

APPLICATION: ACCEPTED AND AMENDMENTS
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COMMONWEALTH of AUSTRALIA
Patents Act 1952

APPLICATION FOR A STANDARD PATENT

609034

I/We

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respectively

hereby apply for the grant of a Standard Patent for an invention entitled:

Method and apparatus for conducting operation in pipe

which is described in the accompanying complete specification.

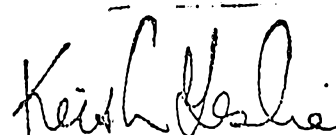
Details of basic application(s):-

<u>Number</u>	<u>Convention Country</u>	<u>Date</u>
63-14678	Japan	27 January 1988
63-285789	Japan	14 November 1988
63-286622	Japan	15 November 1988

The address for service is care of DAVIES & COLLISON, Patent Attorneys, of 1 Little Collins Street, Melbourne, in the State of Victoria, Commonwealth of Australia.

DATED this TWENTY SEVENTH day of JANUARY 1989

To: THE COMMISSIONER OF PATENTS



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a member of the firm of
DAVIES & COLLISON for
and on behalf of the
applicant(s)

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Davies & Collison, Melbourne

FP10-150
(2)

COMMONWEALTH OF AUSTRALIA
PATENTS ACT 1952
DECLARATION IN SUPPORT OF CONVENTION OR
NON-CONVENTION APPLICATION FOR A PATENT

Insert title of invention.

In support of the Application made for a patent for an invention
entitled: "Method and apparatus for conducting operation in pipe"

Insert full name(s) and address(es)
of declarant(s) being the appli-
cant(s) or person(s) authorized to
sign on behalf of an applicant
company.

X (1) Yukio Suzuki, President of
We Kabushiki Kaisha Iseki Kaihatsu Koki of
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Osaka, Japan

do solemnly and sincerely declare as follows :-

1. (a) ~~Koki, the applicant, for the patent~~
~~We are~~

or (b) ~~XXX~~ authorized by Kabushiki Kaisha Iseki Kaihatsu Koki
We are and Sekisui Kagaku Kogyo Kabushiki Kaisha

the applicant.S..... for the patent to make this declaration on ~~the~~ their behalf.

2. (a) ~~Koki, the actual inventor, of the invention~~
~~We are~~

or (b)

- (1) Akito Nagayoshi of 1-1-208, 123-2, Takatsuka-Shinden,
Matsudo-shi, Chiba-ken, Japan
(2) Katsuhide Tsaka of 2-13-503, 832-1, Takatsu,
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(3) Masahiro Ito of 5-22, Shioiri-machi, Yokosuka-shi,
Kanagawa-ken, Japan

~~XX~~ the actual inventor.S..... of the invention and the facts upon which the applicant.S.....
~~are~~
~~XX~~ entitled to make the application are as follows :-
~~are~~

The actual inventors assigned the invention
to the said applicants.

State manner in which applicant(s)
derive title from inventor(s)

3. The basic application.S..... as defined by Section 141 of the Act ~~was~~ were made
(1) in Japan on the 27th day of January, 1988
by Kabushiki Kaisha Iseki Kaihatsu Koki
(2) in Japan on the 14th day of November, 1988
by Kabushiki Kaisha Iseki Kaihatsu Koki
(3) in Japan on the 15th day of November, 1988
by Kabushiki Kaisha Iseki Kaihatsu Koki

4. The basic application.S..... referred to in paragraph 3 of this Declaration ~~was~~ were
the first application..... made in a Convention country in respect of the invention the subject
of the application.

Declared at Tokyo, Japan this 21st day of December, 1988

K.K. Iseki Kaihatsu Koki

Sekisui Kagaku Kogyo K.K.

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DAVIES & COLLISON, MELBOURNE and CANBERRA.

Cross out paragraphs 3 and 4
for non-convention applications.
For convention applications,
insert basic country(s) followed
by date(s) and basic applicant(s).

Insert place and date of signature.

Signature of declarant(s) (no
attestation required)

Note: Initial all alterations.

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METHOD AND APPARATUS FOR CONDUCTING OPERATION IN PIPE

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(56) Prior Art Documents
GB 2192442
US 4442891
US 4222687

(57) Claim

1. An apparatus for conducting operations in the interior of a pipe such as cutting off the pipe for boring a hole in the pipe, removing substances attached to the inner surface of the pipe or a protrusion of a branch pipe extending into the pipe, or disposing a plug into the pipe opening of the branch pipe and the like, by means of a tool having a rotary axis extending in a direction intersecting the axis of the pipe comprising:

support means to be disposed in said pipe so as to be movable in the axial direction of said pipe;

first drive means for rotating said tool about the rotary axis thereof, said first drive means having a tool mounting portion for mounting said tool; and

second drive means for displacing said tool in the radial direction of said pipe and for supporting said first drive means, said second drive means being disposed in said support means;

wherein said second drive means is provided with a plurality of cylinder

mechanisms which is interconnected so that said tool can be displaced in the radial direction of said pipe by a value corresponding to a total amount of expansion and contraction of said cylinder mechanisms.

3. An apparatus for conducting operations in the interior of a pipe as claimed in claim 1, further comprising third drive means for displacing said tool so that said rotary axis of said tool can be displaced in the axial direction of said pipe and also angularly displaced about the axis extending in the axial direction of said pipe, said third drive means being supported by said support means and supporting said second drive means.

7. An apparatus for conducting operations in the interior of a pipe as claimed in claim 3, further comprising:

fluid guide means for guiding operating fluid to actuate said first and second drive means said fluid guide means being provided with a tubular receiving member for receiving a rod extending in the axial direction of said pipe and defining a space to receive said rod, said fluid guide means also being supported by said support means so that said rod can be moved in the axial direction of said pipe;

wherein said receiving member is provided with a plurality of liquid paths for said operating fluid;

wherein said rod has a plurality of holes and a plurality of recesses each of the recesses being disposed in the outer periphery of the rod to extend along the periphery, the recesses being spaced apart from each other in the axial direction of said pipe and communicated respectively with the liquid paths, the holes being respectively communicated with the recesses and extending in the axial direction of said pipe;

wherein said second drive means is supported by said third drive means through said rod; and

wherein said third drive means displaces said tool by moving said rod in the axial direction of said pipe and by rotating said rod about its own axis.

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

COMPLETE SPECIFICATION

609934

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This document contains the
amendments made under
Section 49 and is correct for
printing

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COMPLETE SPECIFICATION FOR THE INVENTION ENTITLED:

Method and apparatus for conducting operation in pipe

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

BACKGROUND OF THE INVENTION

Field of the Invention:

This invention relates to ~~a method and~~ an apparatus for conducting operations such as cutting of a pipe for boring, removal of substance deposited on the inner surface of the pipe or protrusions extending into the pipe, and disposition of a plug of cutoff in a pipe opening of a branch pipe and, more particularly, to a method and an apparatus for conducting operations in a pipe suitable for technology of fitting a plug of cutoff in a branch pipe communicating to a main pipe to thereby close an opening of the branch pipe on the main pipe side, technology of cutting away protrusions of the branch pipe such as to remove the protrusions thereof extending into the main pipe and technology of cutting away a portion of the main pipe such as to bore a hole in the main pipe from the interior thereof to thereby afford communication between the main pipe and the branch pipe.

Description of the Prior Art:

Various methods for disposing new pipes in existing pipes, and for applying coating or lining to the inner surface of an existing pipe have been proposed and executed in order to reproduce, i.e., renew the



existing pipes such as sewer pipes, water-supply pipes, gas pipes, pipes for power line and pipes for telephone line. According to these renewing methods, newly installed pipes are provided in the interior of the existing pipe to be substantially integral therewith.

When the existing pipes having protrusions therein as in the case of a sewer pipe having a portion of a mounting pipe, i.e., a branch pipe protruding into a main pipe is renewed in accordance with the above methods, the existing pipe requires removing of the protrusions therein before pipes to be newly installed are disposed in the existing pipe. However, since the inner surface of the existing pipe is usually circular in shape, it is difficult to correctly cut away the protrusions.

Also, since a pipe opening of the branch pipe is closed with the newly installed pipe when the pipe is renewed according to the above renewing method, it is necessary to bore a hole in the newly installed pipe to thereby open the pipe opening of the branch pipe into the newly installed pipe. In this case, if the axis of the branch pipe is orthogonal to the axis of the newly installed pipe, the hole corresponding to the pipe opening of the branch pipe cannot be accurately bored only by rotating a cutter around the axis extending in the radial direction of the newly installed pipe.

Among various apparatuses for conducting operations in the interior of a pipe for boring a hole in the pipe, there is one comprising a first drive mechanism to rotate a tool about its own rotary axis and a second drive mechanism to displace a tool in the radial direction of said pipe (e.g., see

5 U.S.P. No. 4,442,891.)

A well known apparatus of this type angularly rotates a bracket or an arm about an axis orthogonal to the axis extending in the radial direction of a pipe and that of the pipe so as to move the bracket or the tip portion of the arm in the radial direction of the pipe to thereby displace said tool mounted
10 thereon in the radial direction of the pipe.

According to such a well known apparatus, however, the angle of the rotary axis of a tool with respect to the axis of a pipe varies depending on the position of the tool in the radial direction of the pipe, so that it is impossible to bore a hole accurately. Furthermore, in this well known apparatus, the
15 structure of a second drive mechanism is complicated.

As another apparatus of this type, there is one that displaces a tool in the radial direction of a pipe by means of a cylinder mechanism disposed expandably or contractibly in the radial direction of the pipe (e.g., see U.S. P. No. 4,222,687). However, in case the inner diameter of the pipe is so small
20 that no operator can enter, there is a limit in extending a stroke of a cylinder mechanism, so that, in an apparatus using a cylinder mechanism as second drive means, the range within which the tool can move in the radial direction of the pipe is so small that the pipe cannot be moved to surely cut the pipe.

SUMMARY OF THE INVENTION:

25 It is an object of the present invention to provide such an apparatus for conducting operations in a pipe as to enable cutting off accurately and surely a pipe, protrusions from the pipe, or substances attached to the inner surface of the pipe and fitting a plug into a second pipe accurately and surely.

The apparatus of the present invention for conducting operations in the
30 interior of a pipe such as cutting off the pipe for boring a hole in the pipe, removing substances attached to the inner surface of the pipe, or a protrusion



of a branch pipe extending into the pipe, or disposing a plug into the pipe opening of the branch pipe, and so forth, by means of a tool having a rotary axis extending in the direction intersecting the axis of the pipe comprises:

5 support means to be disposed in the interior of the pipe movably in the axial direction of the pipe; first drive means for rotating said tool about its own rotary axis, said first drive means having a tool mounting portion for mounting said tool thereon; and second drive means for displacing said tool in the radial direction of said pipe, said second drive means supporting said first drive means and disposed in said support means, and is characterised in that said
10 second drive means is provided with a plurality of cylinder mechanisms and that said cylinder mechanisms are interconnected with each other so that said tool can be displaced in the radial direction of said pipe by a value corresponding to a total amount of expansion and contraction of said cylinder mechanisms.

15 A tool such as a cutter is rotated about its own rotary axis by the first drive means and moved in the radial direction of the pipe by the second drive means.

According to the present invention, the tool can be displaced in the radial direction of the pipe within the range corresponding to a total amount
20 of the strokes of both cylinder mechanisms. As a result, it is possible to cut off the pipe, protrusions from the pipe, or substances attached to the inner surface of the pipe accurately and surely and fit a plug into another pipe such as a branch pipe accurately and surely, in the interior of a pipe having such a small bore that no operator can enter.

25 It is preferable that a tool such as a cutter draw a locus of rotation of a smaller diameter than that of a portion to be operated.

In a preferred embodiment of the present invention, said second drive means displaces said first drive means in the radial direction of said pipe to displace said tool in the radial direction of said pipe.

30 In the apparatus of the present invention, it is preferable to further include third drive means for displacing said tool so that said rotary axis of

said tool may be displaced in the axial direction of said pipe and also angularly displaced about the axis extending in the axial direction of said pipe, said third drive means being supported by said support means and supporting said second drive means.

- 5 In this case, said third drive means can displace said tool by displacing said second drive means in the axial direction of said pipe and angularly rotating said second drive means about an axis extending in the axial direction of said pipe.

- 10 The apparatus of the present invention may include: third drive means for displacing said tool so that the rotary axis of said tool may be angularly rotated about the axis of said tool extending in the axial direction of said pipe, said third drive means supporting said second drive means; and fourth drive means for displacing said tool so that said rotary axis of said tool may be displaced in the axial direction of said pipe, said fourth drive means being supported by said support means and supporting said third drive means.

The third drive means of the latter case angularly displaces said second drive means about an axis extending in the axial direction of said pipe to displace said tool. Also, the fourth drive means displaces said third drive means in the axial direction of said pipe to displace said tool.

- 20 The preferred embodiment is further provided with fluid guide means for guiding operating fluid to actuate said first and second drive means, said fluid guide means being provided with a rod extending in the axial direction of said pipe and a tubular receiving member defining a space for receiving the rod, said fluid guide means also being supported by said support means so that
- 25 said rod can be moved in the axial direction of said pipe. Said receiving member has a plurality of liquid paths for said operating fluid. Said rod has a plurality of holes and a plurality of recesses. Each of the recesses is disposed in the outer periphery of the rod to extend along the periphery, the recesses being spaced apart from each other in the axial direction of said pipe and
- 30 communicated respectively with the liquid paths. The holes are respectively communicated with the recesses and extend in the axial direction of said pipe.

Said second drive means is supported by said third drive means through said rod. Said third drive means displaces said tool by moving said rod in the axial direction of said pipe and by rotating said rod about its own axis.

