AUTOMATED BRICKLAYING DEVICE

Original Filed May 15, 1972 11 Sheets-Sheet 1

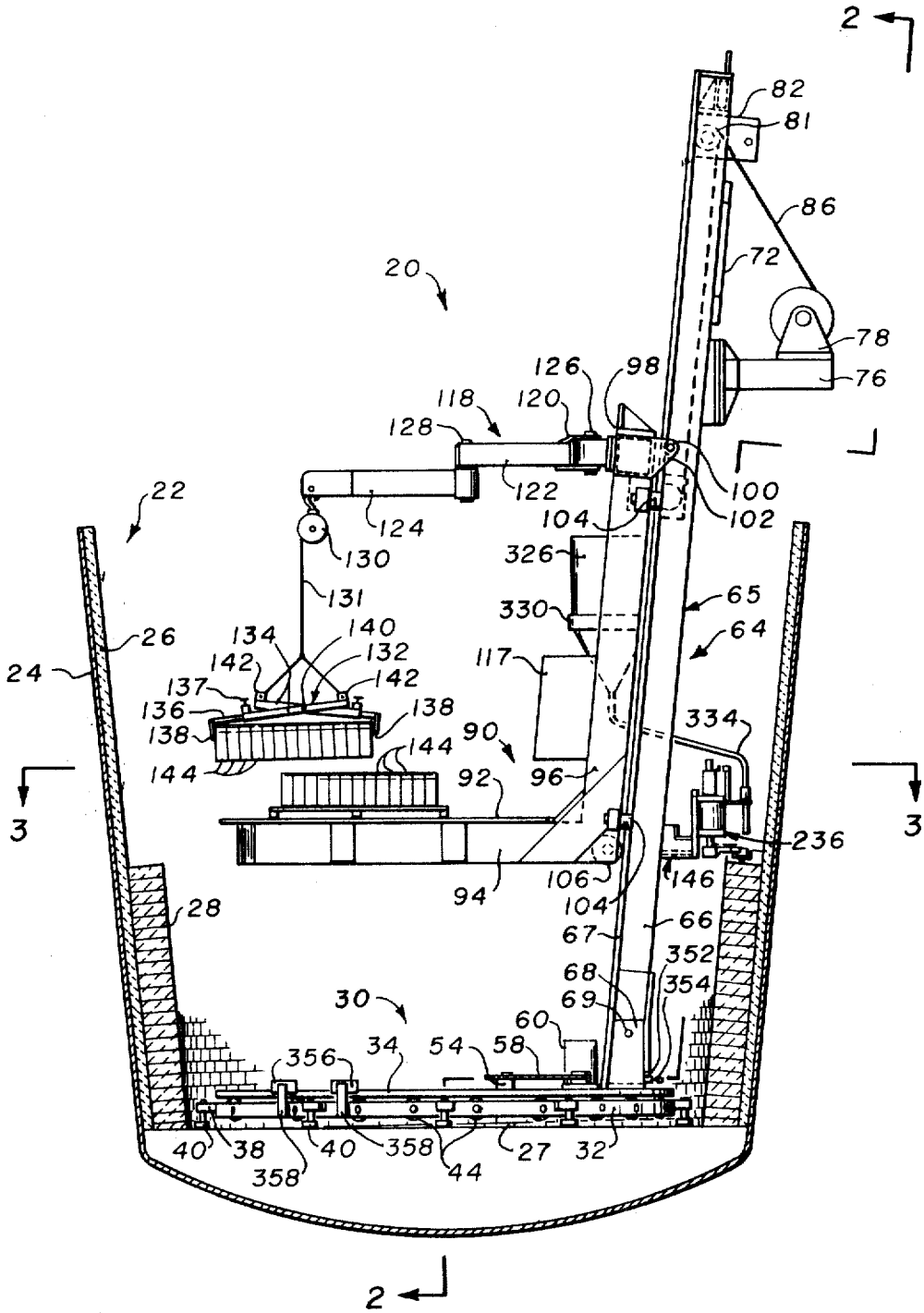
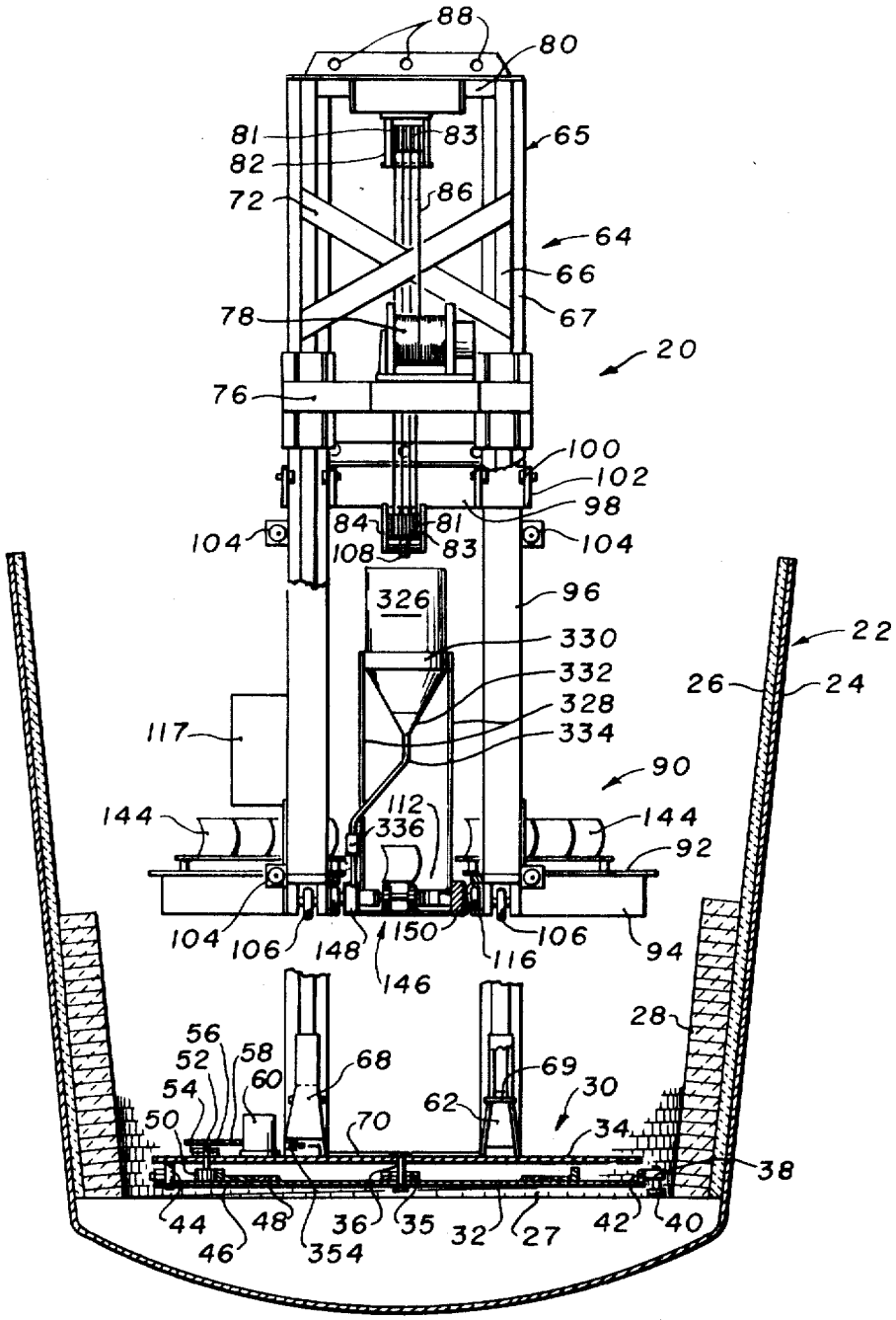


FIG. 1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104
326
96
22
330
332
26
24
328
117
334
90
112
144
336
144
92
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106
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150
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354

FIG. 2

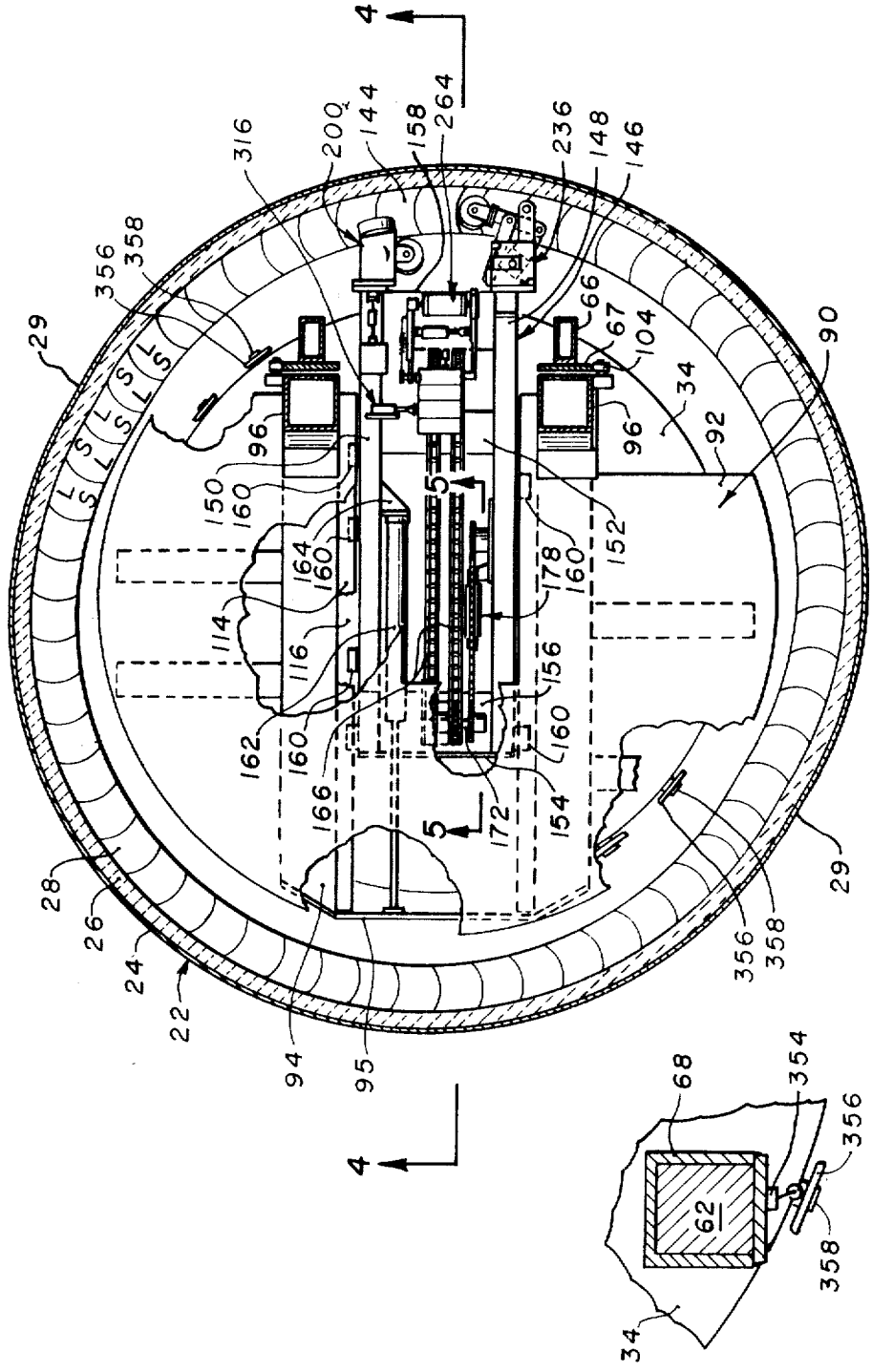
4
4
5
5
316
200
144
158
264
236
148
146
356
358
29
66
67
104
90
34
92
96
96
150
160
164
160
178
160
152
114
116
156
162
160
160
166
172
154
28
26
24
22
94
95
29
356
358

