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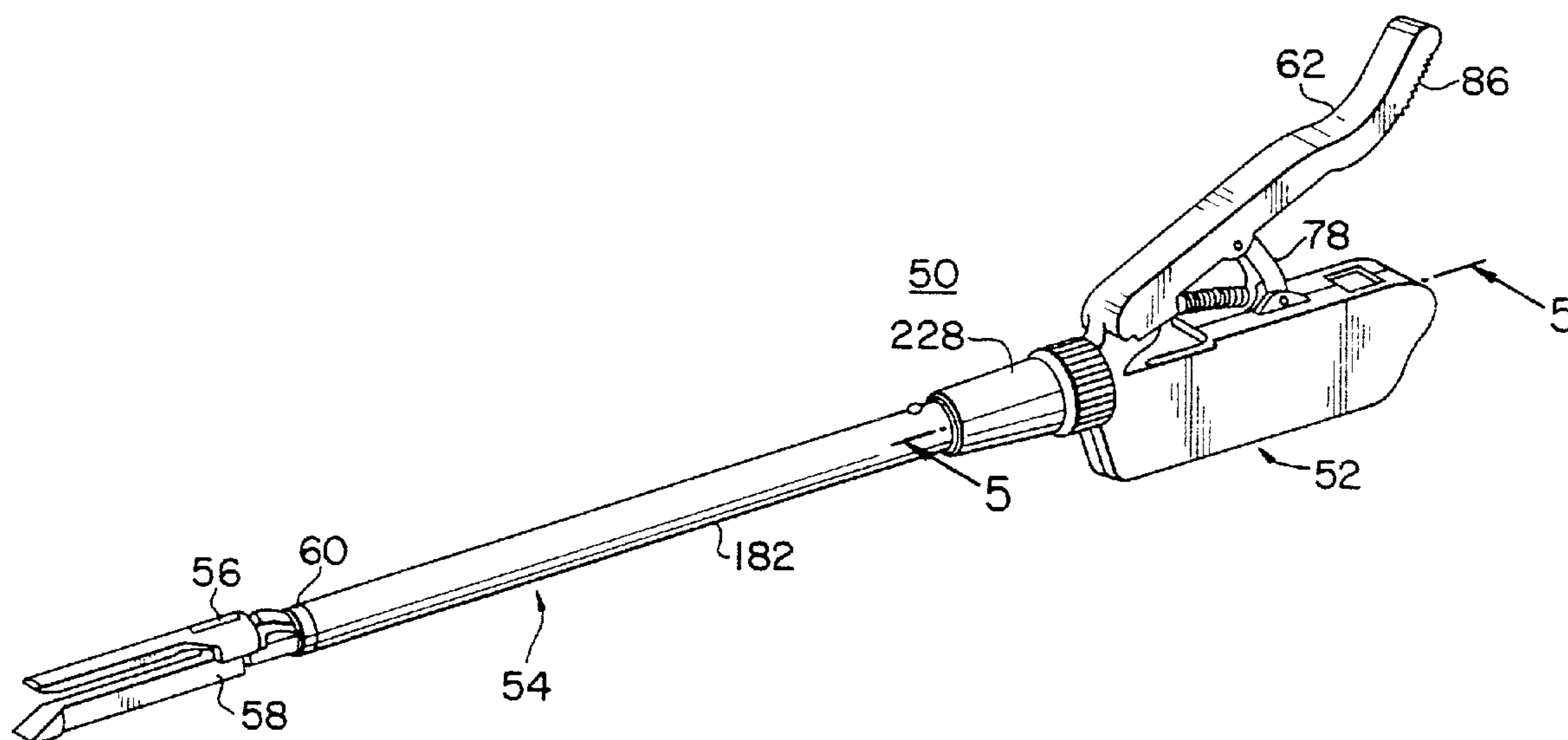
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(72) Inventeurs/Inventors:
GREEN, DAVID T., US;
RATCLIFF, KEITH, US;
BOLANOS, HENRY, US;
BLEWETT, JEFFREY J., US;
BRYAN, GRAHAM W., US;
KAPPEL, GARY S., US;
CASTRO, SALVATORE, US;
LEHN, RANDOLPH F., US

(73) Propriétaire/Owner:
UNITED STATES SURGICAL CORPORATION, US

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(57) Abrégé/Abstract:

A self contained gas powered endoscopic surgical apparatus is provided for placing lateral lines of surgical fasteners into body tissue. The apparatus includes an anvil member and a surgical fastener cartridge member mounted to the distal end of an elongated endoscopic portion. A tubular collar of the endoscopic portion moves distally to engage the anvil member and bias the anvil member and the cartridge member into cooperative alignment, thereby clamping body tissue to be fastened between the anvil member and the cartridge member. A self contained pneumatic system is disposed in the surgical apparatus and is actuable to eject and/or form the surgical fasteners in the clamped body tissue. The apparatus further comprises an interlock which prevents accidental actuation of the firing trigger.



(74) **Agent:** MCFADDEN, FINCHAM

ABSTRACT OF THE DISCLOSURE

A self contained gas powered endoscopic surgical apparatus is provided for placing lateral lines of surgical fasteners into body tissue. The apparatus includes an anvil member and a surgical fastener cartridge member mounted to the distal end of an elongated endoscopic portion. A tubular collar of the endoscopic portion moves distally to engage the anvil member and bias the anvil member and the cartridge member into cooperative alignment, thereby clamping body tissue to be fastened between the anvil member and the cartridge member. A self contained pneumatic system is disposed in the surgical apparatus and is actuatable to eject and/or form the surgical fasteners in the clamped body tissue. The apparatus further comprises an interlock which prevents accidental actuation of the firing trigger.

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SELF CONTAINED GAS POWERED SURGICAL APPARATUS

BACKGROUND OF THE INVENTION

This application is a division of copending Canadian application Serial No. 2,080,160 filed October 8, 1992.

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1. Field of the Invention

This invention relates to surgical stapling apparatus, and more particularly to surgical apparatus which are powered by self contained relatively low pressure gas systems to perform sequential operations such as tissue clamping, staple forming and/or tissue cutting.

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2. Description of Related Art

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Surgical stapling apparatus is known wherein tissue is first grasped or clamped between opposing jaw structure and then fastened by means of fasteners. In some instruments a knife is provided to cut tissue which has been joined. The fasteners are typically in the form of surgical staples however, two part polymeric type fasteners are also known.

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Instruments for this purpose can comprise two elongated fingers which are respectively used to capture or clamp tissue. Typically, one of the fingers carries a disposable cartridge housing a plurality of staples arranged in at least two lateral rows while the other finger comprises an anvil for curling the staple legs into hook form upon their being driven against the anvil. The stapling operation is effected by

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1 a pusher which travels longitudinally along the cartridge carrying finger, with the
pusher acting upon the staples to place rows of staples in body tissue. A knife may
optionally be positioned to operate sequentially immediately behind the pusher and
5 laterally positioned between the staple rows longitudinally cut and/or open the stapled
tissue between the rows of staples. Such instruments are disclosed in Bobrov et al.
(U.S. Pat. No. 3,079,606) and Green (U.S. Pat. No. 3,490,675). The instruments
disclosed therein comprise apparatus for simultaneously making a longitudinal incision
10 and applying a row of staples on both sides of an incision.

A later development disclosed in Green (U.S. Pat. No. 3,499,591)
applies a double row of staples on each side of the incision. This is accomplished by
a cartridge assembly wherein a cam member moves within a guide path between two
sets of staggered staple carrying grooves. Staple drive members located within the
15 grooves each have two staple pusher plates, and sloping surfaces disposed within the
guide path so as to be contacted by the longitudinally moving cam and be driven
along the groove to effect ejection of two staples.

The cartridge assemblies typically come in a plurality of sizes, each
20 varying in both length and number of staples contained therein. Depending on the
procedure to be performed, the surgeon must select the appropriate cartridge
assembly. No provision is currently available to adjust the firing means of the
instrument itself so that a wide variety of staple driving sequences may be
25 accomplished using a single staple cartridge assembly.

The instruments described above were all designed to be used in
surgical procedures wherein surgeons have direct manual access to the operation site.
However, in endoscopic or laparoscopic procedures surgery is performed through a
small incision or through narrow cannulae inserted through small entrance wounds in
30 the skin. In order to address the specific needs of endoscopic and/or laparoscopic

1 surgical procedures, an endoscopic surgical stapling apparatus such as that shown in
Green et al. (U.S. Pat. No. 5,040,715) has been developed. This apparatus is well
suited for such procedures and incorporates a distal end having an anvil and staple
5 cartridge assembly and a manually operated handle assembly interconnected by an
endoscopic portion which permits the instrument to be inserted into a cannula and be
remotely operated by the surgeon.

The instruments discussed above all require some degree of manually
10 applied force in order to clamp, fasten and/or cut tissue. This manual application can
prove awkward or difficult depending upon the orientation of the instrument relative
to the surgeon, the type of tissue being operated on or the strength of the surgeon.
Furthermore, because of the difficulty and expense of cleaning and sterilizing surgical
instruments between uses, there is increasing interest in and demand for instruments
15 which are disposable after use in a single surgical procedure rather than permanent
and reusable. And because of the greater convenience and ease of using self-powered
instruments as well as the more uniform results typically produced by self-powered
instruments (as compared especially to manually powered instruments), there is
20 increasing interest in and demand for instruments which are self-powered.
Accordingly, there is a need for a self-powered endoscopic surgical apparatus to
alleviate these difficulties.

Self contained gas powered surgical staplers are known, as shown, for
25 example, in U.S. Pat. Nos. 3,618,842; 3,643,851; 3,662,939; 3,717,294; 3,815,476;
and 3,837,555. Typically, these staplers include a replaceable cylinder which
supplies gas (e.g., carbon dioxide or nitrogen) at relatively high pressure (e.g., 800
p.s.i.g.) for powering the instrument. The high pressure gas used in these staplers
requires that the staplers be of relatively heavy construction in order to safely
30 accommodate the high pressure involved. Because of their construction, these

1 instruments are relatively expensive to manufacture and therefore generally intended
to be relatively permanent and reusable.

5 Use of a relatively low pressure gas is advantageous to enable a stapler
to be made of lighter construction and less expensive materials. This is desirable to
lower the cost and make the stapler economically disposable. The stapler must,
however, be capable of generating the substantial forces required to form the staples.
Typically, the staples are metal wire which is partially formed prior to use and which
10 must be further formed (e.g., crimped against an anvil) by the stapler. To generate
the relatively large forces required to form the staples with low pressure gas would
ordinarily require a relatively large pneumatic actuator. This is undesirable because a
large actuator makes the stapler bulky and difficult to work with. In addition, a large
actuator unnecessarily consumes a large amount of gas during the portion of actuator
15 motion when relatively large forces are not required, i.e., during the first part of the
actuator stroke when the staple is merely being advanced to the staple forming
position. The gas which is thus effectively wasted substantially reduces the number
of stapling operations which can be performed by the stapler before its gas supply is
20 exhausted. This substantially shortens the useful life of the stapler if the gas supply is
not replaceable, and even if the gas supply is replaceable, it undesirably increases the
frequency with which the gas supply must be replaced.

