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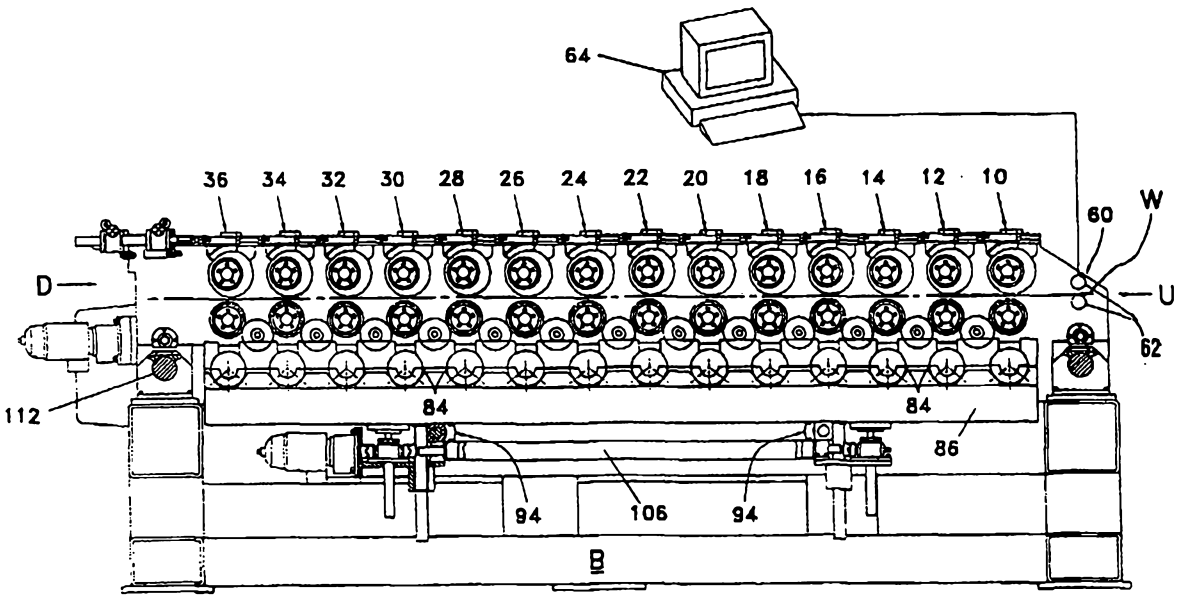

(57) Abstract

A roller die apparatus for supporting pairs of roller dies in predetermined clearances for processing a web workpiece, and for varying the clearances between the dies to accommodate variations in the thickness of a web workpiece and having first and second roller dies rotatably mounted on respective roller die bearings, one of the first and second roller dies being moveable upwardly and downwardly transversely to its axis of rotation, and one of the first and second roller dies being moveable axially along its axis of rotation, thereby achieving adjusting of the die clearance between the first and second roller dies in two planes.

ROLL FORMING APPARATUS AND METHOD

TECHNICAL FIELD

The invention relates to roll forming machinery, forming, a continuous strip of sheet material, and in particular, to such roll forming machinery in which the spacing between the rolls can be adjusted in response to variations in the thickness of the web, or the width of the web.

BACKGROUND ART

Roll forming machinery usually has a plurality of sets of rolls, usually arranged in upper and lower pairs, and usually spaced apart along the length of the machine on roller stands. Typically, the roller dies at one stand will produce a continuous formation in the web, and the roller dies of the next stand will produce another formation, or for example increase the angle of the formation which has already been started at the previous stand and so on.

A wide variety of commercial and other products are made on such roll forming machines, such as roof decking siding, and a large number of components for consumer equipment. The shapes may simply be webs with edge formations formed along one edge or both, or may be C sections or U sections but in many cases consist of relatively complex formations with longitudinal formations being formed along the length of the web, side by side.

Generally speaking at each stand of rolls there are two lower dies and two upper dies arranged in pairs, to form the web on either side of a central web axis. The lower dies engage the underside of the web and the upper dies engage the upper side of the web. The dies have circular shapes, and are mounted on rotatable axles so that the dies can rotate at the same speed as the sheet metal.

A gear drive mechanism is coupled to the dies so as to drive them at the speed of the sheet metal.

Each set of such roller dies must be designed to provide a particular formation in the web. In addition, each pair of dies must have a clearance between them determined by the thickness of the web.

Thus where it is desired to discontinue working on a web of one thickness, and to then run a web of another thickness through the dies, each pair of roller dies must be readjusted to a new clearance, to accommodate the new thickness of the new web. This involves costly down time, in order to make the fine adjustments.

All of this is very well known in the art and is accepted as the normal operating procedure.

It is however well known that a further problem exists in roll forming. The web of sheet material which provides the basic feed stock for the roller machine should preferably maintain its thickness within very narrow limits, along the entire length of the web. If there is any significant variation in thickness in the web, then the dies, being fixed as to clearance, will produce varying effects on the web as the web passes along the roller stands, or the web may jam causing stoppage of the line.

In practice, it is well known that some web material varies in thickness to a greater extent than is permissible. This results in unusual effects being produced in the final formed web, which may warp or bend or twist, or even jam.

Generally speaking, it is not possible to adjust the clearances of the roller dies, during the actual operation of the machine, and the best that can be done is that in the initial set up, the machinist will set the die clearances to a predetermined average web thickness. The results obtained in this way however are not always entirely satisfactory.

It would in theory be desirable to provide for automatic self-adjustment of the spacings or clearances between the pairs of dies in each stand. However, due to the shaping of the dies there are difficulties in such adjustments. Usually the dies will have two surfaces, one of the surfaces being more or less horizontal, or at least parallel to the plane of the web itself, and the other of the surfaces being at a web forming angle.

Another set of problems arises if it is desired to use the same roller dies, to form a web having a width which is greater, or narrower than a preceding web.

In the past each of the stands would have to be manually moved further apart, or closer together, to take in to account the width of the new web to be processed. However, it was time consuming to dismantle the arrangement of dies for one web width, and then reassemble the dies with a greater or lesser number of rolls between them to suit the new web width. In addition, this was awkward and time consuming manual work.

It is therefore desirable to provide for roller die stands arranged in pairs, in which one of each of the stands in each of the pairs shall be transversely moveable relative to the other.

Given both die clearance adjustment, and stand width adjustment, it would be possible, using one set of roller die stands and dies, to provide for the processing of webs both of different thicknesses, and also of different widths. This enables a manufacturer to produce a standard rolled form section such as a "C" section in a variety of widths and in a variety of gauges, from a single machine. This would reduce the capital investment in machinery. In addition would reduce the down time required for change over from one web to another and also reduce the need for skilled labour.

Additional savings would be achieved if the spacer rolls could be introduced between the paris of dies by some form of powered mechanism.

A further problem arises with roll forming certain sections, particularly sections which have the shape of a letter C with inturned flanges, or a partially closed-in box section.

In this type of section, the two edges or flanges of the C, or partially closed-in box, are turned inwardly. This is usually done by roll forming the edge flanges first, and then roll forming the C bends later, i.e. downstream. Special dies are required to form the last bends, and it is desirable to provide for adjustment of these dies. Adjustment of such dies in this location however, to accommodate variations in web thickness and to form different sizes of C-section presents further problems.

DISCLOSURE OF THE INVENTION

One aspect of the invention provides for transverse width adjustment of the die stands, and means for inserting or removing spacer rolls between the dies.

This form of the invention includes a movable support table movable upwardly and downwardly between the die stands, with the spacer rolls stored on the table.

Another aspect of the invention provides a roller die apparatus for supporting pairs of roller dies in predetermined clearances, and having means for moving one of said roller dies upwardly and downwardly transversely to its axis of rotation, and means for moving one of said roller dies axially along its axis of rotation, thereby achieving adjusting of the die clearance in two planes.

Preferably one of the dies is fixed, and the other of said dies incorporates both axial adjustment movement and also transverse adjustment movement, so as to keep all of the adjustment movement in a common location where it is readily accessible for servicing and adjustment.

In another form of the invention means may be provided for moving said lower roller die axially, and further means for moving said upper roller die transversely, thereby adjusting each said die separately from the other.

In this case the lower die would be movable axially, along its axis of rotation, and the upper die would be movable transversely to its axis.

The invention provides an axial movement transmission coupling all of the axial moveable dies together for movement in unison, and further including transverse movement transmission coupling all of the transverse moveable dies for movement in unison, and power for operating each of said movement transmissions.

The invention provides a thickness sensor for sensing the thickness of said web material workpiece, and generating a thickness signal and signal responsive means for generating movement signals for moving said movement transmission means, whereby to procure simultaneous movement of said moveable dies.

The invention also provides for an edge forming roller die assembly for rolling the edge formations and means for moving said at least some of said roller dies relative to one another, to vary the clearance between them.

A further aspect of the invention provides for a straightening assembly, comprising straightening rolls adapted to engage the workpiece after exiting from the roller dies to prevent warping.

The various features of novelty which characterize the invention are pointed out with more particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side elevation of a roller die apparatus for working a web of sheet material partially cut away, and illustrating a plurality of roller die stands at spaced apart intervals along the path of the sheet material and controls shown schematically;

Figure 2 is a top plan of part of Figure 1 in cross section;

Figure 3 is an enlarged side elevation of the roller apparatus of Figure 1, partially cut away to illustrate the movable raise table and spacer rolls;

Figure 4 is a top plan schematic view of the two side plates holding the roller stands, and the transverse movement mechanism;

Figure 5 is a cross section of the roller die apparatus of Figure 1 at the line 5-5, in a first position;

Figure 6 is a cross section, corresponding to Figure 5, showing parts in a second position;

Figure 7 is a cross section corresponding to Figure 5, showing parts in a third position;

Figure 8 is a section of one roller stand, sectioned along the line 8-8 of Figure 2, and showing details of the upper die movement means;

Figure 9 is a section corresponding to a portion of Figure 8 along line 9-9 of Figure 8;

Figure 10 is a section along the line 10-10 of Figure 7 and showing movement;

Figure 11 is a section along the line 11-11 of Figure 10, showing upward and downward movement of the upper die;

Figure 12 is a top plan view partially cut away showing the axial movement mechanism for the upper die;

Figure 13 is a section, corresponding to Figure 11, but showing axial movement of the upper die relative to the lower die;

Figure 14 is a perspective illustration of the upper die bearing housings, and the upward and downward movement mechanism, and the axial movement mechanism;

Figure 15 is a side elevational view of an alternate embodiment of roll forming machine using certain of the features of the embodiment of Figures 1 through 14;

Figure 16 is a top plan view of the embodiment of Figure 15;

Figure 17 is a greatly enlarged top plan view showing the area marked 17 on Figure 16;

Figure 18 is a top plan view greatly enlarged of the area marked 18 in Figure 16;

Figure 19 is a side elevation of area marked 18 in Figure 16;

Figure 20 is a section along the line 20-20 of Figure 19;

Figure 21 is a section along the line 21-21 of Figure 19;

Figure 22 is a section along the line 22-22 of Figure 19;

Figure 23 is a section along the line 23-23 of Figure 19;

Figure 24 is a section along the line 24-24 of Figure 19;

Figure 25 is a section along the line 25-25 of Figure 17;

Figure 26 is a top plan view of a roller die apparatus illustrating a further embodiment of the invention;

Figure 27 is an enlarged section along the line 27-27 of Figure 26, showing one side of the upper angled corner forming dies and side control rolls of the apparatus, and the C-section web, and showing transverse adjustment movement in phantom;

Figure 28 is a perspective illustration of the mounting apparatus upon which the side control rolls are mounted;

Figure 29 is an exploded perspective corresponding to Figure 28; and

Figure 30 is a front elevational view of one of the angled upper dies, showing the adjustable mounting and showing vertical adjustment movement in phantom.

MODES OF CARRYING OUT THE INVENTION

Referring first of all to Figure 1, it will be seen that this illustrates what appears to be at first sight a conventional roll forming apparatus, of type used in conjunction with web sheet metal processing lines. Additional equipment may comprise an uncoiler, a flattener, a cut off die of shear, and a stacker or conveyor, all of which components are essentially well known in the art.

The roll forming apparatus comprises a base indicated generally as B, defining an upstream end U, and a downstream end D, and the web sheet metal passes from right to left, from the end U, to the other end D, continuously, while being progressively roll formed.

The roll forming of the web W, is performed progressively at a series of pairs of roller die stands indicated generally as 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36. The stands are secured to the base B, in spaced apart intervals, along the path of the web W. As shown in Figure 2, each pair of stands is designated as 10A, 10B, 12A and 12B, etc. The stands are moveable relative to one another, so as to accommodate webs W of different widths. The stands 10A and 10B, etc., are supported by continuous upright plates 38 and 40, Figures 1 and 3 the lower end of which are secured to base B.

Each of the stands 10A, 12A, etc. (Figure 5) consist of upper and lower transverse bearing shafts 42 and 44. Upper and lower dies 46 and 48 are adapted to be mounted on the respective shafts 42 and 44. Complementary bearing sleeves 50 and 52 are supported by stands 10B, 12B, etc. and support upper and lower dies 54 and 56.

The apparatus also incorporates means for moving the side plates 38 and 40 transversely relative to one another. This comprises a longitudinal side shaft 58, driven by a suitable motor, and connected in a suitable manner to transverse movement means shafts 59 at each end of plates 38 and 40 for moving all of the stands transversely relative to each other, so as to accommodate strips of webs of different widths (described below).

In accordance with the present invention, as explained above, there is also provided means for adjusting at least one of the upper and the lower dies relative to the other, so as to adjust the clearance between the dies, to match the thickness or gauge of the web material as closely as possible. Such adjustments in accordance with the invention can be made while the web is actually running through the dies, thus compensating for variations in the thickness of the web along its length, all of which will be described below.

Referring to Figure 1 it will be seen that a web thickness sensing unit 60 is provided at the upstream end U of the roll forming apparatus. The thickness sensing unit may typically comprise a pair of rolls 62, and a signal generator (not shown) connected to a computer control centre 64.

In a manner to be described below, the sensing unit 60 senses the thickness or gauge of the web as it passes through the sensing unit, and before it enters the roller die stands. The signal generator 60 sends a gauge signal to the computer 64. By mechanism to be described below the clearances between the dies is adjusted either closer or further apart depending upon the actual thickness or gauge sensed by the sensing unit.

The lower roll shafts have drive gears 70 secured thereon, and upper roll shafts 42 have gears 72 secured thereon meshing with gears 70. Thus as lower roll shafts 44 are all driven in the same rotational direction, all of the upper roll shafts are driven in the reverse rotational direction. The shafts connect telescopically with respective sleeves 50 and 52 and drive them.

This, therefore, causes the dies 46 and 48 and 54, 56 to rotate in opposite directions on opposite sides of the workpiece (W), in well-known manner.

Each of the lower shafts 44 are rotatably mounted in bearings in openings 74 in plate 38.

The upper shafts 42 are carried in bearing housings 76. Each bearing housing 76 is supported in a suitable opening in plate 38.

Bearing housing 76 is able to rotate in a manner to be described below, and thus cause upward and downward movement of upper die 46. This then enables the clearance between the upper and lower dies to be adjusted by adjusting the upper die in a plane transverse to its axis in a manner described below.

Lower bearing sleeves 52 are mounted in suitable openings in side plate 40. Upper bearing sleeves 50 are mounted in upper bearing housings 80 and are rotatable in the same way as housings 76. Roller bearings are mounted within the bearing housings 76 and 80.

The side plates 38 and 40 are between 5 and 6 inches in thickness, in this case, and provide strong support for the shafts, sleeves and dies of the roller stands.

The axial adjustment movement of the upper dies 42 and 54 is achieved by means to be described below thus providing adjustment movement in both the transverse plane, and in the axial direction.

As explained above, the plates 38 and 40, incorporating the die stands 10A, 10B, 12A, 12B etc., are relatively movable away from and towards each other, by means of the two transverse movement transmission shafts 59. The upper and lower shafts 42 and 44 are dimensioned and designed so as to make a telescopic sliding fit within the sleeves 50 and 52. In this way the drive from the die stands 10A, 12A, etc., is transmitted to the die stands 10B, 12B, etc., as described above.

However, referring to Figure 5, 6 and 7, it will be seen that the transverse movement means can be operated to withdraw the shafts 42 and 44 entirely from the sleeves, thereby leaving the vacant space between the free ends of the shaft and the sleeves.

This feature enables easy changeover of the dies if the dies must be changed. More importantly however, this feature permits the insertion of spacer rolls 84, between the free ends of the shafts and the sleeves. This could be achieved manually. However, in accordance with a feature of the invention, the sets of spacer rolls for each of the pairs of die stands supported on a lengthwise support table 86. The support table 86 is of rectangular tubular construction (Figure 5) and along its upper surface it is provided with a plurality of spacer rolls support brackets 88 spaced apart from one another and defining generally downwardly directed three-sided recesses. Along the length of the brackets 88, there are provided retention springs 90 at spaced intervals.

Each set of spacer rolls 84 is provided with a central axial opening, which is designed to fit on the shaft 44 of the stands 10A, 12B, etc.

As shown in Figure 3 a table raising movement means is indicated generally as 94, located beneath the table 86. Figure 3 shows only the one table movement means. However there are two such movement means, one at each end of the table, so as to ensure that when the movement means are operated, the table is maintained level while it is raised or lowered.

Movement means comprises a raise shaft 96, and guide shaft 98. Both shafts run through a drive housing 100. A motor 102 drives a drive shaft 104, and a shaft extension 106 connects the drive from the motor 102 to the other of the table raise movement means (see Figure 1). Other power operated means such as a pneumatic or a hydraulic cylinder could also be used.

Referring again to Figure 5, it will also be appreciated that the table 86 is movable transversely as well as up and down in a vertical plane. The transverse movement is permitted by means of the transverse carriage 108 (Figure 5), in response to movement of side plate 40.

Comparison of Figures 5, 6, and 7 will show that the entire table and raise mechanism has moved substantially to the right to accommodate the simultaneous closing movement of the two side plates 38 and 40, and the roller die stands. Note that in Figure 7 the transverse carriage 108 is extending substantially to the right in a rectangular portion of the base B.

As has already been explained that all of the stands 10A, 12A on one side and 10B, 12B on the other side are all formed as parts of respective continuous side plates 38 and 40 (Figures 1 and 4). At each end of each side plate that is to say the upstream end and the downstream end, there is provided a cross bearing tube of substantial width indicated as 112. The side plates 38 and 40, for each of the stands 10A, 12A, etc., and 10B, 12B, etc., are provided with bearing sleeves 114, adapted to ride on the tubes 112.

This provides a means for permitting movement of the entire set of stands 10A, etc., on the one side, and 10B, etc., on the other side, transversely towards and away from one another in unison. The space between the tube 112 at one end and tube 112 at the other end, is free open space, and permits the raising and lowering of table 86.

It will of course be appreciated that, while the illustrations of Figures 5, 6, and 7 illustrate the lower shaft 44 picking up all of the spacer rolls 84, it is perfectly possible that a particular application will not require all of the spacer rolls. Accordingly, all that is required in this case is simply to insert the shaft 44, (see Figures 6 and 7) part way into the stack of spacer rolls 84. The table 86 would then be lowered, leaving some of the spacer rolls on the shaft 44, and removing downwardly the rest of the spacer rolls, resting on table 86.

The die stands will then be closed up as in Figure 7 and in fact the die stands would be closer together than they are shown in Figure 7, since there would be fewer spacer rolls between the dies.

These operations can be controlled by the computer 64 so that the changeover from one width of web to another width of web would simply require a few instructions to be programmed into the computer, after which the die stands would be moved apart, and then moved partially or fully together, depending upon whether they were picking up all of the spacer rolls or only a selection of them.

Removal of the spacer rolls, or changing their number can be effected in the same way.

