United States Patent [19]

Paramonoff

[11] 3,735,629

[45] May 29, 1973

[54] **APPARATUS FOR FORMING ONE PIECE METALLIC CAN BODIES**

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[73] Assignee: **Standun Inc.,** Compton, Calif.

[22] Filed: **June 11, 1970**

[21] Appl. No.: **45,430**

[52] **U.S. Cl.** ....**72/349,** 72/449, 308/5 R

[51] **Int. Cl.** **B21d 22/28**

[58] **Field of Search** ....72/347–349, 449, 450; 308/5 R

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Primary Examiner—Richard J. Herbst
Attorney—Mahoney, Hornbaker and Schick

[57] **ABSTRACT**

A horizontally movable ram is mounted on a main frame longitudinally reciprocal in a forward working stroke and a rearward return stroke through a rotating crankshaft drivingly connected to the ram by a plurality of pivot arms, the pivot arms being specifically arranged for longitudinally moving the ram at a reduced comparative speed directly approaching and following the ram stroke rearward reversal than directly approaching and following the ram stroke forward reversal permitting an increased period of time for feeding of metal parts to be engaged and worked by the ram. The ram is mounted on the main frame through hydrostatic-type pressurized oil film bearing assemblies with the ram being supported at a rearward location by combined horizontally extending and vertically extending constantly pressurized and flowing oil films with a more forward portion of the ram being additionally peripherally supported by a cylindrical constantly pressurized and flowing oil film. The apparatus die pack may include an initial redraw die and a series of ironing dies, each of said dies including a die ring resiliently retained for limited radial movement and also adjustment alignment, as well as arranged in the particular die for selective removal out of its particular die assembly by pivoting of a cover plate without complete removal of the die assembly from the die pack. Additionally, the ironing die assemblies each include a fluid distribution ring longitudinally adjacent the die ring thereof and preferably removable therewith as an assembly arranged to tangentially distribute a circumferentially moving ring of liquid across the distribution ring ram opening providing lubrication and cooling for the dies and metal parts being formed.

20 Claims, 31 Drawing Figures

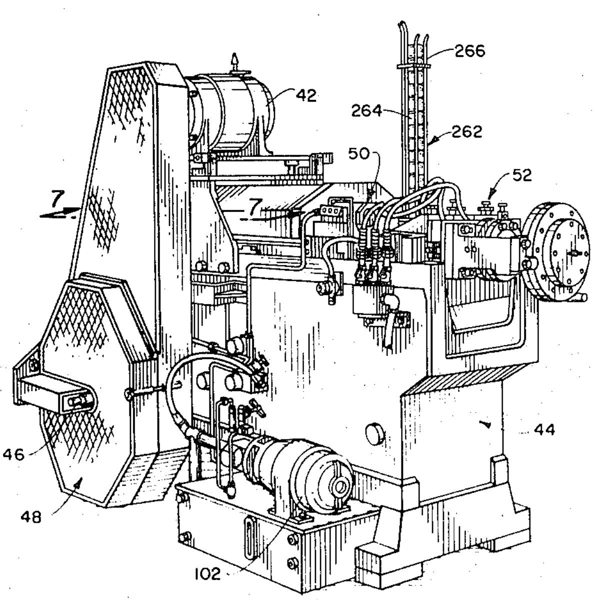

FIG. 1.

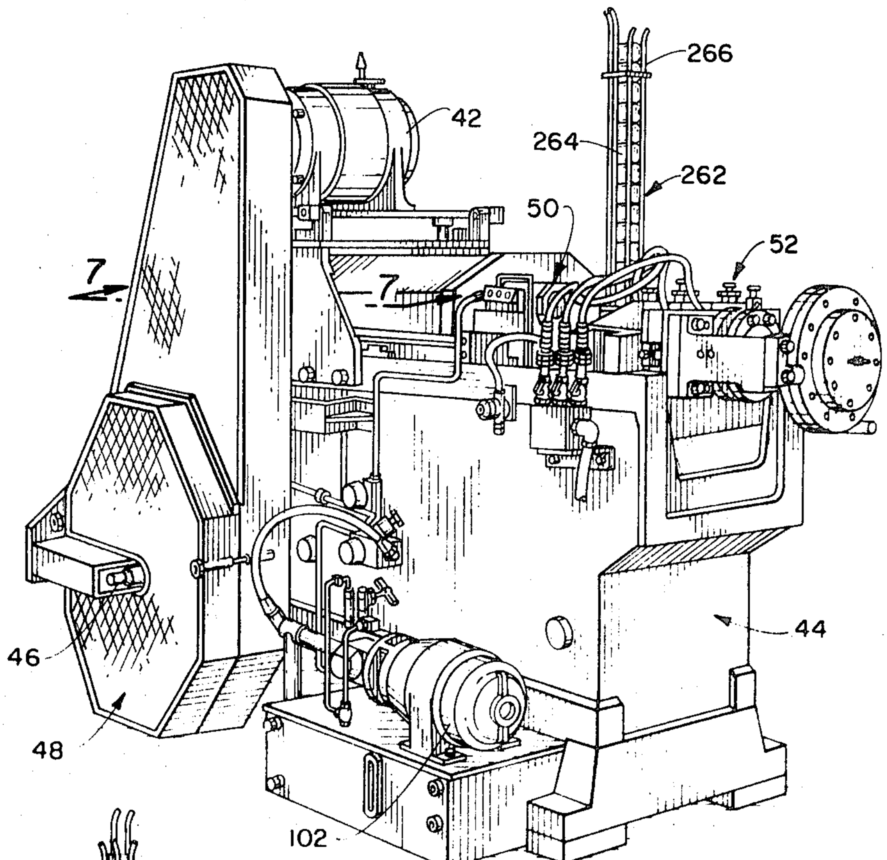

FIG. 2.

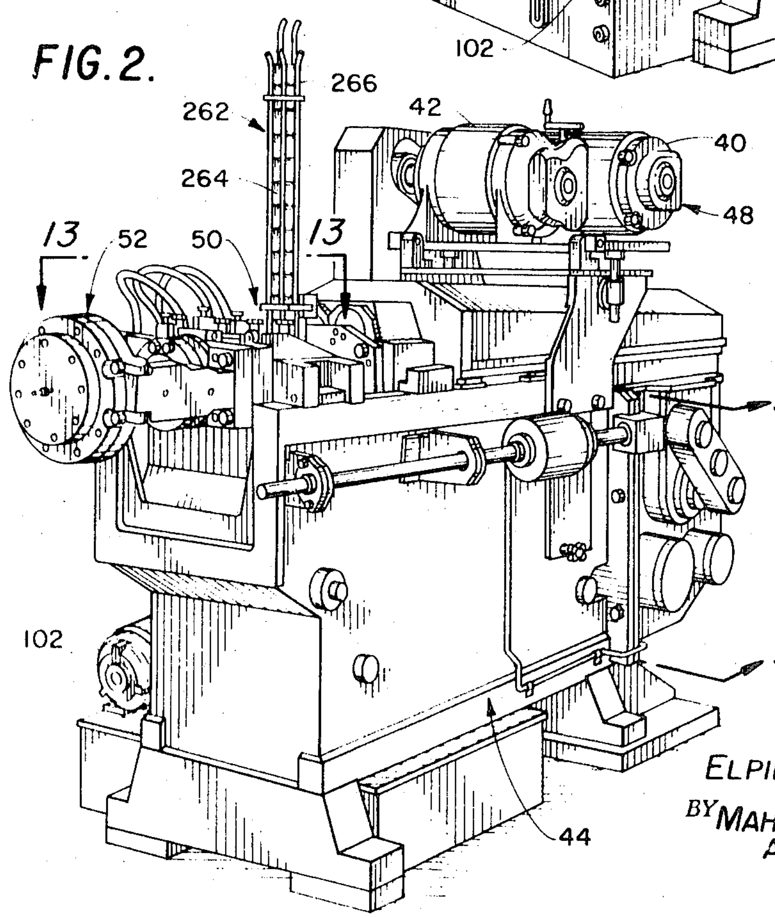

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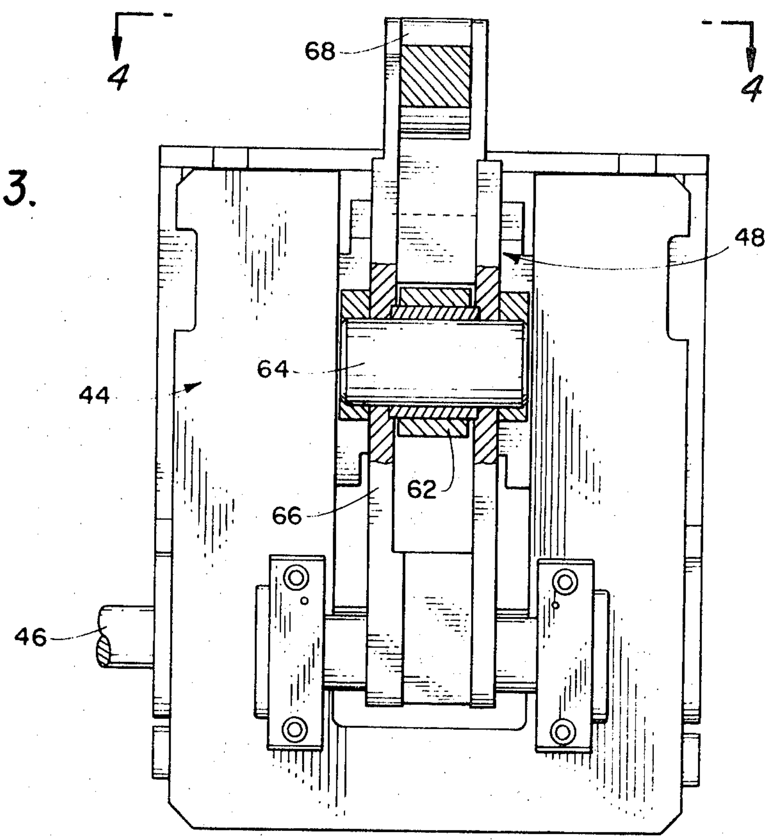
FIG. 3.



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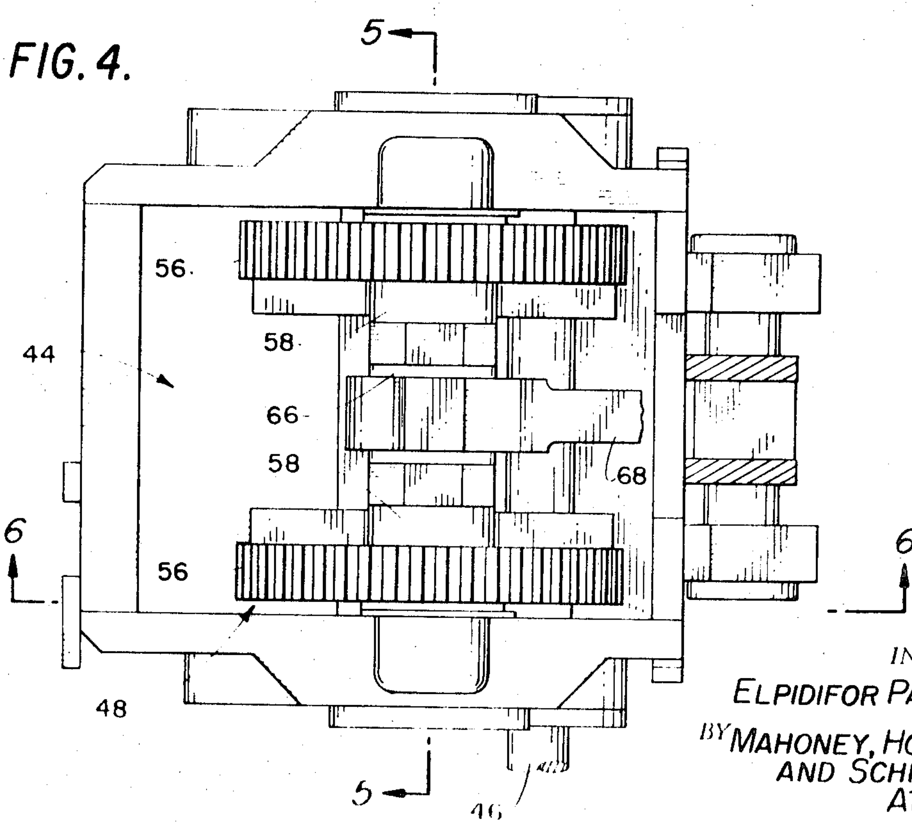

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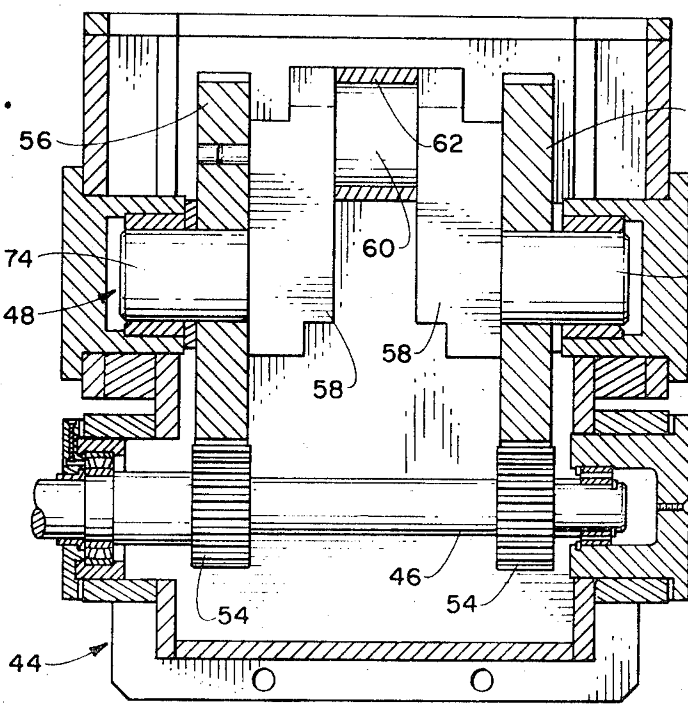
FIG. 5.