25 Although it is desirable to perform most of the functions of the stapling
apparatus automatically using the self-powering elements in the apparatus, it may also
be desirable for the initial function to be at least partly manual. For example, if the
initial function is tissue clamping, it is preferably initiated manually so that it can be
performed slowly and precisely and the results inspected and corrected if necessary
30 before the automatic self-powered portion of the operating sequence begins. See, for
example, U.S. Pat. Nos. 4,349,028 and 4,331,277 to Green.

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Accordingly, there is a present need for a self contained gas powered surgical instrument for driving surgical fasteners into body tissue which instrument can be made of lighter materials and can be made disposable after use.

Because endoscopic procedures are more common than laparoscopic procedures, the present invention shall be discussed in terms of endoscopic procedures and apparatus. However, use herein of terms such as "endoscopic", "endoscopically" and "endoscopic portion", among others, should not be construed to limit the present invention to a stapling and cutting apparatus for use only in conjunction with an endoscopic tube. To the contrary, it is believed the present invention may find use in any procedure where access is limited to a small incision, including but not limited to laparoscopic procedures. Also, as used herein the terms "fasteners" and "staples" shall be treated equivalently. Unless otherwise stated, the term "cartridge assembly" shall include at least the cartridge itself and staples or fasteners and staple drive members disposed therein.

SUMMARY OF THE INVENTION

In accordance with an embodiment of the present invention there is provided a self contained gas powered surgical apparatus for driving surgical fasteners into body tissue comprising: a) a frame having clamping means; b) an endoscopic portion defining a longitudinal axis and extending distally from the frame; and c) a self contained pneumatic system. The endoscopic portion includes: i) an extension tube having a distal end mounted collar tube; ii) a cover tube mounted to the frame; iii) an elongated support fixed to the cover tube; and iv) means for ejecting the surgical fasteners from the cartridge assembly. The extension tube is rotatably connected to the clamping means of the frame for rotatable and longitudinal movement through the endoscopic portion between a first open position and a second closed position. A cover tube is mounted to the frame for rotational movement about a longitudinal axis. An elongated

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support is fixed to the cover tube, the elongated support retains a cartridge assembly and includes a plurality of surgical fasteners slidably mounted therein and has a tissue
5 engaging surface and the elongated support further retains an anvil member and has a fastener forming surface. The anvil member is movable between an open position corresponding to the first position of the extension tube and a closed position corresponding to the second position of the
10 extension tube wherein the fastener forming surface is in close cooperative alignment with the tissue engaging surface of the cartridge assembly. Means are provided for ejecting the surgical fasteners from the cartridge assembly, whereby the fasteners engage the fastener forming surface. A self
15 contained pneumatic system is mounted in the frame and includes a supply of low pressure gas and a pneumatic actuator mechanism associated with the gas supply. The pneumatic actuator mechanism is adapted to cooperate with the means for ejecting the surgical fasteners to fire the
20 surgical fasteners against the fastener forming surface. An interlock means is provided to prevent actuation of the actuator mechanism when the clamping means is not in a closed position.

In accordance with the principles of the invention
25 there is provided a self contained endoscopic surgical instrument which is at least partially operable by means of a relatively low pressure pneumatic assembly. Advantageously, the surgical instrument in accordance with an embodiment of the present invention is a surgical
30 stapling apparatus adapted for placing one or more longitudinal rows of staples. This apparatus may further include a knife for making an incision in body tissue between rows of staples. The latter configuration may find particular use of adjoining two hollow organs or in

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removing an organ, such as the appendix, the gallbladder, etc.

The self contained gas powered surgical instrument of the present invention in an endoscopic stapler configuration comprises a frame; an endoscopic portion defining a longitudinal axis and extending distally from the frame, the endoscopic portion including an elongated housing having a distal member for mounting a cartridge assembly. The cartridge assembly includes a plurality of surgical staples slidably mounted therein and has a tissue engaging surface. An anvil member is also provided and has a staple forming surface and a proximal end mounted to the elongated housing such that the anvil member is movable between an open position and a closed position such that the staple forming surface is in close cooperative alignment with the tissue engaging surface of the cartridge assembly.

The instrument further includes structure for moving the anvil member between the open and the closed positions and structure for ejecting the surgical staples from the cartridge assembly to cause the staples to engage and form on the staple forming surface of the anvil member.

A self contained pneumatic system is disposed in the frame and includes a supply of relatively low pressure gas connected to a pneumatic actuator

1 mechanism. The pneumatic actuator mechanism actuates the structure for ejecting the surgical staples from the cartridge assembly.

5 The surgical instrument may be constructed either as a reusable unit or as a single use, disposable unit or, alternatively may be formed with a reusable handle portion and replaceable staple carrying cartridges.

10 The present invention advantageously permits surgeons to perform internal surgical procedures including stapling and/or cutting simply by manually clamping the tissue to be manipulated and pneumatically actuating the jaw members. This results in greater convenience and ease of use of the instrument as well as more uniform actuation of the instrument mechanisms.

15 The stapler embodiment of this invention is preferably controlled by a manually operable trigger or other similar control. Momentary operation of the trigger initiates an operating cycle of the stapler which normally is automatically completed without continued actuation of the trigger. A safety interlock may also be employed in cooperation with the trigger mechanism to prevent accidental actuation. Preferably the stapler performs only one operating cycle in response to each operation of the control regardless of the length of time the control is operated beyond the time required to initiate an operating cycle. The stapler also cannot begin a new operating cycle until the preceding cycle is complete. Also, a safety mechanism may be incorporated to prevent closure of the jaws if they are misaligned or improperly inserted. In a particularly preferred embodiment of the invention, the operating cycle will not begin unless sufficient gas remains in the reservoir to propel the instrument through a complete cycle. Alternatively, structure may be provided to give a visual or tactile indication of the number of times the instrument has been fired and/or lock out the operating cycle after a given number of firings. Sealing means may be

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1 provided to more efficiently seal the apparatus and prevent excess gas from passing through the interior thereof.

5 In another particularly advantageous embodiment of the invention the surgical element includes adjustment structure which permits the instrument to be selectively preset to fire in a predetermined sequence to drive a given number of staples and/or rows of staples.

10 Further features of the invention, its nature and various advantages will be more apparent from the accompanying drawing and the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

15 Preferred embodiments of the invention are described hereinbelow with reference to the drawings. In the drawings and the description which follows, "proximal" means the end closest to the operator and "distal" means the end furthest from the operator.

20 Fig. 1 is a perspective view of a self contained gas powered endoscopic surgical instrument in accordance with one embodiment of the present invention;

Fig. 2 is an exploded perspective view of the frame and pneumatic assembly of the surgical instrument of Fig. 1;

25 Fig. 3 is an exploded perspective view of the endoscopic portion of the surgical instrument of Fig. 1;

Fig. 3A is a side plan view in partial cut away of the pusher washers and flange member of the pneumatic system in accordance with one embodiment of the present invention;

30 Fig. 4 is an exploded perspective view of one embodiment of the anvil and cartridge assembly of the surgical instrument of Fig. 1;

1 Fig. 5 is a side plan view in cross section taken along line 5-5 of Fig. 1
showing the frame and pneumatic assembly in the unclamped and unfired position;

 Fig. 6 is a transverse view in cross section taken along line 6-6 of Fig.
5 5 oriented toward the proximal end of the instrument showing the frame and
pneumatic assembly in the unclamped position;

 Fig. 7 is a side plan view in cross section showing the frame and
pneumatic assembly in the clamped and unfired position;

10 Fig. 8 is a transverse view in cross section taken along line 8-8 of Fig.
7 oriented toward the proximal end of the instrument showing the frame and
pneumatic assembly in the clamped and unfired position;

 Fig. 9 is a top plan view in cross section taken along line 9-9 of Fig. 5
showing the frame and pneumatic assembly of the surgical instrument;

15 Fig. 10 is a transverse view in cross section taken along line 10-10 of
Fig. 5 oriented toward the distal end of the instrument showing a portion of the frame
and pneumatic assembly;

 Fig. 11 is a side plan view in cross section showing the frame and
20 pneumatic assembly of the present invention in the clamped and fixed position;

 Fig. 12 is a side cut away view in cross section showing the operation
of the pneumatic assembly of the present invention as it is fired;

 Fig. 13 is a side cut away view in cross section taken along line 13-13
25 of Fig. 12 showing the valve and gas tube of the pneumatic assembly;

 Fig. 14 is a side plan view in cross section showing the frame and
pneumatic assembly of a surgical instrument incorporating an adjustable stroke
mechanism;

30 Fig. 15 is a side cut away view in cross section of a surgical instrument
incorporating a metering assembly between the valve and piston assembly;

1 Fig. 16 is a side plan view of a channel member in accordance with
one embodiment of the present invention;

 Fig. 17 is a transverse view in cross section taken along line 17-17 of
5 Fig. 16 oriented toward the proximal end of the channel member;

 Fig. 18 is a transverse view in cross section taken along line 18-18 of
Fig. 16 oriented toward the distal end of the channel member;

 Fig. 19 is a bottom plan view of an anvil member in accordance with
10 one embodiment of the present invention;

 Fig. 20 is a top plan view of the anvil member of Fig. 19;

 Fig. 21 is a side view of the anvil member of Fig. 19;

 Fig. 22 is a top plan view of a cam bar adapter in accordance with one
15 embodiment of the present invention;

 Fig. 23 is a side plan view of the cam bar adapter of Fig. 22;

 Fig. 24 is a from plan view of the cam bar adapter taken along line
24-24 of Fig. 22 oriented toward the proximal end of the adapter;

 Fig. 25 is a side plan view in cross section of the cartridge housing of
20 Fig. 4;

 Fig. 26 is a top plan view of the cartridge housing shown in Fig. 25;

 Fig. 27 is a side cut away view in cross section of the cartridge housing
of Fig. 25 taken along line 27-27 of Fig. 26;

25 Fig. 28 is an exploded perspective view of another embodiment of the
cartridge assembly of the surgical instrument in accordance with the present
invention;

 Fig. 29 is a perspective view of the assembled cartridge assembly of
30 Fig. 28;

1 Fig. 30 is a perspective view in partial cross section of an anvil and
cartridge assembly in accordance with the present invention;

5 Fig. 31 is a perspective view in partial cross section of an anvil in
accordance with the embodiment of Fig. 30;

 Figs. 32 through 34 are side plan views in partial cross section of a
sequence of operations for the anvil and cartridge assembly of Fig. 30;

10 Fig. 35 is a perspective view of another self contained gas powered
surgical instrument in accordance with the present invention;

 Fig. 36 is an exploded perspective view of the handle portion of the
self contained gas powered surgical instrument of Fig. 35;

 Fig. 37 is an exploded perspective view of the endoscopic portion and
jaw structure of the self contained gas powered surgical instrument of Fig. 35;

15 Figs. 38 and 39 are side cross-sectional views of the firing trigger with
integral lockout in the unfired and fired positions; and

 Figs. 40 and 41 are side views of the cartridge and support structure
showing the operation of the clamp lockout structure.