In this case the table 86 is raised until it is in contact with the spacer rolls 84. At this point, the side frames are then moved fully open, withdrawing the shaft 44 from the spacer rolls 84. This will then leave the spacer rolls 84 sitting freely on the racks 88 on the table 86. The table 86 will then be lowered, and the die stands can simply be closed again.

ADJUSTMENT OF DIE CLEARANCE

As generally described above, the adjustment of the die clearances is achieved by moving, in this embodiment, the upper die relative to the lower die. In this embodiment the lower die remains unadjusted.

The adjustment of the upper die takes place in two planes that is to say along the axial direction of the shaft 42, with the die moving together with the shaft 42 in the axial direction, and secondly, the die is moved on an axis transverse to the axial direction of shaft 42, i.e. up and down.

By providing adjustments in both planes, it is possible to adjust for variations in web thickness even while the web is running through the roller dies.

The transverse (up and down) adjustments are best understood with reference to Figures 8, 9, 10, 11 and 14.

As explained, the lower die 48 remains unadjusted. It simply rotates on its shaft 44, which runs in bearings mounted directly in plate 38.

The same is also true of die 56, mounted on its sleeve in plate 40.

The two upper dies 46 in stand 10A and 54 in stand 10B however are mounted respectively on shaft 42, in stand 10B, and in sleeve 50 in stand 10B. Both shaft 42 and sleeve 50 are in turn carried in bearing sleeves indicated respectively as 76 and 80. The bearing sleeves in turn are received in openings formed in their respective plates 38 and 40, so that they can simply rotate.

In order however to provide for adjustment, by means of rotation of the bearing sleeves, the bearing sleeve 76 is provided with an offset shaft recess 120, containing both bearings, and the shaft 42. The axis of the shaft recess 120 is offset from the central axis of the sleeve 76 (see Figure 10). Thus when the sleeve 76 rotates, the axis of the shaft 42 must move relative to the axis of the bearing sleeve 76.

Provided that bearing sleeve 76 is suitably located, so that its thinnest point and its widest point lie on a more or less horizontal access (Figure 10) then movement of bearing sleeve 76 in one direction will cause shaft 42 to move upwardly and the rotation of the sleeve 76 in the other direction will cause shaft 42 to move downwardly.

Turning to stand 10B, it will be seen that shaft sleeve 50 which is mounted in the bearing sleeve 80, also has the same characteristics. That is to say the recess 122 in bearing sleeve 80 is offset with respect to the central axis of bearing sleeve 80 so that the central axis of the sleeve 50 is offset with respect to the central axis of the bearing housing 80.

Thus if the bearing housing 80 is rotated in one direction the shaft sleeve 50 will move upwardly, and if the bearing housing 80 is rotated in the opposite direction the shaft sleeve 50 will move downwardly.

In order to provide for rotational movement of the bearing housings 76 and 80 in unison, each bearing housing is provided with an annular semi gear segment 124, which is welded at a suitable position to the edge of the respective bearing housing 76 and 80.

Two racks 126 are provided in stands 10A and 10B engaging the gear segment 125 (Figures 9 and 10). Each of the racks is mounted on to a respective push pull rod 128. The two push pull rods 128 are mounted so as to extend to the upper regions of respective stands 10A, 12B, etc., and 10B, 12B etc. The push pull rods 128 are threaded along their length, for convenience. Other adjustment means could be used other than the rack and gear segment illustrated.

Each of the racks 126 is secured to its respective push pull rod by means of locknuts 130. The push pull rods 128 are both operated simultaneously, by means of a transverse drive coupling shaft 132 (Figure 2) and a drive motor 134.

Thus, by the operation of motor 134, all of the respective racks 126 can be operated so as to move their respective semi annular gear segments 124, thus moving simultaneously the bearing housings 76 and 80 in the stands 10A, 10B, etc.

Thus all of the upper dies will move simultaneously either upwardly or downwardly by the same increment.

As mentioned above, adjustment also takes place axially along the axis of the shaft, and shaft sleeves. This axial movement is best understood with reference to Figures 8, 12, 13 and 14.

Again, the lower dies 48, 56 remains unadjusted, in this embodiment.

The upper dies 46 and 54 are the dies that are adjusted. This is achieved by the same means in both stands 10A and 10B.

The bearing housing 76 and 80 are both rotatable in their openings in their plates 38 and 40, and they are both axially slidable, to a limited extent, relative to their plates 38 and 40. This axial movement is achieved by means of an annular groove 132, formed in each of bearing housings 76 and 80. A self lubricating anti wear block 134 rides in the groove 132. The block 134 has a central recess 136.

A spur gear 138, is secured in a cross member 140 fastened to the top of the respective plates 38 and 40. The spur gears 138 have a downward axial extension 146. At the free end of extension 146, there is located an offset stub 148. Stub 148 is received in the recess 136 in wear block 134.

It will thus be seen that by the operation of the racks 140, in response to the movement of the push pull rods 142, the spur gears 138 will rotate one way or the other. This will cause an orbital movement of the offset stub 148, the extension 146 and gear 138.

This orbital movement will thus force the respective bearing housing 76 and 80, to move axially one way or the other relative to their respective plates 38 and 40.

It will be appreciated that as a result of this movement there is a slight lateral displacement of the annular gear segments 124, relative to their respective racks 126. However, since the degree of movement is relatively slight, this will not cause any problem in operation.

The push pull rods 142 are again operated by a cross shaft 150, and motor 152 (Figure 5), so that the push pull rods on all of stands 10A, 12A, and 10B, 12B etc., operate simultaneously.

It will thus be seen that during operation of the roll forming line, if the sensor 60 detects a change in the thickness of the web, it will send a signal to computer 64. Computer 64 will thereupon signal motors 134 and 152 to adjust the die clearances in two planes, to accommodate the different web thickness. This adjustment will of course be relatively minor, but will have the effect of maintaining the highest quality of the roll forming action on the web, which would otherwise not occur if the die clearances were not adjusted.

It will of course be appreciated that in the event of a changeover in the operation of the roll forming apparatus from one web to another, the web may have a thickness which is increased or decreased somewhat as compared with the previous web that was being processed.

These adjustments can, in the great majority of cases, be taken into account simply by programming the computer, so that it instructs the motors 134 and 152 to adjust the die clearance to suit the new web thickness.

In the event of an extreme change in web thickness it may of course be necessary to readjust the position of the racks on the push pull rods. This can readily be done simply by loosening off the locknuts, resetting the positions of the racks and locking up the locknuts to hold the racks in the new position.

In accordance with a further embodiment of the invention, illustrated in general in Figures 15 and 16, provision may be made for a somewhat different form of operation than in the Figure 1 through 14 embodiment.

In the Figure 1 through 14 embodiment, the C-section is formed by bending the two outer flanges of the C at the leading end of the machine, and then progressively forming the intermediate bends of the C-section, in downstream sets of rolls.

This however, placed certain restrictions on the size and shape of the C-section that could readily be formed in this way.

In accordance with the embodiment of Figures 15 and 16, the inner bends of the C-section are formed first by the initial sets of rolls, and the final inturned flanges of the C-section are formed last, downstream from the main rolls. This has certain advantages. It enables a greater range of flange sizes, and web depths, to be formed on a single machine. It also provides for easier adjustment.

The embodiments of Figure 15 and 16 also provide a finished C-section straightener, all to be described below, which can in fact be used with the embodiment of Figures 1 through 14 or 16 and 16.

Many of the features of Figures 1 through 14 and Figures 15 and 16 are common to both, and will therefore be described in somewhat less detail, since they have already been described in connection with Figures 1 through 14.

Referring now to Figure 16 it will be seen that this embodiment of the invention comprises a roll forming apparatus indicated generally as 200, and having an upstream end 202 and a downstream end 204. A web of material passes from the upstream end to the downstream end during the process of being formed from a flat web into a C-section.

The apparatus 200 will also have an upstream web thickness measurement device similar to that shown in Figure 1, for providing for continuous adjustment.

The entire apparatus, as before, is supported on a base made up of a frame work of rectangular beams 206, connected to rectangular cross members 208.

As before, there are a plurality of roller die stands indicated as 210, 212, 214, 216, 218, 220, 222 and 224. As shown in Figure 16, in each case each of the stands comprise respective right and left hand die stands indicated by the suffix a-b.

Also, as in the previous embodiment, each of the die stands comprises pairs of upper and lower dies, which mesh with one another to provide the formations desired.

As before, the upper dies are moveable relative to the lower dies by means of push pull rods 226 and 228, the two rods being respectively referenced a and b (see Figure 16) on opposite sides of the apparatus.

The operation of the push pull rods to procure the upward and downward movement, and lateral movement, of the upper die is as already described, and consequently the apparatus is not described in detail again for the sake of simplicity.

Similarly, as in the Figure 1 through 14 embodiment the die stands 210A and 210B, etc., are moveable away from one another and together, to provide for varying spacings between the stands and also, to permit varying numbers of spacer rolls to be introduced therebetween. The spacer rolls indicated as 230 are carried on a spacer roll table 232 operated by means of the raise mechanism 234 (see Figure 15). The spacer rolls, table and raise mechanism all operate in the same way, as is already described in the embodiment of Figures 1 through 14.

As before, the roller die stands are all driven by a common drive motor 236 driving through transmissions 238.

The push pull rods 226 are operated by means of motor 240 and the push pull rods 228 are operated by means of the motor 242.

As mentioned above, this embodiment of the invention provides for the formation of the edge flanges of the C-section downstream from the main roller die stands. The edge flange forming die stands are indicated generally in Figures 15 and 16 as 250 and 252. Each of the edge forming die stands 250 and 252 consists of, in this case, five pairs of outer and inner edge forming dies on each side, indicated as 254 and 256.

As will be seen from Figures 17 through 24, each pair of edge forming dies 254 and 256 consists of outer dies 254 and inner dies 256, the outer dies being of much larger diameter than the inner dies for reasons to be described below.

Each set of dies outer 254 is mounted on respective common mounting frames 258 and each set of inner dies 256 is mounted on sub-frames 260. Sub-frames 260 are mounted on mounting frames 258 and are moveable relative thereto as described below. All of the dies 254, and 256 can be moved as a group towards and away from the other set, to accommodate workpieces of different widths, or to form C-sections of different dimensions by movement of the two mounting frames 258-258.

Thus the two mounting frames 258-258 carrying the two groups of dies 254 and 256 can be moved towards and away from one another by transverse movement means (not shown) similar to Figures 1-14, and moving all of the dies transversely, simultaneously.

The apparatus also provides for upward and downward adjusting movement of the mounting frames 258-258 holding the two groups of dies 254 and 256. These upward and downward adjustment movements are procured by means of motor 262 operating through shaft 264 and gear drives 266, the lower ends of which are connected directly to the mounting frames 258 and 258 respectively. Guide posts 268 guide such vertical movement.

In this way, the positioning of the two groups of horizontal dies can be adjusted up and down, so as to accommodate the manufacture of C-sections of different shapes, i.e., having deeper web sections or shallower sections.

Figure 20 shows that each inner die 254, is mounted on a drive shaft 270, having a driven gear 272, connected by idler gears 272A. One of gears 272 meshes with an elongated drive gear 274. The reason for the elongated drive gear 274 is to permit the upward and downward movement already described, performed by moving the framework 258 upwardly or downwardly, to move all of the pairs of dies in unison.

Gear 274 is mounted on shaft 276 connected to the main drive train 278.

The outer dies 254 are not in themselves adjustable, other than as already explained.

The adjustment of the outer dies relative to the inner dies, in the pairs of the horizontal dies, is best understood with reference to Figures 21, 22 and 23.

Adjustment of the clearance between the outer dies 254 and the inner dies 256 is achieved by providing for adjusting movement of the outer dies as a group, in a vertical plane, and also in a transverse plane. Sub frames 260 are mounted on mounting frames 258 in such a way that they can be moved both vertically and transversely.

Vertical adjustment for the inner dies comprise shafts 280 on which the sub-frame 260 is mounted at each end. The shafts 280 are provided within sleeves 282. Jack screws 284 engage threaded members 286. Shafts 280 are operated by means of the push pull rods 226A and 226B, engaging elongated gears 288 on the upper ends of shafts 280. Members 286 are secured to captive plates 290 secured within either end of sub-frame 260 (Figure 21 and 22). Rotation of shafts 280 will thus raise, or lower, sub-frames 260 relative to frames 258.

The transverse adjustment of the inner dies relative to the outer dies for clearance adjustment, is also achieved by means of movement of sub-frames 260 relative to frames 258 transversely.

Shafts 292 have gears 294 which engage push pull rods 228A and 228B. Shafts 292 are connected to eccentric shafts 296 which extend down through sub-frames 260 and into side frames

38 Shafts 296 at their lower ends have bosses 296, coaxial with shafts 292. Thus rotation of shafts 292 will cause eccentric orbital movement of shafts 296, causing sub-frames 260 to move transversely relative to frames 258.

The apparatus of Figure 15 and 16 further provides an end finishing operation, by means of two pairs of end finishing roll assemblies 300A and 300B, on opposite sides of the apparatus. The end finishing roll assemblies have lower dies 302 and upper dies 305 and intermediate side dies 306. In this way, it is possible for the three dies to engage all three outer surfaces of the C-section and provide final finishing and squaring step.

Inward and outward movement of the two die assemblies is provided by the main transverse movement mechanism already described above (see Figure 1-14).

The lower die 302 in each of the finishing die assemblies 300 will remain fixed as to height, and is not adjustable. The side dies 306 are simply likewise fixed, relative to the lower dies 302, so that they simply adjust inwardly and outwardly, with the inward or outward movement of the entire finishing die assemblies.

The upper dies 304 of each finishing die assembly are moveable upwardly and downwardly, to take into account different dimensions of different C-sections being formed. This is achieved by means of the jack screws 308 operated through suitable transmissions by motors 310. The lower ends of the jack screws are secured by the bearing housing 312 carrying shaft 314 for the upper dies 304.

Operation of the jack screws will thus cause the entire bearing housing 312 to either move upwardly or downwardly.

Finally, in this embodiment, provision is made for straightening the C-section as it exits from the finish rolls.

It is well known that when forming C-sections, they may have a tendency to warp, which implies either that the section will bend upwardly or downwardly, or sideways.

In order to overcome this tendency, there are provided straightening assemblies 320A and 320B which are located just downstream, at the exit of the apparatus. This is best understood with reference to Figure 19 and 25. The straightening assembly comprises a fixed lower roll 322, which is moveable along a sleeve with the side roll, which is located along the pass line of the lowermost web of the C-section. Two, leading and trailing, straightening rolls 324 and 326 are mounted above the lower roll and spaced apart with respect thereto upstream and downstream.

In addition, side rolls 328 are provided for engaging the side portions of the C-section.

As in the case of the rest of the rolls, the straightening rolls are mounted as left and right hand sets of rolls on opposite sides of the apparatus and will move towards and away from one another in conjunction with and in unison with the movement towards and away from one another and all of the rest of the dies in the manner described above.

The lower roll 322 and side roll 328 in and out together. The two upper rolls are mounted on a generally inverted U-shaped yoke 330, which is pivotally mounted on the axle 332 (Figure 19).

The yoke can thus tilt about the axle, bringing one of the rolls downwardly and the other roll upwardly and vice versa.

Connected to one end of the yoke 330 is a jack screw 334 which is operated by motor 336 (Figure 25).

Operation of the motor will thus cause the one end of the yoke to either tilt upwardly or downwardly.

Thus if the C-section is tending to warp up, the jack screw 334 will be raised, thereby causing the trailing die 326 to move downwardly, and thus correcting the upward warp of the C-section.

If the C-section is warping downwardly then the jack screw 334 is operated in the opposite way to depress the leading die 324.

The side rolls are also operable from side to side in order to correct any sideways warping. This is achieved by means of the jack screws 338, operated by motors 340. Operation of the jack screw 338 in one direction will cause the side roll 328 to move in one direction and operation of the jack screw in reverse will move the roll in the other direction.

Thus, by operation of the motors 340-340 on opposite sides, it is possible to move the two side rolls 328 and the two bottom driven rolls, one on each side of the C-section, either to the left or to the right, thus straightening any sideways warping.

Warp sensors, such as optical sensors 342 (Figure 19) and 344 (Figure 25) are connected to computer 64 and would cause appropriate signals to be sent to motors 336 and 340.

A further embodiment of the invention is illustrated in Figures 26 to 30. In this embodiment the workpiece that is intended to be produced is shown in the form of a C-section of rectangular shape indicated generally as C (Figure 27). It has a generally planar web W, side flanges S, and edge flanges E. The edge flanges, in this embodiment, make a right-angle with the side flanges and the side flanges, in this embodiment, make right-angles with the web.

As the web workpiece passes from the upstream end U down through the stations 10A, 10B, 12A, 12B, etc., the edge flanges E are formed first. At subsequent stations, the side flanges are progressively bent up from the web. This bending takes place progressively, at angles typically of 10 to 20 degrees for each set of roller dies.

When the side flanges S reach angles of about 70 to 80 degrees relative to the web W, the edge flanges E will begin to interfere with the upper roller dies, in each pair of dies so that the side flanges S cannot bend in any further.

In order to complete the last bends of the side flange S from 80 to 90 degrees relative to the web, the invention provides sets of upper angled corner forming rolls or dies 400 to 402, spaced apart from one another along the length of the apparatus for reasons to be described below, and staggered alternately from side to side of the apparatus towards the downstream end D.

The purpose for this is to allow the roller die stands to be moved close together, for forming a workpiece which is relatively narrow. If the pairs of angled corner dies 400 and 402 were registering with one another, instead of being staggered or offset, then it would not be possible to bring them as close together as might be desired to make a narrow web.

As shown in Figure 27, the upper angled dies 400 and 402 are mounted on angled axle shafts 404. There is no drive mechanism shown, in this embodiment of the invention, since the friction of the workpiece will be sufficient to drive the angled dies 400 and 402. However if required, the upper dies could of course be driven by suitable angled, or universal drives.

The angled rolls or dies 400 and 402 co-operate with respective lower dies 406 which engage the under surface of the web W. The lower dies 406 are driven by any suitable mechanism such as shaft 408 and gear 410. The angled dies can also be driven, through any suitable means such as angle drives of a type well known in the art, and requiring no description.

Because the angle rolls 400 and 402 are angled, and are of substantial diameter, they are able to reach around the inturned edge flanges E, an reach into the corners defined between the web W and the side flanges S. In this way a full 90 degree bend at this point or even greater angle if required is made possible to make the bend of an angle greater than 90 degrees if desired.

As already noted, the angle dies are staggered offset in pairs, so that even when the opposite roller die stands are brought close together for a narrow workpiece, as in the case of the universal and adjustable roller die line described above, the angle dies do not interfere with one another, and consequently this enables great flexibility in use since the apparatus can be used with relatively narrow web workpieces.

The roller die stands are of adjustable design, of the type described above, in which the roller die stands are mounted in continuous solid mounting plates 412 and 414, with the plates being moveable and adjustable towards and away from one another so as to readily accommodate workpieces of different widths as described above.

In order to hold the precise angle of bend between the workpiece W and the side edges S on each side, a plurality of side edge rolls 416, 418, etc., are provided. The side edge rolls 416 and 418 are freely rotatably mounted on axle shafts 420. As best shown in Figures 28 and 29, the axle shafts 420 of the rolls 416 and 418 are mounted in tilting mounting blocks 422. Mounting blocks 422 are formed with arcuate segments 428 on either side thereof.. Segments 428 are received within arcuate grooves 430, formed in cheek blocks 432. Cheek blocks 432 are adapted to be secured by bolts 434 to main mounting plates 412-414 of the apparatus.

The mounting blocks 422 are formed with an arch shaped channel 436 there through, to receive the lower die shaft 408.

The mounting blocks 422 are provided with slotted recesses 438. The recesses 438 are designed to receive the lower ends 440 of jack screws 442. Jack screws 442 can be operated by means of electrical motor 444.

In this way, operation of the motors 444 in one direction will cause tilting of the blocks upwardly, and operation of the motors 444 downwardly. This will in turn cause inward and outward tilting of the side dies 416 and 418 (see Figure 28).