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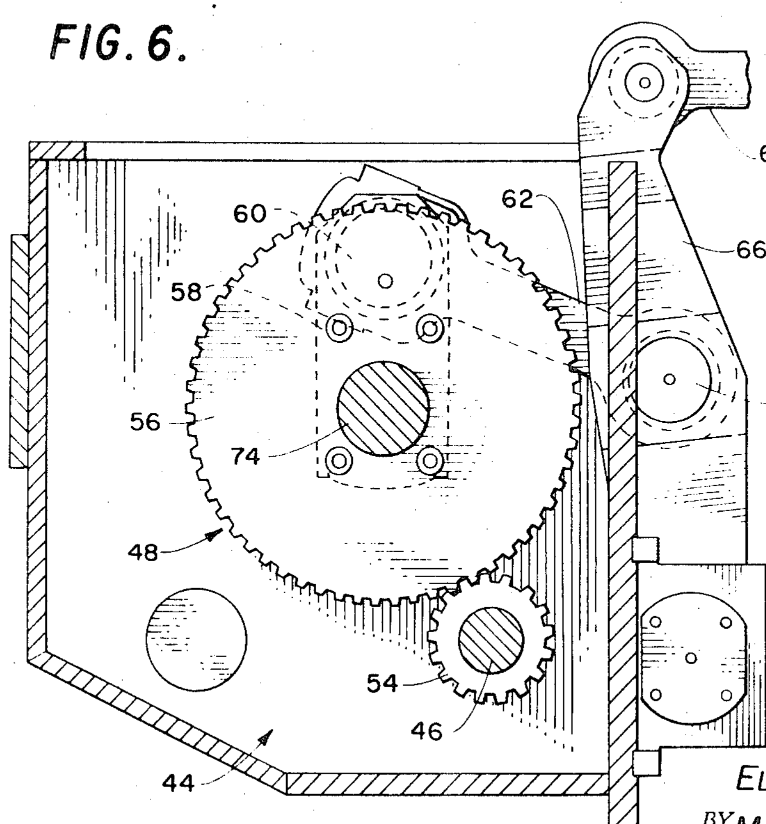

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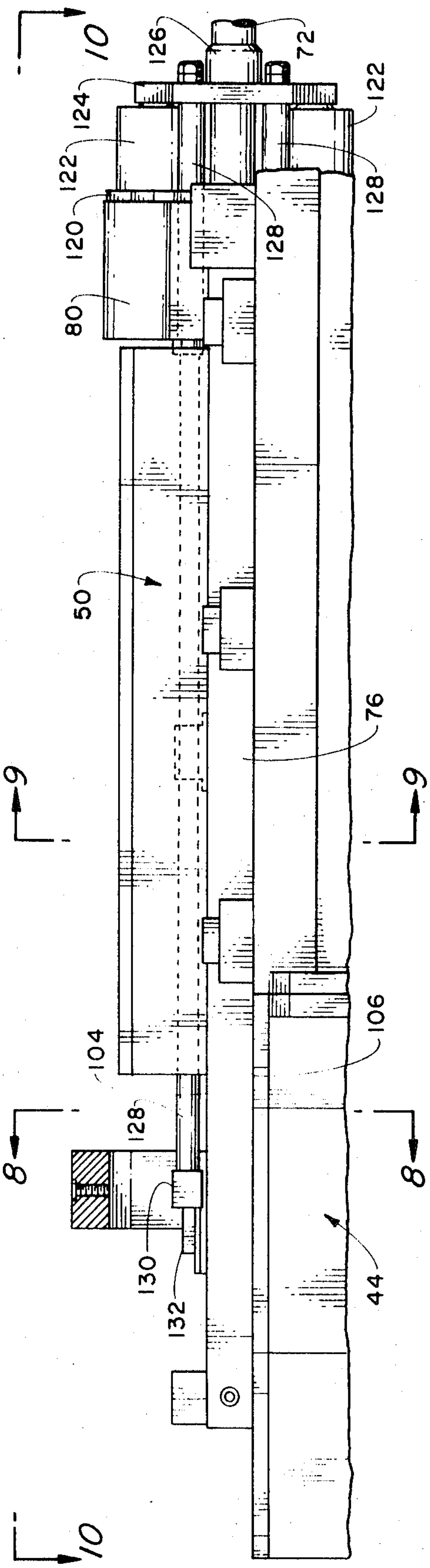

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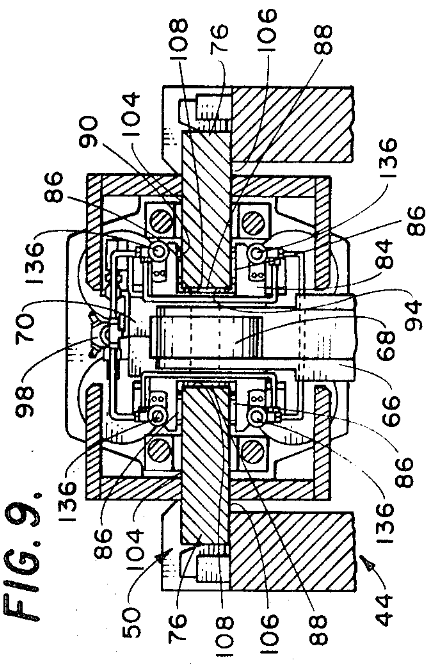

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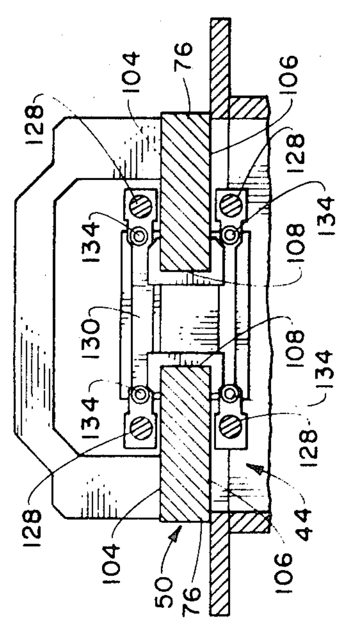

FIG. 8.

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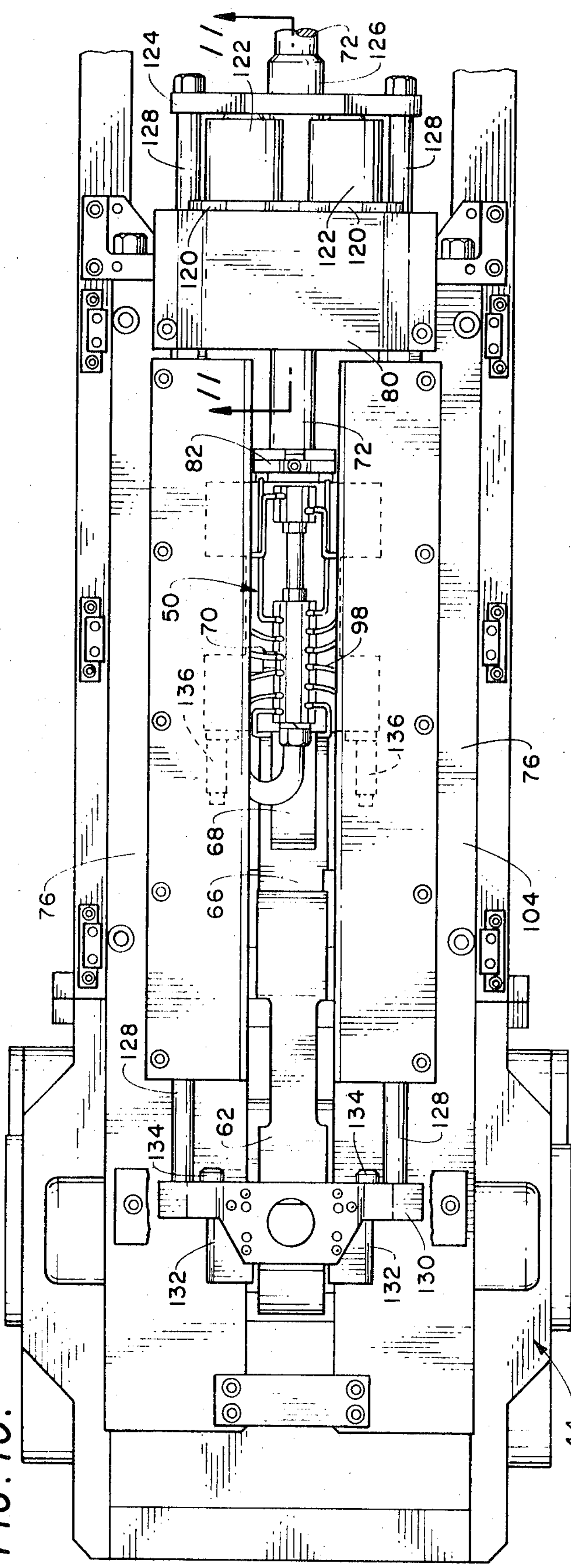

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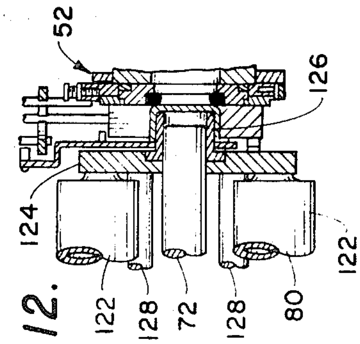

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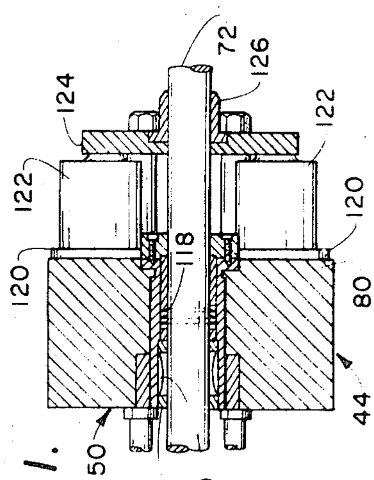

FIG. 11.

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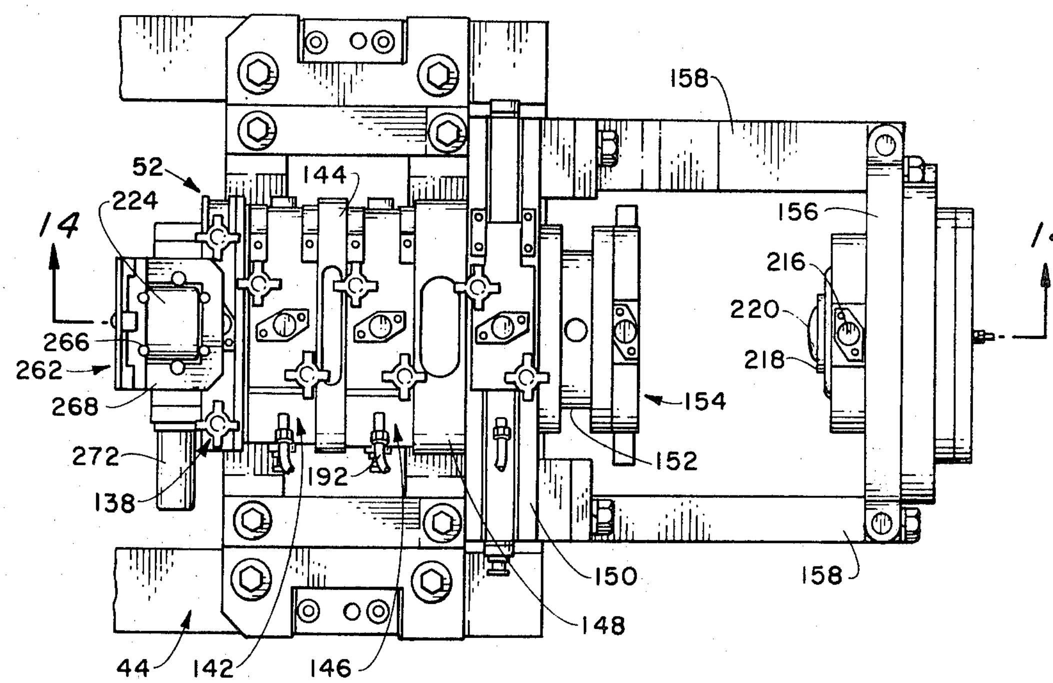
FIG. 13.



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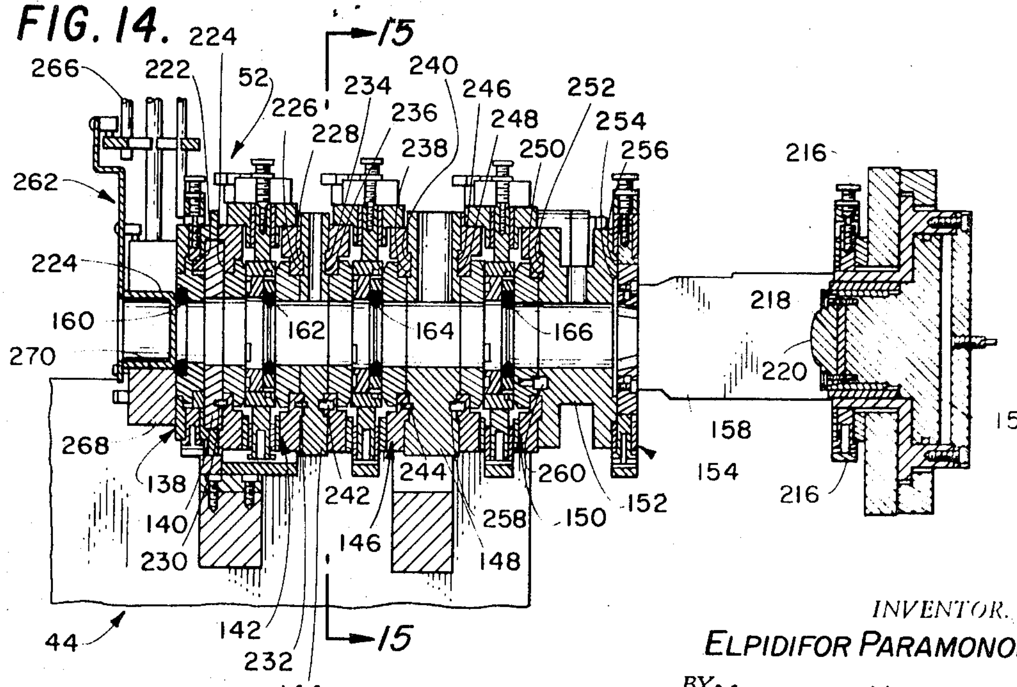

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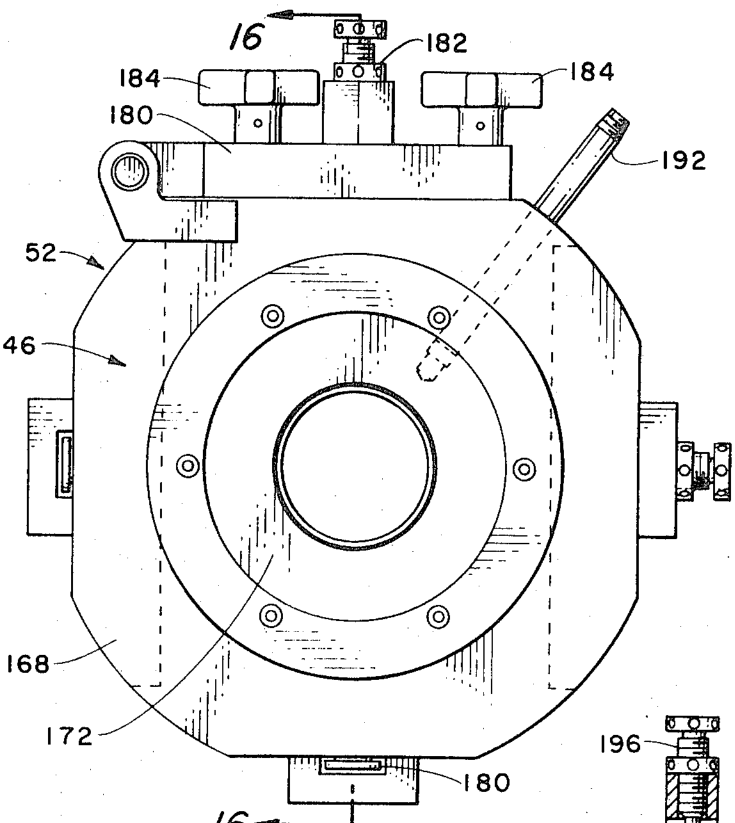
FIG. 15.