FIG. 3

68
354
356
62
358
34

FIG. 13

AUTOMATED BRICKLAYING DEVICE

Original Filed May 15, 1972 11 Sheets-Sheet 4

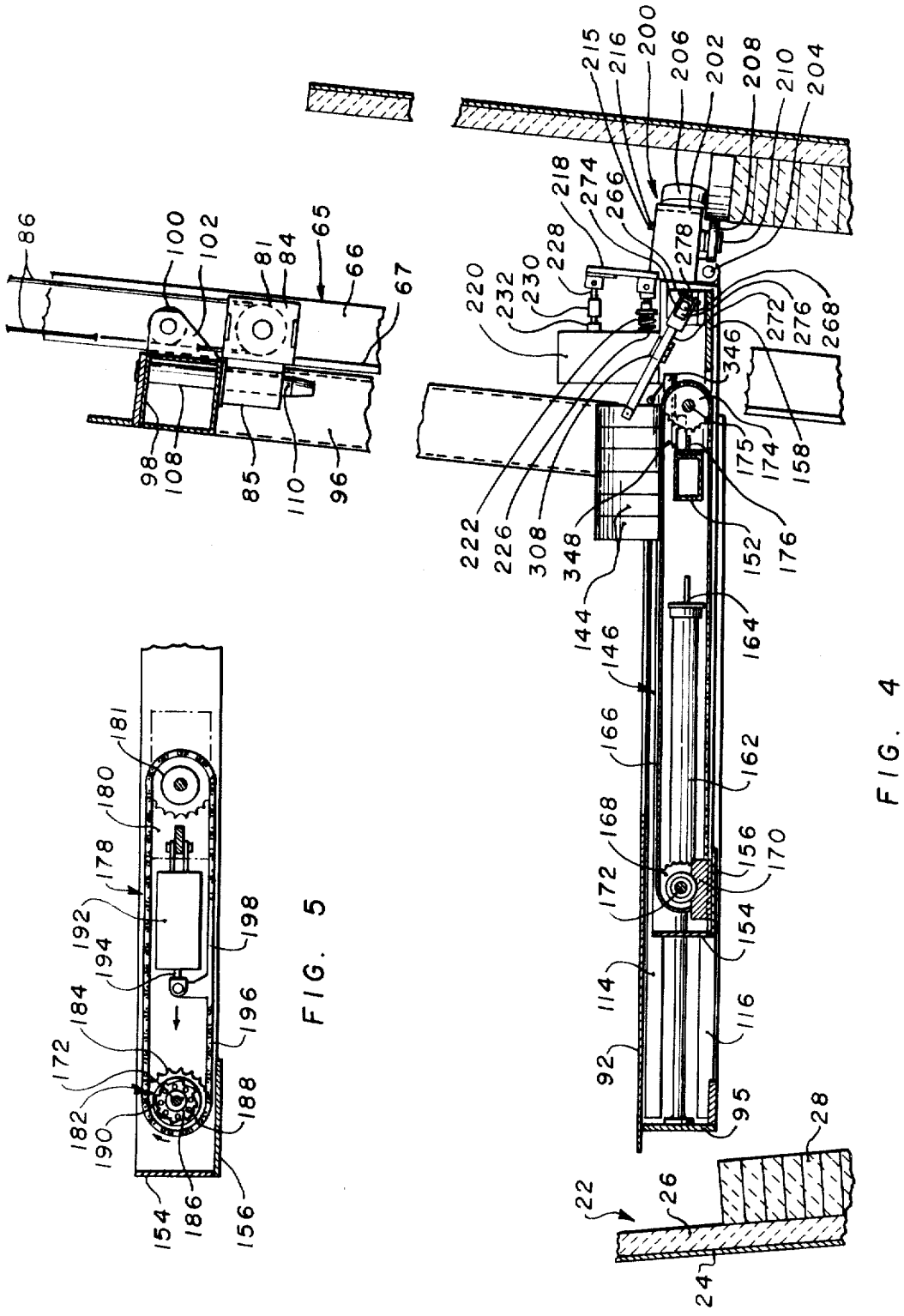

FIG. 4

FIG. 5

AUTOMATED BRICKLAYING DEVICE

Original Filed May 15, 1972 11 Sheets-Sheet 3

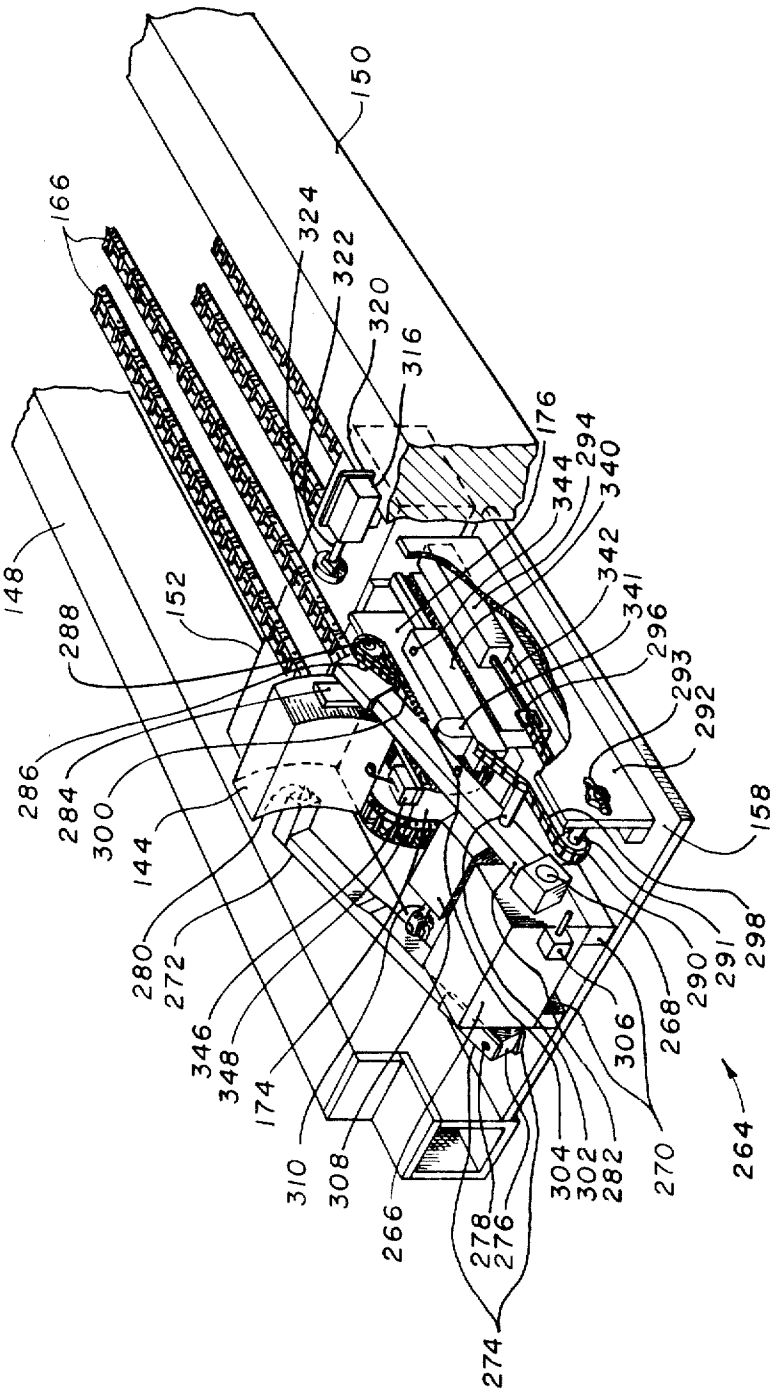

FIG. 6

AUTOMATED BRICKLAYING DEVICE

Original Filed May 15, 1972 11 Sheets-Sheet 6

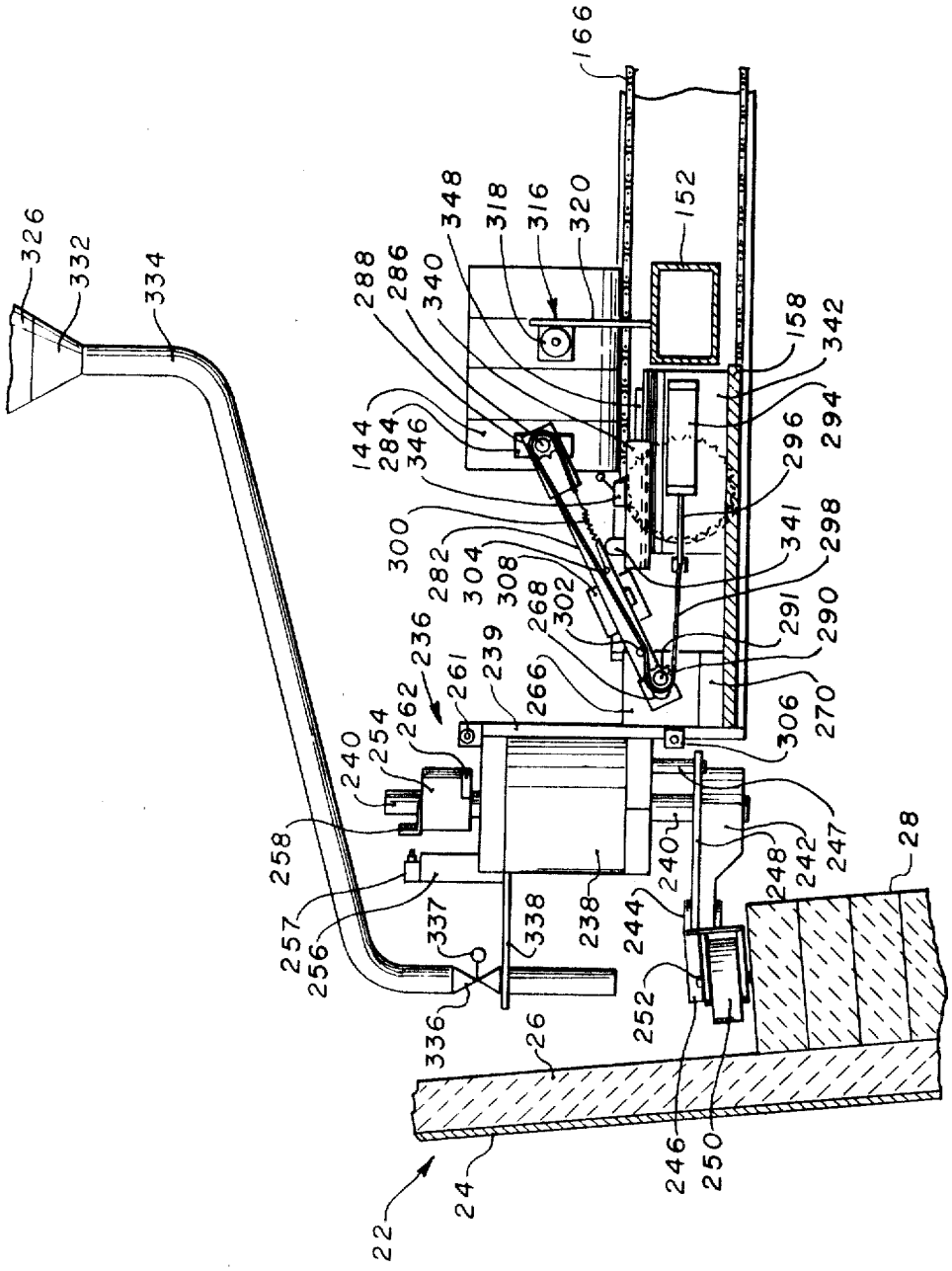

FIG. 7

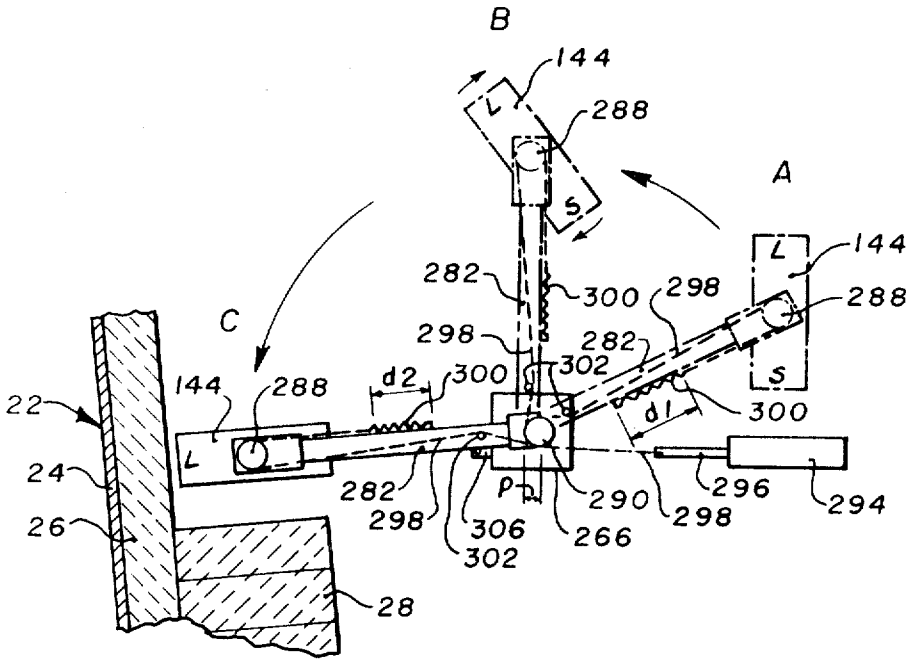
B
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FIG. 8A