By means of a suitable angle sensor 446 (Figure 26), the angle of the side flange S relative to the web W can be detected, and any variation can be instantaneously fed back to the motors 444 which will in turn correct the tilt of the side rolls 416 and 418, thus correcting the angle of the side flanges.

The lower ends 440 of jack screws 442 are pivotally secured in slots 438 by means of axle pins 448.

In certain cases it may be desirable to provide for adjustment of the upper corner forming angled dies 400, 402, to allow for changes in the thickness of the web material for example. Such adjustment will be particularly useful when the invention is used in conjunction with the universal type of roll forming line described above (Figure 1 and 2), in which all of the roller stands can be continuously adjusted to provide greater or lesser clearance between the dies to accommodate changes in the thickness of the workpiece. Thus the corner forming dies may be mounted on moveable mounting bodies 450. Mounting bodies 450 are mounted on parallel posts 452 extending vertically upward from the plates 412-414.

The lower dies 406 are preferably formed so as to extend the full width of the web of the workpiece and are shaped at each end shaped with a narrow angular rim 454 extending outwardly form the main body of the die 406. The upper die is also formed with a complementary ridge 456. The ridge and the rim cooperate together to lock the corner of the workpiece between the rim and the ridge and thus form a precision shaped angular bend, usually of 90 degrees, at this point.

A screw adjustment 458 (Figure 30) is provided which can be operated to cause mounting bodies 450 to slide upwardly or downwardly on posts 452. A dial 460 enables a visual check of the setting of the bodies 450. A motor 462 can be provided for operating screw 458. The motor can be connected to the main control console controlling all of the roller die stands (not shown), enabling the entire line to be automatically adjusted on a continuous basis to accommodate changes in web thickness.

In order to adjust the upper dies transversely, the posts or columns 452 are mounted in bases 464, held by rails 468 (88?). The bases can thus be slid transversely to and fro. An adjustment screw 470 is provided, which can also be motor driven if desired, by means not shown. Operation of screw 470 will cause transverse sliding movement of base 464 thus adjusting the upper die inwardly or outwardly, as shown in phantom in Figure 28, relative to the lower die and relative to the side rolls, to allow for variations in web thickness.

The foregoing is a description of a preferred embodiment of the invention which is given here by way of example only. The invention is not to be taken as limited to any of the specific features as described but comprehends all such variations thereof as come within the scope of the appended claims.

CLAIMS

1. A roller die apparatus for supporting pairs of roller dies (10, 12, 14, 16...) in predetermined axial and transverse clearances for processing a web workpiece, which is an improvement over what was previously as known for adjustment of the upper die vertically relative to the lower die to adjust the vertical clearance between the upper die and the lower die, and in which the invention is characterized by the ability to vary both the axial and the transverse clearances between said roller dies to accommodate variations in the thickness of a web workpiece passing therebetween, said apparatus being comprised of;

first and second roller dies (46, 48, 54, 56) rotatably mounted on respective roller die stands (10A, 10B, 12A, 12B, 14A, 14B...);

moveable die bearing means for moving one of said first and second roller dies (46, 48, 54, 56) upwardly and downwardly transversely to its axis of rotation, and for moving one of said first and second roller dies (46, 48, 54, 56) axially along its axis of rotation, thereby achieving adjusting of the die clearance between said first and second roller dies in two planes, and including;

axial movement transmission means (128) coupling all of said moveable bearing means together for axial movement in unison, and further including;

transverse movement transmission means (142) coupling said moveable bearing means for transverse movement in unison; and,

power operated means (134, 152) for operating each of said movement transmission means.

2. A roller die apparatus as claimed in claim 1 and including a thickness sensor (60) for sensing the thickness of said web material workpiece, and generating a thickness signal in response thereto, and signal responsive means (64) for generating movement signals for moving said movement transmission means, whereby to procure simultaneous movement of said moveable bearing means in response to said thickness signal.

3. A roller die apparatus as claimed in claim 1 and including right and left edge forming roller die assemblies (250, 252) for rolling edge formations and means for moving said edge forming assemblies relative to one another.

4. A roller die apparatus as claimed in claim 1 and including straightening rolls (300A, 300B) adapted to engage the workpiece after exiting from the roller dies to correct warping of the workpiece.

5. A roller die apparatus as claimed in claim 1 and including right and left hand finish die support assemblies (250, 252), located on opposite sides of sides of said workpiece;

respective pairs of inner and outer roller dies (254, 256) being supported on respective said right and left hand die support assemblies, said dies being rotatable about vertical spaced axes, and said dies lying in essentially horizontal planes; and,

means (288, 290) for driving at least said outer dies of said pairs simultaneously.

6. A roller die apparatus as claimed in claim 5 and wherein said die assemblies are mounted on moveable carriages (258), for movement upwardly or downwardly, and including power operated movement means (262, 264, 266) for moving said assemblies upwardly and downwardly, to accommodate workpieces of varying heights.

7. A roller die apparatus as claimed in claim 1 and including;

right and left hand finishing die stands (300A, 300B), said finishing die stands being moveable towards and away from one another;

lower and upper finishing dies (302, 305) on each of said stands;

an intermediate side die (306) between said lower and upper dies on each of said finishing die stands, whereby said upper and lower dies and said side dies may engage a said workpiece on three surfaces normal to one another, along each edge of a said workpiece.

8. A roller die apparatus as claimed in claim 7 and including movement means (308) for moving one of said upper and lower dies relative to the other, whereby to accommodate workpieces of varying height.

9. A roller die apparatus as claimed in claim 8 and including;

fixed lower die means (322) engaging an underside of said workpiece at a predetermined pass line level for said workpiece;

leading correcting die means (324) and trailing correcting die means (326), said leading and trailing correcting die means being mounted on a common mounting yoke (330);

pivotal mounting means (332) for said yoke, whereby said yoke may swing, so as to raise one of said leading and trailing correcting die means and lower the other;

power operated means (334) for swinging said yoke, whereby to cause either said leading correcting die or said trailing correcting die to engage an upper portion of said workpiece, said leading and trailing dies being located spaced apart from one another on opposite sides of said lower die, thereby causing either downward bending of said workpiece or upward bending of said workpiece, to correct warping and straighten said workpiece.

10. A roller die apparatus as claimed in claim 9 and including correcting side die means (328), engageably with opposite sides of said workpiece, and means for moving said correcting die means from side to side, whereby to cause straightening of said workpiece from one side to the other.

11. A roller die apparatus as claimed in claim 1 and including

respective right and left hand die stands (38, 40) for supporting respective pairs of upper and lower dies;

means (59) interconnecting said die stands for movement towards and away from one another;

die drive shafts (42, 44) extending from one of said die stands towards the other of said die stands in each pair, movement of said die stands apart from one another causing separation of said drive shafts from said other of said die stands, whereby to leave a spacing therebetween; and,

a spacer roll support (86) located beneath said die stands, and movement means (96, 102) for moving said spacer roll support upwardly and downwardly, and spacer rolls (84) supported on said spacer roll support, whereby when said die stands are moved apart, said spacer rolls may be moved upwardly into registration with said drive shafts (42, 44), after which said die stands may be moved towards one another, said drive shafts thereby engaging selected ones of said spacer rolls supported therebetween.

12. A roller die apparatus as claimed in claim 11 wherein said die drive shafts (42, 44) are located in first ones of said die stands, and wherein said second ones of said die stands are provided with die support bearing means (50, 52), and said bearing means defining drive recesses for telescopic interengagement with said drive shafts, whereby when said drive shafts are in telescopic inter-engagement with said recesses, whereby said dies on both said die stands are driven simultaneously.

13. A roller die apparatus as claimed in claim 12 wherein said spacer rolls define axial openings , said die drive shafts being dimensioned to be received in said axial openings when said die stands are moved towards one another.

14. A roller die apparatus as claimed in claim 1 and including

side flange corner forming upper dies (400,402);

angled shafts (404) on which said corner forming dies are mounted, whereby said corner forming dies are adapted to fit around said edge flanges (E) of said workpiece and enter into the side flange (S) corners; and,

side flange control rolls (416, 418) engaging the outer surface of said side flanges (S), said control rolls being movably mounted for tilting inwardly or outwardly, so as to produce a greater or lesser degree of bend between the side flanges (S) and the web (W).

15. A roller die apparatus as claimed in claim 14 and including mounting blocks (422) for mounting said side control rolls, and means (423, 430) movably supporting said mounting blocks whereby the same may be tilted between two positions.

16. A roller die apparatus as claimed in claim 14 and including support means (450, 452) moveable in a vertical plane to adjust the location of said angled roll upwardly and downwardly.

17. A roller die apparatus as claimed in claim 14 and wherein said side support means (450, 452) is moveable in a horizontal plane to adjust the location of said angled roll inwardly and outwardly.

18. A roller die apparatus as claimed in claim 14 and including control motor means for moving said side flange control rolls, whereby they can be tilted in and out by said motor means, and side flange angle sensors for sensing the angle of the side flanges, and operating said motor means.

19. A roller die apparatus as claimed in claim 14 and including angled roll mounting means for mounting said angled rolls, and bearing means supported by said mounting means defining a bearing axis, said bearing axis being angled to conform to the roll axis of said angled roll.

20. A roller die apparatus as claimed in claim 19 wherein said mounting means is supported on side support means forming part of said apparatus, and is angled downwardly therefrom towards said workpiece.

21. A roller die apparatus as claimed in claim 20 and wherein said side support means is moveable in a vertical plane to adjust the location of said angled roll upwardly and downwardly.

22. A roller die apparatus as claimed in claim 21 and wherein said side support apparatus is moveable in a horizontal plane to adjust the location of said angled roll inwardly and outwardly.

23. A roller die apparatus as claimed in claim 14 and wherein a lower roll extends the full width of the web of the workpiece and including end flanges formed at each end of said lower roll to engage said corners of said web and said side flanges.

24. A roller die apparatus as claimed in claim 23 and including a ridge formed on said angled dies, said ridge being shaped and oriented to cooperate with said end flanges on said lower rolls and achieve secure engagement of said workpiece at said corner, between said end flanges and said ridges.

25. A roller die apparatus as claimed in claim 1 and including

side flange corner forming upper dies (400,402); and,

side flange control rolls (416, 418) engaging the outer surface of said side flanges (S), said control rolls being movably mounted for tilting inwardly or outwardly, so as to produce a greater or lesser degree of bend between the side flanges (S) and the web (W).

26. A roller die apparatus as claimed in claim 25 and including mounting blocks for mounting said side control rolls, and means movably supporting said mounting blocks whereby the same may be tilted between two positions.

27. A roller die apparatus as claimed in claim 25 and including cheek plates secured in pairs on opposite sides of said mounting blocks, arcuate grooves formed in said cheek plates, and arcuate ridges formed on said mounting blocks and movably received in respective said arcuate grooves.

28. A roller die apparatus as claimed in claim 27 and including arch shaped passageways formed in said mounting blocks for receiving drive shafts therein for driving said lower rolls.

29. A roller die apparatus as claimed in claim 28 and including a slotted recess formed in each said mounting block , and control means for said mounting blocks, a portion of said control means being received in said slotted recess.

30. The method of continuously roller die a web work piece in a roll forming apparatus for supporting pairs of roller dies (10, 12, 14, 16...) in predetermined clearances for processing a web workpiece, and which is an improvement over what was known previously to vary the spacing vertically between the upper and the lower die so as to allow for variations in spacing between the horizontal surfaces of the upper and lower dies, and in which the invention is characterized by;

varying said clearances between said roller dies in two planes to accommodate variations in the thickness of a web workpiece passing there between, said apparatus having first and second roller dies (46, 48, 54, 56) rotatably mounted on respective roller die stands (10A, 10B, 12A, 12B, 14A, 14B...), means for moving one of said first and second roller dies (46, 48, 54, 56) upwardly and downwardly transversely to its axis of rotation means for moving one of said first and second roller dies (46, 48, 54, 56) axially along its axis of rotation, thereby achieving adjusting of the die clearance between said first and second roller dies in two planes, and the method being characterised by the steps of;

moving said one of dies relative to the other along an axis parallel to the axis of rotation, while said web workpiece in moving, and simultaneously moving said die transverse to its axis.

31. The method as claimed in claim 30 and including a thickness sensor (60) for sensing the thickness of said web material workpiece, and including the step of generating a thickness signal in response thereto, and signal responsive means (64) for generating movement signals, and moving said die in response thereto in response to said thickness signal.

32. The method as claimed in claim 30 and including right and left edge forming roller die assemblies (250, 252), and including rolling edge formations on said web and moving said edge forming assemblies relative to one another to compensate for variations in thickness of said web.

33. The method as claimed in claim 30 and including straightening rolls (300A, 300B) adapted to engage the workpiece after exiting from the roller dies, and engaging said workpiece and correcting warping of the workpiece.

34. The method as claimed in claim 30 wherein said apparatus includes respective right and left hand die stands (38, 40) for supporting respective pairs of upper and lower dies means (59) interconnecting said die stands for movement towards and away from one another die drive shafts (42, 44) extending from one of said die stands towards the other of said die stands in each pair, movement of said die stands apart from one another causing separation of said drive shafts from said other of said die stands, whereby to leave a spacing therebetween and, a spacer roll support (86) located beneath said die stands, and movement means (96, 102) for moving said spacer roll support, upwardly and downwardly, and spacer rolls (84) supported on said spacer roll support,

and including the step of moving said spacer rolls moved upwardly into registration with said drive shafts (42, 44);

moving said die stands towards one another, said drive shafts thereby engaging selected ones of said spacer rolls supported therebetween.

35. The method as claimed in claim 30 wherein said apparatus includes fixed lower die means (322) engaging an underside of said workpiece at a

predetermined pass line level for said workpiece, leading correcting die means (324) and trailing correcting die means (326), said leading and trailing correcting die means being mounted on a common mounting yoke (330), pivotal mounting means (332) for said yoke, whereby said yoke may swing, so as to raise one of said leading and trailing correcting die means and lower the other, power operated means (334) for swinging said yoke;

and including the step of causing either said leading correcting die or said trailing correcting die to engage an upper portion of said workpiece, said leading and trailing dies being located spaced apart from one another on opposite sides of said lower die, thereby causing either downward bending of said workpiece or upward bending of said workpiece, to correct warping and straighten said workpiece.

36. The method as claimed in claim 30 and including the step of;

engaging the outer surface of said side flanges (S), and engaging said side flange corners with said side flange upper dies.

37. The method as claimed in claim 36 and including moving said corner dies in a vertical plane to adjust the location of said corner dies upwardly and downwardly, and moving said corner dies in a horizontal plane to adjust the location of said corner dies inwardly and outwardly.

38. The method as claimed in Claim 37 and including the steps of sensing the angle formed by said corner forming dies, and adjusting the angles of said side rolls to correct said angle.

Whilst the above has been given by way of illustrative example of the present invention many variations and modifications thereto will be apparent to those skilled in the art without departing from the broad ambit and scope of the invention as herein set forth.

DATE this 31st day of March, 2000

MICHAEL SURINA
By his Patent Attorneys
INTELLPRO

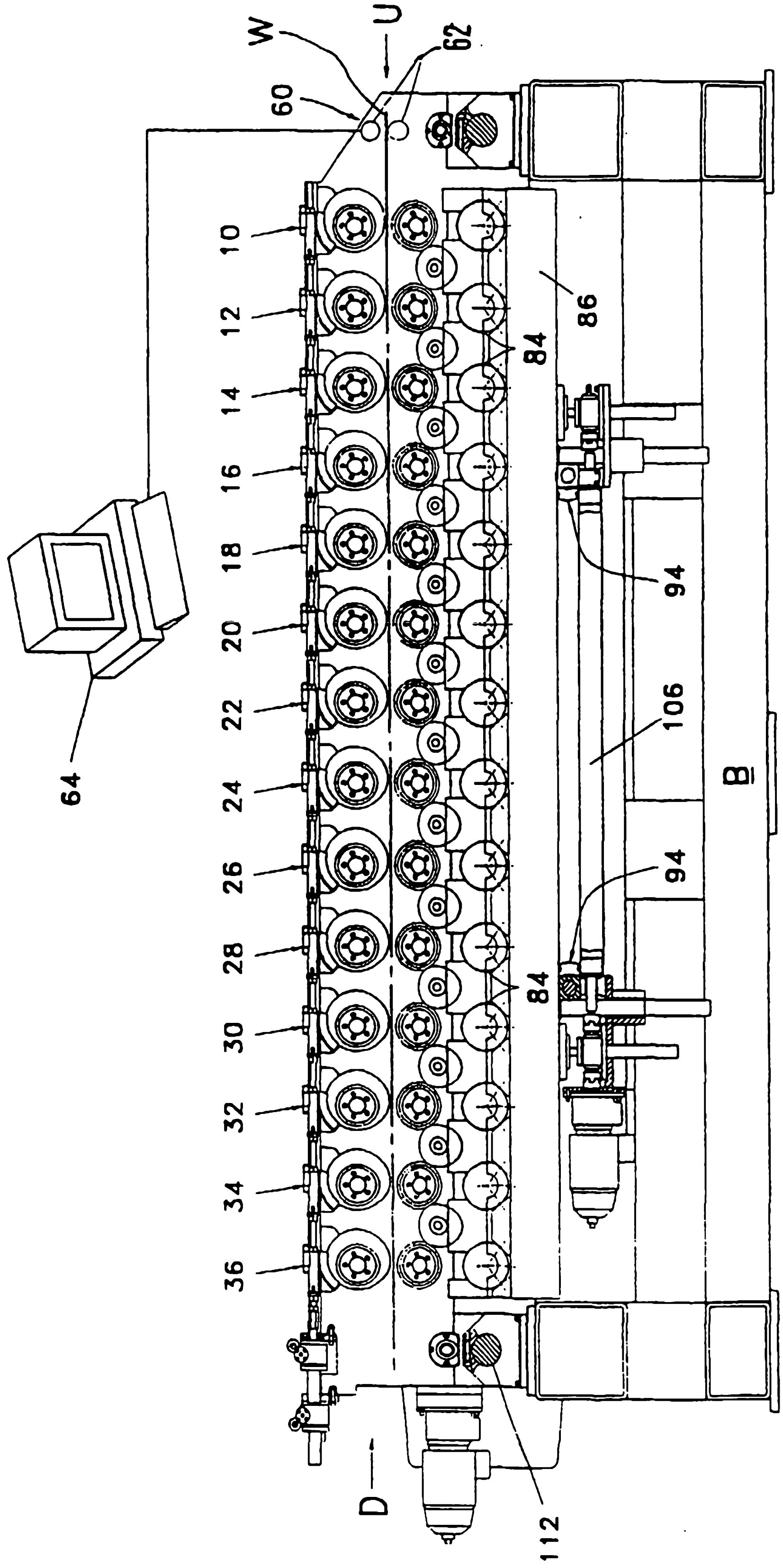

Fig 1

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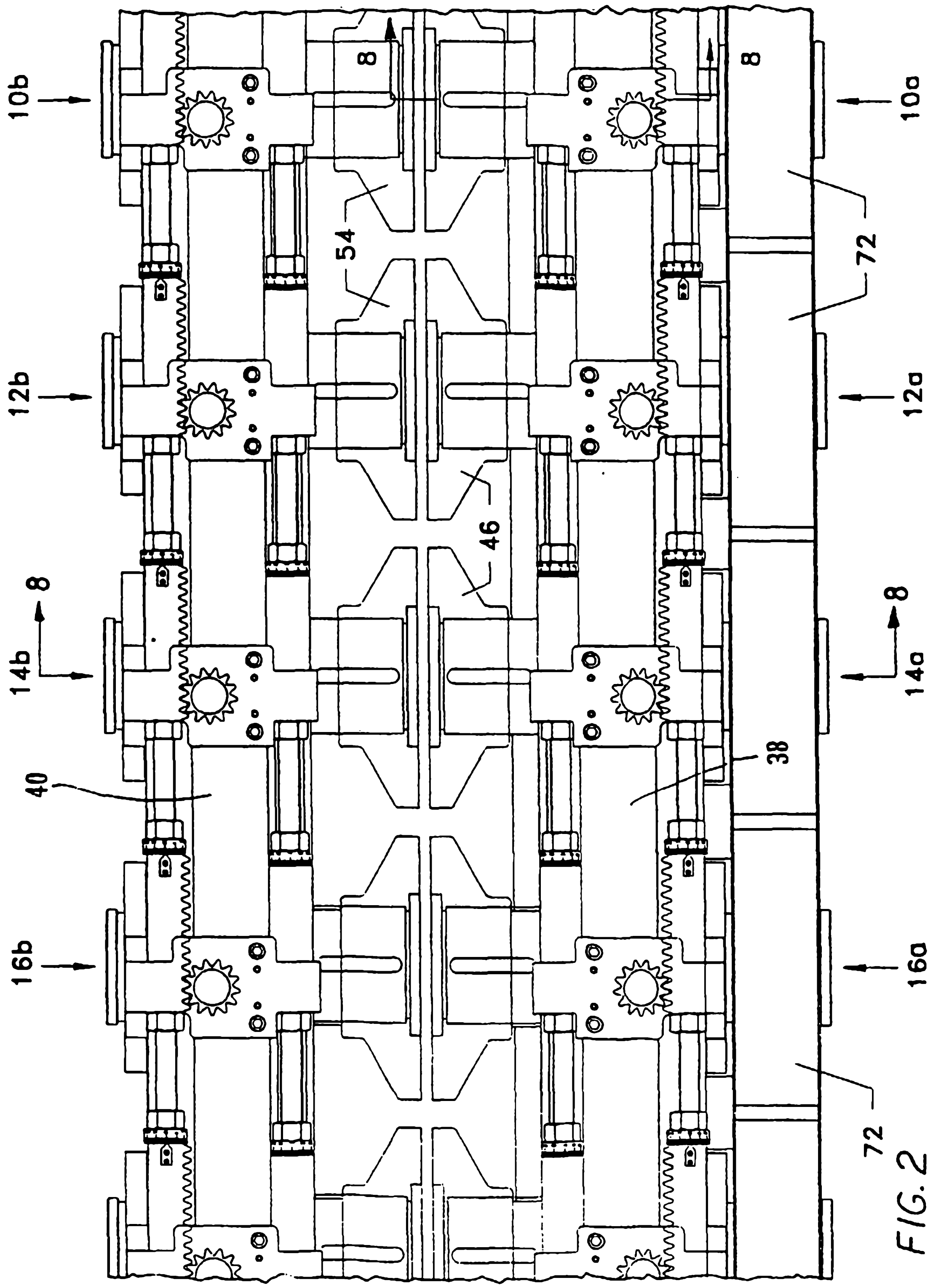