Another preferred embodiment of the present invention further

- 5 comprises: fluid guide means for guiding operating fluid to actuate said first and second drive means. Said fluid guide means is supported by said support means so as to be movable in the axial direction of said pipe and includes a receiving member for receiving a rod extending in the axial direction of said pipe and defining a space to receive said rod rotatably about its own axis.
- 10 Said support means is provided with a first member having spaces extending in the axial direction of said pipe; and a plurality of tubular second members respectively received in said spaces so as to be movable in the direction of said spaces of the first member so that each of said second members may define a first liquid path for operating fluids. Each of said first liquid paths is
- 15 expandable and contractible in the axial direction of said pipe in co-operation with said first member. Said receiving member is provided with second liquid paths for said operating fluids so as to communicate respectively with said first liquid paths of said support means. Said rod has holes and recesses. The recesses are communicated with said second liquid paths and disposed in the
- 20 outer periphery of said rod to extend along the periphery of the rod and spaced apart from each other in the axial direction of said pipe. Said holes are respectively communicated with said recesses and extend in the axial direction of said pipe. Said second drive means is supported by said third drive means through said rod. Said third drive means displaces said tool by
- 25 angularly rotating said rod with respect to said receiving member. Said fourth drive means displaces said fluid guide means in the axial direction of said pipe to displace said tool.

The foregoing and other objects and features of the invention will become apparent from the following description of preferred embodiments of

30 the invention with reference to the accompanying drawing, in which:

Fig. 1 is a plan view showing an embodiment of an apparatus for conducting operations in a pipe according to the present invention;

Fig. 2 is a front view showing the apparatus in Fig. 1;

Fig. 3 is a sectional view taken along the line 3-3 in Fig. 2;

Fig. 4 is a sectional view taken along the line 4-4 in Fig. 2;

Fig. 5 is a plan view showing a front end of the apparatus in Fig. 1 with a cutter being removed;

Fig. 6 is a sectional view taken along the line 6-6 in Fig. 5;

Fig. 7 is a plan view showing an embodiment of the cutter;

Fig. 8 is a front view showing the cutter in Fig. 7;

Fig. 9 is a view showing an embodiment of a controller;

Fig. 10 is a view showing an embodiment of the apparatus in a case when using for cutting protrusions;

Fig. 11 is a sectional view taken along the line 11-11 in Fig. 10;

Fig. 12 is a front view showing an embodiment of a fixture of a plug of cutoff;

Fig. 13 is an enlarged-scale plan view showing a fluid guide mechanism;



Fig. 14 is a sectional view taken along the line 14-14 in Fig. 13;

Fig. 15 is a sectional view taken along the line 15-15 in Fig. 14;

Fig. 16 is a front view showing another embodiment of the apparatus according to the present invention;

Fig. 17 is a plan view showing the apparatus in Fig. 16;

Fig. 18 is an enlarged-scale fragmentary plan view showing a support mechanism and a position locking mechanism with a pat plate of the apparatus in Fig. 16 being removed;

Fig. 19 is a sectional view taken along the line 19-19 in Fig. 18;

Fig. 20 is a cross-sectional view showing the connective relationship between a second member of the support mechanism and the fluid guide mechanism;

Fig. 21 is a sectional view taken along the line 21-21 in Fig. 20;

Fig. 22 is a sectional view taken along the line 22-22 in Fig. 16;

Fig. 23 is a sectional view taken along the line 23-23 in Fig. 16;

Fig. 24 is a side view taken along the line 24-24 in Fig. 16; and

Fig. 25 is an enlarged-scale sectional view taken

along the line 25-25 in Fig. 17.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to Figs. 1 through 4, an apparatus 10 for conducting operations in a pipe 12 is shown.

The apparatus 10 is movably disposed in a first pipe 12 embedded in the ground. The first pipe 12 in the illustrated embodiment consists of an existing pipe 14 and a newly installed pipe 16 made of synthetic resin and disposed inside the existing pipe. The existing pipe 14 and newly installed pipe 16 are connected integrally with each other by means of hardenable filler such as cement and adhesive, which fills a space between both of the pipes.

To the existing pipe 14 is connected a second pipe 18 like a branch pipe. However, a pipe opening of the second pipe 18 is closed with the newly installed pipe 16 and filler. The apparatus 10 is adapted to open the pipe opening of the second pipe 18 to the inside of the newly installed pipe 16 by cutting away a portion of the newly installed pipe 16 and filler corresponding to the pipe opening of the second pipe with a cutter 20 rotating about an axis 19 extending in the direction orthogonal to an axis of the first pipe 12.

Further, in the illustrated embodiment, while the axis 19 corresponds to an axis extending in the radial direction of the first pipe 12, it may employ another



axis extending in the axial direction of the second pipe 18 when the second pipe 18 is inclined to the first pipe 12, for example.

The apparatus 10 comprises a carriage, i.e., a frame bed 22 which is provided with a pair of elongate slide members 24 extending in the axial direction of the first pipe 12. Both of the slide members 24 are connected to each other by a plurality of connecting members 26. The frame bed 22 in the illustrated embodiment is not of a self-propelled type but it may be of a self-propelled type.

A casing 28 is installed on the frame bed 22 and a plurality of manifolds (not shown) are received in the casing 28. Inside the casing 28 there are provided a plurality of electromagnetic valves 30 for controlling the flow of operating fluid, such as operating oil and compressed air, supplied to various drive mechanisms and cylinder mechanisms which will be later described. The operating fluid and electric power are supplied to each of the electromagnetic valves 30 from an operating fluid source and a power supply installed on the ground.

On the frame bed 22 are disposed a drive mechanism 32 for angularly rotating a cutter 20 about an axis 21 extending along the axis of the first pipe 12 and a drive mechanism 34 for shifting the cutter 20 in the axial direction of the first pipe 12. The drive mechanism 32 is composed of a double-acting hydraulic



rotary mechanism provided with an output shaft movable in the axial direction of the first pipe 12 and an actuator for angularly rotating the output shaft about its own axis. On the other hand, the drive mechanism 34 is composed of a double-acting hydraulic cylinder mechanism in which a piston rod is rotatable about its own axis. The piston rod of the drive mechanism 34 is connected to the output shaft of the drive mechanism 32.

As for the drive mechanisms 32,34, use may be made of a double-acting hydraulic operating mechanism functioning as the drive mechanisms 32,34 and commercially available under the name of a hydraulic stroke rotary actuator, for example.

An output shaft 36 of the drive mechanism 34 extends rotatably and slidably through a bearing member 38 supported on the frame bed 22. On the front end of the output shaft 36 is mounted a drive mechanism 40 for shifting the cutter 20 in the radial direction of the first pipe 12. As shown in Figs. 5 and 6, the drive mechanism 40 is provided with a guide rail 42 fixedly attached to the output shaft 36. A case 44 open to upward is supported on the guide rail 42 so as to be slidable along the guide rail 42. In the case 44 is disposed a vertically extending cylinder mechanism 46 so as to move the case 44 in the vertical direction relative to the guide rail 42. A cylinder chamber of the cylinder mechanism 46 is formed in the case 44 and a



piston rod is connected to the lower end of the guide rail 42. The upper opening of the case 44 is closed with a lid 48.

On the case 44 is supported a drive mechanism 50 for rotating the cutter 20 about the axis 19 extending in the radial direction of the first pipe 12. As shown in Figs. 5 and 6, the drive mechanism 50 is provided with a shaft 52 rotatably supported by the case 44 and lid 48 so as to extend in the vertical direction to support the cutter 20. To the shaft 52 is transmitted the rotation of a rotation source 54 such as a hydraulic motor supported by the case 44 through a plurality of bevel gears 56, 58.

As shown in Figs. 7 and 8, the cutter 20 is provided on its upper and side surfaces with a plurality of bits 60 having respective blades. A plurality of bits 60 disposed in the center are mounted on a member 64 extending upward from a cross-like base 62. On the other hand, each of other bits 60 is mounted on a corresponding one of members 66 extending upward from the corresponding ends of the base 62. When the cutter 20 is rotated, each of the bits 60 is disposed such that a conical cutting surface is formed with blades on the upper surfaces of the bits 60 and the maximum diameter of the locus of rotation of each bit 60 comes to be smaller than the inner diameter of the second pipe 18.

The base 62 is provided with a male screw 68



extending downward from the base. As shown in Fig. 6, when the cutter 20 is mounted on the shaft 52, the male screw 68 is screwed into a tapped hole 70 provided in the shaft 52.

As shown in Figs. 1 and 2, the apparatus 10 further comprises a position locking mechanism 71 for releasably fixing the frame bed 22 in position relative to the first pipe 12. The position locking mechanism 71 is provided with a cylinder mechanism 72. One end of a cylinder of the cylinder mechanism 72 is pivotally connected to the bearing member 38, while a piston rod of the cylinder mechanism 72 is pivotably connected to one of a pair of parallel links 74. One end of each of the links 74 is pivotably connected to the bearing member 38 and the other end is pivotably connected to an elongate member 76 extending in parallel to the slide member 24.

Furthermore, each of the drive mechanisms 32, 34, 40 and 50 may be composed of another mechanism provided with an electric drive source such as a pulse motor. Also, instead of the cylinder mechanism 72, use may be made of a mechanism provided with an electric drive source such as a solenoid mechanism and a servo-motor.

As shown in Fig. 9, a controller 90 for controlling the apparatus 10 comprises electromagnetic valves 30a, 30b, 30c, 30d and 30e corresponding individually to hydraulic apparatuses of the drive mechanisms 32, 34, 40

and 50 and cylinder mechanism 72, an oil pressure source 92 provided with a hydraulic pump and a control board 94 for controlling the respective electromagnetic valves. The electromagnetic valves 30a, 30b, 30c, 30d and 30e include direction change-over valves controlled by the control board 94 to change over the fluid path of the operating oil.

The control board 94 is provided with a plurality of change-over switches individually corresponding to the electromagnetic valves. Each of the electromagnetic valves changes over the flow path of the operating oil by the corresponding one of the change-over switches.

In Fig. 9, the solid line represents the flow path of the operating oil and the dotted line represents the flow path of electric current.

Prior to the cutting operation, the apparatus 10 is first disposed in the first pipe 12 from a vertical shaft communicating to the first pipe 12 with the cylinder mechanism 74 being in a contracted state. Thereafter, the apparatus 10 is shifted to a position where the cutter 20 faces to the pipe opening of the second pipe 18 by means of a rope and a winch. In order to shift the apparatus 10 to a predetermined position, the distance between the vertical shaft and the pipe opening of the second pipe 18 may be measured prior to installation of the newly installed pipe 16 to shift the apparatus 10 over the measured distance.

When the apparatus 10 is shifted to the predetermined position, the electromagnetic valve 30e is controlled by the control board 94 to thereby extend the cylinder mechanism 72. By so doing, the elongate member 76 is pressed against the inner surface of the pipe 16. As a result, the apparatus 10 is maintained in a position which is unmovable with respect to the pipe 12.

Further, when the portion corresponding to the pipe opening of the second pipe 18 can be monitored from the interior of the first pipe 12, the apparatus 10 is preferably determined in position such that the cutter 20 is disposed in the central portion of the pipe opening of the second pipe 18 by using a television camera and a monitor for receiving an output signal of the television camera. The positioning of the apparatus may be executed by controlling the electromagnetic valves 30a and 30b using the control board 94 while monitoring the monitor to actuate the first and second drive mechanisms 32 and 34.

At the time of the cutting operation, the cylinder mechanism 46 of the drive mechanism 40 is extended while the drive mechanism 50 is operated. Thus, since the cutter 20 is lifted along the axis extending in the radial direction of the first pipe 12 and is rotated about the axis as noted above, a hole may be bored in that portion of the first pipe 12 which closes the pipe opening of the second pipe 14.

Next, the drive mechanisms 32 and 34 are operated at least once, preferably over and over while the drive mechanism 50 is operated with the cylinder mechanism 46 being in an extended state. Thus, since the cutter 20 reciprocates at least once in the axial direction of the first pipe 12 and in the circumferential direction of the first pipe 12 respectively, the hole as noted above is expanded.

At the time of the cutting operation, when the cutter 20 is shifted by the drive mechanisms 32 and 34 so that the angular displacement, i.e., chord size in the locus of reciprocation in the circumferential direction of the first pipe, of the rotary axis of the cutter 20 is identical with the displacement in the axial direction of the first pipe 12, the locus of motion of the cutter 20 results in a circle. On the other hand, when the cutter 20 is shifted by the drive mechanisms 32 and 34 so that the angular displacement comes to be larger than the displacement in the axial direction of the first pipe 12, the locus of motion of the cutter 20 results in an ellipse having a longer axis extending in the circumferential direction of the first pipe 12. Also, when the cutter 20 is shifted by the drive mechanisms 32 and 34 so that the angular displacement comes to be smaller than the displacement in the axial direction of the first pipe 12, the locus of motion of the cutter 20 results in an ellipse having

a longer axis extending in the axial direction of the first pipe 12.

By adjusting the timing in which the angular displacement comes to the maximum value and the timing in which the axial displacement comes to the maximum value, it is possible to set the direction of the long axis of the ellipse at will. Also, by adjusting the angular displacement and axial displacement, the locus of motion of the cutter 20 results in any desired ellipse in shape and size. Therefore, any desired hole in shape and size can be bored in accordance with the apparatus 10.

During the cutting process, a portion to be cut may be monitored by the television camera and the monitor. In this case, each of the drive mechanisms and cylinder mechanisms may be manually controlled by utilizing the control board 94. More preferably, the control of each of the drive mechanisms and cylinder mechanisms is executed by a computer. By so doing, the boring operation may be effected without requirement of any skill.

Further, when a pulse motor or servo-motor is used for the drive source of the drive mechanisms 32, 34, it is preferable that the angular displacement of the cutter 20 about the axis extending along the first pipe 12 and the displacement of the cutter 20 in the axial direction of the first pipe 12 are gradually increased while the drive mechanism 50 is operated and



while the drive mechanisms 32, 34 are repetitively operated. In consequence, the hole as noted above is gradually expanded.

As shown in Figs. 10 and 11, when the apparatus 10 is used as an apparatus for removing protrusions such as a projection 18a of the second pipe 18 extending into the first pipe 12, use is made of a cutter 20a having a predetermined thickness and displaying a locus of rotation of a disk. The shape and size of the cutter 20a are set so that the maximum diameter of the locus of the cutter 20a rotating about its own rotary axis is smaller than that of a portion to be cut. As for the cutter 20a, use may be made of a cutter provided with a plurality of bits or a grinder-like cutter. For example, the grinder-like cutter may be disposed in front of the motor 54 so that the rotary axis of the cutter extends parallel to the axis 21.