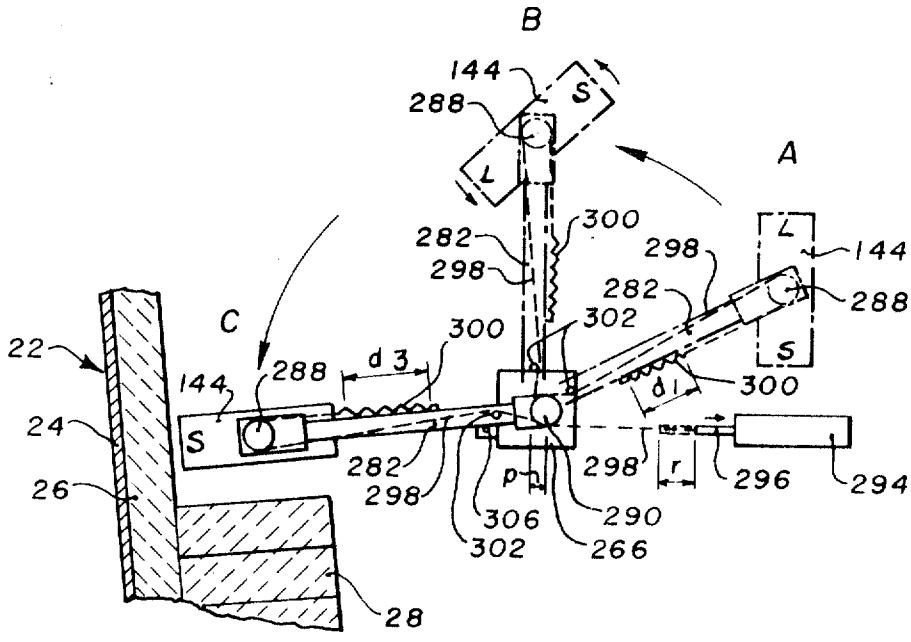
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FIG. 8B

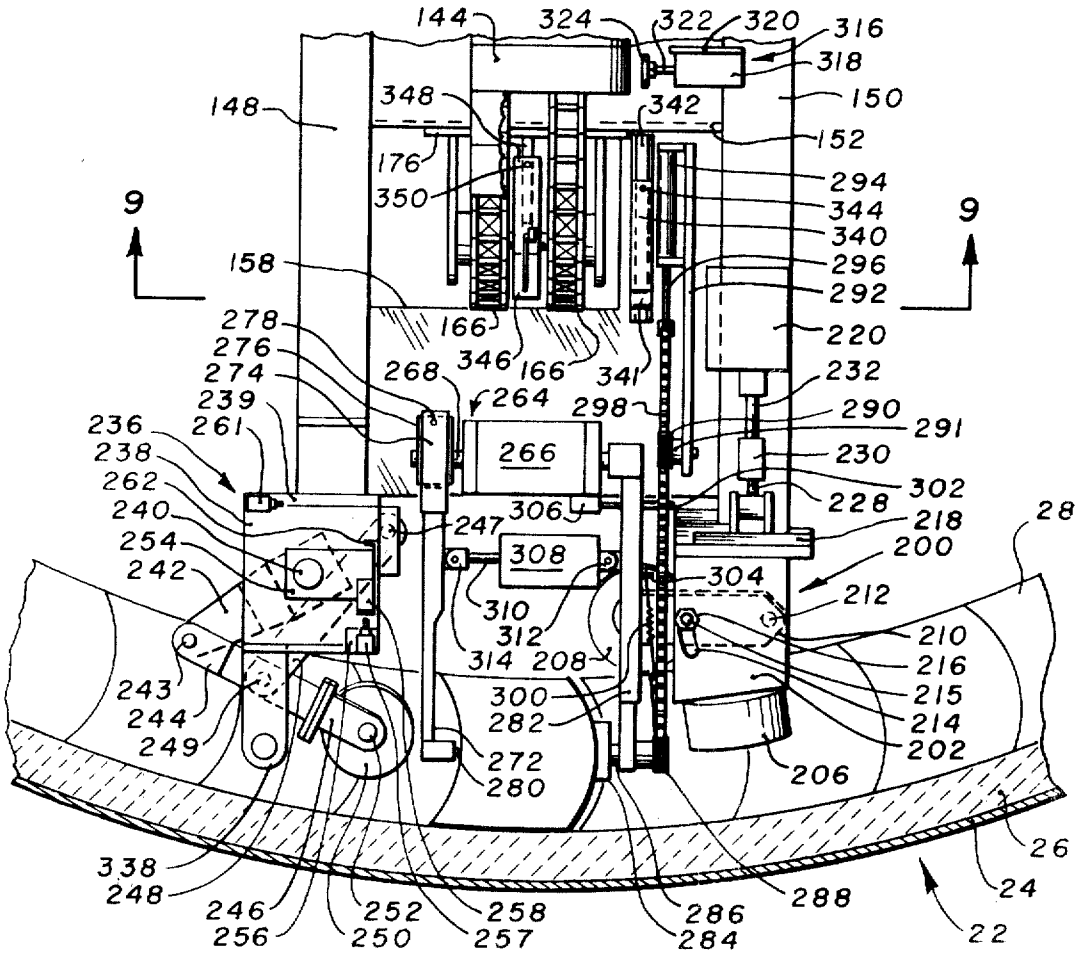
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FIG. 10

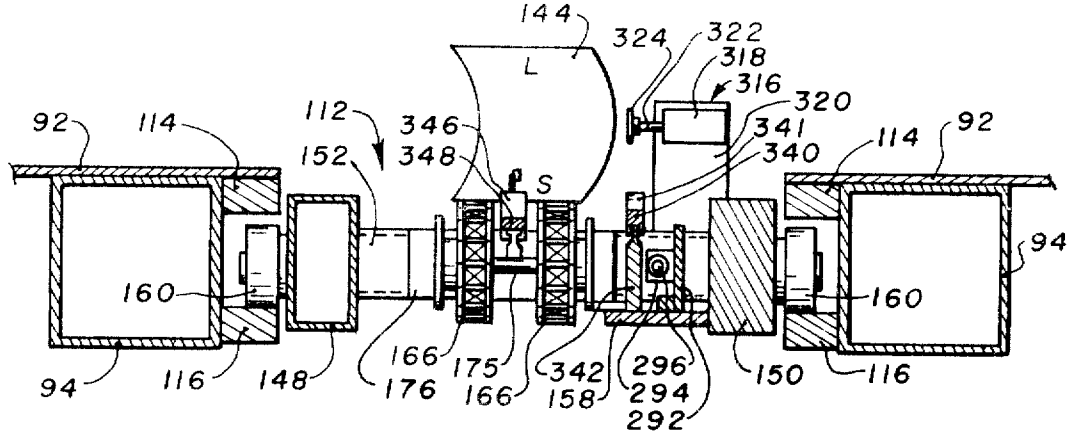
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FIG. 9

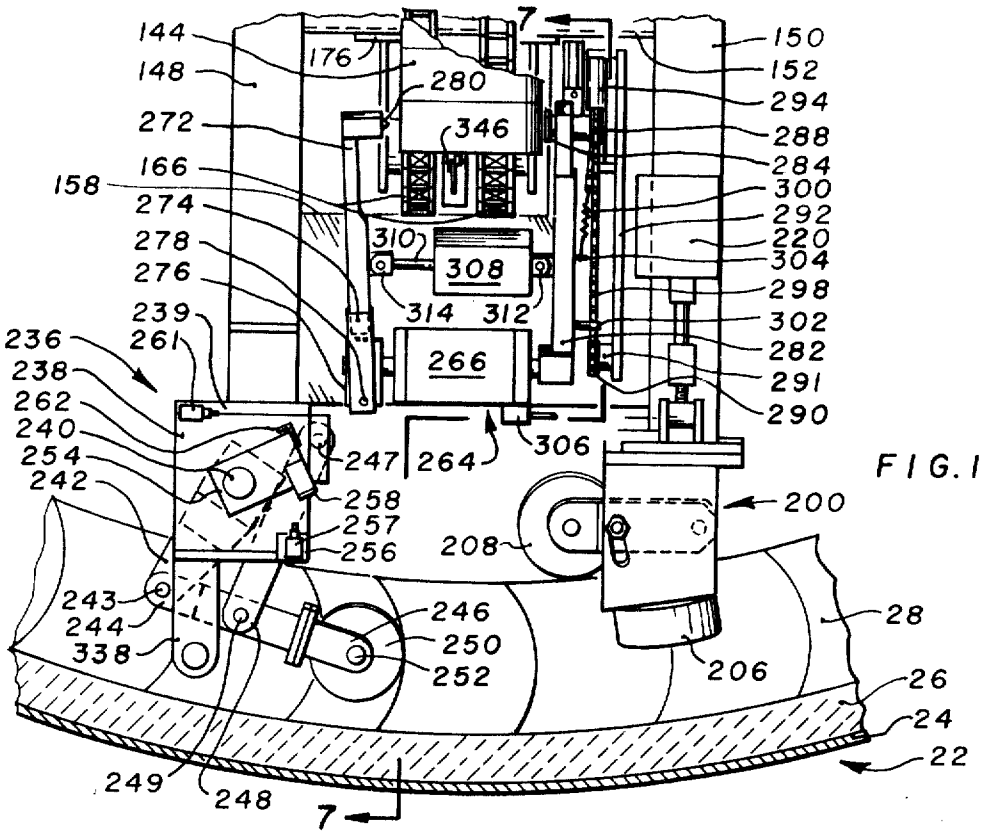
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FIG. 11

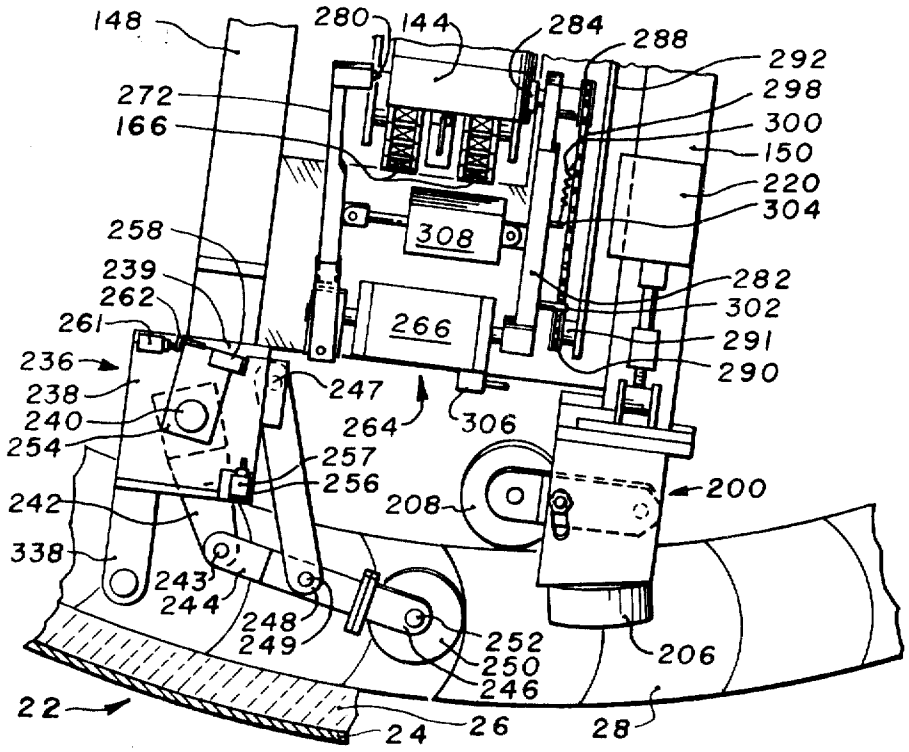
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FIG. 12