20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

 Although the principles of the invention are applicable to other types of
self contained gas powered surgical fastening instruments, the invention will be fully
25 understood from the following illustration of its application to endoscopic surgical
fastening instruments of the type shown, for example, in Green et al. U.S. Patent No.
5,040,715. Also, although the invention is applicable to surgical fastening apparatus
having other constructions, the invention will be illustratively described in its
30 application to surgical staplers in which a staple cartridge containing a plurality of
staples, staple drivers and staple firing means in cooperation with anvil means

1 respectively form opposing jaw structure located on a distal end of the stapler for capturing and joining tissue.

5 **I. Overall Construction and Operation of the Firing Assembly**

As shown in Fig. 1, a self contained gas powered endoscopic surgical instrument 50 constructed in accordance with the principles of this invention includes a frame 52 and an endoscopic portion 54. An anvil 56 and cartridge assembly 58 are mounted in a distal end 60 of endoscopic portion 54 and are preferably
10 interchangeable with other anvil/cartridge assemblies (as discussed in greater detail hereinbelow) to perform a wide variety of surgical fastening procedures as needed.

Anvil 56 and cartridge assembly 60 are manually controlled by means of an articulating handle 62 in the frame 52. This handle 62 interconnects with anvil
15 56 by means of a linkage disposed in endoscopic portion 54 such that when handle 62 is moved from its open position (Fig. 1) to a closed position (Fig. 7), anvil 56 is moved into close approximation with cartridge assembly 58. This operation will be discussed in greater detail below.

Turning now to Fig. 2, an exploded perspective view of the frame and pneumatic system is shown in accordance with the present invention. Frame 52 includes a first housing member 64 and a second housing member 66 enclosing a pneumatic system shown generally at 68. Articulating handle 62 is pivotally
25 connected at a distal end thereof to clamp tube 70 at pivot point 72. Longitudinal grooves 74 formed in both first and second housing members 64, 66 adjacent pivot point 72 slidably receive molded shuttles 76 attached to handle 62 at 72. The molded shuttles 76 are pivotally connected to either side of the pivot point 72 on the distal
30 end of handle 62 and serve to guide the distal end of handle 62 in a longitudinally distal direction as the handle is compressed.

1 A pair of articulating links 78 interconnect an intermediate portion of
handle 62 to a pair of projections 80 formed on an upper surface of housing members
64, 66 respectively. A handle return spring 82 extends between handle 62 and
5 housing members 64, 66 by means of spring anchor pins 84, one of which is disposed
in handle 62 and the other extending between projections 80 which also serve to
pivotally connect articulating links 78 to projections 80. This spring 82 assists in
returning handle 62 from its closed position to its open position.

10 The proximal end of handle 62 is preferably diagonally formed away
from housing members 64, 66 so as to enable the surgeon to more easily release the
handle 62 from its closed position. This is done by placing the hand under the
proximal end of the handle and lifting. A texturized or serrated portion 86 may
15 advantageously be formed on an under surface of the proximal end of handle 62 to
enhance gripping of the handle 62.

 Pneumatic system 68 is wholly contained within housing members 64,
66 and includes a container 88 of relatively low pressure gas longitudinally slidably
mounted therein. The pressure of the gas in container 88 during operation of the
20 stapler is typically less than about 200 p.s.i.g. and preferably in the range from about
80 p.s.i.g. to about 160 p.s.i.g. Any suitable non-toxic gas can be used including but
not limited to halogenated hydrocarbons which are gaseous at room temperature, e.g.,
fluorinated hydrocarbons such as Freon 12 or chlorinated hydrocarbons such as
25 Freon 152A. Container 88 dispenses the relatively low pressure gas through stem 90,
valve 92 and gas tube 94 when the firing trigger 96 is depressed. Spring 97 is
positioned between container 88 and valve 92 and serves to hold the container 88
away from valve 92. Valve 92 is fixed within housing members 64, 66 and is
longitudinally adjustable by means of set screw 93. (Fig. 13) This feature permits
30 the position of valve 92 to be longitudinally changed to compensate for

1 manufacturers' variations in length among containers 88 between a distal end and the proximal end of stem 90.

5 Disposed above container 88 within housing members 64, 66 is a pneumatic actuator 98. Actuator 98 includes a pneumatic cylinder 100 which is held in place by opposing pins 99 and which is closed at its proximal end except for ferrule 102 and is open at its distal end, as well as a pneumatic piston 104 mounted for reciprocal motion in cylinder 100 parallel to the longitudinal axis of endoscopic
10 portion 54. Cylinder 100 is preferably circular in transverse cross-section however other shapes would function acceptably well.

Piston 104 is pneumatically sealed to cylinder 100 by "O" ring 106 molded of polyethylene or the like. Gas dispensed from container 88 is supplied to pneumatic actuator 98 via gas tube 94 which admits the gas to cylinder 100 through
15 ferrule 102 behind piston 104 to drive piston 104 distally in the cylinder. The distal end of piston 104 is adapted to engage the firing mechanism of the surgical apparatus as will be described in greater detail below.

Referring to Figs. 2, 5 and 7, firing trigger 96 is pivotally mounted in
20 a proximal end of housing member 64, 66 by pivot pin 108. Spring 110 is positioned adjacent pin 108 and serves to bias the firing trigger 96 proximally into the prefiring position. A trigger rod 112 extends distally from firing trigger 96 longitudinally to engage piston slide 114 positioned in a lower portion of piston 104. Piston slide 114
25 comprises a substantially "U"-shaped channel which fits into a corresponding groove 116 formed in piston 104. Piston slide 114 is spring loaded in a proximal direction by spring 118 and includes a transverse projection 120 on a lower distal end thereof which engages the distal end of trigger rod 112.

30 Referring now to Figs. 2 and 5-11 and initially to Figs. 2, 5-8 and 11, a rocking lever 120 is pivotally mounted on transverse slide pin 122 and is adapted

1 for transverse movement relative to slide pin 122 between an engaged position prior
to firing (Figs. 7-9) and a disengaged position when articulating handle 62 is open
(Figs. 5 and 6). Cam slide 124 is vertically mounted in first housing member 64 for
5 reciprocal movement between an upper and lower position (Figs. 6 and 8
respectively) and serves to move rocking lever 120 between the engaged position
(Fig. 8) and the disengaged position (Fig. 6). Thus, until the articulating handle 62 is
closed causing cam slide 124 to move rocking lever 120 into the engaged position, the
10 instrument 50 cannot be fired.

Cam slide 124 is normally biased in its upper disengaged position by
cam slide spring 126 mounted in vertical groove 128 of first housing member 64
(Figs. 5 and 6). In this upper position, cam slide 124 extends upward beyond first
housing member 64 (Fig. 6) to engage articulating handle 62 as it is moved to a
15 closed position (Figs. 7 and 8). Cam slide 124 further includes a camming surface
130 which contacts a corresponding camming surface of camming block 132 mounted
on slide pin 122. Camming block 132 is loaded against cam slide 124 by slide spring
134 and moves rocking lever 120 transversely on slide pin 122 between an engaged
20 position and a disengaged position. Referring to Fig. 8, as the articulating handle 62
is compressed toward housing members 64, 66 in the direction of arrow 135 it
contacts cam slide 124 moving it downward and causes camming surface 130 to move
camming block 132 and rocking lever 120 transversely into an engaged position in
25 line with piston 104.

Turning to Figs. 5, 7-9 and 11, once the articulating handle 62 has
been fully compressed (Figs. 7-9) rocking lever 120 is disposed in alignment with
piston slide 114 and can be pivotally moved about transverse slide pin 122 to engage
30 pusher disk 136 at the distal end of container 88. When the instrument is in the
clamped configuration, depression of the firing trigger 96 moves trigger rod 112

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1 distally in the longitudinal direction causing piston slide 144 to engage and pivot
rocking lever 120 which, in turn, engages pusher disk 136 and moves container 88
longitudinally into contact with valve 92 to dispense gas and propel piston 104 in the
5 distal direction. See Figs. 11, 12 and 13.

As piston 104 moves distally, rocking lever 120 remains in its pivoted
firing position by contact with the bottom surface of piston 104. A gap 138 is formed
in the bottom surface of piston 104 near the proximal end thereof which gap
10 effectively allows rocking lever 120 to disengage from piston 104 and pivot back to a
position wherein container 88 is released from engagement with valve 92, stopping
the flow of gas into pneumatic cylinder 100.

Return springs 140, 142 disposed in endoscopic portion 54 drive piston
104 back to its initial prefired position. A camming surface 144 is formed in a distal
15 end of gap 138 and causes rocking lever 120 to move transversely out of engagement
with piston 104 as it returns proximally and the rocking lever 120 moves to its
original prefired position (Fig. 7).

Fig. 14 shows an alternate embodiment of the present invention
20 incorporating an adjustment mechanism 146 which permits the instrument 148 to be
selectively adjusted to change the length of the firing and return strokes of piston
150. This advantageous feature permits the user to selectively fire a predetermined
length of staples using a single instrument. For example, if the user installs a staple
25 cartridge assembly having six rows of staples, each row having a longitudinal length
of 60 mm, the instrument is set using adjustment mechanism 146 to fire the staples in
the entire length of the cartridge. Cartridges having some lesser length of staples may
be inserted and fired depending on the needs of the user.

30 The adjustment mechanism 146 shown in Fig. 14 includes a belt 152
which travels around a pair of longitudinally disposed pulleys 154, 156. A first

1 linkage rod 158 engages the top portion of belt 152 and extends to a gap adjustment
member 160 slidably positioned in piston 150. A second linkage rod 162 engages the
bottom portion of belt 152 and extends to a slidable piston stop 164 disposed within
5 pneumatic cylinder 100.

Belt 152 may be rotated in either the clockwise or counterclockwise
direction by rotating knob 166 disposed in housing 172 between pulleys 154 and 156.
This permits the user to preselect the firing stroke of the instrument 148. For
10 example when belt 152 is rotated counterclockwise, the firing stroke piston stop is
being driven proximally by second linkage rod 162 and the gap 168 wherein the
rocking lever 120 disengages the pneumatic actuator 98 is correspondingly widened.
This permits the user to fire shorter rows of staples without changing cartridge
assemblies. Conversely, when belt 152 is rotated in a clockwise direction, the firing
15 stroke is progressively lengthened this allowing the user to fire up to the entire length
of the rows of staples in the cartridge assembly.

In the instrument 148 shown in Fig. 14, the firing stroke may be preset
to fire either 30 mm or 60 mm rows of staples from a 60 mm length cartridge
20 assembly. These preset positions correspond to camming pins 186 and 170
respectively which serve to disengage first rod linkage 158 from belt 152 so that belt
152 is not rotated during the firing stroke of the pneumatic actuator 98.

Turning now to Fig. 15, another beneficial feature is shown
25 incorporated into the pneumatic system in accordance with the present invention.
This feature comprises a pressure sensor 174 disposed in line between the valve 92
and the pneumatic cylinder 100 to sense and/or regulate the gas delivered from
container 88 to the cylinder 100. During surgical procedures involving the driving of
surgical fasteners and particularly where a knife is used to divide fastened tissue, it is
30 important that when the trigger is depressed there is sufficient gas remaining in the

1 container 88 to complete an entire piston firing stroke. If insufficient gas were
available, the piston may not be able to fasten and/or divide the desired length of
tissue, necessitating duplication of the procedure. Pressure sensor 174 serves to
5 premeasure the amount of gas necessary to achieve the desired piston stroke before
activating to permit the gas to flow into the pneumatic cylinder 100 to drive piston
104.