FIG. 2

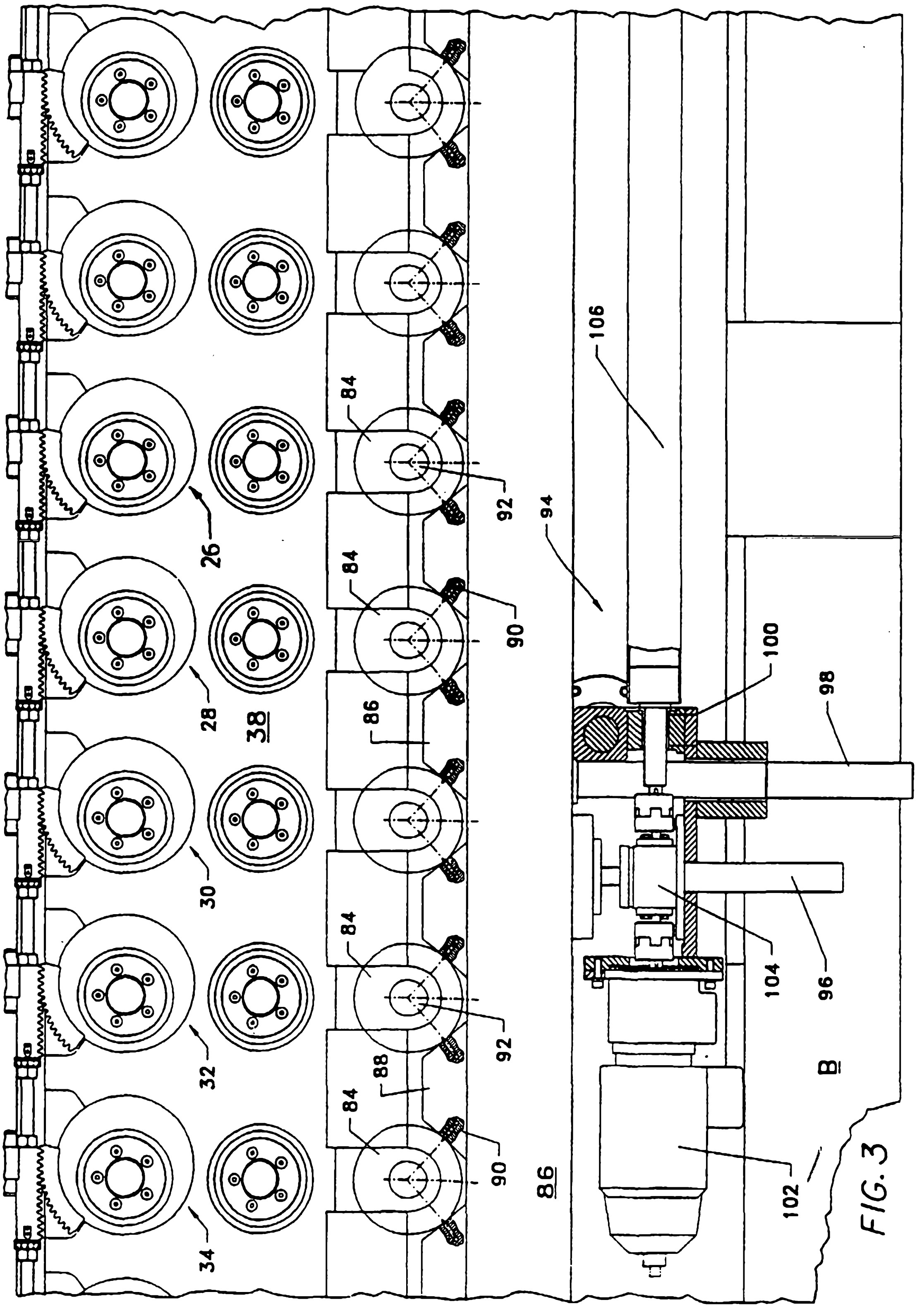

FIG. 3

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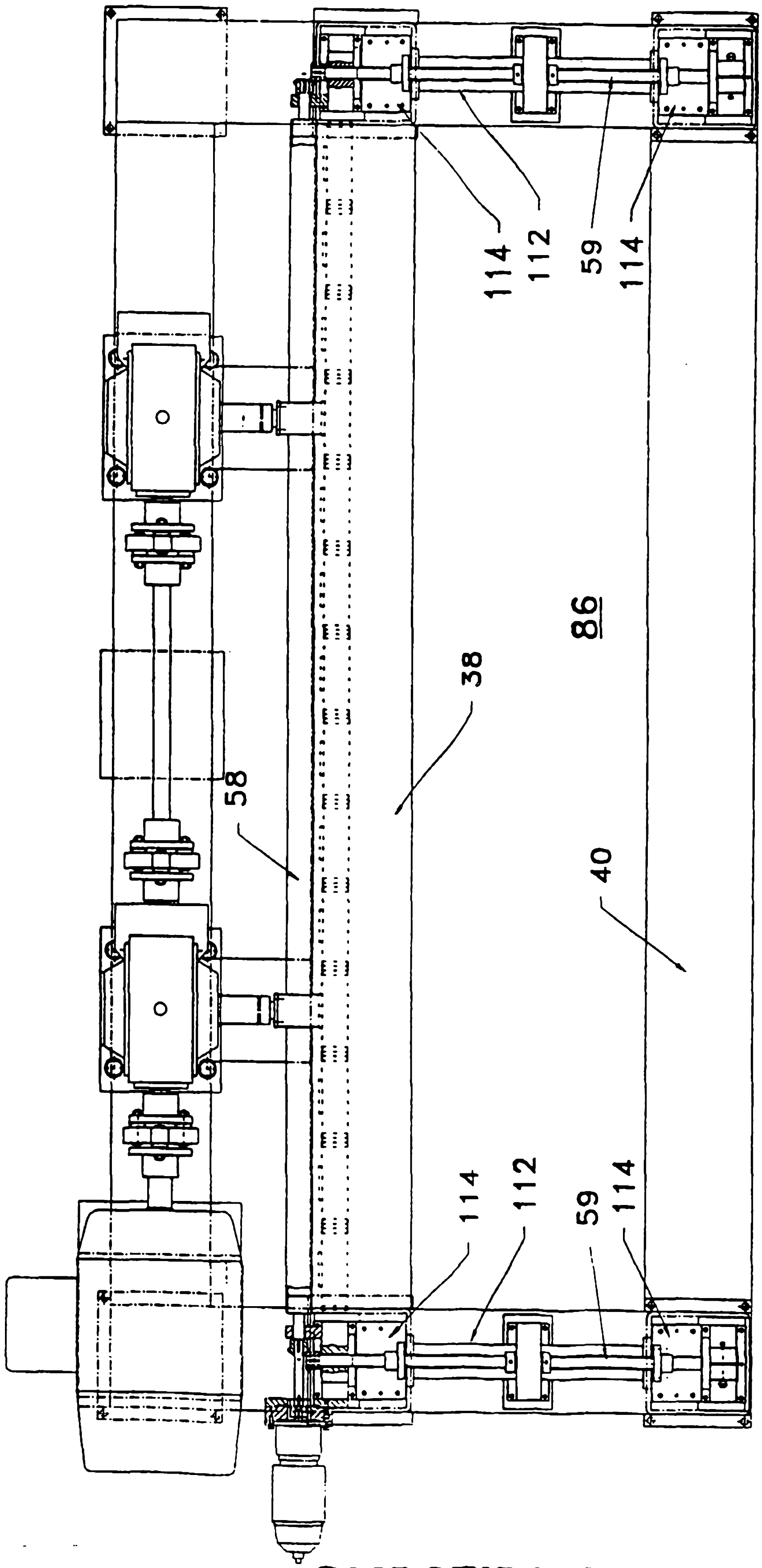
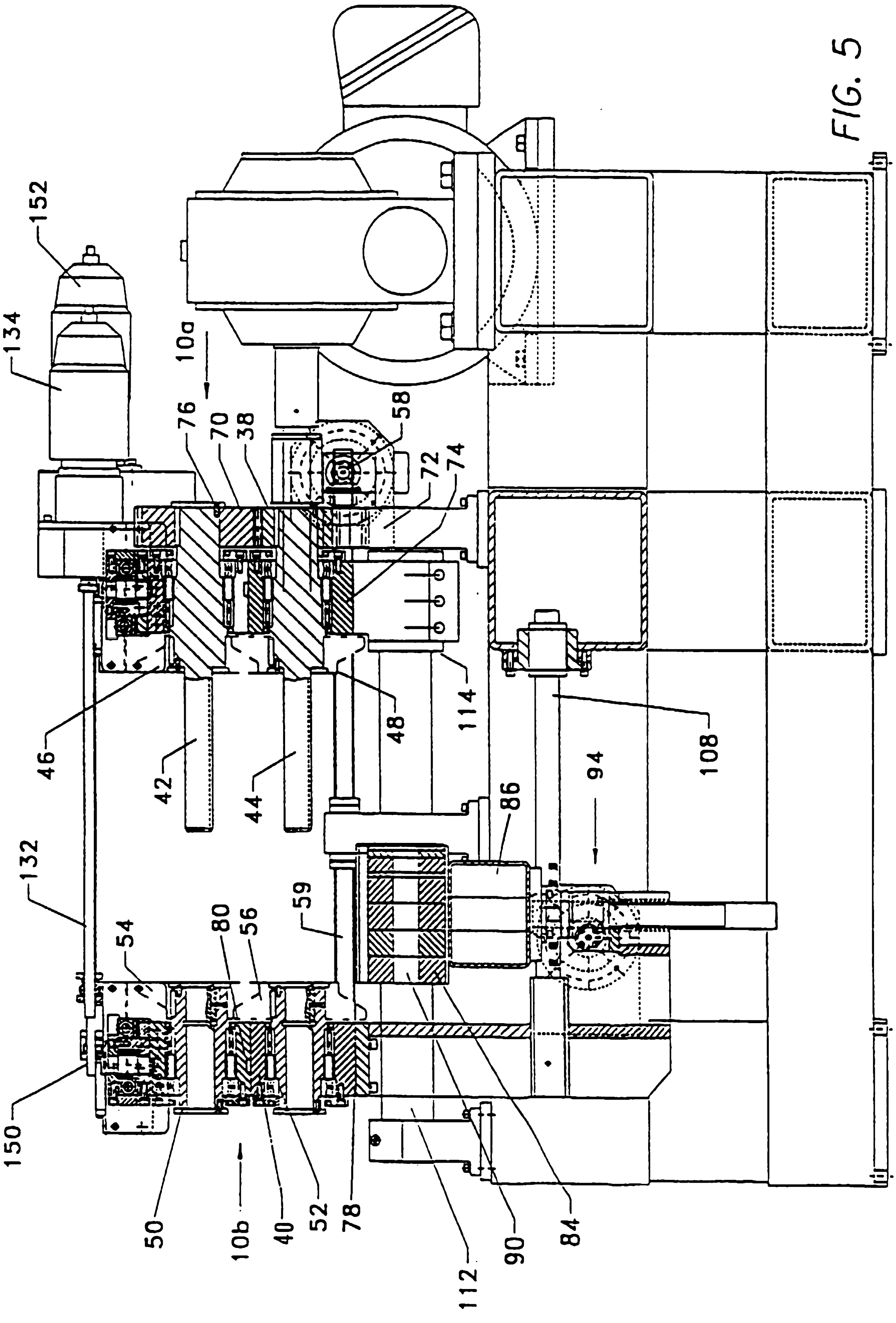


FIG. 4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134
10a
76
70
38
58
72
74
46
42
44
48
114
108
94
86
132
54
80
56
59
150
50
10b
40
52
78
112
90
84