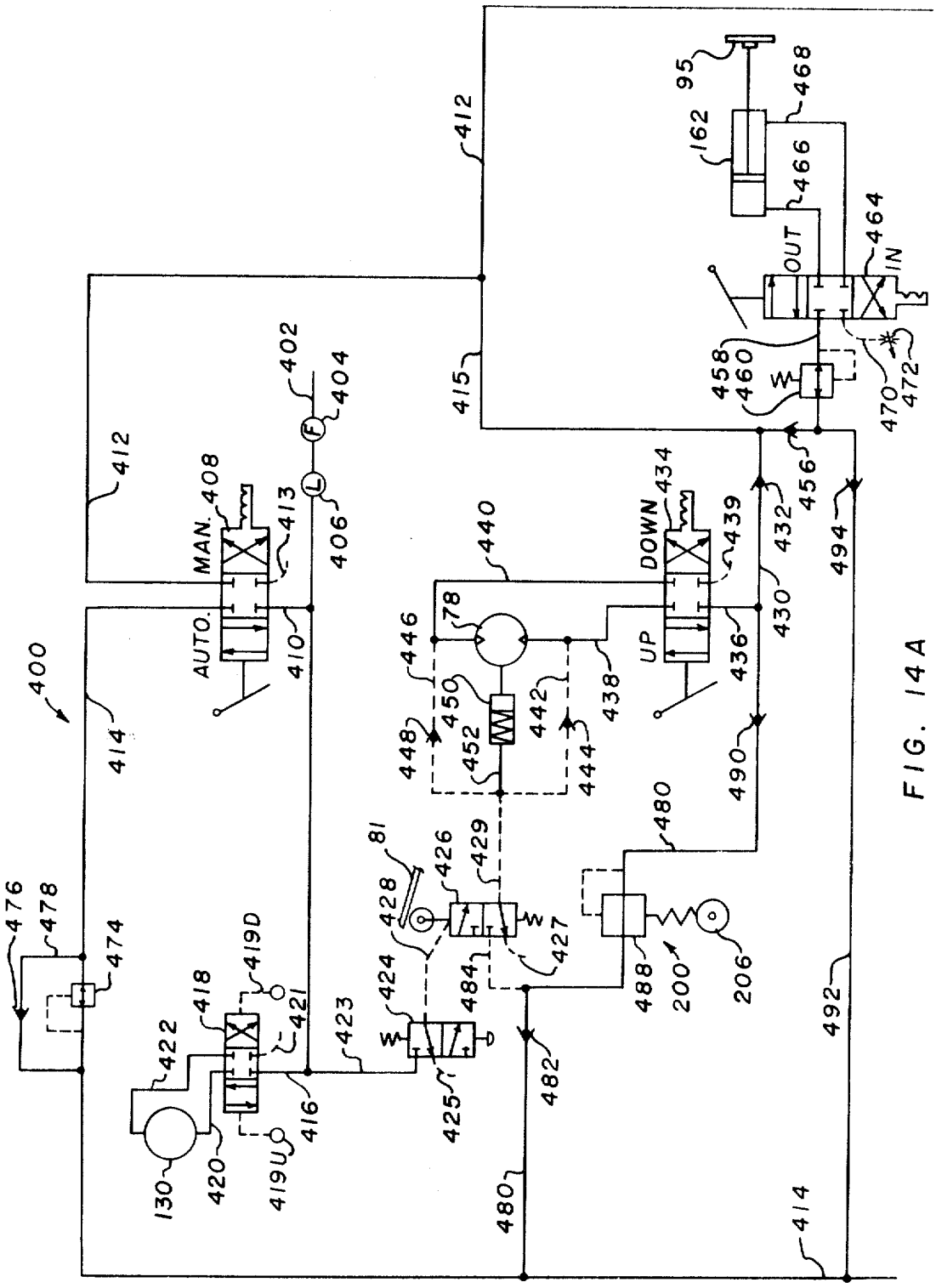
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FIG. 14A

AUTOMATED BRICKLAYING DEVICE

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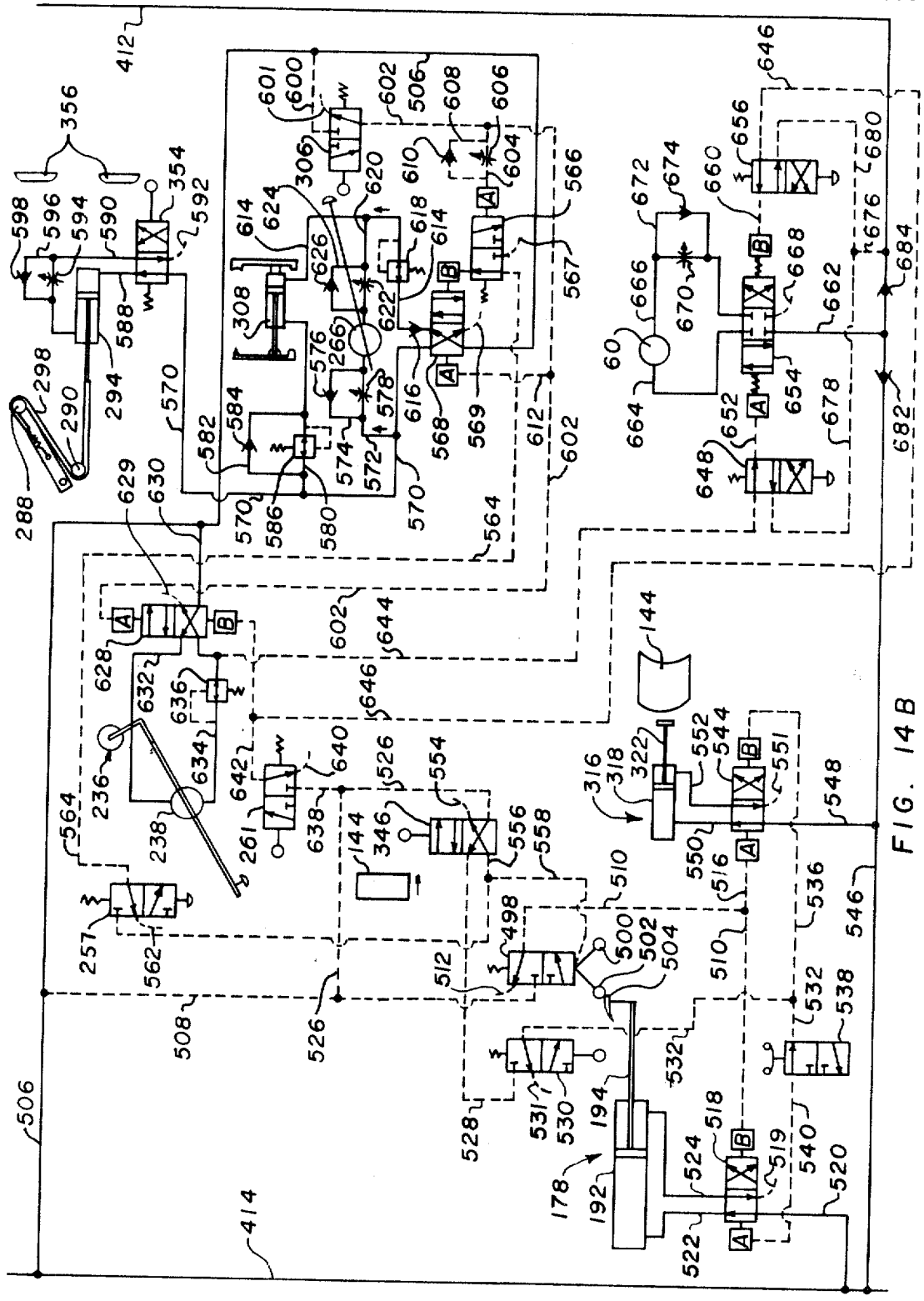

FIG. 14B

United States Patent Office

Re. 28,305
Reissued Jan. 21, 1975

28,305

AUTOMATED BRICKLAYING DEVICE

Ronald Eugene Williamson, Hammondsville, and Sidney Clark Porter, Jr., East Liverpool, Ohio, and Kenneth Frederic Shotting, Coraopolis, Pa., assignors to Combustion Engineering, Inc., Windsor, Conn.

Original No. 3,757,484, dated Sept. 11, 1973, Ser. No. 253,546, May 15, 1972. Application for reissue May 3, 1974, Ser. No. 466,566

Int. Cl. B65g *37/00;* E04g *21/22*

U.S. Cl. 52—749 34 Claims

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

An automated bricklaying device for laying out the refractory brick lining of a metal pouring ladle having an upright frame means mounted on a mounting means for traversing the interior circumference of the ladle. A platform means, which has a delivery means mounted theeon for reciprocal lateral movement, is carried by the upright frame means for substantially vertical movement within the ladle. The delivery means continuously delivers a series of refractory bricks in turn to the circumference of the ladle to be set as the lining thereof. A positioning and indexing means properly positions each brick in turn in the lining as it is delivered from the delivery means. The positioning and indexing means additionally serves to index the upright frame means to a proper position for placement of the next succeeding brick in the lining. A vertical guidance means on the delivery means provides vertical elevational control of the platform means relative to the built up lining.

BACKGROUND OF THE INVENTION

In the making of steel a ladle is required for receiving molten steel from the steel-making furnace, the ladle serving to transport the steel from the furnace to the area in which ingots or castings are made. These ladles must have some means to prevent the molten steel from penetrating to the outer metal sheath of the ladle and as such require a refractory lining. The refractory lining must exhibit the characteristics of being readily adaptable to conform to the shape of the ladle and the ability to withstand widely fluctuating temperatures and erosive action of the molten steel. Since the ladle is moved and tilted about its supporting axis, the lining must be so cohesive to remain in place during movement, yet be capable of being easily removed for repair or replacement.

Ladle linings are presently formed by building up individual refractory blocks in a close fitting pattern. The blocks generally used are curved convexly at one end and concavely at the other, with the chordal plane through the cylindrically curved ends of each form of block not having the same angular relation. By this construction a standard refractory block may be used to build a lining for ladles of varying sizes and varying shapes. This arrangement is shown in U.S. Pat. No. 3,140,333 to W. T. Tredennick.

In forming the ladle lining, the refractory blocks have been placed within the ladle by hand by unskilled laborers generally taking from 16–64 manhours per ladle. Even though the blocks are uniform so that little skill is involved, this use of manual labor adds considerably to the overall cost of steel manufacture. This expense is compounded by the fact that the ladle lining will only last

through approximately 20 charges from the steel-making furnace before the lining must be replaced. This requires that the ladle be taken out of service for lining replacement after only several days' operation.

SUMMARY OF THE INVENTION

There is herein provided an apparatus for automating the laying of refractory bricks within a metal pouring ladle to serve as the working lining thereof, thereby reducing the time necessary for relining as well as the cost. A delivery means, for delivering a series of refractory bricks in turn to the circumference of the ladle to be set as the lining thereof, is supported inside the ladle by a support means. The support means permits of the delivery means longitudinal movement along, reciprocal lateral movement relative to, and revolutional movement about an axis thereof positioned within and substantially parallel to the axis of the ladle to be lined. A brick positioning means is associated with the delivery means and is provided for positioning and firmly setting each brick in turn in the lining as it is delivered to the circumference of the ladle. The delivery means and the brick positioning means are moved longitudinally along, laterally relative to and [revolutionary] *revolutionally* about the axis of the support means by an operating means so as to position the delivery means and brick positioning means relative to the circumference of the ladle. A control means controllably operates this operating means after a brick has been positioned in place in the lining so as to properly position the delivery means and brick positioning means for the placement of the next succeeding brick in the lining.

With such an apparatus, a ladle may be lined in 3–4 hours. Also, only one man is required to operate the bricklaying device.

Although this automated bricklaying device was developed for use in lining metal pouring ladles, it will be apparent from the description hereinbelow that the device is readily adaptable to reline any type of vessel in which relining is periodically required.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view of the automated bricklaying device according to the present invention positioned within the ladle shell;

FIG. 2 is a front elevation view, partly in section, taken along line **2—2** of FIG. 1 with a portion thereof removed;

FIG. 3 is a top view of the automated bricklaying device taken along line **3—3** of FIG. 1;

FIG. 4 is an elevation view, partly in section, taken along line **4—4** of FIG. 3;

FIG. 5 is a detailed section view of the conveyor indexing mechanism according to the present invention taken along line **5—5** of FIG. 3;

FIG. 6 is a perspective view of the brick gripper according to the present invention;

FIG. 7 is an elevation view of a portion of the conveyor assembly taken along line **7—7** of FIG. 11;

FIGS. 8A and 8B are diagrammatic representations showing the operation of the brick gripper according to the present invention;

FIG. 9 is a front elevation view of the conveyor assembly taken along line **9—9** of FIG. 10;

FIGS. 10, 11 and 12 are detailed plan views of a portion of the conveyor assembly showing the sequential operations according to the present invention in laying a brick in the lining of the ladle;

FIG. 13 is a detailed view showing the actuation of a limit switch utilized in the control of the present invention;

FIGS. 14A and 14B are diagrammatic representations of the control system according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, FIGS. 1 and 2 show an automated bricklaying device **20** positioned within a metal pouring ladle **22**. The ladle **22** is comprised of a steel shell **24** with a safety lining **26** forming the interior thereof. Within the safety lining **26** is a working lining **28** which is periodically damaged and eroded during the steelmaking process and needs to be replaced. It is the replacement of this working lining **28** to which the particular bricklaying device **20** of this invention is concerned.

The automated bricklaying machine is comprised of three separate assemblies such that it may be installed and removed from the ladle in three pieces or sections, or alternatively it may be installed or removed as a unit. These three assemblies are the support assembly **30**, the elevator frame assembly **64**, and the carriage assembly **90**. The support assembly **30**, as depicted in FIGS. 1 and 2, is a turntable mechanism comprised of a lower platen **32** supported on the floor of the ladle **22** by means of leveling screws **40** mounted in flanges **38** spaced about the periphery of the platen **32** and an upper platen **34** having a central downwardly extending shaft **36** journaled in bearing **35** on the lower platen **32**. The upper platen **34** is supported from the lower platen **32** for rotation relative thereto about the shaft **36** by a plurality of rollers **44** intermittently spaced about and journaled in an upright ring **42** positioned at the periphery of the lower platen **32**. An annular gear ring **46** having outwardly extending gear teeth is centrally located on the lower platen by an inner locating ring **48** for engaging a pinion gear **50** having a shaft **52** journaled in a bearing **54** of the upper platen **34**. A sprocket **56** is rigidly fixed to the shaft **52** above the platen **34** and is connected to a rotary air motor **60** by a chain **58** for rotating the pinion gear **50** which in turn will rotate the upper platen **34** relative to the lower platen **32**.