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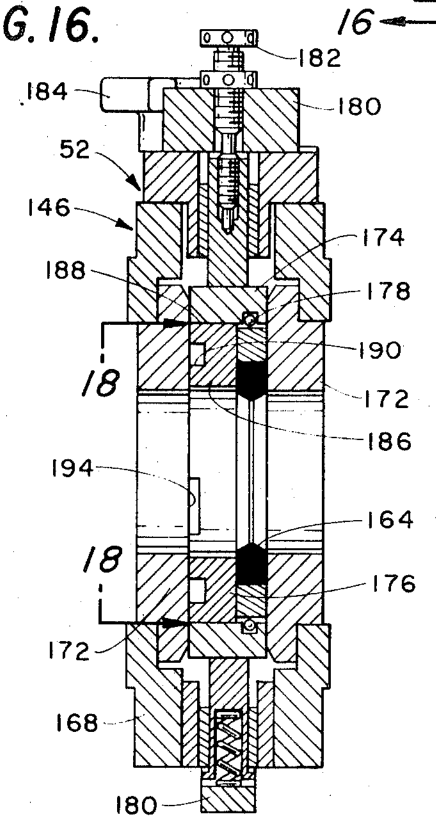

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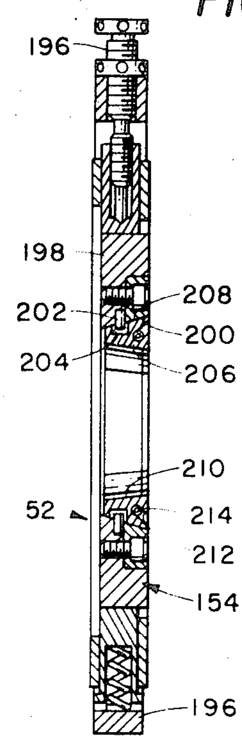

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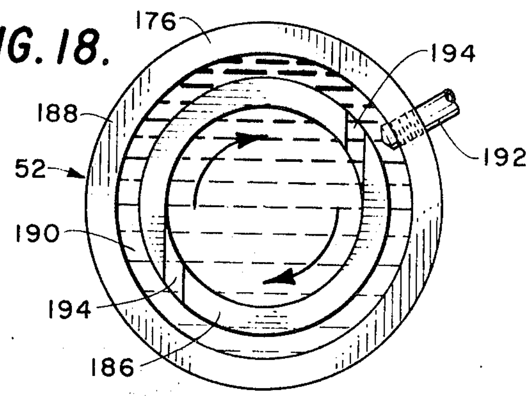
FIG. 18.



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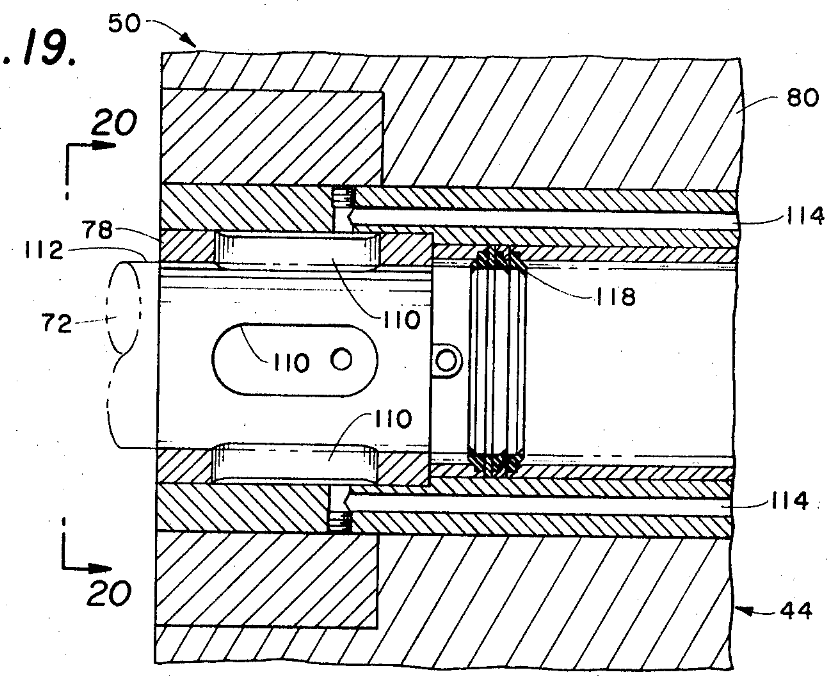

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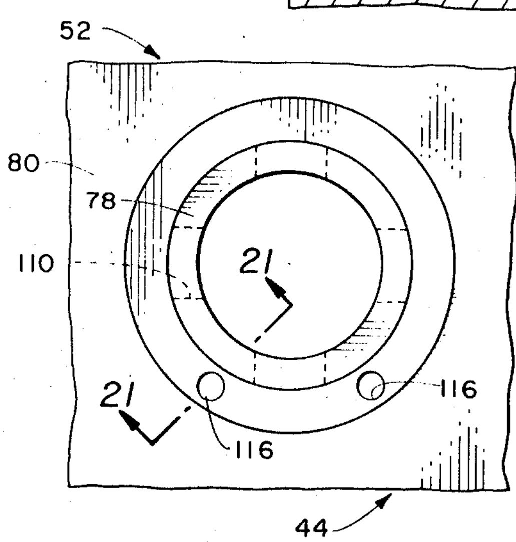

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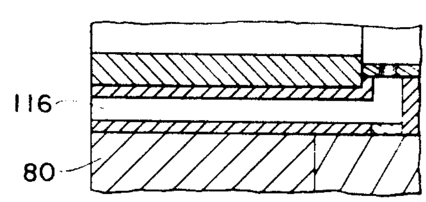

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FIG. 22.

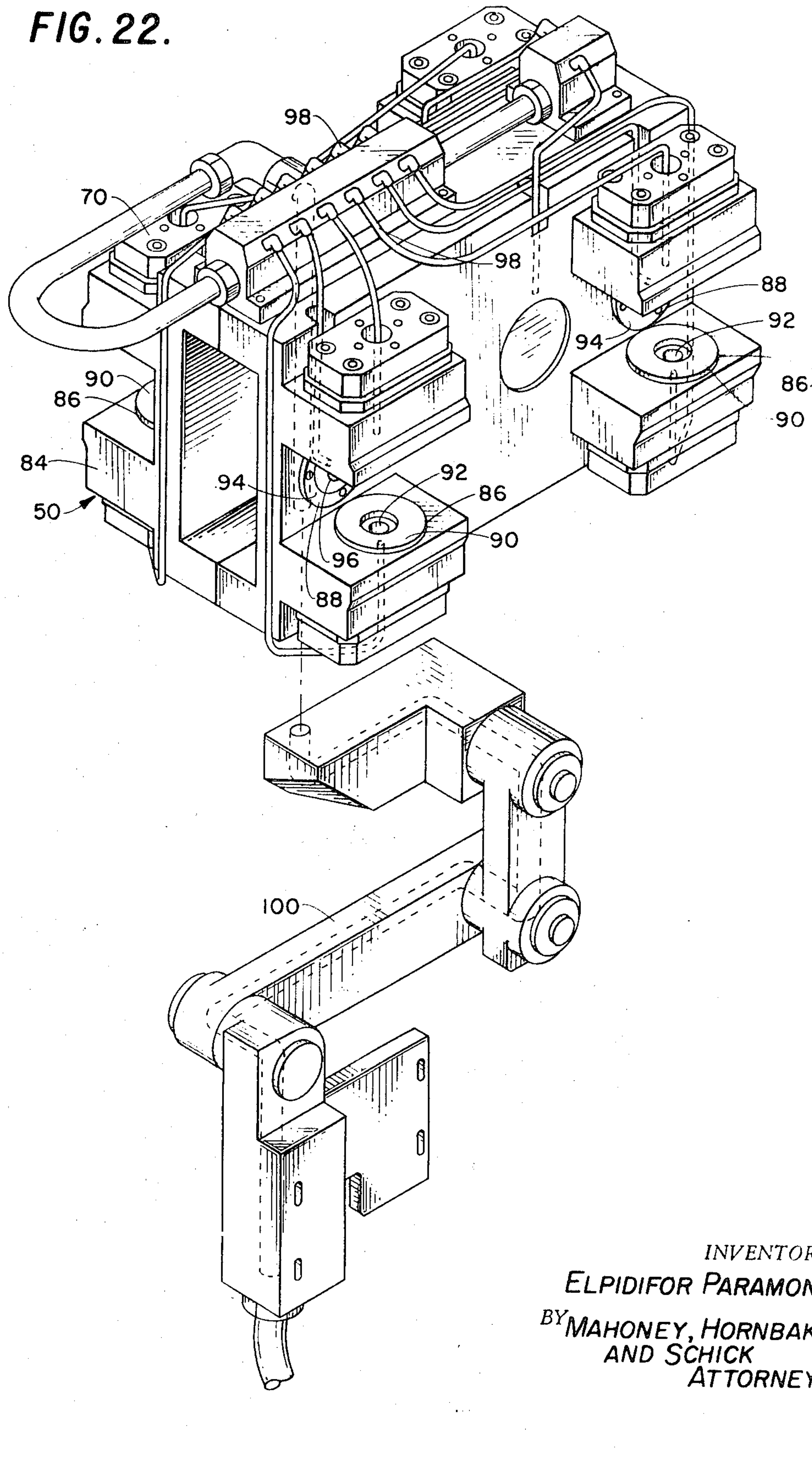

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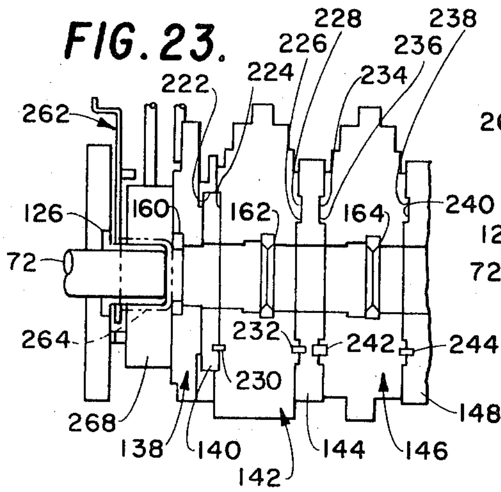
FIG. 23.



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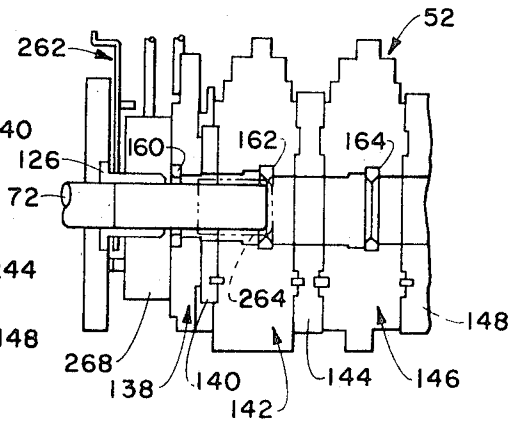

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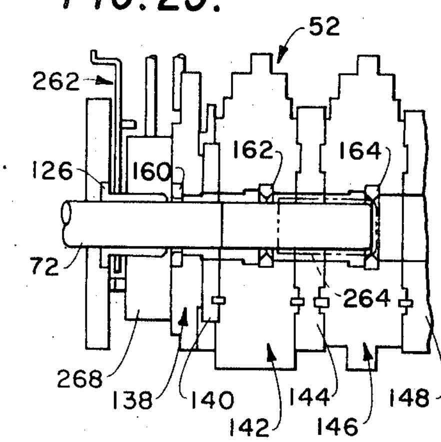

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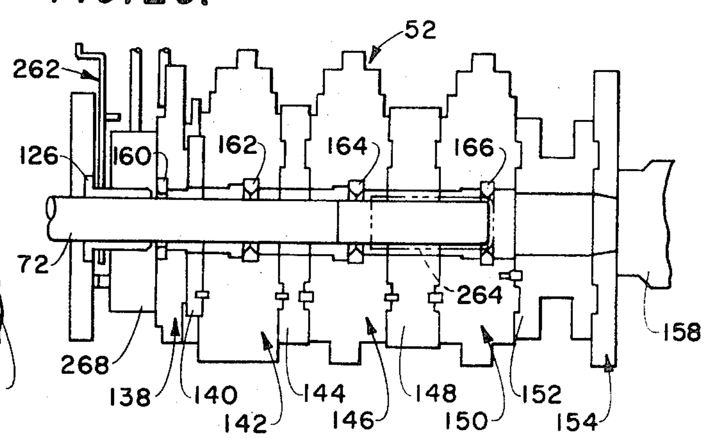

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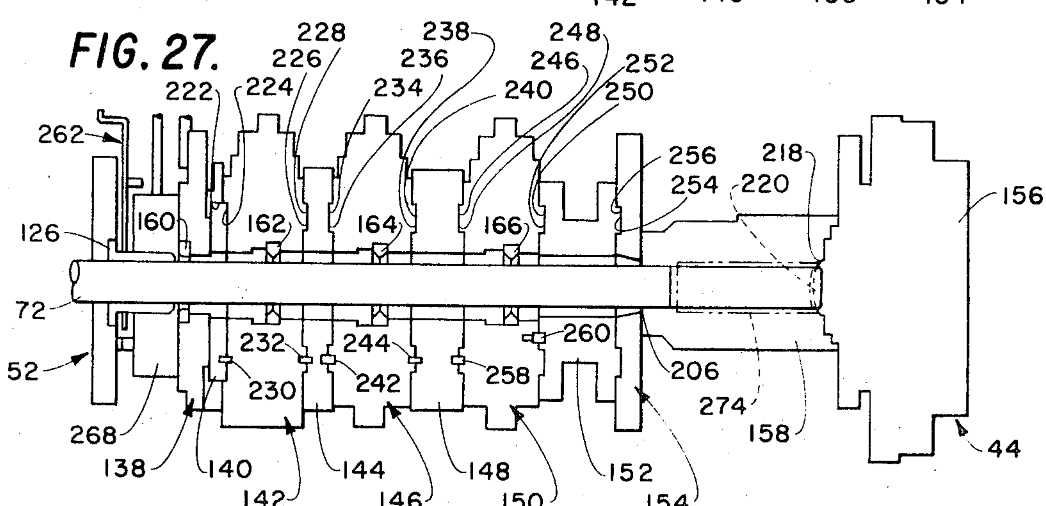

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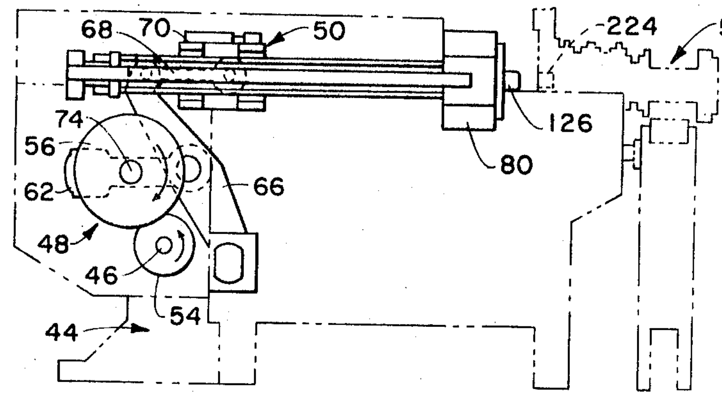

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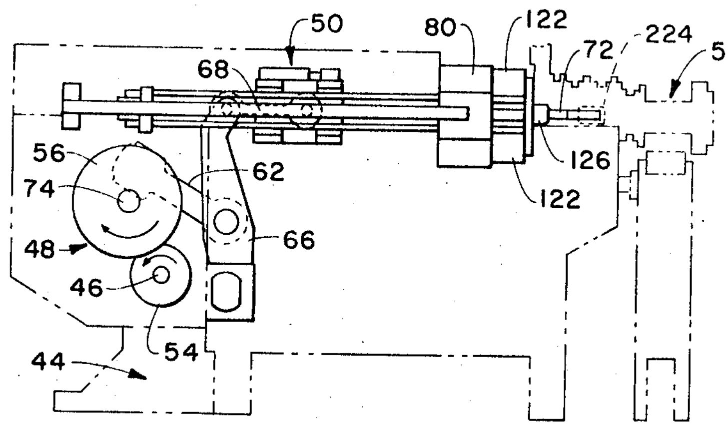

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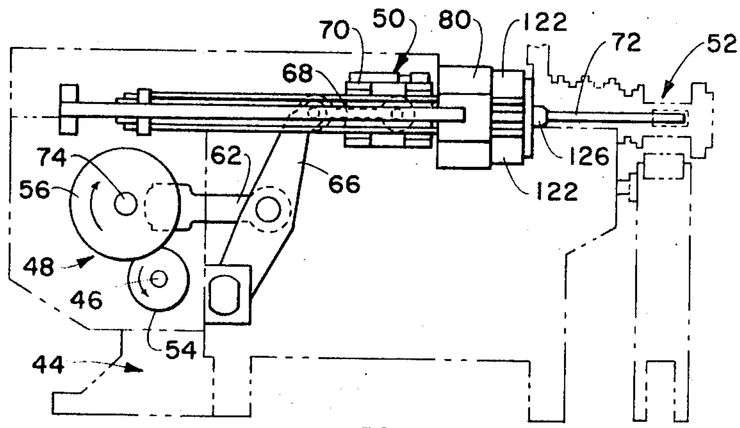

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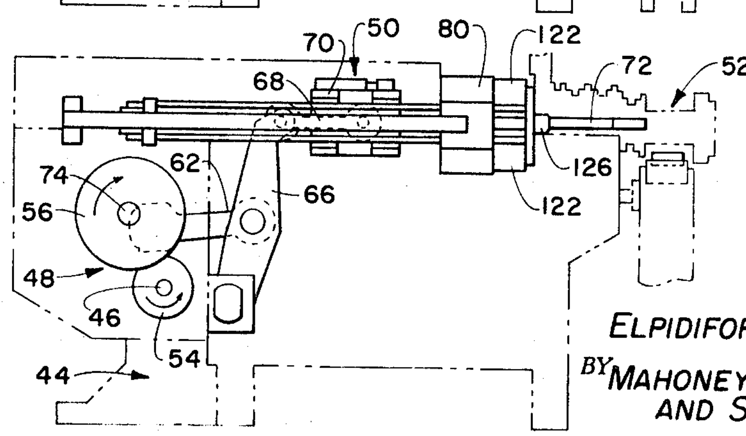

FIG. 31.