At the time of cutting the protrusions, the apparatus 10 is operated in the same way as in the case of boring a hole. Therefore, since the cutter 20a is angularly displaced around the axis extending along the axis of the first pipe 12 and is rotated around the rotary axis of the cutter by the drive mechanisms 32, 34 while the cutter 20a is shifted in the direction of the axis 21 extending along the first pipe 12, the protrusion may be securely cut away up to the proximity of the inner surface of the first pipe 12.



When the apparatus 10 is used as an apparatus for disposing a plug of cutoff in the front end of the second pipe 18, a fixture 100 is used in lieu of the cutter 20 as shown in Fig. 12, for example. The fixture 100 is provided with a disk-like base 102, a male screw portion 104 extending downward from the center of the base and a plurality of projections 106 provided on the upper surface of the base 102. When the fixture 100 is mounted on the rotary shaft 52 of the drive mechanism 50, the male screw portion 104 is screwed into the tapped hole 70 formed in the rotary shaft 52. A plug 108 of cutoff in the illustrated embodiment is made of rubber or cork and determined in position removably on the base 102 by the projection 106.

The operation of closing the front end of the second pipe 18 with the plug 108 of cutoff is carried out before the newly installed pipe 16 is disposed in the existing pipe 14. More specifically, the apparatus 10 is disposed in a predetermined position and the drive mechanism 40 is operated while the drive mechanism 50 is operated under the condition that the plug 108 of cutoff faces toward the front end of the second pipe 18 by properly operating the drive mechanisms 32, 34 to thereby close the front end of the second pipe 18 with the plug 108 of cutoff. By so doing, the plug 108 of cutoff is forced into the front end of the second pipe 18.

Further, if the plug 108 of cutoff is formed on



its outer peripheral surface with a screw, it is possible to prevent the plug 108 of cutoff from getting out of the second pipe 18.

As shown in Figs. 13 through 15, instead of using the bearing member 38, a fluid guide mechanism 110 defining the flow path of the operating oil may be disposed between the drive mechanisms 34,40.

The fluid guide mechanism 110 is provided with a tubular receiving member 112 supported by the drive mechanism 34 and a connecting member 114 so as to extend in parallel to the axis 21, and a rod 116 disposed in the receiving member or carrier member 112 so as to be rotatable about the axis 21 and capable of reciprocating in parallel to the axis 21.

The receiving member 112 includes two pairs of ports 118,120 and 122,124 extending through the receiving member 112 from the outside to the inside. Each of the ports 118,120,122 and 124 is connected to the electromagnetic valve 30 as shown in Figs. 1 and 2 through a hose (not shown).

The rod 116 is connected to the shaft 36 by means of a bolt 126 and a key 128 so that the rear end face of the rod butts against the front end face of the shaft 36 of the drive mechanism 34. The rod 116 has a plurality of recesses 130,132,134 and 136 extending circumferentially on the outer periphery of the rod while being spaced apart from each other in the axial



direction of the rod 116. Each of the recesses 130, 132, 134 and 136 communicates to the corresponding one of the ports 118, 120, 122 and 124. A packing for blocking the operating oil from flowing to the adjacent recess is disposed between the adjacent recesses on the outer periphery of the rod 116.

The width of each of the recesses 130, 132, 134 and 136 in the axial direction of the shaft 36 is set to be larger than the maximum stroke of the shaft 36 so as to prevent the recesses 130, 132, 134 and 136 from getting out of the corresponding ports 118, 120, 122 and 124 of the receiving member 112 even if the rod 116 is shifted relative to the receiving member 112 along with the movement of the shaft 36.

The rod 116 further has a plurality of holes 138, 140, 142 and 144 extending toward the front end face of the rod 116 along the axis 21. Each of the holes 138, 140, 142 and 144 communicates to the corresponding one of the recesses 130, 132, 134 and 136 and opens to the front end face of the rod 116.

The drive mechanism 40 is mounted on the front end of the rod 116. The drive mechanism 40 as shown in Figs. 13 and 14 is provided with a guide rail 146 fixedly attached to the front end of the rod 116 by means of a plurality of bolts, a first slider 148 supported on the opposite side of the guide rail 146 to the rod 116 so as to be slidable in the direction of the



rotary axis 19 of the cutter 20 and a second slider 150 supported on the first slider 148 so as to be slidable in the direction of the rotary axis of the cutter 20.

The drive mechanism 40 as shown in Figs. 13 and 14 is further provided with a pair of double-acting hydraulic cylinder mechanisms 152, 154 formed in the first slider 148 so as to move the cutter 20 in the direction of the rotary axis 19 of the cutter.

A piston rod 156 of the cylinder mechanism 152 projects from the first slider 148 downward and is attached fixedly in position to the lower portion of the guide rail 146 by means of a screw. A piston rod 158 of the cylinder mechanism 154 projects from the first slider 148 upwards and is connected removably to the second slider 150 by means of a screw.

The guide rail 146 includes two pairs of ports 160, 162 and 164, 166 for use of the operating oil. Each of the ports 160, 162, 164 and 166 communicates to the corresponding one of the holes 138, 140, 142 and 144 in the rod 116. The port 160 communicates in common to both cylinder chambers on the extension side of the cylinder mechanisms 152, 154 while the port 162 communicates in common to both cylinder chambers on the contraction side of the cylinder mechanisms 152, 154. Also, the port 164, 166 are connected to the rotation source 54 of the drive mechanism 50.

The drive mechanism 50 for rotating the cutter 20



about its own rotary axis 19 is supported by the second slider 150 in front of the drive mechanism 40. Also, the position locking mechanism 71 for releasably fixing the position of the apparatus 10 relative to the first pipe 12 is mounted on the receiving member 112.

When the operation is done, the operating fluid for use in the drive mechanisms 40,50 passes through the ports 118,120,122 and 124, recesses 130,132,134 and 136 and holes 138,140,142 and 144 of the fluid guide mechanism 110. Thus, when the fluid guide mechanism 110 is used for guiding the operating fluid, it is not necessary to directly connect the drive mechanisms 40,50 to the electromagnetic valves 30 by means of flexible hoses even if the drive mechanisms 40, 50 are so constructed to rotate and shift relative to the drive mechanisms 32,34. In consequence, the angular rotation of the cutter 20 around the axis 21 and the movement of the cutter 20 in the direction of the axis 21 is smoothened.

An apparatus 210 as shown in Figs. 16 and 17 is used as an apparatus for cutting away a portion of the newly installed pipe 16 and filler by means of the cutter 20 rotated about its own axis 19 to thereby open the pipe opening of the second pipe 18 to the newly installed pipe 16.

The apparatus 210 comprises a support bed like a carriage, i.e., a support mechanism 222 disposed in the



first pipe 12 so as to be movable in the axial direction of the pipe 12. The support mechanism 222 is provided with a pair of elongate slide members 224 extending in parallel to each other in the axial direction of the first pipe 12. The support mechanism 222 cannot travel by itself, but it may employ a self-propelled carriage.

As shown in Figs. 23 and 24, when the apparatus 210 is disposed in the first pipe 12, each of the slide members 224 is attached fixedly in position to the side surface of each of the first elongate members 226 so as to be slidably in contact with the inner surface of the first pipe 12. Both of the first members 226 extend in parallel to each other in the axial direction of the first pipe 12 and are interconnected on both ends of the first members 226 by connecting members 228 and 230 without being movable relative to each other.

As shown in Figs. 20, 21, 23 and 24, each of the first members 226 is formed with four holes 232, 234, 236 and 238 extending through the first member 226 in the longitudinal direction thereof. The rear end (as being indicated at the left end in Figs. 16 and 17) of each of the holes 234, 236 and 238 other than the hole 232 formed at the lowermost portion provides a corresponding one of ports 234a, 236a and 238a for receiving the operating fluid. A hose (not shown) connected to an operating fluid source is connected to the corresponding one of the ports.



The lowermost hole 232 receives a shaft 240 so as to be movable in the axial direction of the shaft. On the other hand, other holes 234, 236 and 238 receive respectively the second tubular members 242, 244 and 246 so as to be movable in the axial direction of the second members and prevent the operating fluid from leakage therefrom. The front end of each of the second members 242, 244 and 246 is protruded forward from the first member 226 and closed.

Both of the shafts 240 are interconnected on both rear ends by a connecting member 248 as shown in Figs. 18, 20, 21 and 24 without being movable relative to each other. As shown in Figs. 18 through 20, a drive mechanism 250 for rotating angularly the rotary axis 19 of the cutter 20 about the axis 21 extending along the axis of the first pipe 12 is mounted on the connecting member 248 so as to extend forward from the connecting member 248 between both of the first members 226.

As for the drive mechanism 250, use may be made of a double-acting rotary hydraulic mechanism functioning as a rotary source and commercially available under the name of a hydraulic rotary actuator, for example. However, other mechanisms may be available.

The drive mechanism 250 includes a pair of ports 254 for use of the operating fluid and adapted to swing, i.e., angularly rotate a shaft 252 of the drive



mechanism 250 about the axis 21. Each of the ports 254 communicates to the interior of the front end of the second member 244 through a hose (not shown). The drive mechanism 250 angularly rotates the shaft 252 about the axis 21 in one direction by the operation of the operating fluid supplied to one port 254 while it angularly rotates the shaft 252 in the opposite direction to the aforementioned direction by the the operation of the operating fluid supplied to the other port 254.

Both of the shafts 240 are also interconnected on both front ends by a fluid guide mechanism 256 for guiding the operating fluid without being movable relative to each other. As shown in Figs. 18 through 22, the fluid guide mechanism 256 is provided with a pair of coupling blocks 258 attached fixedly to the front end of the shaft 240, a tubular receiving member or carrier member 260 attached fixedly to both of the blocks 258 so as to extend in parallel to the axis 21 between both of the first members 226 and a rod 262 received in the receiving member 260 so as to be rotatable about the axis 21.

Each of the blocks 258 is formed with four holes extending through the block 258 in parallel to the axis 21. Each hole is provided at a spot corresponding to the hole formed in the first member 226 of the support mechanism 222. In each hole of the block 258 is fitted



the front end of the shaft 240 or second member 242, 244 or 246. The shaft 240 and second members 242, 244 and 246 are attached fixedly to the block 258.

Each block 258 is formed with a plurality of flow paths 264 for use of the operating fluid. Each of the flow paths 264 is connected to the predetermined one of the second members 242, 244 and 246. Each of the second members 242, 244 is formed with a hole 266 for connecting the interior of the second member to the corresponding one of the flow paths 264.

The receiving member 260 is connected on its front end to the rear end of the drive mechanism 250 by means of a plurality of bolts. The receiving member 260 includes two pairs of flow paths 268 extending through the receiving member 260 from the outside to the inside. Each of the flow paths 268 communicates to a flow path of the predetermined one of the second members 242 and 246 through a predetermined one of the flow paths 264 of the block 258. Further, the flow path 264 communicating to the flow path in the second member 244, as mentioned above, communicates to the port 254 in the drive mechanism 250 through a hose (not shown).

As shown in Figs. 19 and 20, the rod 262 of the fluid guide mechanism 256 is connected to the front end of the shaft 252 by means of a bolt 270 and a key (not shown) without relative rotation and movement between the rod 262 and the shaft 252. The rod 262 includes a



plurality of annular recesses 272 extending in the circumferential direction on the outer periphery of the rod while being spaced apart from each other in the axial direction of the rod 262. Each of the recesses 272 communicates to a predetermined one of the flow paths 268 in the receiving member 260. The rod 262 further includes a plurality of flow paths, i.e., holes 274 extending along the axis 21 toward the front end surface of the rod 262. Each of the holes 274 communicates to a predetermined one of the recesses 272 in the rod 262 and opens to the front end surface of the rod 262.

As shown in Figs. 16 and 19, the drive mechanism 250 and fluid guide mechanism 256 are shifted integrally in parallel to the axis 21 by a drive mechanism 276 disposed below the drive mechanism 250. The drive mechanism 276 in the illustrated embodiment is composed of a double-acting hydraulic jack disposed so as to expand or contract in parallel to the axis 21. A cylinder 278 of the jack is connected to the connecting member 228 by a connecting tool 280, and a piston rod 282 is connected to the fluid guide mechanism 256 by a connecting tool 284.

On the front end of the rod 262 is mounted a drive mechanism 286 for shifting the cutter 20 in parallel to its own rotary axis 19. The drive mechanism 286, as shown in Fig. 25, is provided with a guide rail



288 attached fixedly to the front end of the rod 262 by means of a plurality of bolts, a first slider 290 supported on the guide rail 288 so as to be movable in parallel to the rotary axis 19 and a second slider 292 supported on the first slider 290 so as to be movable in parallel to the rotary axis 19.

The guide rail 288 and first slider 290 are brought into engagement with each other so as to be movable relative to each other in parallel to the axis 19 without separating from each other. Similarly, the first and second sliders 290, 292 are brought into engagement with each other so as to be movable relative to each other in parallel to the axis 19 without separating from each other.

The first slider 290 is provided with double-acting hydraulic cylinder mechanisms 294, 296 for shifting the cutter 20 in parallel to its own rotary axis 19. A piston rod 298 of the cylinder mechanism 294 projects downward from the first slider 290 and is attached fixedly to the lower portion of the guide rail 288 by means of a screw. A piston rod 300 of the cylinder mechanism 296 projects upward from the first slider 290 and is connected removably to the second slider 292 by means of a screw. Therefore, the cylinder mechanisms 294, 296 are substantially interconnected in series.

The guide rail 288 is formed with two pairs of

flow paths 302 for use of the operating fluid. Each of the flow paths 302 communicates to the predetermined one of the holes 274 in the rod 262. One of the pair of the flow paths 302 communicates in common to both cylinder chambers on the extension side of the cylinder mechanisms 294, 296 while the other one communicates in common to both cylinder chambers on the contraction side of the cylinder mechanisms 294, 296.

On the second slider 292 is mounted a drive mechanism 304 for rotating the cutter 20 about its own rotary axis 19 in front of the drive mechanism 286. As shown in Figs. 16 and 17, the drive mechanism 304 is provided with a gear box 306 attached fixedly to the second slider 292 by means of a plurality of bolts and a hydraulic motor 308 attached fixedly to the front end of the gear box.