FIG. 5

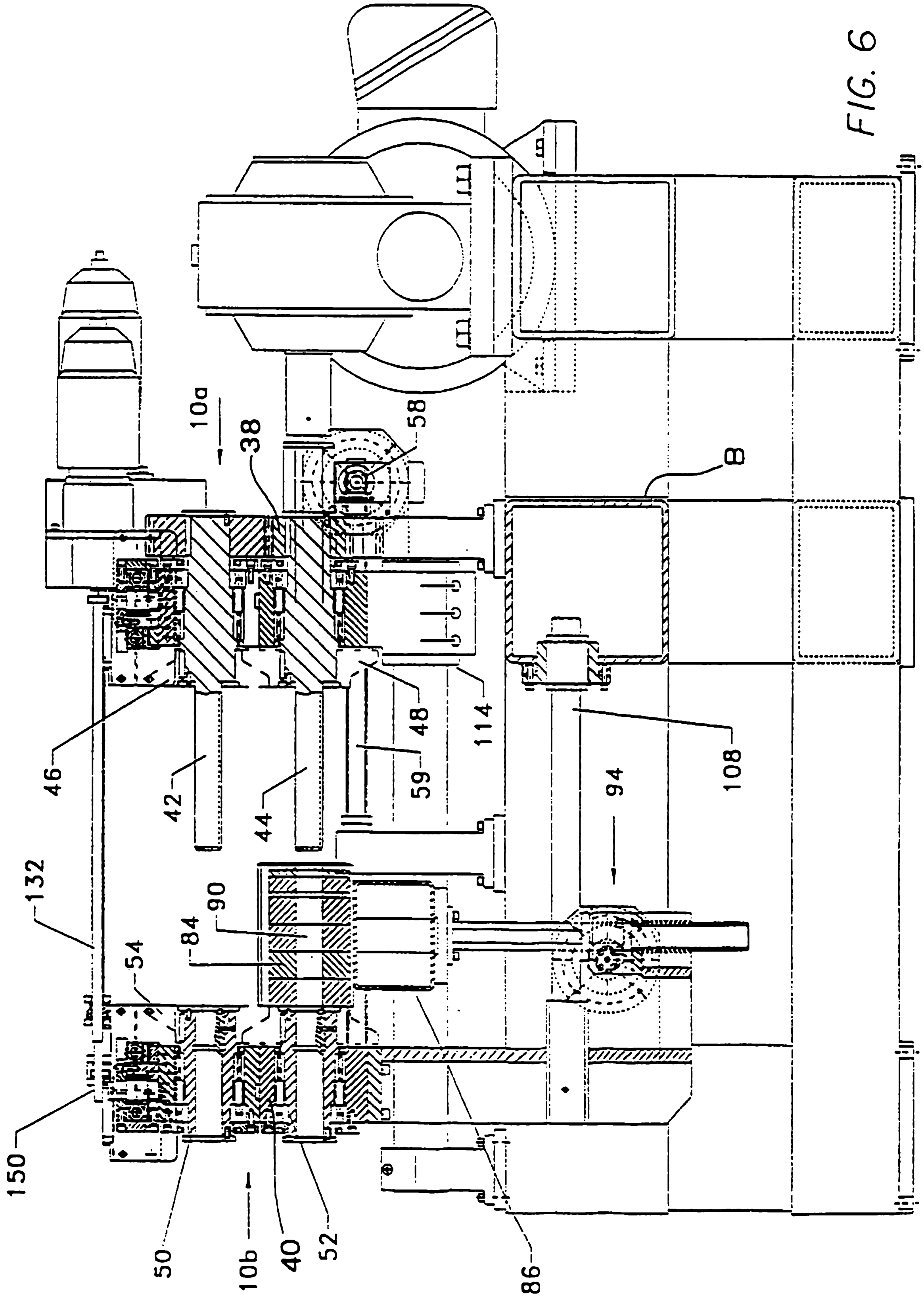


FIG. 6

SUBSTITUTE SHEET

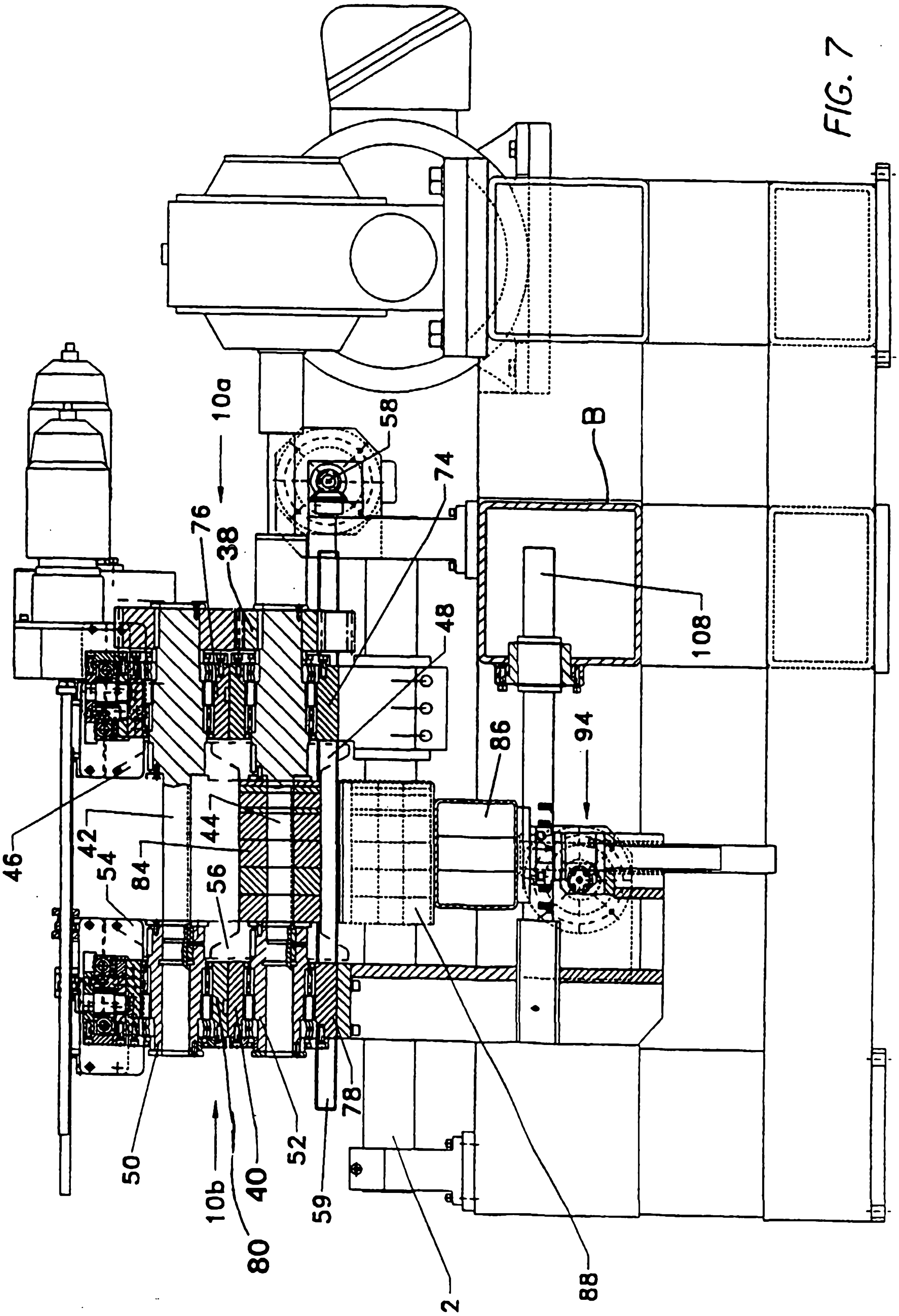

10a
58
74
B
76
38
48
108
86
94
46
42
54
44
84
56
50
40
10b
80
52
59
78
112
88

FIG. 7

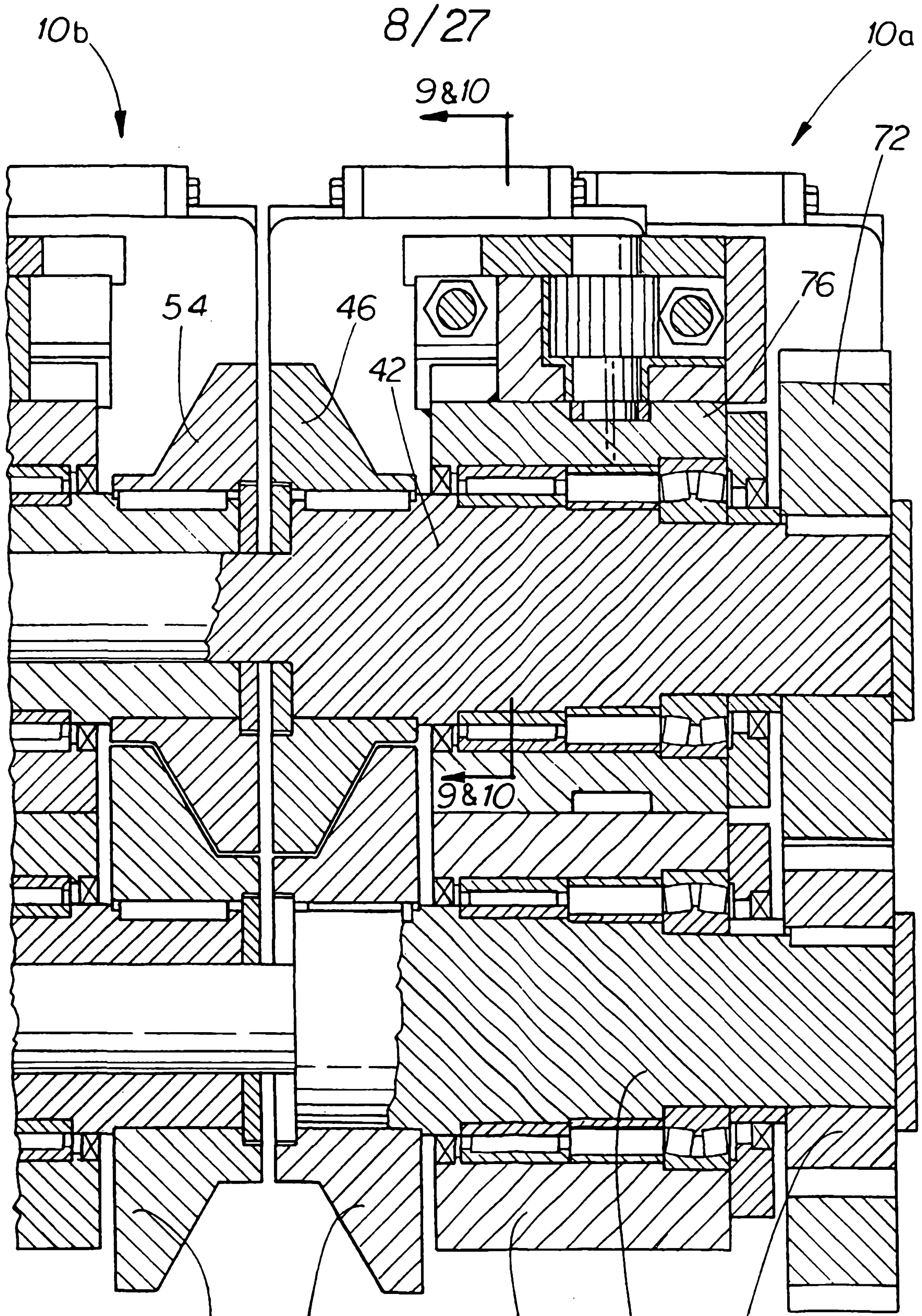


FIG. 8

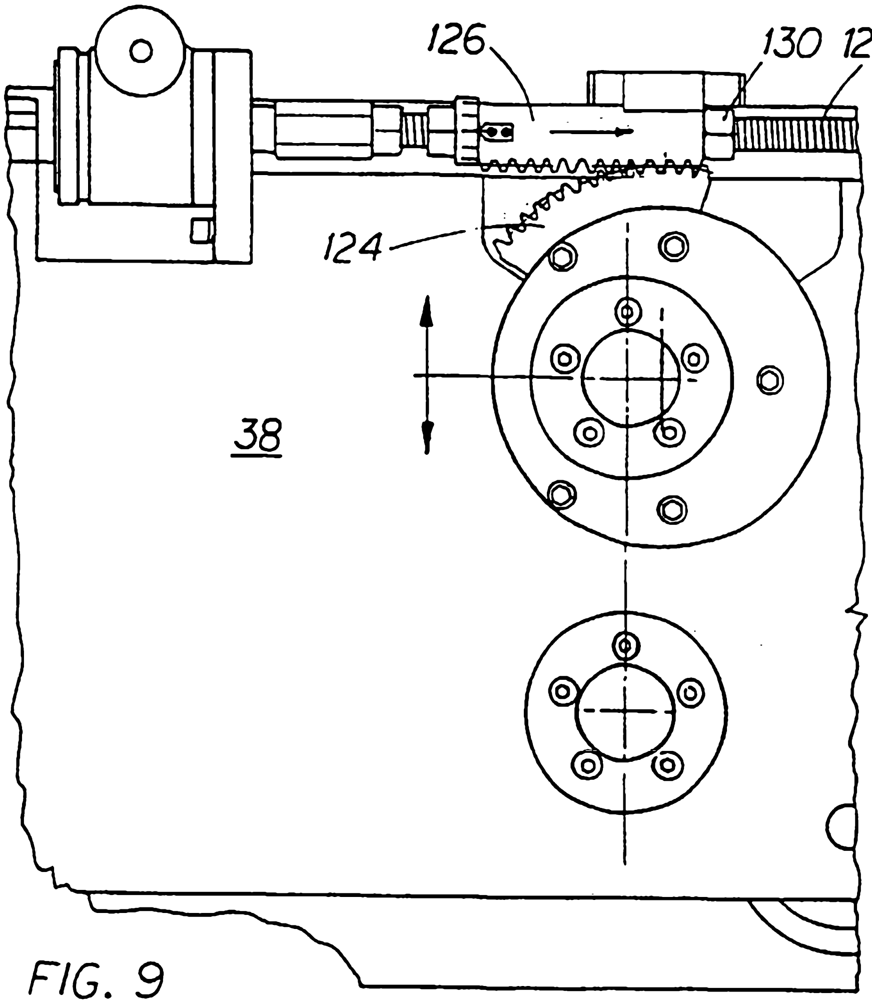


FIG. 9

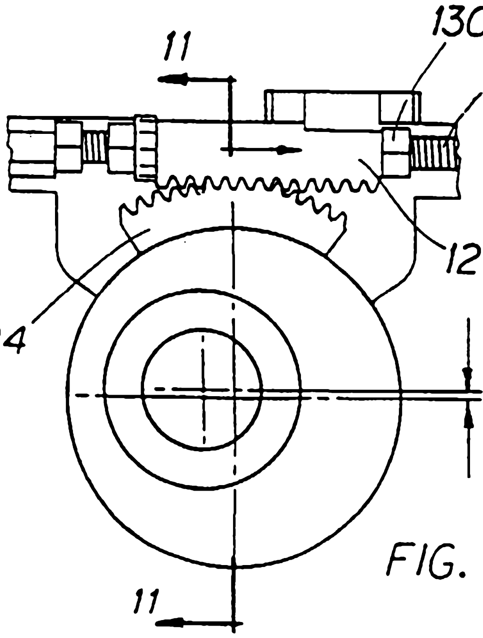


FIG. 10

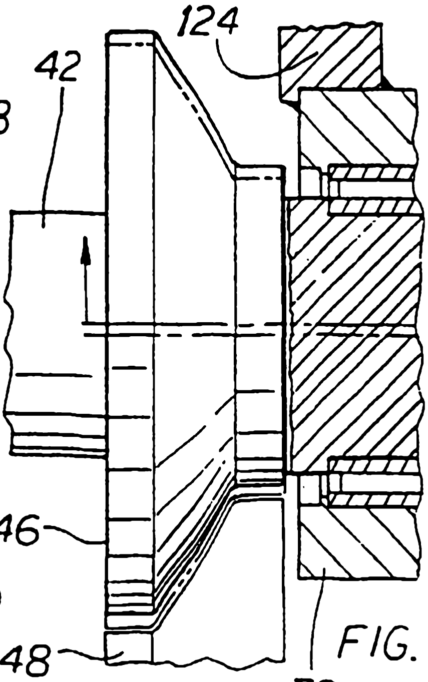


FIG. 11

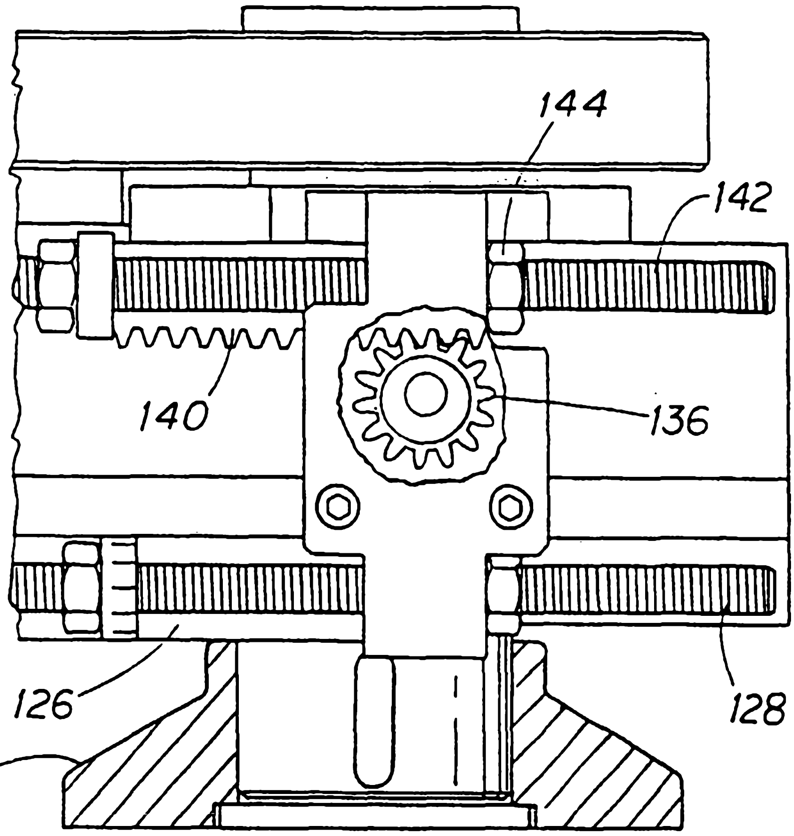


FIG. 12

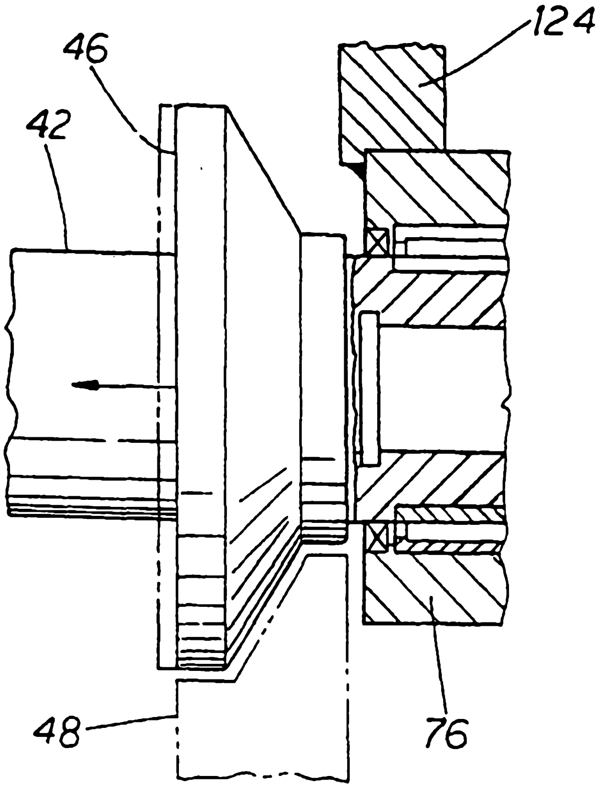


FIG. 13

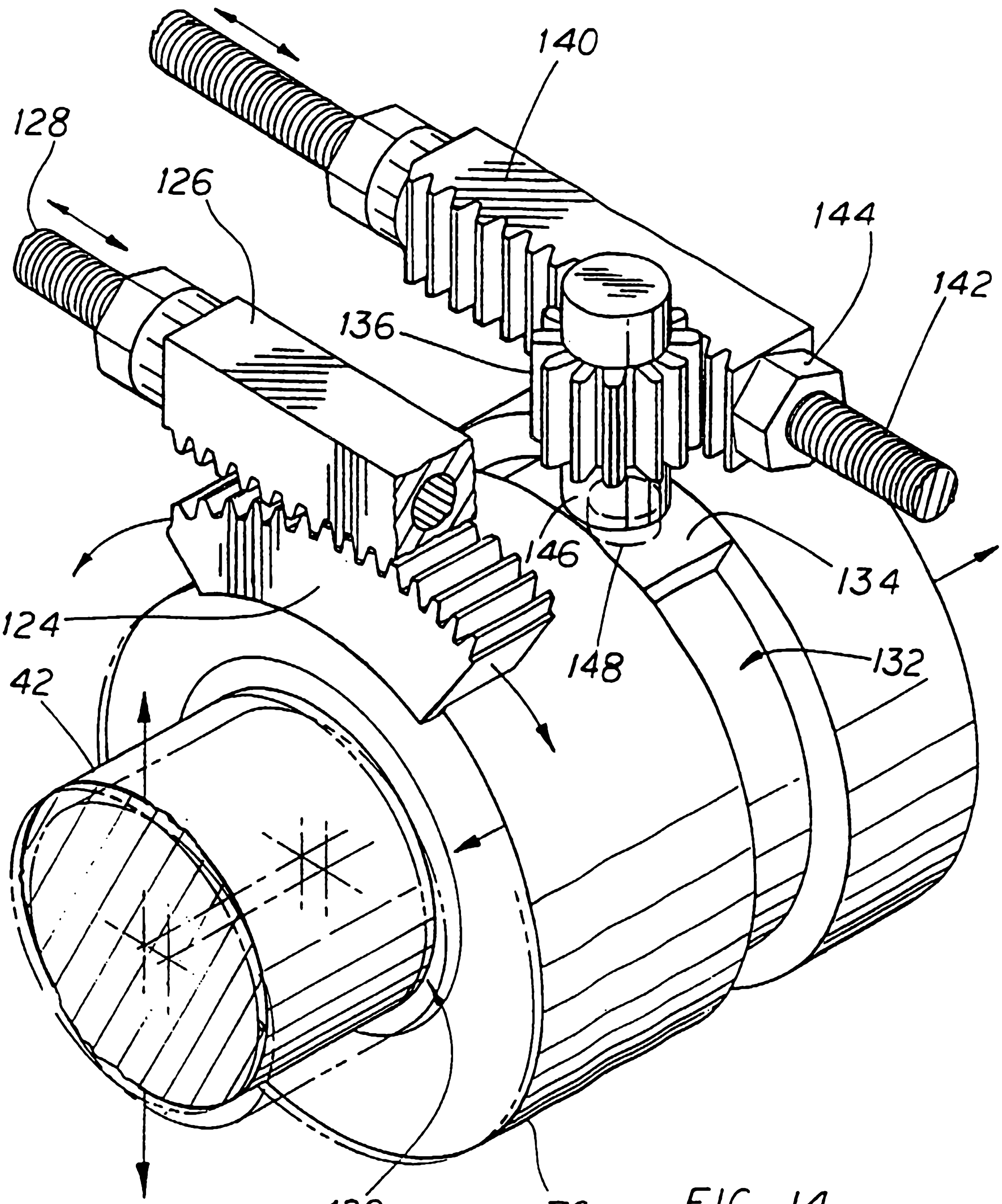
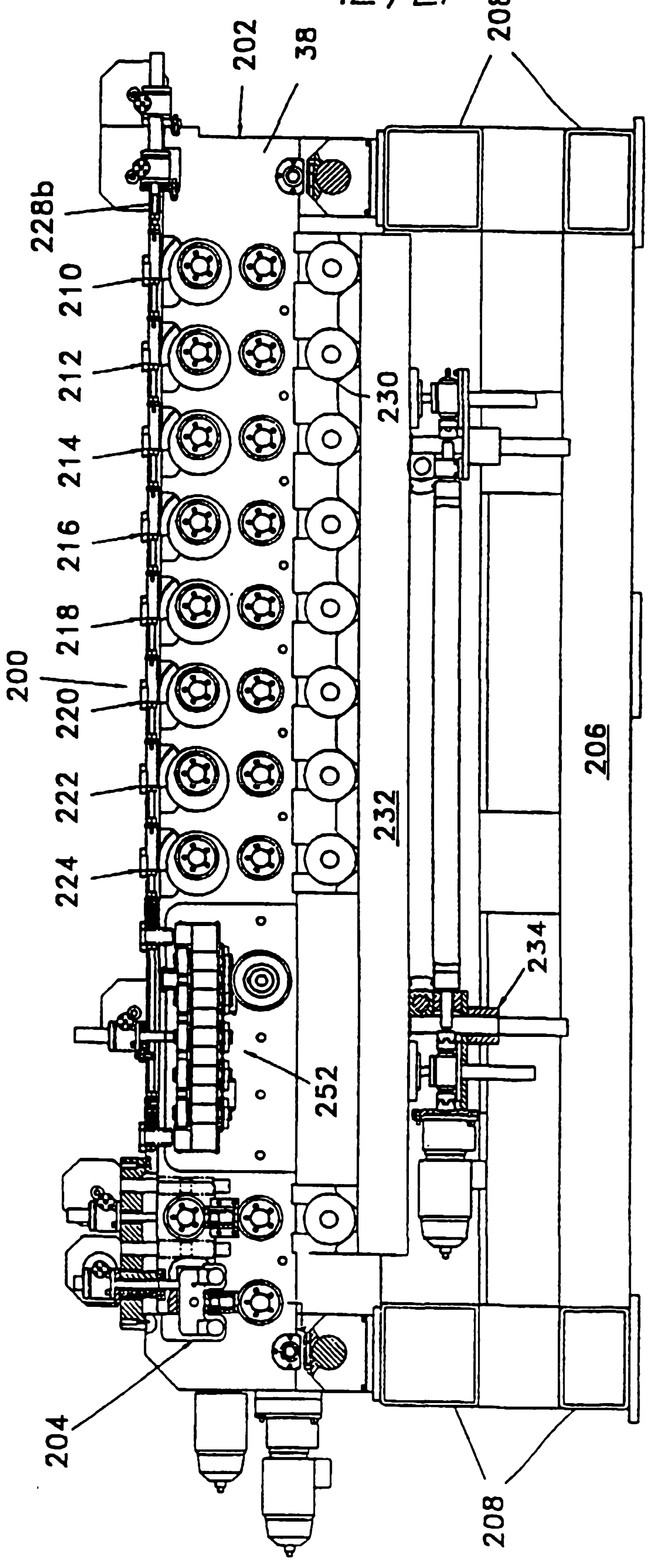