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APPARATUS FOR FORMING ONE PIECE METALLIC CAN BODIES

BACKGROUND OF THE INVENTION

This invention relates to an apparatus for forming one piece metallic can bodies and more particularly, to such an apparatus which may include reciprocal ram acting through a die pack incorporating multiple ironing dies, and sometimes incorporating an initial redraw die, for forming one piece metallic can bodies from previously formed cup-like metallic parts. Even more particularly, the principles of the present invention may include any one or all in combination of a novel mechanical drive for the reciprocal ram arranged for high speed ram movement during a working portion thereof and reduced speed ram movement during a part feeding portion thereof, hydrostatic-type bearing support for the reciprocal ram wherein the ram movements are supported on constantly pressurized and flowing, thickened oil films for maximum movement accuracy and minimum wear, and a novel arrangement of die pack assembly having improved die mounting providing sufficient die lubrication and cooling throughout the working operation with convenient die accessibility for maintenance without disturbing the remainder of the die pack assembly.

Various prior forms of apparatus for forming one piece metallic can bodies have heretofore been provided, all of which have necessarily required the use of a reciprocally movable ram movable through a relatively long forward working and rearward return stroke through multiple stages or ironing dies in order to increase the axial or longitudinal length of a cup shaped metal part in order to produce a finished metallic can body. Obviously, unless multiple ironing stages are incorporated in a single apparatus, the various progressive ironing stages must be accomplished singly, thus the requirement of the extensive ram stroke. To even further increase the problems involved, particularly where the starting cup-like metallic Parts to be ironed into finished can bodies are formed of metals which are more difficult of drawing and ironing, it is sometimes desirable to include with the multiple ironing stages comprised of the multiple ironing dies, an initial redraw stage to thereby even further increase the over-all die pack assembly length and the necessary reciprocal strokes of the ram.

Consequently, three major problem areas have been encountered in the construction of apparatus of the type herein involved. A first major problem area is the manner of drive of the reciprocal ram, that is, exactly how to reciprocally drive the ram over its extensive forward working and return stroke at maximum lineal speeds of predetermined uniformity while still permitting sufficient time during such ram movement for the feeding of cup-like metallic parts into a working position from which the various working oPerations can subsequently follow. Another maJor problem area is exactly how to support the ram during its reciprocal movements while still maintaining repeated trueness of movement with minimum wear for maximum quality of finished can bodies. Still another problem area is that of the die pack assembly wherein sufficient redraw and ironing die support must be maintained while still incorporating proper die and metal part lubrication and cooling, all in a die pack assembly of a convenient form

permitting the maximum ease of periodic maintenance inspections and replacements.

Two general types of ram drive have heretofor been incorporated in various of the metallic can body forming mechanisms, hydraulic drive by hydraulic cylinder systems sometimes including mechanical drive elements therewith and pure mechanical drive solely by a crankshaft and pivotal mechanical linkages. Both of these prior forms of drive have included certain advantages and certain disadvantages, keeping in mind that the over-all goal is maximum speed with a predeterminability of uniformity in movement matched against a sufficient allowable time element during portions of the ram stroke during which the cup-like metallic parts to be ironed or redrawn and ironed may be fed into the proper working position for engagement by the ram to carry out the working operations.

With the ram hydraulic drive, whether or not mechanical drive portions are included therewith, it is possible, with relatively complicated hydraulic controls, to gain relatively high ram speeds during the working operations, while still reducing the ram speeds during the portions of the ram strokes wherein the cup-like metallic part feeding must take place. Driving the ram hydraulically, however, results in sufficiently varying uniformity of ram movement due to hydraulic fluid unavoidable temperature changes and leakage that the quality of the finally produced metallic can bodies can vary over a considerable range. Thus, scrap losses can be extensive and particularly unless the mechanism involved is maintained at peak maintenance preciseness and adjustment.

With the use of mechanical drives in such mechanisms for the reciprocal ram movements, and considering purely the ram movements without introducing the problems of part feeding, relatively high ram speeds can again be obtained and, assuming proper ram movement guiding is maintained by frequent bearing maintenance, constant uniformity of ram reciprocal movement for maximum finished can body quality can likewise be obtained. Introducing the problem of timing for cup-like metallic part initial feeding, however, serves to greatly reduce the possible ram speed during both the feeding and working operations. That is, with mechanical ram drive in the previous can body forming mechanisms, the ram speeds have been of substantially uniform cycle throughout each of the working and return strokes. As a result, the speed of the working stroke is the same as the speed of the return stroke and the speed of the working operation is necessarily limited by the timing required for accomplishing the feeding operation since with mechanical drive it has heretofor been impossible to alter the ram cycling speeds during the feeding operation from that produced during the working operation.

In the second major problem area, that of bearing support for the ram over the relatively long reciprocal strokes required for multiple stage ironing operations, and even including the initial redrawing operation, during which the ram must be extended or projected within the dies over a long unsupported distance, the ram bearing support in the prior can body forming mechanisms has been an operational speed limiting factor if frequent failures and maintenance interruprions for bearing replacements are to be avoided. Again, in the carrying out of multiple redraw and ironing operations on one piece metallic can bodies with the thin metal wall thicknesses involved, little bearing wear in ram guiding movement can be tolerated if the necessary trueness, quality and completed part surface finish is to be maintained. Furthermore, it is fundamental that bearing wear and maintenance problems multiply or increase disproportionately for only slight increases in speed. Thus, the various forms of ram bearing supports in the prior mechanisms have been a greatly limiting factor for the practical operation thereof and have greatly limited the speed of operation from that that would be considered most desirable.

In the die pack areas of the can body forming mechanisms, the third general problem area, proper die and metal part lubrication and cooling must be maintained and this despite the inherent problems presented with the increased ram speeds during ram and metal part movement through the various dies. Also, not only must the mechanisms providing the proper lubrication and cooling be properly integrated within the die pack, but both the cooling mechanisms and the working portions of the dies themselves must be properly securely mounted within the die pack for withstanding the high speed ram operations with the resulting maximum required trueness and quality of produced can bodies. Still at the same time, despite this required provision of proper lubricating and cooling mechanisms with proper support for such mechanisms and the various multiple dies within the die pack, all of the combined elements must be relatively easily accessible at the individual die stages, as well as the total individual die stage assemblies, for efficient servicing and required replacement under minimum time conditions unless along down time delays are to be encountered.

OBJECTS AND SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide an apparatus for forming one piece metallic can bodies wherein the reciprocal ram performing the working operations is mechanically driven to gain inherent advantages of such mechanical drive, yet through a unique form of mechanical linkage by pivotal motion transfer arms between the crankshaft and reciprocal ram, a reduced comparative speed of ram reciprocal movement and movement reversal is obtained directly approaching and following the ram stroke rearward reversal for part feeding than the ram speeds directly approaching and following the ram stroke forward reversal for completion of the ram working operation. According to certain of the principles of the present invention, the pivot arms between the crankshaft and the ram are uniquely connected and arranged producing a longer effective driving pivot arm extension during the forward portions of the ram strokes than during the rearward portions thereof so as to produce higher over-all ram speeds during such forward portions and reduced over-all ram speeds during such rearward portions. Thus, maximum speed of operation is maintained during the working and partial return portion of the ram strokes, yet reduced ram speed is maintained during the required part feeding portions of the ram strokes, thereby effectively controllably varying the ram speeds to gain maximum speed of operation while still gaining the predicted uniformity of ram movement inherent in the mechanical drive thereof.

It is a further object of this invention to provide an apparatus for forming one piece metallic can bodies wherein the main bearing support for the reciprocal ram permits extremely high ram stroke speeds with maximum trueness but virtually free of wear problems resulting in minimum maintenance and downtime losses. According to certain other of the principles of the present invention, the main bearing support for the reciprocal ram is formed by a unique construction of hydrostatic-type pressurized oil film bearing assembly preferably including multiple spaced, generally vertically and generally horizontally reacting pads acting against corresponding slide surfaces with continuously pressurized and continuously flowing thickened oil films distributed therebetween maintaining the pad surfaces spaced from the slide surfaces and pressure oil film supporting the ram aligned both vertically and horizontally during the ram reciprocal movements. Also preferably, the cooperating pad and corresponding slide surfaces are arranged producing force components, taking into account weight, for balancing the ram both vertically upwardly and vertically downwardly for proper captive horizontal reciprocal movements of the ram, while at the same time, the cooperating pad and corresponding slide surfaces are arranged producing force components to accomplish the necessary transverse guiding of the ram.

It is still a further object of this invention to provide an apparatus for forming one piece metallic can bodies wherein a unique form of hydrostatic-type pressurized oil film bearing assembly may be mounted at a forward portion of the stationary ram supporting elements on the apparatus and acting directly against a peripheral surface of the ram in order to give the greatest possible support for the ram rearwardly of the die pack and permit a maximum ram stroke despite the necessity of the ram projecting forwardly an extended free distance while moving through the multiple redraw and ironing die stages. Different from the previously discussed main hydrostatic-type pressurized oil film bearing assemblies, this forward hydrostatic-type pressurized oil film bearing assembly preferably includes a sleeve mounted stationary on the main frame of the apparatus having an inner surface at all times telescoping parts of the reciprocally movable ram and with said inner surface having a plurality of pressurized oil inlets opening through such inner surface and against a peripheral surface of the ram. A constant flow of constantly pressurized oil is forced through the sleeve oil inlets directly against the ram peripheral surface so as to maintain the sleeve and ram surfaces spaced apart pressure oil film supporting the ram during the ram reciprocal movements and again permitting the ram high stroke speed with maximum trueness and virtual freedom from wear.

It is also an object of this invention to provide an apparatus for forming one piece metallic can bodies incorporating a unique die pack assembly wherein maximum die lubricating and cooling liquid distribution is maintained for efficient die and working part lubrication and cooling despite the increased ram speeds. According to this portion of the principles of the present invention, a particular form of fluid or liquid distribution ring is incorporated in each of the stages of the ironing die assemblies, preferably ahead or rearwardly of each of the ironing die rings with the distribution ring having an inlet opening or openings arranged for directing a flow of lubricating and cooling liquid tangentially into the center opening of the distribution ring through which the ram passes. This tangential flow of lubricating and cooling liquid creates a unique form of lubricating and cooling liquid circumferentially moving ring across the distribution ring ram opening thereby insuring the complete distribution of the liquid over the metal part being worked and into the particular ironing die ring during the ram movement through that particular stage of ironing die assembly.

It is still an additional object of this invention to provide an apparatus for forming one piece metallic can bodies incorporating a unique form of die pack assembly wherein each of a plurality of individual ironing die assemblies, preferably including an initial redraw die assembly, are each axially registerable with various die assembly spacers axially therebetween so that the over-all die pack assembly may be assembled and disassembled at will and during each reassembly will always, due to the cooperative registry between the various die pack components, reassemble in exact axially alignment. The various individual die rings are radially adjustably aligned in their individual die ring assemblies and with this registry between the various individual die ring assemblies and their intermediate spacers, the over-all die pack assembly may be disassembled, one die ring assembly axially from its adjacent spacer and adjacent die ring assembly, and reassembled without disturbing the individual die ring radial alignment within any of the individual over-all die ring assemblies, thereby accomplishing maintenance operations in a minimum of time and avoiding the tedious multiple dowel pin alignments between the various die ring assemblies and spacers as has been required in the prior constructions. Still in addition, in each individual die ring assembly, both the individual die ring and the beforementioned liquid distribution ring are preferably secured in a surrounding centering ring, the radial alignment of such centering ring accomplishing the radial alignment of the die ring, and this subassembly in each die ring assembly may be separately removed from the die ring assembly by removal of a covering plate permitting removal of such subassembly without disturbing the remainder of that individual die ring assembly within the over-all die pack assembly, again reducing maintenance time and expense to a minimum.

Other objects and advantages of the invention will be apparent from the following specification and the accompanying drawings which are for the purpose of illustration only.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 are perspective views of an embodiment of the apparatus for forming one piece metallic can bodies of the present invention looking from opposite forward side portions thereof and showing the over-all assembled apparatus;

FIG. 3 is an enlarged, fragmentary, vertical sectional view looking in the direction of the arrows 3—3 in FIG. 2 and showing a part of the ram drive;

FIG. 4 is a fragmentary, horizontal sectional view looking in the direction of the arrows 4—4 in FIG. 3;

FIGS. 5 and 6 are fragmentary, vertical sectional views looking in the direction of the arrows 5—5 and in the direction of the arrows 6—6, respectively, in FIG. 4;

FIG. 7 is an enlarged, fragmentary, somewhat side elevational view primarily of the ram carriage, ram guide assembly and rearward portion of the horizontally reciprocal ram, including a side elevational view of the redraw die assembly and positioning means therefor;

FIG. 8 is an enlarged, fragmentary, vertical sectional view looking in the direction of the arrows 8—8 in FIG. 7 further illustrating the ram carriage and ram reciprocal support;

FIG. 9 is a view similar to FIG. 8 looking in the direction of the arrows 9—9 in FIG. 7;

FIG. 10 is a fragmentary, top plan view with certain parts removed looking in the direction of the arrows 10—10 in FIG. 7;

FIG. 11 is a fragmentary, vertical sectional view looking in the direction of the arrows 11—11 in FIG. 10;

FIG. 12 is a view similar to FIG. 11 but showing a more forward portion of FIG. 11 with a portion of the cup-like metal part feeding mechanism positioned relative to the redrawing die and redrawing die pad, a cup-like metallic part in initially fed position with the redrawing die pad in forward working position within the cup-like metallic part, the forward end of the ram entering the redrawing die pad approaching the bottom wall of the cup-like metallic part and the redrawing die ring spaced forwardly of the redrawing die pad;

FIG. 13 is an enlarged, fragmentary, top plan view looking in the direction of the arrows 13—13 in FIG. 2 primarily showing the die pack portion of the apparatus with the cup-like metallic part feeding mechanism added and with a part therein ready for but not yet engaged by the redrawing die pad, the initial redrawing die ring assembly, a plurality of progressive ironing die ring assemblies, a stripper assembly and a bottom forming die assembly;

FIG. 14 is a fragmentary, vertical sectional view looking in the direction of the arrows 14—14 in FIG. 13 and showing the individual die ring assembly axial registry in the over-all die pack assembly;

FIG. 15 is an enlarged, vertical sectional view looking in the direction of the arrows 15—15 in FIG. 14 and showing an elevation of one of the ironing die ring assemblies;

FIG. 16 is a vertical sectional view looking in the direction of the arrows 16—16 in FIG. 15;

FIG. 17 is an enlarged, vertical sectional view taken from FIG. 14 and more clearly illustrating the stripper assembly portion of the die pack assembly of FIG. 14;

FIG. 18 is an enlarged, vertical sectional view looking in the direction of the arrows 18—18 in FIG. 16 and showing the fluid distribution ring assembly in end elevation;

FIG. 19 is an enlarged, fragmentary, vertical sectional view taken from FIG. 11 and principally illustrating the forward hydrostatic-type pressurized oil film bearing sleeve forwardly supporting the reciprocal ram;

FIG. 20 is a fragmentary, end elevational view of the bearing sleeve assembly of FIG. 19 looking in the direction of the arrows 20—20 in FIG. 19;

FIG. 21 is an enlarged, fragmentary sectional view looking in the direction of the arrows 21—21 in FIG. 20;

FIG. 22 is an exploded, perspective view of the ram mounting assembly and main bearing support showing the pressurized oil supply for the hydrostatic-type pressurized oil film bearing pads thereof;

FIGS. 23 through 27 are somewhat diagrammatic views illustrating progressive stages of movement of the reciprocal ram through the die pack assembly during the working portion of the ram movement and the redrawing, ironing and bottom forming of a cup-like metallic part resulting in a finished one piece metallic can body, the individual die ring assembly axial registry also being shown; and

FIGS. 28 through 31 are somewhat diagrammatic views of the metallic can body forming apparatus showing progressive stages of movement of the ram drive and the reciprocal ram.