The elevator frame assembly **64** is comprised of two spaced T-shaped standards **65** formed by joining together a rectangular beam **66** and a flat plate **67** as shown in FIGS. 1, 2 and 3. Each of the standards **65** has integrally attached thereto at its lower end a connecting couple **68** whose inner surface conforms identically to the outer surface of lugs **62** provided on the platen **34**, the lugs **62** serving to support the elevator frame assembly at an angle conforming to the slope of the ladle wall **24**. A pin **69** passes through the lugs **62** and the connecting bases **68** to hold the standards in place. Standards **65** are interconnected and held in spaced relation by a tie bar **70** at the bottom, an X-brace **72** near the top and a tie bar support **80** at the top, the support **80** having lifting holes **88** for introducing into or removing from the ladle **22**, either the elevator frame assembly **64** or the entire bricklaying device **20**. A hoist motor support **76** integrally attached to the standards **65** extends laterally outward from the elevator frame assembly and supports a rotary air actuated hoist motor **78** thereon. A cable **86** extending from the hoist motor **78** passes over sheaves **81** separated by sheave spacers **83** of the upper and lower hoist blocks **82** and **84**, the upper hoist block **82** being supported from the tie bar support **80** and the lower hoist block **84** being supported by the cable **86**. Actuation of the hoist air motor **78** will effectuate either a lowering or raising of the lower hoist block **84**.

The carriage platform assembly **90** is carried by the elevator frame assembly **64** in such a manner so as to be vertically movable within the ladle **22**. The carriage assembly **90** has horizontal base members **94** supporting a platform **92**. Two carriage upright supports **96** extend upward from the base members **94** inclined relative to the plate at an angle substantially equal to the incline angle of the ladle and elevator frame assembly **64**. The upper portion of the uprights **96** are interconnected by cross support **98** having integrally attached thereto a downwardly extending pin **108**. As best seen in FIG. 4, the cross

support **98** and thus the carriage assembly **90**, is supported from the elevator frame assembly **64** by the lower hoist block extension **[84]** *85*, the pin **108** passing through a hole in the extension **[84]** *85* and being retained in place by a cotter pin **110** extending through a transverse hole in the pin **108**. This manner of supporting the carriage assembly is advantageous in that the lower hoist block **84** remains coupled to the elevator frame assembly **64** upon removal of the carriage assembly **90** therefrom.

A plurality of rollers **100**, **104** and **106** are rotatably mounted from the upright supports **96** so that the carriage platform assembly **90** will be guided in its vertical movement within the ladle **22** by the elevator frame assembly **64**. The upper set of rollers **100** ride on the rear surface of the plate **67** of the elevator standard **65** and are journaled in plates **102** extending outward from the uprights **96** on either side of the standards **65** while the lower rollers **106** are journaled in the uprights **96** to ride along the front surface of the plate **67**. The combination of these two sets of rollers **100**, **106** provides the necessary stability to insure that the carriage assembly **90** remains in position as it is moved up and down the standards **65**. Lateral stability is provided for the carriage assembly **90** by the rollers **104** which pass along the outside edges of the flat plate **67**. There are two rollers **104** positioned at the upper portion of the uprights **96** and two positioned at the lower portion.

A boom mechanism **118** is supported from the cross support **98** for lifting bricks **144** from the pallets of bricks on the platform **92** and placing them on a delivery means or conveyor assembly **146** to be described hereinbelow. A support member **120** attached to the cross support member **98** carries pivot pin **126** to which is mounted for pivotal movement in a horizontal plane a first beam **122**. A second beam **124** is pivotally connected by pin **128** to the first beam **122**. A hoist motor **130** is attached to the distal end of the second beam **124** and a cable **131** extends downward therefrom to carry ice tong grippers **132**. The ice tong grippers are comprised of two hollow tubes **134** into which extend bars **136** having gripping surfaces **138** at the distal ends, the tubes **134** being pivotally connected by pin **140**. Screws **137** tightly hold the bars **136** in place within the tubes **134**. The cable **131** is attached to lugs **142** of the tubes **134** such that upon actuation of the air hoist **130** to retract the cable **131**, the hollow tubes **134** pivot about pin **140** to grip a series of bricks **144**, the bricks then being lifted from the pallet and placed on the conveyor assembly **146**.

As best seen in FIGS. 2, 3, 4 and 9, the platform **92** has been cut away between the horizontal support braces **94** so as to provide a channel opening **112** into which extends the conveyor assembly **146**. Upper and lower flange means **114** and **116** provided on the horizontal support braces serve to support the conveyor assembly **146**.

The conveyor assembly **146** is comprised of two spaced frame members **148** and **150**, interconnected by cross support **152**, end plate **154** and back and front plates **156** and **158**. Support rollers **160** are journaled in the sides of the frame members **148** and **150** and engage the upper and lower flange means **114**, **116** to support and allow free lateral movement of the conveyor assembly **146** within the channel opening **112**. The frame member **150** has four rollers journaled therein while the frame member **148** has only two since frame member **150** will necessarily have to support a greater weight than member **148**, as described hereinbelow. An axial air motor **162** is attached to the inner surface of the frame member **150** with one end connected to a push plate **164** and the other end connected to the end plate **95** of the carriage assembly **90**. The air motor **162** serves the purpose of extending the conveyor assembly **146** outward toward the lining of the ladle or retracting it inward into the carriage assembly **90**.

Two chains **166**, provided between the frame members **148** and **150**, serve as a conveyor to deliver bricks to the front end of the conveyor assembly **146**. The chains **166** are mounted on two sets of sprockets **168**, **174**, the rear

sprockets **168** being interconnected by a common shaft **172** journaled in support **170** on the rear plate **156** and the front sprockets **174** being interconnected by common shaft **175** journaled in support **176** attached to the cross support **152**. The chains **166** are driven, in one direction only, by a conveyor indexing means **178** which is best seen in FIG. 5. The indexing means **178** comprises a one-way friction clutch sprocket **182** having an outer sprocket **184** with inner cam surfaces **190**, an inner cylinder **186** mounted on the common shaft **172** of the rear sprockets **168** and a plurality of balls **188** located therebetween. A forward indexing sprocket **181** and an axial air motor **192** with piston rod **194** are mounted to a forward sprocket mount **180** attached to frame member **148**. The piston rod **194** has attached thereto a chain connector **198** which in turn is connected to the ends of a chain **196** passing over the forward indexing sprocket **181** and the one-way friction clutch sprocket **182**. Extension of the piston rod **194** will effect a clockwise rotation of the outer sprocket **184** which will cause the balls **188** to become tightly engaged between the cam surfaces **190** and the inner cylinder **186** so that the inner cylinder **186**, and in turn the shaft **172**, will rotate clockwise. This action causes the chains **166** to move bricks forward toward the front of the conveyor assembly **146**. Upon retraction of the piston rod **194**, however, the outer sprocket **184** rotates counterclockwise and the balls **188** disengage the inner cylinder **186**, thereby imparting no counterclockwise rotation to the common shaft **172**. Instead, the chains **166** remain stationary.

Located in the forward portion of the conveyor assembly **146** are three devices for placing and properly positioning the bricks in the wall of the lining **28** as they are delivered along the chains **166**: a conveyor positioning mechanism **200**, a brick pusher **236** and a brick gripper **264**. The conveyor positioning mechanism **200**, as best shown in FIGS. 4, 10, 11 and 12, serves a dual function of orienting the extension of the conveyor assembly **146** and also the height of the system relative to the lining of the ladle. A wheel holder **202** is attached to the conveyor assembly **146** and a dogleg connection by a pin **204** so as to allow pivotal movement of the wheel holder **202** thereabout. A support arm **210**, pin connected to the wheel holder **202** by pivot pin **212**, has journaled in its distal end a conveyor extension wheel **208** for riding along the interior surface of the lining **28**. The conveyor extension wheel **208** controls actuation of the conveyor extending motor **162** so as to maintain a constant outward force against the interior of the ladle as bricks are being laid in place. Adjustment of the orientation of the conveyor extension wheel **208** is controlled by a pin **215** on support arm **210** passing through an adjusting slot **214** in the wheel holder **202** and held in place by a nut **216**. A support cam follower wheel **206** is journaled in the front face of the wheel holder **202** for riding along the top row of bricks **144** in the lining **28** to control adjustment of the height of the carriage assembly **[96]** *90*. This is accomplished by means of a pressure regulator mounted in housing **220** on frame member **150**. A pusher block **230** having a regulator plunger **232** adapted to enter the regulator is threaded on a screw **228** attached to the rear support plate **218** of the wheel holder **202**. As the cam follower wheel **206** rides on the lining **28**, the wheel holder will pivot about pin **204** to force the plunger **[236]** *232* into the regulator causing the air hoist **78** to actuate and raise the carriage assembly **90**. A spring **222** shown in FIG. 4 is attached between a stop **226** and the support plate **218** to bias the wheel holder outward to force the plunger **[236]** *232* out of the regulator, thereby causing the air hoist to stop. Generally the spring force is sufficient to allow the cam follower wheel **206** to support about 5% of the weight of the carriage assembly **90**. Thus it is apparent that an extra set of rollers **160** are necessary for supporting frame member **150** in the carriage assembly **90**.

The brick pusher **236** as best shown in FIGS. 7 and 10–12 is attached to the other frame member **148** by means of an upright mounting plate **239** which supports a rotary air actuator **238** with a substantially vertically extending shaft **240**. The shaft **240** has attached thereto at its lower end a linkage system comprised of a drive arm **242** having a drive arm extension **244** pinned at its distal end by pin **243**. A drive arm wheel holder **246** having a drive wheel **250** pinned thereto by pin **252** is integrally attached at an angle to the drive arm extension **244** such that the wheel **250** will rotate in a plane parallel to the upper surface of the lining **28**. A linkage arm **248** pinned to the air motor **238** by pivot pin **247** and pinned to the drive arm extension **244** by pivot pin **249** controls the relative motion of the arm **244**. As can be seen in the sequential views of FIGS. 10–12 as the shaft **240** is rotated in a counterclockwise rotation the drive wheel **250** travels along a fixed path to engage the lastly laid brick and push it into place in the lining **28**.

Operation of the brick pusher **236** is controlled by two limit switches **257** and **261** positioned on a mounting plate **256** and the top surface of the air motor **238** respectively. A shaft block **154** attached to shaft **240** has adjustably positioned thereon two actuating members **258** and **262**. Upon actuation of the air motor **238**, the shaft **240** will rotate in a counterclockwise motion, forcing the lastly laid brick **144** against the next to lastly laid brick in the lining **28** until the forward limit switch **261** is actuated by the plate **262**. A signal will then be sent to reverse the motion of the shaft **240** to return the brick pusher to its retracted position, the operation of the air motor **238** ceasing when the block **258** actuates the return limit switch **257**.

The brick gripper **264** for placing a brick **144** in the lining **28** is positioned on two base pads **270** on the front of the front plate **158**, and comprises an air motor **266** which rotates a shaft **268** extending outward from both sides thereof as best seen in FIGS. 6 and 10–12. Two spaced arms **272** and **282** are attached to the protruding ends of the shaft **268**. Swing arm **272** is attached to the shaft **268** by means of two spaced flanges **274** engaging a block **276** rigidly fixed to the shaft **268** and a pivot pin **278** passing therethrough. The distal end of the swing arm **272** is provided with a gripping pivot point **280** for gripping one end of the brick **144** and allowing the brick to rotate thereabout. The positioning arm **282** is rigidly fixed to the shaft **[266]** *268* so as to only rotate therewith. The distal end of the positioning arm **282** is provided with a rotating gripper **284** and a sprocket **288** interconnected by a shaft **286** journaled in the arm **282**. A clamping axial air motor **308** is pin connected to the positioning arm **282** by pin **312**, and has a piston rod **310** connected to the swing arm **272** by pivot pin **314**. Retraction and extension of the piston rod within air motor **308** will cause the swing arm **272** to pivot about the pin **278** to grip or release, respectively, a brick **144** between the gripping point **280** and the rotating gripper **284**.

As best shown in FIGS. 6, 7 and 10, a fixed sprocket **290** is rotatably mounted on a shaft **291** which is adjustably fixed within a slot **293** in a mounting bracket **292** affixed to the front plate **158** in spaced relation from the air motor **266**. The vertical elevation of the shaft **291** is substantially the same as that of the shaft **268** of the air motor **266**. Positioned on the rear of the mounting bracket **292** is an axial air motor **294** with a piston rod **296** extending outward therefrom toward the fixed sprocket **290**. A chain **298** is mounted around a roller **302** journaled in the side of the positioning arm **282**, and the two sprockets **288** and **290**, one end of the chain being mounted to the piston rod **296** and the other end being fixed to a spring **300** attached to the side of the positioning arm **282** by pin **304**.