It is also envisaged that a counter mechanism can be incorporated to
10 operate in conjunction with the pneumatic system 68 in order to monitor the number
of firings which the instrument has been subjected to. This number can be visually
displayed to the operator so that, for example, after a given number of firings, the
instrument can be overhauled or replaced. Similarly, where a relatively small number
of firings are available from a single gas container, this counter mechanism will assist
15 the operator in recognizing when the container is nearing exhaustion. In a
particularly desirable embodiment, the counter mechanism can be combined with a
lockout mechanism which will disable the firing mechanism after a preselected
number of firings.

20 As seen in Fig. 15, upon depressing firing trigger 96, gas is released
from container 88 substantially as described hereinabove. However, after leaving
stem 90 and passing through nozzle 92, the gas contacts pressure plate 176. Pressure
plate 176 is preset by means of spring 178 to keep orifice 180 closed until a
25 predetermined gas pressure is realized at the pressure plate 176. Once this threshold
pressure is realized, pressure plate 176 moves out of contact with orifice 180
permitting gas to pass therethrough and into pneumatic cylinder 100 to drive piston
104 distally. In the event that insufficient gas is available to reach this threshold
30 pressure, pressure plate 176 continues to block orifice 180 and the instrument cannot
be fired.

1 Referring now to Fig. 3, there is shown in exploded detail an
endoscopic portion 54 in accordance with one embodiment of the present invention.
At a proximal end, piston 104 is longitudinally reciprocally slidable through clamp
5 tube 70 and extends into the proximal end of cover tube 182. The distal end of piston
104 is provided with an attachment flange 184 which flange 184 mounts a plurality of
pusher washers 186 thereon. These pusher washers 186 are formed in a substantially
abbreviated frustoconical cross-section from a resilient material such as, for example,
10 commercial spring steel or type 302 stainless steel. These washers are typically
known as Belleville Spring Washers available through SPEC Associated Spring
Raymond, Barnes Group Inc. The washers are especially suited for high loads in
small spaces and may be combined in varying sequences to achieve numerous load
carrying possibilities. In the embodiment of Fig. 3, a total of twelve pusher washers
15 are used substantially as shown in Fig. 3A with duplicate washers arranged in six
opposing sets. A spring support washer 188 is positioned on flange 184 distal to
pusher washers 186 and serves to engage the proximal ends of inner and outer return
springs 140 and 142. Lock washer 189 holds the washers in place on flange 184.
20 Attachment flange 184 has a chamfered distal tip and is configured and dimensioned
to be received between the proximal fingers 190 and channel 192.

As shown in Figs. 3 and 16-18, channel 192 is an elongated structure
slidably mounted in endoscopic portion 54 for reciprocal longitudinal motion therein.
25 As mentioned above, channel 192 has fingers 190 at a proximal end thereof to receive
attachment flange 184 of piston 104. At a distal end of channel 192 there is provided
a fork 194 defining a slot 196 therebetween. Fork 194 has a pair of opposed ramping
surfaces, 198 and 200 respectively, the purposes of which will be described in greater
detail below. Proximal to fork 194 is abutting structure 202 which structure extends
30 below the lowermost dimension of fork 194.

1 Referring back to Fig. 3, an extension sleeve 204 is disposed within the
cover tube 182 and is fixed on a proximal end thereof to clamp tube 70. Sealing
member 206 is mounted on flange 208 of clamp tube 70 and serves to sealably isolate
5 the frame 52 of the instrument 50 from the endoscopic portion 54. Inner and outer
return springs, 142 and 140 respectively, are contained within upper extension spacer
210 and lower extension spacer 212 which are, in turn, fixed within the extension
sleeve 204. Spring support washer 188 abuts the proximal ends of inner and outer
10 return springs 142 and 140 and, when the instrument is fired, transmits the energy of
the compressed springs 142, 140 to the piston 104, returning it to its prefired
position.

Support structure 214 is also disposed within extension spacers 210,
212 and function to releasably receive anvil and/or cartridge assemblies in instrument
15 50. Support structure 214 is retained in place within extension spacers 210, 212 by
transverse support key 216. An anvil return spring 218 is affixed to an underside
portion of support structure 214 and assists in the retention of the anvil within the
instrument.

20 A collar assembly, shown generally at 220, is attached to the respective
distal ends of external sleeve 204 and extension spacers 210, 212. This assembly 220
includes a forward collar tube 222, a collar tube spacer 224 and a rear collar tube
226, each having camming bosses 268, 270 formed on inner surfaces therein as will
25 be described in greater detail below.

In the embodiment of the present invention shown in Figs. 1-3, the
endoscopic portion 54 is rotatable relative to the frame 52 by means of rotation knob
228 (Figs. 1 and 2). This rotation knob 228 is in the form of an abbreviated
frustoconical structure having a bore therethrough dimensioned to receive a proximal
30 end of cover tube 182. At a proximal end of knob 228, knurling 229 may be

1 provided to facilitate rotation. Once connected to cover tube 182, rotation of knob
228 causes the distal working end of the instrument to rotate.

Referring now to Figs. 4 and 19-27, there is illustrated an anvil 230
5 and cartridge assembly, shown generally at 232, in accordance with one embodiment
of the present invention. Anvil 230 is an elongated piece which is mounted in support
214 by means of proximal legs 250. At its distal end, anvil 230 has an anvil plate
236 with a tissue contacting surface 238 having staple forming depressions 240 (See
10 Fig. 19). At its proximal end, anvil 230 is provided with an upper camming surface
242 and locking surface 244, which surfaces are engagable with corresponding top
arcuate camming surface 246 formed in forward collar tube 222. Transverse
opposing projections 248 are formed on legs 250 at the proximal end of anvil 230 and
provide an engagement point for anvil 230 to be cammed between an open and closed
15 position by the interaction of camming surface 242, locking surface 244 and top
arcuate camming surface 246 of collar tube 222. Preferably, the radius of curvature
of the top arcuate camming surface 246 is shorter than the radius of curvature of
camming surface 242 and equal to the radius of curvature of locking surface 244.
20 This configuration prevents flexing of the camming surface 246 of collar tube 222 and
lateral movement of the anvil as it is being cammed closed.

Anvil plate 230 also has a longitudinal center groove 252 to permit
passage of a knife 254. Anvil 230 is further provided with parallel aligning surfaces
25 256 positioned below camming surface 242. These aligning surfaces are dimensioned
to fit outside projections 258 on cartridge housing 260 upon closure of the anvil 230.
The engagement of the aligning surfaces 256 and the corresponding projections 258 of
cartridge housing 260 serves to more accurately and securely align anvil 230 and
cartridge housing 260 upon closure. Further visual confirmation of alignment is
30 facilitated by a pair of parallel longitudinal indentations 262 formed in the distal end

1 of anvil 230. These indentations 262 allow the surgeon to view the closed structure
of the anvil 230 and cartridge assembly 232 to confirm accurate longitudinal
alignment thereof.

5 Further, as shown in Fig. 21, the horizontal plane formed by tissue
contacting surface 238 intersects the horizontal plane formed by the camming portion
of the proximal end of anvil 230 at an obtuse angle " α ". This angular orientation
pre-cambers the anvil 230 and balances the closure force applied by the anvil 230 to
10 the captured tissue.

First and second camming surfaces, 264 and 266 respectively, are
formed in a sidewall portion of the proximal end of anvil 230. These camming
surfaces engage camming bosses, 268 and 270 respectively, formed on inner opposing
sidewalls of collar tube assembly 220. Anvil 230 is inserted into collar tube assembly
15 220 and projections 248 engage with support structure 214 bring camming surfaces
264 and 266 into engagable alignment with camming bosses 268 and 270. Cartridge
assembly 232, discussed in greater detail hereinbelow, is fixedly inserted into collar
tube assembly 220 and remains stationary relative to anvil 230.

20 During fabrication of anvil 230, the anvil blank may advantageously be
formed by metal injection molding and thereafter coined and coated as described
below. A wide variety of staples and fasteners are contemplated for use with the
present apparatus. In a preferred embodiment for use with titanium fasteners, it has
25 been found that forming of the fasteners in the staple forming depressions 240 is
facilitated by applying a hard, relatively smooth surface on the staple forming portion
of the anvil 230. The preferred method of application of this surface is by electroless
plating, with the surface being formed of a metallic alloy such as, for example,
30 nickel, gold, silver, titanium nitride or chromium. Where nickel is used, the applied
surface is preferably in the range of $100\ \mu$ - $2000\ \mu$ in thickness with an optimum

1 thickness of between 200 μ - 500 μ . Ranges for other alloy may vary depending upon
their inherent characteristics.

Where nickel is to be applied, the preferred method is an electroless
5 plating method including the steps of: electrocleaning the anvil in a cyanide-
containing cleaner, reversing polarity at predetermined intervals, preferably about
every 10-15 seconds, at a current of about 50 amps/ft²; rinsing thoroughly; rinsing in
a solution containing a strong acid, preferably 20% HCL, dipping several times;
10 immersing the anvil in a NiCL strike tank for plating, preferably for two to four
minutes at a current of about 50 amps/ft²; rinsing; and immersing the anvil in an
electroless Ni bath, preferably Enthone 418 or 431, for a time sufficient to achieve
the desired plating thickness. For example, at a deposition rate of .0005 in/hr, a time
of between 30 to 40 minutes would be required to achieve a thickness of about 300 μ
15 $\pm$ 50 μ . Other coating procedures are also contemplated including vapor deposition,
etc. and are encompassed by the present invention.

Turning now to Figs. 4 and 22-27, there is illustrated a replaceable
cartridge assembly 232 in accordance with the present invention. The cartridge
20 assembly 232 includes: a cartridge housing 260; a cartridge 272 having a plurality of
pushers 274 and staples 276 disposed in longitudinal arrangement therein; and a
plurality of cam bars 278 removably disposed in cam bar adapter 280 and a cam bar
alignment tab 282 as well as a knife 254 mounted in the cam bar adapter 280.

25 Referring specifically to Figs. 25-27, the proximal end of cartridge
housing 260 comprises a substantially elongate channel of semi-circular cross-section
having a forward and rearward portion 284 and 286 respectively. A transverse
locking slot 288 is formed in rearward portion 286 and serves to engage and retain
30 support structure 214. Upon insertion into collar tube assembly, the forward end of

1 support structure 214 is biased by the rearward portion 286 of cartridge housing 260 until the support structure 214 engages locking slot 288.

Rearward projection 290 is formed in the base of cartridge housing
5 260. The function of this projection 290 will be described in greater detail below. Forward of the projection 290 is a bore 292 which receives shear pin 294 formed on cam bar adapter 280 (Figs. 22-24). A pair of crimps 296 is provided in opposing
10 sidewalls of the rearward portion of the proximal end of the cartridge housing. These crimps 296 provide a friction fit with cam bar adapter 280.

The forward portion 284 of the proximal end of cartridge housing 260 has projections 258 which, upon closure of the cartridge assembly 232 and anvil 230, contact and align with anvil aligning surfaces 256 as described above.