FIG. 14

12/27


202
38
208
228b
210
212
214
216
218
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222
224
230
232
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252
204
208

FIG. 15

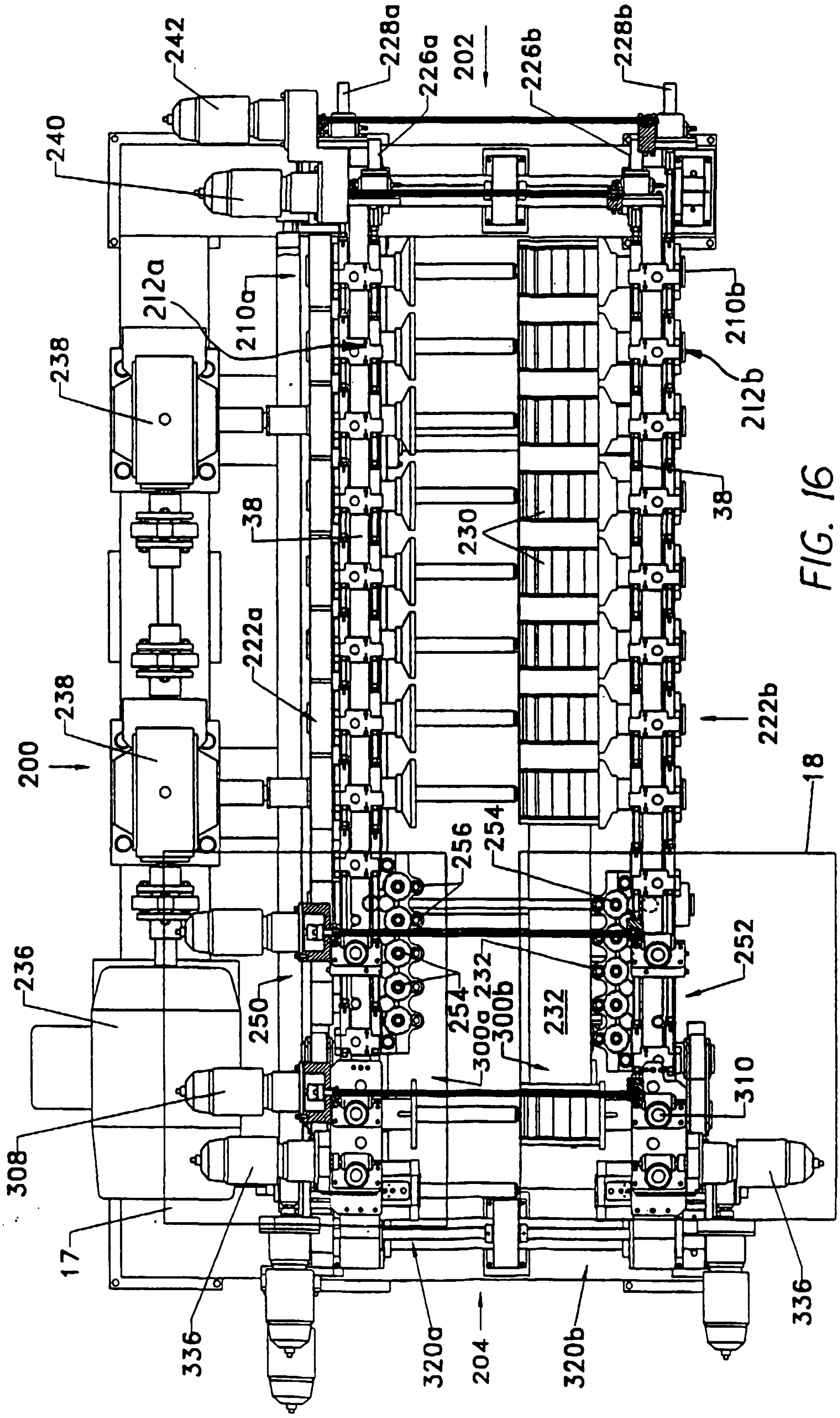


FIG. 16

SUBSTITUTE SHEET

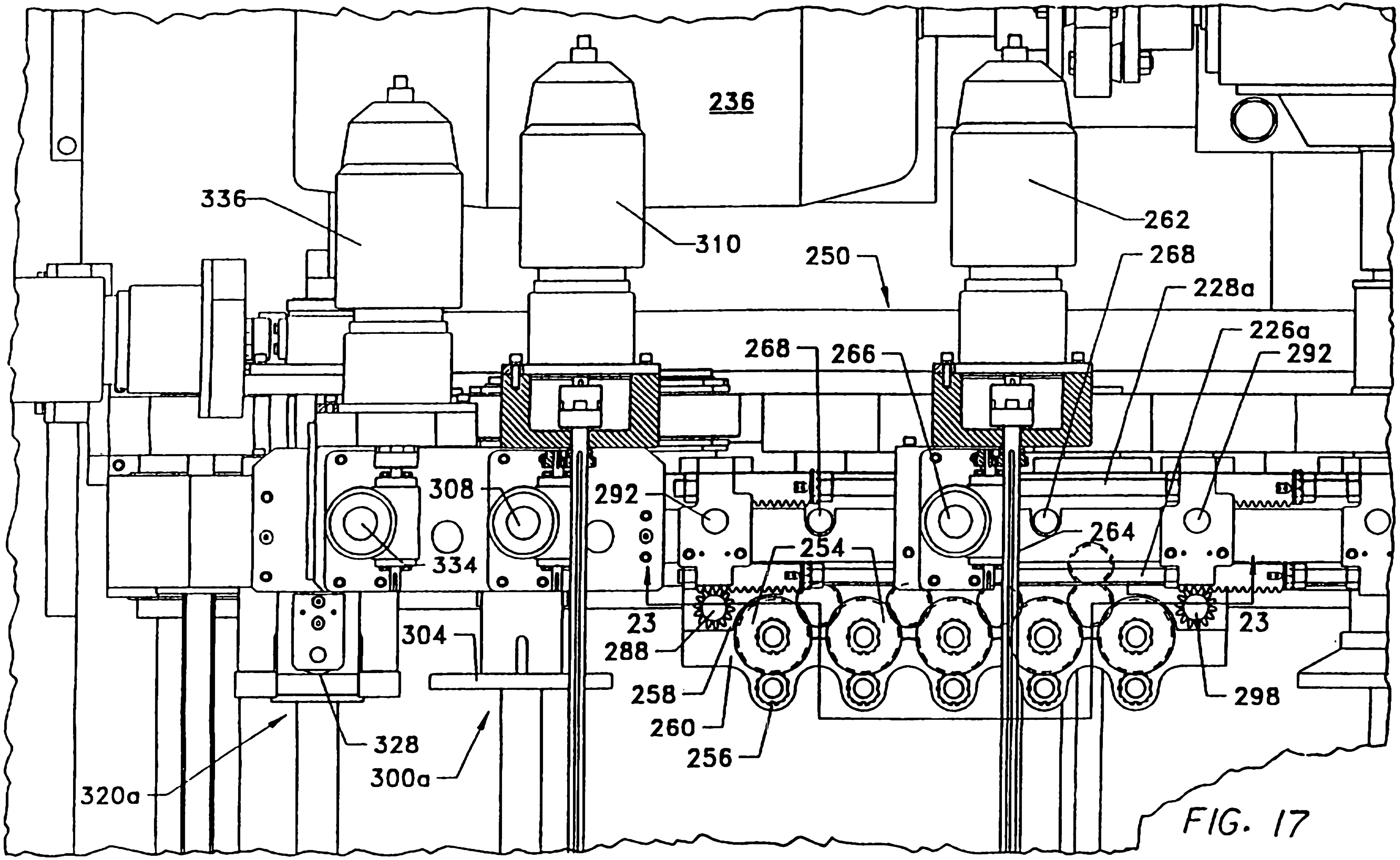

236
336
310
262
250
268
228a
226a
292
268
266
308
292
264
254
334
23
23
304
288
258
298
260
256
328
300a
320a

FIG. 17

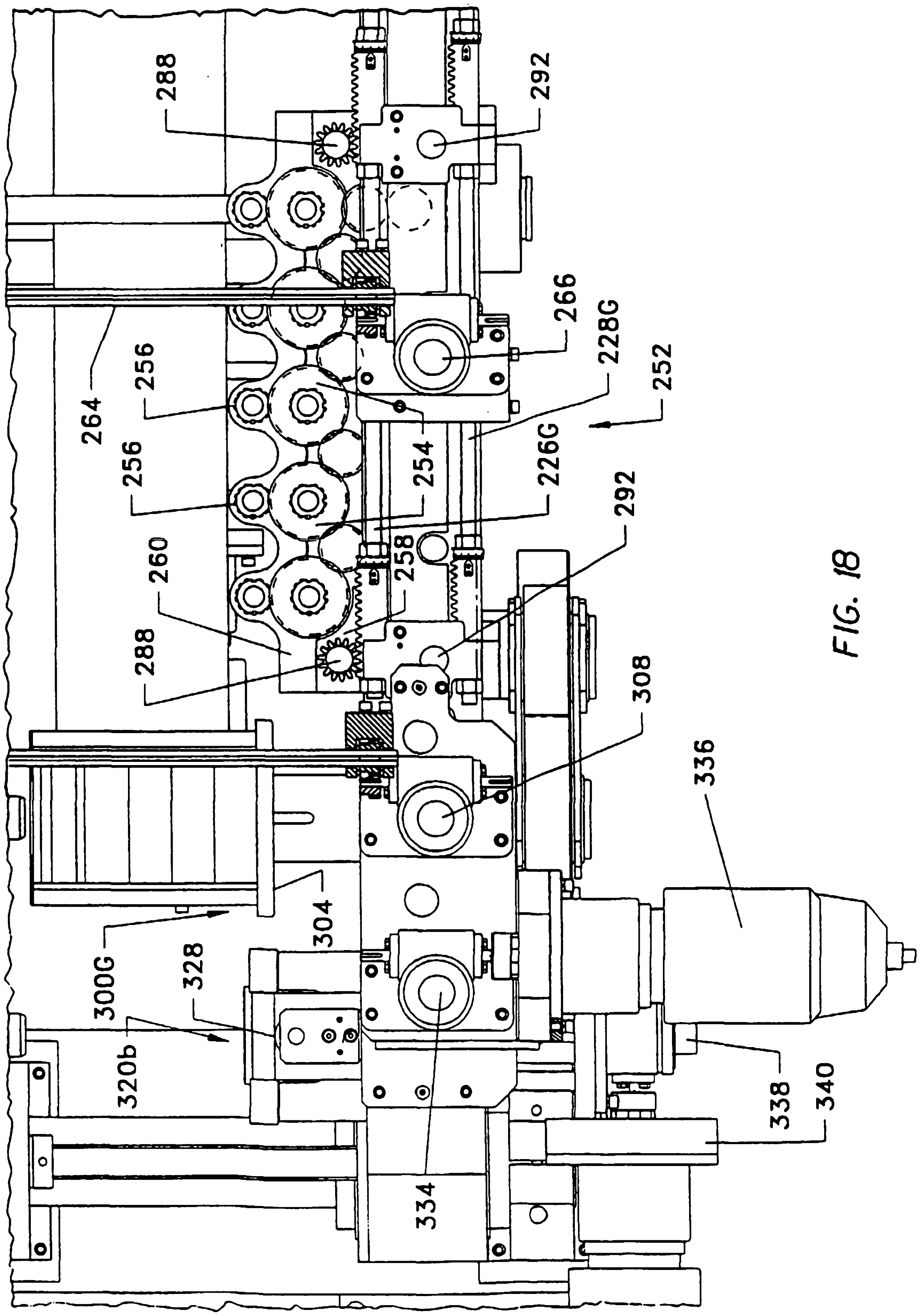
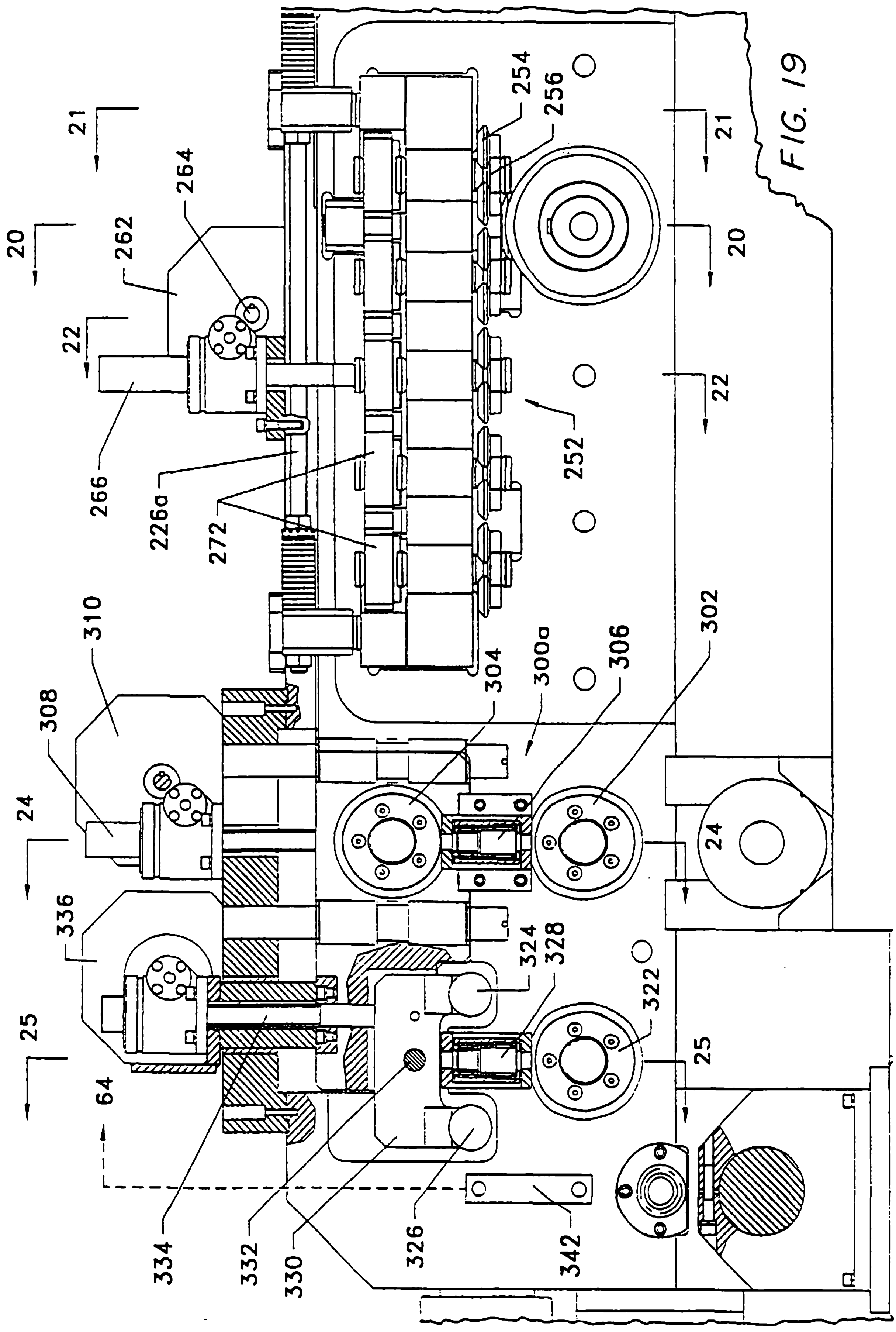

288
292
266
228G
252
264
256
254
226G
256
292
260
258
288
308
336
304
300G
328
320b
338
340
334

FIG. 18

16/27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256
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20
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22
266
226a
272
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308
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302
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322
25
64
334
332
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326
342