As shown in Fig. 25, the gear box 306 supports a rotary shaft 310 for supporting the cutter 20 so as to be rotatable about the axis of the rotary shaft 310. The rotation of the hydraulic motor 308 is transmitted to the rotary shaft 310 through gears 312, 314 disposed in the gear box 306.

To the front end of the hydraulic motor 308 is fixedly attached a port bed 316 for use of the operating fluid. The port bed 316 is provided with a pair of ports 318 for use of the operating fluid. Each of the ports 318 communicates to the remaining flow paths 302



of the drive mechanism 286 through a hose (not shown) while it communicates to the hydraulic motor 308.

On the port bed 316 is mounted a plate member 320, on which is mounted a remote-controllable television camera 322 for taking a picture of portions to be worked. An output signal from the television camera 322 is supplied to a monitor installed on the ground.

The apparatus 210 further comprises a position locking mechanism 334 for releasably locking the position of the support mechanism 222 relative to the first pipe 12. The position locking mechanism 334, as shown in Figs. 18 and 21, is provided with a pair of double-acting hydraulic cylinder mechanisms 336 provided in correspondence to the first members 226 of the support mechanism 222. A cylinder of each of the hydraulic cylinder mechanisms 336 is pivotally connected to the corresponding one of the first members 226, while a piston rod of the hydraulic cylinder mechanism 336 is pivotally connected to the lower surface of a common pad plate 338 disposed so as to cover the upper portion of the support mechanism 222.

The pad plate 338 is bent to have approximately the same curved surface as the inner surface of the first pipe 12 and pivotally connected to one end of a plurality of links 340. The other ends of the links 340 are pivotally connected to the first member 226 so as to



Each of the cylinder mechanisms 336 includes a pair of ports 342 each communicating to the operating fluid source through a hose (not shown) and are operated synchronously.

As shown in Figs. 19 and 24, the apparatus 210 further comprises a stroke sensor 344 for generating an electric signal in accordance with the displacement of the cutter 20 in parallel to the axis 21, a rotary sensor 346 for generating an electric signal in accordance with the angular displacement of the cutter 20 around the axis 21 and an inclinometer 348 for generating an electric signal in accordance with a slant angle of the apparatus 210 with respect to the vertical line.

The stroke sensor 344, rotary sensor 346 and inclinometer 348 are known devices each provided with a body and an actuator. The body of the stroke sensor 344 is connected to the connecting member 228 while the actuator thereof is connected to the fluid guide mechanism 256. The body of the rotary sensor 346 is connected to the connecting member 228 while the actuator thereof is connected to the rotary axis of the drive mechanism 250. The body of the inclinometer 348 is mounted on the connecting member 228 such that the actuator of the inclinometer 348 extends along a vertical line. Output signals from the sensors 344, 346

and inclinometer 348 are supplied to the monitor installed on the ground.

Prior to the cutting operation, the apparatus 210 is first disposed in the first pipe 12 from a vertical shaft connected to the first pipe 12 under the condition that the cylinder mechanism 336 of the position locking mechanism 334 is contracted. When the cylinder mechanism 336 is contracted, the pad plate 338 is lowered toward the support mechanism 222, as shown in Fig. 16, to thereby permit the apparatus 210 to move relative to the first pipe 12.

Next, the apparatus 210 is shifted to a position where the cutter 20 faces to the pipe opening of the second pipe 18 by means of a rope and a winch.

When the portion of the first pipe 12 corresponding to the pipe opening of the second pipe 18 can be monitored from the interior of the first pipe 12, the apparatus 210 is determined in position by using the television camera 322 such that the cutter 20 is disposed in the center of the pipe opening of the second pipe 18. For that end, the portion photographed by the television camera 322 is reproduced on the monitor on the basis of the output signal from the television camera 322 and the apparatus 210 is shifted or the drive mechanisms 250, 276 are operated to move the cutter 20 as monitoring the reproduced image.

When the apparatus 210 is shifted to a



predetermined position, the cylinder mechanism 336 of the position locking mechanism 334 is extended. By so doing, since the pad plate 338 is pressed against the inner surface of the newly installed pipe 16, the apparatus 210 is maintained in position to be unmovable relative to the first pipe 12.

When the pair of cylinder mechanisms 336 are used as in the case of the apparatus 210, the pad plate 338 is pressed against the inner surface of the newly installed pipe 16 more severely in comparison with a case when one cylinder mechanism is used. Consequently, the apparatus 210 is maintained stably with respect to the first pipe 12.

When the cutting operation is done, the cylinder mechanisms 294, 296 of the drive mechanism 286 are extended as the motor 308 of the drive mechanism 304 is operated. Accordingly, since the cutter 20 is lifted along the rotary axis 19 thereof while being rotated about the rotary axis 19, a hole is bored in that portion of the first pipe 12 which closes the pipe opening of the second pipe 18.

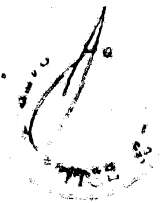
Next, the drive mechanisms 250, 276 are operated at least once, preferably over and over while the motor 308 of the drive mechanism 304 is operated under the condition that the cylinder mechanisms 294, 296 are extended. Therefore, the drive mechanism 250 and fluid guide mechanism 256 are reciprocated at least



once along the axis 21 while the rod 262 of the fluid guide mechanism 256 is reciprocated at least once about the axis 21, so that the cutter 20 is reciprocated at least once in parallel to the axis 21 and in the circumferential direction of the first pipe 12 respectively through the drive mechanisms 286,304. As a result, the hole as noted above is expanded.

At the time of the cutting operation, when the cutter 20 is shifted by the drive mechanisms 250,276 such that the angular displacement of the rotary axis 19 of the cutter 20 and displacement in the direction of the axis 21 come to proper values, the locus of motion of the cutter 20 results in a circle or an ellipse. Further, by adjusting the timing in which the angular displacement comes to the maximum value and the timing in which the displacement in the axial direction comes to the maximum value, it is possible to set the direction of the long axis of the ellipse at will. Further, by adjusting the angular displacement and displacement in the direction of the axis 21, the locus of motion of the cutter 20 results in a desired ellipse in shape and size. Therefore, a desired hole in shape and size may be bored in accordance with the apparatus 210.

During the cutting process, the portion to be cut may be monitored by the television camera 322 and the monitor. In this case, each of the drive mechanisms and



cylinder mechanisms may be manually remote-controlled. More preferably, each of the drive mechanisms and cylinder mechanisms is remote-controlled by a computer. By so doing, the boring operation may be effected without requirement of any skill.

When the cutting operation is done, it is preferable that the displacement of the cutter 20 in the direction of the axis 21 and angular displacement of the cutter 20 about the axis 21 are gradually increased by repeatedly operating the drive mechanisms 250, 276 while operating the drive mechanism 304. By so doing, the hole as noted above may be gradually expanded.

When the apparatus 210 is used as an apparatus for removing the protrusions such as substances deposited on the inner surface of the first pipe 12 and projections of the second pipe 18 extending into the first pipe 12, use may be made of a cutter 20a as shown in Figs. 10 and 11 instead of the cutter 20.

When the operation of removing the protrusions is done, it is preferable that the drive mechanism 286 is operated while the drive mechanisms 250, 276 and 204 are operated. Thus, since the cutter 20 is shifted toward the inner surface of the first pipe 12 while being rotated about its own rotary axis 19, angularly rotated about the axis 21 and reciprocated in the direction of the axis 21, the protrusions may be securely removed so as to be cut away up to the proximity of the inner surface



of the first pipe 12.

When the apparatus 210 is used as an apparatus for disposing a plug of cutoff in the front end of the second pipe 18, use is made of a fixture 100 as shown in Fig. 12, instead of the cutter 20. The operation of closing the front end of the second pipe 18 with the plug 108 of cutoff is performed by operating the drive mechanism 286 while operating the drive mechanism 304 after the apparatus 210 is disposed in a predetermined position such that the plug 108 of cutoff faces to the front end of the second pipe 18.

Upon completion of the operation, the apparatus 210 is taken out of the first pipe 12 with the cylinder mechanisms 294, 296 of the drive mechanism 286 and cylinder mechanism 336 of the position locking mechanism 334 in a contracted state.

In the apparatus 210, when the drive mechanism 276 is operated, the members 234, 236 and 238 of the support mechanism 222 are shifted in the direction of the axis 21 relative to the first member 226, so that the flow paths of the operating fluid for use in the drive mechanisms 250, 286 and 304 are contracted.

Further, when the drive mechanism 250 is operated, the rod 262 of the fluid guide mechanism 256 is rotated relative to the receiving member 260. However, since the positional relation between the recess 272 of the rod 262 and the flow path 268 of the receiving member

260 in the direction of the axis 21 is fixed constant, the flow paths of the operating fluid for use in the drive mechanisms 286 and 304 are maintained.

Therefore, according to the apparatus 210, even if the drive mechanisms 286, 304 are rotated or shifted relative to the drive mechanisms 250, 276, it is not necessary to directly connect the operating fluid source to the drive mechanisms 286, 304 through flexible hoses. As a result, the angular rotation of the cutter 20 about the axis 21 and the movement of the cutter 20 in the direction of the axis 21 may be performed smoothly. Further, even if the length of the whole apparatus in the axial direction of the pipe is set to be a smaller size, the maximum length of the flow path of the support means may be set to be a larger size.

The apparatus 10 or 210 may be suitable to the application, in addition to the boring operation, protrusion removing operation and disposing operation of the plug of cutoff, to the operation of forming a tapped hole in the inner wall of a pipe or operation of screwing a bolt into the tapped hole, for example, by attaching another jig or tools to the rotary axis 52 or 310 instead of the cutter 20 and fixture 100.

2

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An apparatus for conducting operations in the interior of a pipe such as cutting off the pipe for boring a hole in the pipe, removing substances attached to the inner surface of the pipe or a protrusion of a branch pipe extending into the pipe, or disposing a plug into the pipe opening of the branch pipe and the like, by means of a tool having a rotary axis extending in a direction intersecting the axis of the pipe comprising:

support means to be disposed in said pipe so as to be movable in the axial direction of said pipe;

first drive means for rotating said tool about the rotary axis thereof, said first drive means having a tool mounting portion for mounting said tool; and

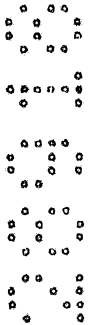
second drive means for displacing said tool in the radial direction of said pipe and for supporting said first drive means, said second drive means being disposed in said support means;

wherein said second drive means is provided with a plurality of cylinder mechanisms which is interconnected so that said tool can be displaced in the radial direction of said pipe by a value corresponding to a total amount of expansion and contraction of said cylinder mechanisms.

2. An apparatus for conducting operations in the interior of a pipe as claimed in claim 1, wherein said second drive means displaces said first drive means in the radial direction of said pipe to displace said tool.

3. An apparatus for conducting operations in the interior of a pipe as claimed in claim 1, further comprising third drive means for displacing said tool so that said rotary axis of said tool can be displaced in the axial direction of said pipe and also angularly displaced about the axis extending in the axial direction of said pipe, said third drive means being supported by said support means and supporting said second drive means.

4. An apparatus for conducting operations in the interior of a pipe as claimed in claim 3, wherein said third drive means displaces said second drive means in the axial direction of said pipe and angularly displaces the same about an axis



extending in the axial direction of said pipe to displace said tool.

5. An apparatus for conducting operations in the interior of a pipe as claimed in claim 1, further comprising:

third drive means for displacing said tool so that the rotary axis of said tool can be angularly rotated about the axis extending in the axial direction of said pipe, said third drive means supporting said second drive means; and

fourth drive means for displacing said tool so that said rotary axis of said tool can be displaced in the axial direction of said pipe, said fourth drive means being supported by said support means and supporting said third drive means.

6. An apparatus for conducting operations in the interior of a pipe as claimed in claim 5:

wherein said third drive means angularly rotates said second drive means about the axis extending in the axial direction of said pipe to displace said tool; and

wherein said fourth drive means displaces said third drive means in the axial direction of said pipe to displace said tool.

7. An apparatus for conducting operations in the interior of a pipe as claimed in claim 3, further comprising:

fluid guide means for guiding operating fluid to actuate said first and second drive means said fluid guide means being provided with a tubular receiving member for receiving a rod extending in the axial direction of said pipe and defining a space to receive said rod, said fluid guide means also being supported by said support means so that said rod can be moved in the axial direction of said pipe;

wherein said receiving member is provided with a plurality of liquid paths for said operating fluid;

wherein said rod has a plurality of holes and a plurality of recesses each of the recesses being disposed in the outer periphery of the rod to extend along the periphery, the recesses being spaced apart from each other in the axial direction of said pipe and communicated respectively with the liquid

paths, the holes being respectively communicated with the recesses and extending in the axial direction of said pipe;

wherein said second drive means is supported by said third drive means through said rod; and

wherein said third drive means displaces said tool by moving said rod in the axial direction of said pipe and by rotating said rod about its own axis.

8. An apparatus for conducting operations in the interior of a pipe as claimed in claim 5, further comprising:

fluid guide means for guiding operating fluid to actuate said first and second drive means the fluid guide means being supported by said support means so as to be movable in the axial direction of said pipe and including a receiving member for receiving a rod extending in the axial direction of said pipe and defining a space to receive the rod rotatably about its own axis;

wherein said support means is provided with a first member having spaces extending in the axial direction of said pipe; and tubular second members received in said spaces of said first member so as to be movable in the axial direction of said spaces, said second members being respectively received along the axial direction of said spaces of the first member so that each of the second members may define a first liquid path for said operating fluids, and each of said first liquid paths being expandable and contractible in the axial direction of said pipe in co-operation with said first member;

wherein said receiving member is provided with second liquid paths respectively for said operating fluids so as to communicate respectively with said first liquid paths of said support means;

wherein said rod has holes for operating fluids and recesses the recesses being respectively communicated with said second liquid paths and disposed in the outer periphery of said rod to extend along the periphery of the rod and spaced apart from each other in the axial direction of said pipe; the holes being respectively communicated with said recesses and extending in the axial direction of said pipe;

wherein said second drive means is supported by said third drive means



through said rod;

wherein said third drive means angularly rotates said rod with respect to said receiving member to displace said tool; and

wherein said fourth drive means displaces said fluid guide means in the axial direction of said pipe to displace said tool.

