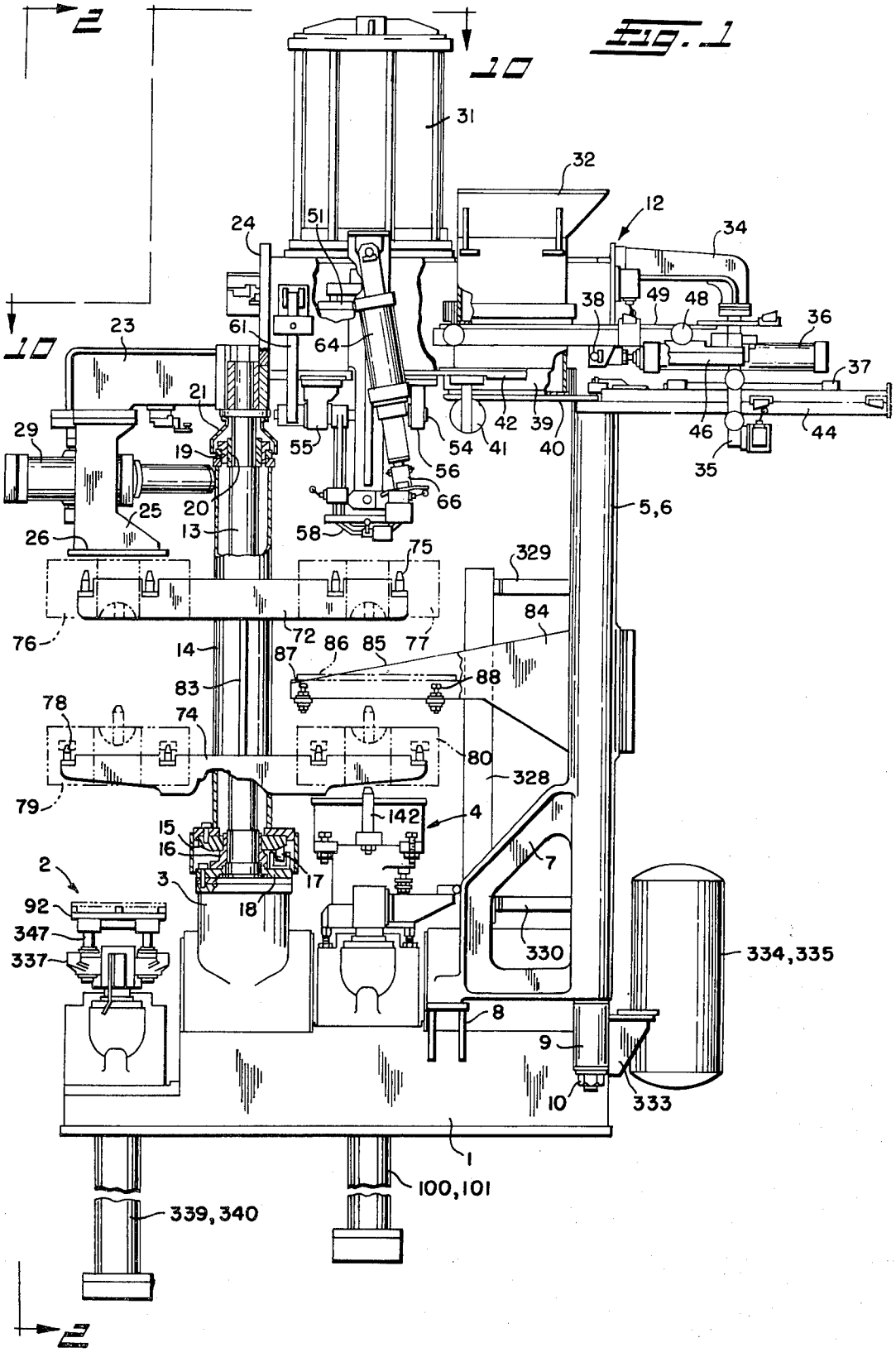
Primary Examiner—Francis S. Husar
Assistant Examiner—John E. Roethel
Attorney, Agent, or Firm—Donnelly, Maky, Renner & Otto

[57] **ABSTRACT**

A foundry molding machine utilizing a match-plate and two sets of rubber lined cope and drag slip flasks with two stations; one station assembling one set of flasks with the match-plate therebetween and then rolling over the flask-match-plate assembly to fill the drag with sand while supporting the assembly on the cope and jolting and applying a low pressure preliminary squeeze to the sand within the drag, rolling the assembly back to fill the cope and then supporting the assembly on the sand within the drag for the application of jolt and high pressure squeeze to the sand in both the cope and drag, separating the assembly and indexing the cope and drag vertically separated to a second station while simultaneously indexing the second set of flasks to the first station, holding the sand rammed flasks vertically separated in the other station to permit coring and closing the flasks and stripping the sand cakes thus assembled therefrom to be placed on a bottom board while the second set of flasks are being filled and rammed at the first station; the indexing and roll-over of such flasks being obtained each by a piston-cylinder assembly having controlled stroke deceleration on extension thereof.

11 Claims, 40 Drawing Figures




Fig. 1
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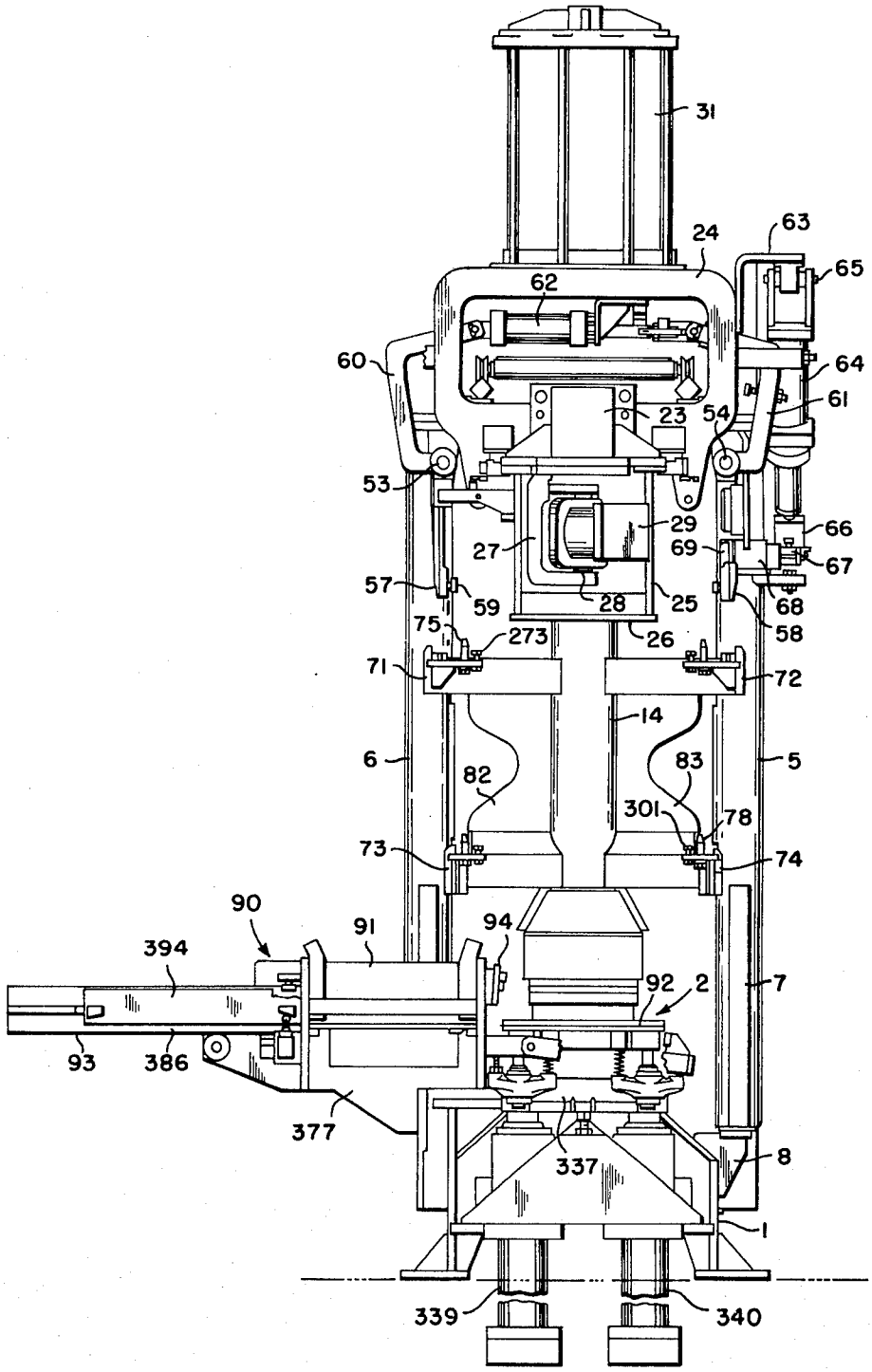