The bricks **144** are delivered in what is termed an upright position lying on a longitudinal edge to the front of

the conveyor assembly **146** where the brick gripper **264** grasps the bricks and translates them to the wall of the ladle **22** to form the lining **28** thereof. The bricks must be reoriented from the upright position to a horizontal position since the bricks of the lining **28** lie on one side wall surface with one of the longitudinal edges abutting the safety lining **26** and the other longitudinal edge facing inward toward the center of the ladle. As previously noted, the bricks are standard refractory bricks generally described in U.S. Pat. 3,140,333 with one of the longitudinal edges being longer than the other. Normally, in a circular ladle, the longer of the two longitudinal edges is placed against the safety lining **26** so that successive bricks in the lining naturally arc or bend to conform to the circular surface of the ladle. Often, however, the size of the ladles used in steel shops is increased by making the ladles elliptical in fashion with flat spots or regions on the circumference of the ladle. In this situation, it is necessary along the flat region to alternately reverse the orientation of the bricks so that the short longitudinal edge is alternately placed against the ladle safety lining **26** to form a straight region of lining. This is shown at flat region **29** on FIG. 3, the "S" denoting a short longitudinal edge and "L" denoting a long longitudinal edge. It is this dual reorientation of the bricks with which the chain **298** and sprockets **288, 290** are concerned, the operation of which is best seen in FIGS. 8A and 8B.

The center of the fixed sprocket **290** is positioned behind the pivot point of the gripper arm **282** so that rotation of the arm **282** will cause a change in the distance along the path of the chain **298** between the end of the piston rod **296** and the sprocket **288** on the arm **282**. The spring **300** connected to the end of the chain **298** either extends or compresses to accommodate this change in distance and in turn causes the sprocket **288** to rotate relative to the arm **282**. For rotation of the arm **282** from position A to position C in FIG. 8A, the distance becomes less and the spring **300** compresses to pull the chain **298** around the sprocket **288** thereby causing a clockwise rotation of the sprocket and brick relative to the arm **282**. For example, in position A, the arm **282** is oriented at an angle of [26°–½°] *26½°* and picks up a brick [**244**] *144* lying on its short longitudinal edge (denoted by "S"). The initial length of spring **300** is "d_1" and the center of the fixed sprocket is spaced a distance "p" behind the pivot point of the arm **282**. When the rotary air motor **266** is actuated, the arm **282** rotates counterclockwise 159° through position B to position C where the bricks **144** are released, the arm **282** being [5°–½°] *5½°* below the horizontal, and the brick **144** having rotated clockwise [63°–½°] *63½°* so that it is roughly parallel to the top surface of the lining **28**. The spring **300** has compressed to a length "d_2." The distance "p" between the center of the sprocket **290** and the pivot axis of the arm **282** depends on the size of the sprockets **288** and **290** and the amount of rotation of the arm **282** and may be determined empirically in order to effectuate the desired rotation of the brick **144**.

For the situation where the brick **144** is to be laid in the lining **28** in a reverse orientation, (i.e. the short longitudinal edge abutting the safety lining **26**) the piston rod **296** of the air cylinder **294** is retracted to rotate the brick **144** counterclockwise during rotation of the arm **282** by the air motor **266**. Using the same example as above for FIG. 8A, the brick **144** is initially grasped when the arm **282** is in position A with the spring **300** having a length "d_1," and the piston rod **296** extended fully. However, as the arm **282** is rotated from position A through B to C, the piston rod **296** is retracted a distance "r," causing the brick **144** to rotate counterclockwise [116°–½°] *116½°* relative to the arm **282** such that the short longitudinal edge is adjacent the lining **26**, In this situation, the spring **300** stretches from "d_1" in position A to "d_3" in position C. Again the distances "p" and "r" are dependent on the size of the sprockets **288, 290** and the amount of rotation of the arm **282** and may be determined empirically.

Of course it should be understood that there are other ways of combining the spring **300**, the chain **298**, and the two sprockets **288, 290** to properly reorient the brick **144** before it is placed in the lining **28** of the ladle **22**. This may be accomplished simply by wrapping the chain **298** in the opposite direction around the sprocket **288**, that is, first passing the chain **298** underneath and then around the top of the sprocket **288** to the spring **300**. In this situation the spring **300** would stretch and the sprocket **288** would rotate clockwise during the rotation of the arm **282** for laying both a normal oriented and a reverse oriented brick **144**. Or the size of the sprockets **288, 290** could be varied and the separation between the center of the fixed sprocket **290** and the center of rotation of the arm varied, or even the position of the fixed sprocket **290** could be changed. The only thing necessary in making these changes is to ensure that it is possible to effectuate two different amounts of angular rotation of brick **144** as the arm **282** is rotated from position A (picking brick up) to position C (releasing brick).

Also provided on the front plate **158** of the conveyor assembly are several mechanisms for controlling the operation of the brick laying machine **20**. As shown in FIGS. 6 and 7, an arm stop slide **340** is adjustably positioned along a bracket **342** by means of a screw **344**. An upward protruding member **341** is provided on the arm stop slide **340** for controlling the height of the gripper arms **272, 282** when picking up a brick **144**. Forward motion of the arms **272, 282** is controlled by a limit switch **306** which in the preferred embodiment in FIG. 6 is shown to be attached to the front of the air motor **266**. Upon actuation of limit switch **306**, the arms **272, 282** stop rotating and the brick **144** held therebetween is released, with the arms then returning to pick up another brick. The advancement of the bricks **144** along the chains **166** is controlled by a brick limit switch **346** attached to a bracket **348** adjustably locatable on the front sprocket support **176** by means of a screw **350** as shown in FIGS. 7 and 10. Upon actuation of the limit switch [**348,**] *346*, the bricks are stopped and remain stationary until the forwardmost brick is picked up by the gripper **264**.

A brick aligner mechanism **316** for ensuring alignment of the bricks **144** on the conveyor chains **166** comprises an axial air motor **318** adjustably mounted on a bracket **320**, positioned on the frame member **150** as shown in FIGS. 6, 7, 9 and 10. The axial air motor **318** has a piston rod **322** to the end of which is attached a disc **324**. As the bricks **144** are advanced along the chain **166**, the air cylinder **318** is periodically actuated to extend the disc **324** to push the bricks transversely on the chain **166** thereby aligning them for pickup by the gripper mechanism **264**.

Also positioned on the conveyor assembly **146** is a mortar bucket **326** supported by a cross support **330** connected to two uprights **328** mounted on frame members **148** and **150** as shown in FIGS. 1, 2 and 7. The mortar bucket **326** contains a slurry type mortar delivered to the lining **28** by gravity in a flexible hose **334**, one end of which is connected to the lower nozzle **332** of the mortar bucket **326** and the other end of which is positioned in a hose support **338** extending outward from the air motor **238**. A control valve or clamp means **336** having an actuator **337** is provided for controlling the flow of mortar to the lining. It should be noted that the use of mortar is not necessary due to the interlocking action of the bricks **144**, but is merely shown for the situation where it is desired to supplement the holding of the bricks in place in the lining.

The operation of the automated bricklaying device **20** is as follows. The ladle **22** is cleaned of excessive slag and dirt accumulation and inspection and repair of the bottom and the safety lining **26** is undertaken in the conventional manner. The bottom brick lining and well block are laid up as is the skew brick ring which is com-

prised of one tapered starter set **27** and several spiraling courses of semi-universal refractory brick **144**, also in the conventional manner. The tapered starter set is necessary to provide that the working lining **28** is built up by spiraling courses.

The automated bricklaying device **20** is then lowered into the ladle, either as a whole unit or in components as previously noted and leveled by screw jacks **40** on turntable **30** to rest on the bottom brick lining. The bricklaying machine may then be connected to a power source and operated in a manner to be described hereinbelow.

As previously noted, the bricklaying device **20** in the preferred embodiment is a totally air operated device as opposed to, for example, an electrically operated device. This is merely a matter of preference, depending on the type of shop in which the bricklaying machine will be used and the capabilities thereof, and it makes no major difference what type of power source is employed. It is conventional in most steel shops to use air as a source of power to operate various devices for operation therein and, as such, air was initially chosen to supply the power for operation.

The particular control diagram **400** for the preferred embodiment is depicted diagrammatically in FIGS. 14A and 14B. As a key to aid in understanding the diagrammatic representation, the following should be noted. The numbers **412** and **414** on FIG. 14A represent typical main air supply lines for operating the various air motors and air cylinders of the bricklaying machine **20**; the numbers **428** and **442** on FIG. 14A represent typical pilot lines for switching control valves from one position to another; the number **476** on FIG. 14A represents a typical check valve which permits air to flow in the line **478** in one direction (to the right) and prohibits air flow in the other direction (to the left); the number **594** of 14B represents a typical adjustable flow control valve to control the flow of air therethrough; the number **474** on FIG. 14A represents a typical pressure regulator which controls the amount of air pressure delivered to the left-hand portion of the line **414**; the number **424** on FIG. 14A represents a typical mechanically actuated control valve with a spring return which will return to its normal position upon release of the operator; the number **518** on FIG. 14B represents a typical air actuated control valve whose position is changed by providing air to one of the chambers "A" or "B," the valve remaining in that position until air is provided to the other of the chambers; and the numbers **408** on FIG. 14A and **538** on FIG. 14B represent typical manually actuated control valves whose position is changed manually and maintained thereat by detents.

With the above brief description of the diagrammatic representation in FIGS. 14A and 14B, the operation of the bricklaying machine **20** is as follows. The main supply of air to the machine is provided from a compressor (not shown) by the supply line **402**, a filter **404** and lubricator **406** being provided in the line **402** so that the air to the system is clean and lubricated. Air is supplied by branch line **416** to the control valve **418** to operate the air hoist **130** of the boom mechanism **118** independent of the rest of the system. The control valve **418** is a three-position valve for controlling the air motor **130** to raise, to lower, or to stop the cable **131**. Actuator **419U** shifts the valve **418** to supply air from line **416** to line **420** to raise the cable **131**, with air in down line **422** exhausting through vent line **421** while the actuator **419D** shifts the valve **418** to the other side so that air is delivered to the down side of the air motor **130** to lower the cable **131**.

The remainder of the operation of the bricklaying machine is controlled by the three-position manually-actuated valve **408** which, in FIG. 14A, is shown in a neutral position sending no air to the system. Initially the valve **408** is placed in the "manual" position so that air will be provided from the branch line **410** to the main manual control line **412**, and the air in the automatic line **414** will exhaust to the atmosphere through vent line **413**. The main hoist valve **434**, as with the valve **408**, is a three-position valve to which air is delivered via lines **412**, **415**, **430** and **436** to control the air hoist **78** for raising and lowering the carriage platform assembly **90** on the elevator frame assembly **64**. The control system is also provided with a conventional spring biased brake **450** and a slack cable limit switch **426** for restricting operation of the air hoist **78**. The brake **450** automatically locks the air hoist **78** in place if no air is sent to it along pilot line **452** and the slack cable limit switch releases the air in line **429**, **452** if the cable **81** of the hoist **78** is slack, the slack position being shown in FIG. 14A. If the cable **81** is not slack, the valve **426** is depressed so that no air will be released from line **429** as described hereinafter. Pilot air is delievered for manual operation by pilot lines **442** and **446** joined to the air hoist up and down lines **438** and **440** respectively. Check valves **444** and **448** are positioned in pilot lines **442**, **446** to prevent a reverse flow from one pilot line to the other, which would prevent release of the brake **450**.

Lowering of the cable **86** of the hoist **78** and thus the carriage assembly **90**, is accomplished by placing valve **434** in the "down" position so that air will be provided from line **436** through line **440** to both the brake **450** and the "down" side of the air hoist **78**. Air is released from the "up" side of the motor **78** through the "up" line **438** to vent line **439**. The carriage assembly **90** is lowered until it is at the approximate height necessary to start laying bricks in the lining, in which case the valve **434** is placed back in its neutral position (see FIG. 4). Next, the conveyor assembly **146** is extended from beneath the carriage assembly **90** so that the conveyor extension wheel **208** rides against the inner surface of the lastly laid bricks in the lining **28**. The conveyor extension valve **464** is placed in the "out" position and air is delivered to the extension air motor **162** by lines **412**, **415**, **458** and **466**. A pressure regulator **460** in the line **458** controls the amount of air pressure in line **458** to the right of the regulator **460** and as such the amount of pressure delievered to the extension motor **162**. Normally the regulator **460** is set so as to provide a sufficient force on the conveyor extension wheel **208** to properly set the bricks **144** in the lining **28** against the safety lining **26**, this occurring as the conveyor assembly **[90]** *146* revolves around the circumference of the ladle, notwithstanding the fact that the turntable assembly is not positioned in the center of the ladle and notwithstanding the fact that the ladle may be elliptical. As air is delivered to the extension motor **162** by line **466**, air in the "in" line **468** is controllably released to the atmosphere through the vent line **470** and flow control valve **472** situated therein.