The distal end of the cartridge housing 260 comprises a channel
15 structure of substantially rectangular cross-section. This distal end constitutes the cartridge receiving portion and is dimensioned to receive cartridge 272 therein. Bores 298 and projection 300 serve to engage pins and bores respective in the cartridge 272 so as to align and retain the cartridge 272 within the cartridge receiving portion of the
20 cartridge housing 260.

Referring to Fig. 26, the cartridge receiving portion in the distal end of cartridge housing 260 and the proximal end of cartridge housing 260 are joined at an obtuse angle θ defined by the intersection of the horizontal planes of both the
25 proximal and distal ends of the cartridge housing 260. This angular orientation serves to pre-camber the cartridge assembly and facilitates accurate closure and alignment of the jaw elements as well as more secure retention of subject tissue.

The cartridge 272 includes longitudinal groove structure 302 for
30 receiving and guiding knife 254 and a plurality of pushers 274 abutting staples 276.

1 The staples 276 are advantageously arranged in six longitudinal rows with three rows positioned on either side of groove structure 302.

Two pairs of longitudinal slots are formed in the cartridge housing 260
5 and are adapted to receive a pair of double cam bars 278 therein. Each pair of cam bars serving to drive three corresponding longitudinal rows of staples. Further, the two pairs of longitudinal slots extend to the end of cartridge 232.

Cam bars 278 are provided with a cam surface 304 in an upper distal
10 end thereof and an overhanging ledge 306 with vertical surface 308 in a lower distal end. This overhanging ledge 306 is dimensioned to extend into the longitudinal slots to a point wherein the vertical surface 308 of the overhanging ledge 306 drops down and abuts the forward edge 310 of the cartridge retaining portion of the cartridge housing 260 when the cam bars 278 move to their distal fired position. At their
15 proximal end, cam bars 278 are provided with hook structure 312 for releasably engaging cam bar adapter 280.

Referring now to Figs. 22-24, there is shown multiple views of the cam bar adapter 280 in accordance with one embodiment of the present invention. The
20 cam bar adapter 280 comprises a forward section 314 and a rearward section 316. The forward section 314 is substantially rectangular in shape and has a central longitudinal groove 318 formed therein and dimensioned to receive the longitudinal groove structure 302 therein when the cam bar adapter is urged to its forwardmost position. Flanges 320 and shelves 322 serve to removably retain the proximal end of
25 cam bars 278.

The rearward section 316 is rectangular in shape with projections 324
formed in the proximal end thereof. The rearward section is dimensioned to be
30 receivable within the slot formed in fork 194 in channel 192. The projections 324 are

1 dimensioned to engage ramping surface 198 to allow the fork 194 to ride up and over
the projections 324 when the fork 194 is moved in the distal direction.

Vertical bore 326 and longitudinal groove 328 are formed in the
5 rearward section 316 and serve to retain and hold the shank of knife 254. Shear pin
294 is integrally formed with cam bar adapter 280 on a bottom surface thereof and, in
the prefiring position, is aligned with and receivable into bore 292. Also, in this
prefiring position, the rearward section 316 of the cam bar adapter 280 is disposed
10 over rearward projection 290 to effectively shield engagement of abutting structure
202 with projection 290.

Turning now to Figs. 28-34, there is shown a second preferred
embodiment of an anvil and cartridge assembly in accordance with the present
invention. Referring to Figs. 28 and 29, the cartridge assembly 330 comprises a
15 cartridge housing 332 mounting a cartridge 334 containing a plurality of pushers 336
disposed beneath staples 338, in a distal end thereof. A pair of cam bars 340 are
positioned in the cartridge housing 332 and are adapted to move longitudinally
through parallel longitudinal slots formed in cartridge 334. A camming surface 342 is
20 formed on an upper distal end of cam bars 340 with an overhanging ledge 344 formed
on a lower distal end. Vertical ledge 346 is formed proximal to overhanging ledge
344 and is adapted to engage the distal end of cartridge housing 332 when the cam
bars 340 are driven to their full distal position. A cam bar alignment tab 348 engages
25 both cam bars 340 and holds them in parallel alignment. A cam bar adapter 350 is
adapted to fixedly receive the shank portion of cam bars 340.

Cartridge 334 is designed with three longitudinal rows of staples with
each row of staples being offset from adjacent rows as shown in Fig. 28. This
embodiment of the present invention does not utilize a knife structure and is designed
30 to place rows of staples in body tissue.

1 Referring to Figs. 30-31, an anvil 352 is shown having substantially the
same design as anvil 230 described hereinabove with respect to the previous
embodiment. The primary difference is that the distal portion 354 of anvil 352 is
5 narrowed to receive and form three longitudinal rows of staples in contrast to the six
rows of staples and knife accommodated by anvil 230. Anvil 352 includes a pair of
longitudinally extending parallel legs 356 having transverse opposing projections 358.
Parallel aligning surfaces 360 are formed in sidewalls of anvil 352 and serve to
10 overfit and align anvil 352 on cartridge housing 332. First and second camming
surfaces 362, 364 are formed in sidewalls of anvil 352 proximal to parallel aligning
surfaces 360 and serve to engage camming bosses 268, 270 formed in forward collar
tube 222 and rear collar tube 224, respectively.

15 Upper camming surface 366 is formed on an upper surface of anvil 352
proximal to distal end 354 with locking surface 368 formed distally adjacent upper
camming surface 366. Both the upper camming surface 366 and the locking surface
368 are adapted to engage and be cammed by top arcuate camming surface 246
formed in the distal end of forward collar tube 222.

20 Figs. 35-39 show a further embodiment of the present invention similar
to that shown in Figs. 1-15 with the jaw structure of Figs. 28-34. Referring to Figs.
35-36, the handle portion of this embodiment further includes annular seals 101, 103
provided between the distal end of frame 52 and the proximal end of cover tube 182.
25 These seals serve to further inhibit the escape of insufflation gas from the operative
site. Seals 107 and 109 are positioned adjacent the proximal and distal ends,
respectively, of clamp tube 70 to better seal off insufflation gas from the area of the
piston 104.

30 A counter mechanism is also disposed in handle portion 52 and
comprises a counter ratchet 400 attached to trigger rod 112 and a leaf spring 402

1 mounted in housing 66 so as to engage the teeth on the bottom surface of counter
ratchet 400. Numerical indicators are longitudinally disposed on an outer surface of
the counter ratchet 400 and correspond to the number of times the instrument has
5 been fired. An access plate 404 having a viewing window 406 therein is positioned in
the outside surface of housing 66.

In operation, each time the instrument is fired the leaf spring 402
engages a respective proximally located tooth of the counter ratchet 400, effectively
10 sliding the counter ratchet 400 distally to align the next lower number in viewing
window 406. The counter mechanism of this embodiment further includes a locking
feature whereby the trigger button 96 is retained in the fired position when the leaf
spring 402 engages the most proximal surface of the counter ratchet 400 and prevents
the firing rod 112 from returning to its proximal unfired position.

15 This embodiment of the present invention further includes an integral
trigger button rotary safety mechanism comprising a rotary safety shaft 408 disposed
within a roller 410. The rotary safety mechanism is rotatably positioned in trigger
button 96 with the roller 410 extending out beyond the plane of the back surface of
20 trigger button 96. Projections 412 are eccentrically formed on both sides of rotary
safety shaft 408 and extend out beyond the plane of the side surfaces of the trigger
button 96. Spring 414 serves to normally bias the rotary safety mechanism with the
projections 412 disposed in their distalmost orientation.

25 Referring now to Figs. 38 and 39, in the instrument's unfired position
(Fig. 38) projections 412 are in their distalmost position and are disposed in direct
alignment with the proximal ends of the housing members 64, 66. In this position,
the trigger button 96 cannot be accidentally depressed to fire the instrument. In order
30 to disengage the safety mechanism, the roller 410 is moved in the direction of arrow
416 which serves to rotate projections 412 from their distalmost position (Fig. 38) to

1 their proximalmost position (Fig. 39) effectively allowing trigger button 96 to be
depressed to fire the instrument. As soon as roller 410 is released, spring 414 returns
the safety mechanism to its normal position to prevent subsequent accidental firings.

5 Fig. 37 shows the endoscopic portion and the jaw portion of the
surgical apparatus of Fig. 35. The anvil 418 of this embodiment is provided with a
pair of angled proximal legs 420. This feature permits the anvil 418 to be opened
wider to more easily receive tissue between the anvil 418 and cartridge 58. The
10 angled proximal legs 420 preferably extend at an angle of between 0 and 30° from the
longitudinal plane of the anvil.

A clamp lockout structure is shown in detail in Figs. 37, 40 and 41
incorporated into the support structure 214 and upper extension spacer 210. The
clamp lockout structure comprises a leaf spring 430 having a diagonally downwardly
15 extending projection 432 attached thereto. A slot 434 is formed through the top
surface of support structure 214 and is adapted to engage and receive projection 432
whenever the support structure is not longitudinally aligned. This clamp lockout
structure is designed and configured to prevent the instrument jaws from closing on
20 tissue unless the cartridge and/or jaw elements are properly emplaced within the
apparatus.

In operation in the stapling apparatus of Fig. 37, leaf spring 430 and
projection 432 are normally disposed above support structure 214. The proximal ends
25 of the cartridge 334 and the anvil 418 are inserted through collar tube 222 and
brought into engagement with the distal end of support structure 214. (See Fig. 40)
In the event that the cartridge 334 and/or the anvil 418 are not properly and/or
completely inserted into engagement with support structure 214, the resulting angular
30 disposition of the support structure 214 brings slot 434 into alignment with projection
432. (See Fig. 41) As the operator attempts to depress the handle 62, the extension

1 spacer 210 begins to move distally causing projection 432 to enter slot 434 and
become entrapped therein effectively preventing any further distal movement of the
extension spacer 210 and, in turn, preventing approximation of the anvil 418 and the
5 cartridge 334.

II. Operation of the Instrument

In use, the endoscopic portion of the instrument is inserted into the
10 body, preferably through an endoscopic tube. It is further preferred that the
endoscopic tube apparatus be capable of maintaining a sealed pneumoperitoneum, with
the internal sealing member of the housing further maintaining this seal despite
introduction of the instrument in accordance with the invention into the endoscopic
tube. As a practical matter, the jaws of the instrument are closed for insertion into
15 the endoscopic tube, either by pinching the anvil and cartridge prior to insertion or by
closing the articulating handle to cam the jaws closed prior to insertion.

After insertion into the endoscopic tube, the endoscopic portion may be
rotated in order to appropriately orient the instrument at the stapling site. Rotation of
20 the endoscopic portion relative to the body may be attained by rotating the instrument,
as a whole, by rotating the endoscopic portion relative to the frame using rotation
knob 228 (See Fig. 1), or by a combination thereof.