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Fig. 2

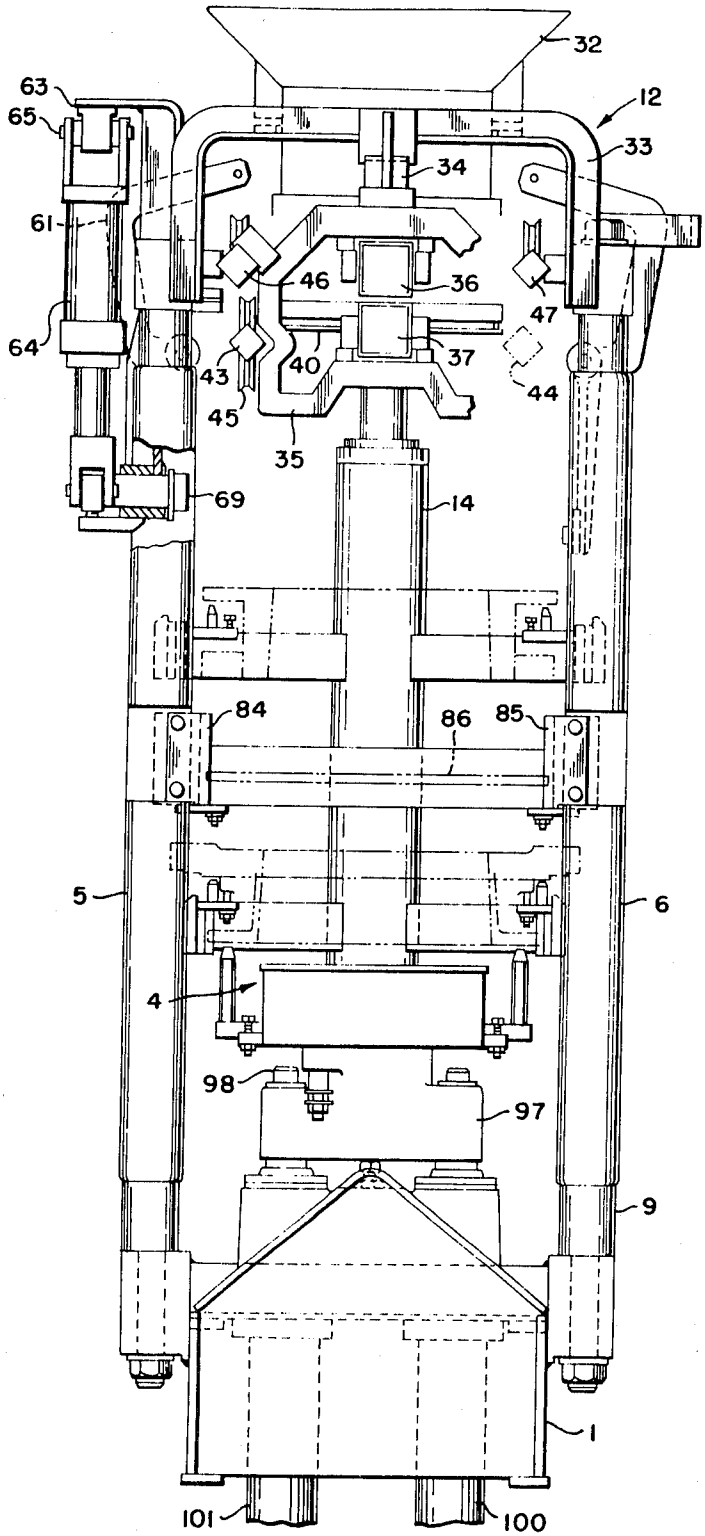

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Fig. 3

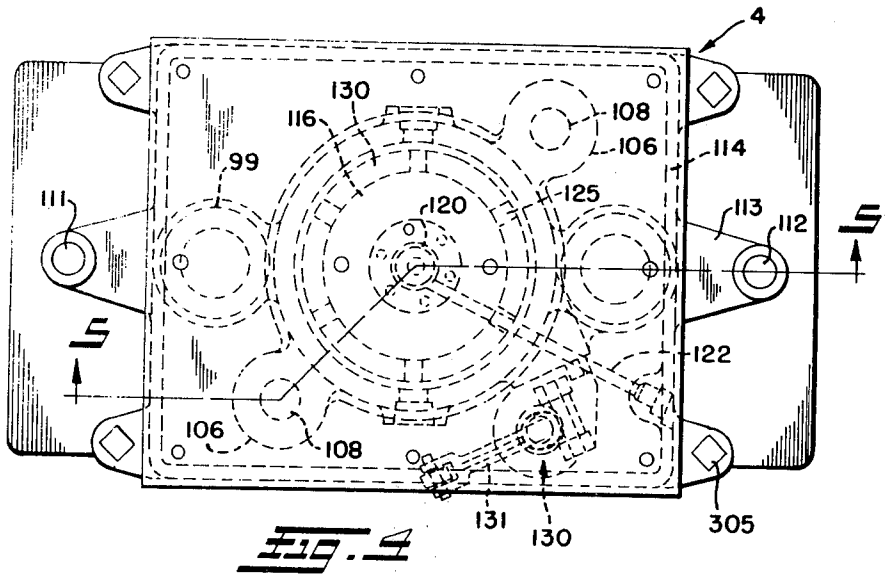

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Fig. 4

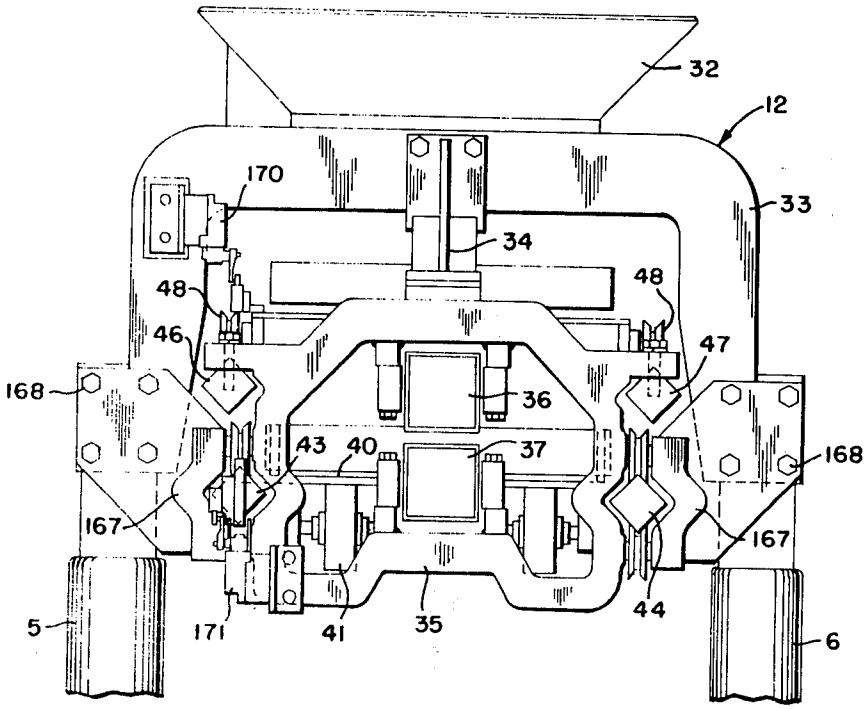

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Fig. 7

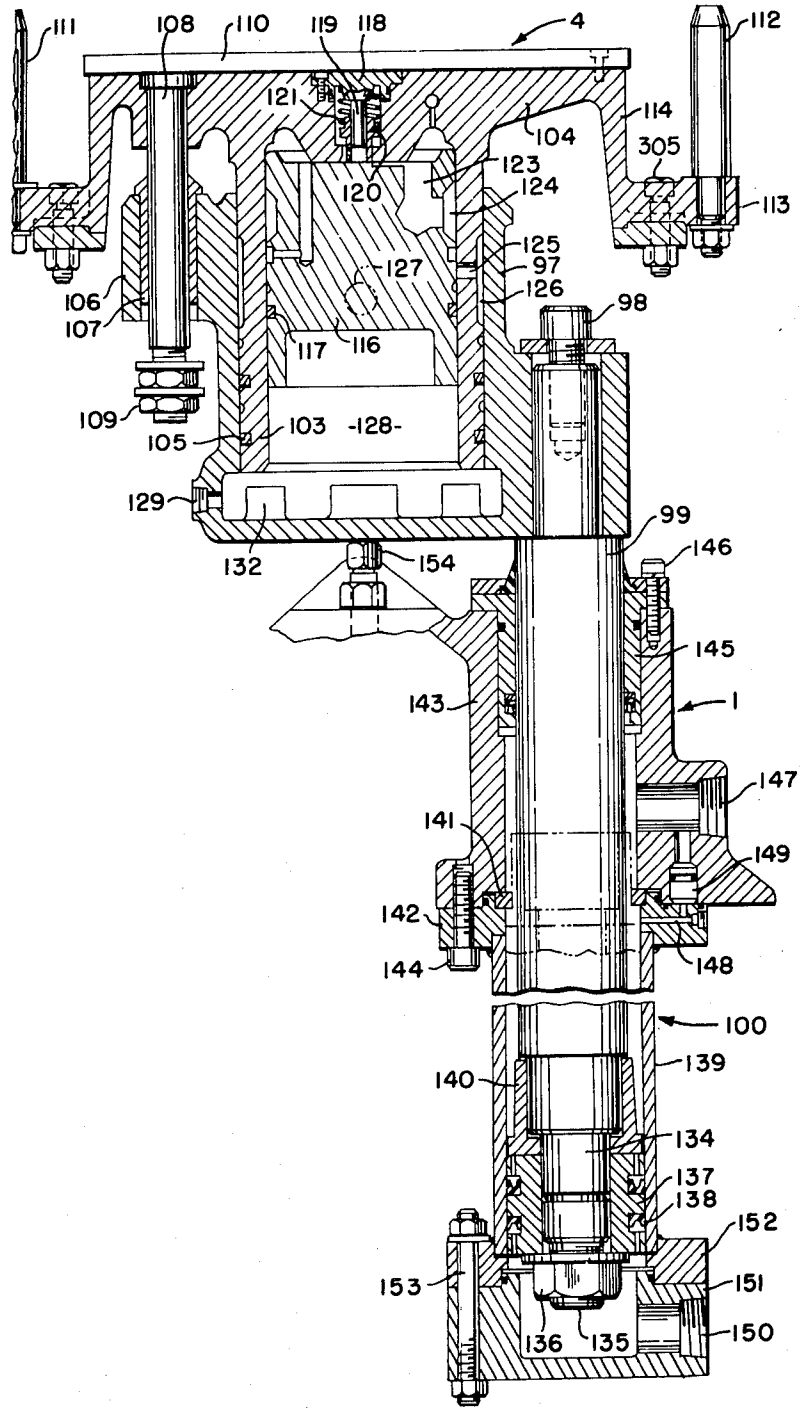

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Fig. 5

FIG. 9

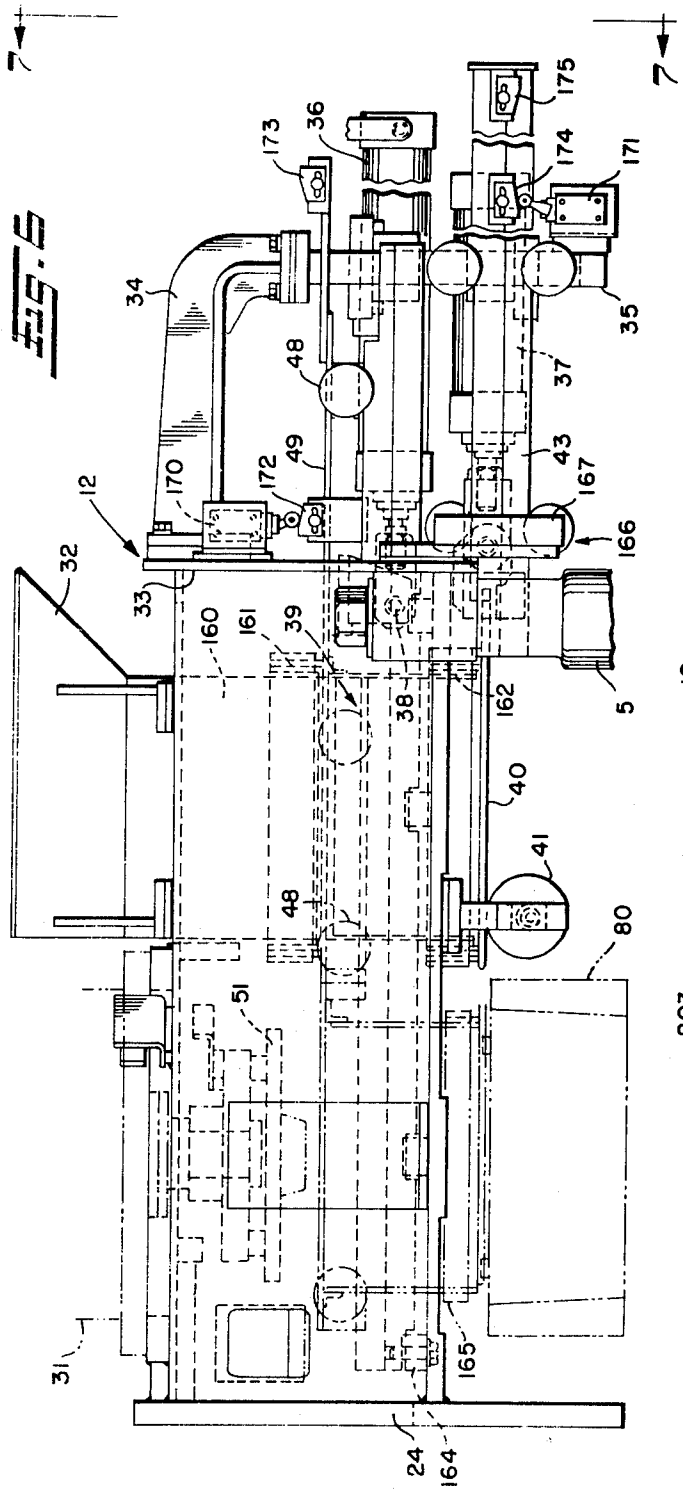
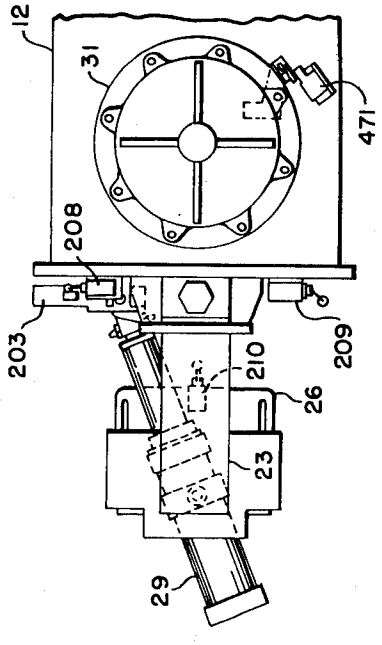

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FIG. 10


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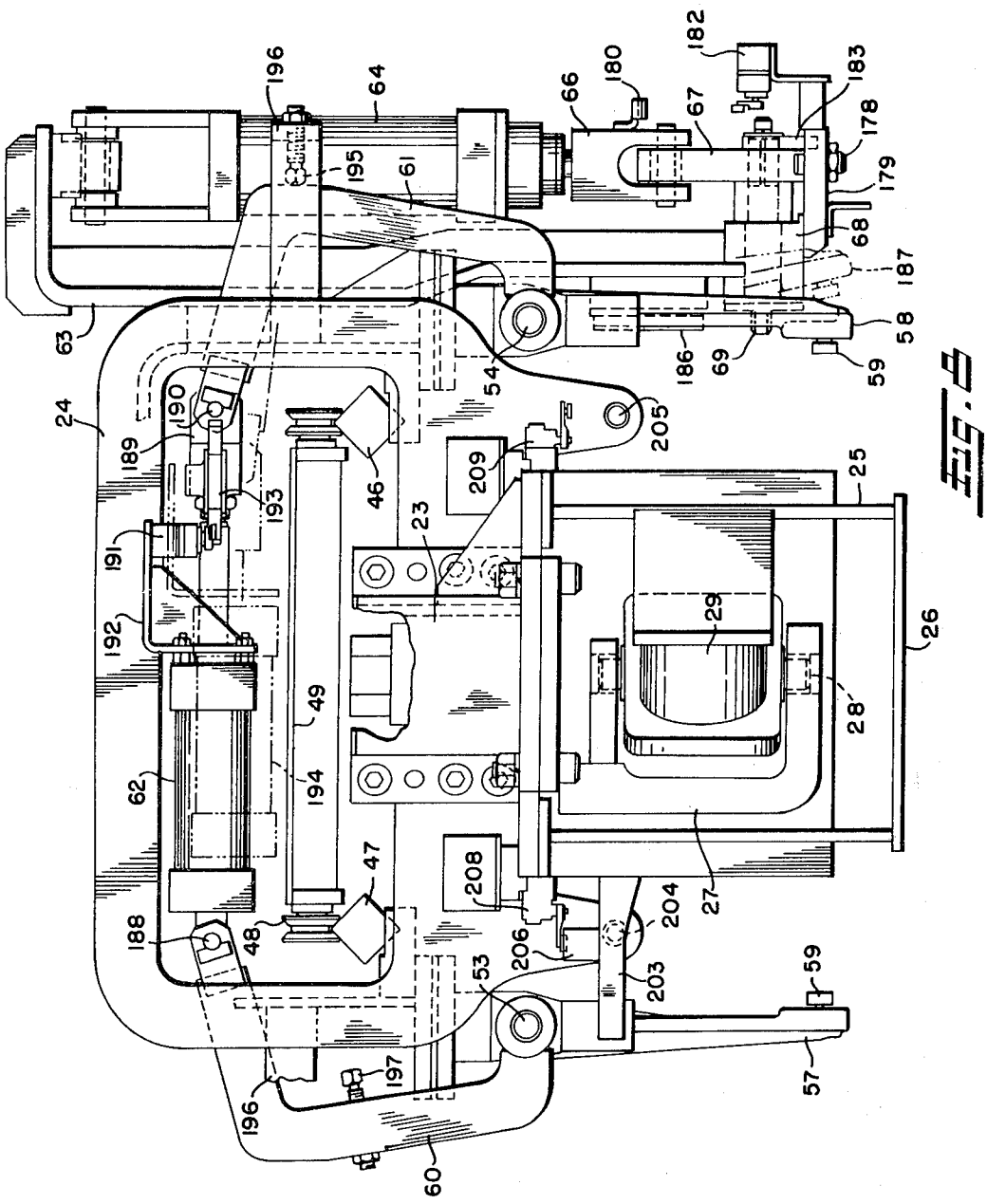