DESCRIPTION OF THE BEST EMBODIMENT CONTEMPLATED:

An embodiment of the over-all assembly of the apparatus for forming one piece metallic can bodies incorporating the principles of the present invention is illustrated in FIGS. 1 and 2 and, except as hereinafter specifically pointed out, is formed of generally standard components and standard materials appropriate for performing the functions required. The main drive for the can body forming apparatus is supplied by an electric drive motor **40** through a usual variable speed drive **42**, both of which are mounted at an upper portion of a main frame generally indicated at **44**, the variable speed drive in turn through usual belting driving a flywheel (not shown) mounted on a main drive shaft **46**. The foregoing driving elements constitute a part of a ram mechanical drive assembly generally indicated at **48** which, with a ram support and guide assembly generally indicated at **50** and a die pack assembly generally indicated at **52** constitute the major working portions of the apparatus, each of which will be described in detail below.

RAM MECHANICAL DRIVE ASSEMBLY

Referring for the moment to FIGS. **1** through **6**, the ram mechanical drive assembly **48** further includes the main drive shaft **46** projecting transversely into the interior of the main frame **44** and mounting a pair of spaced drive gears **54** which are operably engaged with a pair of spaced bull gears **56**. A crank arm **58** is secured to each of the facing sides of the bull gears **56** projecting radially of that particular bull gear with radially outer ends of the crank arms mounting an axially extending crank pin **60** therebetween. The rearward end of a transfer arm **62** is rotatably connected to the crank pin **60** axially between the crank arms **58** and the forward end of the transfer arm is rotatably connected to an axially extending connecting pin **64** mounted intermediate and preferably generally midway of the generally vertically extending length of a bifurcated drive arm **66**.

The lower end of the drive arm **66** spaced below the connection of the transfer arm **62** thereto is pivotally mounted on the main frame **44** and the upper end of the drive arm spaced above the transfer arm is pivotally connected to the rearward end of a drive rod **68**. The drive rod **68** extends generally longitudinally forwardly into an intermediate portion of a slide assembly **70** forming a part of the ram support and guide assembly **50** as seen, for instance, in FIG. **10**, the slide assembly being shown in FIG. **22** removed from the apparatus, all of which will be hereinafter described more in detail. For purposes of present discussion, it is sufficient to state that the slide assembly **70** is forwardly and rearwardly longitudinally reciprocal on the main frame **44** and at the forward end thereof secures the rearward end of a longitudinally extending and likewise longitudinally forwardly and rearwardly reciprocal ram **72** which is cylindrical in configuration.

Thus, now also referring to the diagrammatic showing in FIGS. **28** through **31** and considering the center mounting of the bull gears **56** and therefore the crank arsm **58** on stub-like crankshaft **74** as shown in FIG. **5**, it is seen that the crankshaft **74** in its rotation drives the crankarms **58**, which crankarms are connected through a plurality or series of pivot arms, the transfer arm **62**, drive arm **66** and drive rod **68**, to the ram **72** for producing generally horizontally reciprocal forward and rearward movement of the ram. Also considering, and again as will be hereinafter described more in detail, that the forward portions or to the right as shown in FIGS. **28** through **31** of the reciprocal strokes of the ram **72** are the working portions thereof and the rearward portions or to the left as shown in FIGS. **28** through **31** are the part feeding portions thereof, it will be seen that the ram stroke working portions are at a higher rate of speed than are the part feeding portions thereof due to the particular connecting and arrangement of the pivot arms between the crankshaft **74** and the ram **72**. During the forward 180° of rotation or right side rotation around the crankshaft **74** of the crank arms **58**, the forward end of transfer arm **62** is extended further from the radial outward end of the crank arms increasing the leverage on the drive arm **66** so as to increase the speed thereof, whereas in the rearward (left side) 180° of rotation of the crank arms, the effective lever arm to the drive arm **66** is shorter due to the doubling of the crank arms **58** on the transfer arm **62**, thereby reducing the effective lever arm movement to the drive arm **66** and therefore the ram **72**.

Furthermore, as can be clearly seen from FIGS. **5**, **6** and **28** through **31**, with the crank arms **58** secured for rotation with the crankshaft **74** and the transfer and drive arms **62** and **66** pivotally connected thereto, it is obvious that the forward movement of the ram **72** from the ram stroke rearward reversal toward the ram stroke forward reversal is in a particular changing speed pattern of movement which is the same, but exactly reversed, in the ram movement from the forward reversal back to the rearward reversal. This is to say, with the particular pivot arm connection, from the slower rearward reversal, the ram is moved forwardly in a particular changing speed pattern to the faster forward reversal and then begins and carries through an exact reversal of this changing speed pattern of movement from he forward reversal back to the rearward reversal, always being the same for a constant speed of the crankshaft **74**.

As is more clearly shown diagrammatically in FIGS. **28** through **31**, in FIG. **28**, the drive arm **66** is in its rearmost pivoted position drawing the ram **72** to its rearmost position and it is seen that the transfer arm **62** is at its rearmost point of rotation by the crankshaft **74** thereby constituting a minimum length lever arm. In FIG. **29**, the drive arm **66** and ram **72** have moved forwardly and the transfer arm **62** is entering its forward 180° of rotation about the crankshaft **74** so that the effective lever arm to the drive arm and ram has increased in length from the FIG. **28** position and will continue to increase in length. In FIG. **30**, the transfer arm **62** has reached its maximum forward position moving the drive arm **66** pivotally to its forwardmost position and likewise the ram **72**, whereas in FIG. **31**, the transfer arm and ram are moving rearwardly and the effective lever arm thereon in decreasing and will continue to decrease until it reaches the position shown in FIG. 28.

With this unique drive connection to the ram 72, the ram moves at a higher rate of speed during the forward working portions of the ram strokes and at a slower relative speed during the rearward part feeding portions of the ram strokes. Despite the drive to the ram 72 being purely mechanical, therefore, a high rate of ram speed is maintained during the forward portions and reversal of the ram forward and rearward reciprocal stokes, yet the ram moves at a relative reduced speed during the rearward portions and reversal of the ram strokes. This provides the ram strokes during the working portions thereof possible at maximum speed and reduced time while still providing slower speed and increased time during the ram stroke part feeding portions, the latter requiring such increased time for proper part positioning.

RAM SUPPORT AND GUIDE ASSEMBLY

According to the broad principles of the present invention, the ram support and guide assembly provides both vertically and horizontally reacting force components for supporting the ram and its support or mount longitudinally movable in the reciprocal strokes, said force components preferably effectively reacting in all degrees of vertical and horizontal. The particular embodiment illustrated includes the ram support and guide assembly 50 as best seen in FIGS. 7 through 12 and FIGS. 19 through 22. Furthermore, the major portion of the ram support and guide assembly 50 is formed by a main hydrostatic-type pressurized oil film bearing assembly principally comprised of the previously mentioned ram slide assembly 70 and a transversely spaced pair of stationary slides or slide plates 76 best seen in FIGS. 7 through 10, while an auxiliary portion of the ram support and guide assembly 50 is formed by a forward hydrostatic-type pressurized oil film bearing assembly principally comprised of a stationary bearing sleeve 78 best seen in FIGS. 19 and 20 mounted within and secured stationary to the main frame through a cylinder and bearing assembly 80. As previously stated, the rearward extremity of the ram 72 is secured to and movable with the slide assembly 70 projecting longitudinally forwardly from a forward surface thereof, such securement being obtained through an adjustable collar assembly 82.

The ram slide assembly 70 is shown removed from the apparatus in FIG. 22 and without the ram 72 mounted thereon, such assembly including a particularly formed ram support and guide assembly 50 mounting a plurality of sets of vertically spaced, vertically upwardly and downwardly acting bearing pads 86, and sets of transversely spaced, horizontally oppositely acting bearing pads 88. As shown, each of the vertically acting bearing pads 86 has a horizontal annular face surface 90 surrounding a central oil inlet 92, and each of the horizontally transversely acting bearing pads 88 has a vertical annular face surface 94 surrounding a central oil inlet 96, the oil inlets each being connected through a pressurized oil system 98 downwardly through a pivotal oil supply linkage 100 and an oil pressure pump 102 (FIGS. 1 and 2) to a source of oil supply. As is also shown, the vertically acting bearing pads 86 of each set are positioned with the upper pad acting downwardly and the lower pad acting upwardly, there being transversely aligned vertically acting bearing pad sets spaced transversely outwardly from the longitudinal axis of the ram 72 at each of the forward and rearward extremities of the slide assembly frame 84. Also, the horizontally transversely acting bearing pads 88 of each of forward and rearward sets thereof include one pad acting oppositely outwardly from either side of the slide assembly frame 84.

As shown in FIGS. 7 through 10, the slides or slide plates 76 are secured stationary on the main frame 44, there being two transversely uniformly spaced apart throughout the longitudinal extents thereof and each presenting a transversely inwardly and longitudinally extending, upwardly facing horizontal surface 104 and downwardly facing horizontal surface 106, such horizontal surfaces terminating transverely inwardly in longitudinally extending and transversely inwardly facing vertical surfaces 108. Thus, as shown generally, for instance, in FIG. 10 and particularly in FIG. 9, the slide assembly 70 is longitudinally slidably mounted on the slide plates 76 with the horizontally facing surfaces 90 of the vertically downwardly acting bearing pads 86 adjacent the slide upwardly facing horizontal surfaces 104 and the horizontally facing surfaces 90 of the vertically upwardly acting bearing pads 86 adjacent the slide downwardly facing horizontal surfaces 106 with the vertically facing surfaces 94 of the horizontally transversely outwardly acting bearing pads 88 adjacent the slide transversely inwardly facing vertical surfaces 108 so as to capitivate the slide assembly 70 for guided horizontally slidable movement longitudinally along the slide plates 76. At the same time, during such movement longitudinally forwardly and rearwardly of the slide assembly 70 along the slide plates 76 and carrying the ram 72 longitudinally forwardly and rearwardly therewith, constantly pressurized and constantly flowing oil is directed from the various bearing pad oil inlets 92 and 96 creating a constantly pressurized, thickened oil film between the various facing bearing pad and slide plate surfaces suspending the slide assembly 70 slidably movable along the slide plate 76.

In the unique form of the hydrostatic-type pressurized oil film bearing assemblies of the present invention as created by the coacting slide assembly 70 and slide plates 76 just described, and as is true of the somewhat similarly acting forward hydrostatic-type pressurized oil film bearing assembly formed in part by the bearing sleeve 78 as will be hereinafter described, there is a constantly pressurized and constantly flowing oil film created from outside oil pressure at all times between each of the slide assembly bearing pad and slide plate facing surfaces actually oil film suspending, and as a consequence of a particular pad and slide plate surface positioning and oil pressure regulating, creating a self-centering of the slide assembly 70 on the slide plates 76, which prevents any possible metal to metal contact despite the obvious horizontal and transverse loads supported by such oil films. Furthermore, this oil film suspension is not dependent on relative motion between the coacting and facing surfaces of the slide assembly 70 and the slide plates 76, but will rather be present whether the coacting and facing surfaces are stationary or moving relative to each other. This hydrostatic-type pressurized oil film suspension between the coacting and facing surfaces should be differentiated from the usual form of hydrodynamic bearings wherein a thickened film of oil is dependent on the movement and speed between the coacting and facing surfaces and wherein a decrease in the relative speeds between the surfaces will cause a sinking of the oil film causing at least periodic metal to metal contact.

Further in the present unique form of hydrostatic-type pressurized thickened oil film assemblies herein involved, the oil pressures to the various oil inlets are regulated to obtain preferably substantial self-centering of the slide assembly **70** horizontally longitudinally movable along the slide plates **76**. Furthermore, in the particular embodiment shown, the clearance between the coacting and facing surfaces of the bearing pads **86** and **88** and the slide plates **76** is preferably in the order of two thousandths inches and the oil film pressure constantly maintained by constant flow is in the order of 600 to 800 pounds per square inch at the bearing pad and slide plate surfaces. With hydrostatic-type pressurized thickened oil film bearing assemblies of this form, a greater clearance between the coacting and facing surfaces will create a softer, less load supporting bearing where as a lesser clearance between such surfaces will create a stiffer bearing, but in any case, different from the conventional hydrodynamic bearings involved with sinking oil films and metal to metal contact, with the hydrostatic-type oil bearings of the present invention, there will always be an oil film suspension between the various coacting and facing surfaces regardless of motion or the usual clearances.

More particularly to the construction of the bearing pads **86** and **88** of the ram slide assembly **70**, as shown, for instance, in FIG. **22**, each of the pad surfaces **90** and **94** is a raised flat surface forming a quite broad raised flat surface area which surrounds and terminates inwardly in a recessed oil inlet area having either the oil inlet **92** or **96**. Also, as clearly shown in FIG. **22**, the portions of the ram slide assembly **70** outwardly of the peripheries of the pad surfaces **90** and **94** are recessed due to the raising of such pad surfaces. With the relatively broad and flat pad surfaces **90** and **94**, the surface areas thereof being far greater than the individual oil inlet areas thereof, and with these pad surfaces being raised and isolated from the remainder of the ram slide assembly **70**, these pad surfaces with the before-described pressurized oil films thereon form the sole support for the ram slide assembly **70** on the main frame slide plates **76** and insure that the hydrostatic-type pressurized thickened oil films will be the only bearings between the ram slide assembly **70** and the main frame slide plates **76** during movement therebetween as described.

Thus, the ram support and guide assembly **50** including the slide plates **76** and the vertically and horizontally transversely acting bearing pads **86** and **88** effectively provide force components effectively reacting in all degrees of vertical and horizontal by combining the reaction forces of the various opposed horizontal and vertical surfaces and despite the fact that in this particular embodiment such surfaces are only generally straight horizontal and vertical.