9. An apparatus for conducting operations in the interior of a pipe substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 7th day of February, 1991.

DAVIES & COLLISON

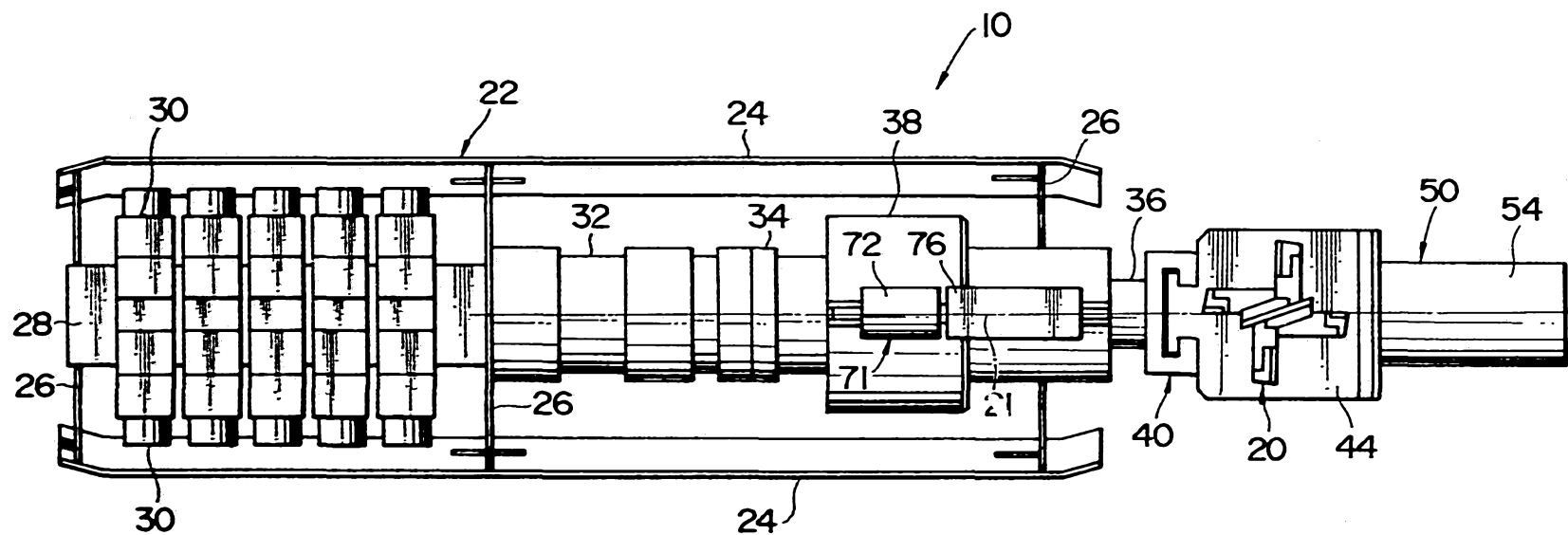
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SEKISUI KAGAKU KOGYO KABUSHIKI KAISHA