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FIG. 8

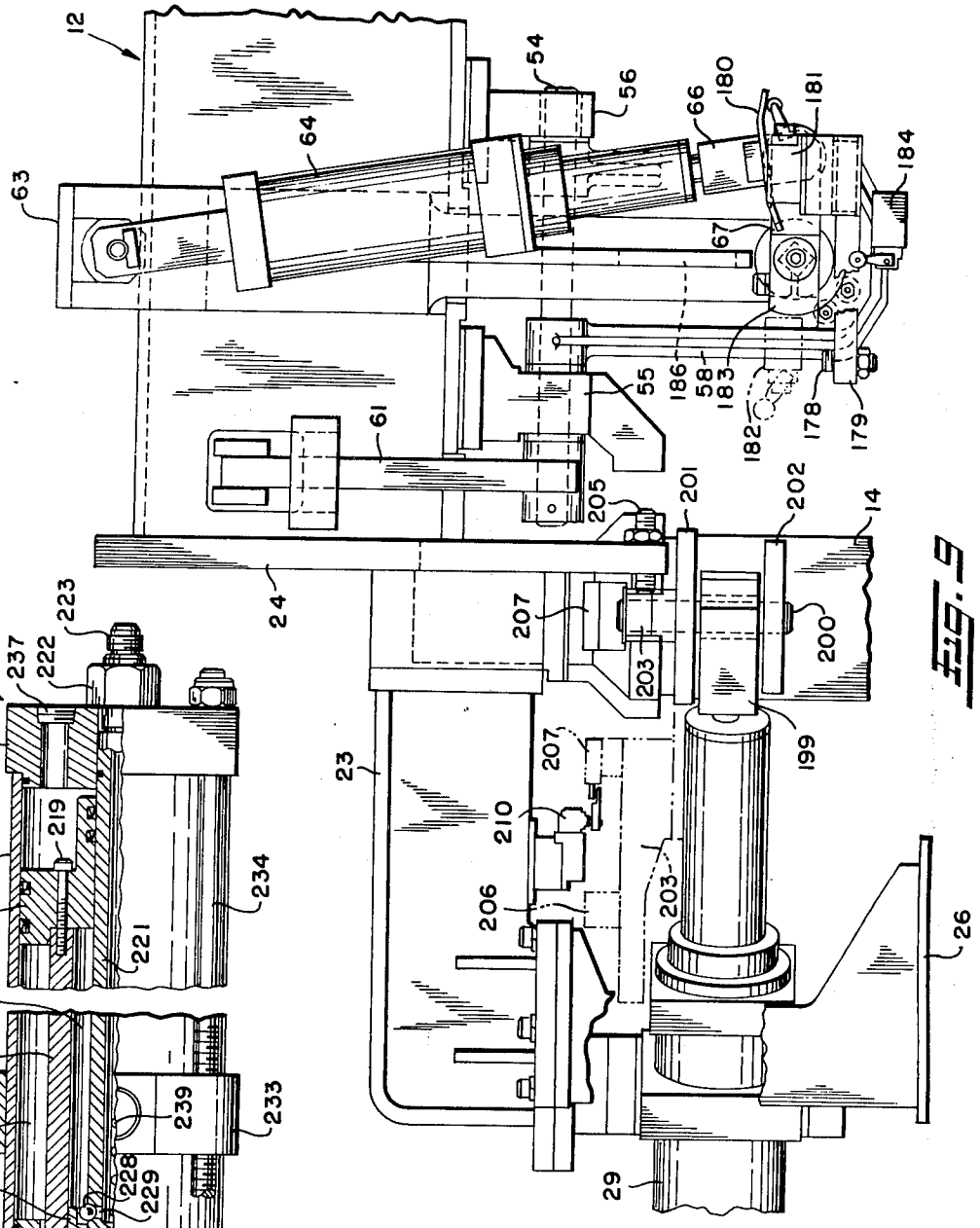

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FIG. 9

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FIG. 11

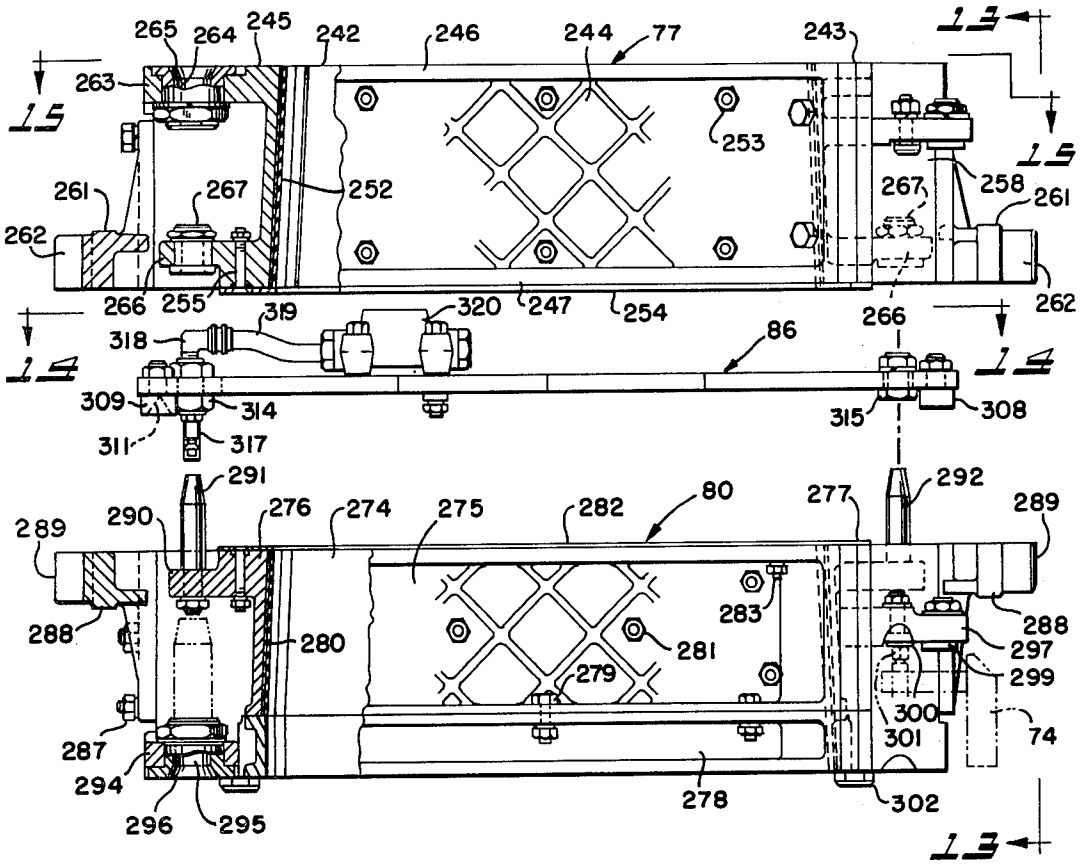

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Fig. 12

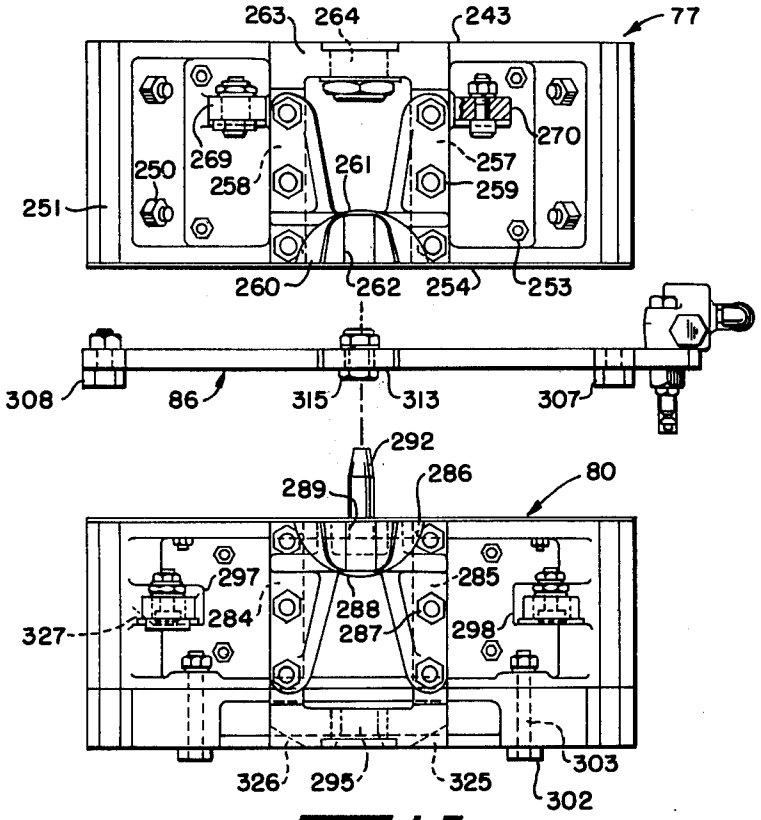

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Fig. 13

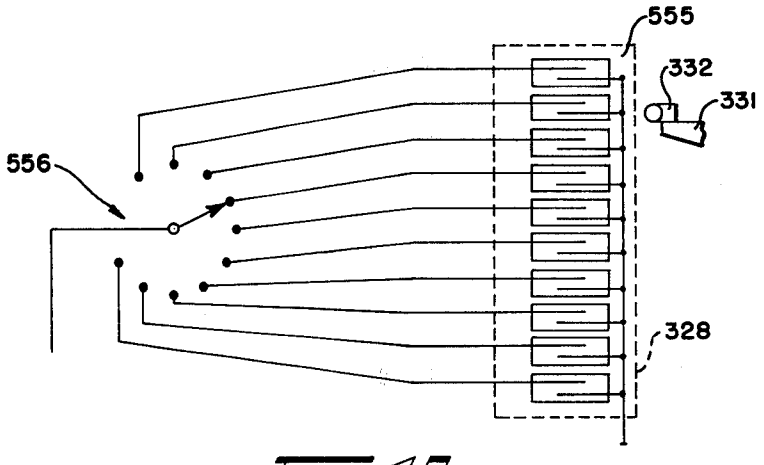

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Fig. 40

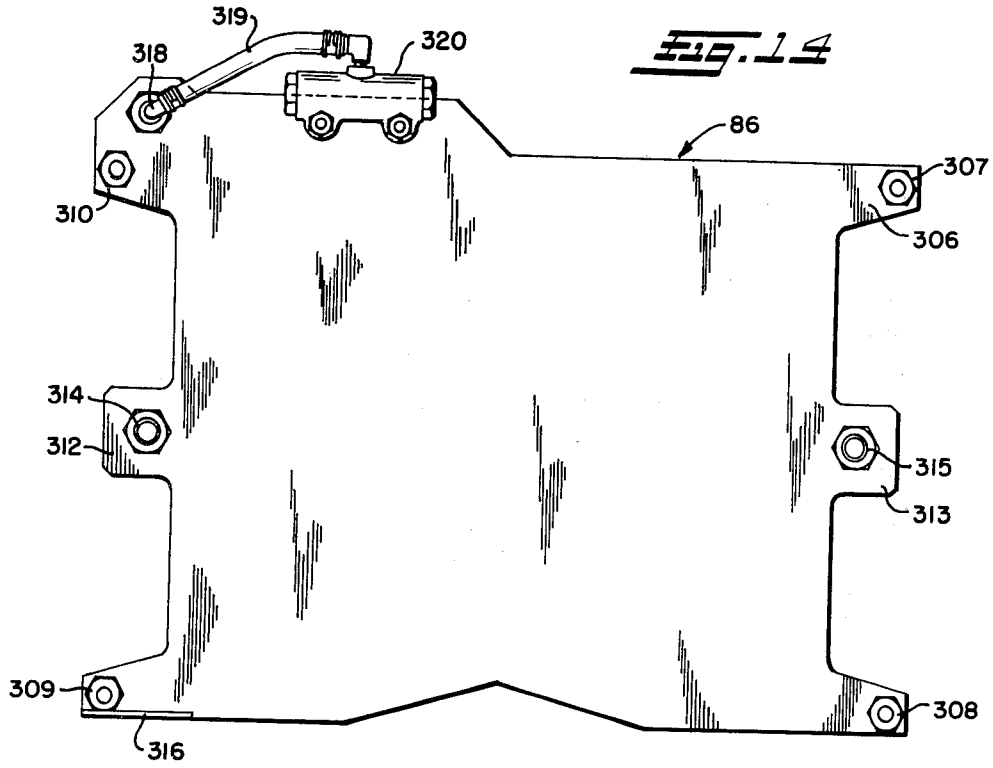

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Fig. 14

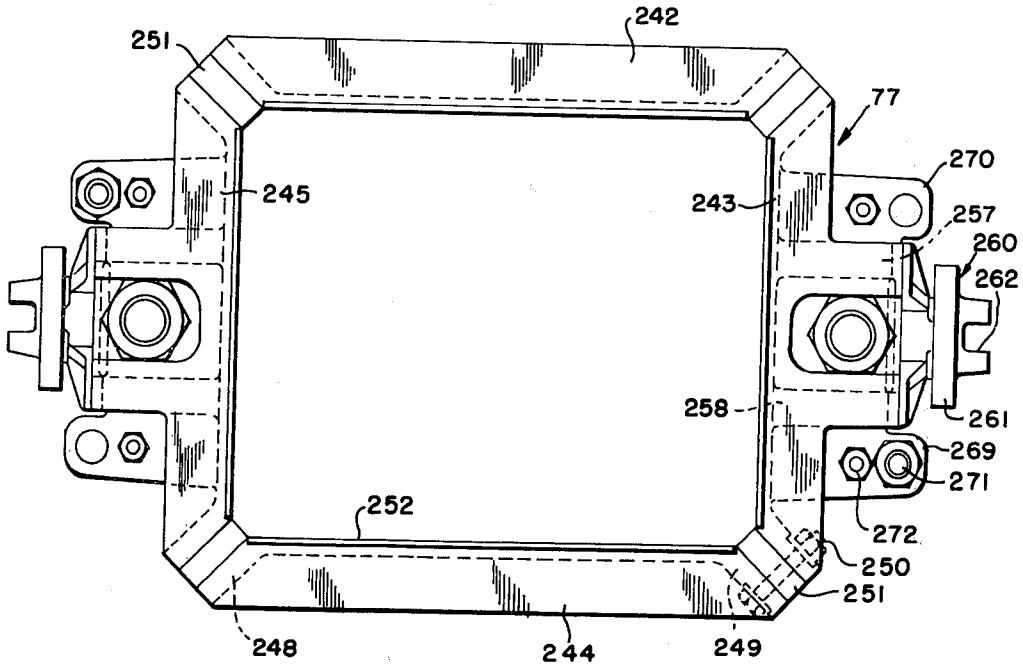

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Fig. 15

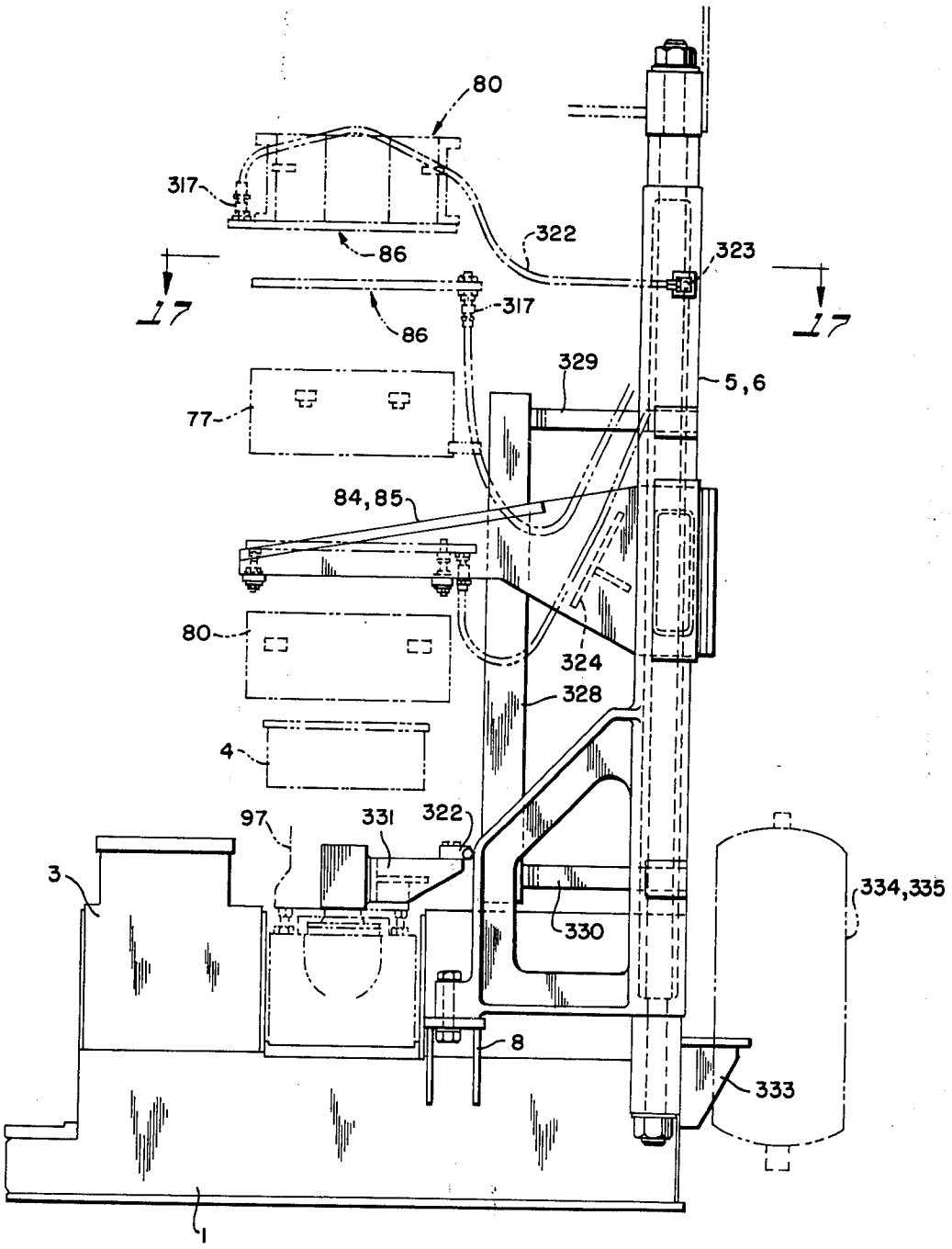
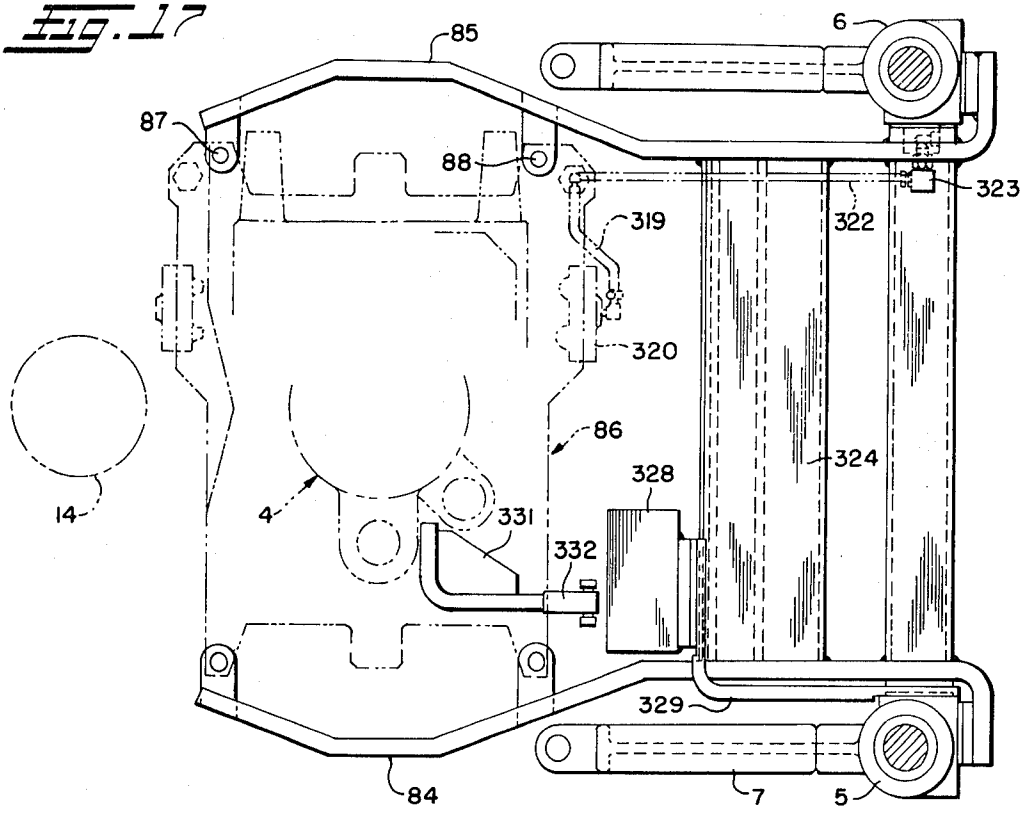

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Fig. 16

Fig. 17


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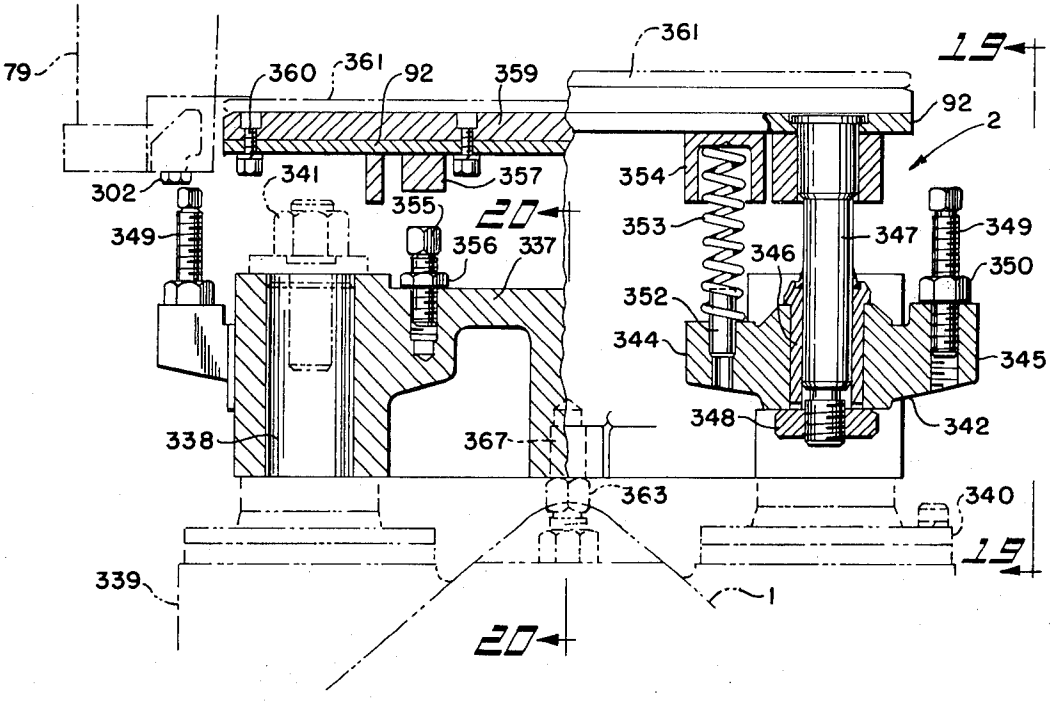