After the conveyor assembly **146** has been properly positioned against the lining **28**, the carriage assembly is again lowered until the cam follower wheel **206** rests on the top surface of the lining **28**. A manual override valve **424** has been provided where it is desired to release the brake **450** when the cable **86** on the air hoist **78** is slack, such as might occur if the hoist **78** were lowered too far when the cam followed wheel **206** rested on the lining **28**. When the valve **424** is actuated, air passes from branch line **423** to pilot line **428** to actuate the slack cable limit switch **426** so that air in line **429** is not released to the atmosphere through vent line **427**, but instead passes to release the brake **450**. Although the valve **426** is positioned to pass air from line **429** through line **484** to line **480**, no such passage occurs due to the check valve **482** being situated in line **480**. Normally the manual override valve **424** is positioned so that any air in pilot line **428** is released to the atmosphere throuhg vent line **425**.

After the carriage assembly **90** is properly positioned within the ladle the main control valve **408** is shifted to provide air to the automatic line **414** and drain air in the

manual line **412** through vent line **413**. The air pressure in the automatic line **414** is controlled by the pressure regulator **474**, a bypass line **478** with check valve **476** being provided in parallel to allow drainage of the automatic line **414** when the valve **408** is in a "manual" position. For automatic operation, the main hoist valve **434** is placed in an "up" position and a pilot line **484** from line **480** provides air to release the brake **450** if the cable **86** is not slack. A pressure regulator **488** in line **480**, controlled by the conveyor positioning mechanism **200** as described hereinabove, serves to provide air to the hoist **78**. If the plunger **232** (see FIG. 4) is not depressed into the regulator due to the force exerted by spring **222** being greater than that exerted on the cam follower wheel **206**, then no air is allowed to pass through the regulator to line **436** to actuate the hoist **78** to raise the carriage assembly **90**. Instead, since the brake **450** is released, the carriage assembly **90**, and thus the conveyor assembly **146**, will start to move downward along the elevator frame assembly **64**. As the force on the cam follower wheel **206** forces the plunger into the regulator **488**, air from line **480** is allowed to pass through the regulator to the main hoist valve **434** to actuate the hoist mechanism **78**. As the hoist mechanism is actuated, the conveyor assembly **146** is raised, relieving the weight which the cam wheel **206** supports until the spring **222** forces the regulator plunger **232** out of the regulator **488** to stop the flow of air therethrough. The conveyor assembly **146** continues to oscillate, falling downward since the brake **450** is released and rising since the plunger **232** is inserted, until a balance of forces is maintained in which the conveyor assembly rests at the proper height. The air hoist **78** is periodically actuated as the cam wheel **206** rides on the spiraling courses of bricks built up in the lining **28** and thus this type of mechanism provides a self-regulating control of the height of the carriage assembly **90** in the ladle **22**. Alternatively, a limit switch could be used in place of the pressure regulator **488** if precise modulating control of the height of the platform is not required.

Air from the automatic line **414** is provided to the extension motor **162** by branch line **492** which connects to the line **458**, the operation of the extension motor **162** being as previously described for manual operation with the valve **464** in an "out" position. Check valves **490**, **432**, **494**, and **456** are provided in branch lines **480**, **430**, **492** and **415** respectively so that the air in these lines will not be released to the atmosphere during either automatic operation or manual operation. These check valves are necessary since both the automatic and manual lines are commonly connected to the branch lines **436** of the main hoist valve **434** and **458** of the main conveyor extension valve **464**.

With the conveyor assembly **146** properly positioned relative to the circumference of the ladle **22** and ready for operation to lay bricks, the boom mechanism **118** is operated to place bricks **144** on the conveyor chains **166**. The stop-start switch **538** is then placed in a start position (as shown in FIG. 14B allowing air to pass between pilot lines **532** and **540**) and the manual operator **500** on the front index switch **498** is actuated. Air passes from line **508** through the valve **498** to the pilot line **510** into chamber "B" of conveyor indexing valve **518** to switch valve **518** so that air passes from branch line **520** to return line **524** to retract the piston rod **194** of the indexing motor **192**, air from the other side of the motor **192** being exhausted through extension line **522** and vent line **519**. Pilot air from line **510** is also provided to chamber "A" of the brick aligner valve **544** by line **516** so that air from line **548** passes through valve **544** to line **550** to extend the piston rod **322** of the brick aligner motor **318** to align the bricks **144** on the chains **166**. The piston rod **194** of the conveyor indexing motor **192** is retracted until the rod actuator **504** engages the operator of the rear indexing switch **530** to allow pilot air in line **528** to pass through valve **530** into pilot line **532**. Pilot air is initially delivered to pilot line **528** from pilot line **508** via line **526** which passes through the brick limit switch **346** as long as a brick **144** does not engage the operator of the valve **346**. The air in line **532** passes through the stop-start switch **538** into chamber "A" to switch valve **518** to extend the piston rod **194** of the conveyor indexing motor **192**. At the same time, pilot air in line **532** is delivered by line **536** to chamber "B" of the brick aligner valve **544** causing the valve to change positions to retract the piston rod **322** of the brick aligner cylinder **318**. The piston rod **194** is extended until the rod actuator **504** engages the operator **502** of the valve **498** to return the rod as previously described by manual actuation of operator **500**.

This sequence of operation of advancing bricks **144** along the length of the conveyor assembly **146** continues until a brick **144** actuates the operator of the brick limit switch **346** to switch the valve **346** to pass air therethrough from line **526** to line **556**. Pilot air is then delivered by line **558** into a chamber in valve **498** to actuate the valve **498** for returning the piston rod **194** in the indexing cylinder **192**. However, when the rod actuator **504** engages the operator of valve **530**, the valve **518** will not switch to extend the rod **194** until the brick **144** is removed to release the brick limit switch **346** since air is not then being delivered to line **528**. As thus far described, each of the valves and limit switches **498**, **530** and **346** are provided with vent lines **512**, **532** and **554** respectively so that any air in the connecting lines is released to the atmosphere. This is necessary since the air in either chamber "A" or "B" of valves **518** and **544**, if not released, would oppose the air sent to the other of the chambers and would thus prevent switching of the valves **518** and **544**.

After a brick **144** has actuated the valve **346**, the air in line **556** passes to valve **[261]** *257* of the brick pusher mechanism **236** which is actuated to allow air into line **564** only when the brick pusher mechanism is in a return position. The air in line **564** then passes to chamber "B" of the gripper control valve **568** to switch the valve to allow air to pass therethrough from line **506** to line **570**. The air in chamber "A" of valve **568** is exhausted through vent line **601** via lines **612**, **602**. From line **570**, the air is delivered to the clamp cylinder **308** by line **580** which has a pressure regulator **586** positioned therein for controlling the clamping force applied by the motor **308** in order not to crush or crack the bricks grasped by the arms **272**, **282**. A bypass line **582** with check valve **584** is connected in parallel across the pressure regulator **586** to provide a quick exhaust of air from the clamp motor **308** when the signal is given to release the brick. Line **570** also delivers air to the rotary air motor **266** by line **572** to take the brick **144** from the chains **166** and place it in the wall of the ladle **22**, the motion being clockwise as shown in FIG. 14B. A check valve **576** in bypass line **574** is connected in parallel across a flow control valve **578** in line **572**, the check valve **576** passing air quickly to the air motor **266** while preventing back flow therefrom and the flow control valve **578** controlling the air released from the air motor **266** during the return thereof to pick up another brick.

The air in line **570** also passes through the valve **354** located on the base of the connecting couple **68** of the elevator frame assembly **64** to control the operation of the sprockets **288**, **290** and chain **298** on the gripper arm **282**. If the operator on the valve **354** has not been actuated, then air is delivered to line **588** to keep the piston rod extended in the air motor **294**. Actuation of the operator on the valve **354** can best be seen in FIG. 13 wherein the upper platen **34** has rotated relative to the lower platen **32** such that the limit switch **354** is located adjacent to the cam trippers **356** supported by supports **358** from the bottom platen **32**. As the upper platen **34** continues to rotate relative to the lower platen **32**, the operator of the limit switch **354** will be depressed by the cam tripper **356** thus causing the valve **354** (see FIG. 14B) to shift positions so that air in line **570** is delivered to line **590**. The air in line **590**

passes through a flow control valve **594** to the air cylinder **294** to controllably retract the piston rod **296** as the gripper arms **272, 282** rotate to lay a brick in the lining **28**. A bypass line **596** with check valve **598** is provided in parallel to control valve **594** so that air will be exhausted quickly through line **590** to vent line **592** when the valve **354** is not actuated by the cam tripper **356**.

As the gripper arms **272, 282** rotate to deliver the brick **144** to the circumference of the ladle **22**, the arm **282** engages and actuates a limit switch **306** as best seen in FIG. 6. Referring again to FIG. 14B, when the limit switch **306** is actuated, air is provided from pilot line **600** to line **602** and, in turn, to lines **612** and **604**. Pilot air in line **604** enters chamber "A" of valve **566** to shift the valve to release the air in chamber "B" of valve **568** through vent line **567**, and pilot air in line **412** enters chamber "A" of valve **568** to shift the valve **568** so air is supplied from line **506** to line **614**. Flow control valve **606** positioned in line **604** restricts the release of air from chamber "A" of valve **566** in order to provide a time delay before air may again be delivered to chamber "B" of valve **568** to cause actuation of the motor **266** to lay a brick. Bypass line **608** with check valve **610** is provided in parallel to the flow control valve **606** in order to effect a quick shifting of valve **566**. The air in line **614** is passed to extend the piston rod of the clamp motor **308** to release the brick held thereby and is also sent, via branch line **620**, to return the brick gripper arms **272, 282** to pick up another brick **144**. A bypass line **624** with check valve **626** is connected in parallel fashion across the flow control valve **622** in line **620** so that air will be quickly sent to the air motor **266** to return the arms **272, 282**, and will be released through the flow control valve **622** upon actuation of the air motor **266** to lay a brick. The pressure regulator **618** in line **614** is set so that only a small amount of air, which is all that is needed to effect the return of the brick gripper and release of the brick, is delivered to the air motor **266** and the clamp motor **308**. A check valve **616** is placed in line **614** so as to allow a build-up of air on the return side of the motor **266** when laying a brick in order that the brick is not slammed into the lining. When the valve **568** is in the position shown in FIG. 14B, air in line **570** is released to the atmosphere by vent line **569**.

Pilot line **602** also delivers air to chamber "A" of the brick pusher valve **628** to switch the valve to allow air to pass from line **630** into line **634** to the push side of the air motor **238**, thus actuating the brick pusher mechanism **236** to push the brick **144** into place against the lastly laid brick in the lining **28**. A pressure regulator **636** is provided in line **634** in order that the force of the brick pusher **236** does not become too great so as to crush bricks. Air in the return side of the motor **238** is quickly exhausted through vent line **629**. As the brick pusher **236** is actuated, air is also sent to actuate the turntable air motor **60**. Pilot line **644** continuously delivers air through the normally unactuated control valve **648** to line **652** into chamber "A" of turntable control valve **654** to force the valve into position to allow air to pass from line **662** into line **664**, thereby actuating air motor **60** to turn the turntable **30** clockwise. The valve **654** is a three-position air actuated, spring biased valve such that when air is not being continuously provided to chamber "A" or "B," then the spring bias will force the valve **654** into a neutral position as shown in FIG. 14B. The brick pusher mechanism **236** is more quickly actuated than the turntable air motor **60** since a flow control valve **670** is positioned in line **666** to controllably exhaust the air in the other side of the air motor **60** through the vent line **668**. A bypass line **672** with check valve **674** is connected in parallel across the flow control valve **670** to allow air to pass quickly in line **666** to the counterclockwise rotation side of the air motor **60** if the valve **[668]** *654* were in position to deliver air from line **662** to line **666**.

The brick pusher **236** continues to rotate, due to actuation of both the air motors **238** and **60**, until the limit switch **[257]** *261* is actuated, thus indicating occurrence of a predetermined amount of rotation which is sufficient to allow placement of the next brick in the lining **28**. When this occurs, valve **[257]** *261* shifts to allow air in line **638** to pass to line **642** into chamber "B" of valve **628** to switch the valve to return the brick pusher **236** to its return position. The air in chamber "A" is exhausted through vent line **601** of valve **306**, the valve **306** being in its unactuated state since the gripper arms on the brick gripper **264** have returned to their return position. When the brick pusher valve **628** changes positions upon air entering chamber "B," the air in line **634**, and thus in line **644**, is released to the atmosphere to the vent line **629**. The valve **654** then returns to its neutral position due to the spring bias and also due to momentarily air being sent to chamber "B" by pilot line **646**.

During operation of the brick gripper **264** and the operation of the brick pusher **236**, the conveyor indexing mechanism **192** has been actuated (due to release of valve **346** when the brick gripper **264** picked up the brick **144**) to deliver the next to be laid brick along the conveyor chains **166**, thus actuating the valve **346** and sending air from line **526** to line **556**. When the brick pusher **236** returns, valve **[261]** *257* will be actuated and air will be delivered from line **556** to line **564** and another brick will be laid in place in the manner described above.