Referring to Figs. 3, 5-8 and 32-34, with the instrument properly
25 oriented so that the tissue to be fastened is disposed between the open jaws of the
instrument, i.e., between the tissue contacting surfaces of anvil member 230 and
cartridge 302, the jaws are closed to clamp the tissue. In the first embodiment, the
surgeon presses down on actuating handle 62, thereby sliding collar tube assembly
220 distally, via clamp tube 70, extension sleeve 204, and extension spacers 210, 212.
30

Referring to Figs. 32-34, as collar tube assembly 220 moves distally in

1 the direction of arrow A from a first position where the top arcuate camming surface
246 at the distal end of forward collar tube 222 is proximal to camming surface 242,
(Figs. 32-33), to a second position where the top arcuate camming surface 246 is
5 engaged with locking surface 244, (Fig.34), the top arcuate camming surface 246
contacts the camming surface of the anvil, thereby forcing the anvil to cam via
camming surfaces 264, 266 on camming bosses 268, 270 until the anvil is brought
into close cooperative alignment with the cartridge assembly. Fig. 34 illustrates the
10 instrument with the jaws in a closed position.

After closing the instrument jaws, the instrument is ready to be fired.
When the surgeon is ready to emplace the staples and cut tissue, firing trigger 96 is
depressed to actuate the pneumatic actuator 98 as discussed in detail above. Piston
104, attached to the proximal end of channel 192 is driven distally causing camming
15 surface of forks 194 to ride up and over projection 324 of the cam bar adapter 280
and drive the cam bar adapter in a distal direction. Shear pin 294 is severed and the
cam bars and knife are driven longitudinally through the cartridge to sequentially
drive and form staples and cut tissue.

20 As piston 104 contacts return springs 140, 142, pusher washers 186 are
compressed on themselves and serve to store energy as the piston moves distally
toward the cartridge assembly. This initial compression occurs in the range of
between about 20 p.s.i. to about 150 p.s.i. and preferably within a range of about
25 30 p.s.i. to about 60 p.s.i. Near the end of the distal stroke of the piston 104, this
stored energy is released to drive the cam bars 278 through the final distal limits of
their travel within the longitudinal slots in the cartridge. At the distal extreme of the
longitudinal stroke, the overhanging ledges 306 of cam bars 278 drop over the edge
of the cartridge housing thus abutting vertical surface 308 with edge 310.
30

1 After firing, return springs 140, 142 engage piston 104 and return it to
its original position. The return motion of piston 104 causes rocking lever 120 to be
cammed aside by camming surface 144 of piston 104. In the embodiment containing
5 knife 254 discussed above, the cam bars 278 are pulled out of cam bar adapter 280
and remain in position in the longitudinal slots of the cartridge 334. The cam bar
adapter, with knife 254 attached, moves proximally within cartridge housing 272 until
the outer edges of cam bar adapter 280 impinge on crimps 296.

10 The cam bar adapter 280 is held in place by crimps 296 while camming
surface 200 of fork 194 causes the fork to ride up and disengage with projection 324
of the cam bar adapter. Channel 192 continues to move in the proximal direction
until abutting structure 202 is positioned proximally to rearward projection 290
formed in the floor of cartridge housing 260. At this point, the entire cartridge
15 assembly 232 is deactivated.

 In the event that the surgeon should accidentally attempt to again fire
the instrument without replacing the deactivated cartridge with a new unfired
cartridge, the resulting distal longitudinal motion of the channel 192 moves abutting
20 structure 202 into contact with rearward projection 290 effectively preventing further
movement of forks 194 toward cam bar adapter 280.

 After firing, articulating handle 62 is raised with the assistance of
handle return spring 82 which action retracts collar tube assembly 220. This
25 retraction causes anvil 230 to cam out of engagement with cartridge assembly 232.
Similarly, raising of articulating handle 62 causes cam slide 124 to move upward
disengaging the pneumatic firing mechanism.

 In order to replace the cartridge assembly, the instrument is withdrawn
from the patient. The cartridge assembly is released and may be removed by pulling
30 it distally out of collar tube assembly 222.

1 To reinsert a new cartridge assembly, the proximal end of the cartridge
assembly is inserted into collar tube assembly 222 until engaging and locking into
support structure 214. The instrument is now ready for reinsertion and continued use.

5 Operation of the instrument with the cartridge and anvil assembly
shown in Figs. 28-31 is substantially similar to that described above. Tubular tissue
to be ligated and/or divided is captured within the anvil 352 and the cartridge
assembly 330 such that the tissue is transversely oriented therebetween. The cartridge
10 assembly 330 and anvil 352 are approximated by means of camming surfaces 362,
364 and camming bosses 268, 270, as described above. The staples 338 are fired,
ligating the tissue.

 Unlike the previous embodiment, the cartridge assembly 330 does not
include a knife and therefore does not require that the cam bars be retracted by
15 channel 192. In operation, the distal end of channel 192 engages the proximal end of
cam bar adapter 350 and drives cam bars 340 to their extreme distal position (Fig.
34). In that position, overhanging ledges 344 drop over the distal end of cartridge
housing 332 and remain there. As the piston 104 retracts, channel 192 moves away
20 from cam bar adapter 350 and retracts to a position proximal to rearward project 290,
this leaving cam bars 340 and cam bar retainer 350 in the distal position within
cartridge assembly 332. Opening, removal and replacement of the deactivated
cartridge are effected in substantially the same way as described above with respect to
25 the second alternative embodiment.

 It will be understood that various modifications can be made to the
various embodiments of the present invention herein disclosed without departing from
the spirit and scope thereof. For example, various sizes of the instrument are
30 contemplated, as well as various types of construction materials. Also, various
modifications may be made in the configuration of the parts. For example, in the

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1 first embodiment the elongated slot for allowing access to the thumbwheel may be
placed alternatively in the left body portion or right body portion. Therefore the
above description should not be construed as imitating the invention but merely as
5 exemplifications of preferred embodiments thereof. Those skilled in the art will
envision other modifications within the scope and spirit of the present invention as
defined by the claims appended hereto.

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CLAIMS:

1. A self contained gas powered surgical apparatus for driving surgical fasteners into body tissue comprising;

a) a frame having clamping means; and
b) an endoscopic portion defining a longitudinal axis and extending distally from the frame, said endoscopic portion including:

- i) an extension tube having a distal end mounted collar tube, the extension tube rotatably connected to the clamping means of the frame for rotatable and longitudinal movement through the endoscopic portion between a first open position and a second closed position;
- ii) a cover tube mounted to the frame for rotational movement about the longitudinal axis;
- iii) an elongated support fixed to the cover tube, said elongated support retaining a cartridge assembly including a plurality of surgical fasteners slidably mounted therein and having a tissue engaging surface and said elongated support further retaining an anvil member having a fastener forming surface, the anvil member being movable between an open position corresponding to the first position of the extension tube and a closed position corresponding to the second position of the extension tube wherein the fastener forming surface is in close cooperative alignment with the tissue engaging surface of the cartridge assembly; and
- iv) means for ejecting said surgical fasteners from said cartridge assembly, whereby said

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fasteners engage said fastener forming surface,

c) a self contained pneumatic system mounted in said frame and including a supply of low pressure gas and a pneumatic actuator mechanism associated with said gas supply, said pneumatic actuator mechanism being adapted to cooperate with said means for ejecting said surgical fasteners to fire said surgical fasteners against said fastener forming surface; and

d) interlock means for preventing actuation of the actuator mechanism when said clamping means is not in a closed position.

2. The self contained gas powered surgical apparatus of claim 1 wherein said interlock means comprises a linkage engageable with said clamping means and movable between a first locked out position when said clamping means is in an open unclamped position and a second disengaged firing position when said clamping means is in a closed clamped position.

3. The self contained gas powered surgical apparatus of any one of claims 1 to 2, further comprising a seal to substantially atmospherically isolate the endoscopic portion from the frame.

4. The self contained gas powered surgical apparatus of any one of claims 1 to 3, wherein the cartridge assembly comprises: a cartridge housing; a cartridge holding the plurality of surgical fasteners slidably disposed therein in abutment with corresponding pushers, the cartridge defining a plurality of longitudinal slots accessing the pushers; and a cam bar adapter removably mounting a plurality of cam bars, the cam bars adapted for

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longitudinal movement through the longitudinal slots to engage the pusher and eject the staples.

5. The self contained gas powered surgical apparatus of claim 4, wherein the plurality of cam bars are adapted for a single distal pass through the longitudinal slots.

6. The self contained gas powered surgical apparatus of claim 5, wherein the cam bars are detached from the cam bar adapter after a single distal pass through the longitudinal slots and are retained therein to disable the cartridge assembly.

7. The self contained gas powered surgical apparatus of claim 4 further comprising a knife mounted to the cam bar adapter and adapted for longitudinal motion through the cartridge.

8. The self contained gas powered surgical apparatus of claim 7 further comprising means for disabling the knife after a single distal pass through the cartridge.

9. The self contained gas powered surgical apparatus of claim 8, wherein said means for disabling the knife comprises disengagement means for disengaging the channel from the cam bar adapter after a single distal pass of the knife through the cartridge.

10. The self contained gas powered surgical apparatus of any one of claims 1 to 9, wherein the means for ejecting said surgical fasteners from said cartridge assembly includes a channel and a cam bar adapter mounting

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at least one cam bar for ejecting surgical fasteners, said channel adapted for longitudinal movement within the elongated support and rotation movement with the endoscopic portion.

11. The self contained gas powered surgical apparatus of any one of claims 1 to 9, wherein the self contained pneumatic system includes a pneumatic actuator mechanism associated with said gas supply, said pneumatic actuator mechanism including a piston connected to said channel, a cylinder and a firing mechanism such that when said firing mechanism is activated, gas from said gas supply passes into said cylinder to drive said piston and channel in a longitudinally distal direction to cause said channel to move said cam bar distally to eject said surgical fasteners.

12. The self contained gas powered surgical apparatus of any one of claims 1 to 11, wherein said pneumatic system further comprises pressure sensing means disposed in line between said gas supply and said pneumatic actuator mechanism to prevent firing of said surgical apparatus unless a sufficient volume of pressurized gas is available for a complete cycle of firing.

13. The self contained gas powered surgical apparatus of any one of claims 1 to 11 further comprising adjusting means for selectively adjusting the longitudinal travel of said means for ejecting said surgical fasteners.

14. The self contained gas powered surgical apparatus of any one of claims 11 to 13 further comprising spring assist means disposed in cooperation with said piston

- 40 -

to extend the longitudinal distal stroke of said channel.

15. The self contained gas powered surgical apparatus of claim 14, wherein said spring assist means comprises a plurality of pusher washers disposed on a distal end of said piston and adaptable to store potential energy for release during a firing stroke of said piston to extend the longitudinal distal stroke of said channel.