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Fig. 18

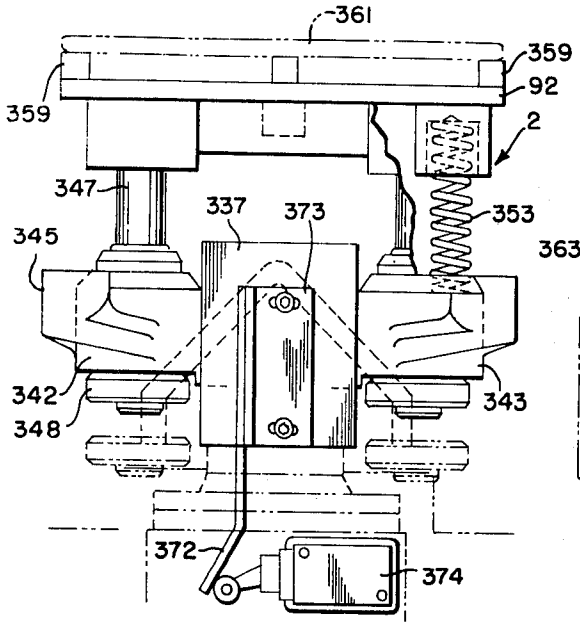


Fig. 19

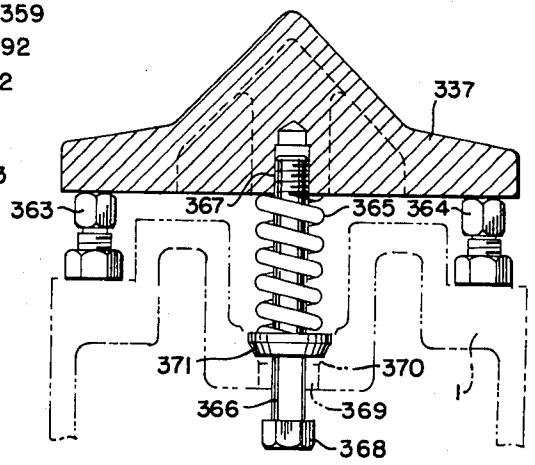


Fig. 20

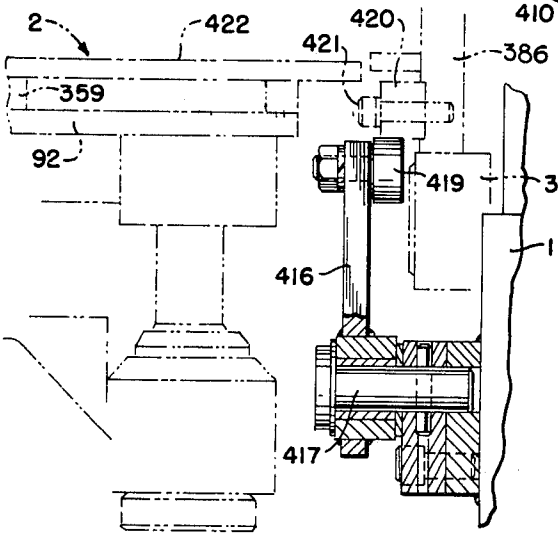


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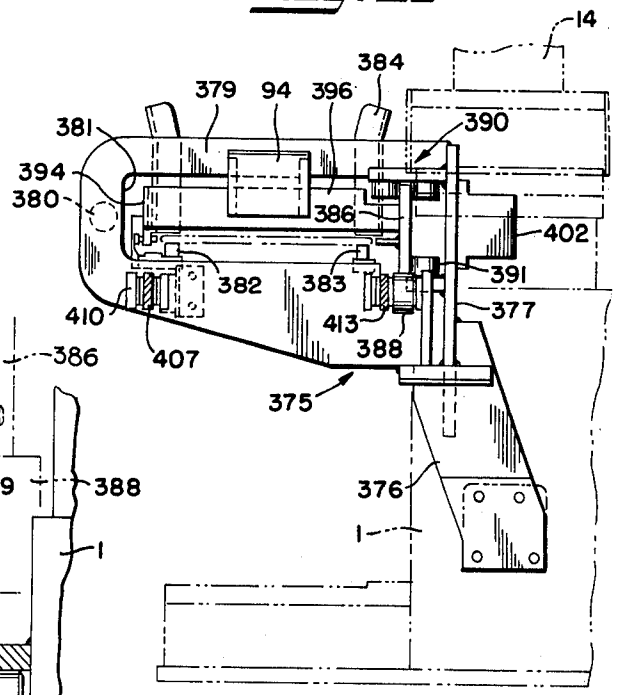


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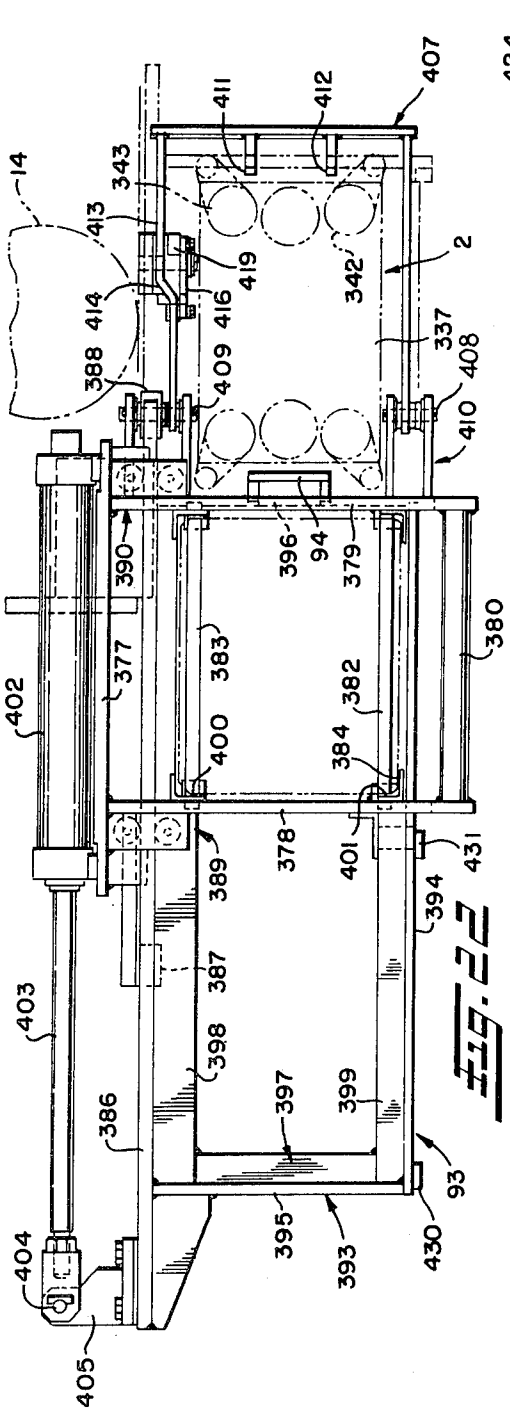

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FIG. 22

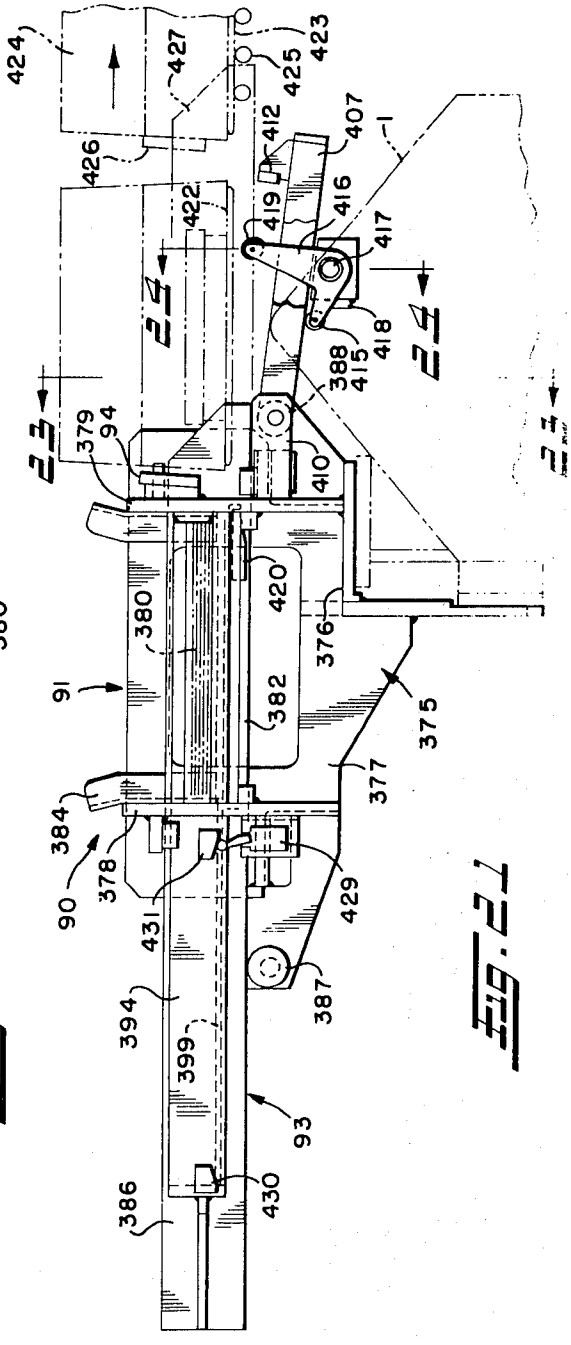

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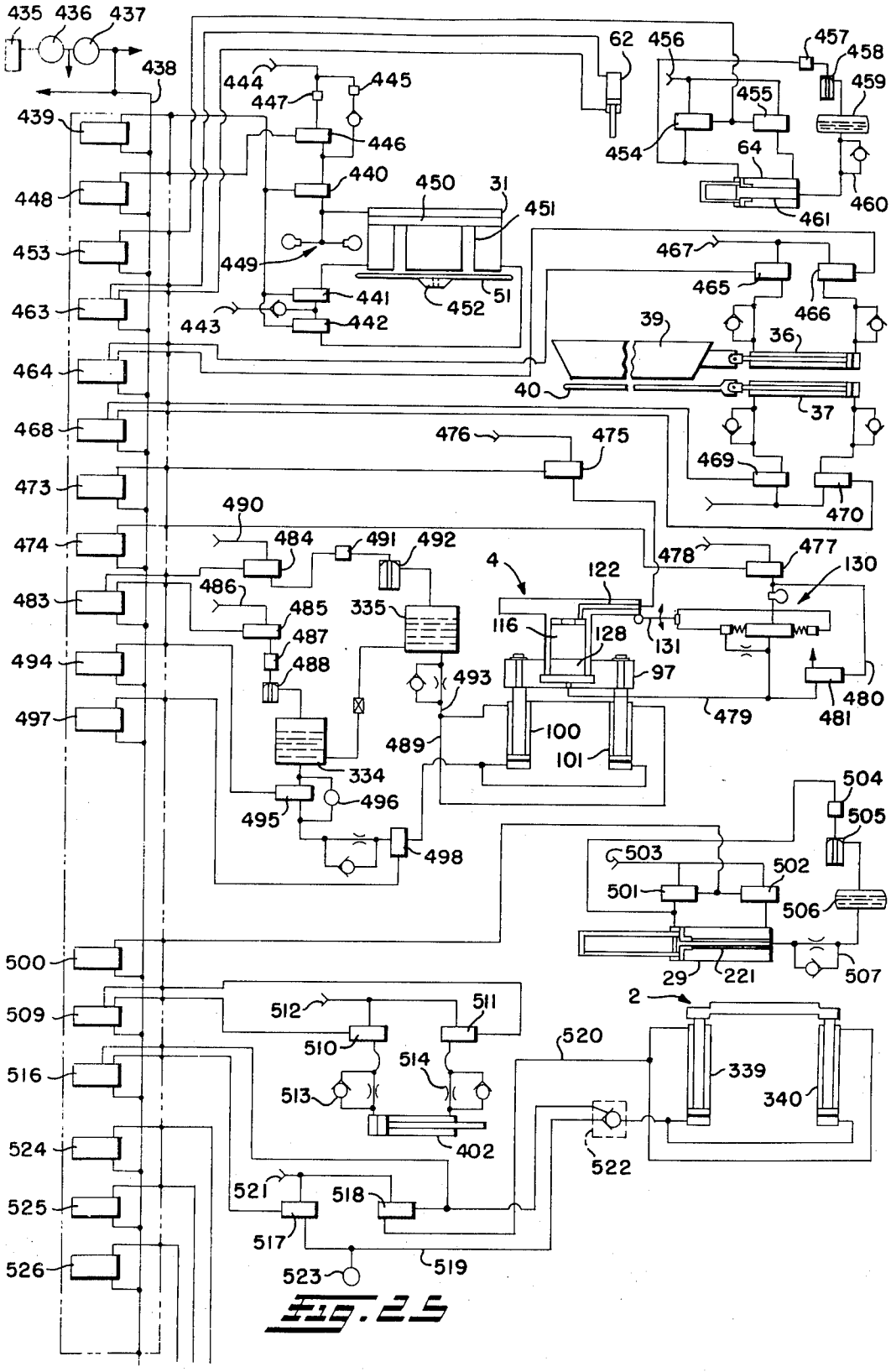

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Fig. 2S

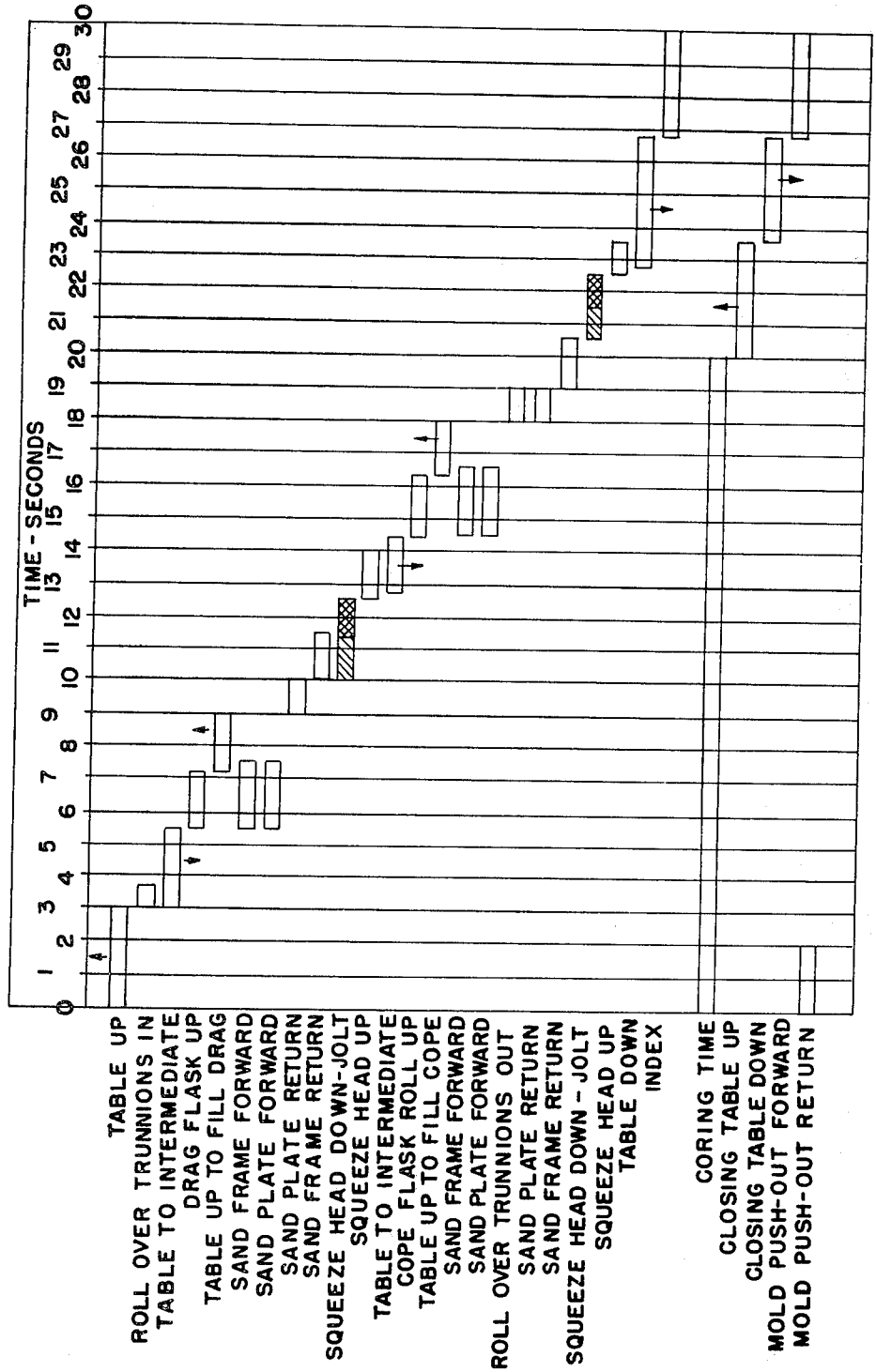

TIME - SECONDS
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30
TABLE UP
ROLL OVER TRUNNIONS IN
TABLE TO INTERMEDIATE
DRAG FLASK UP
TABLE UP TO FILL DRAG
SAND FRAME FORWARD
SAND PLATE FORWARD
SAND PLATE RETURN
SAND FRAME RETURN
SQUEEZE HEAD DOWN-JOLT
SQUEEZE HEAD UP
TABLE TO INTERMEDIATE
COPE FLASK ROLL UP
TABLE UP TO FILL COPE
SAND FRAME FORWARD
SAND PLATE FORWARD
ROLL OVER TRUNNIONS OUT
SAND PLATE RETURN
SAND FRAME RETURN
SQUEEZE HEAD DOWN - JOLT
SQUEEZE HEAD UP
TABLE DOWN
INDEX
CORING TIME
CLOSING TABLE UP
CLOSING TABLE DOWN
MOLD PUSH-OUT FORWARD
MOLD PUSH-OUT RETURN