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FIG. 1



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FIG. 2

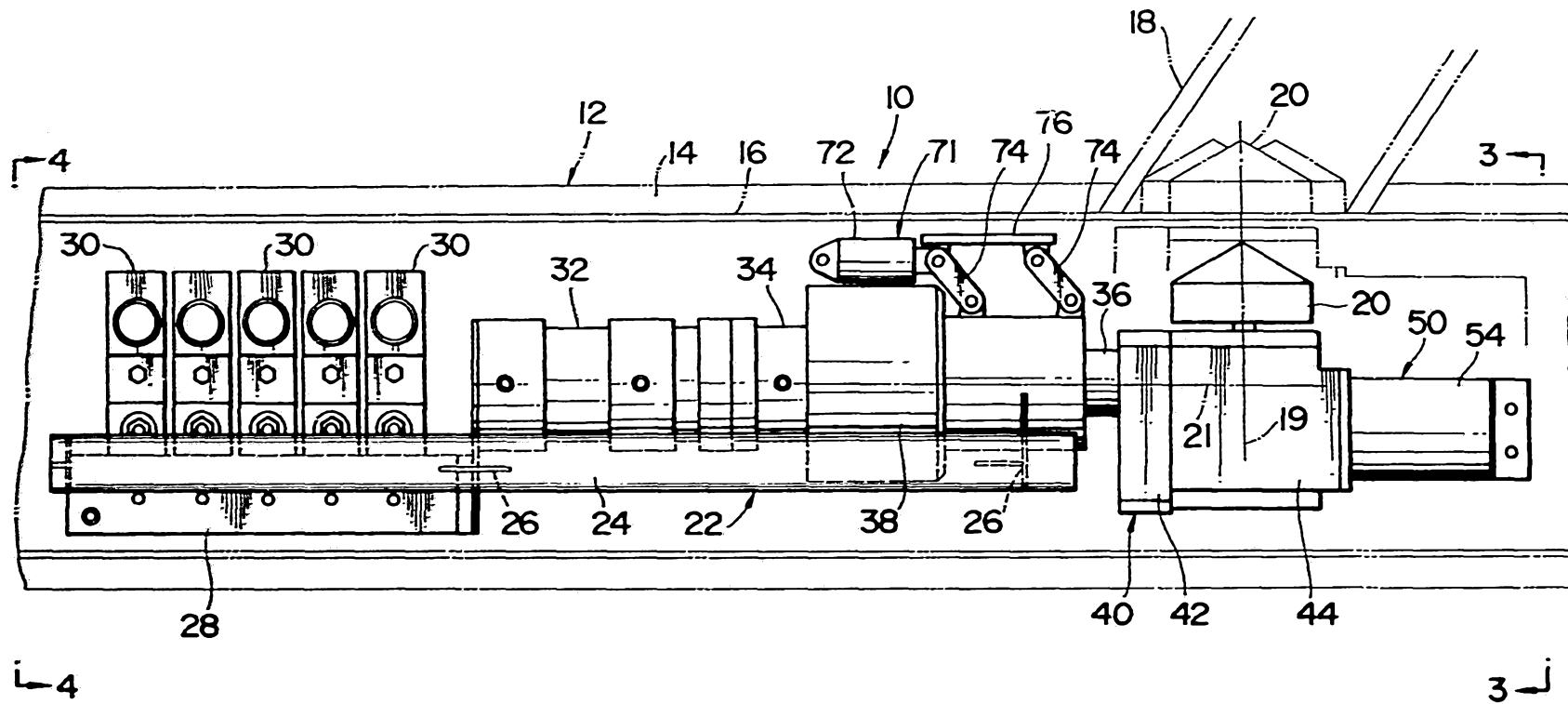


FIG. 3

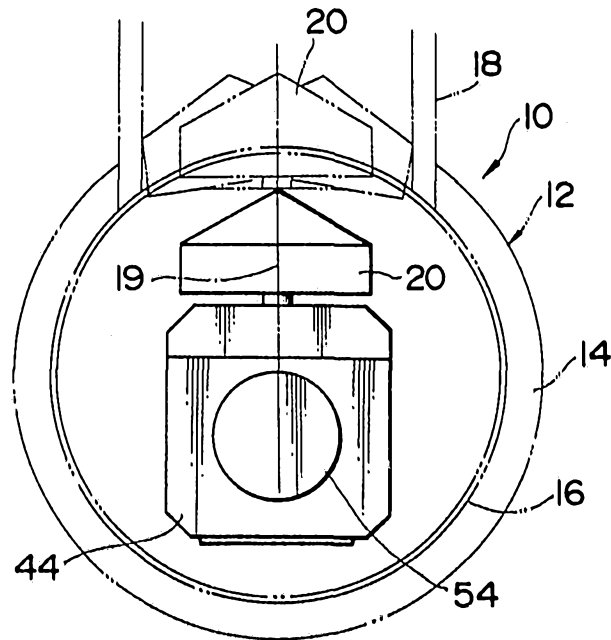


FIG. 4

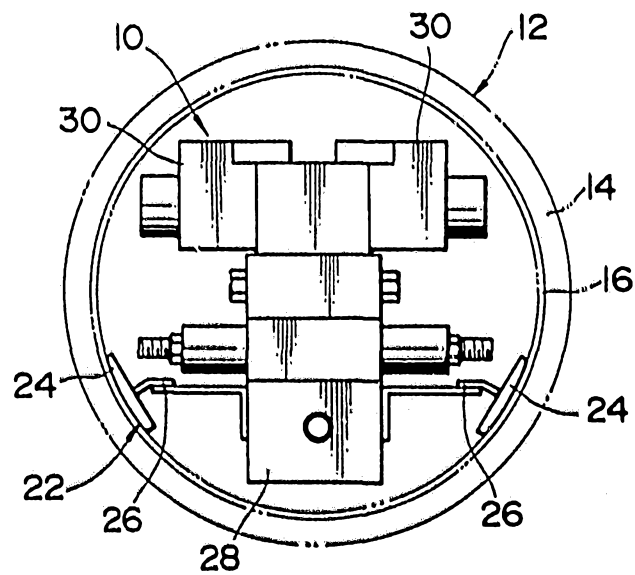


FIG. 5

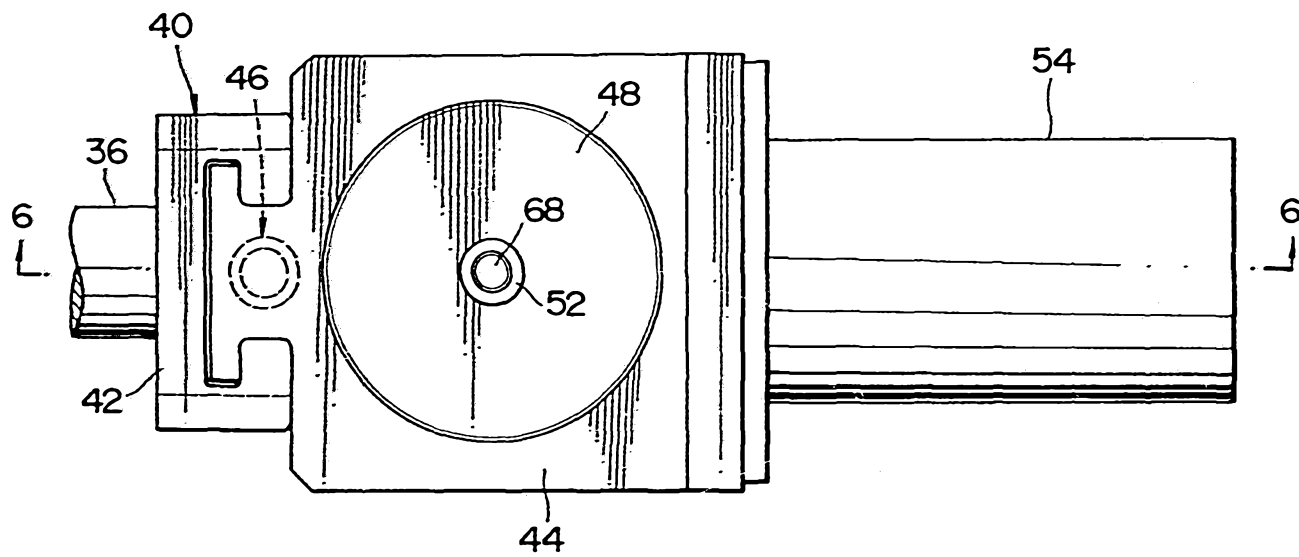


FIG. 6

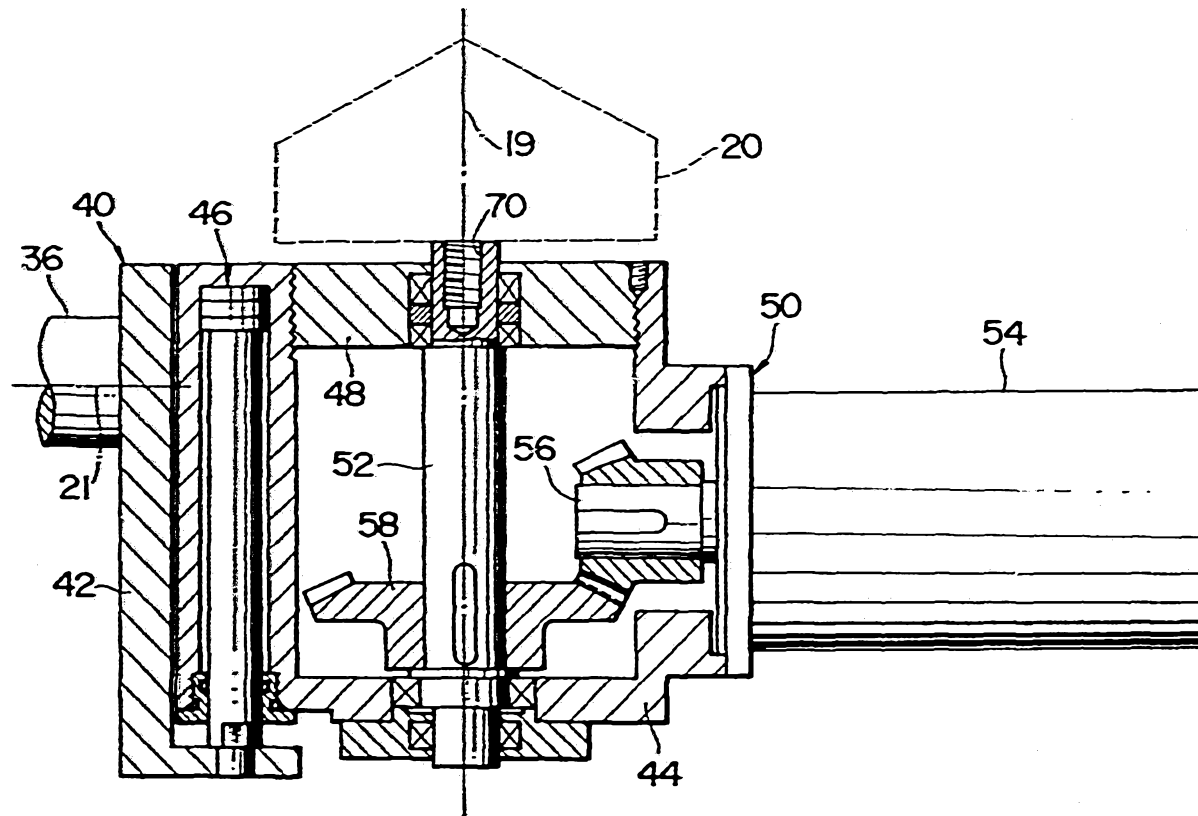


FIG. 7

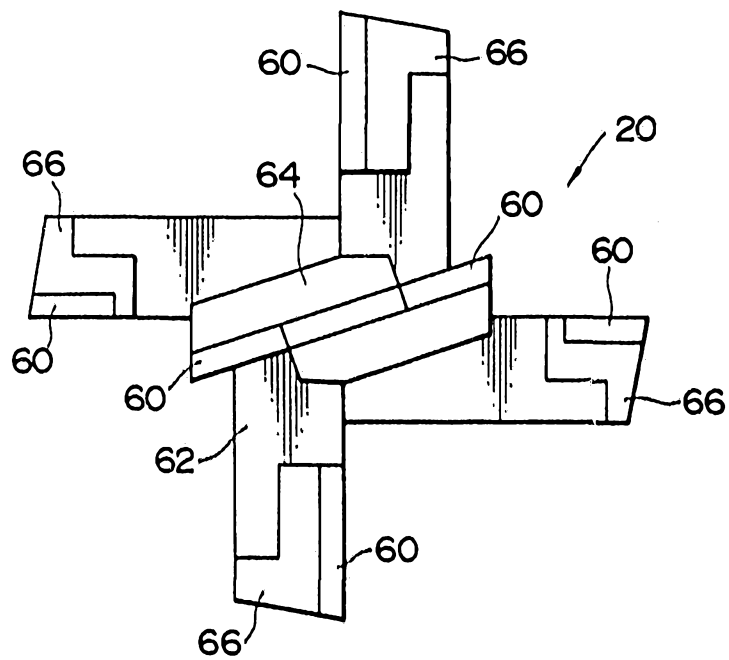


FIG. 8

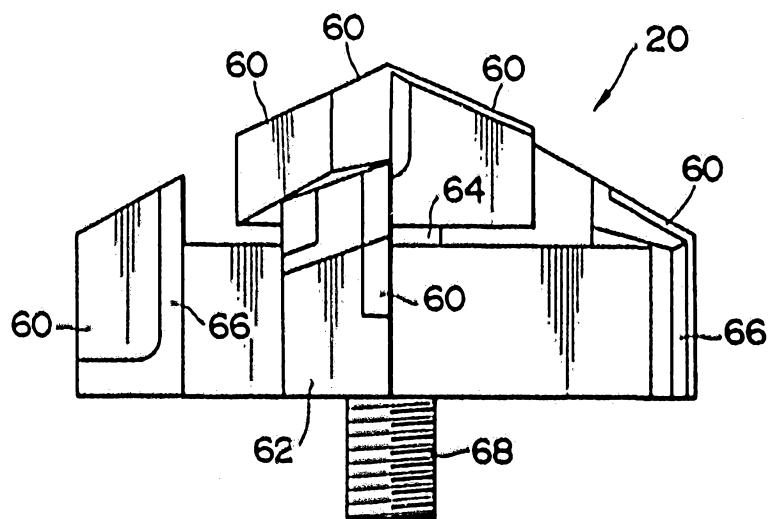


FIG. 9

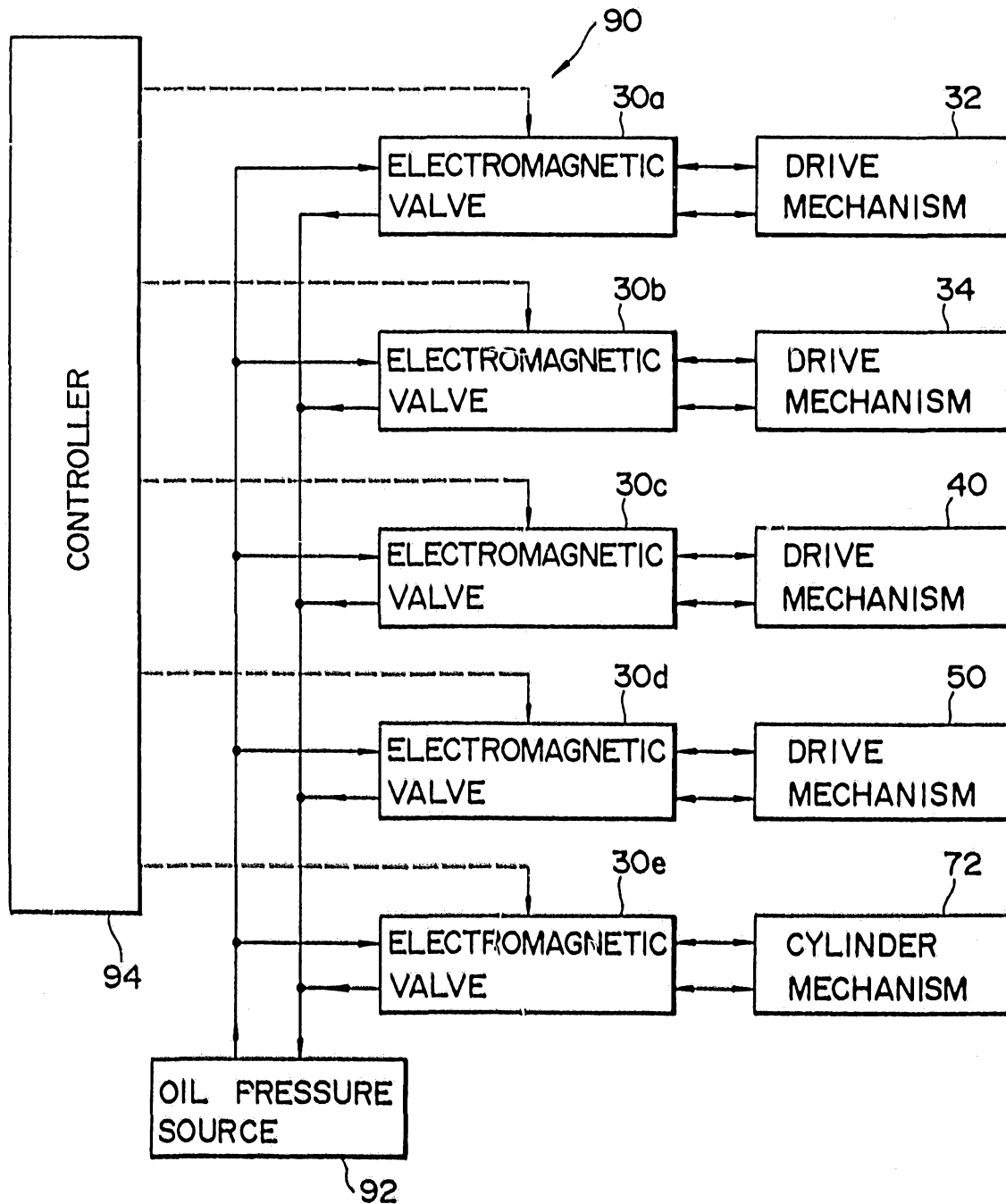


FIG. 10

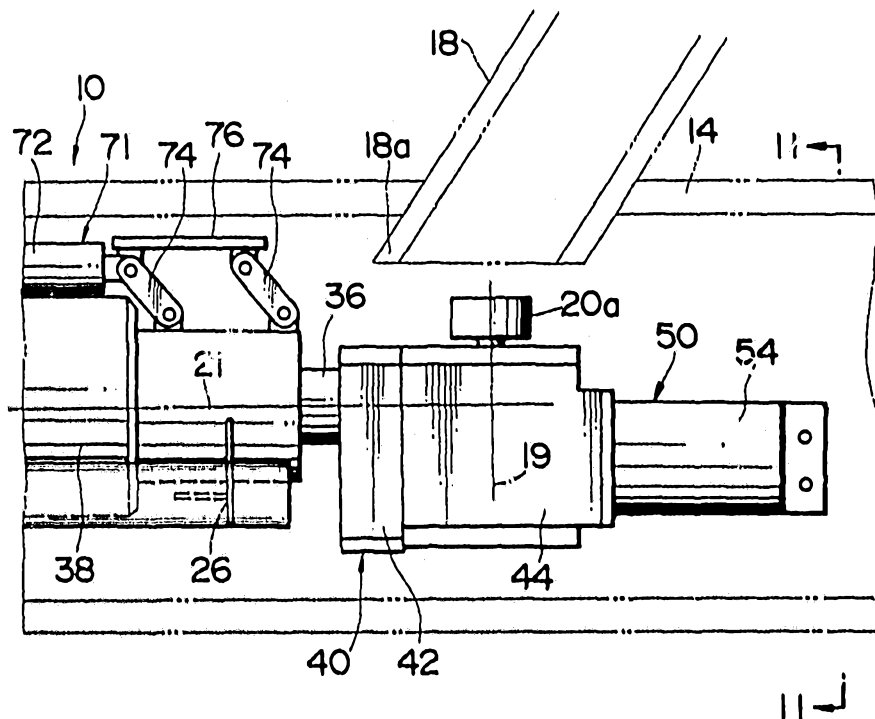


FIG. 11

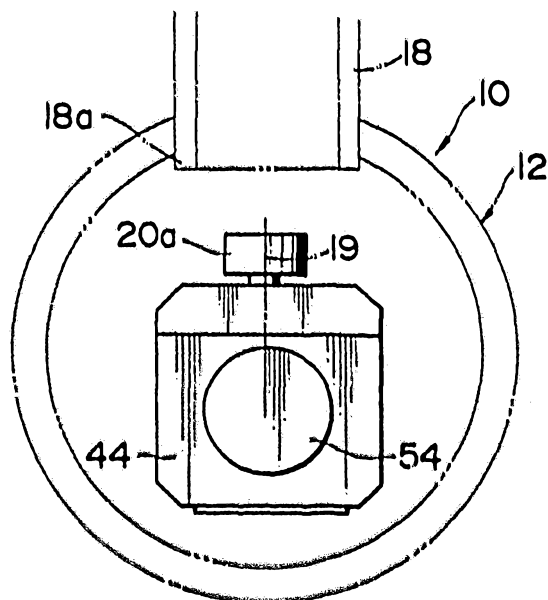
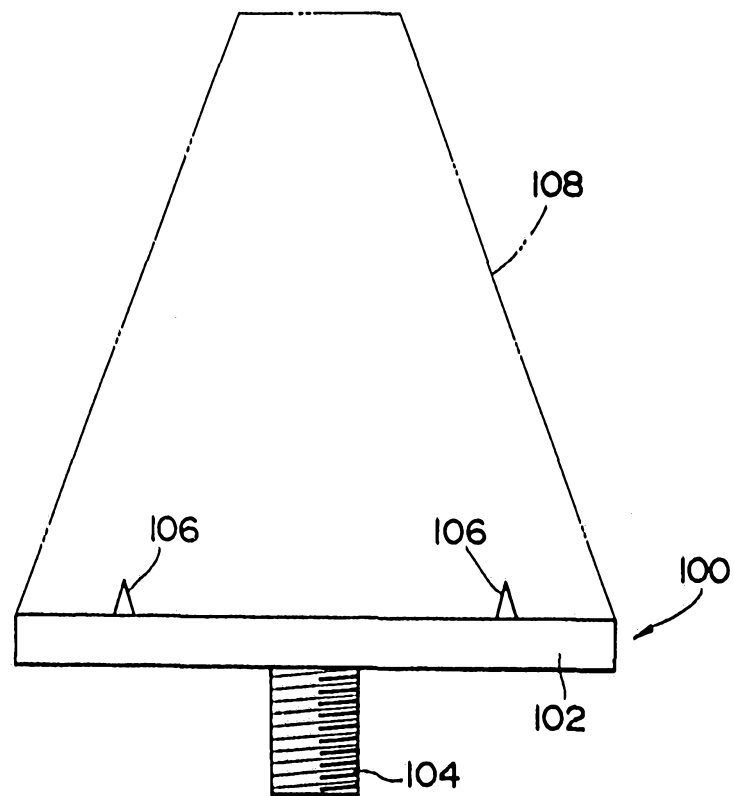


FIG. 12



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FIG. 13

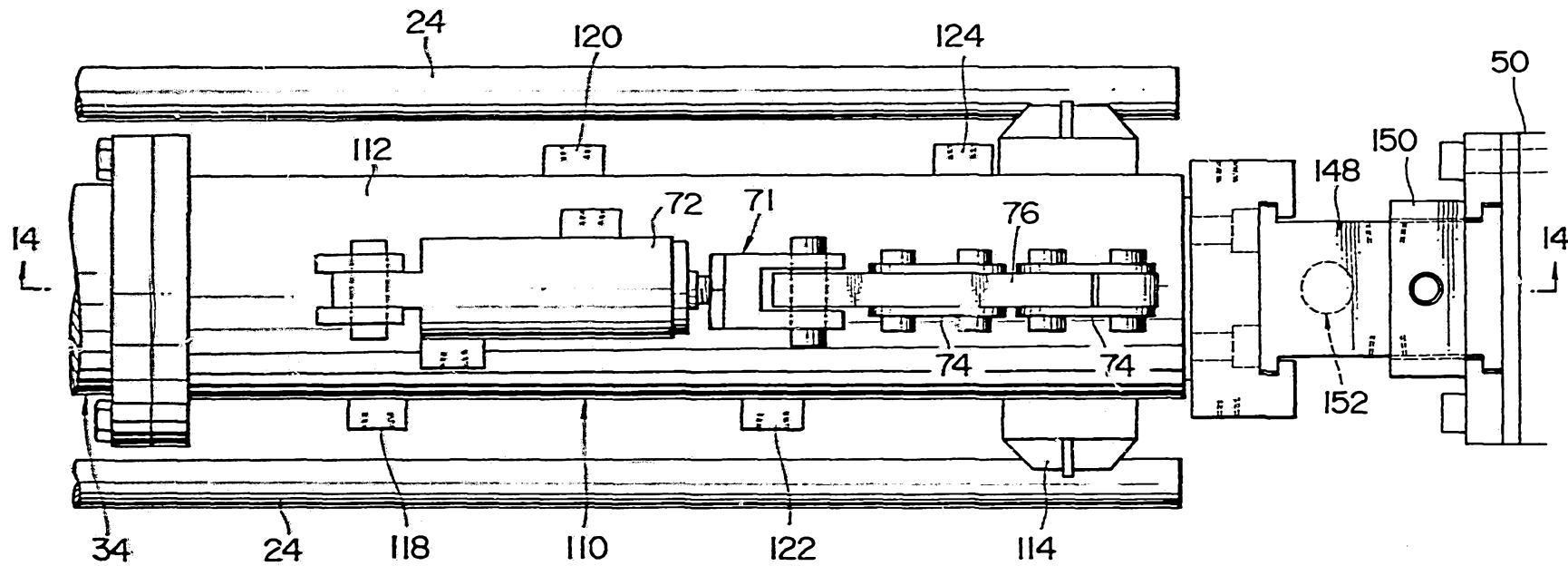


FIG. 14

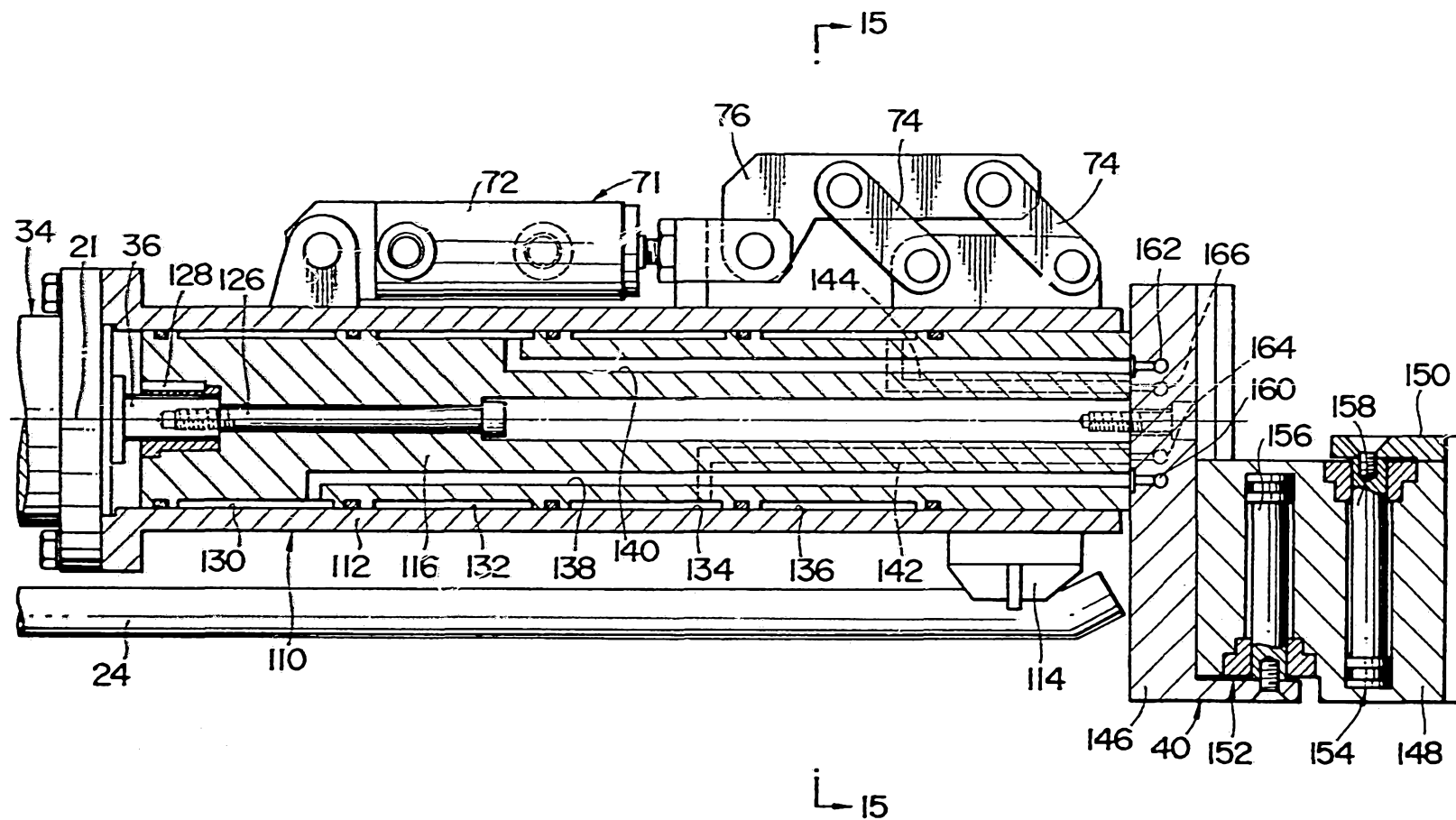
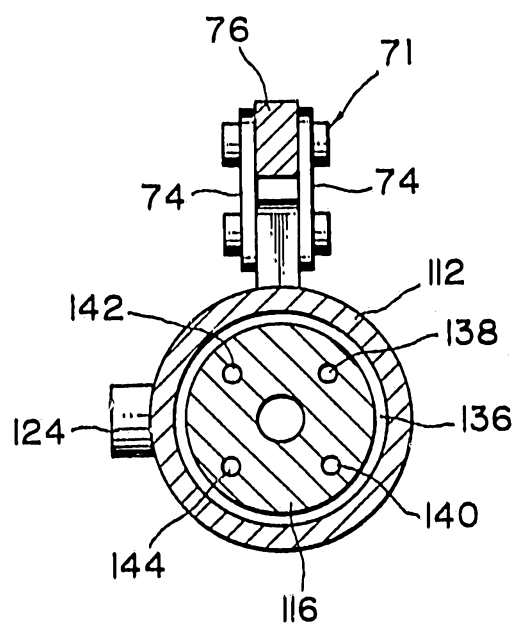
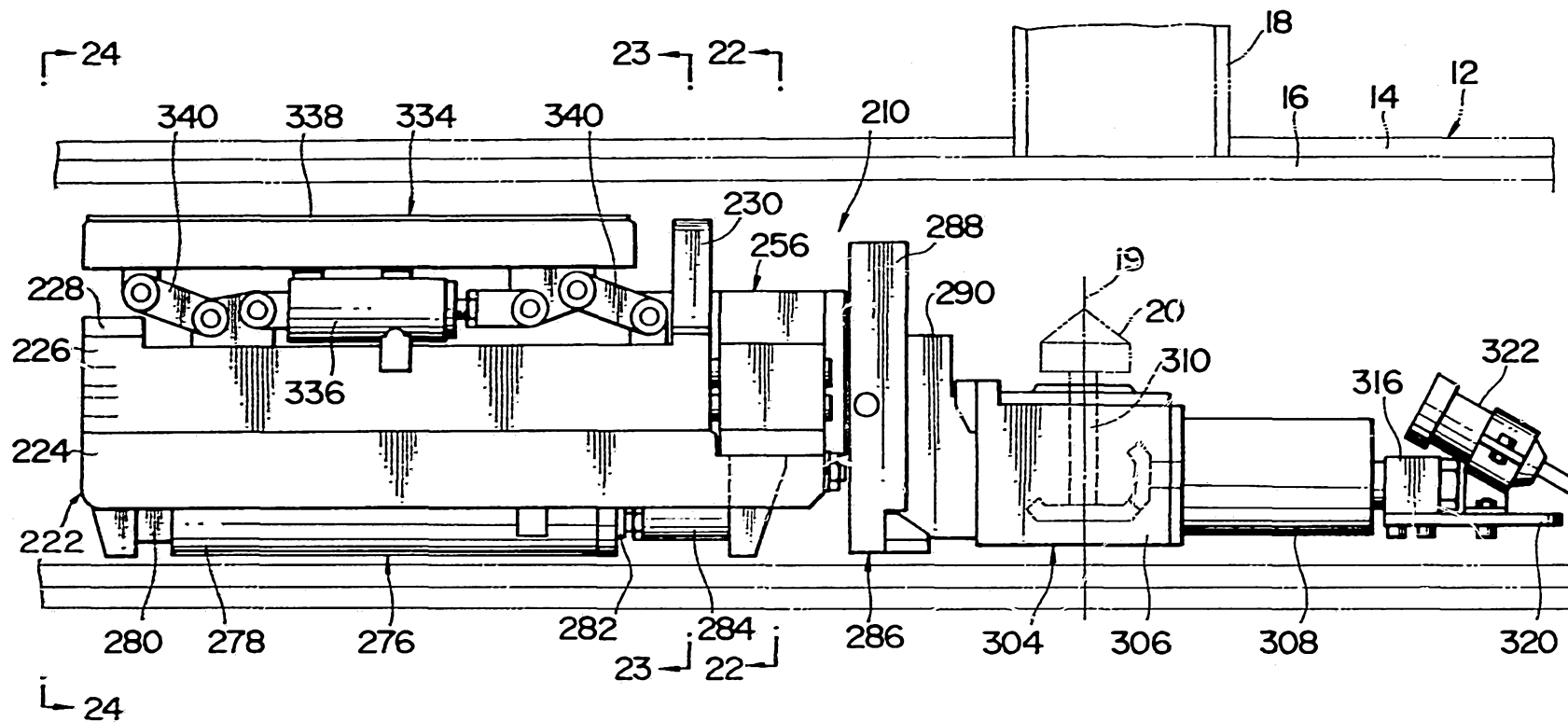