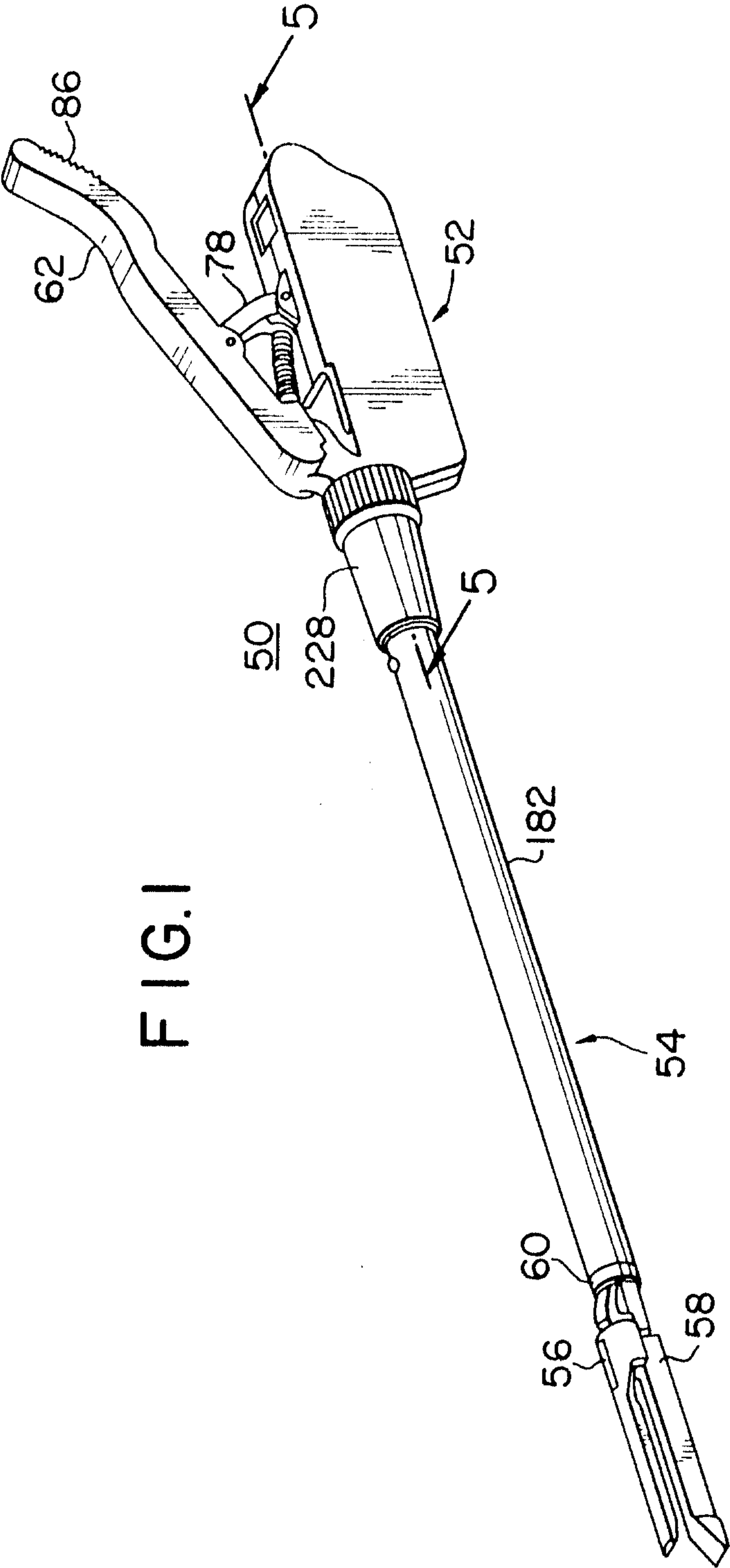
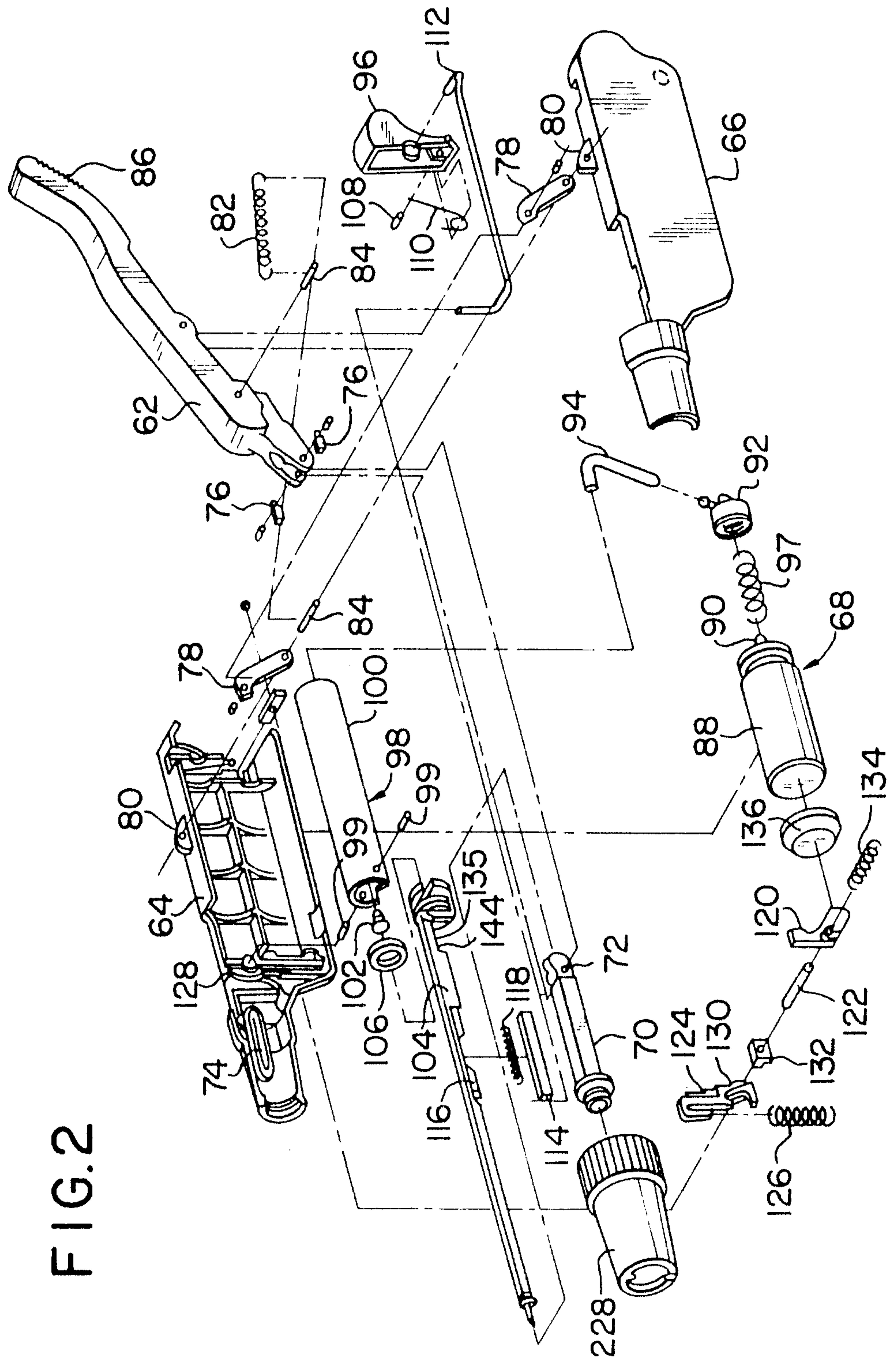