When initially orienting the conveyor assembly **146** relative to the circumference of the ladle **22**, it may be necessary to actuate air motor **60** in order to turn the conveyor assembly. This is accomplished by placing the main control valve **408** in the "manual" position and using push button valves **648** and **656**. If the air motor **60** is to be operated to turn the turntable **30** clockwise, valve **648** is continually depressed to deliver air from lines **680, 676** to chamber "A" of valve **654**. The operation for counterclockwise rotation of the turntable **34** is accomplished by actuation of valve **656** in a similar manner to that done for clockwise rotation. Check valves **682** and **684** are provided in lines **546** and **[415]** *412* respectively so that air will not be fed into the manual line during automatic operation or fed into the automatic line during manual operation.

From the foregoing it is apparent that there is herein provided an automated bricklaying device **20** which permits the rapid buildup of the spiraling courses of refractory brick **144** necessary to form the working lining **28** of a metal pouring ladle **22**. The shell of the ladle **22** provides a circumferential guidance while the spiraling brick courses themselves provide the necessary height guidance so that the bricks are properly placed to form the working lining **28**. A conveyor indexing mechanism to the front of a conveyor assembly **146** wherein a brick gripper mechanism **264** grasps the bricks one at a time and lays them in the lining **28** of the ladle **22**. A brick pusher mechanism **236** and a conveyor extension wheel **208** attached to the front of the conveyor assembly **146** serves to firmly secure and set each brick against the previously laid brick and causes actuation of a turntable motor **60** to index the device **20** to the proper position for laying the next brick in the lining. During operation of the pushing cycle and indexing cycle, if it is desirous mortar may be provided to be placed in the working lining so as to ensure a proper seating and holding of the bricks within the ladle.

It will be understood that various changes in the details, materials and arrangements of parts which have been herein described and illustrated in order to explain the matter of the invention may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. An automated bricklaying device for laying out the brick lining of a vessel, the device comprising:

a delivery means for delivering a series of bricks in

turn to the circumference of the vessel to be set as the lining thereof;

a brick positioning means associated with said delivery means for *both circumferentially and laterally* positioning and firmly setting each brick in turn in the lining as it is delivered to the circumference of the vessel;

a supporting means for supporting said delivery means and said brick positioning means inside the vessel and for permitting, of said delivery means and said brick positioning means, longitudinal movement along, reciprocal lateral movement relative to and revolutional movement about an axis thereof positioned within and substantially parallel to the axis of the vessel to be lined;

an operating means for moving said delivery means and said brick positioning means longitudinally along, laterally relative to and revolutionally about said axis of said support means so as to position said delivery means and said brick positioning means relative to the circumference of the vessel; and

[a] *automatic* control means for controllably operating said operating means [after a brick has been positioned in place in the lining for properly positioning said delivery means and said brick positioning means] *including means for stopping said operating means when said delivery means and said brick positioning means are properly positioned* for the placement of the next succeeding brick in the lining, *said means being responsive to the position of the lastly laid brick in the lining.*

2. The apparatus of claim 1 wherein said support means includes an upright frame assembly mounted within the ladle, and a platform assembly carried by said upright frame assembly for longitudinal movement therealong, said delivery means being mounted to said platform assembly for reciprocal lateral movement relative thereto.

3. The apparatus of claim 2 wherein said support means further includes a turntable placed in the bottom of the vessel, said turntable comprising a lower platen and an upper platen supported by said lower platen for rotational movement relative thereto, the axis of rotatior being said axis of said support means, and wherein said upright frame assembly is mounted to said upper platen whereby, when said upper platen rotates relative to said lower platen, said delivery means revolves about said axis of rotation.

4. The apparatus of claim 3 wherein said operating means includes a hoist means for selectively raising and lowering said platform assembly along said upright frame assembly and a reciprocating drive means for selectively extending and retracting said delivery means relative to said platform assembly.

5. The apparatus of claim 4 wherein said operating means further includes a rotary actuating means for imparting rotary movement to said upper platen of said turntable relative to said lower platen.

6. The apparatus of claim 5 wherein said *automatic* control means includes a first limit switch means for causing operation of said rotary actuating means and *wherein said means of said automatic control means for stopping said operating means is* a second limit switch means for stopping operation of said rotary actuating means, said second switch means being actuated to stop said rotary actuating means after said brick positioning means has moved a predetermined distance relative to the circumference of the vessel.

7. The apparatus of claim 6 wherein said first limit switch means is actuated to cause operation of said rotary actuating means after said placement means has placed a brick in the lining.

8. The apparatus of claim 4 wherein said control means includes a vertical guidance means on said platform assembly, said vertical guidance means causing actuation of said hoist means so as to maintain a fixed vertical relation between said platform assembly and the built up lining.

9. The apparatus of claim 4 wherein said control means includes an extension guidance means on said delivery means, said extension guidance means actuating said reciprocating drive means so as to maintain a fixed relation between said delivery means and the built up lining.

10. The apparatus of claim 1 wherein said delivery means is a conveyor means having a conveyor indexing means for selectively advancing the bricks on said conveyor means to the circumference of the vessel.

11. The apparatus of claim 10 wherein said delivery means includes a placement means for taking a brick from said conveyor means and placing it in the circumference of the vessel.

12. The apparatus of claim 1 wherein said brick positioning means comprises a first means for pushing a brick delivered to the circumference of the vessel into engagement with the previously laid brick and a second means for pushing a brick delivered to the circumference of the vessel into engagement with the interior wall of the vessel.

13. An automated bricklaying machine for laying out the refractory brick lining of a metal pouring ladle, the machine comprising:

an upright means extending into the ladle;

a mounting means for supporting said upright means for traversing about the circumference of the ladle;

a platform means carried by said upright means for vertical movement therealong;

means for selectively raising and lowering said platform means relative to said upright means;

a delivery means on said platform means reciprocally laterally movable relative thereto for delivering a series of refractory bricks in turn to the circumference of the ladle to be set as the lining thereof;

a positioning and indexing means on said delivery means for properly positioning each brick in turn in the lining while indexing said platform means to a proper position for placement of the next succeeding brick in the lining; and

vertical guidance means on said [conveyor] *delivery* means for providing vertical elevational control of said platform means relative to the built up lining.

14. The apparatus of claim 13 wherein said mounting means is a turntable placed on the bottom of the ladle, said turntable comprising a lower platen and an upper platen supported by said [.] lower platen for rotational movement relative thereto.

15. The apparatus of claim 14 wherein said upper platen is supported by means of a plurality of rollers journaled on the side of said lower platen and wherein said lower platen has a plurality of leveling screws for leveling said lower platen.

16. The apparatus of claim 15 wherein said turntable includes a gear ring mounted to said lower platen; a pinion gear having a shaft journaled in said upper platen and having teeth engaging teeth of said gear ring; a sprocket means fixed to said shaft of said pinion gear; a rotary actuating motor mounted to said upper platen; and a chain means for said sprocket means and said rotary actuating motor whereby, when said rotary actuating motor is actuated, said upper platen is rotated relative to said lower platen.

17. The apparatus of claim 16 wherein said positioning and indexing means includes a second means for pushing a brick in the lining into engagement with the previously laid brick in the built up lining.

18. The apparatus of claim 17 wherein said second means is a brick pusher having a rotary actuating means; a wheel means; a linkage means connected at one end to said rotary actuating means and connected at the other end to said wheel means such that upon actuation of said rotary actuating means said wheel means follows a fixed

path to push brick in the lining into engagement with the previously laid brick.

19. The apparatus of claim 18 wherein there is a control system associated with said brick pusher and said rotary actuating motor on said turntable for actuating said rotary actuating motor on said turntable when said rotary [actuator] *actuating means* of said brick pusher is actuated.

20. The apparatus of claim 19 wherein said brick pusher includes a limit switch means which, when actuated, stops said brick pusher from pushing and indicates that said platform means is in a proper position for placement of the next succeeding brick in the lining.

21. The apparatus of claim 13 wherein said delivery means includes a conveyor means for advancing bricks thereon toward the circumference of the ladle and a placement means for taking bricks in said conveyor means one at a time and placing them in turn in the lining.

22. The apparatus of claim 21 wherein said delivery means further includes a conveyor indexing means having a one-way friction clutch and a reciprocating drive means whereby said conveyor means is advanced when said one-way friction clutch is driven in a first direction by said reciprocating drive means and said conveyor means remains stationary when said one-way friction clutch is driven in a second direction by said reciprocating drive means.

23. The apparatus of claim 21 wherein said placement means is a brick gripper for transferring a brick in a first position on said conveyor means to a second position in the lining.

24. The apparatus of claim 13 wherein said positioning and indexing means includes a first brick pushing means for laterally pushing a brick in the lining into engagement with the interior wall of the ladle.

25. The apparatus of claim 24 wherein said lateral brick pushing means is an exterior wheel positioned on said delivery means.

26. The apparatus of claim 13 wherein said means for selectively raising and lowering said platform means is a hoist motor positioned on said upright means.

27. The apparatus of claim 26 wherein said vertical guidance means is a wheel means carried by said delivery means which rides on the top of the built up lining, said wheel means actuating said hoist means on said upright means for maintaining a fixed vertical relation between said platform means and the built up lining.

28. The apparatus of claim 13 wherein said platform means includes a means for picking up bricks resting on said platform means and placing them on said delivery means.

29. In a bricklaying machine for lining a ladle with bricks having a conveyor means, a placement means having a pickup position and a placement position, a brick positioning means having a return position and a pushing position, and an apparatus positioning means, a control system for controllably operating the machine to perform a series of sequential operations comprising, in combination:

a first means for operating the conveyor means to deliver the bricks to the placement means;

a second means for operating the placement means to place the bricks in the lining of the ladle;

a third means for operating the brick positioning means to properly position the bricks in the lining;

a fourth means for operating the apparatus positioning means to index the conveyor means, the placement means and the brick positioning means relative to the circumference of the ladle;

a first switch means for controlling said first means such that when said first switch means is actuated, said first means is operable to cause said conveyor means to stop, said first switch means being actuable whenever a brick on said conveyor means is in position for removal therefrom by said placement means;

a second switch means for controlling said second means such that when said second switch means is actuated, said second means is operable to cause said placement means to pick up a brick from said conveyor means and move said brick toward said ladle lining, said second switch means being actuable whenever said first switch means is actuated and said brick positioning means is in a return position;

a third switch means for controlling said second means, said third means and said fourth means such that when said third switch means is actuated, the following operations take place:

a. said second means is operable to cause said placement means to stop, to release the brick held thereby, and to return to its pickup position,

b. said third means is operable to cause said brick positioning means to move towards said pushing position to properly position said brick released by said placement means in said ladle lining, and

c. said fourth means is operable to cause said apparatus positioning means to move said conveyor means, said placement means and said brick positioning means relative to said circumference of said ladle, said third switch means *being* actuable when said placement means is in the placement position to place said brick in said lining; and

a fourth switch means for controlling said third means and said fourth means such that when said fourth switch means is actuated the following operations take place:

a. said third means is operable to return said brick positioning means to its return position, and

b. said fourth means is operable to cause said apparatus positioning means to stop, said fourth switch means being actuable when said apparatus positioning means has indexed said conveyor means, said placement means and said brick positioning means to a proper position for placement of the next succeeding brick in the lining.

30. The apparatus of claim 29 wherein said first means is a conveyor indexing means including a one-way friction clutch for driving said conveyor means in one direction only.

31. The apparatus of claim 30 wherein said conveyor indexing means includes a reciprocal drive motor having an advancing motion and a retraction motion, said reciprocal drive motor being controlled by two limit switch means for causing advancing motion and for causing retraction motion.

32. The apparatus of claim 29 wherein there is a fifth means for operating said placement means to place bricks in the lining in one of two different orientations and wherein there is a fifth limit switch means for controlling said fifth means.

33. The apparatus of claim 29 wherein said fourth means includes a vertical drive means, a lateral drive means and a rotational drive means [whereby] *and wherein* said third and fourth limit switch means [controlling] *control* operation of said rotational drive means, said vertical drive means and said lateral drive means [being controlled so as] to maintain a fixed vertical and lateral relation between [said] *the* conveyor means *and the circumference of the ladle* as said rotational drive means rotates the conveyor means, the placement means and the brick positioning means.

34. The apparatus of claim 29 wherein said control system is a pneumatic control system and wherein said first, second, third and fourth means are pneumatic operating means and said first, second, third and fourth limit switch means are pneumatic limit switches.

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U.S. Cl. X.R.

52—747

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : Re.28,305

DATED : January 21, 1975

INVENTOR(S) : Ronald E. Williamson, et al

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

Column 1, line 9	Ser. No. 466,566 should read Ser. No. 466,565
Column 1, line 24	delete "theeon" and insert --thereon--.
Column 6, line 23	delete "154" and insert --254--.
Column 10, line 18	delete "delievered" and insert --delivered--.
Column 10, line 42	delete "delievered" and insert --delivered--.
Column 10, line 72	delete "throuhg" and insert --through--.
Column 12, line 28	delete "532" and insert --531--.
Column 14, line 51	following "mechanism" insert --178 operates to deliver a series of refractory bricks 144--.

Signed and Sealed this

eighteenth Day of *May 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks