United States Patent [19]

Howeler et al.

[11] 3,857,265

[45] Dec. 31, 1974

[54] **APPARATUS FOR ELECTROHYDRAULICALLY FORMING TUBULAR ELEMENTS**

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[73] Assignee: **Continental Can Company, Inc.**, New York, N.Y.

[22] Filed: **May 12, 1972**

[21] Appl. No.: **252,829**

Related U.S. Application Data

[63] Continuation of Ser. No. 749,885, Aug. 2, 1968, abandoned.

[52] **U.S. Cl.** **72/56**, 72/63, 113/115

[51] **Int. Cl.** **B21d 26/12**

[58] **Field of Search** .... 72/56, 63; 29/421 E; 100/264, 272; 425/242, 450; 113/115

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Primary Examiner—Richard J. Herbst
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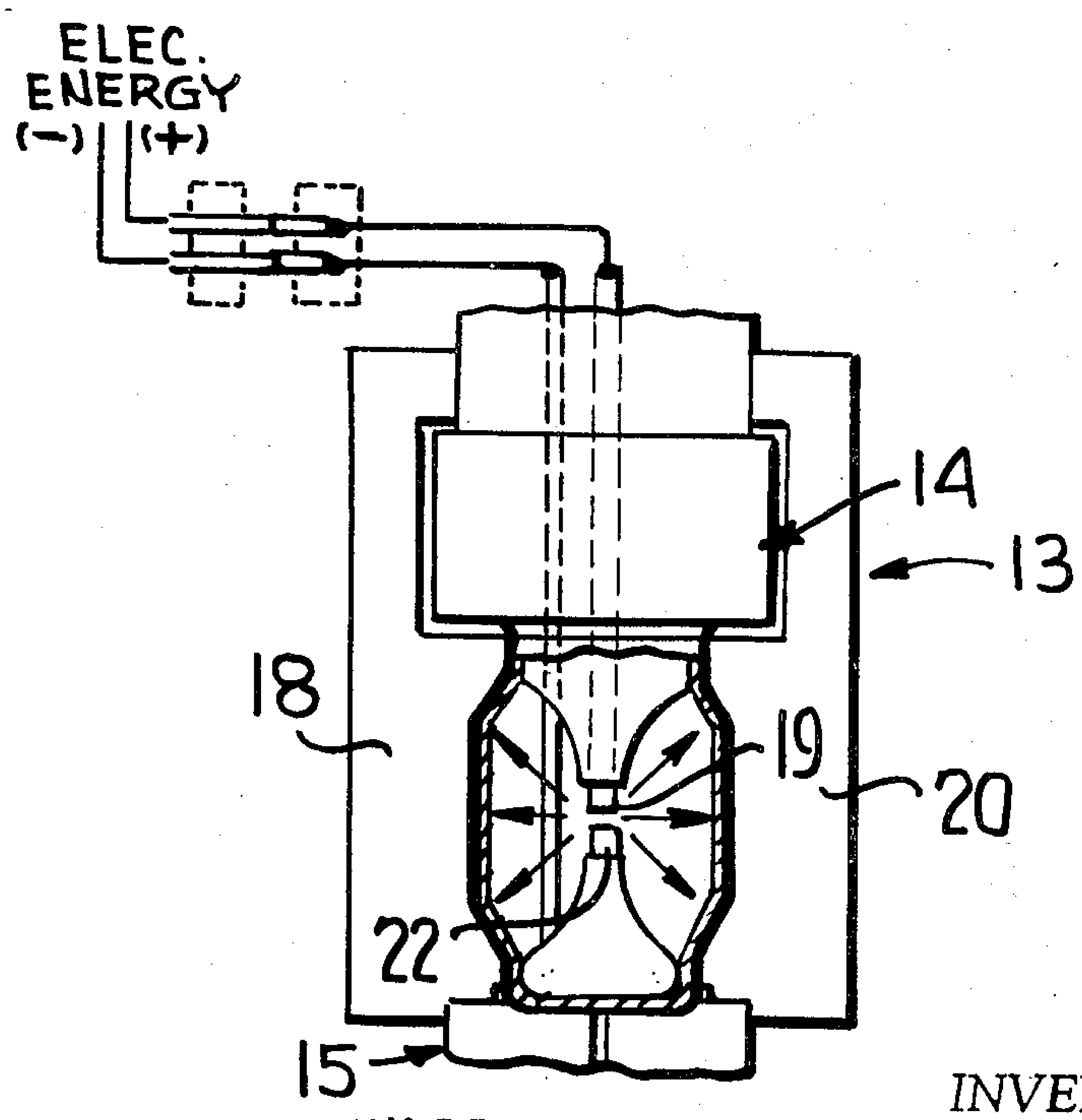
[57] **ABSTRACT**

This invention relates to a novel apparatus for forming or reforming tubular elements by positioning a tubular element internally of a split mold and generating an electrical discharge in a chamber internally of each tubular element whereby a shock wave is created to radially outwardly expand the chamber and force the tubular element into conformity with the split mold cavity.

7 Claims, 30 Drawing Figures



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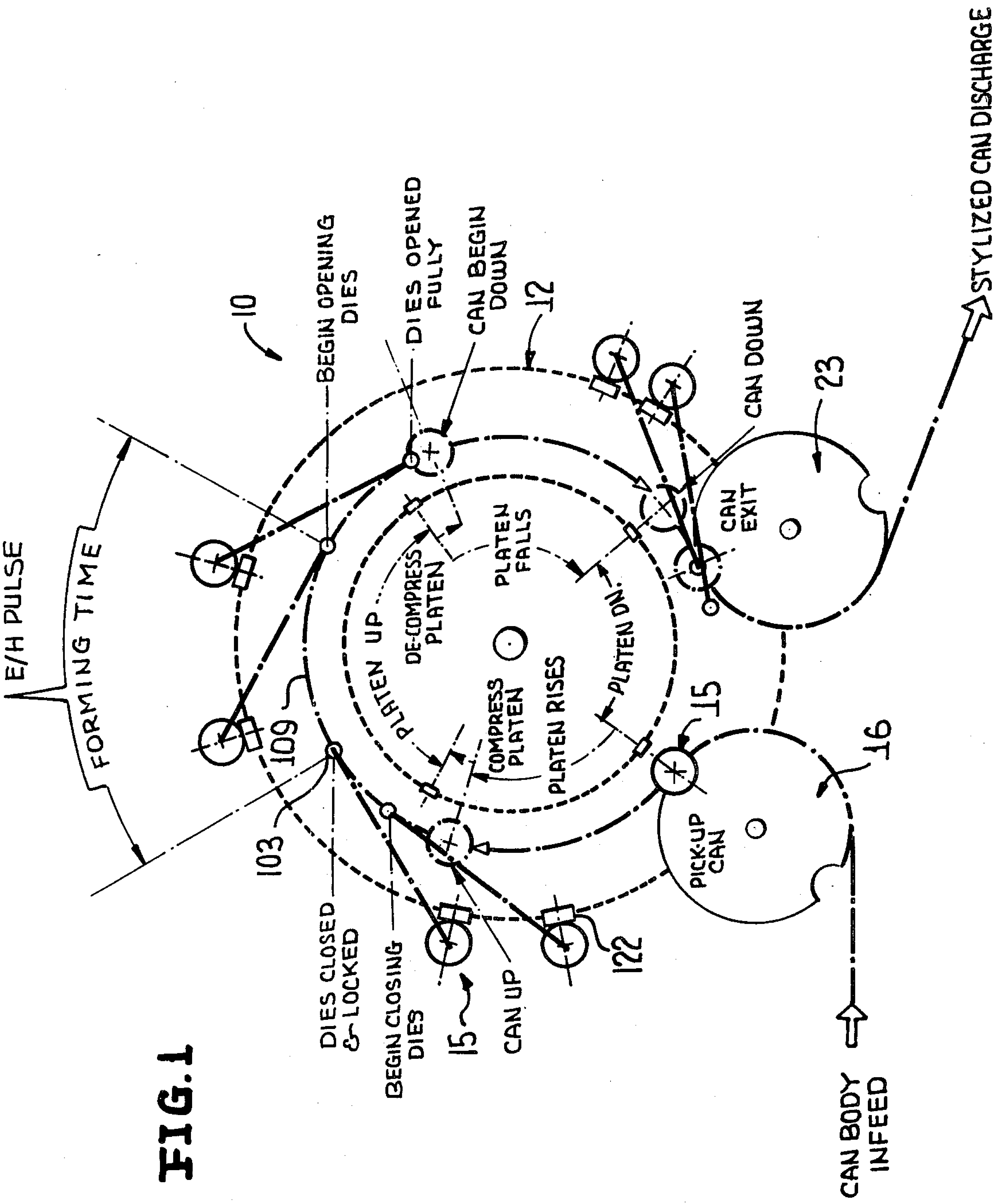

FIG. 1

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FIG.2

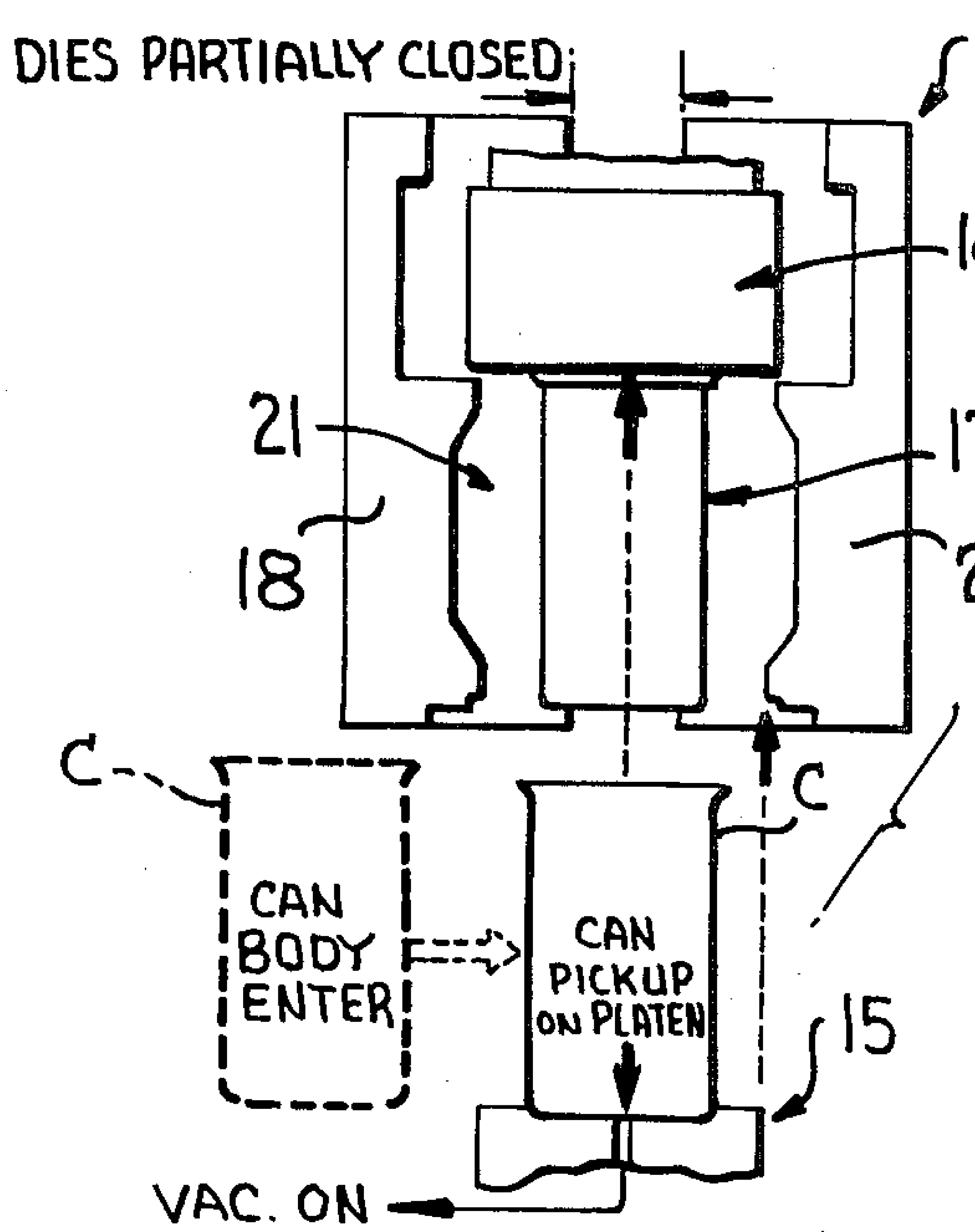


FIG.2A

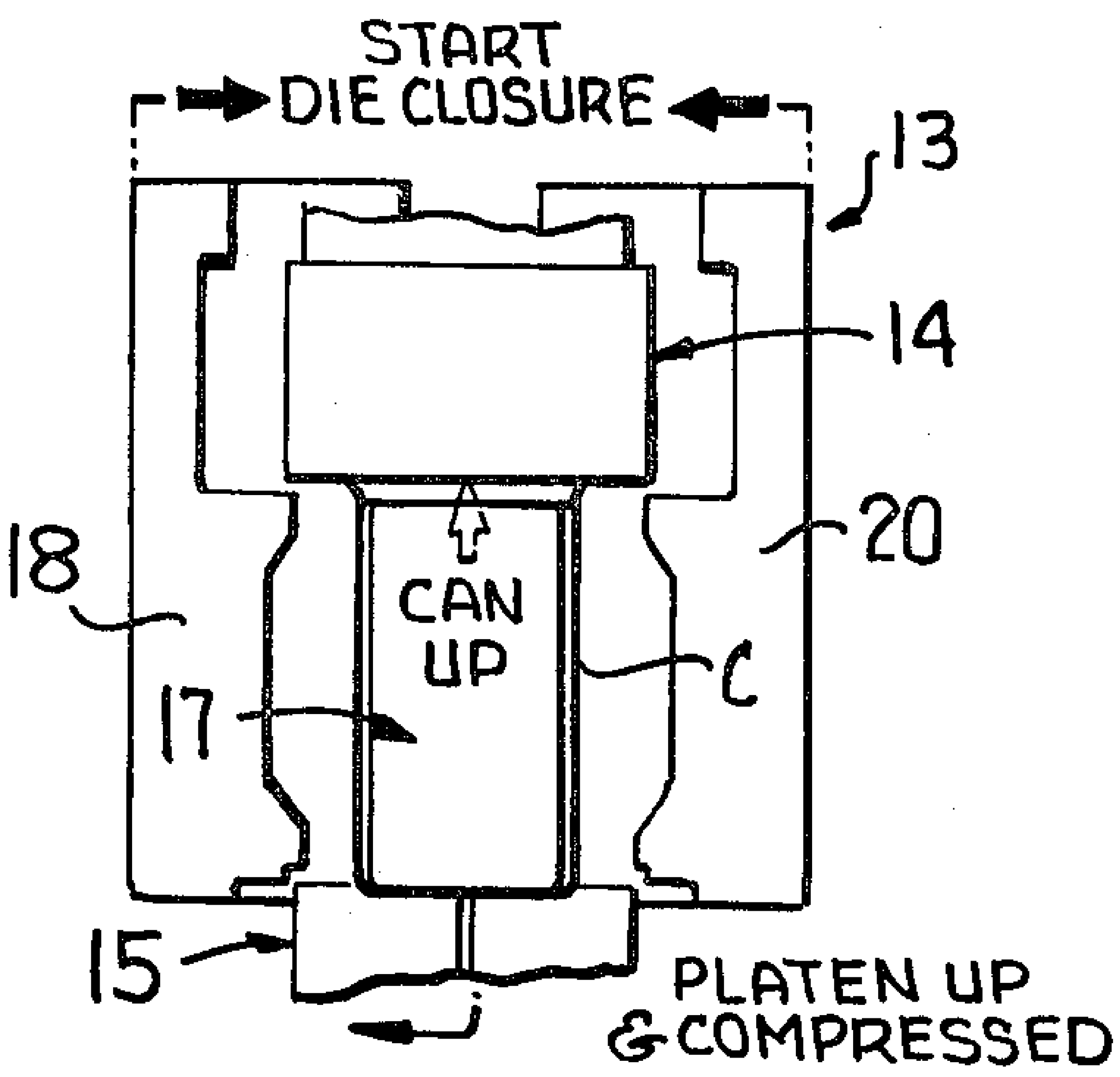


FIG.2B

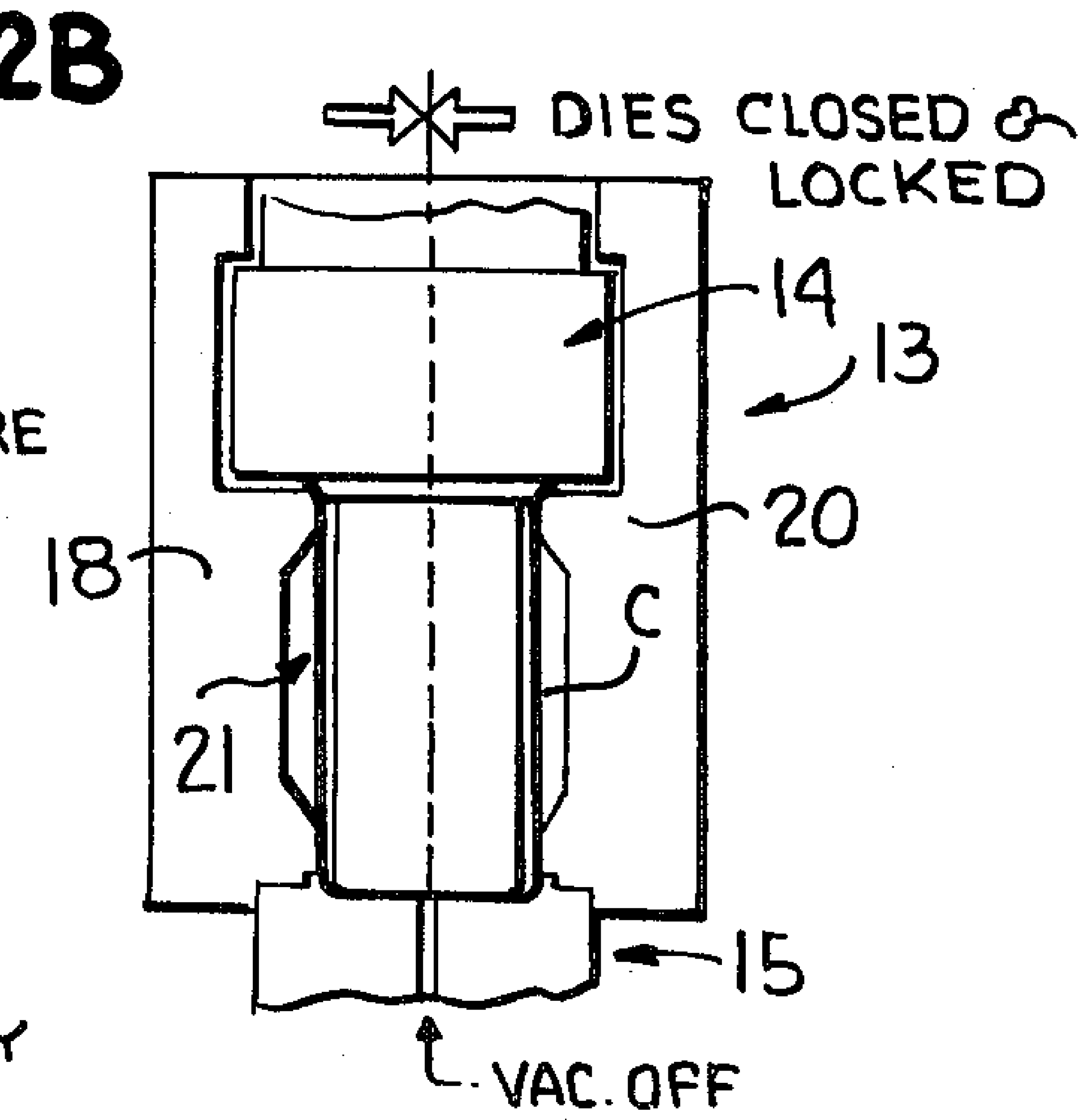


FIG.2C

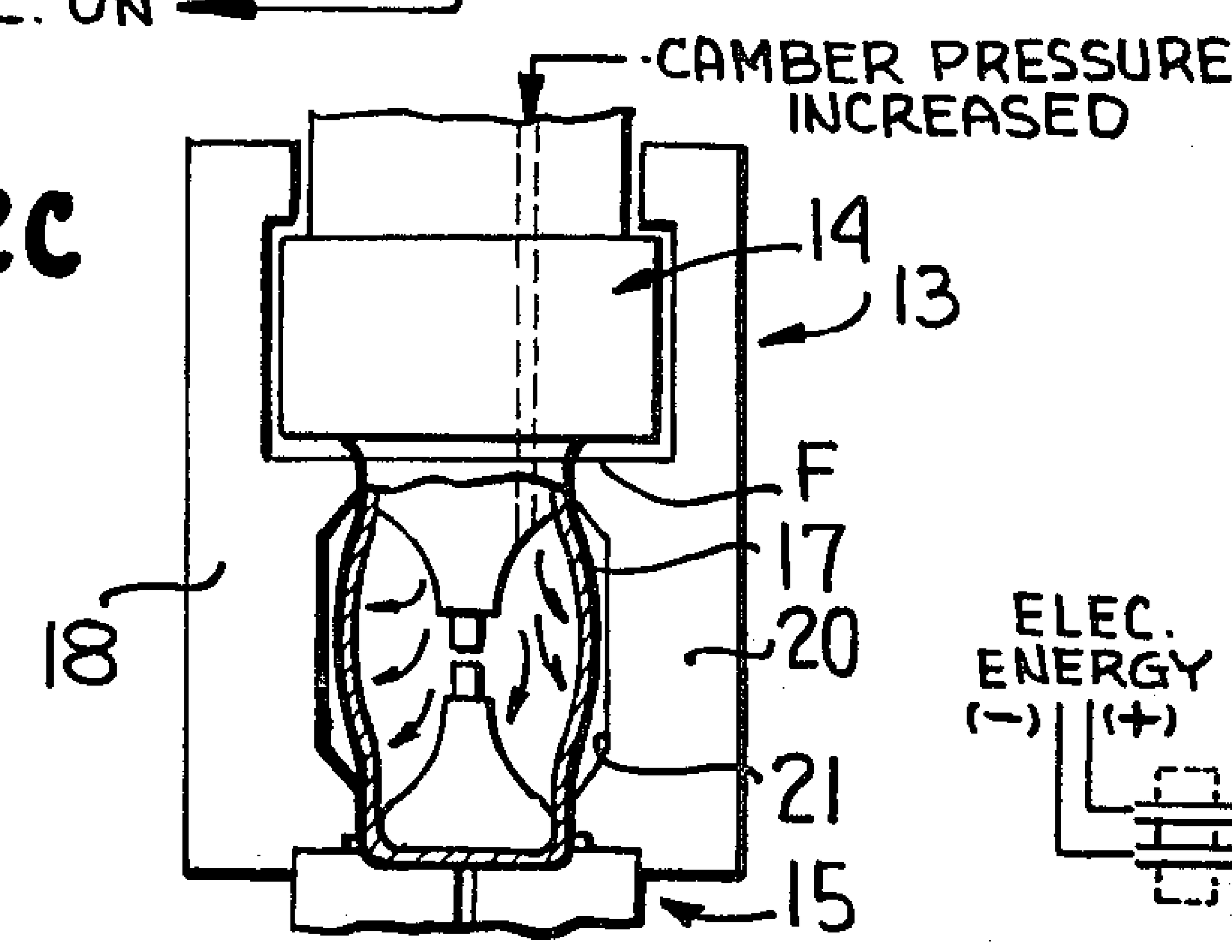


FIG.2D

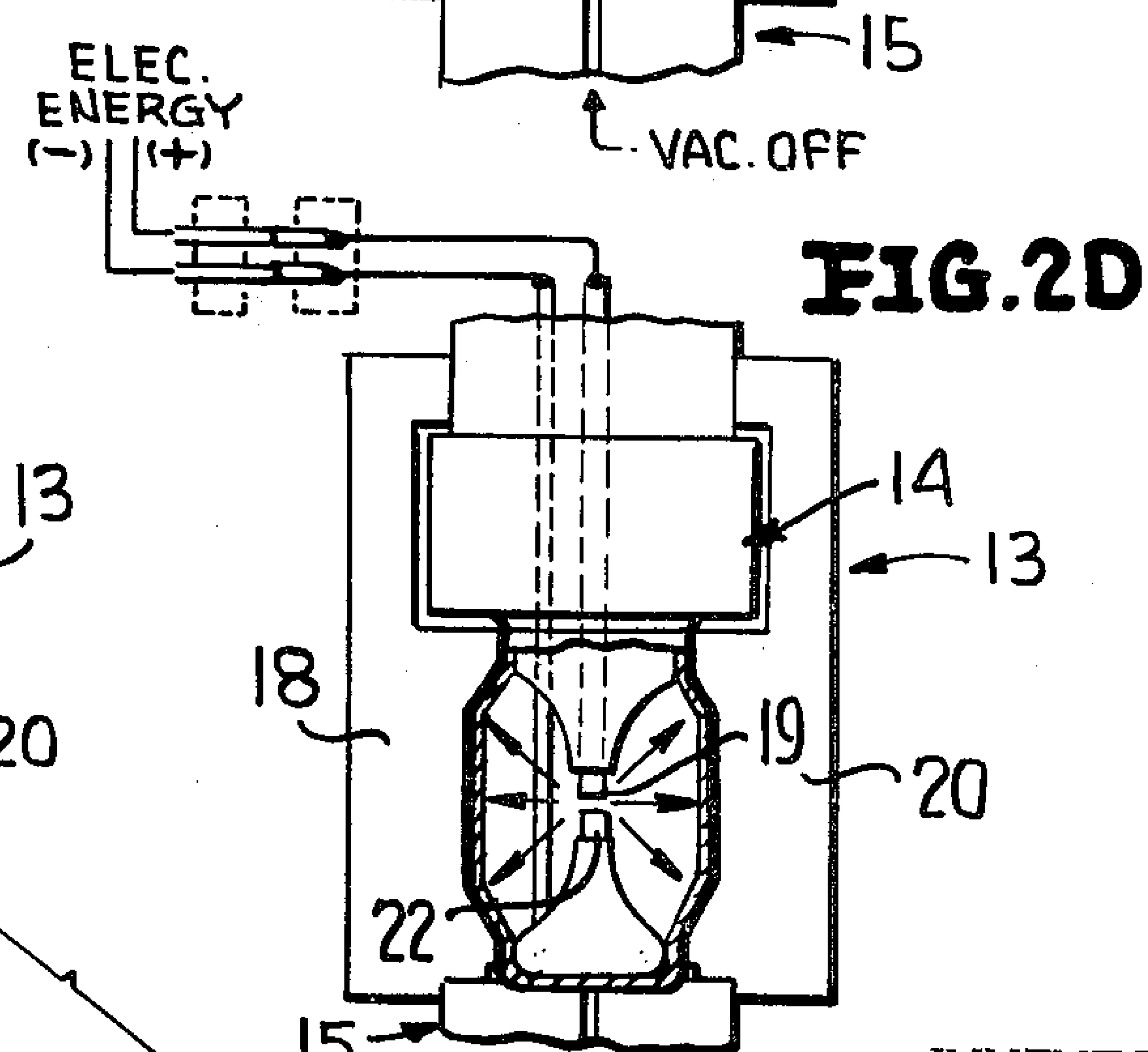
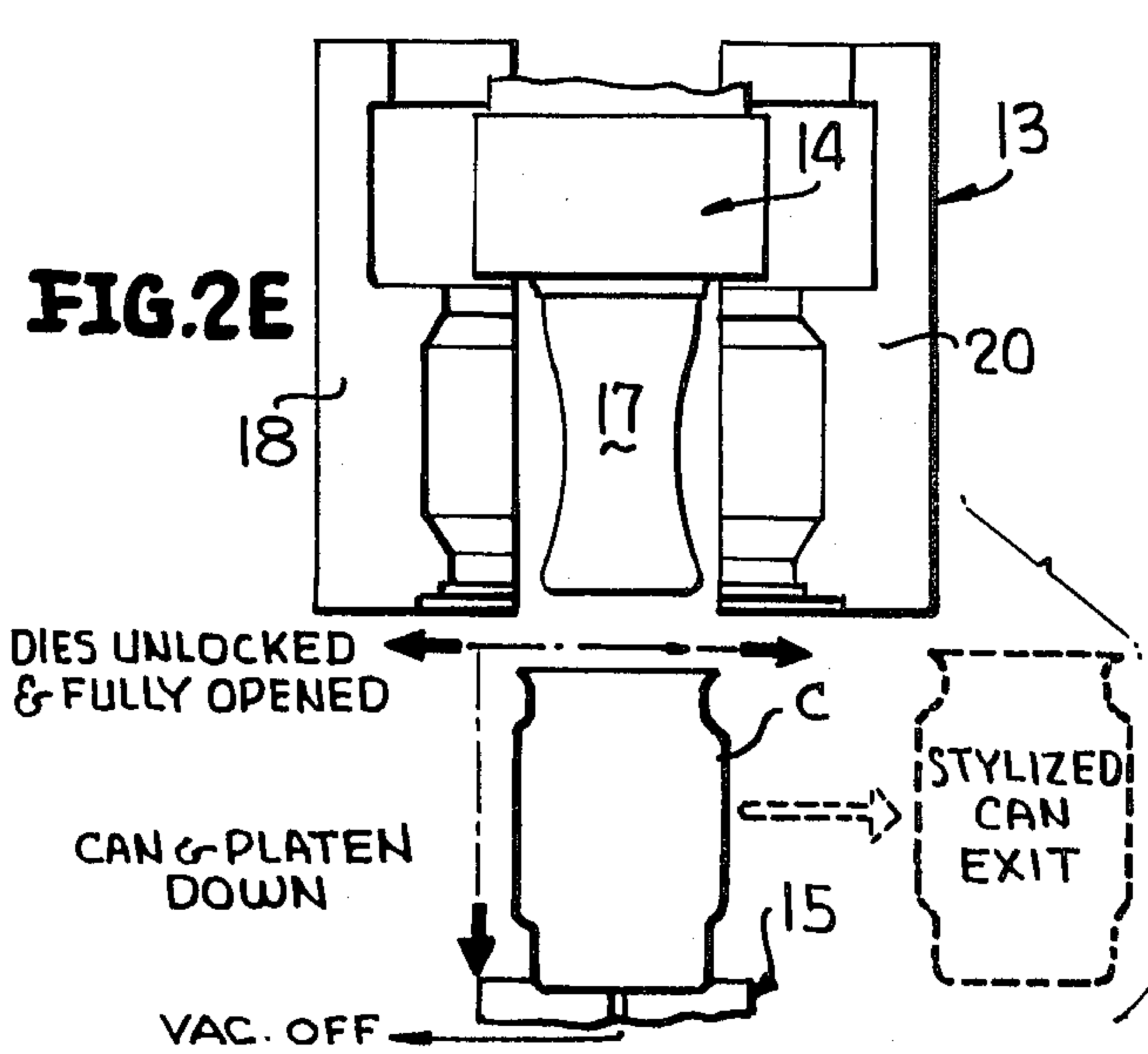


FIG.2E



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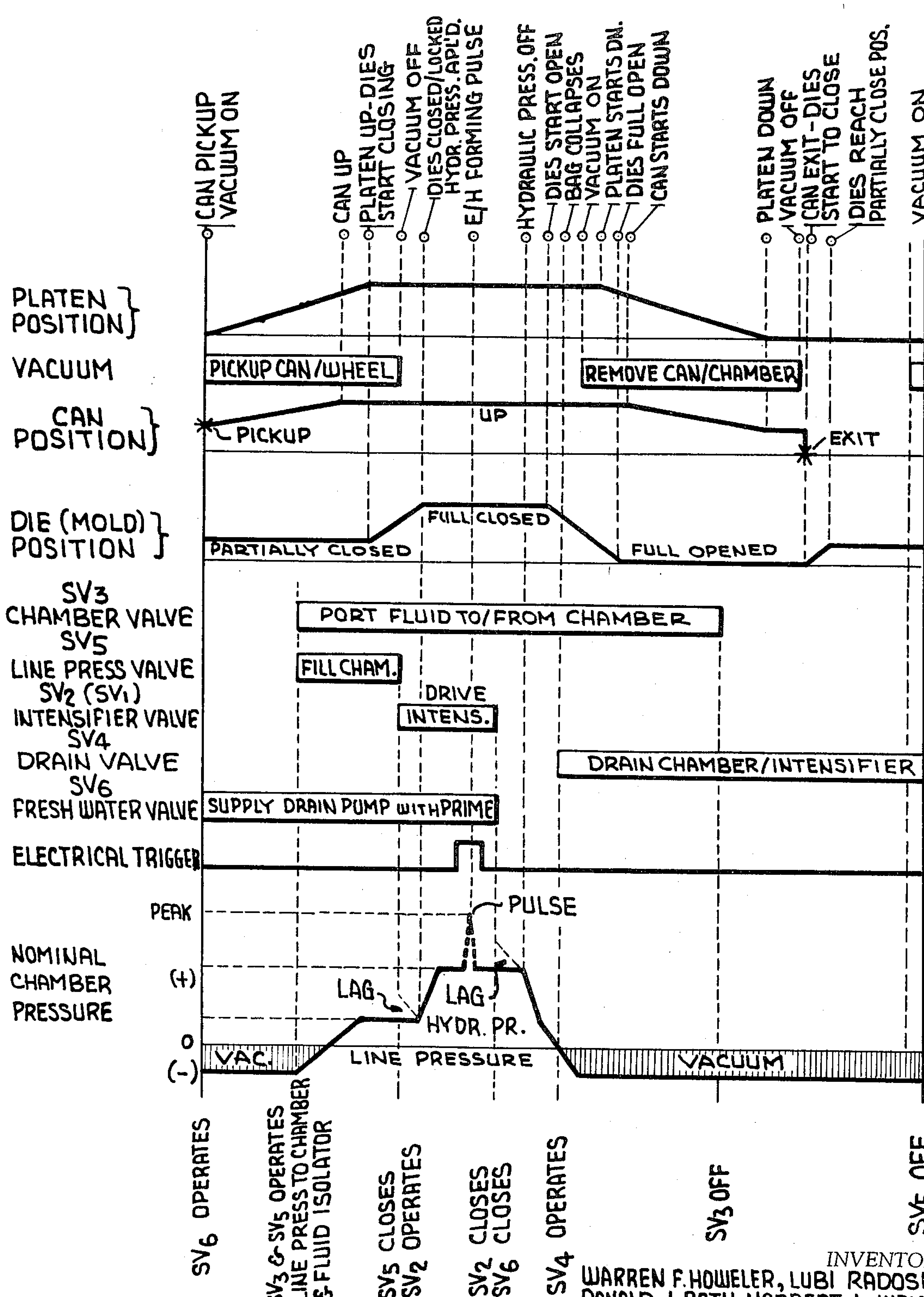

FIG.3

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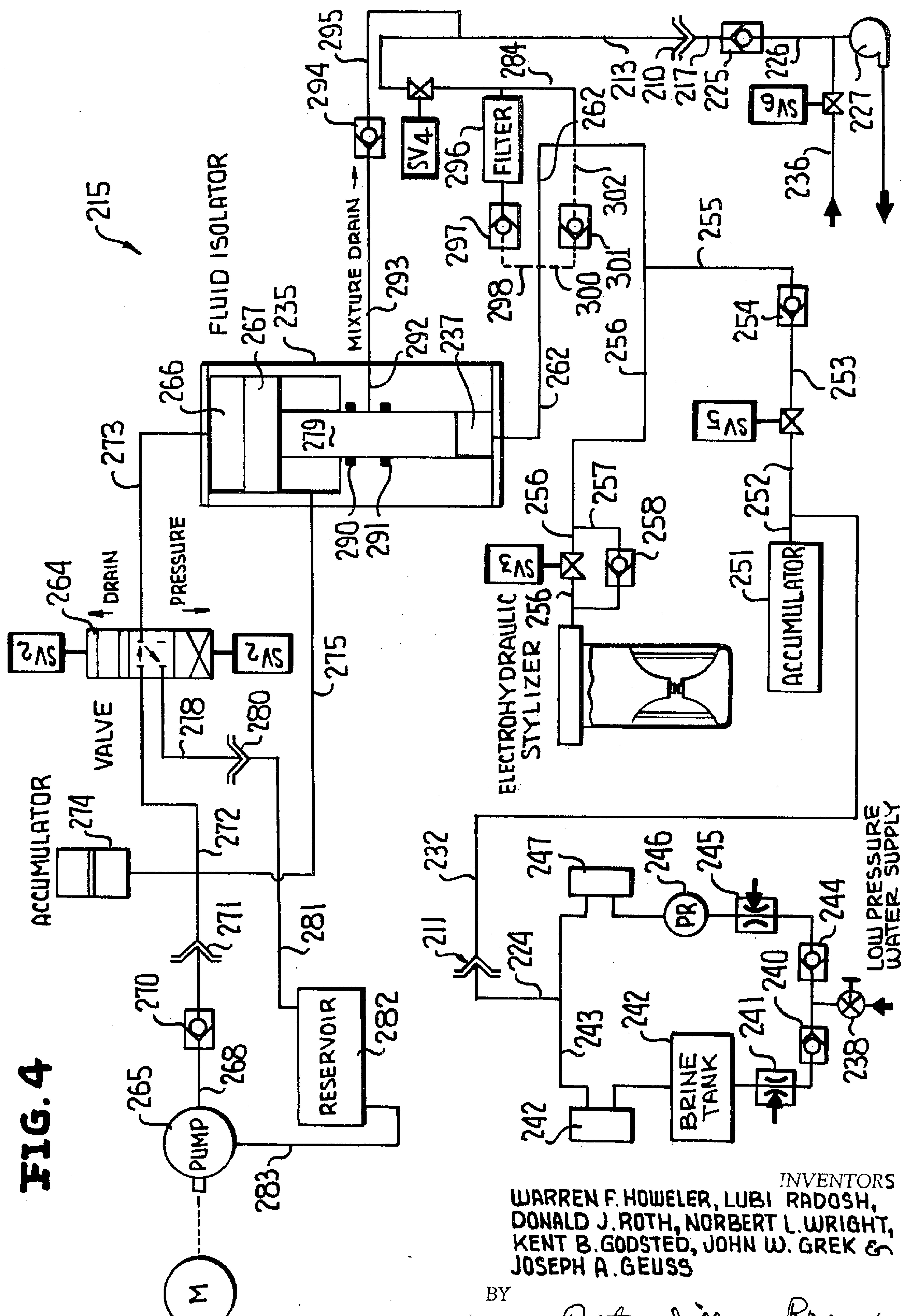

FIG. 4

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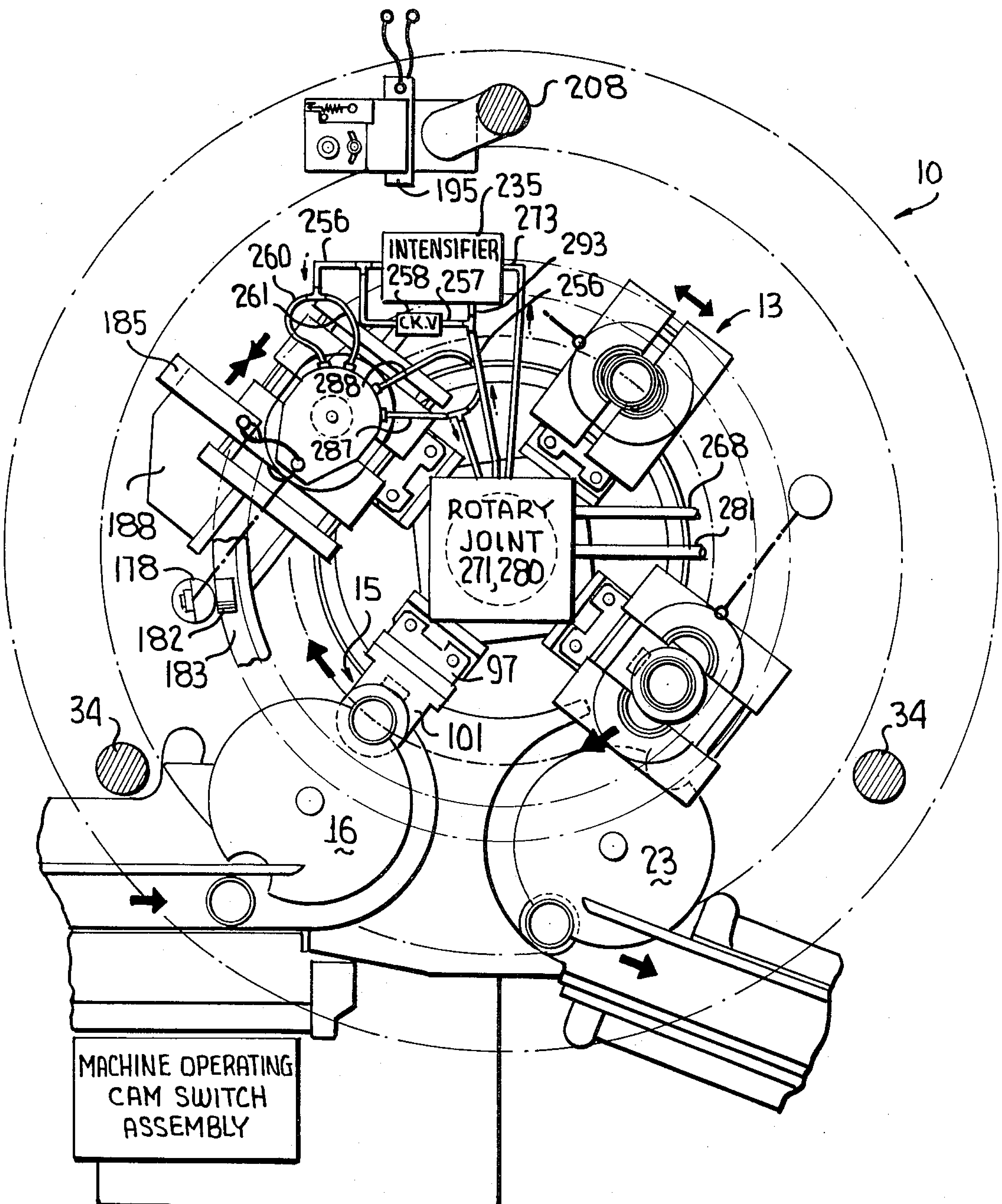
FIG.5



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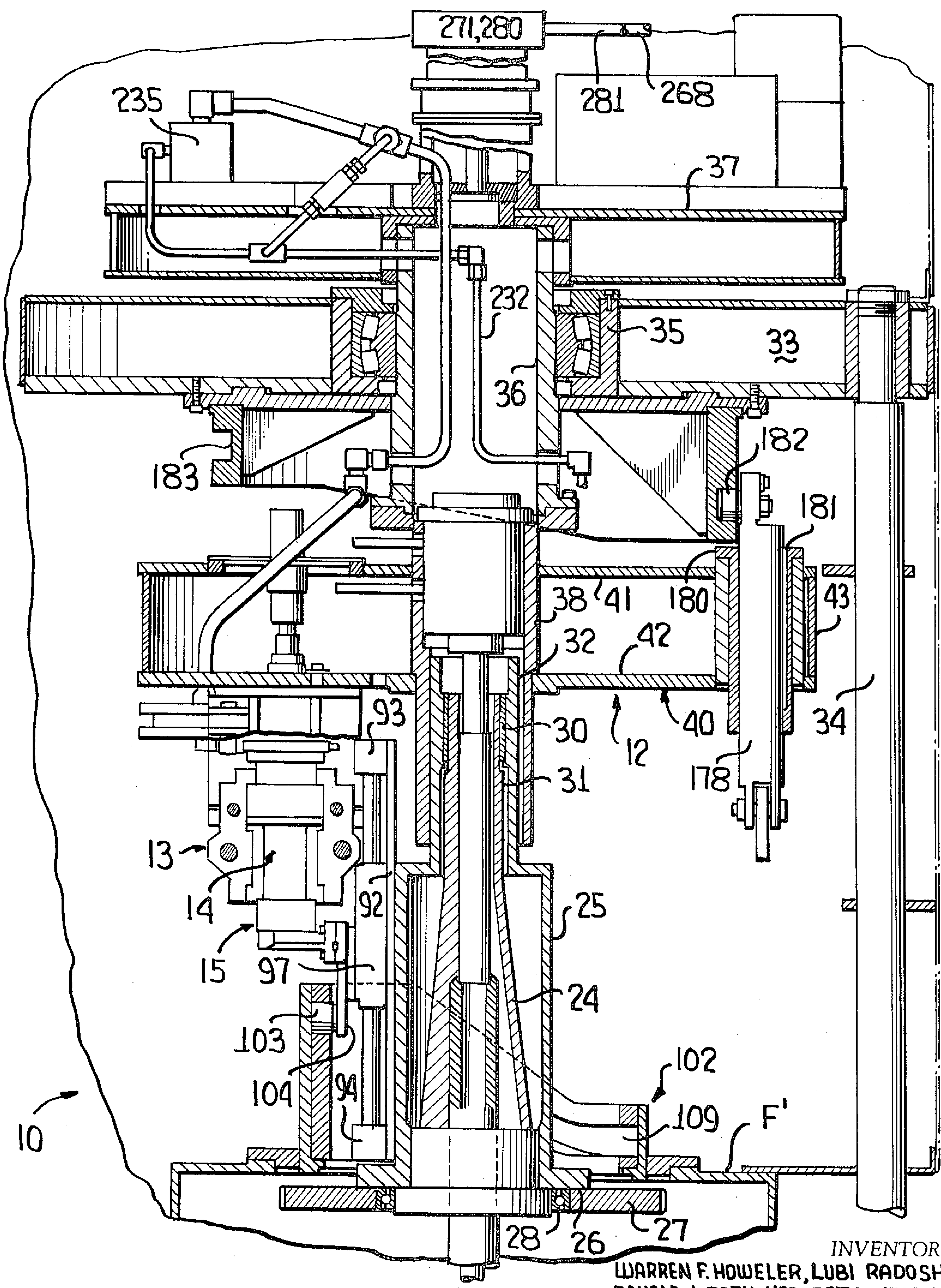

FIG.6

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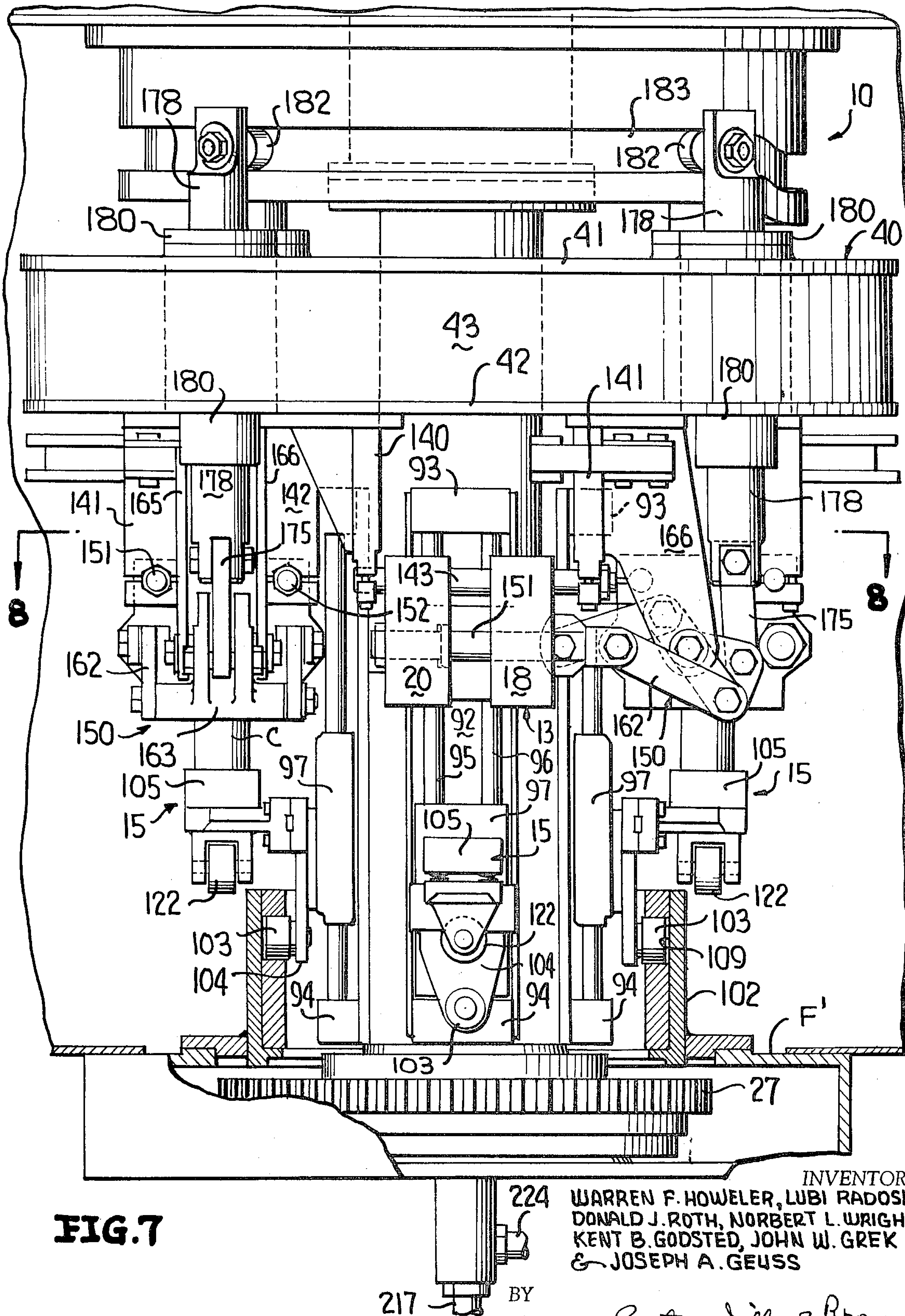

FIG.7

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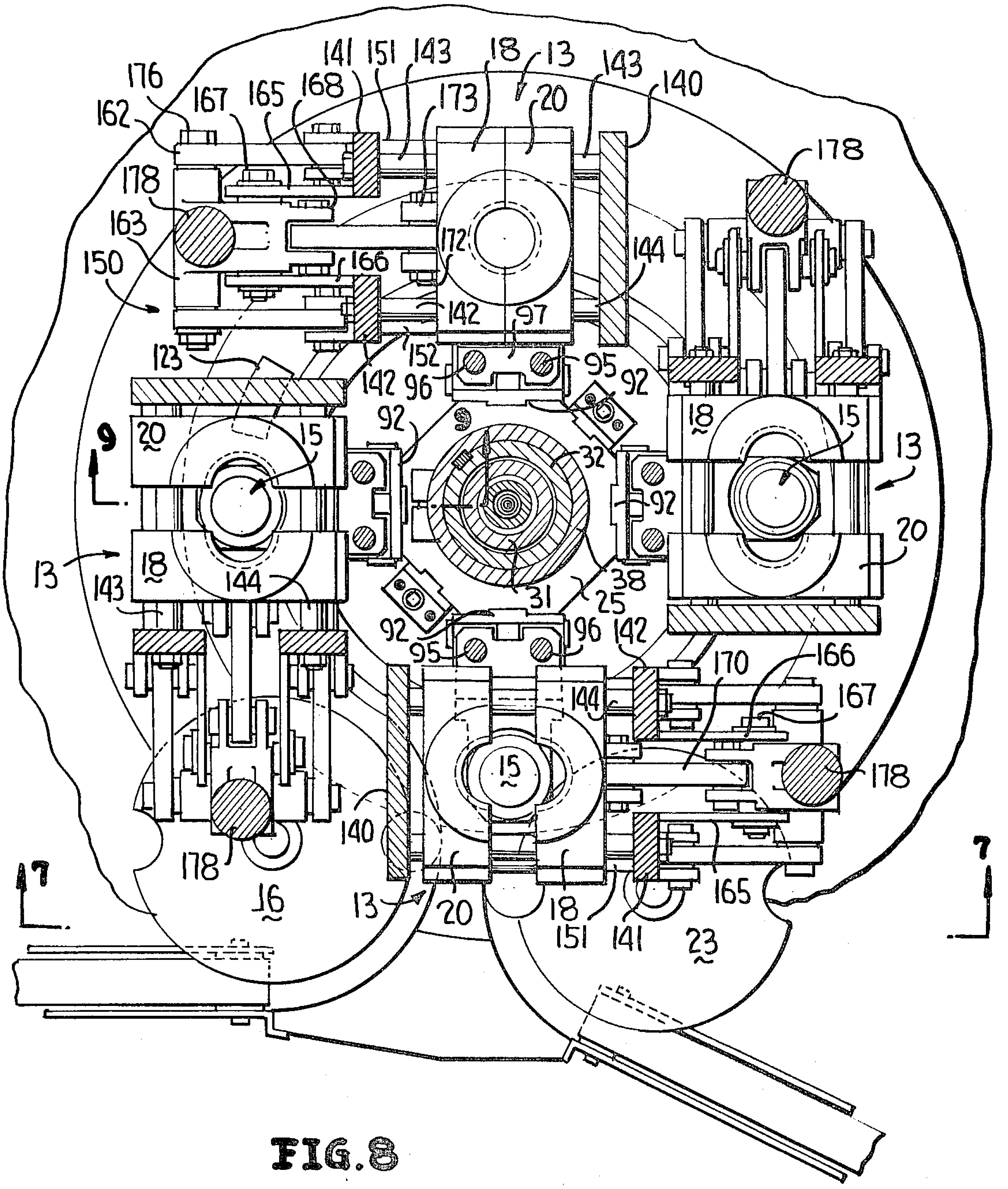

FIG. 8

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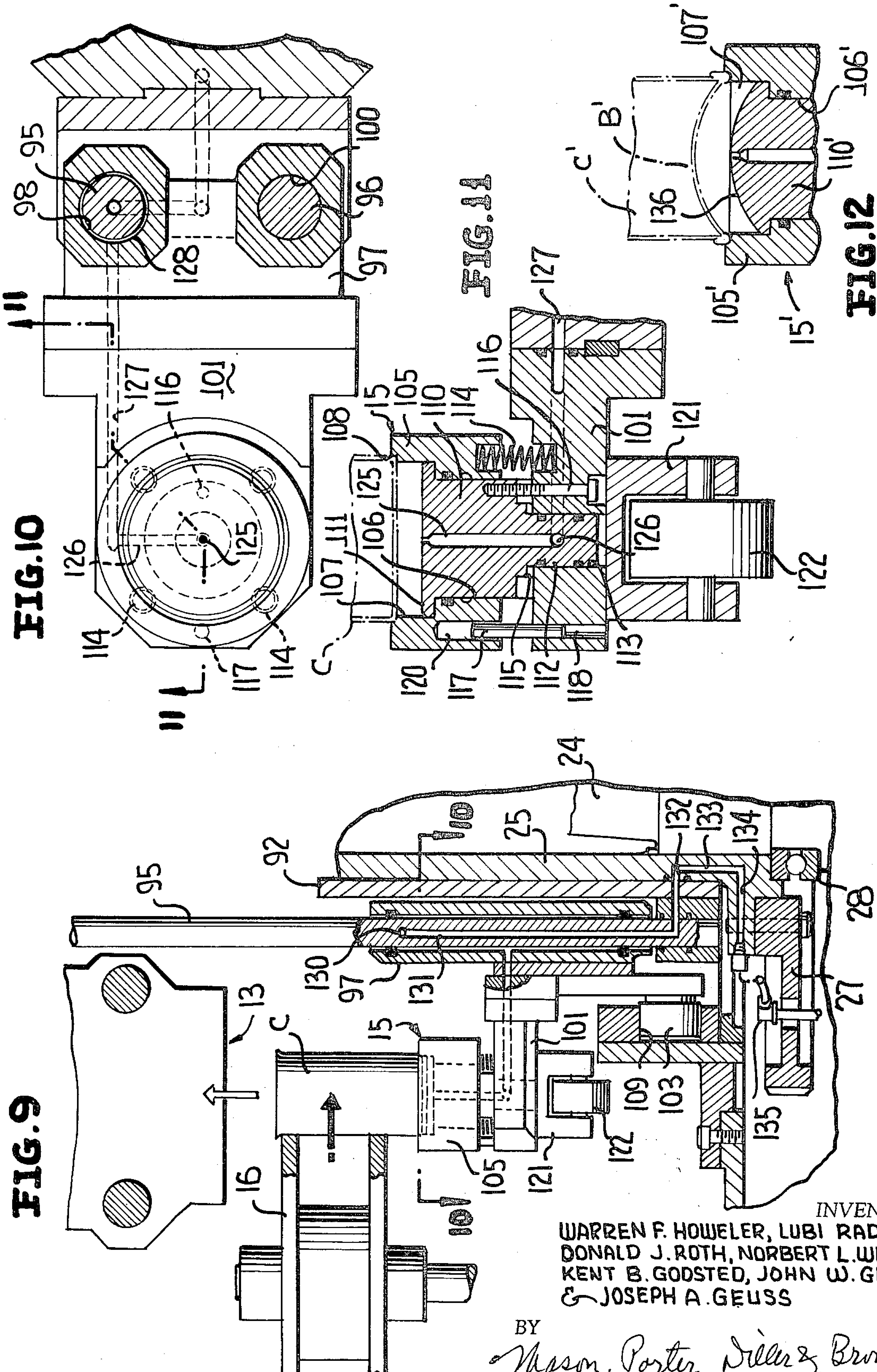

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FIG. 13

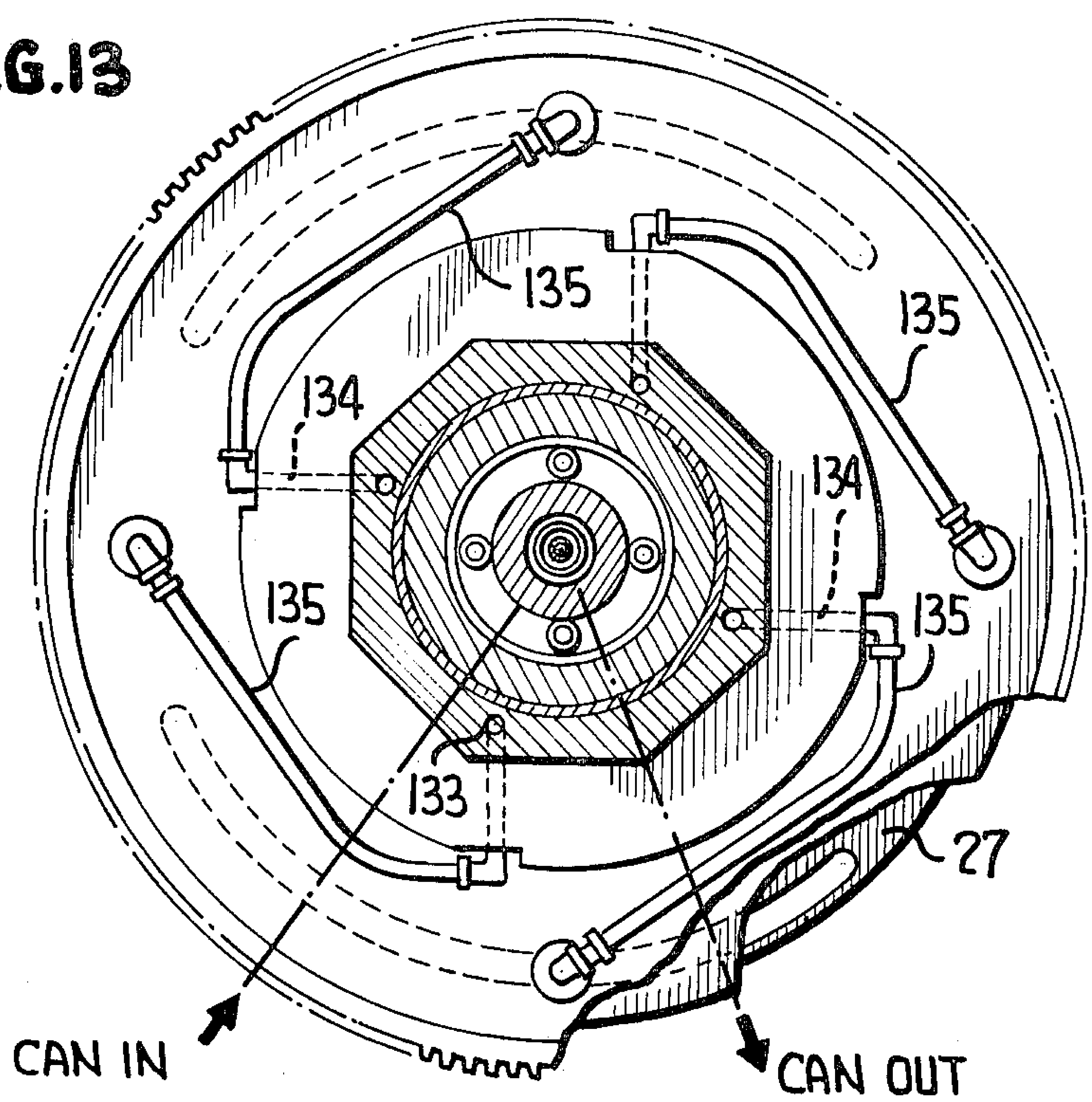

FIG. 14

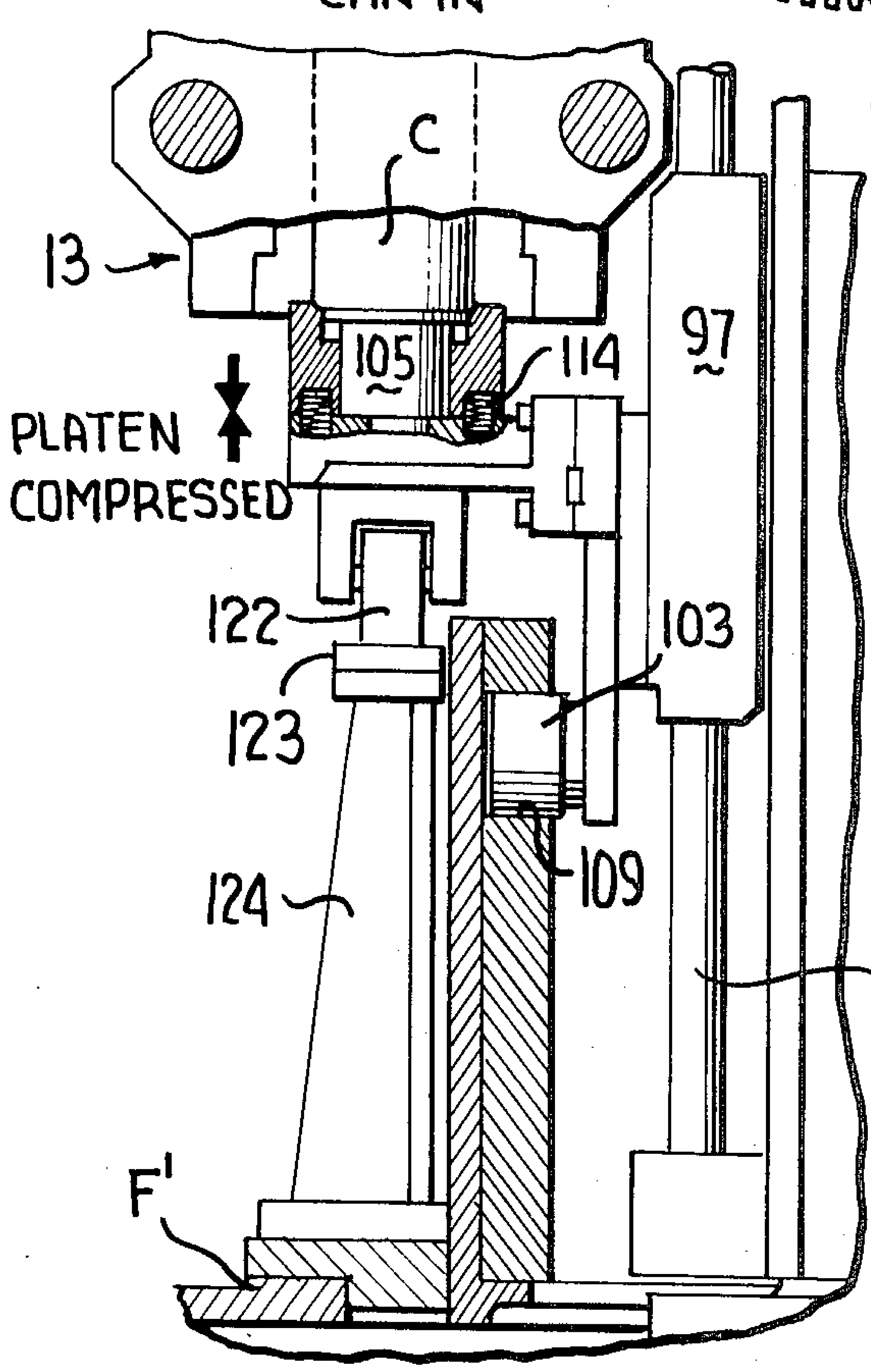

FIG. 15

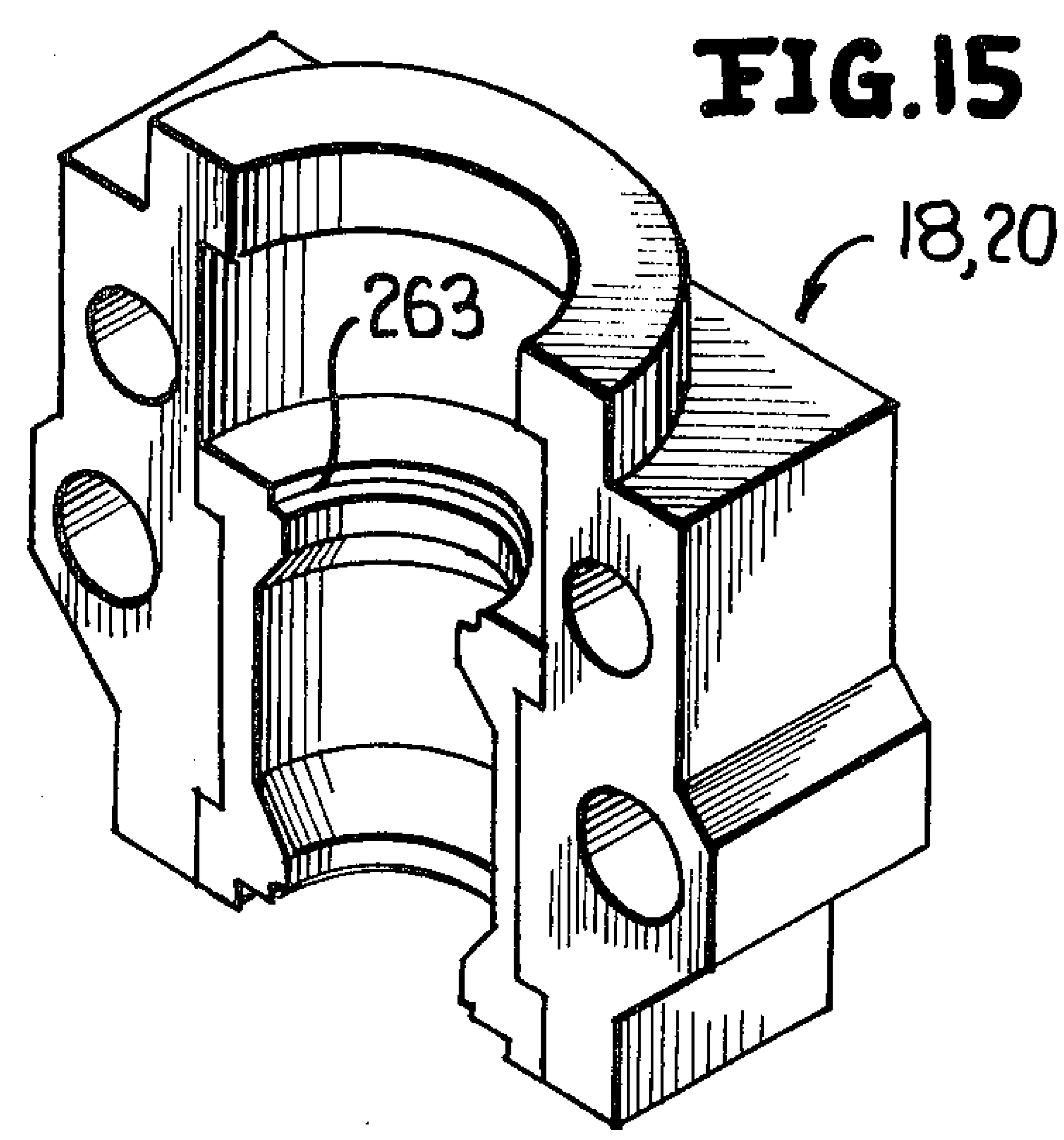

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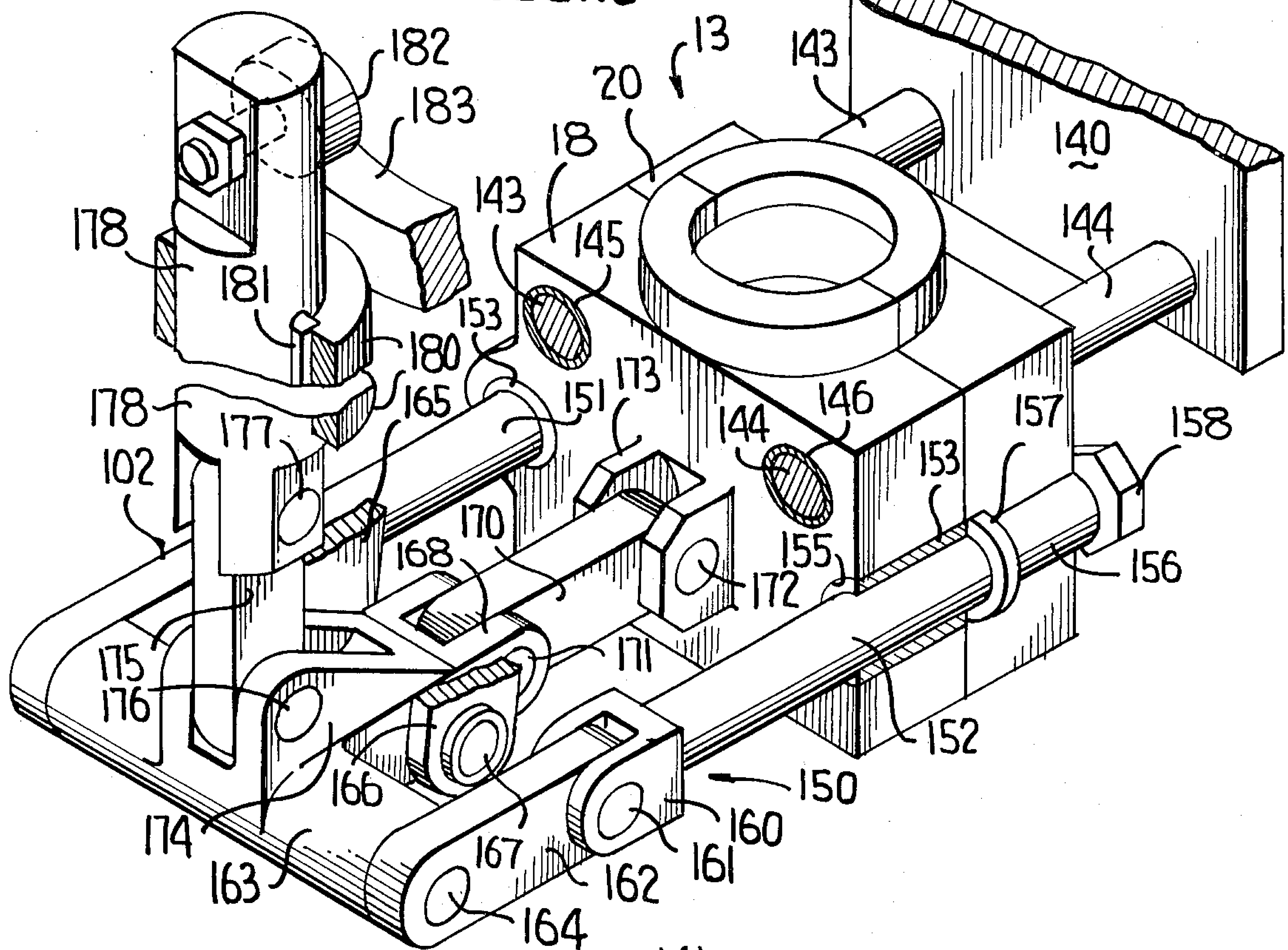
FIG.16



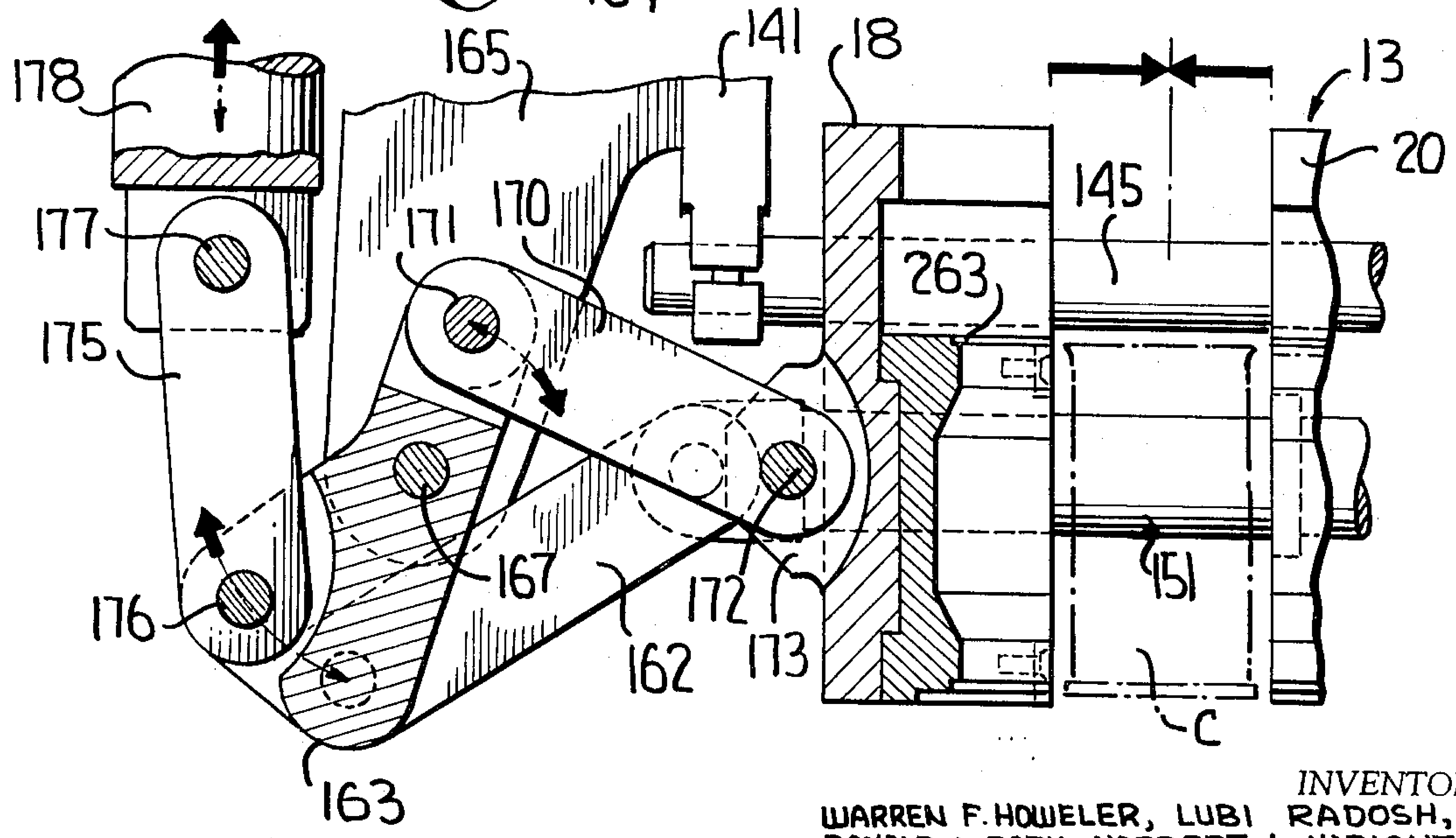


FIG.17

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FIG.18

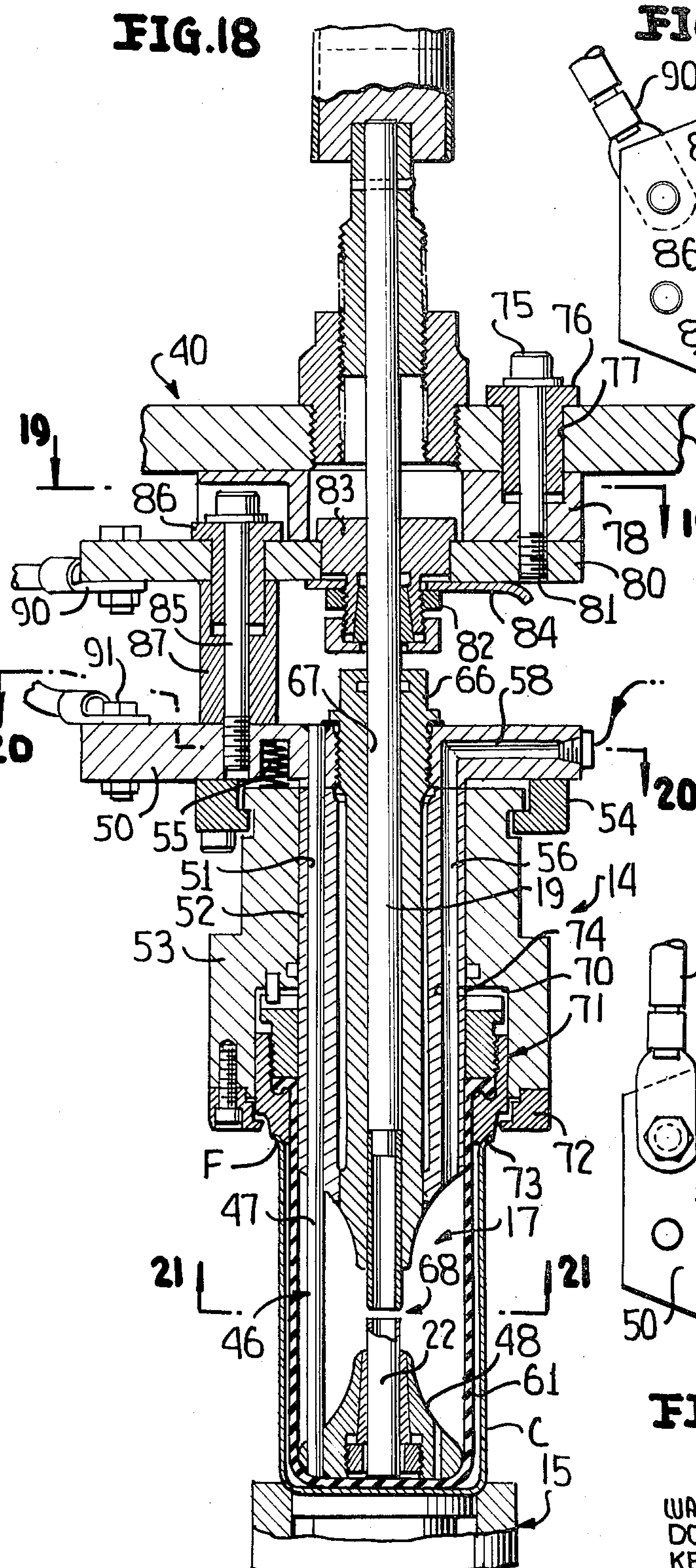


FIG.19

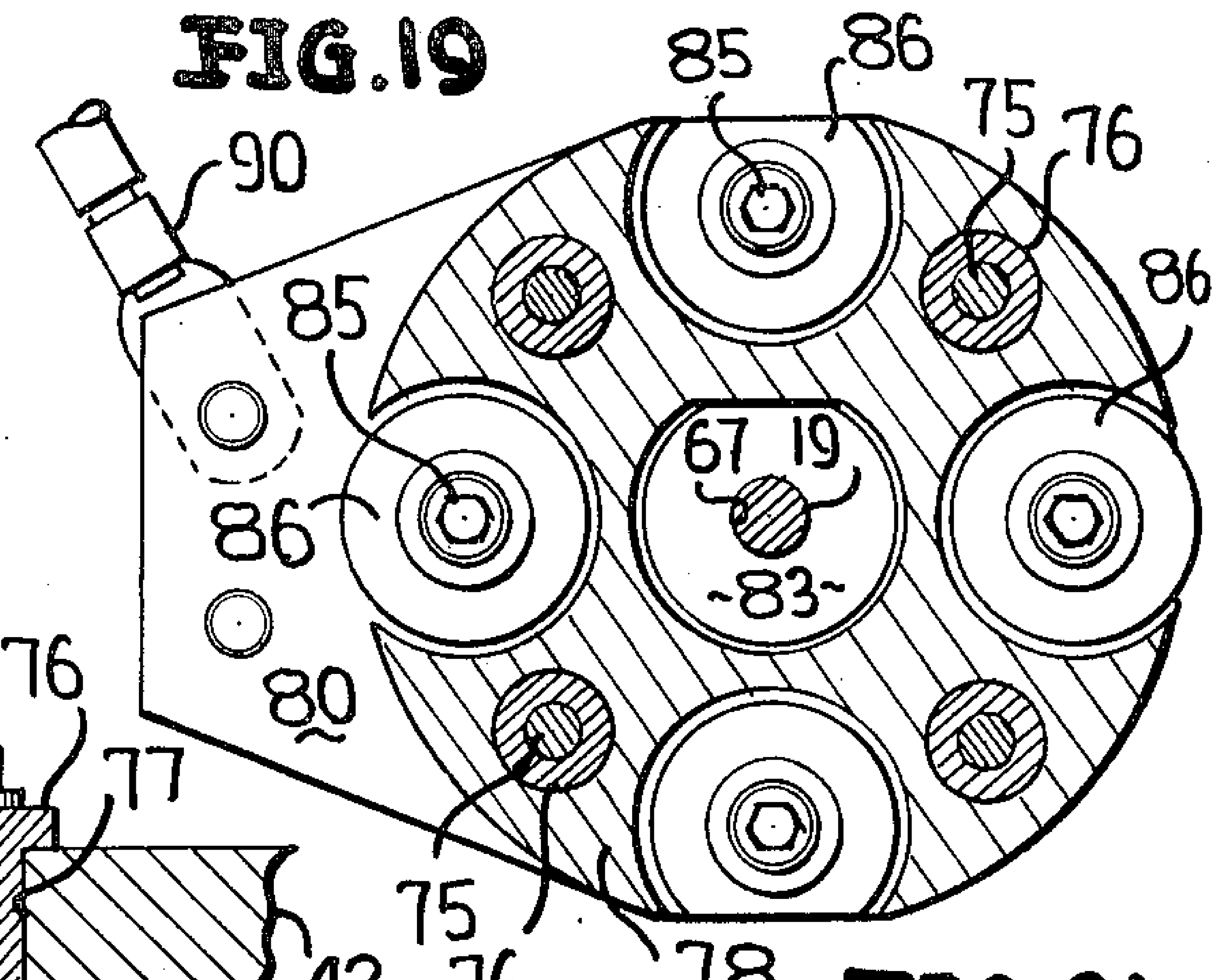
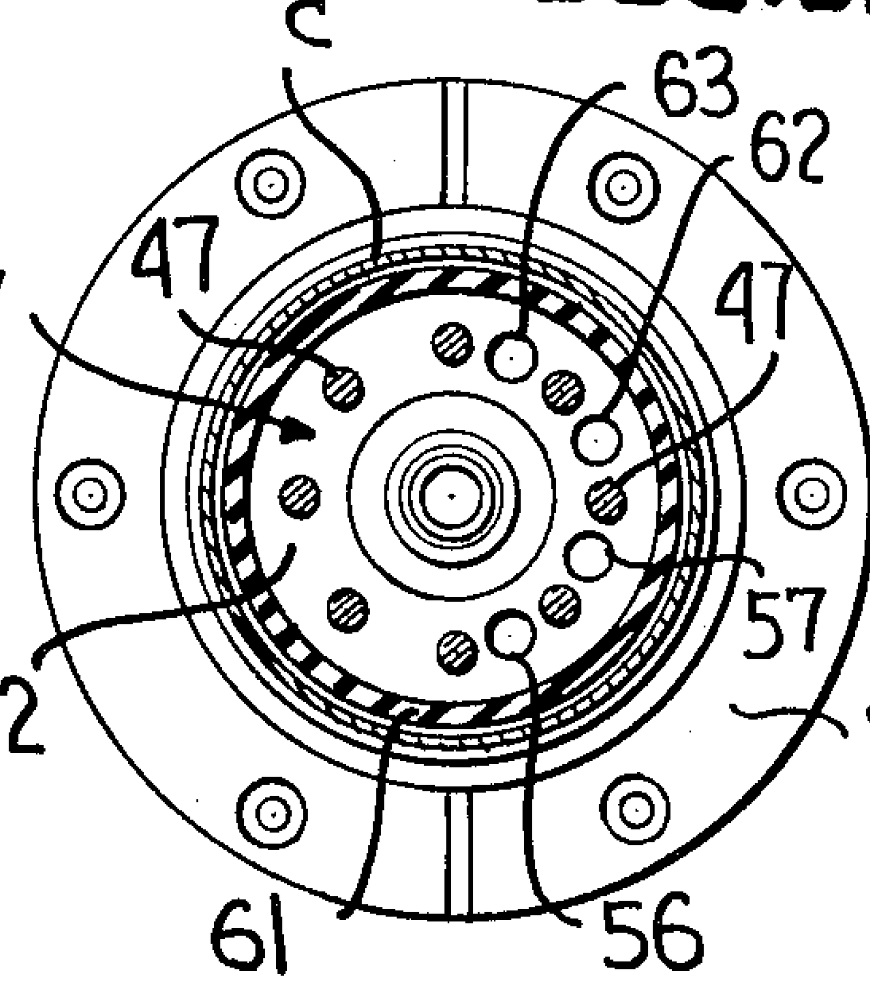


FIG.21



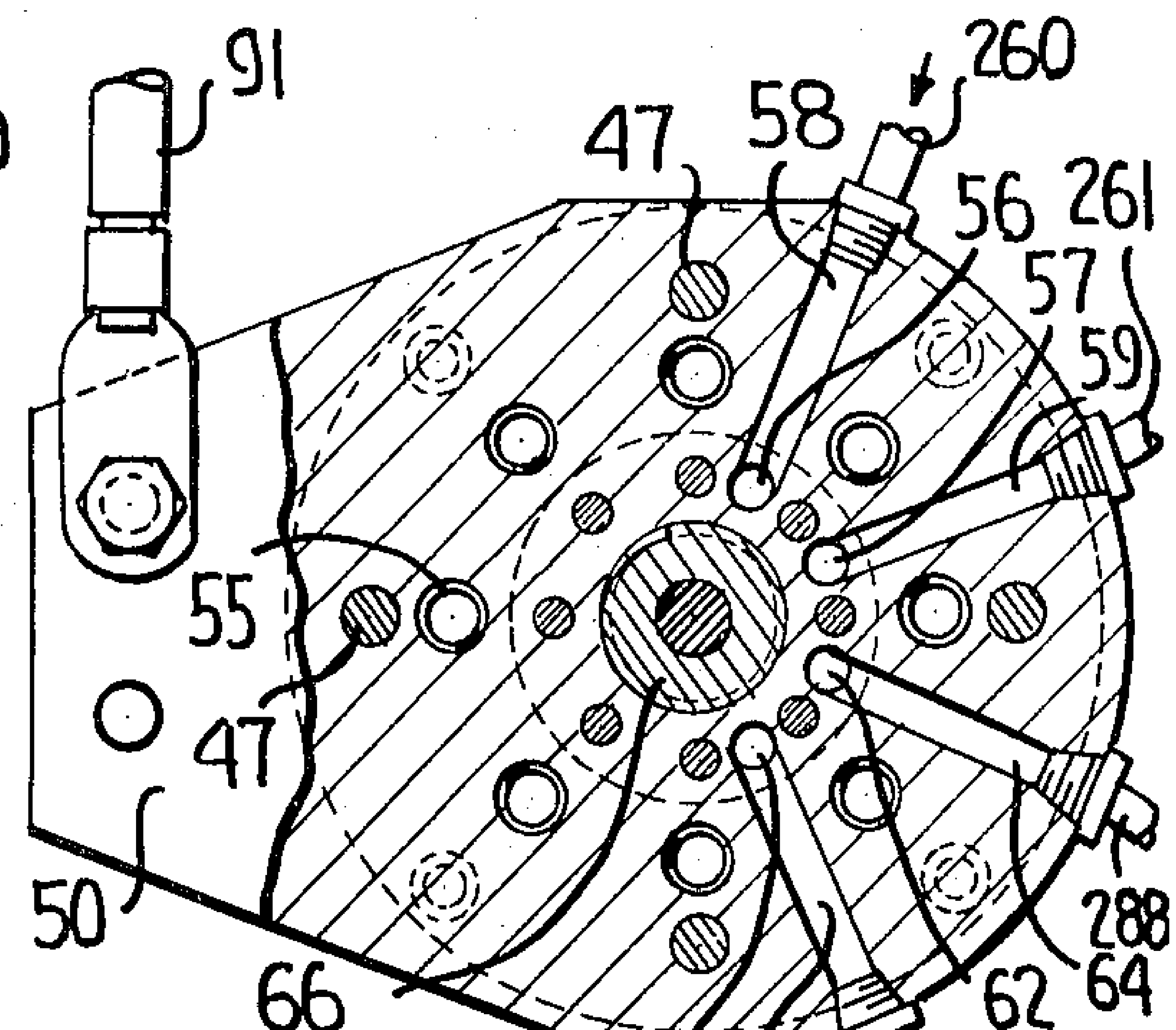


FIG.20

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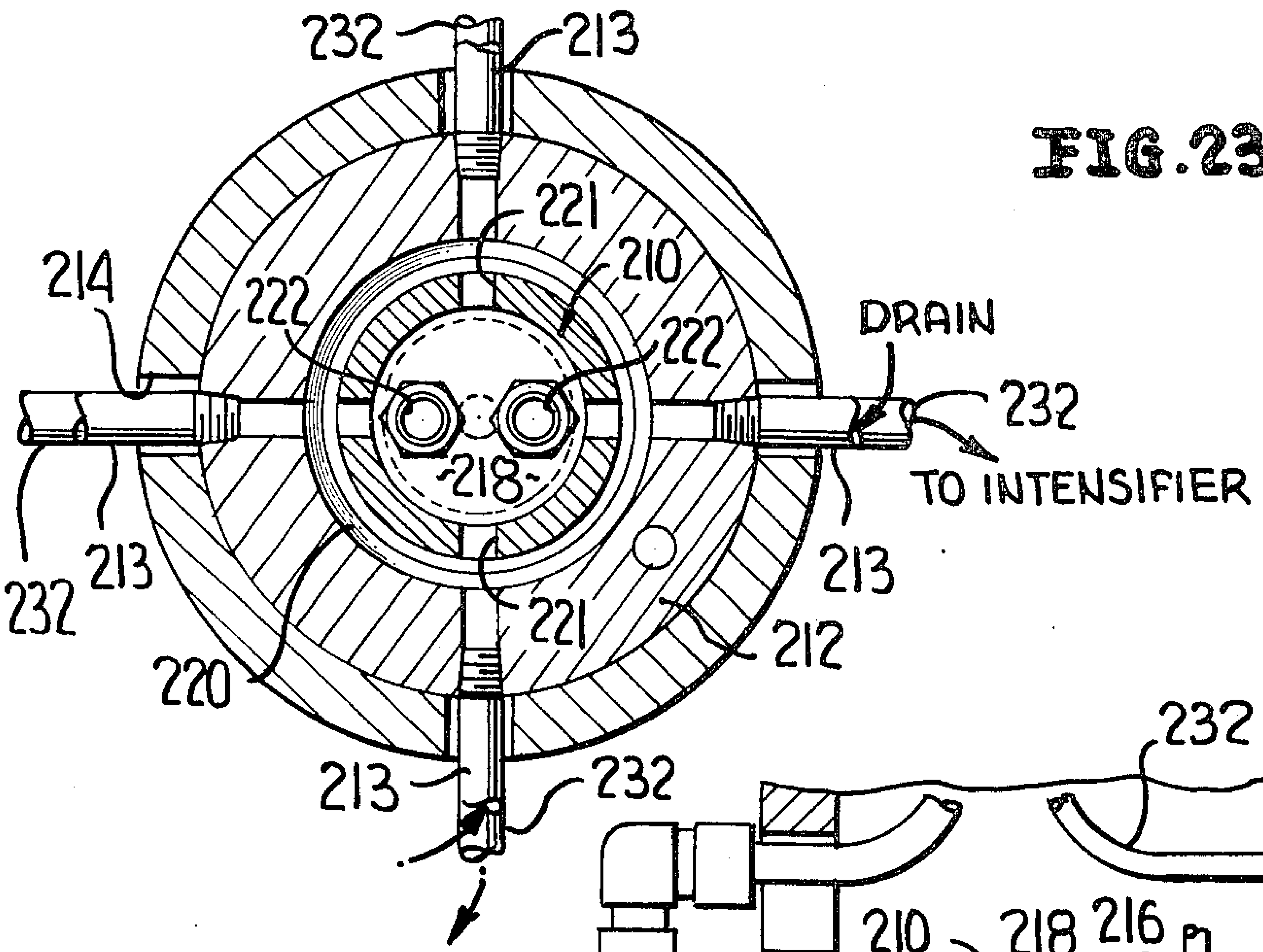

FIG.23

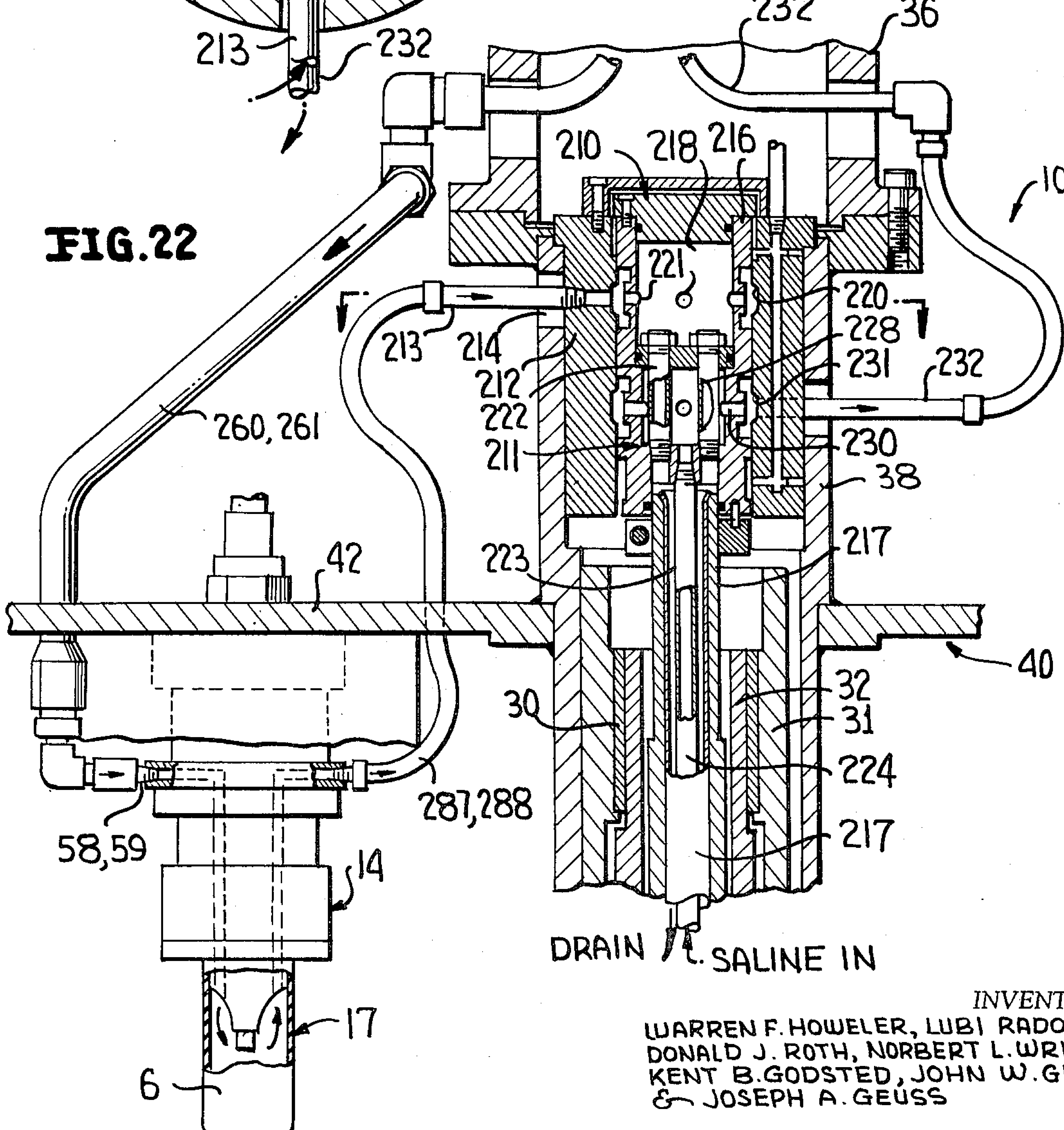

FIG.22

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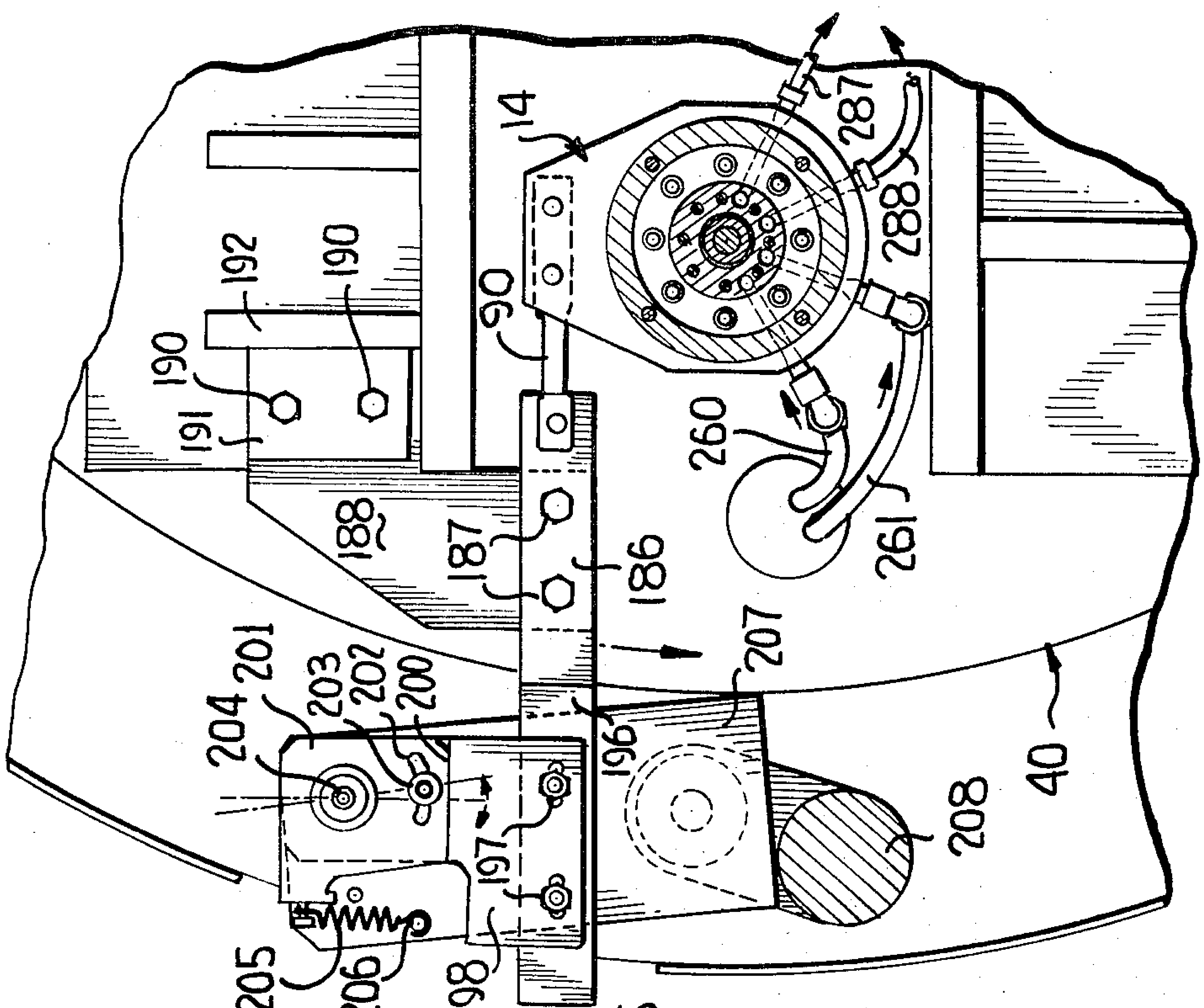

FIG.25

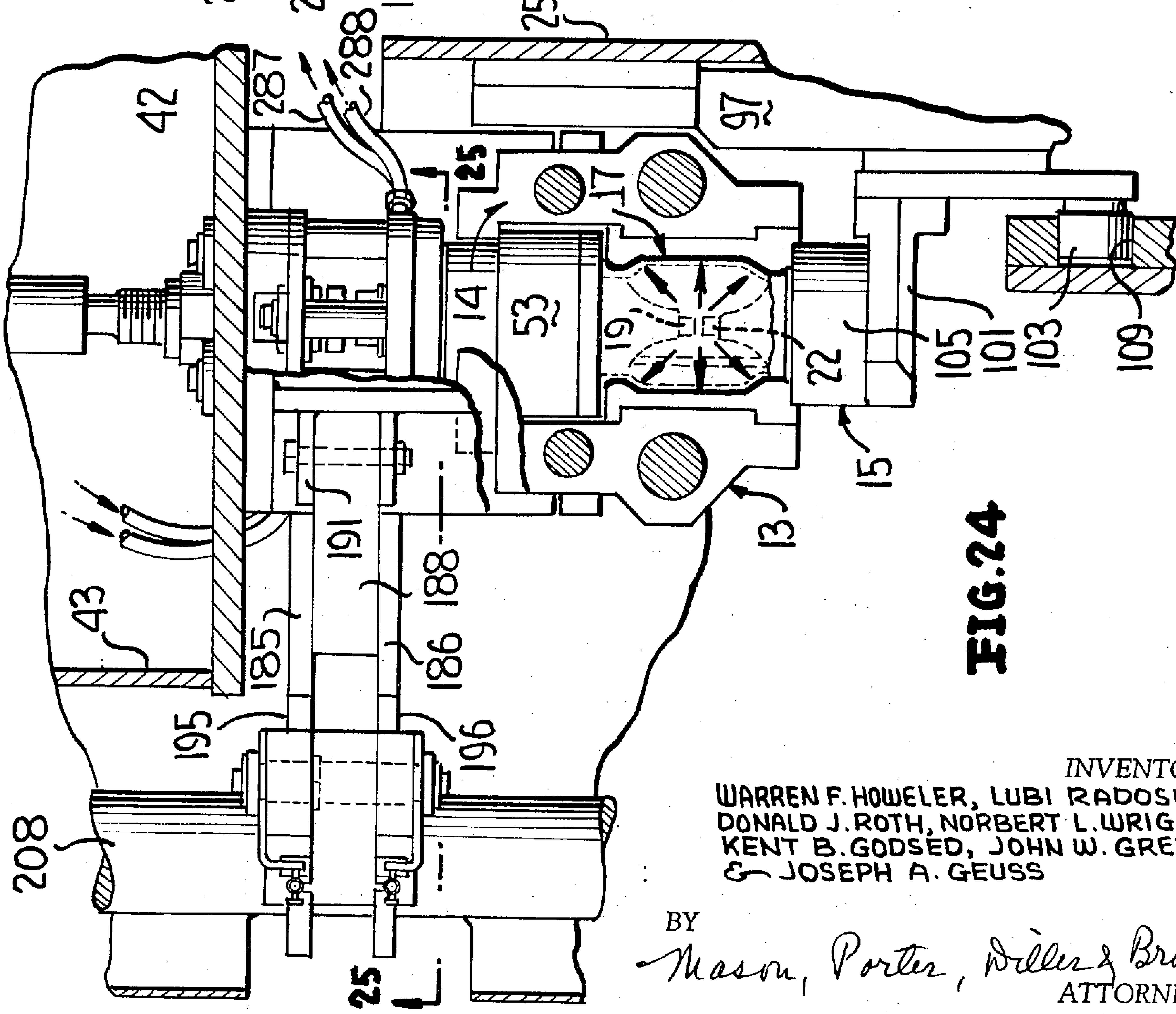

FIG.24

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APPARATUS FOR ELECTROHYDRAULICALLY FORMING TUBULAR ELEMENTS

This is a continuation application of application Ser. No. 749,885, filed Aug. 2, 1968, entitled APPARATUS FOR ELECTROHYDRAULICALLY FORMING TUBULAR ELEMENTS, now abandoned.

A primary object of this invention is to provide a novel apparatus for "stylizing" one-piece metallic can bodies or similar tubular elements by hydraulic and electrohydraulic forces. The term "stylizing" is intended to mean the reforming of a tubular can body to a desired configuration, and more specifically to not only changing the over-all contour of the can body but to impress, emboss or otherwise transfer minute details to an exterior surface of the can body. For example, from the standpoint of consumer acceptance it might be found desirable to manufacture can bodies in which beer is to be packaged to a "beer barrel" configuration such that upper and lower end portions are of a smaller diameter than a central body portion, and the latter is preferably provided with circumferential grooves disposed in axially spaced relationship. This imparts to the can body the appearance of a "miniature" beer barrel.

In accordance with the invention one-piece can bodies are sequentially delivered by a lifter platen to a position beneath a pair of mold bodies of a split mold in axial aligned relationship to a support carrying a flexible chamber. The can body is elevated and a peripheral flange thereof is clamped between a portion of the chamber support and portions of the mold body upon the closing of the split mold. Liquid under pressure is then delivered to the chamber which causes the progressive expansion thereof which in turn forces the can body into general conformity with a mold cavity of the split mold. At this point the pressure is not sufficiently high to transfer minute details from the mold cavity to the exterior surface of the can body. Thereafter an electrical discharge is created in the chamber while still under pressure to create a high energy shock wave to terminate the stylizing operation by forcing the exterior surface of the can body into intimate contact with the mold cavity upon the momentary high-force expansion of the chamber. Thereafter the pressure is relieved, the chamber is purged, the split mold is opened, and the lifter platen is lowered to remove the stylized can body incident to the discharge thereof from the apparatus.

In addition to the broader aspects of the invention heretofore described, it is also a primary object of the invention to clamp each can body in the split mold in such a manner as to produce stylized can bodies of substantially uniform repetitive heights, and to provide novel means for increasing the clamping forces in proportion to the increase of pressure in the chamber.

Still another object of this invention is to provide a novel apparatus for stylizing can bodies in the manner heretofore set forth wherein novel linkage means are provided for closing the split molds in such a manner which preloads the links of the linkage mechanism to thereby effectively clamp closed the split molds and resist the high forming forces, particularly the electrohydraulic force which approximates 30,000 p.s.i.

Still another object of the invention is to provide novel means for pressurizing the fluid chamber in the form of an intensifier which is so arranged in a hydraulic system that noncorrosive hydraulic fluid is used to pressurize the corrosive medium (saline solution) within the chamber to thereby reduce the high cost which would otherwise be involved in employing noncorrosive stainless steel or other material in a hydraulic system containing only corrosive fluid.

A final object of this invention is to provide a novel apparatus of the type heretofore set forth wherein a plurality of split molds and expansible chambers are carried by a turret, each of the chambers includes a pair of electrodes, and both the power supply and a storage capacitor (or inductor) are located externally of the turret thereby eliminating the necessity of high voltage rotary electrical and hydraulic connections as well as eliminating the need for a splash-proof ignitron which would otherwise be required if the storage capacitor were carried by the turret.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more clearly understood by reference to the following detailed description, the appended claimed subject matter, and the several views illustrated in the accompanying drawings.

IN THE DRAWINGS

FIG. 1 is a highly schematic top plan view of the apparatus of this invention, and illustrates the various operations which are performed and the areas at which they are performed between the time a can body is fed to a turret of the apparatus and thereafter discharged therefrom in its stylized form.

FIG. 2 is a schematic view of one of a plurality of split molds and expansible chambers carried by the turret, and illustrates the manner in which a can body on a lifter platen is raised upwardly into external telescopic relationship to the expansible chamber and internal telescopic relationship to a mold cavity.

FIG. 2A is a schematic view similar to FIG. **2**, and illustrates the can body in its uppermost position as a pair of split mold bodies begin to close.

FIG. 2B illustrates the mold of FIG. **2A** in its completely closed and locked position with a peripheral flange of the container body clamped between a support of the expansible chamber and portions of the mold bodies.

FIG. 2C is a schematic view with a portion of the expansible chamber broken away for clarity, and illustrates the chamber being radially expanded under the influence of hydraulic pressure to conform the can body to the general contour of the mold cavity.

FIG. 2D is a schematic view of the can body after it has been stylized by the discharge of electrical energy across a pair of electrodes to transfer intimate cavity designs to the exterior of the now stylized can body.

FIG. 2E is a schematic view illustrating the open position of the mold and the now purged chamber, and illustrates the stylized can being removed by downward movement of the bottom die body or lifter platen.

FIG. 3 is a timing diagram, and indicates the relationship between turret rotation and the relationship of a can body to the operations being performed relative thereto.

FIG. 4 is a schematic illustration of the hydraulic system of the apparatus, and illustrates a fluid isolator or intensifier for pressurizing the expansible chambers.

FIG. 5 is a fragmentary top plan view of the apparatus with certain structure removed for clarity, and illustrates means for feeding can bodies to the apparatus, the manner in which four split molds carried by a turret are opened and closed, and means for discharging stylized can bodies from the turret.

FIG. 6 is a fragmentary axial sectional view taken through the apparatus with certain portions removed for clarity, and illustrates the mounting of the turret, and cam and cam follower means for lifting a can body carried by a bottom die body into external telescopic relationship to one of the expansible chambers prior to closing the split mold associated therewith.

FIG. 7 is a fragmentary side elevational view, partially in section, taken generally along line 7—7 of FIG. 8, and illustrates a linkage mechanism associated with each split mold for opening and closing the same through the operation of a cam and cam follower mechanism.

FIG. 8 is a fragmentary sectional view taken generally along line 8—8 of FIG. 7 and more clearly illustrates the four split molds and the linkage mechanisms associated therewith.

FIG. 9 is a fragmentary sectional view taken generally along line 9—9 of FIG. 8 when the split mold is at a feed station, and illustrates the manner in which a can body is transferred from a star wheel to a position in alignment with the open split molds by a cam and cam follower mechanism.

FIG. 10 is an enlarged fragmentary sectional view taken generally along line 10—10 of FIG. 9, and illustrates a plurality of passages for connecting a vacuum source to the under side of a can body carried by the bottom die body for holding the can body thereon.

FIG. 11 is a sectional view taken generally along line 11—11 of FIG. 10, and illustrates one of a plurality of compression springs associated with the lower die body or platen.

FIG. 12 is a fragmentary sectional view of another platen, and illustrates the convex configuration of a chamber when employed in conjunction with a bottom seamed or seamless can body.

FIG. 13 is a cross sectional view taken generally along line 13—13 of FIG. 6, and illustrates four vacuum lines each of which is associated with one of the platens.

FIG. 14 is a fragmentary cross-sectional view similar to FIG. 9 but taken at a position at which the can body has been lifted by the platen to its uppermost position, and illustrates a cam follower for supporting the platen during the forming operation.

FIG. 15 is a perspective view of one of the split mold bodies, and illustrates the particular configuration of a cavity formed therein.

FIG. 16 is a fragmentary perspective view of one of the split molds, and illustrates the manner in which a cam and cam follower associated with a linkage mechanism closes the split mold.

FIG. 17 is a fragmentary sectional view taken through the split mold and linkage mechanism of FIG. 16, and illustrates the manner in which the cam follower is moved upwardly to close the split mold.

FIG. 18 is an axial sectional view taken through one of four identical transducers of the apparatus, and illustrates an interior rigid cage structure surrounded by an expansible bag-like element which defines the expansible chamber, and additionally illustrates the container body in external telescopic relationship thereto.

FIG. 19 is a cross-sectional view taken generally along line 19—19 of FIG. 18, and illustrates the manner in which one of a pair of electrodes is connected to a conductor.

FIG. 20 is a sectional view taken generally along line 20—20 of FIG. 18, and illustrates the manner in which the other of the electrodes is connected to a conductor and passage means for introducing and removing liquid from the chamber.

FIG. 21 is a cross-sectional view taken generally along line 21—21 of FIG. 18, and more clearly illustrates the internal cage structure of the transducer and particularly a plurality of circumferentially spaced electrode-supporting pillars.

FIG. 22 is a fragmentary cross-sectional view taken through a stationary central supporting column of the turret, and illustrates a pair of rotary valves forming a portion of the hydraulic system of FIG. 4 for pressurizing and purging the transducer chambers.

FIG. 23 is a cross-sectional view taken generally along line 23—23 of FIG. 22, and more clearly illustrates the manner in which the valves are coupled to each of the four transducers and to drain.

FIG. 24 is a fragmentary cross-sectional view of one of the transducers, and illustrates alignment between stator and rotor contacts for creating an electrical discharge across the electrodes.

FIG. 25 is a sectional view taken long line 25—25 of FIG. 24, and more clearly illustrates the relative position between the stator and rotor contacts at the time of discharge.

GENERAL DESCRIPTION

The can body stylizing apparatus of this invention is generally designated by the reference numeral **10** and includes a rotatable turret **12** which carries four identical split molds **13** (FIG. **2**), a transducer **14**, and a bottom mold body or platen **15**. Referring in particular to FIGS. **1** through **2D**, a can body C is delivered to an infeed star wheel **16** which transfers the can body C in overlying relationship to the platen **15** which is moved counterclockwise, as viewed in FIG. **1**. A vacuum holds the can body C upon the platen **15** as the platen **15** rises upwardly to position the can body C in external telescopic relationship to an expansible chamber **17** of the transducer **14**. As the platen **15** is elevated mold bodies **18, 20** defining therebetween a mold cavity **21** begin to close (FIG. 2A), fully close, and clamp a peripheral flange F between a portion of the transducer **14** and portions of the split molds **18, 20** (FIG. **2B**) at which point the split molds **18, 20** are locked and the vacuum is cut off (FIG. **2B**).

Liquid is then introduced into the interior of the chamber (FIG. **2C**) to progressively expand the chamber and thereby radially expand the container C into general conformity with the contour of the cavity **21**. At a pressure of approximately 600–800 p.s.i. the can body C is not in intimate contact with the cavity surface and any minute details thereon would not be totally and accurately transferred to the can body exterior. In order to transfer such minute details an electrical discharge is created across a gap between a pair of electrodes **19, 22** which creates a momentary shock wave resulting in a force of approximately 30,000 p.s.i. which forces the exterior of the can body C into intimate contact with the mold cavity **21**.

The chamber **17** is purged, the platen **15** is decompressed and lowered (FIG. **2E**), the split mold **13** is subsequently fully opened, and the now stylized can body is removed from the apparatus by a discharge star wheel **23** (FIG. **1**).

DETAILED DESCRIPTION

Referring in particular to FIG. **6** of the drawings, the turret **12** includes a stationary tubular upstanding support **24** which is fixed to an underlying portion (not shown) of a frame F'. A rotatable tubular member **25** surrounds the support **24** and a lower end portion thereof includes a flange **26** to which is welded a gear **27**. A suitable bearing **8** is positioned between the gear **27** and the lower end portion of the support **24** while a bushing **30** is disposed between reduced end portions **31, 32** of the support **24** and the rotatable member **25**, respectively.

Another stationary support **33** (FIG. **6**) of a generally annular configuration is supported above the support member **24** and in axial alignment therewith by a plurality of supporting rods **34**. A bearing assembly **35** mounts a tubular member **36** for rotation relative to the stationary support **33**. The tubular member **36** carries a table **37** at its upper end and is secured at its flanged lower end (unnumbered) to another tubular member **38** which is in turn secured to the reduced end portion **32** of the rotatable member **25**. In this manner rotation imparted to the rotatable member **25** by the gear **27** is transferred by the tubular members **36, 38** to rotate the table **37** as well as a turret member **40** which is welded or otherwise secured to the tubular member **38**.

The turret member **40** is formed by an upper annular plate **41**, a lower annular plate **42** and a peripheral plate **43**. Four identical transducers, each being referred to generally by the reference numeral **14**, are suspendingly supported from the lower plate **42** at points equidistant from the axis of rotation of the turret member and in 90° spaced relationship to each other.

Referring in particular to FIG. **18** of the drawings, each of the transducers **14** includes an internal rigid cage structure **46** defined by a plurality of circumferentially spaced conductive rods **47** which are welded at their lower ends to a conductive electrode support **48** and at their upper ends to a conductive metallic plate **50**. The rods **47** pass through bores **51** in an annular insulating member **52** which is in internal telescopic relationship to an annular supporting collar **53** which is suspended from the plate **50** by a flanged clamping collar **54**. A plurality of springs **55** permit limited axial movement of the collar **53** relative to the plate **50**. The annular insulating member **52** further includes a pair of passages **56, 57** which are in fluid communication with respective passages **58, 59** of the plate **50** (FIG. **20**) and collectively the passages **56** through **59** function to introduce a fluid medium, such as a low (4 percent) concentrate saline solution, into the interior of an expansible chamber **17** defined in part by a flexible bag-like element **61**. A pair of passages **62, 63** likewise formed in the annular insulating member **52** are in fluid communication with respective passages **64, 65** of the plate **50** for purging the liquid from the chamber **17**.

Another annular insulating member **66** is threadably secured to the plate **50** at its upper end portion and the electrode **19** passes through a bore **67** thereof in axially aligned spaced relationship to the electrode **22** to therebetween define an electrode-electrode gap **68** across which electrical energy is discharged to expand the bag-like element **61** radially outwardly during the second phase of the stylizing operation heretofore described in conjunction with FIG. **2D**.

The bag-like element **61** is supported at its upper end portion within a chamber **70** of the collar **53** by means of a two-piece piston **71** which is mounted for limited axial movement in the chamber **70**. The piston **71** is prevented from moving completely out of the chamber **70** by means of a restraining collar **72**. A lower annular arcuate surface **73** of the piston **71** is contoured to clamp the peripheral flange F of each of the can bodies C in conjunction with the mold bodies **18, 20**, as will be described more fully hereafter. The clamping force is increased in proportion to an increase in pressure internally of the chamber **17** by means of a pair of ports **74** which conduct incoming pressurized liquid from the passages **56, 57** into the chamber **70** above the piston **71**.

Each transducer **14** is suspended from the plate **42** of the turret member **40** by a plurality of circumferentially spaced bolts **75** (FIGS. **18** and **19**) received in flanged insulators **76** which project through bores **77** of the plate **42**. An annular insulator **78** maintains the plate **42** in spaced relationship to a conductive plate **80** into bores **81** of which each of the bolts **75** is secured.

The conductive plate **80** is connected to the electrode **19** by a coupling **82** which includes a conductive collar **83** and a conductive plate **84**. The conductive plate **80** is likewise supported in spaced relationship to the plate **50** by a plurality of bolts **85**, each of which passes through insulators **86, 87** and is threadably secured in a bore **88** of the plate **50**. Conductors **90, 91** are secured to the respective plates **80, 50** by bolts and nuts (unnumbered). Current will therefore flow along a path traced from the conductor **90**, the conductive plate **80**, the collars **83, 84**, the electrode **19**, the electrode **22**, the support **48**, the rods or pillars **47**, the plate **50** and the conductor **91**.

Reference is now made to FIGS. **7** through **9** which illustrate the manner in which each of the platens **15** is mounted for sliding movement upon the rotatable member **25** between a lowermost position (FIG. **9**) at which time the can body C is removed from the infeed star wheel **16** to an uppermost position (FIG. **15**) at which time the split mold **13** is completely closed. Four plates **92** (FIG. **8**) are secured in a conventional manner to the rotatable member **25**, and at upper and lower ends of each plate **92** is a radially outwardly directed bracket **93, 94**, respectively (FIGS. **6, 7** and **9**). The brackets **93, 94** each have a pair of bores (unnumbered) which receive cylindrical rods **95, 96**. The rods **95, 96** are in parallel relationship to each other and define a slide path for a slide **97** which includes a pair of bores **98, 100** (FIG. **10**) in which are received the rods **95, 96**. A bracket **101** which carries the platen **15** is secured to the slide **97**. Thus, upon upward movement being imparted to the slide **97** from the position shown in FIG. **9** the slide **97** is guided upwardly by the rods **95, 96** to the position shown in FIG. **24** while opposite movement is likewise guided by the rods **95, 96**.

Each of the slides **97** is reciprocated upwardly and downwardly during the rotation of the rotatable member **25** by means of a cam track **102** (FIG. **6**) which encircles the rotatable member **25** and is suitably secured to the frame F'. A cam roller or follower **103** is positioned in a groove **109** of the cam track and is secured to the slide **97** by a plate **104**. As the rotatable member **25** rotates each slide **97** carried thereby similarly rotates as does each plate **104** and platen **15** whereupon the cam follower **103** lifts and lowers each platen **15** in sequence to the operations being performed by the apparatus **10**.

Each platen **15** includes a tubular supporting head **105** which is bored at **106** and counterbored at **107** (FIG. **11**). A lip of the head is rounded as at **108** to receive the bottom radius of the can body C. A cylindrical insert **110** having a peripheral flange **111** is positioned within the bore **106** while a reduced stem **112** thereof is positioned in a bore **113** of the bracket **101**. A plurality of springs **114** disposed in opposed recesses of the bracket **101** and the head **105** normally urge the latter upwardly to the position illustrated in FIG. **11**. However, the head **105** may move downwardly until a shoulder **115** contacts the upper surface of the bracket **101**. The insert **110** is secured in the position illustrated in FIG. **11** by means of a bolt **116** which permits sliding movement and prevents rotational movement. A pin **117** force fit into a bore **118** of the bracket **101** includes an end portion slidably received in a bore **120** of the head **105** to likewise permit vertical sliding movement of the head **105** while preventing rotation thereof.

A generally inverted U-shaped bracket **121** is secured to the under side of the bracket **101** and carries cam roller or follower **122** which rides upon a cam track **123** (FIG. **14**) supported by an upright support **124** of the frame F'. The function of the springs **114** is to permit the can body C to be placed under a predetermined compressive force between the head **105** and the shoulder **73** of the transducer **14** prior to the closing of the split mold **13**. The function of the cam follower **122** when it is on the upper portion of the cam track **123** is to support the bracket **101** against the extremely high forces (30,000 p.s.i.) created during an electrical discharge across the electrodes **19, 22**.

The can C is preferably held on the head **105** of the platen **15** by a partial vacuum created in the bore **107** (FIG. **11**). The volume beneath the bottom wall of the can C is connected to a conventional vacuum source (not shown), such as a vacuum pump, by a passage **125** in the head **110**, a radial port **126** (FIG. **10**) in the stem **112** and a portion of the bracket **101**, a port **127** which opens into the bore **98** of the slide **97**, an annular chamber **128** between the bore **98** and the exterior surface of the rod **95**, a radial bore **130** (FIG. **9**) in the rod **95**, an axial passage **131** in the rod **95**, a passage **132** at the lower end of the rod **95** which passes through the plate **92** and terminates at a passage **133** in the rotatable member **25**, a passage **134** and a conduit **135** which passes through an opening (unnumbered) in the gear **27**. Suitable seals (unnumbered) are provided for preventing undesirable leakage.

FIG. **12** illustrates a modified platen **15'** wherein a head **105'** having a bore **106'** and a counterbore **107'** receives an insert **110'** having a convex upper surface **136**. The surface **136** is formed of a convex configuration to cooperate with a correspondingly contoured dome-shaped bottom B' of a container C'.

The split molds **13** are of identical construction and the mold bodies **18, 20** thereof are mounted for sliding movement relative to each other between the open and closed positions illustrated in FIGS. **7, 8** and **16**. The mold bodies **18, 20** are supported from the lower plate **42** of the turret member **40** by means of a plate **140** to one side of each of the molds **13** (FIG. **8**) and a pair of plates **141, 142** at an opposite side of each of the molds. The uppermost ends of the plates are welded to the under side of the plate **42** while the lower ends are rigidly connected together by a pair of cylindrical rods **143, 144**. The rods **143, 144** are preferably coupled to the plates **141, 142** in a removable manner as, for example, by projecting threaded end portions through bores of the plates **140** through **142** and employing nuts to fasten the assembly whereupon the split molds **13** can be readily removed, repaired or replaced.

The mold bodies **18, 20** include aligned bores in each of which is a bushing **145, 146** through which is respectively received the rods **143, 144**, as is best illustrated in FIG. **16**.

The molds **13** are opened and closed by a linkage mechanism **150** (FIG. **16**) which includes a pair of rods **151, 152** each of which is surrounded by bushings **153** in the bores **155**. The bores **155** are in alignment with bores **156** of the mold body **20** which receive an end portion of each of the rods **151, 152**. The end portions of the rods **151, 152** carry flanges **157** and are secured in position by a nut **158**, in a manner clearly illustrated in FIG. **16**.

Each of the rods **151, 152** includes a bifurcated end portion **160** which is secured by a pivot pin **161** to a link **162**. Each of the links **162** is in turn connected to a generally T-shaped member **163** by a pin **164**. The T-shaped member **163** is supported by a pair of plates **165, 166** which are welded to the under side of the plate **42** of the turret member **40**, and the lower end portions thereof are pivotally connected by a pin **167** to a bifurcated extension **168** of the member **163**. The extension **168** is in turn connected to a link **170** by a pin **171** and another pin **172** secures each of the links **170** to a bifurcated portion **173** of each of the mold bodies **18**.