The forward hydrostatic-type pressurized oil film bearing assembly for supporting the ram reciprocally movable forwardly and rearwardly horizontally along the main frame **44** in the ram forward and rearward strokes, as hereinbefore stated, includes the bearing sleeve **78** which is mounted stationary on the main frame in the cylinder and bearing assembly **80**, said cylinder and bearing assembly being positioned on the main frame forwardly of the forward and rearward movement of the hereinbefore described slide assembly **70** and partially overlying the forward termination of the slide plates **76** as can be seen generally in FIGS. **7** and **10.** As is particularly shown in FIGS. **11** and **19**, the bearing sleeve **78** is secured at the rearward portion of the cylinder and bearing assembly **80** at all times telescoping an axially or longitudinally intermediate portion of the ram **72**, the ram being longitudinally forwardly and rearwardly slidable relative thereto and hydrostatic-type pressurized thickened oil film supported thereby during such movement. The particulars of formation of the bearing sleeve **78** with its constant pressurized oil supply and exhaust are shown in FIGS. **19** through **21**, a portion of the ram **72** being shown in phantom lines in its positioning through the bearing sleeve in FIG. **19.**

As shown, the bearing sleeve **78** is hollow cylindrical having four equally circumferentially spaced and axially or longitudinally elongated oil inlet openings or slots **110** radially therethrough and opening radially inwardly against a periphery **112** of the cylindrical ram **72.** An oil inlet conduit **114** is formed through the cylinder and bearing assembly **80** to each of the oil inlet slots **110** for providing a supply of pressurized oil from the previously described pressurized oil system originating at the oil pressure pump **102** (FIGS. **1** and **2**), and a pair of oil outlet conduits **116** are formed from just forwardly of the bearing sleeve **78** rearwardly through the cylinder and bearing assembly as best seen in FIGS. **20** and **21.** In the preferred form shown, the oil inlet slots **110** extend axially or longitudinally a majority of the axial or longitudinal length of the bearing sleeve **78.**

Thus, during the horizontally forwardly and rearwardly reciprocal movements of the ram **72**, intermediate portions of the ram are supported on hydrostatic-type pressurized thickened oil films of the same general characteristics as discussed relative to the main bearing assembly formed by the slide assembly **70** and the slide plate **76**, in this forward bearing assembly, the pressurized oil constantly flowing and constantly pressurized flowing through the oil inlet conduits **114**, through the oil inlet slots **110** against the ram periphery **112** and outwardly through the oil outlet conduits **116**, thereby providing a unique bearing support spaced forwardly of the main bearing support for the ram **72** in its relatively long longitudinal extension forwardly through the die pack assembly **52** in the ram forward and rearward reciprocations. The forward hydrostatic-type pressurized oil film bearing assembly including the bearing sleeve **78**, therefore, likewise effectively provides force components effectively reacting in all degrees of vertical and horizontal by continuing the opposed vertical and horizontal forces from the sleeve slots **110** against the ram periphery **112** to additionally support the ram **72**, despite the fact that in this particular embodiment such forces are only generally direct vertical and horizontal.

As is also shown in FIG. **19**, the cylinder and bearing assembly **80** includes a wiper seal assembly **118** forwardly of the bearing sleeve **78** and the forward ends of the oil outlet conduits **116** for separating the pressurized oil supply to the bearing sleeve from cooling and lubricating liquids supplied to the die pack assembly **52** and necessarily covering the ram periphery **112** during the travel of the ram reciprocally through the die pack assembly.

Referring particularly to FIGS. 7 through 12, a further important part of the cylinder and bearing assembly 80 is formed by pairs of transversely spaced upper and lower air cylinder assemblies generally indicated at 120 each including a cylindrical air piston 122, with the air pistons being forwardly and rearwardly reciprocal in such assembly and being shown forwardly extended in FIGS. 7 and 10 through 12. A transversely extending forward hold down plate 124 is secured to the forward end of the air pistons 122 and has a forwardly projecting, hollow cylindrical draw pad 126 secured thereto, said draw pad being axially or longitudinally aligned with the ram 72 and receiving the ram telescopically therethrough during the forward and rearward reciprocal movements of the ram, all for a purpose to be hereinafter described. The air pistons 122 are urged forwardly extended by a constant supply of pressurized air to thereby urge the forward hold down plate 124 and the draw pad 126 forwardly, and the rearward movement of the air pistons telescoped rearwardly within the cylinder and bearing assembly 80 is controlled by two pairs of transversely spaced, upper and lower pull rods 128 forwardly connected to the hold down plate 124 spaced outwardly of the air pistons and extending rearwardly above and beneath the slide plates 76 as best seen in FIGS. 7 through 10.

The rearward ends of the pull rods 128 are secured to a rear crosshead 130 which is forwardly and rearwardly slidable on guideways 132 mounted on the main frame 44, and on a forward surface of the rear crosshead adjacent the connections thereof to the pull rods are four bumpers 134 rearwardly aligned with four oil actuated shock absorbers 136 projecting rearwardly from and movable with the previously described slide assembly 70 of the main ram bearing assembly. Thus, as the slide assembly 70 of the ram main bearing assembly moves forwardly moving the shock absorbers 136 forwardly away from the bumpers 134, the air pistons 122 of the cylinder and bearing assembly 80 will move the forward hold down plate 124 and the draw pad 126 to their forward extended positions as shown, and as the slide assembly moves rearwardly ultimately engaging the shock absorbers 136 rearwardly with the bumpers 134 on the rear crosshead 130, the pull rods 128 will be moved rearwardly withdrawing or rearwardly telescoping the pistons into the cylinder and bearing assembly and rearwardly withdrawing the draw pad 126. As will also be hereinafter described more in detail, the timing of the movement of the ram 72 and the forward movement of the draw pad 126 is such that the draw pad moves forwardly ahead of the leading or forward end of the ram so that the draw pad first forwardly positions followed by the forward end of the ram moving forwardly therethrough.

DIE PACK ASSEMBLY

As shown in FIGS. 1 and 2, the die pack assembly 52 is mounted on the main frame 44 forwardly of the ram support and guide assembly 50 for receiving the ram 72 horizontally reciprocally forwardly and rearwardly through a major portion thereof, the particulars of the die pack assembly being best seen in FIGS. 13 through 18. As shown in FIGS. 13 and 14, the die pack assembly 52, starting at the rearward or left end and moving axially or longitudinally toward the forward end, includes a redraw die ring assembly 138, a register ring 140, a first ironing die ring assembly 142, a spacer ring 144, a second ironing die ring assembly 146, a spacer ring 148, a third ironing die ring assembly 150, a spacer ring 152 and a stripper assembly 154, all of which are secured axially or longitudinally stacked, one axially or longitudinally adjacent the next. The die pack assembly 52 also includes a doming or bottom forming die assembly 156 spaced axially or longitudinally forwardly from the stripper assembly 154 on supports 158 and forming the forward termination ofthe die pack assembly.

The redraw die ring assembly 138 supports a redraw die ring 160 and the first, second and third ironing die ring assemblies 142, 146 and 150 support first, second and third ironing die rings 162, 164 and 166 respectively, all of said die ring assemblies being similar by the inclusion of mechanism for centering the various die rings for proper axial or longitudinal alignment with the centerline of the ram 72. Also, all of the die ring assemblies are preferably formed with a particular construction permitting selective upward removal of a portion of the assembly including the particular die ring thereof after pivoting of a cover for access at the upper portion of the die pack assembly 52 without complete disassembly thereof, and at least the first, second and third ironing die ring assemblies 142, 146 and 150 are formed with a particular fluid distribution ring therein for the distribution of cooling and lubricating liquids during the operation of the apparatus.

For illustrating such die ring assembly construction, the second ironing die ring assembly 146 is illustrated in detail in FIGS. 15, 16 and 18, and includes a main body 168 supporting axially spaced wear rings 172 axially between which is vertically slidably supported the assembly of an outer centering ring 174 telescoping a cooling and lubricating fluid distribution ring 176 secured at the rearward portion thereof and the second ironing die ring 164 resiliently mounted through a resilient O-ring 178 at the forward portion thereof. As shown, the assembly of the centering ring 174, fluid distribution ring 176 and resilient O-ring 178 is vertically slidably supported in the main body 168 and is accessible for removal by pivoting of cover 180 along with centering screw mechanism 182 therein, said cover being retained in working closed position during operation of the apparatus by hand screws 184 removably secured downwardly into the main body 168. Thus, when maintenance operations are required on the particular die ring or the particular fluid distribution ring where included, it is merely necessary to selectively release the hand screws 184 and pivot the cover 180 open for slidable removal of the assembly of, in this case, the centering ring 174, the fluid distribution ring 176 and the second ironing die ring 164 for free access to the die ring and fluid distribution ring, the assembly being replaced in working position by a mere reversal and refastening of the hand screws 184.

The fluid distribution ring 176 is, of itself, a unique formation giving vastly improved cooling and lubricating liquid distribution over the periphery of the ram 72 as it moves longitudinally therethrough and as carried to the various die rings by such ram movement. As shown in FIGS. 16 and 18, the fluid distribution ring 176 includes an inner annular portion 186 having an inner diameter spaced larger than the periphery of the ram 72 and an outer annular portion 188 spaced outwardly from said inner annular portion forming an annular fluid channel 190 therebetween which is closed axially rearwardly by the rearward of the wear rings 172 as seen in FIG. 16. Cooling and lubricating liquid is fed to the fluid channel 190 by a fluid inlet 192 and preferably a pair or more of equally circumferentially spaced, tangential openings 194 are formed through the inner annular portion 186 and open tangentially into the center opening thereof so that the cooling and lubricating liquid passing interiorly of the fluid distribution ring 176 flows therein in a tangential direction circumferentially around the center opening of said ring producing a circumferentially moving annulus or ring of cooling and lubricating liquid sometimes virtually centrally closed, through which the ram 72 passes insuring a complete and total coverage of said ram and proper distribution to the various die rings, as well as over the particular metal part being formed and as will be hereinafter described.

As shown in FIGS. 13 and 14 and in enlarged detail in FIG. 17, the stripper assembly 154 of the die pack assembly 52 also includes centering screw mechanisms 196 which bear inwardly against a two piece retainer ring 198 having an inner axially or longitudinally extending, but radially or transversely outwardly angled cam surface 200, that is, the surface angling from a lesser diameter rearwardly toward the third ironing die ring assembly 150 to a great diameter forwardly toward the doming or bottom forming die assembly 156. A limit ring 202 is positioned partially outwardly in the retainer ring 198 and extends inwardly of the inner cam surface 200 projecting into outwardly opening, circumferential slots 204 of a plurality of stripper segments 206. The stripper segments 206 have outer cam surfaces 208 oppositely matching the inner cam surface 200 of the retainer ring 198, forwardly inwardly angled inner surfaces 210, and in their plural assembly form an inwardly rearwardly angled, annular slot 212 receiving a garter spring 214.

The arcuate lengths of the stripper segments 206 are such that when the segments are normally rearwardly positioned radially inwardly aligned with the retainer ring 198 as shown in FIG. 17, the segments circumferentially abut and the inner diameter formed by the inner surfaces 210 thereof is at a minimum. When, however, a metallic part passes therethrough from rearwardly to forwardly thereof having an outer diameter larger than said segment minimum inward diameter, these segments move forwardly and outwardly along the retainer ring inner cam surface 200 as permitted by the garter spring 214 so as to increase in inner diameter and permit the passage of the larger diameter metallic part therethrough. Upon the larger diameter metallic part passing forwardly beyond these stripper segments 206, the segments are immediately urged rearwardly along the retainer ring inner cam surface 200 to a lesser diameter so that when the metallic part is attempted to be moved reversely rearwardly through the opening formed by the stripper segments, the segments will engage the same, all for a usual stripping purpose as will be hereinafter more clearly explained.

The final portion of the die pack assembly 52 is formed by the doming or bottom forming die assembly 156 spaced forwardly of the stripper assembly 154 as shown in FIGS. 13 and 14. The bottom forming die assembly 156 again includes centering screw mechanisms 216, but more importantly centrally mounts a bottom forming die 218 which faces centrally, axially or longitudinally rearwardly and rearwardly presents an arcuately domed working surface 220. The domed working surface 220 of the bottom forming die 218 is received in a recess (not shown) at the forward end of the ram 72 when the ram reaches its forward maximum travel through the die pack assembly 52 in its forward stroke as will also be hereinafter explained more in detail.

Another important feature of construction of a major part of the die pack assembly 52 is the fact that all of the redraw die ring assembly 138, the first ironing die ring assembly 142, the second ironing die ring assembly 146, the third ironing die ring assembly 150 and the stripper assembly 154 all axially or longitudinally register with their respective intermediate register and spacer rings 140, 144, 148 and 152, respectively. That is to say, all of the redraw, first ironing, second ironing, and third ironing die ring assemblies 138, 142, 146 and 150, and the stripper assembly 154 have either axially opening recesses or axial projections, either full circular or annular axially or longitudinally meeting with their respective intermediate register and spacer rings 140, 144, 148 and 152 so that each of the die ring assemblies and this stripper assembly is in full axial registry with all others of said die ring and stripper assemblies in the over-all die pack assembly 52 permitting quick disassembly of the die pack assembly for access to any part thereof and the reassembly will again bring all individual assemblies into the exact same axially or longitudinal alignment, one with the other and the various centering screw mechanisms in each assembly need not be disturbed. The only dowel pin connection required within the die pack assembly 52, therefor, is an individual dowel pin projecting between the various assemblies and their adjacent register or spacer ring to prevent rotation therebetween as will be hereinafter described more in detail, but such dowel pins not serving any axial or longitudinal alignment function as has been required with multiple dowel pins in the prior constructions.

Referring more particularly to FIGS. 14 and 23 through 27, the redraw die ring assembly 138 is provided with an exactly centered, circular recess 222 receiving a major part of the register ring 140 axially, in perfect fit and registry, therein, the remaining portion of the registry ring axially toward the first ironing die ring assembly 142 being received in a similar circular, exactly centered and exactly fitting recess 224 of the first ironing die ring assembly 142. Projecting oppositely from the first ironing die ring assembly 142 axially toward the spacer ring 144 is an exactly centered, annular projection 226 received axially into an exactly fitting and exactly centered annular recess 228 of the next axially adjacent spacer ring 144. An anti-rotation dowel pin 230 is positioned axially between the register ring 140 and the first ironing die ring assembly 142 while a dowel pin 232 is similarly received between the first ironing die assembly 142 and the spacer ring 144, the latter dowel pin 232 projecting from the area of the first ironing die ring assembly forming the annular projection 226 and into the area of the spacer ring 144 within the annular recess 228.

The spacer ring 144 has an axially opposite annular recess 234 exactly axially aligned, but oppositely axially facing from the annular recess 228 receiving an exactly matching annular projection 236 of the second ironing die ring assembly 146, an axially opposite and axially aligned annular projection 238 of the second ironing die ring assembly 146 being received exactly fitting into a matching annular recess 240 of the next spacer ring 148 with anti-rotation dowel pin 242 between the spacer ring 144 and the second ironing die ring assembly 146 and anti-rotation dowel pin 244 between the second ironing die ring assembly and the spacer ring 148. Similarly, an opposite annular recess 246 of the spacer ring 148 receives an annular projection 248 of the third ironing die ring assembly 150, an opposite annular projection 250 of the third ironing die ring assembly 150 is received in an annular recess 252 of the spacer ring 152, and finally, an opposite annular projection 254 of the spacer ring 152 is received in an annular recess 256 of the stripper assembly 154, an anti-rotation dowel pin 258 being positioned between the spacer ring 148 and the third ironing die ring assembly 150 and an anti-rotation dowel pin 260 being positioned between the third ironing die ring assembly and the spacer ring 152. It will also be particularly noted that all of the matching annular recesses and projections between the first, second and third ironing die ring assemblies 142, 146 and 150, the stripper assembly 154 and the spacer rings 144, 148 and 152 are all exactly axially aligned and of the identical radial dimensions and axial dimensions so that in this sense, the various second and third ironing die ring assemblies and the spacer rings 144 and 148 are interchangeable, likewise permitting complete removal or the adding of identical additional ironing die ring assemblies and spacer rings giving maximum versatility to the die pack assembly 52 particularly when considered in combination of the previously discussed axial registry for exact centering radial positioning between all of the redraw die ring and ironing die ring and stripper assemblies with the spacer rings axially therebetween as hereinbefore discussed.