FIG. 19

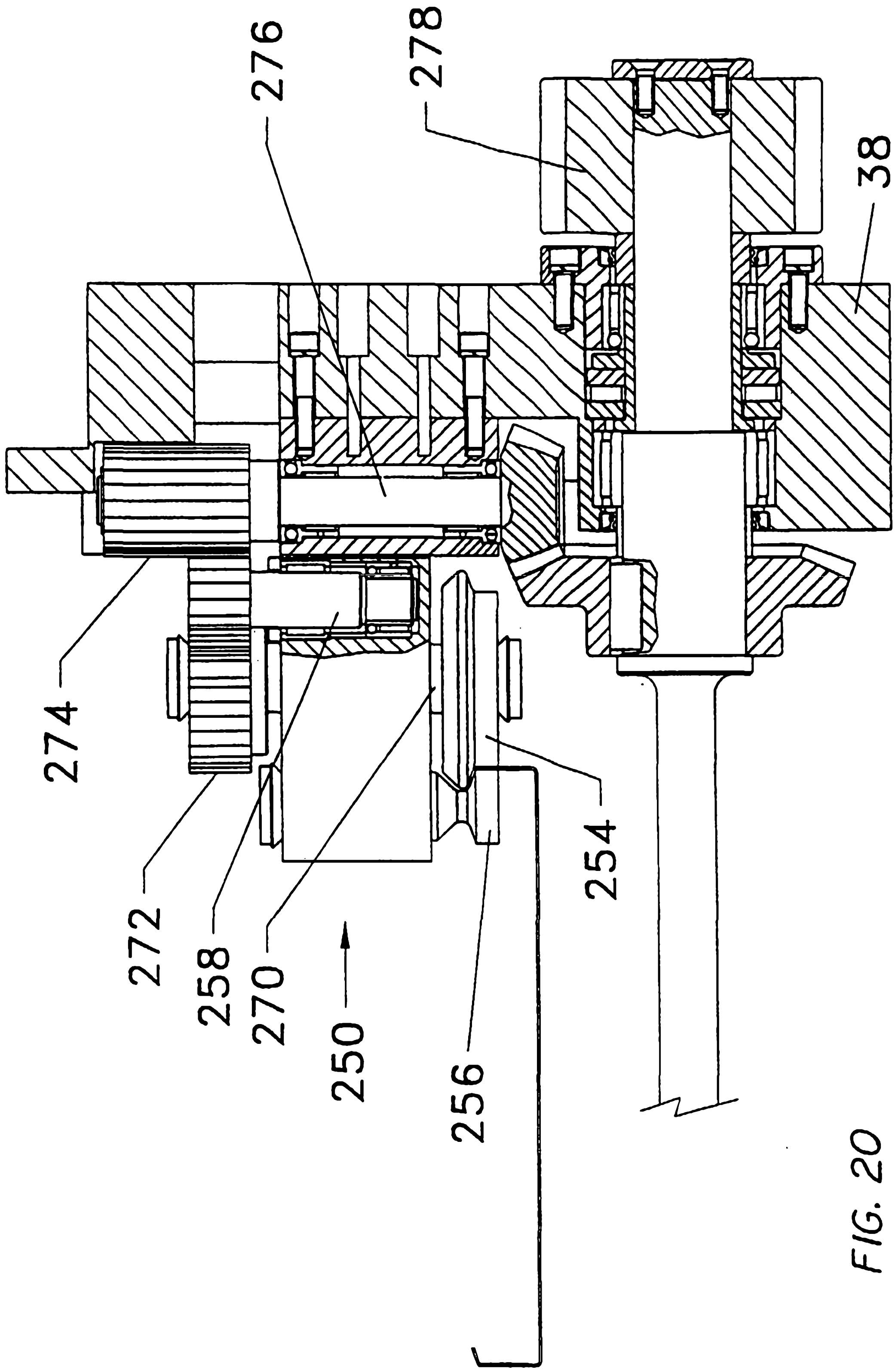
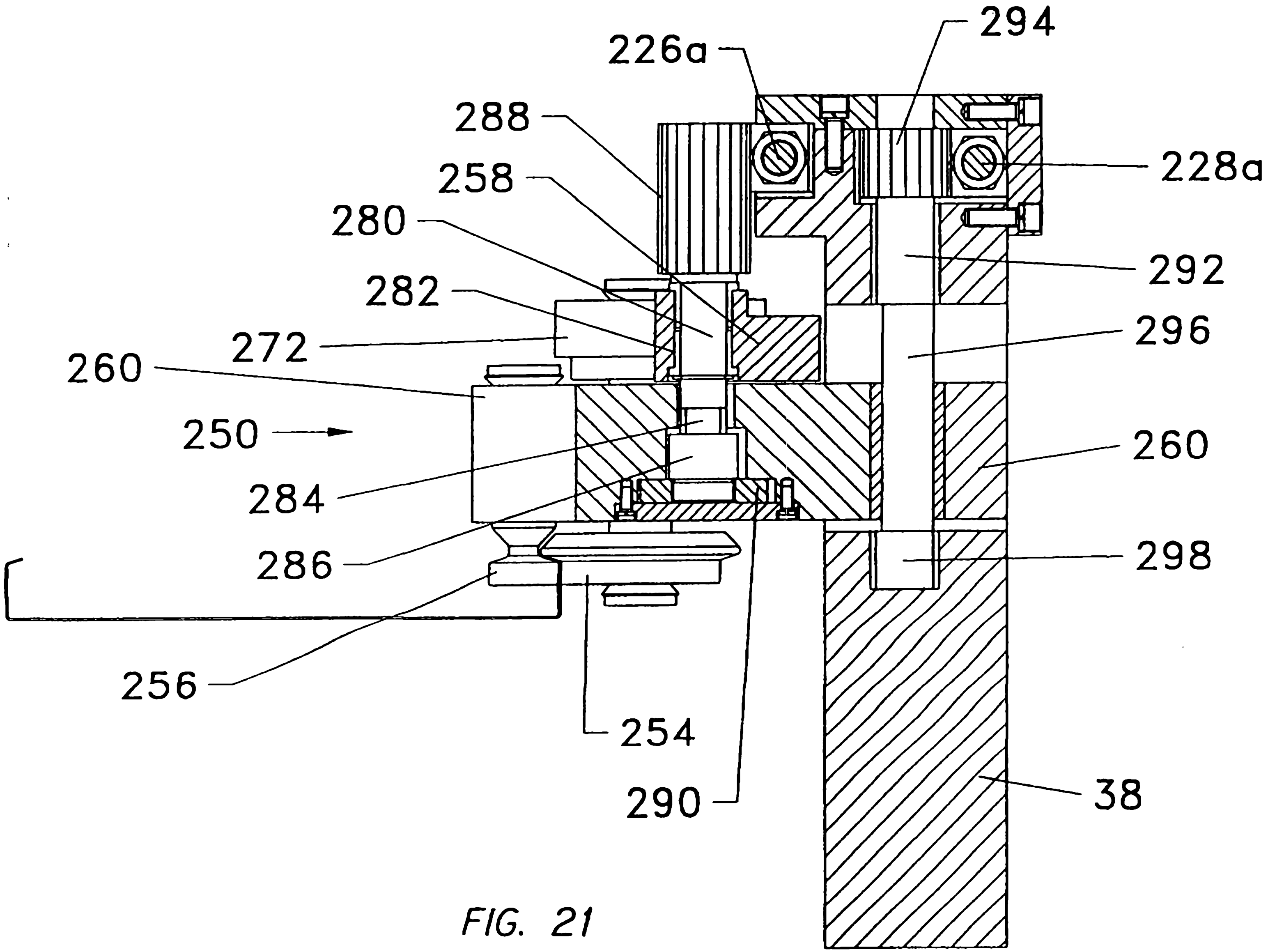


FIG. 20

SUBSTITUTE SHEET


294
226a
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228a
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280
292
282
272
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260
284
286
298
256
254
290
38