FIG. 26

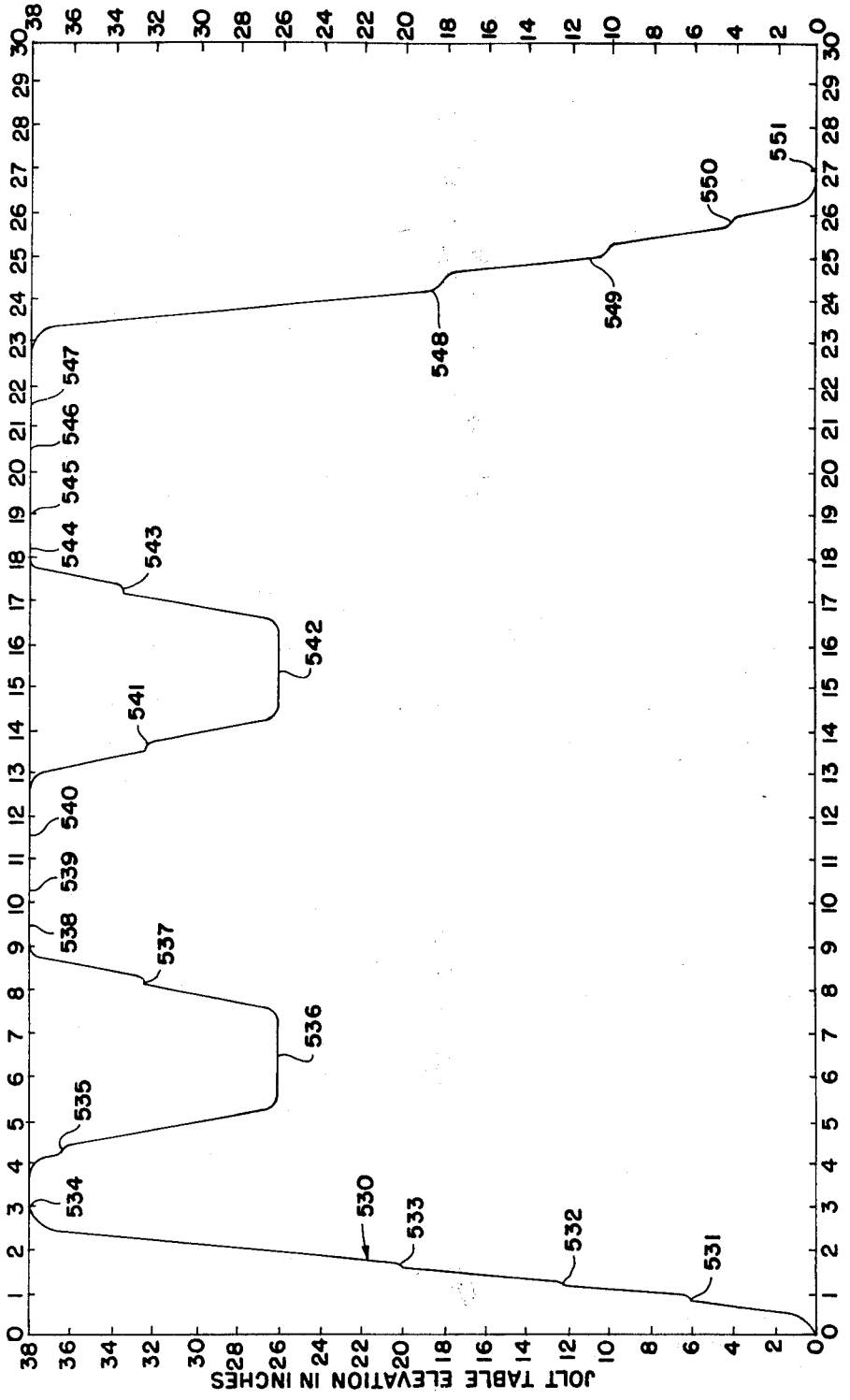

JOLT TABLE ELEVATION IN INCHES
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FIG. 27

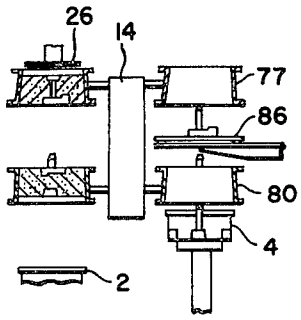


Fig. 28

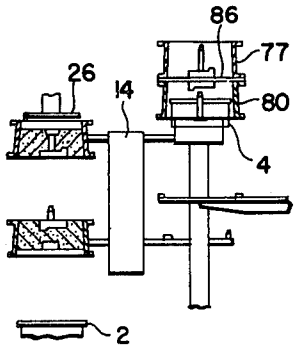


Fig. 29

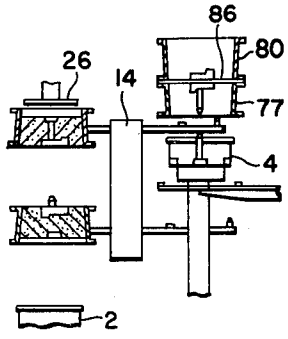


Fig. 30

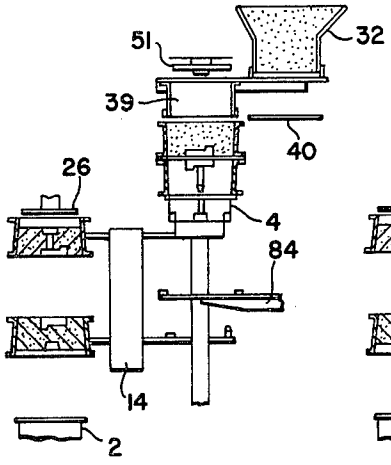


Fig. 31

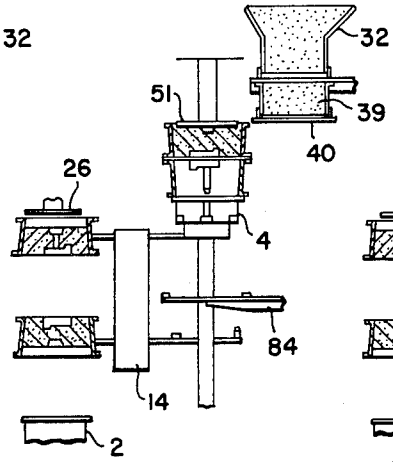


Fig. 32

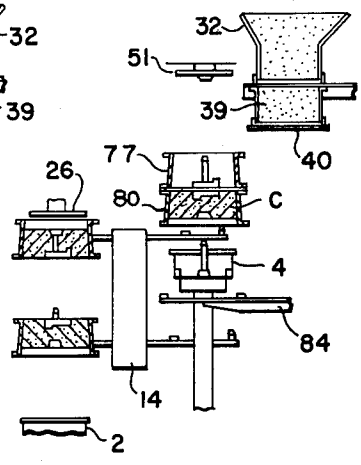


Fig. 33

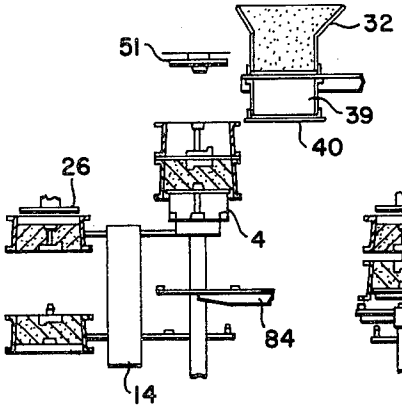


Fig. 34

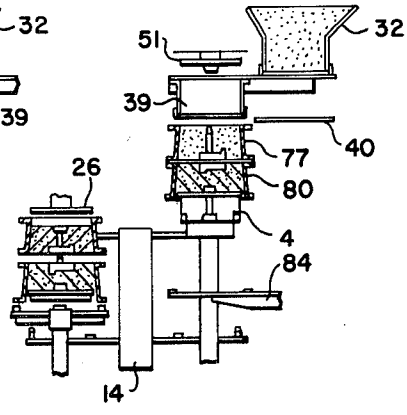


Fig. 35

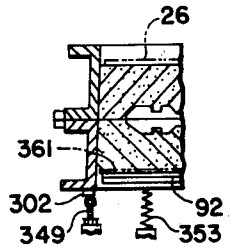


Fig. 36

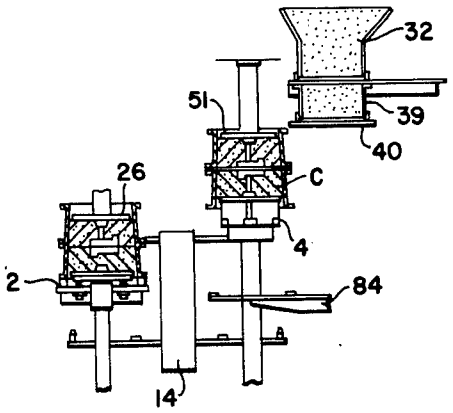


Fig. 37

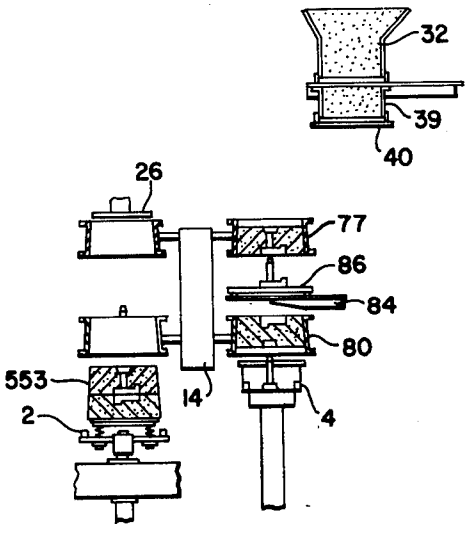


Fig. 38

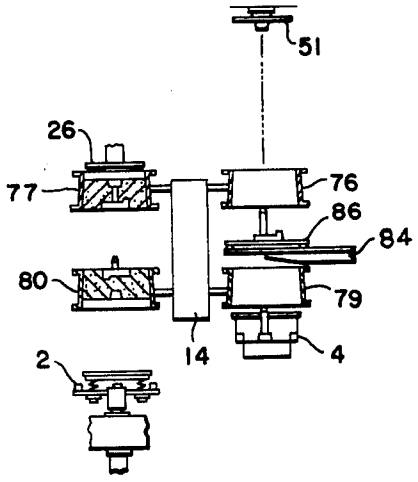


Fig. 39

PROCESS FOR PRODUCING FOUNDRY SAND MOLDS

This application is a division of Ser. No. 131,528, filed Apr. 5, 1971, now U.S. Pat. No. 3,815,662; which is a divisional of Ser. No. 672,063, filed Oct. 2, 1967, now U.S. Pat. No. 3,589,432.

This invention relates generally as indicated to a foundry molding machine and method and more particularly to a high speed automatic match-plate molding machine and process for producing as many as 120 completed foundry molds per hour.

Automatic match-plate molding machines have heretofore been employed to produce completed foundry molds but match-plate molding machines generally require the operator to stop the cycle of the machine in order to afford sufficient time to set cores. This substantially reduces the productive capacity of the machine. The ability to employ both a high pressure squeeze and a jolting action normally ensures molds rammed to a uniform high hardness and quality. It is therefore highly desirable to provide a match-plate molding machine and method which will have the high productive capacities heretofore noted and which will yet produce accurate molds of uniform high hardness.

It is accordingly a principal object of the present invention to provide a foundry molding machine and method which will produce rapidly complete foundry molds uniform high hardness and density.

It is another principal object to provide a matchplate molding machine and method in which the molds can be cored without reducing the cycle time of the machine or process.

A further principal object is the provision of a match-plate molding machine and method which can utilize both a high pressure ramming and a jolt action to obtain the desired mold hardness and uniformity.

Another object is the provision of a match-plate molding machine and method which employs a preliminary compaction of the sand within the drag prior to the final high pressure squeeze of the sand in both the cope and drag.

A further object is the provision of a match-plate molding machine and method which employs two sets of flasks which can be indexed as a pair between two stations permitting a mold to be formed at one station while the mold is cored and closed at the other station.

Yet another object is the provision of a match plate molding machine in which the size of the molds produced can readily be changed.

A still further object is the provision of a match-plate molding machine utilizing an over-head pneumatic squeeze avoiding long stroke hydraulic mechanisms.

Yet a further object is the provision of a match-plate molding machine utilizing unique indexing cylinder assemblies for movement of the sand filled flasks avoiding shocks which might affect the quality of the molds produced.

Another object is the provision of a match-plate molding machine which avoids high stresses on the match-plate while still providing a high pressure and squeeze and jolt action.

Still another object is the provision of unique slip flasks for the production of match-plate molds which will retain the sand cakes therein until positively stripped therefrom.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

In said annexed drawings:

FIG. **1** is a side elevation partially broken away of a machine in accordance with the present invention;

FIG. **2** is a front elevation of the machine seen in FIG. **1** as viewed from the line **2—2** of FIG. **1**;

FIG. **3** is an enlarged rear elevation of the machine shown in FIGS. **1** and **2** with parts thereof partially broken away;

FIG. **4** is a somewhat enlarged top plan view of the jolt table assembly;

FIG. **5** is a fragmentary vertical section of the jolt table with parts broken away taken substantially on the line **5—5** of FIG. **4**;

FIG. **6** is an enlarged side elevation partially broken away of the head assembly of the machine;

FIG. **7** is a rear elevation of the head assembly partially broken away as taken substantially from the line **7—7** of FIG. **6**;

FIG. **8** is an enlarged fragmentary front elevation of the head of the machine showing in greater detail the roll-over mechanism;

FIG. **9** is a side elevation partially broken away illustrating the roll-over and indexing mechanism as viewed from the right-hand side of FIG. **8**;

FIG. **10** is a fragmentary top plan view of the machine as taken substantially from the line **10—10** of FIG. **1**;

FIG. **11** is an enlarged fragmentary detail view partially broken away and in section of the piston-cylinder assembly used for the roll-over and indexing operations of the machine;

FIG. **12** is an enlarged exploded view of the cope and drag flasks with the match-plate therebetween with portions of the flasks broken away and in section;

FIG. **13** is an end elevation of such cope and drag flask-match-plate assembly as taken substantially from the line **13—13** of FIG. **12**;

FIG. **14** is a plan view of the match-plate as seen from the line **14—14** of FIG. **12**;

FIG. **15** is a top plan view of the cope flask as seen from the line **15—15** of FIG. **12**;

FIG. **16** is a side elevation of the base and match-plate support assembly with the cope and drag flasks being shown in phantom lines and also showing the roll-over position of the match-plate and drag flask in phantom lines;

FIG. **17** is an enlarged horizontal section taken substantially from the line **17—17** of FIG. **16**;

FIG. **18** is a fragmentary vertical section partially broken away of the closing table assembly;

FIG. **19** is a side elevation of such assembly partially broken away taken substantially from the line **19—19** of FIG. **18**;

FIG. **20** is a vertical section taken substantially on the line **20—20** of FIG. **18**;

FIG. **21** is a front elevation of the mold push-off and bottom board feeder;

FIG. 22 is a top plan view of the mold-push-off and bottom board feeder seen in FIG. 21;

FIG. 23 is a vertical section taken substantially on the line 23—23 of FIG. 21 showing the bottom board feeder and mold push-off in end elevation;

FIG. 24 is an enlarged detail section of the bottom board stop latch assembly taken substantially on the line 24—24 of FIG. 21;

FIG. 25 is a schematic piping diagram illustrating more clearly the operation of the various components of the machine;

FIG. 26 is a time and motion chart illustrating the sequence of the operation of the components of the machine;

FIG. 27 is a time and motion diagram illustrating the movement of the jolt table during the cycle of the machine;

FIGS. 28 through 35 are schematic illustrations illustrating the sequence of operation through the beginning of the mold closing operation;

FIG. 36 is an enlarged schematic illustration indicating the mold contacting the stripping plate and the relation of the flask stripping abutments;

FIGS. 37 through 39 are schematic views similar to FIGS. 28 through 35 illustrating the remaining sequence of operations for the completion of the cycle; and

FIG. 40 is a portion of the schematic wiring diagram illustrating some of the table position responsive switches and the means to select one of a group of such switches for operation in the circuit.

MACHINE — GENERAL ARRANGEMENT (FIGS. 1-3)

Referring first to FIGS. 1 to 3, it will be seen that the illustrated embodiment comprises a fabricated base 1 which supports from left to right as seen in FIG. 1 a closing table assembly 2, a turret base 3, a jolt table assembly 4, and laterally spaced posts 5 and 6 at the rear of the machine. Such posts comprise spacers which include forwardly offset supports 7 fastened to brackets 8 of the base and rods extending through such spacers and through bosses 9 projecting laterally from the base. Such rods may be held in place by nuts indicated at 10.

A head frame 12 is supported by the columns 5 and 6 and also by turret post 13 which extends upwardly from the turret base 3 through turret sleeve 14. The lower end of the turret sleeve 14 is secured to a thrust disc 15 surrounding split bushing 16 which in turn surrounds the turret post 13 and such disc is supported on tapered thrust rollers 17 in turn supported on thrust roller support 18 mounted on the turret base 3. The upper end of the turret sleeve 14 is secured to split bushing 19 surrounding bushing 20 on the upper reduced diameter portion of the post 13. Sand shields such as indicated at 21 cover the relatively rotating parts of the thrust sleeve and post. The upper end of the post 13 is secured in forwardly extending turret cylinder support frame 23 which is secured to frame 24 forming the forward wall of the head frame 12. Pendently secured to the outer or forward end of the frame 23 is a housing 25 which is closed at its lower end by pressure plate 26. A cylinder bracket 27 in the housing 25 provides a vertical axis trunnion support indicated at 28 for indexing piston-cylinder assembly 29.

The head frame 12 which extends between the post 13 and the rear posts 5 and 6 supports vertically extending pneumatic squeeze cylinder assembly 31 and sand hopper 32 in side-by-side fixed relation at the top of the machine. As seen more clearly in FIG. 3, the head frame 12 includes an inverted U-shape frame member 33 bridging the posts 5 and 6 and a rearwardly extending cylinder support bracket 34 is secured thereto which includes depending open frame 35 which in turn supports on the interior thereof sand box cylinder assembly 36 and slide plate cylinder assembly 37. The rod of the piston-cylinder assembly 36 is connected at 38 to the sand box carriage 39. The rod of the piston-cylinder assembly 37 is connected to slide plate 40 positioned subjacent the bottom of the sand box 39 and supported on rollers 41 mounted on brackets secured to the underframe member 42 of the head frame 12. The slide plate 40 is also secured to rearwardly extending rails 43 and 44 which fit between paired V-groove rollers 45 mounted on the frame 35. The frame 35 also supports the ends of fixed rails 46 and 47 on which ride the V-groove rollers 48 supporting the sand box 39 for shuttling movement. The sand box includes a top cut-off plate 49 which extends rearwardly of the hopper 32 in the retracted position to block flow of sand from the hopper as the sand box carriage is indexed forwardly.

The squeeze piston-cylinder assembly 31 includes a pair of rods supporting on their ends squeeze board 51 in sand retracted position will vertically clear the top of the sane box 39 to permit the latter to be indexed therebeneath. Horizontally extending pivot shafts 53 and 54 are each mounted between spaced shaft support brackets 55 and 56 secured to the underside of the head frame 12. U-shape trunnion supports 57 and 58 are secured to such shafts 53 and 54, respectively, and each support is provided with inwardly directed arcuately arranged sets of rollers indicated at 59. Trunnion links 60 and 61 are also secured to the shafts 53 and 54, respectively, and such links are interconnected by otherwise unsupported piston-cylinder assembly 62. As indicated, the rod of the assembly is pivotally connected to the link 61 while the blind end of the assembly is pivotally connected to the link 60.

A roll-over cylinder mounting bracket 63 is secured to the side of the head frame 12 and pivotally supports the blind end of roll-over piston-cylinder assembly 64 at its upper end as indicated at 65. The rod of the assembly 64 is connected to a clevis 66 which is connected to roll-over stop arm 67 mounted on a pin journalled in hub 68 which is provided on its inner end with a roll-over locater 69. Such locater comprises an elongated key which is normally in a vertical orientation and which can be swung through 180° by the action of the roll-over piston-cylinder assembly 64.

Supported on the turret sleeve 14 are a pair of cope flask support arms 71 and 72 and vertically therebeneath drag flask support arms 73 and 74. Each arm extends on both sides of the turret as seen more clearly in FIG. 1. Each of the cope flask supporting arms is provided with inwardly offset pairs of locating pins indicated at 75 which locate and support cope flasks 76 and 77, one on each side of the center turret. Similarly, the drag flask support arms 73 and 74 are each provided with inwardly offset pairs of locating and supporting pins 78 which are spaced somewhat farther apart than the pins 75 on the cope supporting arms 72. The paired pins 78 support drag flasks 79 and 80 in vertically spaced alignment with the cope flasks 76 and 77, respectively, one set of such flasks being on each side of the turret sleeve 14. The cope and drag supporting

arms are vertically interconnected by gusset plates **82** and **83** cut to the shape seen more clearly in FIG. **2** to clear supporting arms **84** and **85** for match-plate **86** which is held in vertical alignment with the cope and drag flasks **77** and **80** and also in vertical alignment with the jolt table assembly **4** and the squeeze head **51.** The match-plate **86** is supported on inwardly offset upwardly projecting pairs of buttons shown at **87** and **88,** one of each pair being on the arms **84** and **85.**

The paired cope and drag flasks are indexed to opposite sides of the turret by the indexing piston-cylinder assembly **29** and when the flasks are above the jolt table assembly **4** they are adapted to be assembled with the match-plate **86** therebetween for the ramming of sand therein. When on the opposite side of the turret above the closing table assembly **2,** the flasks with the sand cakes therein are adapted to be cored in such vertically spaced condition and then cooled and stripped from the flasks to be placed upon a bottom board and pushed from the machine by the bottom board dispenser and mold push-off assembly shown generally at **90** in FIG. **2.** The bottom boards are placed in a magazine **91** and indexed onto the closing table **92** by mold push-off carriage **93** which also moves mold push-off plate **94** moving the completed mold on the bottom board previously indexed onto the closing table **92** from the machine on a suitable conveyor, extending to the right as seen in FIG. **2** or toward the viewer as seen in FIG. **1.**

JOLT TABLE ASSEMBLY (FIGS. 4 and 5)

Referring now additionally to FIGS. **4** and **5,** it will be seen that the jolt table assembly **4** includes a jolt table base **97** which is secured by fasteners **98** to the upper reduced diameter ends of rods **99** of lift piston-cylinder assemblies **100** and **101.** The jolt table base receives in its cylindrical bore cylindrical extension **103** of the jolt table **104** and piston rings **105** are provided between the cylindrical surfaces. The base **97** is provided with bosses **106** in which are positioned guide bushings **107** which receive guide pins **103** depending from the table **104.** Stop nuts **109** are provided on the lower ends of the guide pins limiting relative movement between the jolt table and the jolt base. The top of the table is provided with a wear plate **110** and upstanding locating pins **111** and **112** are secured in opposite lateral extensions **113** from the skirt portion **114** of the table **104.**

The cylindrical projection **103** receives within its interior cylindrical surface jolt ram **116** and piston rings **117** are provided between the exterior surface of the jolt ram and the interior surface of the cylindrical projection **103** of the table **104.** A poppet guide **118** is secured in the top of the table **104** which includes a vertically extending guide pin **119** surrounded by poppet valve member **120** which is urged by compression spring **121** to its lowermost or closed position. Jolt air pressure is supplied to the upper side of the poppet valve member **120** through passage **122** in the table seen more clearly in FIG. **4.** The upper end of the ram **116** is provided with an L-shaped passage **123** which communicates with exterior groove **124** which, when the ram moves down, communicates with a plurality of exhaust ports **125** in the cylindrical projection **103.** Such exhaust ports are in communication with vertically elongated annular passage **126** in the exterior of the projection **103** and such passage communicates with the exhaust ports **127.** The lower end of the ram **116** is supported by air pressure within the plenum chamber **123** therebeneath and such pressure is supplied through port **129** from servo valve **130** which includes a sensing arm **131** sensing the position of the table with respect to the jolt base. When the pressure in the chamber **128** is exhausted or at a reduced level, the ram will seat against the projections **132** as will the lower edge of the cylindrical projection **103** so that the table **104** will be bottomed and thus firmly supported when the jolt mechanism is not in operation. Reference may be had to the copending application of Edward D. Abraham et al. Ser. No. 629,599 entitled "Foundry Molding Machine," filed Apr. 10, 1967 for a more clear disclosure of the illustrated jolt mechanism.

The rods **99** of the lift piston-cylinder assemblies **100** and **101** have a reduced diameter lower end portion indicated at **134** which terminates in a threaded end portion **135.** A nut and washer illustrated at **136** secures piston **137** to the lower end of cash rod. The pistons are provided with packings **138** which slidingly seal the piston with respect to the cylinder **139.** A pilot member **140** is secured between the piston and the shoulder end of the rod and cooperates with cushion ring **141** positioned between the head flange **142** of the cylinder **139** and the cylindrical boss **143** of the base **1.** The head flange **142** and the boss **143** are held togethr by fasteners **144** and the rod **99** extends through a guide bushing **145** held to the boss by fasteners **146.** Air is supplied to the top of the piston through port **147** and branch passage **148** bypasses the cushion ring **141** through check valve **149.** Air is supplied to the bottom of the piston through port **150** in the bottom head **151** of the cylinder **139** held to the cylinder flange **152** by fasteners indicated at **153.**

In its lowermost position, the table base **97** is supported on adjustable stop buttons **154** and a spring pilot, not shown, is provided to cushion the base in its lowermost position.

SAND DISPENSER (FIGS. 6 and 7)

Referring now additionally to FIGS. **6** and **7,** it will be seen that sand in the hopper **32** falls through chute **160** through an aperture in the cut-off plate **49** forming a part of the sand box carriage into the sand box, the bottom of which is closed by slide plate **40.** This condition will be obtained when both of the piston-cylinder assemblies **36** and **37** are retracted. A sand wiper **161** surrounds the chute **160.** A sand wiper **162** also surrounds the lower end of the sand box **39.** The lower end of the wiper **161** rubs against the top surface of the plate **49** while the wiper **162** rubs against the top surface of the slide plate **40.**

The piston-cylinder assemblies **36** and **37** are secured to the interior of the cylinder assembly support frame **35** which is held by the cylinder support bracket **34** to the rear of the main head frame **12.** As seen perhaps more clearly in FIG. **7,** the support frame **35** also supports sand box carriage rails **46** and **47** on which the V-groove rollers **48** ride. It is noted that there are two such rollers for each rail supporting the carriage for shuttling movement to and from a position beneath the hopper **32** and beneath the squeeze head or board **51.** It is noted that each of the rails **46** and **47** extends from the cylinder support frame **35** at the rear to mounting bracket **164** near the front of the head frame so that when the piston-cylinder assembly **36** is extended, the carriage will move to the phantom line position indicated at **165** vertically aligned with the squeeze board and the cope or drug flask therebeneath.

The rails **43** and **44**, which are secured to the slide plate **40** and extend rearwardly thereof, are each vertically confined between a pair of rollers **165** mounted on bracket **167** secured to the posts **5** and **6** by the fasteners indicated generally at **168**. Such rails also extend between the vertically spaced V-groove rollers **45** secured to the exterior of the cylinder support frame **35** and in this manner the slide plate **40** is held in horizontal position regardless of the position thereof. The formed edge of the slide plate **40** is, of course, supported by the cylindrical rollers **41** and thus maintained against the underside of the sand box carriage. Accordingly, the sand box carriage and the slide plate are independently movable at the direction of the respective piston-cylinder assemblies. The position of the sand box carriage and the slide plate is ascertained during the cycle of operation of the machine by limit switches illustrated at **170** and **171** which are tripped respectively by adjustable actuators shown at **172** and **173**, and **174** and **175**. The switch actuators **172** and **173** are mounted on the cut-off plate **49** of the sand box carriage **39** and it can be seen that in the retracted position the actuator **172** will trip limit switch **170** while in the extended position the actuator **173** will trip such limit switch. The actuators for the limit switch **171** for the slide plate **40** are mounted on the rail **43** and sense the extended and retracted position of the slide plate.

It will be understood that when both the slide plate and the sand box carriage are retracted, sand will drop into the box **39** which is closed by the plate **40**. When both the sand box carriage and the slide plate **40** are extended to the phantom line position **165**, a charge of sand will be positioned over the flask therebeneath. The sand box carriage and the slide plate are thus indexed forwardly simultaneously. Now, with the sand box carriage held in the extended position, the slide plate **40** is retracted and the charge of sand drops into the flask. When the sand box carriage retracts, the aperture in the cut-off plate then moves beneath the hopper and its associated chute and sand again drops into the sand box with the slide plate closing the bottom of the box. It will be understood that a sand box utilizing conventional power operated louver doors may equally well be employed.

ROLL-OVER AND INDEXING (FIGS. 8—11)

Referring first to FIG. **8**, the roll-over piston-cylinder assembly **64**, the clevis **66** of which is connected to the distal end of the roll-over stop arm **67**, which pivots the roll-over locater key **69** through 180°, is limited in its movement by adjustable stops **178** projecting upwardly through stop bracket **179** secured to the hub **68** at the lower end of the roll-over mounting bracket **63**. The clevis **66** is provided with a limit switch actuator **180** which engages limit switches **181** and **182** at the opposite ends of the roll-over stroke. A further limit switch actuator **183**, which is secured to the back end of the roll-over locater **69** adjacent the stop arm **67**, engages switch **184** at the midpoint of the roll-over stroke. In FIG. **8**, the cylinder **64**, the stop arm **68** and thus the actuator **183** are shown at midposition. The midposition limit switch **184** is employed to reverse the piston-cylinder assembly **64** at the midpoint of the roll-over.

The roll-over locater key **69** fits within the crotch of the U-shape trunnion arm **58** as does fixed vertical key **186** secured to the depending portion of the bracket **63**. It will be understood that the locater key rotates from a vertical position 180° to a vertical position and in both such positions will be vertically aligned with the fixed key **186**.

The trunnion arms **57** and **58** in their flask supporting position will project slightly interiorly of the locater key **69** and in their retracted position as seen at **187** in FIG. **8**, they will be substantially exteriorly of the key. Extension and retraction of the trunnion arms is, of course, obtained by the piston-cylinder assembly **62**, the blind end of which is pivoted at **188** to trunnion link **60** while the rod eye **189** thereof is pivoted at **190** to the trunnion link **61**. A limit switch **191** is mounted on bracket **192** secured to the rod end of the cylinder assembly **62** and such switch is actuated by the cammed ends of limit switch actuator **193** mounted on the rod eye **189**. Retraction of the piston-cylinder assembly **62** will move the assembly to the phantom line position **194** seen in FIG. **8** which simultaneously retracts the trunnion arms **57** and **58**, the latter to the phantom line position **187**. Inward movement of the trunnion arms is limited by adjustable stops **195** secured in brackets **196** while outward movement is limited by adjustable stops **197** on the trunnion links **60** and **61**.

The turret piston-cylinder assembly has its rod eye **199** connected by pin **200** between plates **201** and **202** secured to the turret sleeve **14**. The plate **201** includes a radially projecting offset arm **203** adapted to engage adjustable stops **204** and **205** in the depending portions of the head frame member **24**. The offset arm **203** also includes limit switch actuators **206** and **207**. The actuator **206** engages limit switches **208** and **209** at each end of the indexing stroke while the actuator **207** engages limit switch **210** sensing the midpoint of the indexing stroke. As seen more clearly in FIG. **9**, this latter limit switch is secured to the underside of the turrent cylinder support and pressure plate bracket **23**. In FIG. **9**, the arm **203** is shown in phantom line position at the midpoint wherein the actuator **207** engages the limit switch **210**.

It can now be seen that the roll-over piston-cylinder assembly **64** like the turrent indexing piston-cylinder assembly **29** is controlled by limit switches at the ends of the stroke as well as a midposition limit switch. Structurally, the piston-cylinder assemblies **64** and **29** are substantially the same and FIG. **11** illustrates the unique piston-cylinder assembly employed to obtain both the indexing and roll-over functions of the machine.

In FIG. **11**, there is illustrated broken away and in section the turrent indexing cylinder **29** but it will be appreciated that the roll-over cylinder **64** is substantially identical in form and operation. The assembly comprises a cylinder barrel **212** extending between rear head **213** and front head **214**. A bearing housing **215** is secured to the front head by suitable fasteners **216** and is provided with a bushing **217** interposed between two sliding seals. The bushing rides against piston rod **218** which is secured by fasteners **219** to piston **220**. The piston is provided with seals running against the interior of the cylinder barrel **212** and the exterior of hollow fixed rod **221**. The fixed rod is secured to the rear head **213** by the nut indicated at **222** and a connection **223** is provided for a hydraulic line.

At its forward end, the hollow fixed rod **221** is provided with a piston **225** which is secured thereto by nut **226**. The piston **225** is provided with seals against the interior of the hollow rod **218** and includes an annular skirt **227** which retains ball **228** in check valve orientation with the beveled seat of port **29**.

Fasteners **230** secure to the forward end of the rod **218** rod cap **231** which is provided with air breather ports indicated at **232.** A trunnion mounting **233** is provided and tie rods **234** interconnect the front and rear heads with the trunnion mounting. The front head **214** is provided with a laterally extending tapped port **236** to which a pneumatic line is connected, while the rear head **213** is provided with rearwardly extending tapped port **237** to which a pneumatic line is connected. The interior of the fixed rod **221** is, of course, connected to a source of hydraulic pressure by means of the connection **223** and the interior of the fixed rod **221** is in communication with oil chamber **238** through a plurality of ports **239.**

To retract the assembly, air is supplied through the port **236** to the rod end of the assembly entering air chamber **240** moving the piston **220** to the rear. Oil enters the oil chamber **238** through the check valve port **229** and the ports **239** as they are uncovered by rear movement of the piston **220.** To extend the piston-cylinder assembly, air is supplied through the port **237** and oil now cannot escape from the oil chamber **238** except through the ports **239** since the check valve port **229** will be closed. As the piston **220** approaches the end of its stroke, it will successively cover the ports **239** restricting oil flow from the chamber **238** causing a controlled deceleration. The port directly beneath the ball **228** may be quite small in diameter while the other ports may be somewhat larger. This decelerates the rod of the piston-cylinder assembly on extension and accordingly there is obtained a snubbing and shock absorbing action.