Each of the T-shaped members **163** includes a further bifurcated portion **174** which is connected to a link **175** by a pin **176**. The link **175** is in turn pivotally connected by a pin **177** to a rod **178** which is mounted for sliding telescopic movement in a sleeve **180** (FIGS. **6** and **7**) carried by the turret member **40**. Each rod **178** is prevented from rotating by a groove and key, which is generally designated by the reference numeral **181**. A cam follower or roller **182** is carried by the upper end portion of each of the rods **178** and is received in a cam track **183** which is fixedly secured to the under side of the stationary support **33**, in the manner best illustrated in FIG. **6** of the drawings.

As the turret member **40** rotates the follower **182** moves in the track **183** to raise and lower each of the rods **178** to respectively close and open each of the split molds **13**, in the manner best illustrated in FIG. **17**. Upon upward movement of the rods **178**, the rods **151, 152** are drawn to the left as viewed in FIG. **16** to pull along therewith the mold body **20** while the downward pivoting movement of the extension **168** from the position shown in FIG. **17** to that shown in FIG. **16** moves the mold body **18** from left to right until the bodies are in the closed position shown in FIG. **16**. It will be noted that the link **170** applies a force through the mold body **18** in a direction opposite to that which draws the mold body **20** toward the mold body **18**. Thus, it is possible by the linkage mechanism **150** to preload the split molds **13** in the closed position to thereby effectively resist forming forces which might otherwise tend to open the same.

Reference is now made to FIGS. **24** and **25** of the drawings which illustrate a pair of contacts **185, 186** secured by bolts **187** to an insulating plate which is in turn secured by bolts **190** to a bifurcated bracket **191** which is secured to a vertical plate **192.** The plate **192** is fixedly secured in any conventional manner, as by welding, adjacent each of the transducers. The contact **186** is connected to its associated transducer by the conductor **90** while the contact **185** is connected to the transducer by the conductor **91.**

Another pair of contacts **195, 196** are supported from a post **197** adjacent the rotatable turret member **40.** The contacts **195, 196** are each secured by bolts and nuts **197** to a generally L-shaped insulating member **198** having a recess **200** in which is seated a plate **201** having an arcuate aperture **202** through which passes a bolt **203.** A pivot pin **204** and an insulating bushing associated therewith journals each of the members **198** for slight pivoting movement relative to the pivot pin **204,** as indicated by the unnumbered double headed arrows in FIG. **25.** A spring **205** is connected to each of the plates **201** and a pin **206** passing through a support member **207** which is conventionally secured to an upstanding support **208** of the apparatus frame F'. The contacts **195, 196** are mounted for pivotal movement to permit the faces thereof to come into intimate contact during the rotation of the rotatable member **40** such that upon reaching the position shown in FIGS. **24** and **25** a discharge is created across the electrodes **19, 22** from a source of electrical energy (not shown) such as a storage inductor or capacitor which is connected to the contacts **195, 196** by conductors (not shown).

A pair of rotary valves **210, 211** (FIG. **22**) form part of a hydraulic system **215** (FIG. **4**) of the apparatus **10.** The valve **210** includes a sleeve-like housing **212** which rotates with the tubular member **38** and includes four conduits **213** which pass through openings **214** and are each connected to an associated one of the transducers **14.** A stationary sleeve **216** is fixedly support atop a rigid conduit **217** and includes an interior chamber **218** which is connected to an annular channel **220** of the housing **212** by four ports **221.** Liquid within the chamber **218** is connected to a drain by means of a plurality of tubular bolts **222** of the valve **210** which open into the chamber **218** and into an annular passage **223** formed between the conduit **217** and another conduit **224.** The conduit **217** is connected to a check valve **225** (FIG. **4**) and to a conduit **226** which is in turn connected to a pump **227.**

The valve **211** delivers low concentrated saline solution to the various transducers by means of the conduit **224,** a chamber **228** in the sleeve **216,** a plurality of ports **230** in the sleeve **216,** an annular channel **231,** and a plurality of conduits **232** which are each connected to one of the transducers **14** and a fluid isolator **235** (FIG. **4**) in a manner which will be described immediately hereafter in conjunction with a description of the operation of the apparatus **10.**

STYLIZING OPERATION

The infeed star wheel **16** rotates counterclockwise as viewed in FIG. **1** during which time the clockwise rotation of the turret **12** brings the platen **15** into underlying axial registration with the can body C. At this time a vacuum is being drawn over the flow path heretofore described relative to FIGS. **9** through **11** of the drawings and as the can body C seats upon the shoulder **108** (FIG. **11**), the can body C is firmly held upon the head **105** of the platen **15** as the latter begins to rise as the cam follower **103** (FIG. **6**) moves upwardly under the influence of the cam track **109** (FIG. **6**). During this upward movement the platen **15** is guided by the slide **97** as it moves upwardly along the rods **95, 96** (FIGS. **7** to **9**).

During the upward movement of the platen **15** a solenoid valve SV6 (FIG. **4**) is operated to conduct water from a suitable source through a conduit **236** to the pump **227** to avoid loss of its "prime." The solenoid valve SV6 is one of a plurality of valves associated with each of the transducers which is operated in sequence by a plurality of timing cams (not shown) which are rotated in a conventional manner in synchronism with the rotation of the turret **12** to initiate the various operations of the apparatus **10.**

A pair of solenoid valves SV3 and SV5 are then operated to conduct a low (4 percent) concentrate saline solution to an outlet chamber **237** of the intensifier **235** and to the chamber **17** of the transducer **14.** The saline solution is created by conducting water from a suitable source through a valve **238** (FIG. **4**) and diverting the flow through a check valve **240,** a needle valve **241,** a brine tank **242** and a conventional rotometer **242** which monitors the saline solution flowing through a conduit **243** which, as need be, may be supplied with fresh water flowing through a check valve **244,** a needle valve **245,** a pressure regulator **246** and a rotometer **247** to provide the desired concentrate of the solution to the conduit **224** which delivers the same to the chamber **228** of the valve **211** (FIG. **22**) and thence to a selected one of the transducers through the conduit **232** which is connected to a conventional accumulator **251** by a conduit **252.** The conduit **252** continues the flow of the solution through a valve (unnumbered) of the solenoid valve SV5, a conduit **253,** a check **254,** a conduit **255,** a conduit **256** which includes a branch **257** having a check valve **258** and conduits **260, 261** (FIG. **5**) which are connected to the ports **58, 59** (FIG. **20**). This begins to fill the chamber **17** of the transducer **14** with the low concentrate saline solution, and also fills the outlet chamber **237** of the fluid isolator **235** through a conduit **262.**

The platen **15** continues to rise and eventually reaches the top of its stroke at which time the flange F contacts the shoulder **73** of the transducer piston **71** and upon the contact of the cam follower **122** with the cam surface **123** (FIG. **14**) the head **105** compresses the springs **114** to intimately urge the flange F against the shoulder **73,** as is best illustrated in FIG. **18.** This upward movement also raises the piston **71** slightly upwardly from the position shown in FIG. **18** to allow clearance between the can body flange F and clamping shoulders **263** of each of the mold bodies **18, 20** as they are closed about the can body C.

After the platen **15** is fully raised and the springs **114** are compressed the die bodies **18, 20** begin to close as the cam follower **182** (FIGS. **6** and **16**) begins to rise by means of the cam track **183** which draws the associated rod **178** upwardly to eventually close the mold through the linkage **150,** in the manner heretofore described.

The vacuum is now cut off to the platen **15** in a conventional manner and the solenoid valve SV5 is closed to terminate the saline solution feed. A solenoid valve

SV2 is then operated to switch a valve **264** to its power position at a time that the chamber **17** is at line pressure (40 p.s.i.) and after the mold bodies **18, 20** have been fully closed. During the introduction of the solution into the chamber **17** air is expelled between the container body C and the exterior of the bag-like element **61** as the latter conforms to the contour of the can body C, although the latter is not deformed at this time. A continuously operating motor M (FIG. **4**) drives a pump **265** to conduct hydraulic fluid into a chamber **266** of the isolator **235** behind a piston **267** over a flow path defined by a conductor **268**, a check valve **270**, a conventional rotary joint **271** carried by the rotating table **37** (FIG. **6**), a conduit **272**, and a conduit **273**. As the pressure begins to increase in the chamber **266** a piston **279** begins to move downwardly to increase the pressure in an accumulator **274** through a conduit **275** and to also increase the pressure within the chamber **17** through the conduit **262**, the conduit **256**, the conduits **260, 261**, the ports **58, 59**, and the passages **56, 57**. The pressure is increased in the chamber **17** until it is approximately between 600–800 p.s.i. at which time the bag-like element **61** is expanded radially outwardly to force the container body into general conformity with the mold cavity **21**. However, at this time the fluid pressure is insufficient to intimately urge the exterior surface of the can body C into intimate relationship to the fine details of the mold cavity surface.

The introduction of the fluid into the chamber **17** also increases the clamping force exerted upon the can body flange F due to the ports **74** (FIG. **18**). The gradual expansion of the can body C also expels air from between the can body and the die except in the fine detail areas.

The continued rotation of the turret **12** eventually brings the rotary contacts **185, 186** into alignment with the stationary contacts **195, 196**, respectively, which closes a circuit from the stored energy source (not shown) which causes a discharge across the electrodes **19, 22** and the spark gap **68** to cause a momentary shock wave which expands the bag-like element **61** further outwardly at a force up to 30,000 p.s.i. This results in the further radial expansion of the can body C and urges the exterior surface thereof into intimate contact with the fine detailed portions of the mold cavity **21**. An ignitron may be placed in series with the stored energy source to more accurately control the discharge of the capacitor and the ensuing electrohydraulic (E-H) pulse. While a force of 30,000 p.s.i. has been indicated as being satisfactory for most operations, the pressure developed may be approximately between 25,000–75,000 p.s.i. for less than 100 micro-second at a capacitor discharge across the electrodes of 30,000 joules at 10,000 volts.

After the can has been "stylized" the solenoid valves SV2 and SV6 are closed to respectively remove the drive pressure to the fluid isolator **235** and to close the flow from the conduit **236** to the pump **227**. With the valve **264** now in its drained position the pressure in the accumulator **274** acting through the conduit **275** forces the piston **279** upwardly and hydraulic fluid in a chamber **266** is conducted to a reservoir by the conduit **273**, the valve **264**, a conduit **278**, a rotary valve **280** adjacent the rotary valve **271**, a conduit **281** and a reservoir **282** which is preferably connected to the pump **265** by a conduit **283**. As the piston **273** rises fluid is withdrawn from the chamber **17** through the passages **62, 63** (FIG. **20**), passages **64, 65**, conduits **237, 238** and a conduit **262** until such time as the pressure within the chamber **17** is zero, as is the pressure within the chamber **70** (FIG. **18**) which releases the clamping force of the piston **71**. As the mold bodies begin to open a solenoid valve SV4 is operated to its open position and the centrifugal pump **227** continues to remove the fluid from the chamber **17** through the conduits **287, 288**, the conduit **213** (FIG. **22**) of the valve **210**, the valve **210**, the conduit **217**, the check valve **225** and the conduit **226**. The centrifugal pump **227** creates a vacuum internally of the chamber **17** such that the bag-like element **61** collapses against the pillars **47** of the cage **46** (FIG. **2E**) to permit the now stylized can body to be readily removed therefrom during downward movement of the platen **15**.

Vacuum is again applied to the platen **15** to clamp the stylized can body to the head **105** and the platen **15** begins to lower as its roller **122** descends along the cam surface **123** to completely decompress the springs **114** just prior to the die bodies reaching their fully opened position under the influence of the cam track **183**, the cam follower **182** and the rod **178** associated with the linkage mechanism **150**. After the die bodies **18, 20** are fully open and the springs **114** are fully decompressed, the platen **15** begins to lower as the follower **103** descends to the lower position of the cam track **109**, after which the vacuum to the platen is discontinued and the stylized can body is discharged to the star wheel **21**.

Between approximately 302°–312° the cam track **183** is contoured to close the die bodies partially in order that the die bodies can clear the star wheels **16, 21**, the vacuum is again applied to the platen **15** for subsequent can body pick-up, and the solenoid valves SV4 and SV6 are respectively closed and opened to terminate the draining of the chamber **17** and the intensifier **235**, and to provide water to the evacuation pump **227** to prevent the loss of its prime. Thereafter the cycle of the apparatus **10** continues in the manner heretofore described.

It is pointed out that the saline solution is a corrosive liquid and care must be taken in order that the saline solution does not admix with the noncorrosive hydraulic fluid introduced into the chamber **226** of the fluid isolator **235** (FIG. **4**). To this end a pair of O-ring seals **290, 291** surround the piston **279** on opposite sides of the radial port **292** which is connected by a conduit **293** to a check valve **294** which is in turn connected by a conduit **295** to the conduit **213**. Any hydraulic fluid which seeps past the O-ring seal **290** is thereby withdrawn from the area between the seals **290, 291** during the purging of the chamber **17** upon the operation of the centrifugal pump **227**. Likewise, any of the corrosive saline solution which seeps upwardly past the O-ring seal **291** is likewise conducted to drain through the port **292**, the conduit **293**, the check valve **294**, etc. during the purging of the chamber **17**.

If some slight contamination of the saline solution does occur, it may be removed prior to being introduced into the chamber **237** of the isolator **235** by removing a portion of the conduit **262** and directing the saline solution from the conduit **255** directly to the conduit **284**, a filter **296**, a check valve **297** and a conduit **298** connected to the remaining portion of the conduit **262**, while reverse flow can be prevented by a conduit **300**, a check valve **301**, and a conduit **302**.

While preferred forms and arrangements of parts have been shown in illustrating the invention, it is to be clearly understood that various changes in details and arrangement of parts may be made without departing from the spirit and scope of this disclosure.

The embodiments of the invention in which an exclusive property or privelege is claimed are defined as follows:

1. Apparatus for reforming tubular elements comprising means for conveying tubular elements between loading and discharging stations, mold means carried by said conveying means for receiving the tubular elements in cavities of said mold means, flexible chamber means internally of each mold means and in telescopic relationship to the tubular element therein, means for periodically conducting a fluid medium into said chamber means, means for generating an electrical discharge in said chamber means whereby each tubular element is reformed by the fluid medium to the configuration of the cavities, means for opening each mold means for the removal of each reformed tubular element therefrom, means surrounding said chamber means for clamping a peripheral edge of each tubular element against cooperating clamping surface means of each mold means, means for increasing the pressure of the fluid medium in the chamber means prior to the operation of said generating means, and means for increasing the clamping force between said clamping means and said clamping surface means depending upon the increase of pressure of the fluid medium in the chamber means.

2. Apparatus for reforming tubular elements comprising means for conveying tubular elements between loading and discharging stations, mold means carried by said conveying means for receiving the tubular elements in cavities of each mold means, flexible chamber means internally of each mold means and in telescopic relationship to the tubular element therein, means for periodically conducting a fluid medium into said chamber means, means for generating an electrical discharge in said chamber means whereby each tubular element is reformed by the fluid medium to the configuration of the cavities, means for opening each mold means for the removal of each reformed tubular element therefrom, means surrounding said chamber means for clamping a peripheral edge of each tubular element against cooperating clamping surface means of each mold means, said surrounding means is a member mounted for sliding movement externally of said chamber means, and means for moving said member toward said clamping surface means for clamping the peripheral edge of each tubular element.

3. Apparatus for reforming tubular elements comprising means for conveying tubular elements between loading and discharging stations, mold means carried by said conveying means for receiving the tubular elements in cavities of said mold means, flexible chamber means interiorly of each mold means and in telescopic relationship to the tubular element therein, means for periodically conducting a fluid medium into said chamber means, means for generating an electrical discharge in said chamber means whereby each tubular element is reformed by the fluid medium to the configuration of the cavities, means for opening each mold means for the removal of each reformed tubular element therefrom, means surrounding said chamber means for clamping a peripheral edge of each tubular element against cooperating clamping surface means of each mold means, said surrounding means is an annular piston mounted for sliding movement externally of said chamber means, a housing surrounding said piston and defining a chamber therewith, and means for introducing a fluid medium into said chamber for moving said piston toward said clamping surface means for clamping the peripheral edge of each tubular element.

4. Apparatus for reforming tubular elements comprising means for conveying tubular elements between loading and discharging stations, mold means carried by said conveying means for receiving the tubular elements in cavities of said mold means, flexible chamber means internally of each mold means and in telescopic relationship to the tubular element therein, means for periodically conducting a fluid medium into said chamber means, means for generating an electrical discharge in said chamber means whereby each tubular element is reformed by the fluid medium to the configuration of the cavities, means for opening each mold means for the removal of each reformed tubular element therefrom, said tubular elements are closed at one end thereof and are open at another end, rigid immovable means for clamping the closed end of each tubular element between said chamber means and said mold means, and means for clamping the open end of each tubular element between said chamber means and said mold means whereby the reformed tubular elements are of generally uniform heights due to localized reforming of the tubular elements between the clamped ends thereof.

5. Apparatus for reforming tubular elements comprising means for conveying tubular elements between loading and discharging stations, mold means carried by said conveying means for receiving the tubular elements in cavities of said mold means, flexible chamber means internally of each mold means and in telescopic relationship to the tubular element therein, means for periodically conducting a fluid medium into said chamber means, means for generating an electrical discharge in said chamber means whereby each tubular element is reformed by the fluid medium to the configuration of the cavities, means for opening each mold means for the removal of each reformed tubular element therefrom, said mold means include a plurality of split molds, each split mold is defined at least in part by a pair of mold bodies which are movable away from each other by said opening means and toward each other by closing means, said opening and closing means include linkage means coupled to each of said mold bodies, one of said linkage means is operative by said closing means to draw one of the pair of mold bodies toward and into contact with the other of the mold bodies, and the other of said linkage means is operative by said closing means to push the other of the mold bodies toward and into contact with said one mold body.

6. The reforming apparatus as defined in claim **5** wherein said one and another linkage means include a plurality of pivotal links, and said links are disposed in generally parallel relationship in the closed position of said mold bodies.

7. The reforming apparatus as defined in claim **6** including means mounting said mold bodies for guidable sliding movement relative to each other between the open and closed positions thereof.

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