METALLIC PART FEED ASSEMBLY

The metallic part feed assembly generally indicated at 262 is secured to the main frame 44 positioned between the ram support and guide assembly 50 and the die pack assembly 52 and in the particular embodiment shown, the metallic parts being fed to the apparatus of the present invention and formed thereby are cup-like metallic parts 264 which are formed into one piece metallic can bodies. The metallic part feed assembly 262 includes an upstanding and upwardly open supply chute 266 which may be connected at its upper end to other forms of conveying equipment for receiving the cup-like metallic parts 264 downwardly therein. As shown in FIGS. 1 and 2, the cup-like metallic parts 264 rest in the supply chute 266 one above the other fed downwardly therein by gravity or other forces assisting them where provided, each of the metallic parts being positioned with the upper open end thereof facing rearwardly of the apparatus or away from the die pack assembly 52 and toward the ram support and guide assembly 50.

As is further shown in FIGS. 13 and 14, but without the cup-like metallic parts 264 therein, the metallic part feed assembly 262 further includes a U-shaped positioning yoke 268 at the lower opening of the supply chute 266 for receiving the cup-like metallic parts 264 one at a time downwardly therein and resting at a positioning surface 270 at the lower extremity of the U-shaped opening in the yoke 268. As will be more clear from the following description of the over-all operation of the apparatus, when one of the cup-like metallic parts 264 is positioned in the positioning yoke 268 resting downwardly against the arcuate positioning surface 270 with the remaining cup-like metallic parts resting thereon and stacked thereabove in the supply chute 266, the open end of the metallic part will be rearwardly aligned with the draw pad 126 and the path of longitudinal travel of the ram 72, while the closed end of the metallic part will be forwardly aligned with the redraw die ring 160 and the remaining die rings forwardly thereof. A slide 272 is provided for selective inward sliding blocking the lower opening of the supply chute 266 when it is desired to stop the gravity feeding of the cup-like metallic parts 264 for maintenance or other purposes.

OPERATION

Referring first to FIG. 28, as the ram 72 moves rearwardly to the rearward end of its return stroke and withdrawing the redraw die draw pad 126 rearwardly through the forcing of the air pistons 122 rearwardly into the cylinder and bearing assembly 80 as hereinbefore described and shown in FIG. 28, both the ram 72 and the redraw die draw pad 126 are rearwardly of interference with the lowermost of the cup-like metallic parts 264 in the metallic part feed assembly 262 and this lowermost metallic part can move downwardly by gravity alone or other assisting force where provided and the weight of the other metallic parts thereabove to the positioning surface 270 of the positioning yoke 268. Thus, as shown in FIG. 23, as the ram 72 begins its forward movement and releases the air pistons 122 as hereinbefore described, the air pistons move forwardly moving the redraw die draw pad 126 forwardly into the open end and fully within the particular cup-like metallic part 264. The particular cup-like metallic part 264 remains in the described position telescoping the redraw die draw pad 126 and spaced slightly rearwardly of the redraw die ring 160 while the ram 72 enters longitudinally forwardly into the redraw die draw pad to ultimately engage the bottom wall of the cup-like metallic part 264, that exact positioning being shown in FIG. 23.

After engaging the closed bottom wall of the cup-like metallic part 264 within the redraw die draw pad 126, continued forward movement of the ram 72 in its forward stroke carries the cup-like metallic part forwardly through the redraw die ring 160 from the redraw die draw pad 126, that is, forwardly and angularly inwardly through the precalculated annular spacing between the forward end of the redraw die draw pad 126 and the redraw die ring 160 performing a redrawing operation thereon and carrying the cup-like metallic part from the position shown in FIG. 23 to the position shown in FIG. 24. It will be noted that once the particular cup-like metallic part 264 has been moved forwardly from the redraw die draw pad 126 and through the redraw die ring 160 by the ram 72, this metallic part remains unsupported outwardly and is supported only by the ram 72 between the redraw die ring 160 and the first ironing die ring 162, and between the remaining ironing die rings 164 and 166, as well as the stripper assembly 154.

Continuing the forward movement of the ram 72 in its forward stroke, in FIG. 24, the cup-like metallic part 264 is just being forced forwardly to enter the first ironing die ring 162 by the ram 72 and in passage therethrough, the first stage of the ironing operation takes place wherein the sidewalls of the cup-like metallic part are ironed and thinned causing an elongation of said sidewalls and the over-all longitudinal length of the metallic part. Subsequently, the ram **72** forces the cup-like metallic part **264** through the second ironing die ring **164** as shown in FIG. **25** and the third ironing die ring **166** as shown in FIG. **26** continuing to iron the metallic part sidewalls and cause a lengthening thereof. After leaving the third ironing die ring **166**, the cup-like metallic part **264** carried on the ram **72** passes forwardly through the stripper assembly **154** forcing the stripper segments **206** forwardly and radially outwardly as hereinbefore described to permit such passage, the stripper segments closing rearwardly and radially inwardly therebehind adjacent the periphery of the ram **72** when such passage is complete.

At completion of the forward stroke of the ram **72**, the redrawn and ironed cup-like metallic part **264** is forced forwardly against the bottom forming die **218** with the arcuately domed working surface **220** of said bottom forming die forming the bottom wall of the cup-like metallic part into its arcuately recessed final formation, thereby producing the final one piece metallic can body **274** as shown in FIG. **27.** From the position shown in FIG. **27,** the ram **72** immediately starts its return stroke beginning to move rearwardly through the die pack assembly **52** and carrying the final one piece metallic can body **274** rearwardly therewith ultimately engaging the open end of the can body against the now closed stripper segments **206** of the stripper assembly **154.** As the ram **72** still continues its rearward movement in the rearward stroke thereof, the engagement of the open end of the final one piece metallic can body **274** against the stripper segments **206** of the stripper assembly **154** causes the can body to remain stationary and the ram to continue rearward movement and when such disengagement or stripping is complete, the can body falls downwardly from the die pack assembly **52** to a further conveying system (not shown) for removal from the apparatus.

During this redrawing and ironing of the particular cup-like metallic part **264** for ultimately producing the final one piece metallic can body **274,** the ram **72** and the redraw die draw pad **126,** of course, remain forwardly block further downward movement of the next cup-like metallic part into the positioning yoke **268** against the positioning surface **270.** As the ram **72** moves rearwardly in its return stroke through the redraw die draw pad **126,** however, and ultimately withdraws the redraw die draw pad to the position shown in FIG. **28,** the next cup-like metallic part **264** can move downwardly into position ready for engagement by the redraw die draw pad and ram in the next forward stroke of the ram, thereby receiving the working operation. Furthermore, it is during this withdrawal of the ram **72** rearwardly from the redraw die draw pad **126** and the withdrawal of the die pad from the positioning yoke **268** of the feed assembly **262** that the ram is automatically slowed in its rearward stroke, reversal and initial forward stroke movement by the unique lever arm driving arrangement of the ram by the ram mechanical drive assembly **48** as hereinbefore described so as to permit increased time for this metallic part feeding and consequently permit an increase speed of operation.

According to the principles of the present invention, therefore, apparatus for forming one piece metallic can bodies is provided wherein the reciprocal ram **72** performing the working operation is mechanically driven by the ram mechanical drive assembly **48** to gain the inherent advantages of such mechanical drive, yet through a unique form of mechanical linkage by pivotal motion transfer arms between the crankshaft **74** and the reciprocal ram including the crankarms **58**, the transfer arm **62**, the drive arm **66** and the drive rod **68**, a reduced comparative speed of ram reciprocal movement and movement reversal is obtained directly approaching and following the ram stroke rearward reversal for feeding of the cup-like metallic part **264** than the ram speeds directly approaching and following the ram stroke forward reversal for completion of the ram working operation in its movement through the die pack assembly **52.** Also, due to the unique hydrostatic-type pressurized oil film bearing assemblies for supporting the ram **72** horizontally forwardly and rearwardly reciprocal in carrying out its working and return strokes including the main bearing support formed by the slide assembly **70** and the slide plate **76,** and further preferably including the forward bearing assembly formed by the bearing sleeve **78** and the ram periphery **112,** extremely high ram stroke speeds may be maintained with maximum trueness, but virtually free of wear problems resulting in minimum maintenance and down time losses.

Still further according to the principles of the present invention, a unique die pack assembly is provided having exact axial registry between the various die assemblies and stripper assembly and the spacer rings therebetween for quick convenient disassembly, reassembly and certain elements of interchangability providing maximum versitility and interchangability. The die pack feature of convenient removal of each of the individual working die rings from the die pack without disassembly of the remainder of the same, so that all of the necessary maintenance operations can be quickly and conveniently performed additionally adds to such versatility. Furthermore, at least each of the ironing die assemblies of the die pack assembly includes a novel form of cooling and lubricating fluid distribution ring providing a circumferentially moving annulus of lubricating liquid across the particular die assembly for penetration by the ram and the cup-like metallic part being carried thereby during the working operation to ensure total lubrication and cooling for the ram and metallic part, as well as the die rings of the various die assemblies.

I claim:

1. In metal forming apparatus of the type having a main frame mounting a longitudinally reciprocal ram driven by a rotating crankshaft and movable in forward and rearward strokes with forward and rearward reversals between said strokes, said ram being adapted for having a metal part positioned to be engaged thereby during a rearward portion and said rearward reversal of said ram strokes and for engaging and forming said metal part during a more forward portion of said strokes; the improvements comprising: drive transfer means including a plurality of pivot arms connected one to another between and to said crankshaft and ram for transferring said crankshaft rotations into said ram reciprocal forward and rearward strokes and into a reduced comparative speed of ram reciprocal movement and movement reversal directly approaching and following said ram stroke rearward reversal than directly approaching and following said ram stroke forward reversal, "said pivot arm connection" in said drive transfer means reciprocally driving said ram in a particular changing speed pattern of movement from said ram stroke rearward reversal forwardly to said ram stroke forward reversal and in an exactly reverse changing speed pattern of movement from said ram stroke forward reversal rearwardly to said ram stroke rearward reversal.

2. Metal forming apparatus as defined in claim 1 in which said drive transfer means includes said plurality of pivot arms being connected forming a longer effective driving pivot arm extension between said crankshaft and ram directly approaching and following said ram stroke forward reversal then directly approaching and following said ram stroke rearward reversal providing a reduced comparative speed of ram reciprocal movement and movement reversal directly approaching and following said ram stroke rearward reversal than directly approaching and following said ram stroke forward reversal.

3. Metal forming apparatus as defined in claim 1 in which said pivot arms of said drive transfer means include a crank arm secured to and extending radially from said crankshaft, a transfer arm having a rearward end pivotly connected to an outer end of said crank arm and a forward end extending at all times forwardly of said crank arm, means pivotly connecting said transfer arm forward end to said ram.

4. Metal forming apparatus as defined in claim 1 in which said pivot arms of said drive transfer means include a crank arm secured to said crankshaft and extending radially therefrom, a transfer arm pivotly connected to an outer end of said crank arm and having a forward end at all times spaced forwardly of said crank arm, a drive arm having a lower end pivotly secured to said main frame, said transfer arm forward end being pivotly connected to said drive arm intermediate upward extension of said drive arm, means pivotly connecting an upper portion of said drive arm to said ram, said drive arm upper portion being spaced above said drive arm pivotal connection to said transfer arm forward end.

5. Metal forming apparatus as defined in claim 1 in which said ram is mounted on a ram carriage and is movable generally horizontally in said forward and rearward strokes by forward and rearward movements of said ram carriage; and in which hydrostatic-type pressurized oil film bearing assemblies include ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame, one of said ram carriage and main frame oil bearing parts including slides having surfaces thereon parallel to said ram movements, and the other of said ram carriage and main frame oil bearing parts including spaced pads having flat surfaces thereon parallel to said ram movements, said pads being positioned with said pad surfaces at all times at least partially generally vertically facing and adjacent said slide surfaces, pressurized oil inlets opening through each of said pad surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlet over and between said pad and slide facing surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage during said ram and ram carriage reciprocal movements, at least certain of said ram oil bearing parts being positioned exerting vertical force components through said oil films acting generally vertically downwardly against opposed upward force components of facing of said main frame oil bearing parts providing support at least by vertical force components of said ram horizontally movable on said main frame, each of said pads being comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surface area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil films thereon against said slides supporting said ram carriage on said main frame during said horizontally reciprocal movement.

6. Metal forming apparatus as defined in claim 1 in which said ram is mounted on a ram carriage and is generally horizontally reciprocal on said main frame movable in said forward and rearward strokes by forward and rearward strokes of said ram carriage; and in which hydrostatic-type pressurized oil film bearing assemblies include ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame, one of said ram carriage and main frame oil bearing parts including slides having at least partially generally upwardly and downwardly facing surfaces thereon parallel to said ram movements, the other of said ram carriage and main frame oil bearing parts including generally horizontally spaced sets of generally vertically spaced pads with said pads having flat surfaces thereon parallel to said ram movements, said vertically spaced pads of each set being positioned with said surfaces of one pad adjacent and generally downwardly facing said slide upwardly facing surfaces and said surfaces of the other pad generally upwardly facing said slide downwardly facing surfaces, pressurized oil inlets opening through each of said pad horizontal surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlet over and between said pad and slide facing surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage by at least both vertically upward and downward force components during said ram and ram carriage reciprocal movements to thereby support said ram horizontally movable on said main frame, each of said pads being comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surface area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil films thereon against said slides supporting said ram carriage on said main frame during said horizontally reciprocal movement.

7. Metal forming apparatus as defined in claim 1 in which said ram is mounted on a ram carriage and is generally horizontally reciprocal on said main frame movable in said forward and rearward strokes by forward and rearward strokes of said ram carriage; and in which hydrostatic-type pressurized oil film bearing assemblies include ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame, said main frame oil bearing parts including slides having generally upwardly and downwardly facing surfaces thereon parallel to said ram movements, said ram carriage oil bearing parts including sets of generally vertically spaced pads generally transversely horizontally spaced at opposite sides of a longitudinal axis of said ram, each of said pads having a flat surface thereon parallel to said ram movements, one of said pads of each of said vertically spaced sets being positioned with one pad surface generally downwardly facing said slide upwardly facing surfaces and the other pad surfaces generally facing said slide downwardly facing surfaces with a slide spaced generally vertically therebetween, pressurized oil inlets opening through each of said pad surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlet over and between said pad and slide facing surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage by at least both vertically upward and downward force components during said ram and ram carriage reciprocal movements to thereby support said ram horizontally movable on said main frame, each of said pads being comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surface area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil film thereon against said slides supporting said ram carriage on said main frame during said horizontally reciprocal movement.

8. Metal forming apparatus as defined in claim 1 in which said ram is mounted on a ram carriage and is movable generally horizontally in said forward and rearward strokes by forward and rearward strokes of said ram carriage; in which hydrostatic-type pressurized oil film bearing assemblies include ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame, one of said ram carriage and main frame oil bearing parts including slides having surfaces thereon parallel to said ram movements, the other of said ram carriage and main frame oil bearing parts including spaced pads having flat surfaces thereon parallel to said ram movements, said pads being positioned with said pad surfaces at all times facing and adjacent said slide surfaces, pressurized oil inlets opening through each of said pad horizontal surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized thickened oil films through said inlet over and between said pad and slide facing surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage during said ram and ram carriage reciprocal movements, said ram carriage oil bearing parts being positioned and through said pressure oil films producing vertical and transversely opposite horizontal force components acting generally vertically downwardly horizontally transversely opposite against correspondingly facing and oppositively acting of opposed vertical and transversely opposite horizontal force components of said main frame oil bearing parts providing support at least by vertical forces and opposed transverse forces of said ram carriage horizontally movable on said main frame, each of said pads being comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surface area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil films thereon against said slides supporting said ram carriage on said main frame during said horizontally reciprocal movement.