The valving for the piston-cylinder assemblies as seen more clearly in FIG. **10** is controlled by the limit switches and particularly the neutral limit switch **210** which will cause the piston-cylinder assembly to reverse its stroke. For example, the piston-cylinder assembly **29** will initially retract until the limit switch **210** is tripped and it will extend and obtain in its extension the deceleration or shock absorption obtained by the ports **239** communicating with the oil chamber **238.**

COPE-DRAG-MATCH-PLATE (FIGS 12–17)

Referring now to FIGS. **12, 13, 14** and **15,** it will be appreciated that the machine is provided with paired sets of cope and drag flasks and a single match-plate. During the mold forming operation, a drag will be elevated by the jolt table to pick up the match-plate and the two are then further elevated to pick up the cope flask to form the cope-match-plate-drag assembly. The cope **77** comprises four side wall members **242, 243, 244** and **245,** each of which may comprise aluminum castings having top and bottom flanges as indicated at **246** and **247** for the wall **244** and angularly directed end flanges shown at **248** and **249** which are joined to the opposing end flanges of the adjacent wall member by fasteners **250** extending through filler blocks **251.** The interior surfaces of the flask wall members are provided with liner plates **252** which are provided with studs projecting through the wall members and secured in place by the nuts indicated at **253.** The liners **252** are preferably provided with a lamination of rubber material on the order of about ⅛ inch thickness on the interior surface thereof which will assist the retention of the sand cake within the flask. Alternatively, a series of indentations providing a waffling or knurled effect may be on the interior surface of the liner. The inner surface of the flask tapers at about 3°. The lower peripheral edge of the flask is provided with a wear plate indicated at **254** secured in place by fasteners **255.**

The end wall members **243** and **245** each include vertically oriented outwardly projecting walls **257** and **258** to the outer ends of which are secured by fasteners **259** split trunnion members **260.** Each split trunnion member includes a semi-circular ridge **261** and outward projections forming vertically oriented keyway **262.** Between the walls **257** and **258** at the top of the cope there is provided a bridge portion **263** which receives guide bushing **264,** the top edge of which is beveled as indicated at **265** in FIG. **12.** Between each of the wall members **257** and **258** adjacent the bottom of the cope flask there is provided a projection **266** which includes a guide bushing **267.** The guide bushing **267** and **264** are vertically aligned between the outwardly projecting walls **257** and **258** on each end of the flask. Exteriorly of the walls **257** and **258** on each end of the flask, there is provided horizontally aligned projections as seen at **269** and **270** in FIGS. **13** and **15,** each of which is provided with a guide bushing **271** and a stop button **272.** The guide bushings mate with the locater pins **75,** seen, for example, in FIG. **2,** and the stop buttons contact the adjustable stops **273** seen on the cope supporting arms **71** and **72.**

The drag flask **80** is similarly constructed and includes opposite side wall members **274** and **275** and end wall members **276** and **277.** The side wall members may comprise aluminum castings held together in the same manner as for the cope flask which filler blocks between the mating end flanges. An upset ring **278** is secured to the bottom of the flask walls by the fasteners **279.** The similarly constructed upset ring **278** has straight or vertical interior walls while the interior wall of the main portion of the drag flask, like the entire interior of the cope flask is provided with a taper on the order of 3°. Also like the cope flask, the interior surface of the tapered portion of the drag flask is provided with liners **280** held in place by fasteners **281** and again a lamination of rubber or like material is provided on the interior surface to facilitate the holding of the sand cake within the flask. A top wear plate **282** is secured to the flask by fasteners **283.**

The top end walls of the flask **276** and **277** are each provided with laterally spaced vertically oriented outwardly projecting walls indicated at **284** and **285** to the ends of which are secured split trunnion members **286** by the fasteners indicated at **287.** Such split trunnion members may be identical in form to those secured to the ends of the cope flask and each one comprises a semi-circular ridge **288** and an outwardly projecting vertically oriented keyway **289.** Behind each split trunnion member projecting from the end walls of the flask are projections **290** to which are secured upwardly extending locater pins **291** and **292.** At the bottom edges of the projecting members **284** and **285** is a bridge member **294** and each bridge member is provided with a guide bushing **295** having a downwardly flaring pilot edge **296.**

Each end wall of the drag flask is provided with two projections indicated at **297** and **298** in FIG. **13,** each of which is provided with a guide bushing **299** and a stop button **300.** The guide bushings **299** fit over the locater pins **78** on the cope flask supporting arms **73** and **74,** seen more clearly in FIG. **2,** and the stop buttons will be engaged by the adjustable stops **301.** It is noted that the projections **297** and **298** of the drag flask are more widely spaced than the projections **269** and

270 on the cope flask and this provides a clearance between such projections and the centrally projecting split trunnion for the cope flask supports to pass therethrough. Four hex rest buttons **302** are provided on the underside of the drag flasks secured in place of the studs **303**.

The guide bushings **295** and the locater pins **291** and **292** are vertically aligned with each other as well as with the guide bushings **267** and **264** on the cope flask. The guide bushings **295** of the drag flask as well as the guide bushings **264** of the cope flask are adapted to receive the guide pins **111** and **112** on the jolt table assembly **4**. The rest buttons **302** will be contacted by the adjustable stops **305** seen in FIGS. **4** and **5**.

The match-plate **86** which fits between the cope and drag flasks in the molding station is seen more clearly in FIG. **15** and includes projections **306** at the corners to which support buttons indicated at **307, 308, 309** and **310** are secured. The buttons **307** and **309** may be provided with conical cavities indicating generally at **311** while the buttons **308** and **310** may be flat on the bottom. These buttons are adapted to be contacted by the adjustable supports **87** and **88** on the arms **84** and **85** seen more clearly in FIG. **1**.

The match-plate also includes center opposite projections **312** and **313** in which are situated guide bushings **314** and **315** which are vertically aligned with the guide pins **291** and **292** projecting upwardly from the drag flask **80**. The edge of the projection for the stop button **309** is provided with a radius at each corner as indicated at **316** in FIG. **14** to avoid excessive wear to the air hose which is connected to the quick disconnect coupling **317** on the underside of the match-plate. The coupling is connected by elbow **318** to hose **319** connected to vibrator **320**. It will be appreciated that the match-plate will be provided on its top with a cope pattern and on its bottom with a drag pattern and these may be removably secured in place.

It will be appreciated that the guide pins **291** and **292** will project upwardly through the guide bushings **314** and **315** pinning the drag and match-plate together and continued upward movement of the sub-assembly of the match-plate and drag will then cause the guide pins **291** and **292** to enter the guide bushings **267** in the cope flask pinning the entire assembly together.

Referring now to FIGS. **16** and **17**, it will be seen that the hose **322** connected to the quick disconnect coupling **317** on the match-plate **86** is connected at its opposite end to swivel manifold **323** mounted on the post **6** and in the upright position of the match-plate on the arms **84** and **85** the hose will be draped against a support **324** extending between such arms. As the drag flask **80** is elevated to pick up the match-plate, the hose **322** flask **80** is elevated to pick up the match-plate, the hose **322** with considerable drape therein will be elevated along with the match-plate and when the assembly is turned over by the roll-over mechanism, the hose will be draped over the bottom of the upturned drag. To facilitate this draping of the hose **322** over the bottom of the drag **80**, hose recesses seen at **325, 326** and **327** in FIG. **13** may be placed in the projecting portions of the drag.

A limit switch enclosure **328** is supported from the post **5** by brackets **329** and **330**. A limit switch holder bracket **331** is secured to the base **97** of the jolt table assembly **4** and supports at its outer end limit switch magnet holder **332**. The holder **332** is positioned to move adjacent the limit switch enclosure **328** as the jolt table assembly elevates assembling the drag, matchplate and cope.

At the rear of the base **1**, brackets **333** are provided for oil-air tanks **334** and **335**.

CLOSING TABLE ASSEMBLY (FIGS. 18–20)

The closing table assembly **92** includes a guide head **337** which is secured to the upper ends **338** of the rods of lift piston-cylinder assemblies **339** and **340** by the suitable large fasteners **341**. Lateral projections **342** and **343** are provided on each side of the guide head at each rod connection and each projection includes fore and aft projections seen at **344** and **345**. The center of each main projection is provided with a guide bushing as indicated at **346** through which project guide pins **347** secured to the closing table **92**. The lower end of each guide pin is threaded and a guide pin stop collar **348** is affixed to the guide pin beneath the guide limiting upward movement of the table **92** with respect to the guide head **337**. The exterior projection **345** of each lateral projection is provided with an adjustable stop screw **349** held in place by lock nut **350**. The four such stops thus provided are arranged to contact the rest buttons **302** on the bottom of the drag flask **80** seen more clearly in FIG. **12**.

The interior projections **344** of each of the four lateral projections is provided with an upstanding guide pin **352**, centering compression spring **353**, the upper end of which is received within retainer **354** secured to the underside of the table **92**. The compression springs urge the table upwardly with respect to the guide head **337** to the extent permitted by the adjustable stop collars **348**.

The guide head **337** is provided with two adjustable stop screws **355** held in adjusted position by lock nuts **356** which screws are adapted to be contacted by buttons **357** on the underside of the table **92** limiting movement of the table **92** toward the guide head **337**.

Three rails **359** are mounted on the table **92** by the fasteners indicated at **360** and such rails extend parallel to the direction of movement of the bottom board **361** placed thereon by the bottom board dispenser and mold push-off **90**. As seen in FIG. **20**, the guide head **337** is supported in its lowermost position on the base **1** by adjustable stops **363** and **364** and a cushion spring **365** surrounds cushion guide rod **366** which is threaded in the underside of the guide head **337** as indicated at **367**. The head **368** of the guide rod **366** projects through aperture **369** in the base **1**, the upper end of which is beveled as shown at **370**. A cushion spring seat **371** is slidably mounted on the rod **366** and engages the beveled portion **370** of the aperture **369** compressing the spring **365** as the guide head **337** descends to its lowermost position. A similar spring cushion arrangement is provided for the jolt table assembly in its lowermost position.

A limit switch actuator **372** is secured by bracket **373** to the end of the guide head **337** and engages limit switch **374** signalling that the closing table assembly **2** is in its lowermost position.

BOTTOM BOARD DISPENSER AND MOLD PUSH-OFF (FIGS. 21–24)

The bottom board dispenser and mold push-off assembly **90** is mounted on a frame **375** at the side of the base **1** as indicated more clearly in FIG. **21** and such frame includes a pedestal **376** from which extends a main support plate **377** to which is secured two C-

shape plates 378 and 379. These plated may be connected at their outer ends by tubular frame member 380. These plates are also interconnected adjacent the lower edges of the openings 381 therein by bottom board rails 382 and 383. Bottom boards are stacked on top of such rails within the magazine 91 which is formed at the four corners of the magazine by the bottom board guides 384.

Bottom board carriage 93 comprises a main vertically oriented elongated plate 386 which is supported on rollers 387 and 388 at the lower edge thereof which are mounted on the frame 375 and the top edge is confined between pairs of rollers indicated at 389 and 390. Additional back-up rollers seen at 391 in FIG. 23 are also provided maintaining the plate 386 and thus the carriage in its proper position. The sets of rollers 389 and 390 as well as the rollers 391 are mounted on the main vertical frame plate 377.

The carriage 93 includes a frame 393 projecting outwardly from the main frame plate 386, which frame includes an outboard longitudinal member 394 parallel to the main plate 386 which projects through the openings 381 in the frame members 378 and 379. The outboard frame member 394 is joined at the rear of the carriage to the main plate by member 395 and also to the main plate at the front of the carriage by member 396. The upwardly projecting mold push-off plate 94 is connected to the front carriage cross member 396. Within the carriage frame, there is a horizontal plate structure shown generally at 397 which includes side plates 398 and 399, each of which is provided with a shoulder as indicated at 400 and 401, respectively. These shoulders which are aligned engage behind the edge of a bottom board supported on the bottom board rails 382 and 383 and when the carriage is indexed forwardly, they will shove the lowermost bottom board forwardly onto the closing table assembly 2. The plate structures 398 and 399 from the shoulder to the forward end of the carriage present an opening which is wider then the bottom boards within the magazine. The remaining bottom boards within the magazine will be retained in place by the lower edges of the forward bottom board guides 384 and the plate structures 398 and 399 will simply slide beneath the stack of bottom boards as the lowermost one is dispensed forwardly.

The carriage is indexed by the piston-cylinder assembly 402 mounted on the interior of the main frame plate 377. The rod 403 of the piston-cylinder assembly is connected at 404 to bracket 405 extending laterally from the main carriage plate 386.

A stop latch frame 407 is pivoted to pins 408 and 409 mounted on laterally spaced pairs of brackets 410 extending from the C-shaped frame plate 379. The pin 409 also serves as the axle for the roller 388. The front of the frame is provided with upstanding stop blocks 411 and 412 which in the elevated position of the latch frame will block movement of the bottom boards to the right as seen in FIG. 21. The arm 413 of the frame 407 is off-set as indicated at 414 and the inner inwardly off-set portion of such arm extends over the roller 415 on bell crank 416 pivoted at 417 to the frame 1. A stop 418 limits counterclockwise movement of the bell crank as seen in FIG. 21 and the stop latch assembly will normally be supported in the position indicated with the stop blocks 411 and 412 beneath the path of movement of the bottom boards. The roller 419 on the longer arm of the bell crank 416 projects into the path of cam 420 which is longitudinally adjustably secured by fasteners 421 to the main carriage plate 386. Accordingly, as the carriage indexes forwardly, the cam 420 will strike the roller 419 pivoting the bell crank in a clockwise direction as seen in FIG. 21 elevating the frame 407 to position the stop blocks 411 and 412 within the path of the bottom board indicated at 422 being dispensed onto the rails 359 of the closing table 92. The stop blocks will be elevated after the preceding bottom board 423 with the completed mold 424 thereon has cleared. The completed mold and bottom board are pushed from the closing table onto conveyor 425 by the mold push-off plate 94 on the leading end of the carriage 93 which moves to the phantom line position indicated at 426. The main carriage plate 386 will move to the phantom line position indicated at 427.

A limit switch 429 is mounted on the frame member 378 and is adapted to be tripped by actuators 430 and 431 mounted on the exterior of the outboard carriage frame member 394. The limit switch signals and the sand cake or completed mold push-out forward and return. The action of the carriage in pushing the completed mold or sand cake out, of course, also deposits a bottom board on the closing table assembly 2 for receipt of the next completed mold from the cope and drag flasks thereabove.

It will be appreciated that the bottom board may, if desired, be placed on top of the sand in the drag flask immediately after the drag is filled with the preliminary squeeze driving the bottom board about an inch into the drag flask. If the bottom board is added at that time, it may be retained in place by means of resilient rubber latch inserts or a piston-cylinder operated latch.

FLUID CONTROLS (FIG. 25)

The various components of the machine are operated principally by pneumatic systems and air for such systems is supplied through three-way cock valve 435 through filter 436 and lubricator 437 to main manifold pressure line 438. The first valve in the manifold 439 is a double solenoid four-way valve which is operative to move the squeeze board 51 up and down. The valve 439 supplies pilot pressure to normally closed three-way valve 440 and normally open three-way valves 441 and 442. With the latter two valves open, air is supplied from source 443 to the rod end of the squeeze cylinder 31 and the upper or blind end of the cylinder is vented in the normally closed condition of valve 440. In this manner, the squeeze board 51 in its inoperative position is maintained up. When the valve 439 supplies the pilot pressure to the valves 440 through 442, the latter two are vented, while the valve 440 connects the blind end of the squeeze cylinder 31 to source 444 which passes through low pressure squeeze regulator 445 bypassing normally closed three-way valve 446 and high squeeze pressure regulator 447. The valve 446 is operated by single solenoid squeeze full pressure valve 448. A pair of pressure switches indicated at 449 sense the pressure above the piston 450 of the assembly 31 and will cause the assembly to retract upon the attainment of the desired squeeze pressure. It is here noted that the piston 450 is connected to the squeeze board 51 by two piston rods 451 and that the squeeze board may be provided with a removable projection 452 which will form a pouring basin in the top of the sand mold surfaces. The pattern on the cope side of the match-plate may be provided with a sprue pin which will telescope within the projection 452 and the molten metal will be poured into the pouring basin and through the passage formed

by the sprue pin on the cope pattern.

The roll-over cylinder assembly **64** is operated by single solenoid valve **543** which supplies pilot air pressure to normally closed three-way valve **454** and normally open three-way valve **455**. The normally open valve **455** supplies pressure from source **456** to the blind end of the cylinder **64**. When the valve **453** is operated, the valve **455** will be closed venting the blind end of the cylinder **64** and opening valve **454** to provide pressure to the rod end of the assembly **64** from the source **456**. The opening of valve **454** also supplies pressure through air regulator **457** and quick exhaust valve **458** to air-over-oil tank **459**. This forces oil through the flow control **460** into the fixed rod **461** and to the oil chamber surrounding such rod. This oil chamber would correspond to the oil chamber **238** for the turrent indexing cylinder assembly seen more clearly in FIG. **11**.

When the roll-over cylinder assembly **64** reaches its midpoint, valve **453** will be deenergized and the valves **454** and **455** will revert to their normally closed and normally opened conditions, respectively. The air pressure in the rod end of the assembly will now be vented as well as the pressure on the air-over-oil tank **459**. The now open condition of the valve **455** forces the assembly to extend pushing the oil from the oil chamber back into the tank **459**. As the rod approaches the end of its stroke, the piston will progressively cover the ports interconnecting the oil chamber and the interior of the fixed rod to obtain the controlled deceleration.

The trunnion cylinder assembly **62** which extends to position the trunnions in operative association beneath the split trunnions projecting from the cope and drag flasks is operated by double solenoid four-way valve **463**. One solenoid is energized to extend the piston-cylinder assembly to cause the trunnions to engage while the other retracts the trunnions to clear the cope-drag-match-plate assembly for vertical movement therepast.

The piston-cylinder assembly **36** operating the sand box carriage **39** is operated by double solenoid four-way valve **264** which supplies pilot pressure alternatively to normal closed three-way valves **465** and **466**. In the closed condition of the valves **465** and **466**, the cylinder is vented and when one of the valves is opened pressure is supplied from the source **467** to extend or retract the sand box carriage.

The slide plate **40** is controlled in similar manner from double solenoid four-way valve **468** and **470**. It is noted that the carriage **39** and the slide plate **40** will not extend until the squeeze board **51** is retracted and this signal is obtained by the limit switch **471** seen more clearly in FIG. **10** which is actuated when the squeeze board is retracted.

The jolt action is obtained by the energization of single solenoid four-way valves **473** and **474**, the former opening normally closed three-way valve **475** supplying air from source **476** through the inlet port **122** of the jolt table. The other valve **474** when energized opens normally closed valve **477** supplying air from source **478** to the servo valve **130**. The servo valve **130** supplies air through line **479** to the plenum chamber **128** beneath the jolt ram **116** elevating the same to jolt position and also elevating the table slightly from its bottomed condition firmly supported on the table base **97**. A pilot line **480** when pressurized by the opening of the valve **477** shifts valve **481** to a blocking condition. When the valve **474** is deenergized, the valve **477** will close venting the pilot line **480** shifting the valve **481** to vent the line **479** and thus the plenum chamber **128** bottoming the jolt table **4** on the base **97**.

Table assembly **4** is raised and lowered by double solenoid four-way valve **483** which in alternate conditions supplies air to normally closed three-way valves **484** and **485**. When the valve **485** is opened, air is supplied from source **486** through air regulator **487** and quick exhaust valve **488** to the top of air-over-oil tank **334** forcing hydraulic fluid into line **480** connected to the blinnd ends of the piston-cylinder assemlies **100** and **101** causing the table assembly **4** to elevate. When the valve **484** is opened, air from source **490** is supplied through pressure regulator **491** and quick exhaust **492** to air-over-oil tank **335** forcing hydraulic fluid into line **493** connected to the rod ends of the assemblies **100** and **101** causing the table assembly **4** to descent. It will, of course, be understood that when the tank **335** is pressurized, the tank **334** is vented, and vice versa.

When the pattern is drawn from the cope and the drag from the pattern, it may be desired that the table move more slowly an this may be accomplished by energization of single solenoid four-way valve **494** actuating valve **495** requiring the hydraulic fluid from the blind ends of the assemblies **100** and **101** to pass through adjustable restricting valve **496**. To lock the table in a desired position of elevation, single solenoid four-way valve **497** is energized to actuate two-way valve **498** blocking the line **489** to fix the volume of liquid supporting the table assembly **4**.

The paired cope and drag flasks are indexed to and from the molding and closing stations by means of the turret cylinder assembly **29** which is controlled by single solenoid four-way valve **500** supplying pilot pressure to normally closed three-way valve **501** and normally open three-way valve **502**. When these valves shift, the air is supplied from source **503** to the rod end of the assembly **29** and also through pressure regulator **504** and quick exhaust element **505** to the top of air-over-oil tank **506**. Hydraulic fluid is then forced through flow control unit **507** into the fixed rod **221** and the oil chamber **238** of the asssembly **29** seen more clearly in FIG. **11**. The shifting of the valve **502** vents the blind end of the assembly **29**. When the midpoint limit switch is actuated, the valve **500** is deenergized repositioning the valves **501** and **502** in their normal positions supplying air to the blind end of the assembly **29** and venting the rod end. The piston then forces oil from the oil chamber **238** and as it closes, the ports **239** provide controlled deceleration on extension.

The piston-cylinder assembly **402** of the bottom board dispenser and mold push-off assembly **90** is controlled by single solenoid four-way valve **509** which supplies air alternately to normally closed three-way valves **510** and **511** in turn alternately supplying air from source **512** to the rod and blind ends of the assembly **402** through flow control units **513** and **514**.

The closing table assembly **2** is controlled by means of a double solenoid four-way valve **516** which alternately supplies pilot air to normally closed three-way valves **517** and **518** which in turn alternately pressurize lines **519** and **520**, respectively, from source **521**. The pilot line for the valve **518** also operates pilot operated check valve **522** in line **519**. A pressure switch **523** is also provided in line **519** which is connected to the blind ends of the piston-cylinder assemblies **339** and **340**.

Additional single solenoid four-way valves **524**, **525** and **526** may be employed to control pattern sprays for

the top and bottom of the match-plate as well as blow offs for the cope and drag flasks.

OPERATIONAL SEQUENCE (FIGS. ≈–40)

The operation of the machine may perhaps best be understood by viewing the time and motion diagrams of FIGS. **26** and **27** in conjunction with the schematic sequence views **28–39.** The machine starts its cycle with the jolt table assembly **4** down, the squeeze board **51** retracted and the sand carriage **39** and its associated slide plate **40** also retracted. A match-plate **86** is in proper position on the arms **84** and **85** and the turret is indexed to an extended position of the cylinder **29** so that a pair of cope and drage flasks are positioned in alignment with the table assembly **4** and the squeeze board **51** on opposite sides of the match-plate **86.**

The cycle starts by elevation of the jolt table assembly **4** which is, of course, obtained by energization of the solenoid valve **483.** The movement of the table is illustrated by the time and elevation curve **530** in FIG. **27.** After about 6 inches of movement, the table buttons **305** contact the drag **80** as indicated by the curve deviation at **531.** At this point, the locater pins **111** and **112** on the table assembly **4** telescope into the guide bushings **295** on the drag **80** and the top of the table also telescopes well within the drag as seen in FIG. **29.** After about 6 additional inches of movement of the assembly **4,** the drag **80** picks up the match-plate **86** as indicated by the curve deviation **532** at which time the locater pins **291** and **292** on the cope will telescope into the guide bushings **314** and **315** on the match-plate **86.** As the table assembly **4** continues upwardly, the match-plate **86** will contact the cope as indicated by the curve deviation **533** and the pins **291** and **292** projecting through the guide bushings **314** and **315** will enter the guide bushings **267** in the cope **77.** The upward movements of the table, of course, lifts the drag from the turret supporting arms, the match-plate from the fixed arms **84** and **85** and the cope from the turret supporting arms.

The table assembly **4** continues upwardly to its full elevation as indicated at **534** in FIG. **27** moving from the FIG. **28** to the FIG. **29** position in the elapsed time of approximately 3 seconds at which time the piston-cylinder assembly **62** actuated by the solenoid valve **463** is extended pivoting the trunnion arms **57** and **58** beneath the laterally projecting trunnions on the cope-drag-match-plate assembly formed by the split trunnions on the cope and drag to position the rollers **59** beneath the mating semi-circular ridges **261** and **288.** The table assembly **4** now descends and the flask-match-plate assembly is deposited on the trunnion rollers as indicated by the curve deviation **535.** The table continues down to an intermediate position indicated in FIG. **30** and at **536** in FIG. **27** which will clear the flask-match-plate assembly for roll-over. At this time, the roll-over piston-cylinder assembly **64** is actuated by the solenoid valve **453** and the flask-match-plate assembly is turned over so that the drag **80** is on top with the bottom thereof opening upwardly. At this time, the piston-cylinder assemblies **36** and **37** are actuated simultaneously by the valves **464** and **468** to extend the sand box and the slide plate **40** therebeneath to a position beneath the squeeze board **51** and above the upturned drag.

The table assembly **4** is now again elevated and contacts the inverted flask-match-plate assembly lifting the same from the trunnion rolls as indicated by the curve deviation **537.** At this point, the top surface of the table **4** will engage the peripheral edge of the downward cope and the table pins **111** and **112** will enter the guide bushings **264.** The difference in elevation between the points **535** and **537** is occasioned by the fact that the empty drag is supported on the table buttons **305.** Because of the larger opening of the drag, it telescopes over the top surface of the table **4** while the cope peripherally rests upon the top surface.

When the table obtains its full height as indicated at **538** in FIG. **27,** the piston-cylinder assembly **37** is retracted pulling the slide plate **40** from beneath the sand box **39** permitting the charge of sand therein to fall within the inverted drag as seen in FIG. **31.** The sand box **39** is then retracted by the retraction of the piston-cylinder assembly **36** and simultaneously the jolt action commences at approximately the piston **539** by actuation of the valves **473** and **474.** The jolt action may continue to approximately the point **540** at which time the squeeze board **51** is brought down to apply a preliminary squeeze at approximately 20 p.s.i. as seen in FIG. **32.**

After the preliminary squeeze, the squeeze head is retracted and the table assembly **4** now descends depositing the drag-up flask-match-plate assembly on the trunnions os indicated by the curve deviation **541.** The table continues down to its intermediate position **542.** In this position, with the table clear of the flask-match-plate assembly supported on the trunnions, the piston-cylinder assembly **64** is again actuated to invert the assembly placing the drag down and the cope up in the original position as seen in FIG. **33.**

The preliminary squeeze applied to the sand within the drag forms a sand cake C within the drag of sufficient rigidity to prevent the sand cake from falling from the rubber-lined drag upon inversion. The table assembly **4** is now again elevated as seen in FIG. **34** and lifts the flask-match-plate assembly off of the trunnions as indicated by the curve deviation **543** in FIG. **27.** The difference in elevation between the deviations **541** and **543** is caused by the drag now being down and filled with sand cake C. The top of the table assembly **4** telescopes within the drag and supports the assembly by direct contact with the sand cake. This also accounts for the curve deviation **543** being lower than the deviation **535.** At this time, the sand box **39** and the slide plate **40** are again indexed fowardly by the extension of the piston-cylinder assemblies **36** and **37.**

The table continues upwardly and at the position indicated at **544** in FIG. **27,** the piston-cylinder assembly **37** is retracted to withdraw the slide plate from beneath the extended sand box **39** as seen in FIG. **35.** In such figure, it will be observed that the pattern on the cope side of the match-plate **86** is provided with an upstanding sprue pin. Also at this point, the piston-cylinder assembly **62** is retracted pivoting the trunnion arms **57** and **58** outwardly to clear the flask-match-plate assembly. It is here noted that the keyway formed by the complementary split trunnions projecting laterally from the flask-match-plate assembly will ride up the retainer key **186** which provides lateral stability for the assembly. At this point **545** in FIG. **27,** the piston-cylinder assembly **36** is retracted indexing the sand box **39** out from under the squeeze board **51.** At approximately the point **546,** the squeeze head is now brought down on the loose sand within the upturned cope as seen in FIG. **37** and a preliminary squeeze to approximately 20 p.s.i. may be applied until approximately the

point **547** wherein a final squeeze and jolt can be applied with the squeeze pressure being approximately 80 p.s.i. At this point, the table will be locked in its elevated position and the sand within the cope and drag will both be compressed against the match-plate since the assembly is supported by the table on the sand cake within the drag.

After relief of the pressure, the squeeze head is elevated and the table descends to the point **548** wherein the table is slowed by energization of the slow-draw actuating valve **494.** At this curve deviation, the cope is deposited on the arms **71** and **72** and the pattern on the match-plate is drawn therefrom. After the cope with the sand cake therein is deposited on the turret arms, the slow-draw valve is deenergized and the table continues down to the point **549** wherein the slow-draw valve is again energized slowing the descent of the table to deposit the match-plate on its supporting arms **84** and **85** and, of course, drawing the drag from the drag pattern. After this drawing of the drag, the table again continues downwardly to the curve deviation **550** wherein the slow-draw valve is again energized to slow the descent of the table gently depositing the drag with the sand cake therein on the turret arms **73** and **74.** The table continues down to its lowermost position seen in FIG. **38** and at the point **551** the piston-cylinder assembly **29** is energized by the valve **500** causing the turret to index. Accordingly, sand cakes are formed witin both the cope and drag within a cycle time of approximately 30 seconds.

The indexing piston-cylinder assembly **29** now swings the cope and drag with the sand cakes therein to the front of the machine as seen in FIG. **39** to the closing and coring station which is vertically above the closing table assembly **2** and, of course, vertically aligned with the pressure plate **26.** At the same time, the indexing cylinder assembly **29** swings an empty set of cope and drag flasks from the closing station to the molding station and as the jolt table asembly **4** moves again through its cycle seen in FIG. **27,** the originally produced sand cakes are held vertically separated at the closing station for a period of approximately 20 seconds or about two-thirds that required to form the sand cake in the other set of flasks.

Upon the completion of the desired coring time, the closing table assembly **2** is elevated by energization of the valve **516** as seen in FIG. **35.** The closing table **92** with the bottom board **361** thereon will initially contact the undersurface of the sand cake in the drag **80** as indicated, for example, in FIG. **36** compressing somewhat the springs **353.** Continued upward movement assembles the cope and drag and lifts the former with its sand cake therein from the cope turret supporting arms further compressing springs **353.**

Further continued upward movement of the closing table assembly causes the pressure plate **26** to telescope into the top of the cope. This finally compresses springs **353** and causes positive contact between the adjustable stops **349** and the rest buttons **302** on the underside of the drag. The clearance between the adjustable stops **349** and the rest buttons **302** of the drag preferably disappears only when the pressure plate **26** fully compresses the springs **353.** The weight of the cope and drag is ordinarily insufficient to compress fully such springs maintaining a slight clearance between the stops and the rest buttons.

It can now be seen that slight continued upward movement of the closing table assembly will cause the stops **349** to, in effect, lift the cope and the drag flasks from the sand cakes restrained from upward movement by the pressure plate **26.** As soon as the sand cakes are stripped from the cope and drag flasks, the closing table assembly **2** now descends to the position of FIG. **38** depositing the cope flask and then the drag flask on the turret supporting arms and lowering the now assembled completed mold into position to be shoved from the machine onto conveyor **425** seen in FIG. **21.** When in such position, the piston-cylinder assembly **402** is retracted causing the carriage **93** to index forwardly so that the push-off plate **426** engages the assembled and completed mold shown at **553** in FIG. **38** while simultaneously dispensing a new bottom board from the magazine **91** onto the closing table. The elevation and lowering of the closing table assembly and the indexing of the carriage **93** takes place in approximately 10 seconds which may occur at the end of the molding cyle as seen more clearly in FIG. **26.** The extension of the carriage **93** may occur simultaneously with the indexing of the empty flasks to the molding station and, of course, the simultaneous positioning of filled flasks at the closing station. The piston-cylinder assembly **402** is extended as the table assembly **4** starts up during the next cycle. If the mold does not require a core, the coring time illustrated on the time and motion chart of FIG. **26** can be eliminated and the closing table will start up as soon as the flasks with the sand cakes therein have been indexed thereabove. This avoids unnecessary exposure of the mold surfaces.

It can now be seen that although the machine produces sand cakes within the cope and drag within 30 seconds, additional coring and closing time is required. The machine still produces a completed mold within every 30 seconds due to the use of two sets of cope and flasks and the indexing of such sets from the molding station to the closing station and back again.

The various positions of the mold table assembly **4** seen by the curve **530** in FIG. **27** may be controlled by a plurality of reed type magnetic proximity limit switches within the limit switch enclosure **328.** For example, there may be a limit switch at the opposite ends of the table stroke signalling the table down and the table up. There may also be a limit switch signalling the position of the table which is clear of the roll-over as indicated by the intermediate positions **536** and **542** on the curve **530.** The action of the vibrator **320** can also be controlled by limit switches in the enclosure **328.**

Three limit switches may signal the beginning of the slow draw for the picking off of the cope as indicated at **548,** the stripping of the match-plate from the drag as indicated at **549** and the drawing of the table from the drag as indicated at **550.** There will also be a bank of reed switches for each of the switches starting a slow draw operation, the selected one of which will be effective to stop the slow draw and permit the table to continue down at its normal rate of descent. As indicated in FIG. **40,** there may be a bank of 10 vertically stacked reed switches for each of the draw operations as indicated at **555,** each of which is in series with one of the peripherally arranged contacts of the selector switch **56.**

The operator will select one of the vertically arranged reed switches for operation in the cycle by movement of the selector switch and as the magnet upon the holder **332** secured to the arm **331** on the base of the table assembly **4** moves thereby, it will close that switch will then be effective in the circuit to stop

the slow draw at the desired point. Variations in pattern structure and depth may require different slow draw periods and this can readily be obtained with the selector switches. The housing of the switches **555** in the enclosure **328** avoids the necessity of physical contact between the moving table and the switches and keeps the switch gear from dirt and debris which is so abundant in foundry molding machine operation.

It can now be seen that there is provided a machine and method which will rapidly produce complete foundry molds of uniform high hardness and density. Moreover, a match-plate molding machine is provided in which the molds can be cored without reducing the cycle time of the machine or process. The jolt action and preliminary squeeze avoids the stressing of the match-plate. With the present invention, completed ready to use molds can be produced at the rate of 120 or more per hour.

Other modes of applying the principles of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

We, therefore, particularly point out and distinctly claim as our invention:

1. A process for producing foundry sand molds comprising the steps of assembling cope and drag flasks with a pattern therebetween, placing the drag flask up and filling it with sand, preliminarily squeezing the sand therein, then turning the assembly over and filling the cope flask with sand, squeezing such sand in both the cope and drag flasks, vertically separating the cope and drag flasks, and then laterally indexing such flasks vertically separated for coring and closing.

2. A process as set forth in claim **1** including the step of jolting the cope and drag flasks to facilitate the ramming of sand therein.

3. A process as set forth in claim **1** including the step of supporting peripherally the cope flask as the drag flask is filled, and supporting the preliminarily squeezed sand cake within the drag flask as the cope flask is filled.

4. A process as set forth in claim **1** wherein the assembly is turned over by the retraction and extension of a piston-cylinder assembly having controlled deceleration on extension.

5. A process for producing completed foundry sand molds comprising the steps of ramming cope and drag flasks with a pattern therebetween at one station, vertically separating such flasks to draw the pattern therefrom, indexing such vertically separated flasks to a second station, holding such flasks vertically separated at such second station to permit coring, and then closing such flasks and stripping the sand molds therefrom.

6. A process as set forth in claim **5** including two sets of cope and drag flasks, and indexing such sets alternately to and from the two stations.

7. A process as set forth in claim **5** including the step of indexing empty flasks into such one station as the sand rammed flasks are indexed from such one station.

8. A process as set forth in claim **5** including the steps of placing the drag flask up and filling it with sand at such one station, preliminarily squeezing the sand therein and then turning the assembly over and filling the cope-flask with sand and then finally squeezing such sand in both the cope and drag flasks.

9. A process as set forth in claim **5** wherein the ramming of the cope and drag flasks is accomplished by both high pressure squeeze and jolt.

10. A process as set forth in claim **5** including the step of placing a bottom board under the sand molds at the second station.

11. A process as set forth in claim **5** wherein the closing of such flasks and the stripping of the sand molds therefrom is accomplished at such second station.

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