FIG. 15

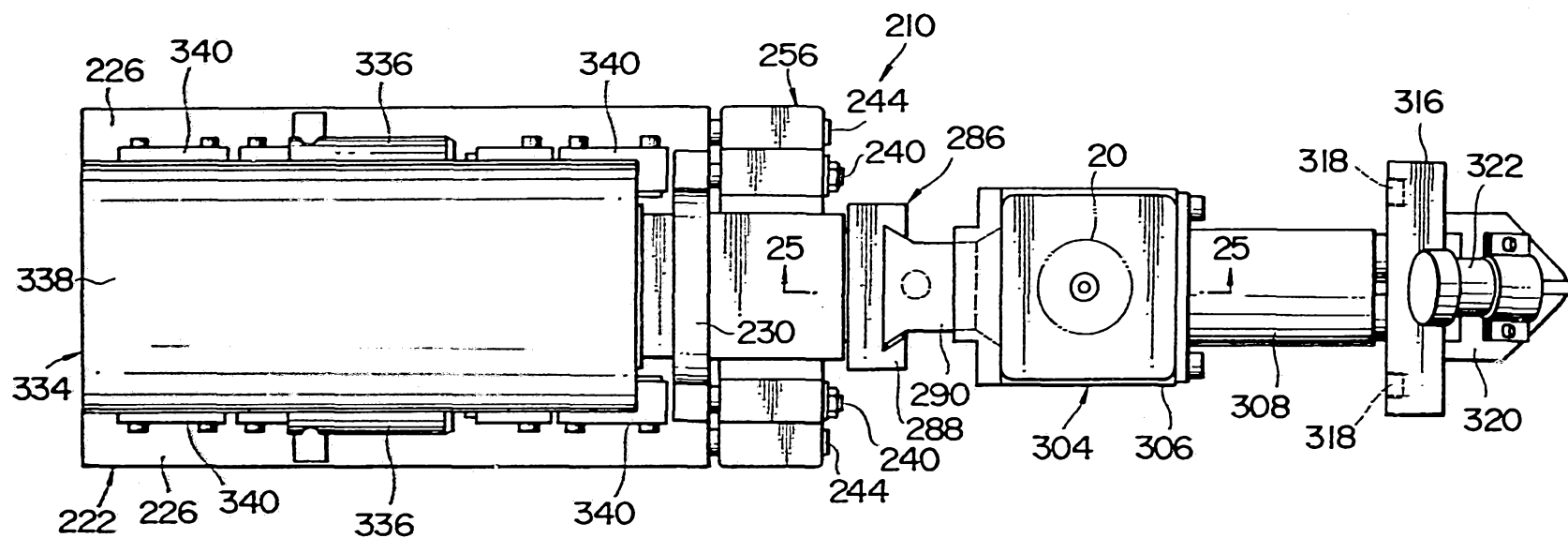


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FIG. 16



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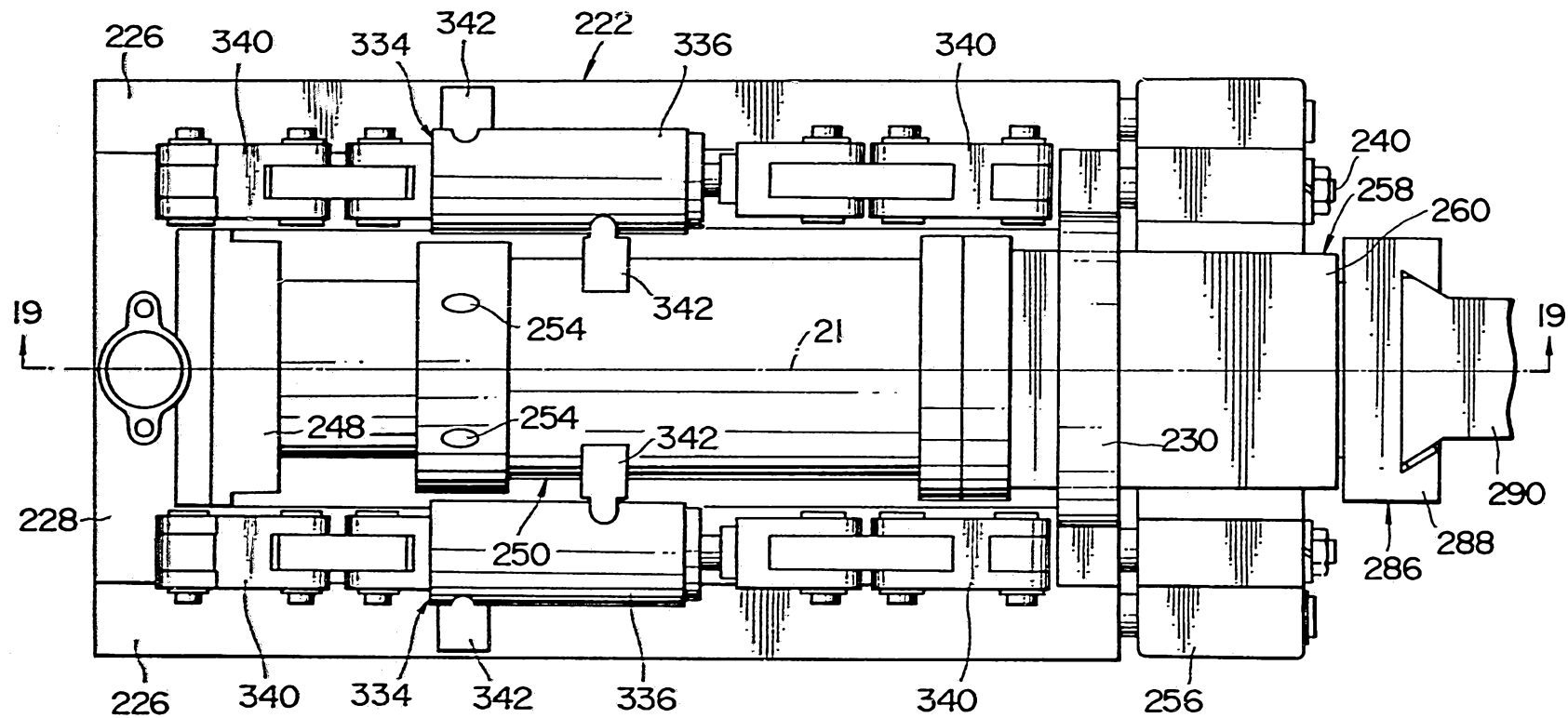
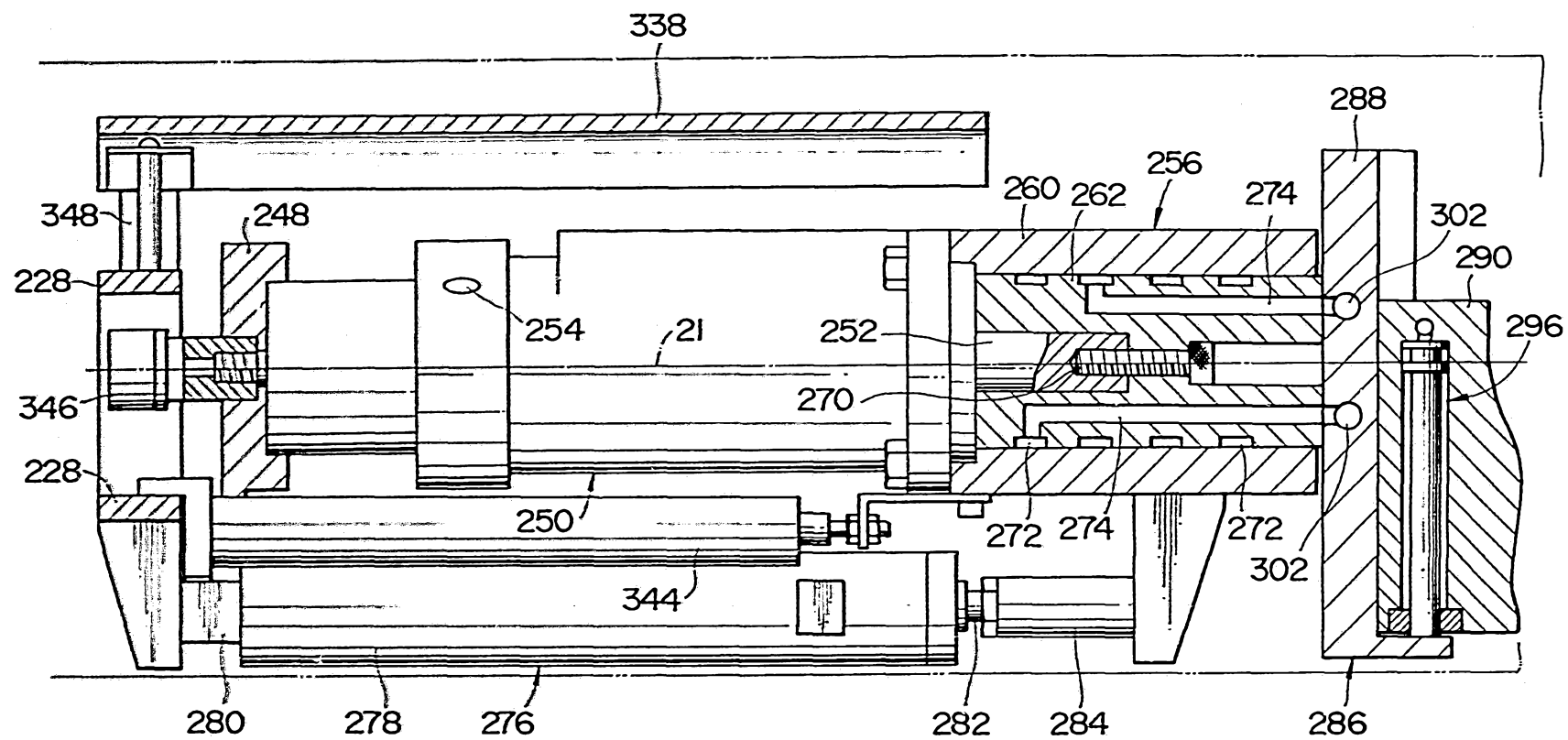


FIG. 19



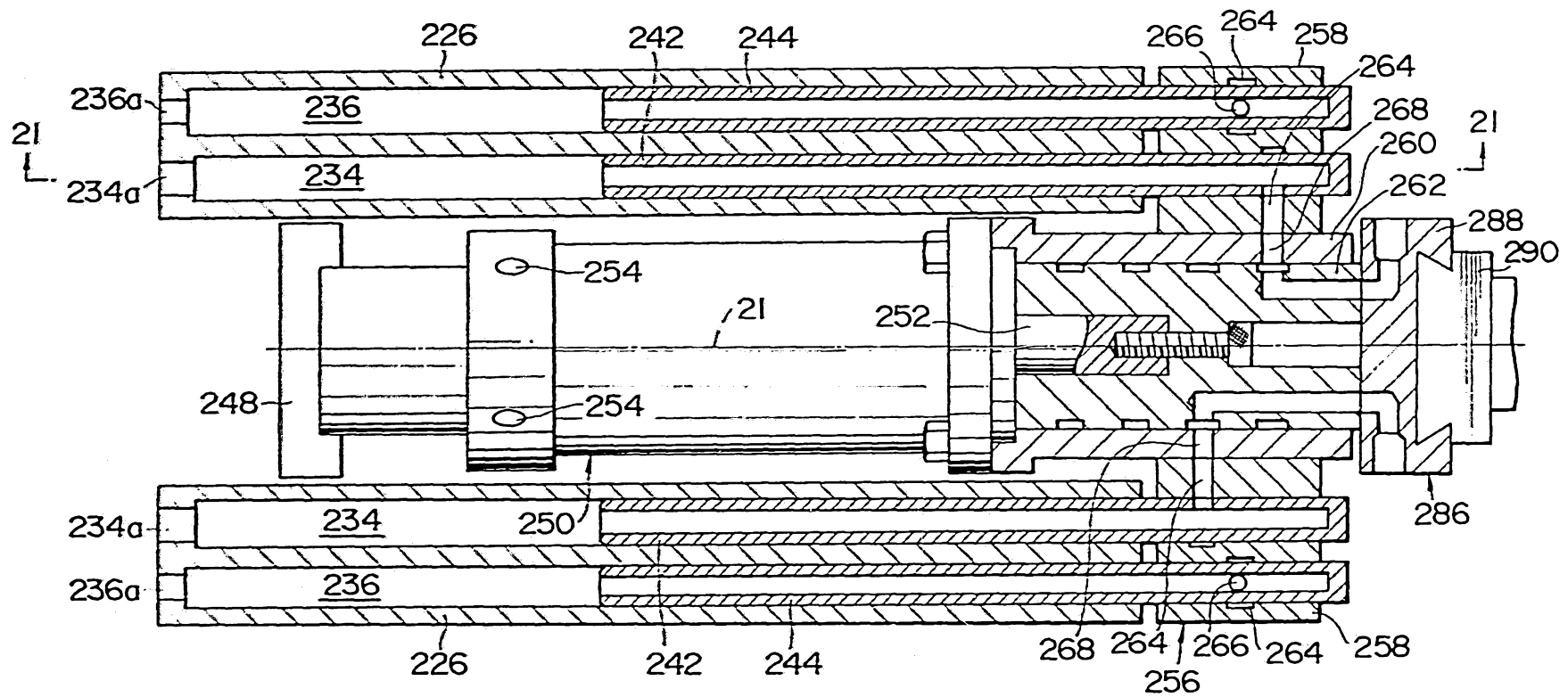
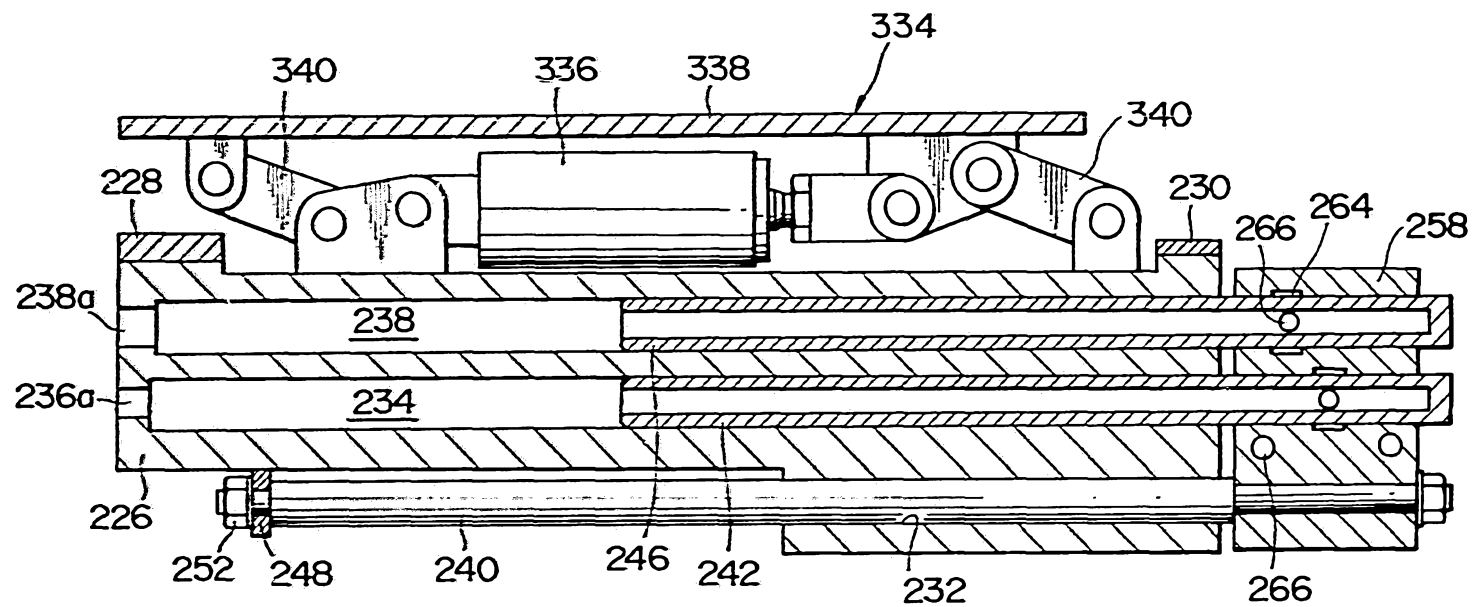


FIG. 21



100

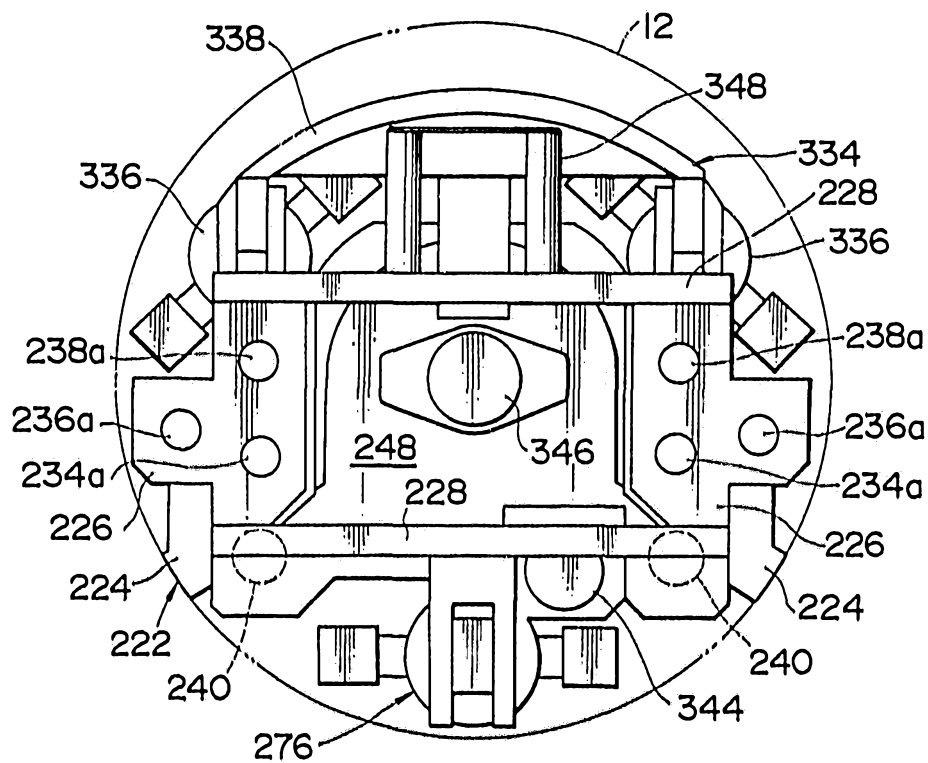


FIG. 25