9. Metal forming apparatus as defined in claim 1 in which said ram is mounted on a ram carriage and is generally horizontally reciprocal on said main frame movable in said forward and rearward strokes by forward and rearward strokes of said ram carriage; in which hydrostatic-type pressurized oil film bearing assemblies include ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame, said main frame oil bearing parts including slides having upwardly and downwardly facing generally horizontal surfaces thereon and oppositely transversely facing generally vertical surfaces thereon all parallel to said ram movements, said ram carriage oil bearing parts including sets of vertically spaced pads transversely horizontally spaced at opposite sides of a longitudinal axis of said ram, each of said pads having a generally horizontal flat surface thereon parallel to said ram movements, one of said pads of each of said vertically spaced sets being positioned with one pad horizontal surfaces downwardly facing said slide upwardly facing horizontal surfaces and the other pad horizontal surfaces upwardly facing said slide downwardly facing horizontal surfaces with a slide spaced vertically therebetween, pressurized oil inlets opening through each of said pad horizontal surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlet over and between said pad and slide facing horizontal surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage by both vertically upward and downward forces during said ram and ram carriage reciprocal movements to thereby support said ram horizontally movable on said main frame; in which said ram carriage oil bearing parts include at least one set of pads having generally vertical flat surfaces thereon parallel to said

ram movements and in the same general longitudinal location of said vertically spaced pads, each of said vertical surface pads being positioned with one pad vertical surfaces transversely facing a corresponding of said slide vertical surfaces, pressurized oil inlets opening through each of said pad vertical surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlet over and between said pad and slide facing vertical surfaces maintaining said pad surfaces spaced transversely from said slide surfaces and pressure oil film supporting said ram carriage transversely during said ram reciprocal movements and in which each of said ram carriage pads is comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surface area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil films thereon against said slides supporting said ram carriage on said main frame during said horizontally reciprocal movement.

10. Metal forming apparatus as defined in claim 1 in which said ram is mounted on a ram carriage projecting generally horizontally forwardly therefrom and is generally horizontally reciprocal on said main frame in said forward and rearward strokes by forward and rearward generally horizontal movements of said ram carriage; in which hydrostatic-type pressurized oil film bearing assemblies including ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame, one of said ram carriage and main frame oil bearing parts including slides having surfaces thereon parallel to said ram movements, the other of said ram carriage and main frame oil bearing parts including spaced pads having flat surfaces thereon parallel to said ram movements, said pads being positioned with said pad surfaces at all times at least partially generally vertically facing and adjacent to said slide surfaces, pressurized oil inlets opening through each of said pad surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlets over and between said pad and slide surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage during said ram and ram carriage reciprocal movements, at least certain of said ram carriage bearing parts being positioned exerting vertical force components through said oil films acting generally vertically downwardly against opposed upward force components of facing of said main frame oil bearing parts providing support at least by vertical force components of said ram carriage on said main frame, each of said pads being comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surface area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil films thereon against said slides supporting said ram carriage on said main frame; and in which a hydrostatic-type pressure oil film bearing sleeve is secured stationary on said main frame at all times spaced forwardly of said ram carriage and telescoping part of said ram during said reciprocal movements of said ram, said bearing sleeve having a plurality of pressurized oil inlets opening through an inner surface of said sleeve against a peripheral surface of said ram spaced about said ram peripheral surface, pressurized oil supply means connected to said bearing sleeve oil inlets distributing a constantly flowing and pressurized, thickened oil film through said inlets over and between said sleeve inner surface and said ram peripheral surface maintaining said sleeve and ram surfaces spaced apart by said constantly flowing and pressurized oil film for pressure oil film supporting said ram part during said ram reciprocal movements so that the combination of said ram carriage and said bearing sleeve in spaced relationship support said ram in such movements.

11. Metal forming apparatus as defined in claim 1 in which said ram is mounted on a ram carriage projecting generally horizontally forwardly therefrom and is generally horizontally reciprocal on said main frame in said forward and rearward strokes by forward and rearward generally horizontal strokes of said ram carriage; in which hydrostatic-type pressurized oil film bearing assemblies including ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame, one of said ram carriage and main frame oil bearing parts including slides having generally horizontal surfaces and transversely spaced generally vertical surfaces thereon parallel to said ram movements, the other of said ram carriage and main frame oil bearing parts including spaced horizontal pads having generally horizontal flat surfaces thereon and transversely spaced vertical pads having generally vertical flat surfaces thereon parallel to said ram movements, said horizontal pads being positioned with said pad horizontal surfaces at all times generally vertically facing and adjacent said slide horizontal surfaces, said vertical pads being positioned with said pad vertical surfaces at all times generally vertically facing and adjacent corresponding of said slide vertical surfaces, pressurized oil inlets openings through each of said horizontal and vertical pad horizontal and vertical surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlets over and between said pad and slide horizontal and vertical surfaces maintaining said pad surfaces spaced from slide surfaces and pressure oil film supporting said ram carriage during said ram and ram carriage reciprocal movements, at least certain of said ram carriage oil bearing parts being positioned acting generally vertically downwardly against correspondingly facing and upwardly acting of said main frame oil bearing parts through said facing horizontal surfaces and said pressurized oil film therebetween providing said horizontal support of said ram carriage on said main frame, said ram carriage and main frame oil bearing parts having said facing vertical surfaces acting generally horizontally between said ram carriage and main frame with said pressurized oil film therebetween providing transverse support of said ram carriage on said main frame, each of said pads being comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surfaces area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil films thereon against said slides supporting said ram carriage on said main frame during said horizontal reciprocal movement; and in which a hydrostatic-type pressure oil film bearing sleeve is secured stationary on said main frame at all times spaced forwardly of said ram carriage and telescoping parts of said ram during said reciprocal movements of said ram, said bearing sleeve having a plurality of pressurized oil inlets opening through an inner surface of said sleeve against a peripheral surface of said ram spaced about said ram peripheral surface, pressurized oil supply means connected to said bearing sleeve oil inlets distributing a constantly flowing and pressurized, thickened oil film through said inlets over and between said sleeve inner surface and said ram peripheral surface maintaining said sleeve and ram surfaces spaced apart by said constantly flowing and pressurized oil film for pressure oil film supporting said ram parts during said ram reciprocal movement so that the combination of said ram carriage and said bearing sleeve in spaced relationship support said ram in such movements.

12. In metal forming apparatus of the type having a main frame mounting a longitudinally reciprocal ram on a ram carriage both movable in generally horizontal forward and rearward strokes with forward and rearward reversals between said strokes, said ram being adapted for having a metal part positioned to be engaged thereby and formed at least during a part of said forward stroke; the improvements comprising: hydrostatic-type pressurized oil film bearing assemblies including ram carriage and main frame oil bearing parts supporting said ram carriage on said main frame during said ram and ram carriage generally horizontal reciprocal movements, said ram carriage oil bearing parts being secured movable with said ram carriage and moving relative to said main frame oil bearing parts secured stationary on said main frame; one of said ram carriage and main frame oil bearing parts including slides having surfaces thereon parallel to said ram movements; the other of said ram carriage and main frame oil bearing parts including spaced pads having flat surfaces thereon parallel to said ram movements, said pads being positioned with said pad surfaces at all times at least partially generally vertically facing and adjacent said slide surfaces, pressurized oil inlets opening through each of said pad surfaces and connected to pressurized oil supply means distributing constantly flowing and pressurized, thickened oil films through said inlets over and between said pad and slide surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage during said ram and ram carriage reciprocal movements; at least certain of said ram carriage oil bearing parts being positioned exerting vertical force components through said oil films acting generally vertically downwardly against upward force components of facing of said main frame oil bearing parts providing at least by vertical force components horizontal support of said ram carriage movable on said main frame; and each of said spaced pads being comprised of a raised flat surface area constituting said pad surface horizontally isolated from all surrounding surfaces, said each pad surface surrounding and terminating inwardly in an oil inlet area having said oil inlet, the total of said pad surface area being greater than said oil inlet area for each pad, said isolated pad surfaces with said pressurized oil films thereon against said slides supporting said ram carriage on said main frame during said horizontally reciprocal movement.

13. Metal forming apparatus as defined in claim **12** in which said one of said ram carriage and main frame oil bearing parts include said slides having a least partially generally upwardly and downwardly facing surfaces thereon parallel to said ram movements; and in which said other of said ram carriage and main frame oil bearing parts include horizontally spaced sets of vertically spaced pads, each of said sets of vertically spaced pads having one of said pad flat surfaces facing at least partially generally upwardly and the other of said pad flat surfaces facing at least partially generally downwardly corresponding to said slide surfaces at all times facing said corresponding of said slide surfaces.

14. Metal forming apparatus as defined in claim **12** in which said other of said ram carriage and main frame oil bearing parts include at least certain of said pads being transversely spaced sets of longitudinally spaced pads and forming at least a part of said at least certain ram carriage oil bearing parts and said corresponding main frame oil bearing parts.

15. Metal forming apparatus as defined in claim **12** in which said one of said ram carriage and main frame oil bearing parts include said slides having at least partially generally upwardly facing surfaces and at least partially generally downwardly facing surfaces thereon parallel to said ram movements; and in which said other of said ram carriage and main frame oil bearing parts include at least partially generally upwardly and downwardly acting pads at spaced longitudinal locations and at spaced transverse locations all acting against corresponding upwardly and downwardly facing oil bearing part slide surfaces providing through said facing surfaces and said pressurized oil film therebetween upward and downward horizontal force component support of said ram carriage in said longitudinal reciprocal movements of said ram and ram carriage on said main frame.

16. Metal forming apparatus as defined in claim **12** in which said one of said ram carriage and main frame oil bearing parts include said slides having at least partially generally transversely facing surfaces thereon facing transversely opposite and extending parallel to said ram movements; and in which said other of said ram carriage and main frame oil bearing parts include said pads having generally horizontally spaced corresponding at least partially transversely facing surfaces thereon parallel to said ram movements and facing said surfaces on said oil bearing part slides, said pressurized oil inlets opening through each of said pad surfaces and connected to pressurized oil supply means distributing a constantly flowing and pressurized, thickened oil film through said inlets over and between said pad and slide surfaces maintaining said pad surfaces spaced from said slide surfaces and providing force components also transversely pressure oil film supporting said ram carriage during said ram and ram carriage longitudinal reciprocal movements.

17. Metal forming apparatus as defined in claim 12 in which said one of said ram carriage and main frame oil bearing parts include slides having upwardly and downwardly facing generally horizontal surfaces thereon and generally vertical surfaces thereon facing transversely oppositely, all of said horizontal and vertical surfaces extending parallel to said ram movements; in which said other of said ram carriage and main frame oil bearing parts include horizontally spaced sets of vertically spaced pads, each of said sets of vertically spaced pads having one of said pad horizontal surfaces facing upwardly and the other of said pad horizontal surfaces facing downwardly at all times generally facing corresponding of said slide horizontal surfaces, said pressurized oil inlets opening through each of said pad horizontal surfaces distributing said constantly flowing and pressurized, thickened oil films over and between said pad and slide horizontal surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage both upwardly and downwardly during said ram and ram carriage longitudinal reciprocal movements; and in which said other of said ram carriage and main frame oil bearing parts include pads having generally horizontally spaced vertical surfaces thereon parallel to said ram movements and facing corresponding of said vertical surfaces on said oil bearing part slides, pressurized oil inlets opening through each of said pad vertical surfaces and connected to pressurized oil supply means distributing a constantly flowing and pressurized, thickened oil film through said inlets over and between said pad and slide vertical surfaces maintaining said pad surfaces spaced transversely from said slide surfaces and transversely pressure oil film supporting said ram carriage during said ram and ram carriage longitudinal reciprocal movements.

18. Metal forming apparatus as defined in claim 12 in which said one of said ram carriage and main frame oil bearing parts include said slides having upwardly facing generally horizontal surfaces and downwardly facing generally horizontal surfaces thereon and generally vertical surfaces thereon facing transversely oppositely, all of said horizontal and vertical surfaces extending parallel to said ram movements; in which said other of said ram carriage and main frame oil bearing parts include upwardly and downwardly acting pads at spaced longitudinal locations and at spaced transverse locations all acting against corresponding upwardly and downwardly facing oil bearing part slide surfaces providing through said facing horizontal surfaces and said pressurized oil film therebetween upward and downward horizontal support of said ram carriage in said longitudinal reciprocal movements on said main frame; and in which said other of said ram carriage and main frame oil bearing parts include longitudinally spaced sets of pads each having vertical surfaces thereon parallel to said ram movement, said pad vertical surfaces of each set facing transversely oppositely and facing corresponding of said vertical surfaces on said oil bearing part slides, pressurized oil inlets opening through each of said pad vertical surfaces and connected to pressurized oil supply means distributing a constantly flowing and pressurized, thickened oil film through said inlet over and between said pad and slide vertical surfaces maintaining said pad surfaces spaced transversely from said slide surfaces and transversely pressure oil film supporting said ram carriage during said ram and ram carriage longitudinal reciprocal movements.

19. Metal forming apparatus as defined in claim 12 in which said ram projects forwardly from said ram carriage; and in which a hydrostatic-type pressurized oil film bearing sleeve is secured stationary on said main frame at all times spaced forwardly of said ram carriage and telescoping parts of said ram during said reciprocal movements of said ram and ram carriage, said bearing sleeve having a plurality of pressurized oil inlets opening through an inner surface of said sleeve against a peripheral surface of said ram spaced about said ram peripheral surface, pressurized oil supply means connected to said bearing sleeve oil inlets distributing a constantly flowing and pressurized, thickened oil film through said inlets over and between said sleeve inner surface and said ram peripheral surface maintaining said sleeve and ram surfaces spaced apart by said constantly flowing and pressurized oil film for pressure oil film supporting said ram parts during said ram and ram carriage reciprocal movements so that the combination of said ram carriage and said bearing sleeve in spaced relationship support said ram in such movements.

20. Metal forming apparatus as defined in claim 12 in which said ram projects forwardly from said ram carriage; in which said one of said ram carriage and main frame oil bearing parts include slides having upwardly and downwardly facing generally horizontal surfaces thereon and generally vertical surfaces thereon facing transversely oppositely, all of said horizontal and vertical surfaces extending parallel to said ram movements; in which said other of said ram carriage and main frame oil bearing parts include horizontally spaced sets of vertically spaced pads, each of said sets of vertically spaced pads having one of said pad horizontal surfaces facing upwardly and the other of said pad horizontal surfaces facing downwardly at all times generally facing corresponding of said slide horizontal surfaces, said pressurized oil inlets opening through each of said pad horizontal surfaces distributing said constantly flowing and pressurized, thickened oil films over and between said pad and slide horizontal surfaces maintaining said pad surfaces spaced from said slide surfaces and pressure oil film supporting said ram carriage both upwardly and downwardly during said ram and ram carriage longitudinal reciprocal movements; in which said other of said ram carriage and main frame oil bearing parts include pads having generally horizontally spaced vertical surfaces thereon parallel to said ram movements and facing corresponding of said vertical surfaces on said oil bearing part slides, pressurized oil inlets opening through each of said pad vertical surfaces and connected to pressurized oil supply means distributing a constantly flowing and pressurized, thickened oil film through said inlets over and between said pad and slide vertical surfaces maintaining said pad surfaces spaced transversely from said slide surfaces and transversely pressure oil film supporting said ram carriage during said ram and ram carriage longitudinal reciprocal movements; in which all of said pads of said other of said ram carriage and main frame oil bearing parts are similarly formed and isolated; and in which a hydrostatic-type pressurized oil film bearing sleeve is secured stationary on said main frame at all times spaced forwardly of said ram carriage and telescoping parts of said ram during said reciprocal movements of said ram and ram carriage, said bearing sleeve having

a plurality of pressurized oil inlets opening through an inner surface of said sleeve against a peripheral surface of said ram spaced about said ram spaced about said ram peripheral surface, pressurized oil supply means connected to said bearing sleeve oil inlets distributing a constantly flowing and pressurized, thickened oil film through said inlets over and between said sleeve inner surface and said ram peripheral surface maintaining said sleeve and ram surfaces spaced apart by said constantly flowing and pressurized oil film for pressure oil film supporting said ram parts during said ram and ram carriage reciprocal movements so that the combination of said ram carriage and said bearing sleeve in spaced relationship support said ram in such movements.

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