FIG. 21

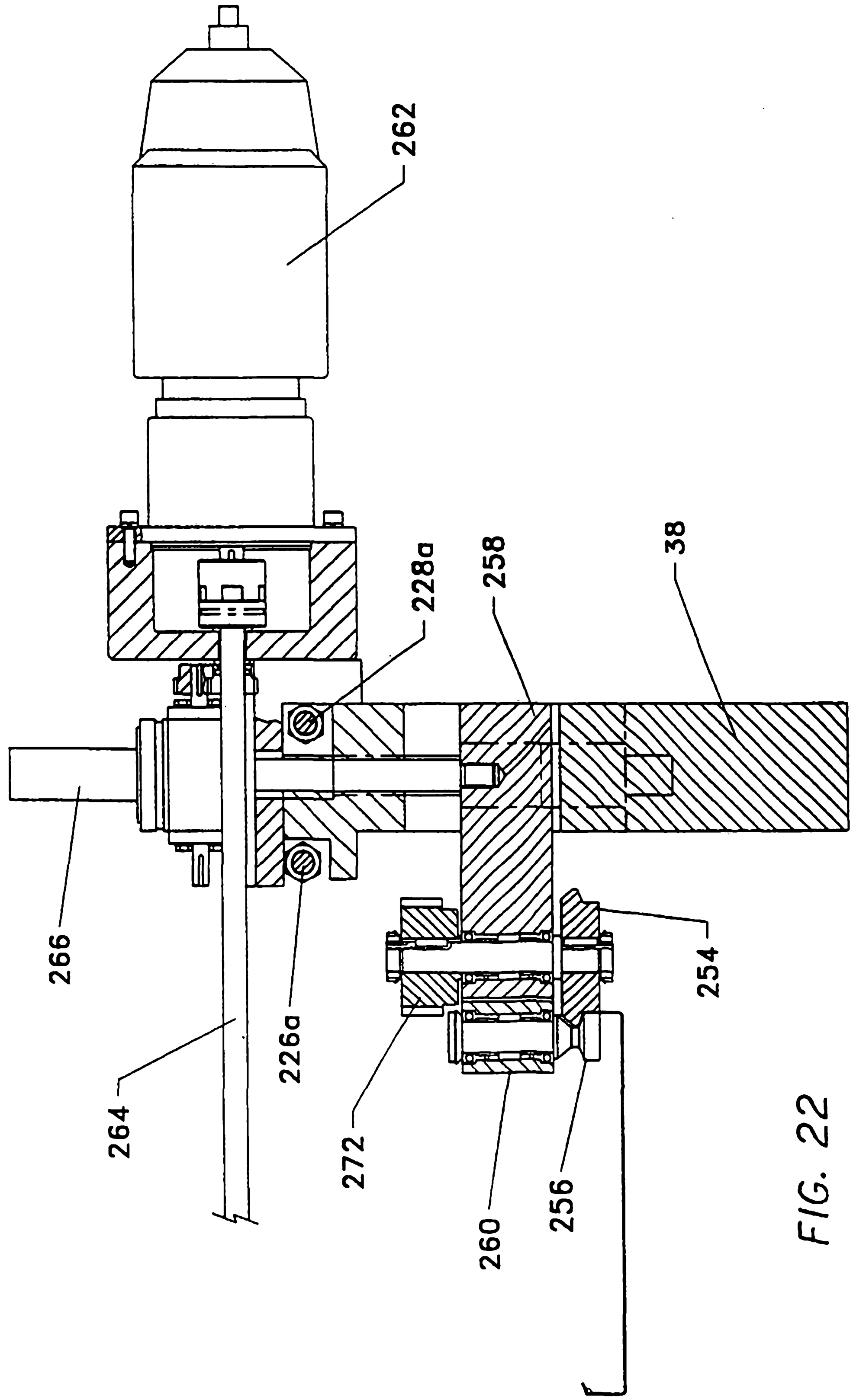


FIG. 22

SUBSTITUTE SHEET

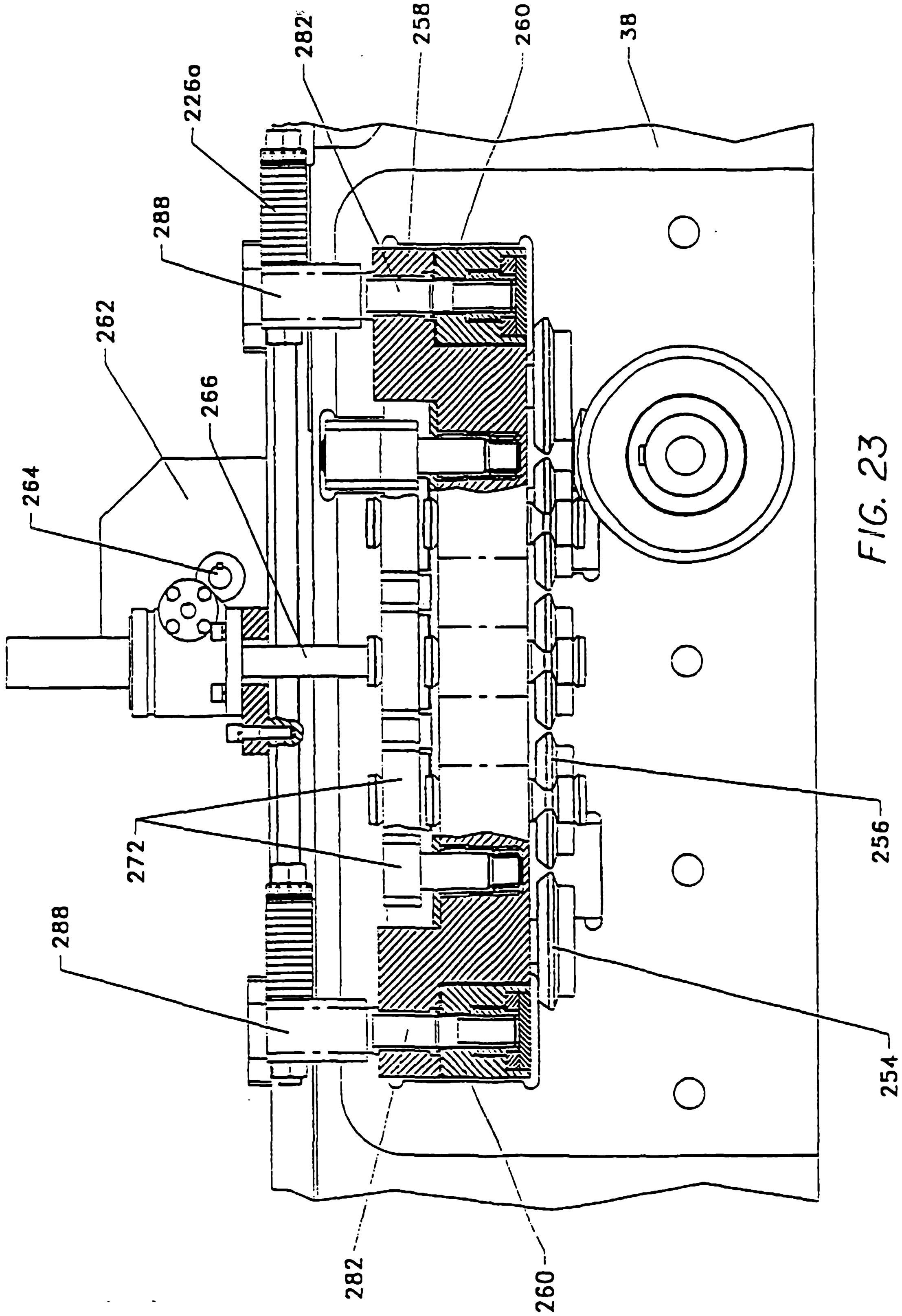


FIG. 23

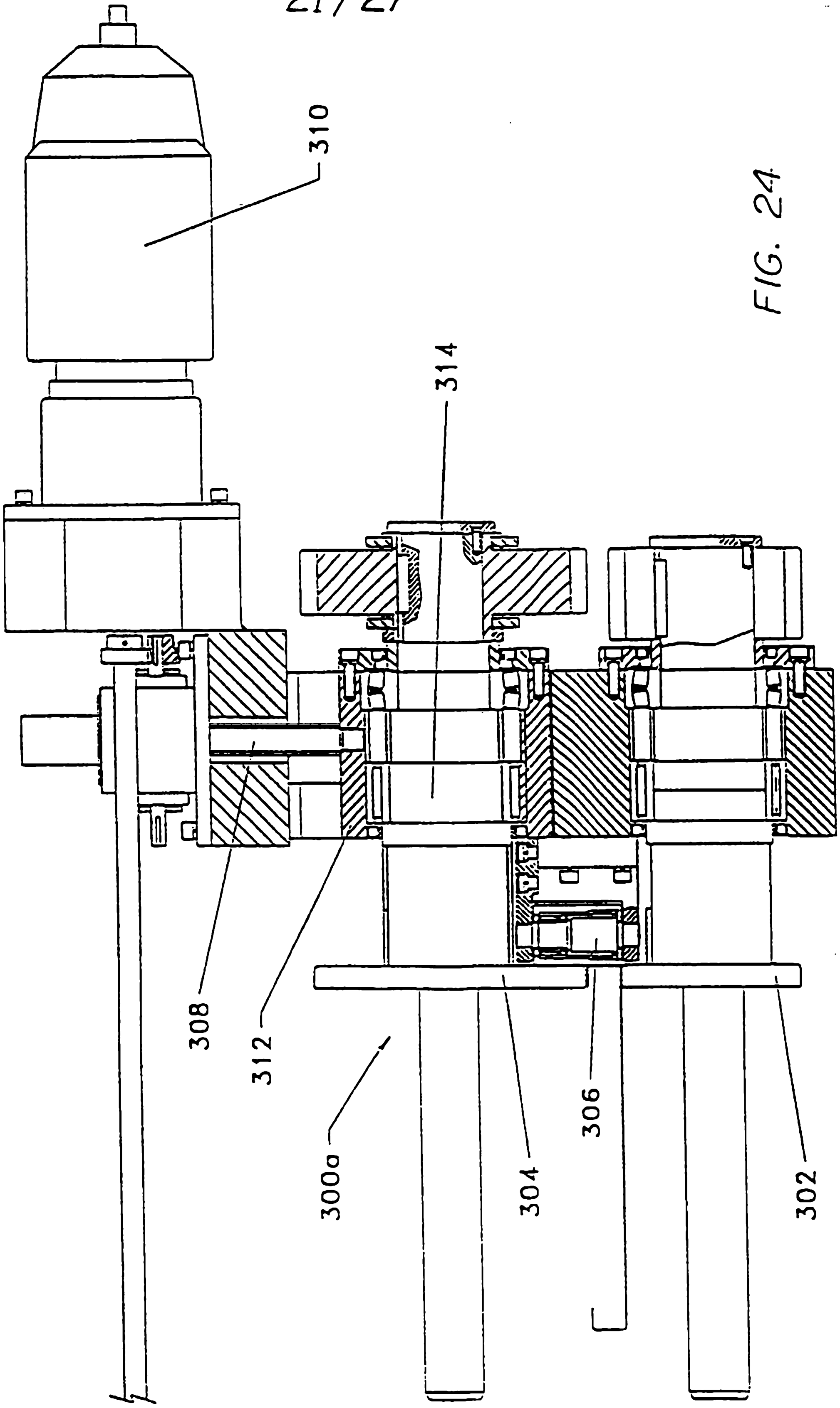


FIG. 24

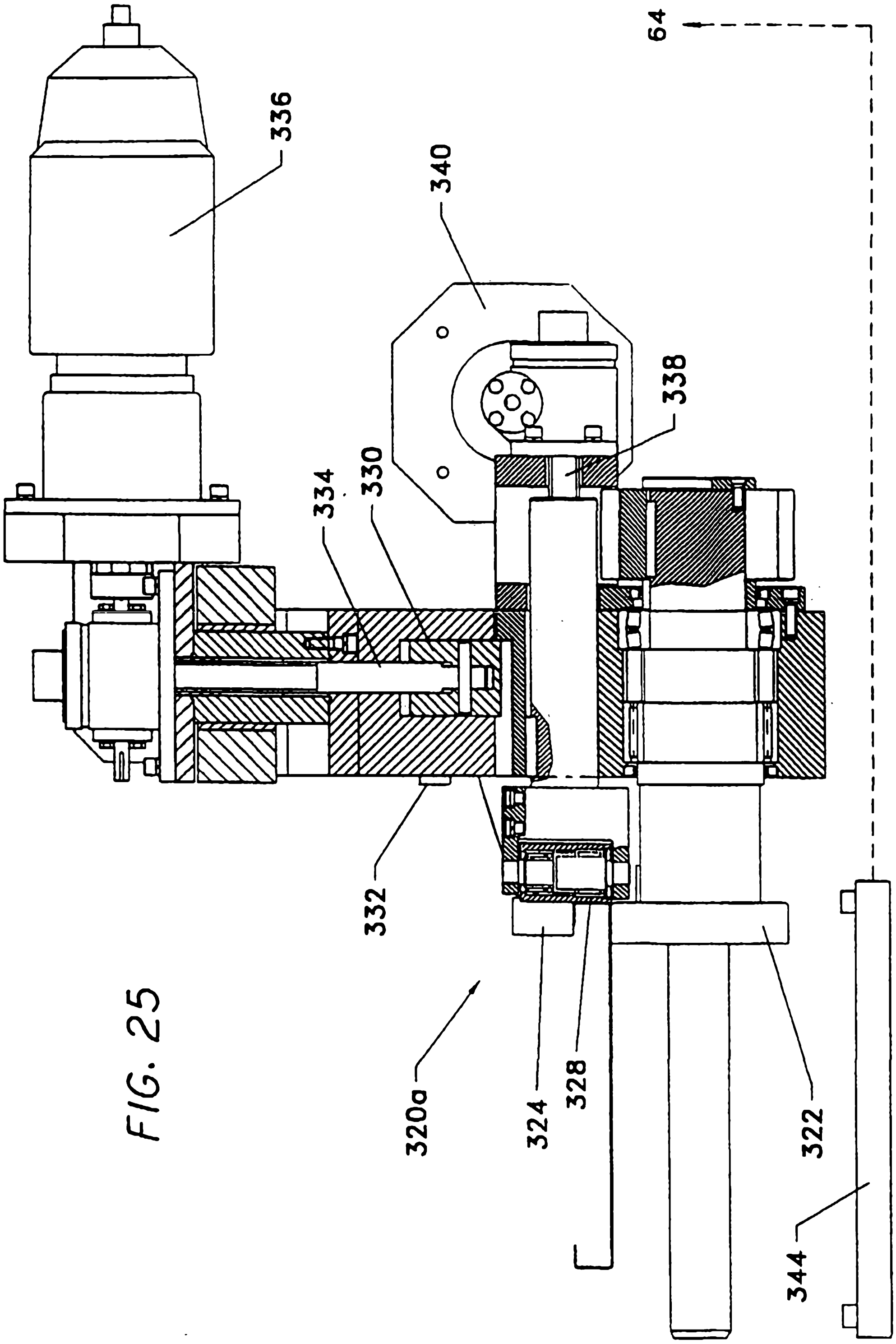


FIG. 25

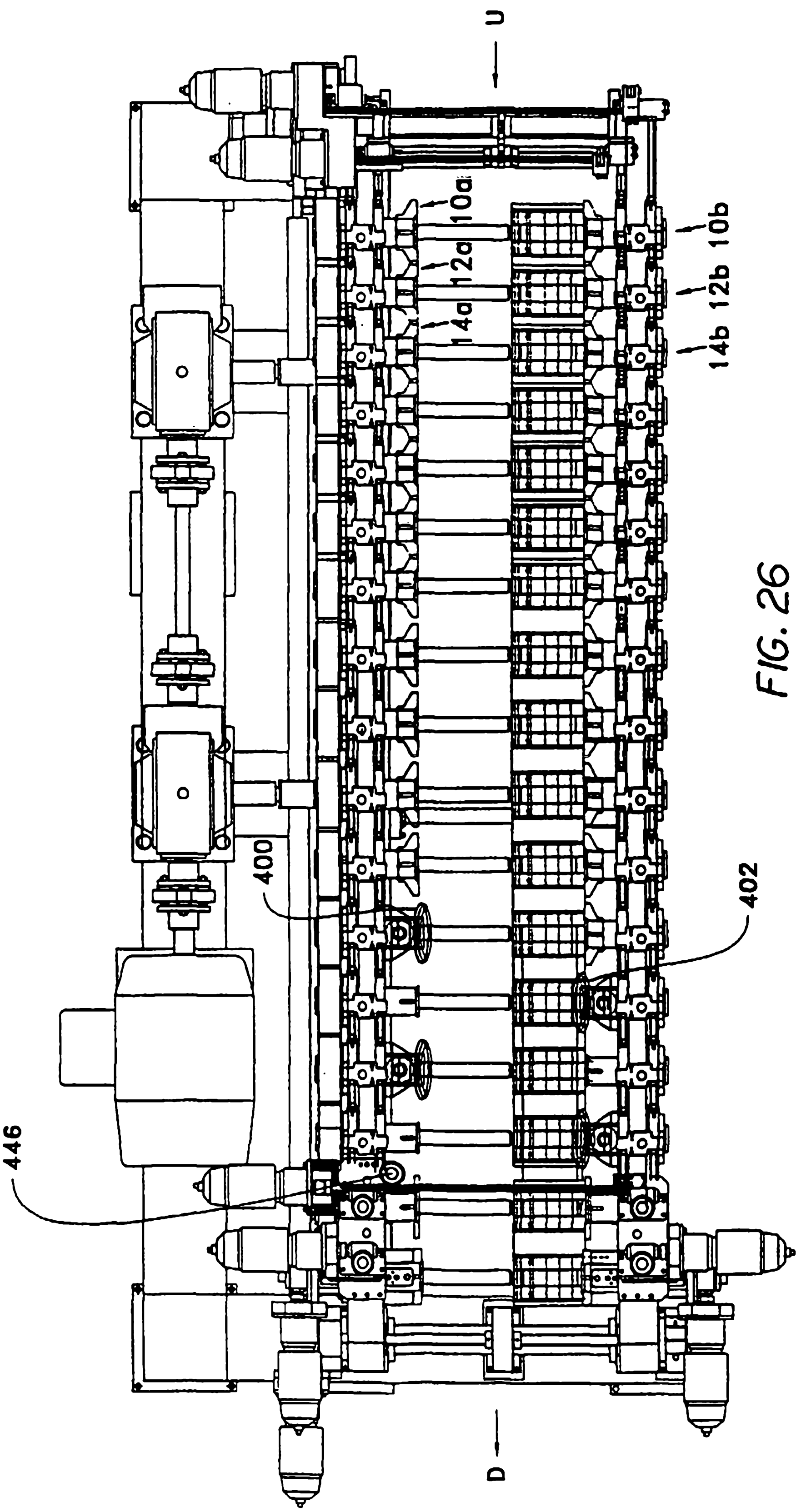


FIG. 26

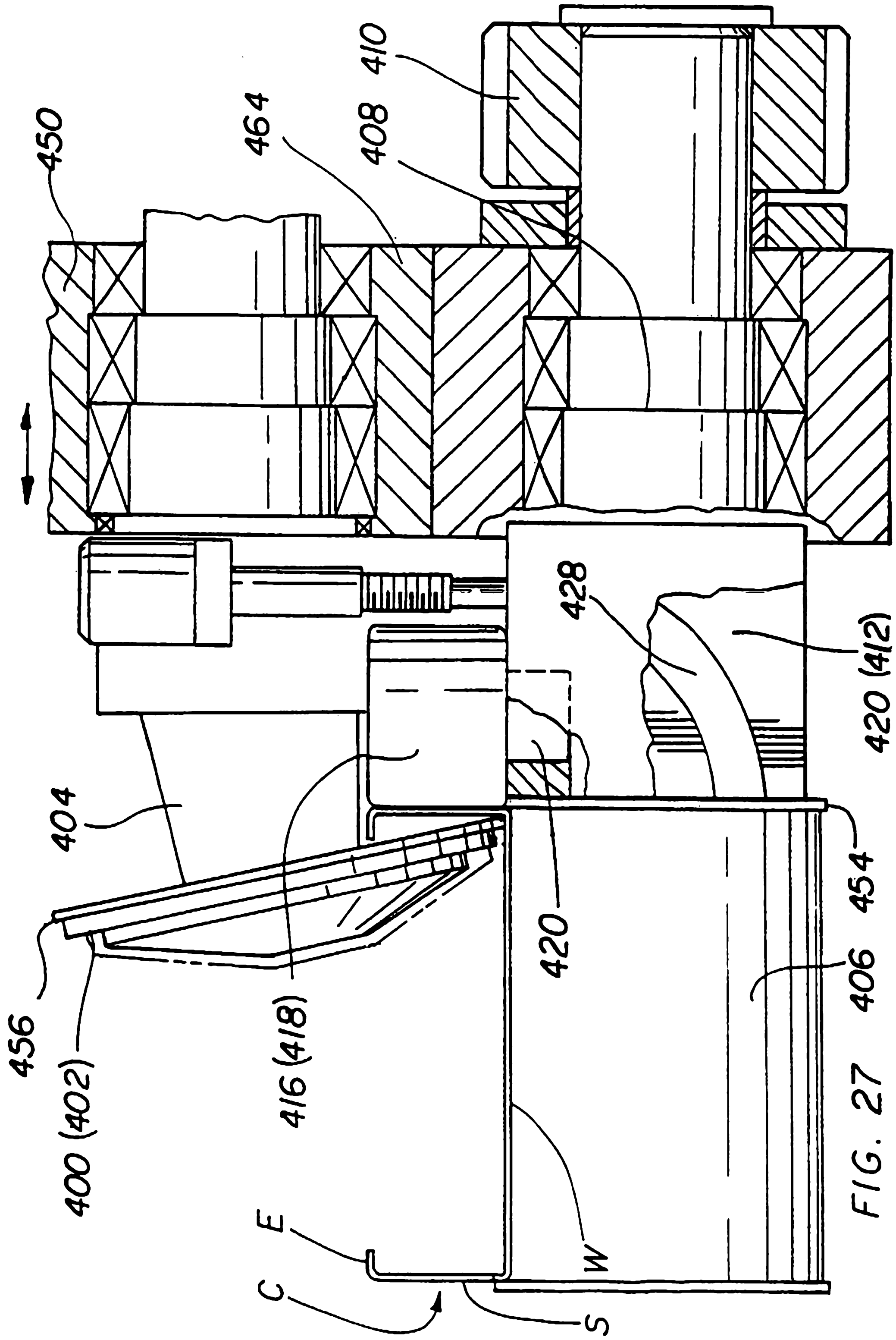

410
408
464
450
428
420 (412)
404
420
454
406
456
400 (402)
416 (418)
E
C
W
S

FIG. 27

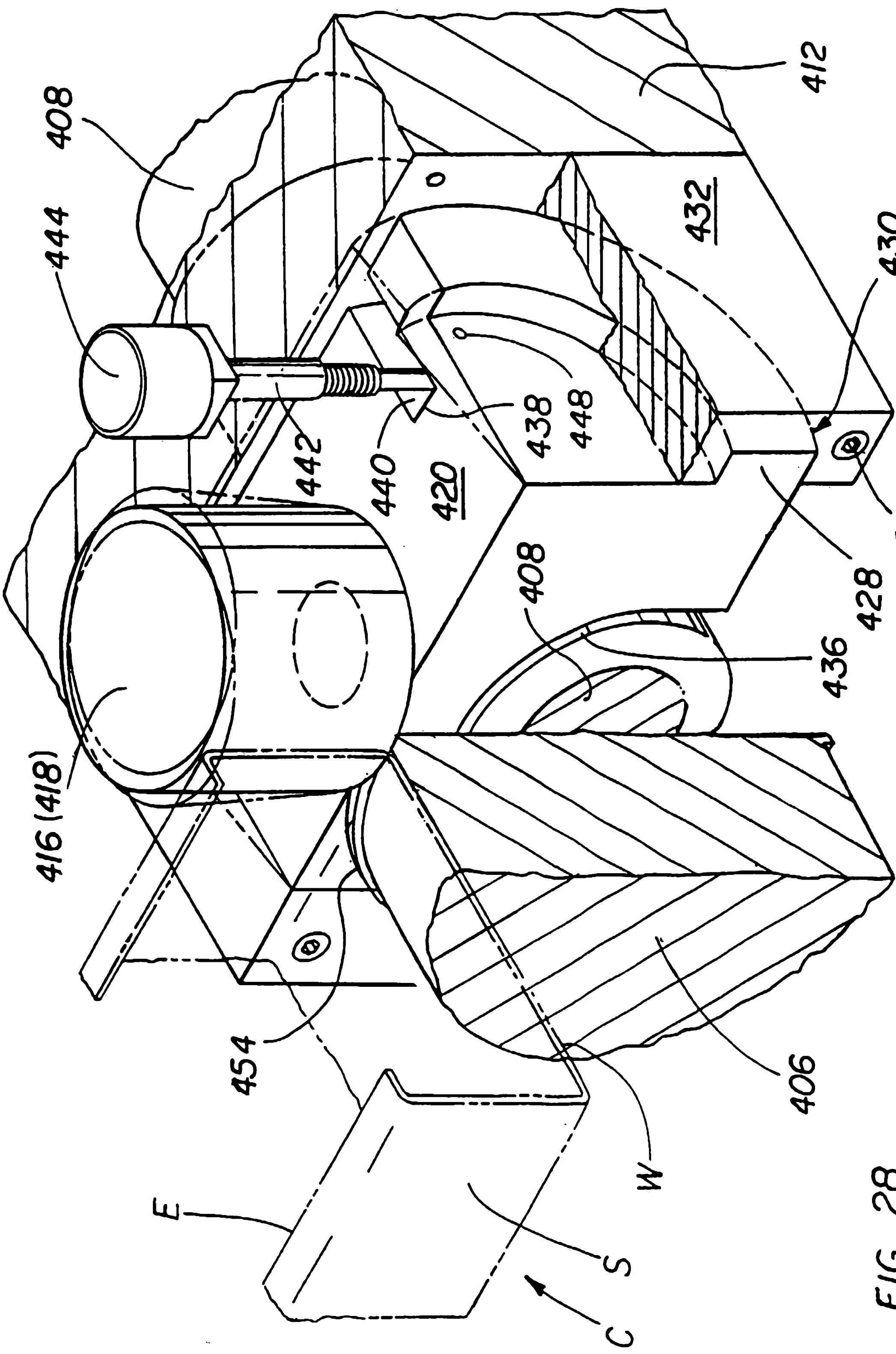
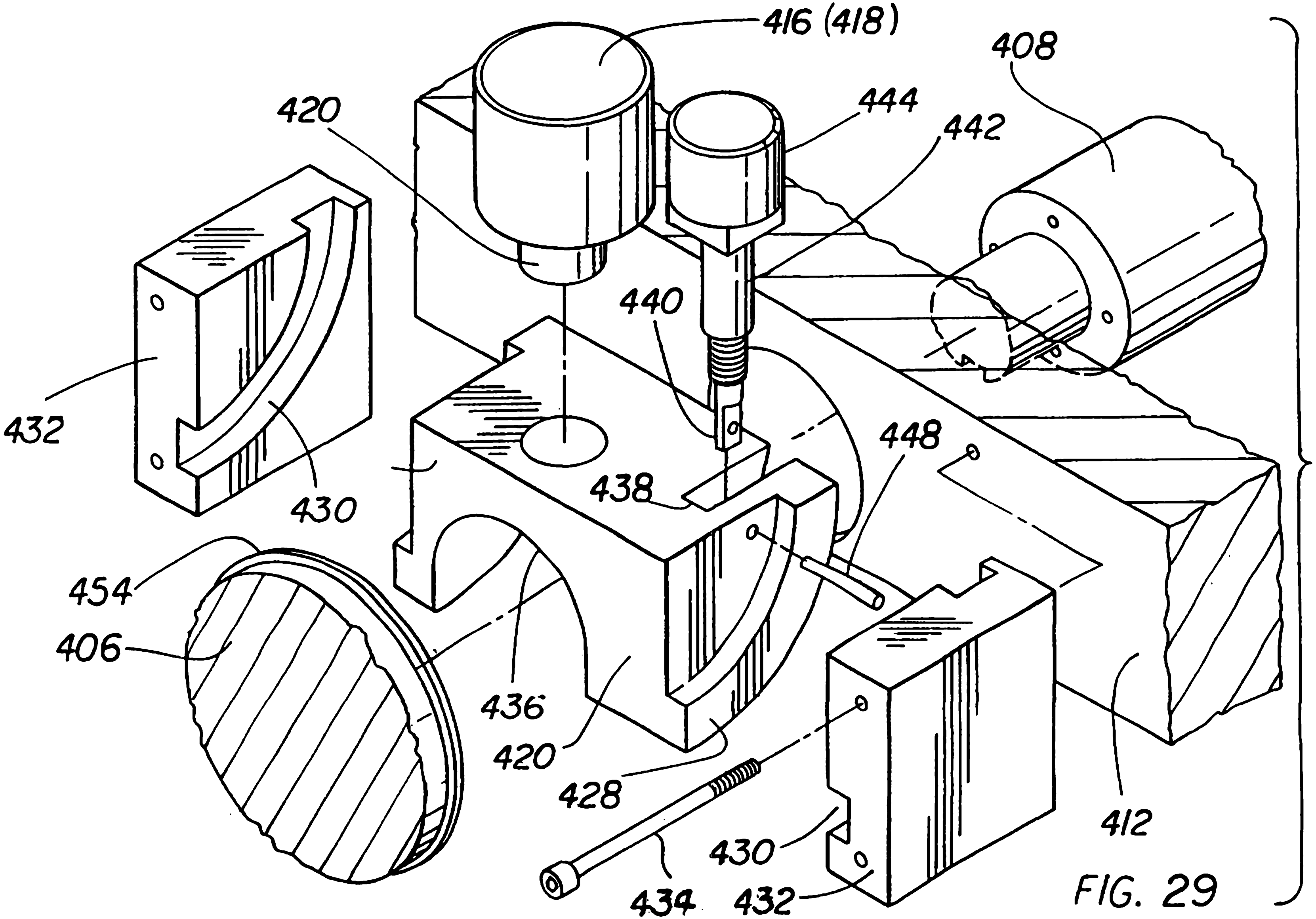

408
444
412
432
430
438
448
442
440
420
434
428
436
416 (418)
454
406
W
E
S
C

FIG. 28


416 (418)
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432

FIG. 29

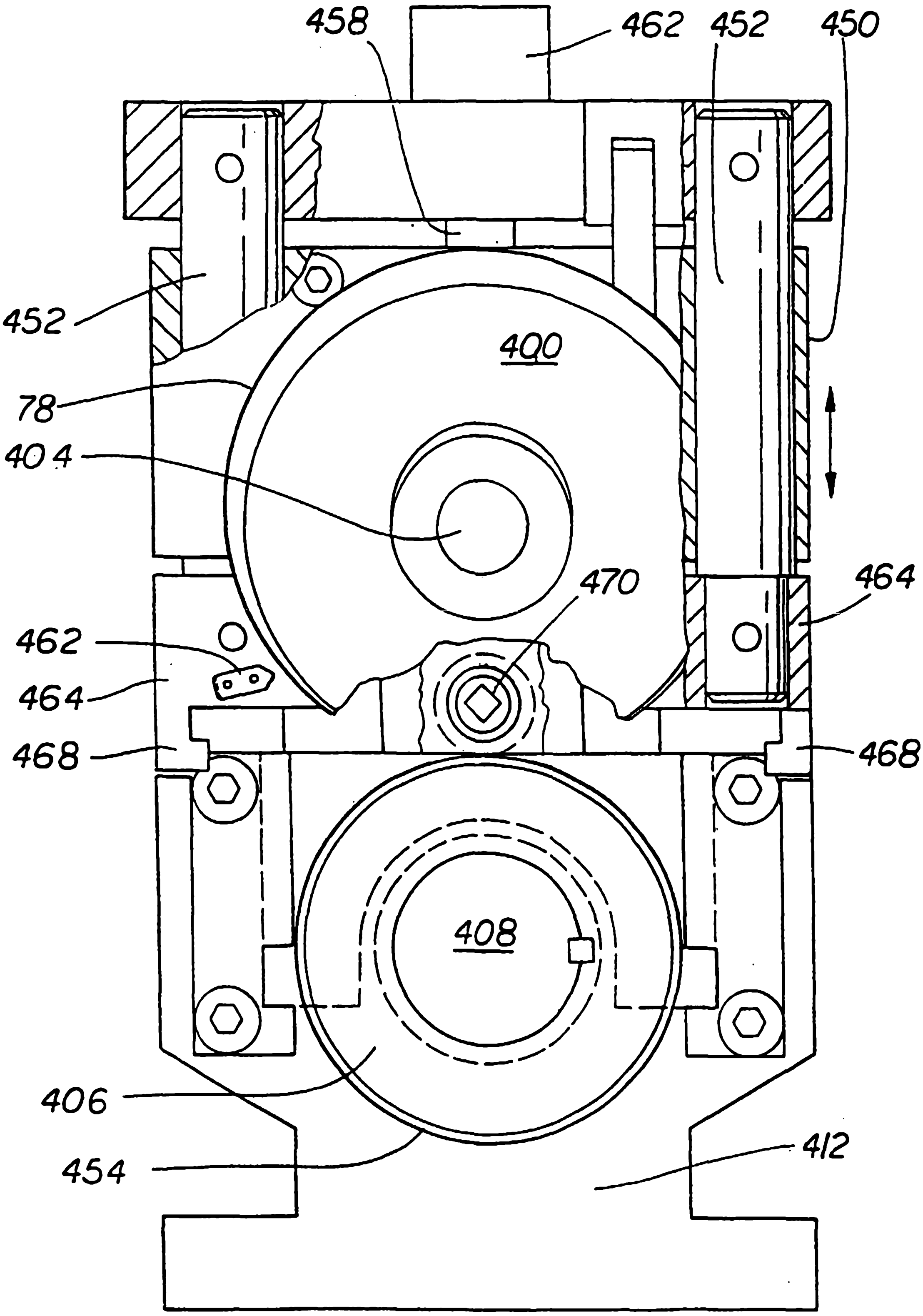

FIG. 30

SUBSTITUTE SHEET