FIG. 1

FIG. 2



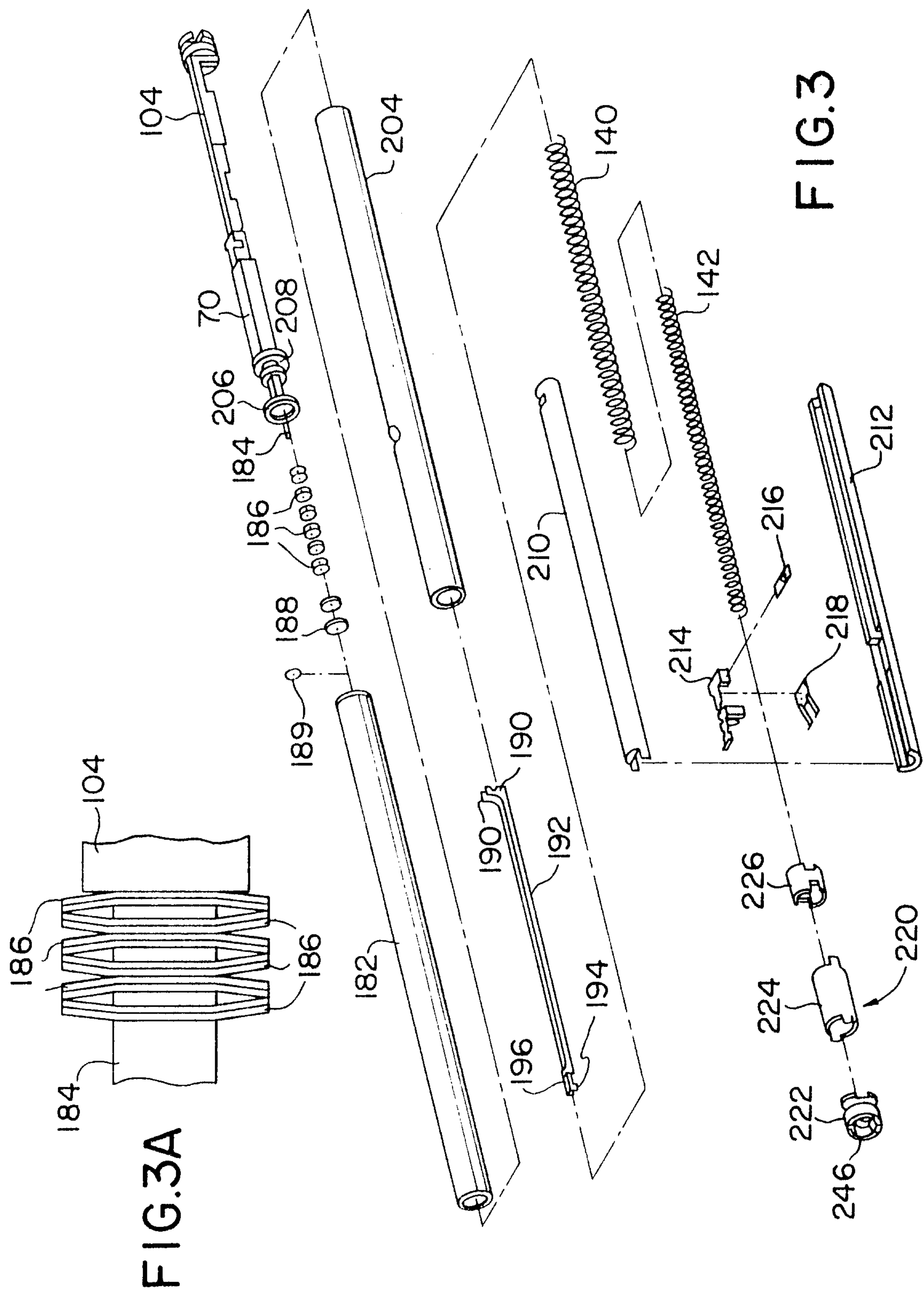


FIG. 4

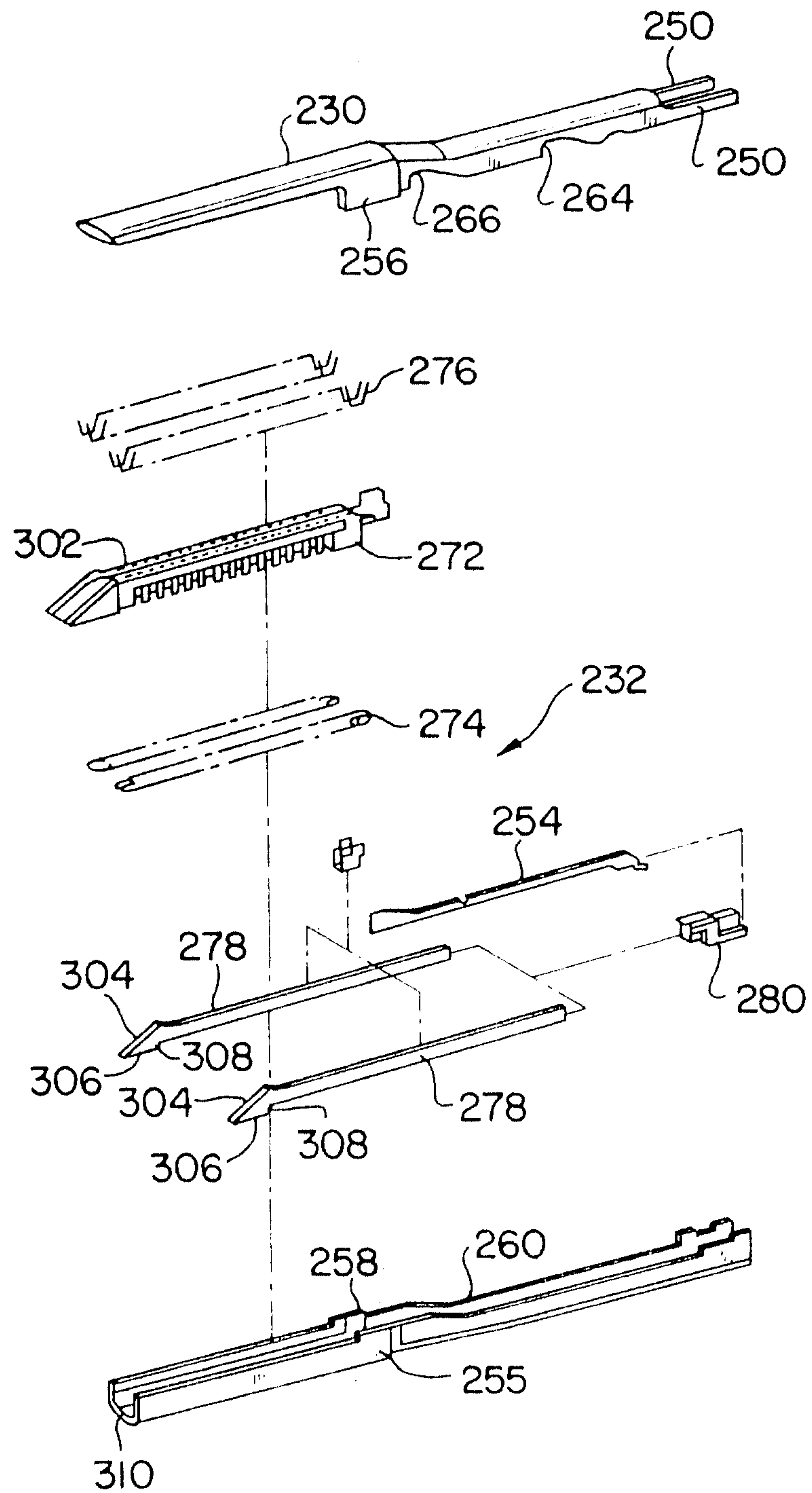


FIG.5

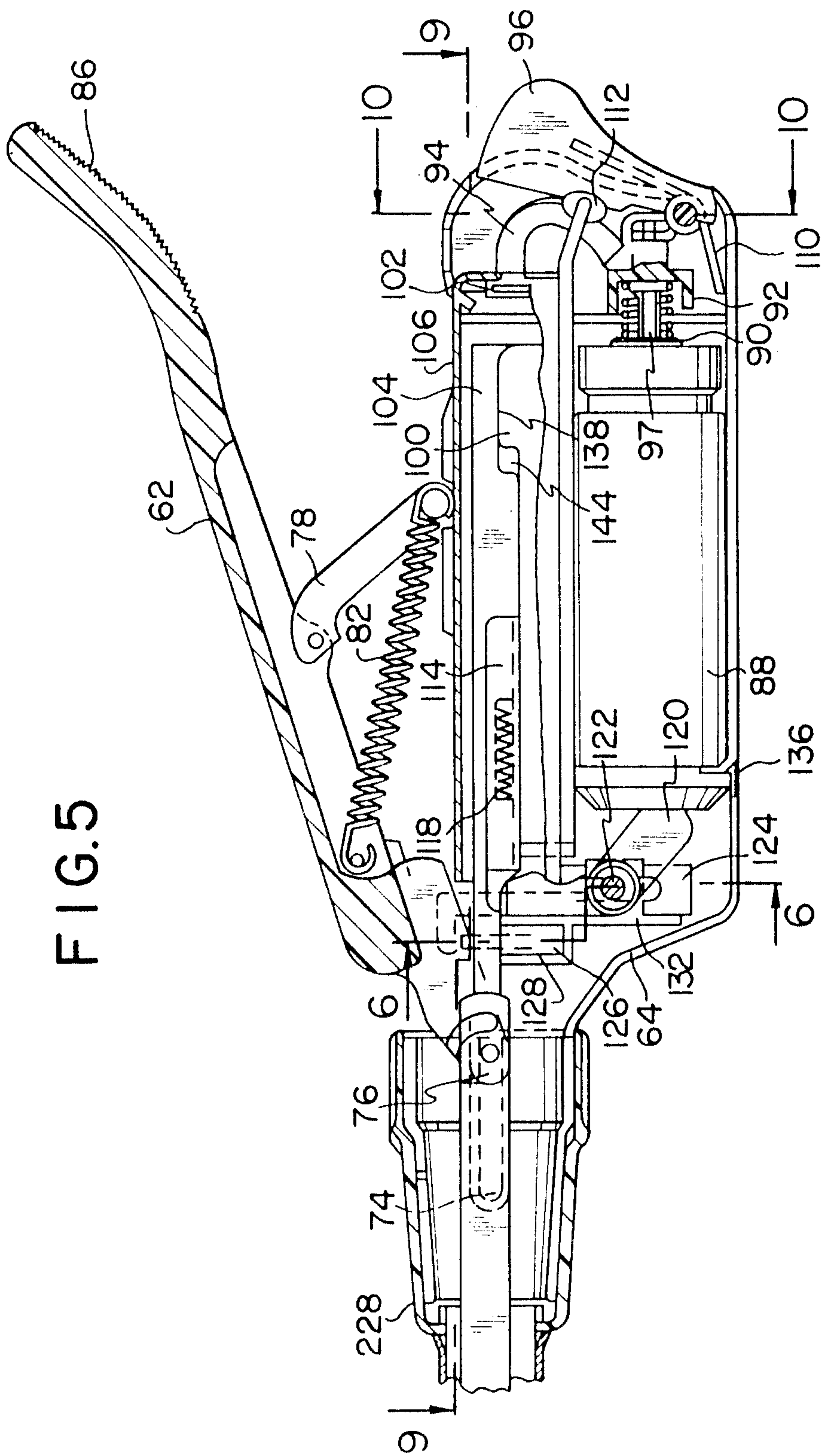


FIG.6

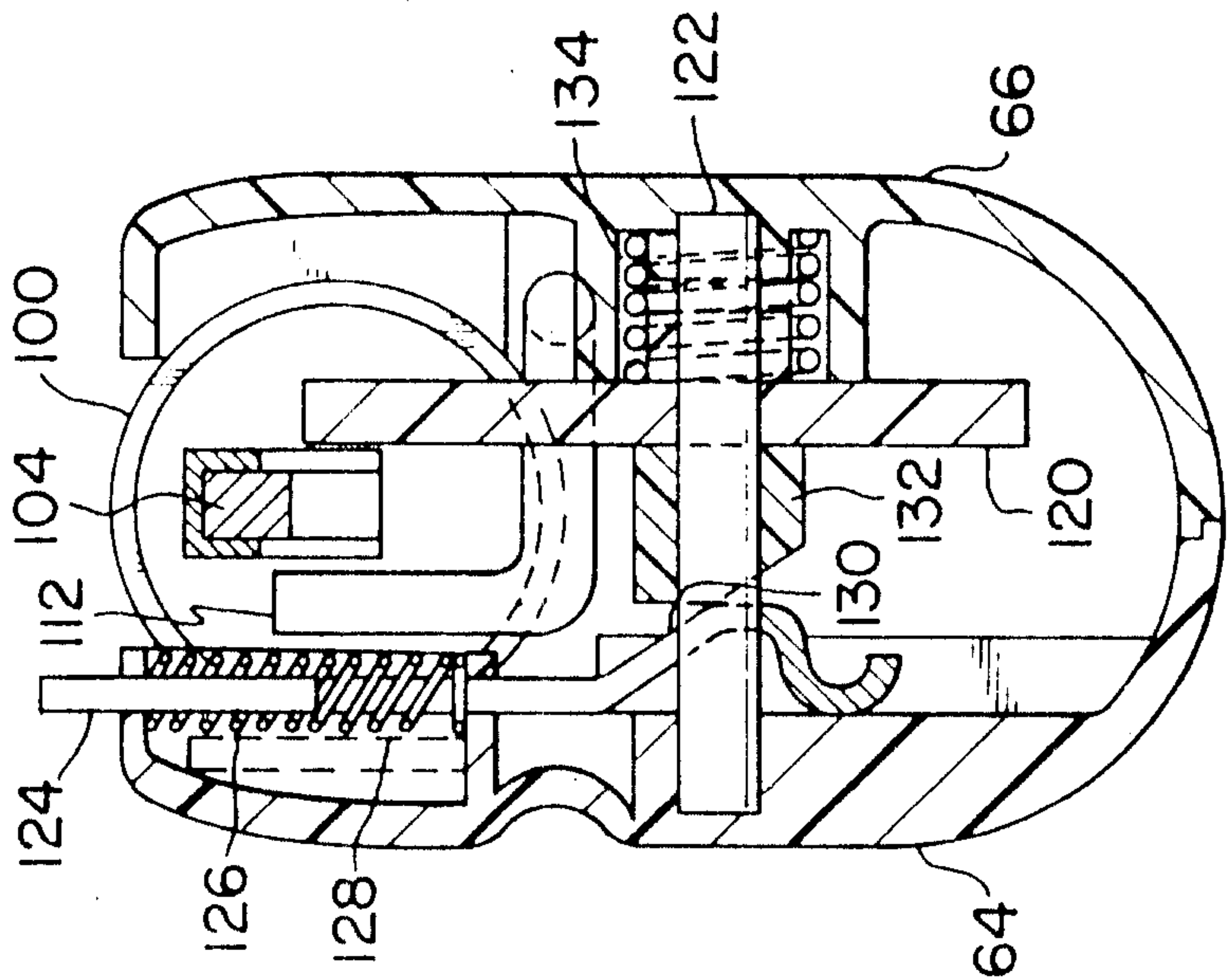


FIG.8

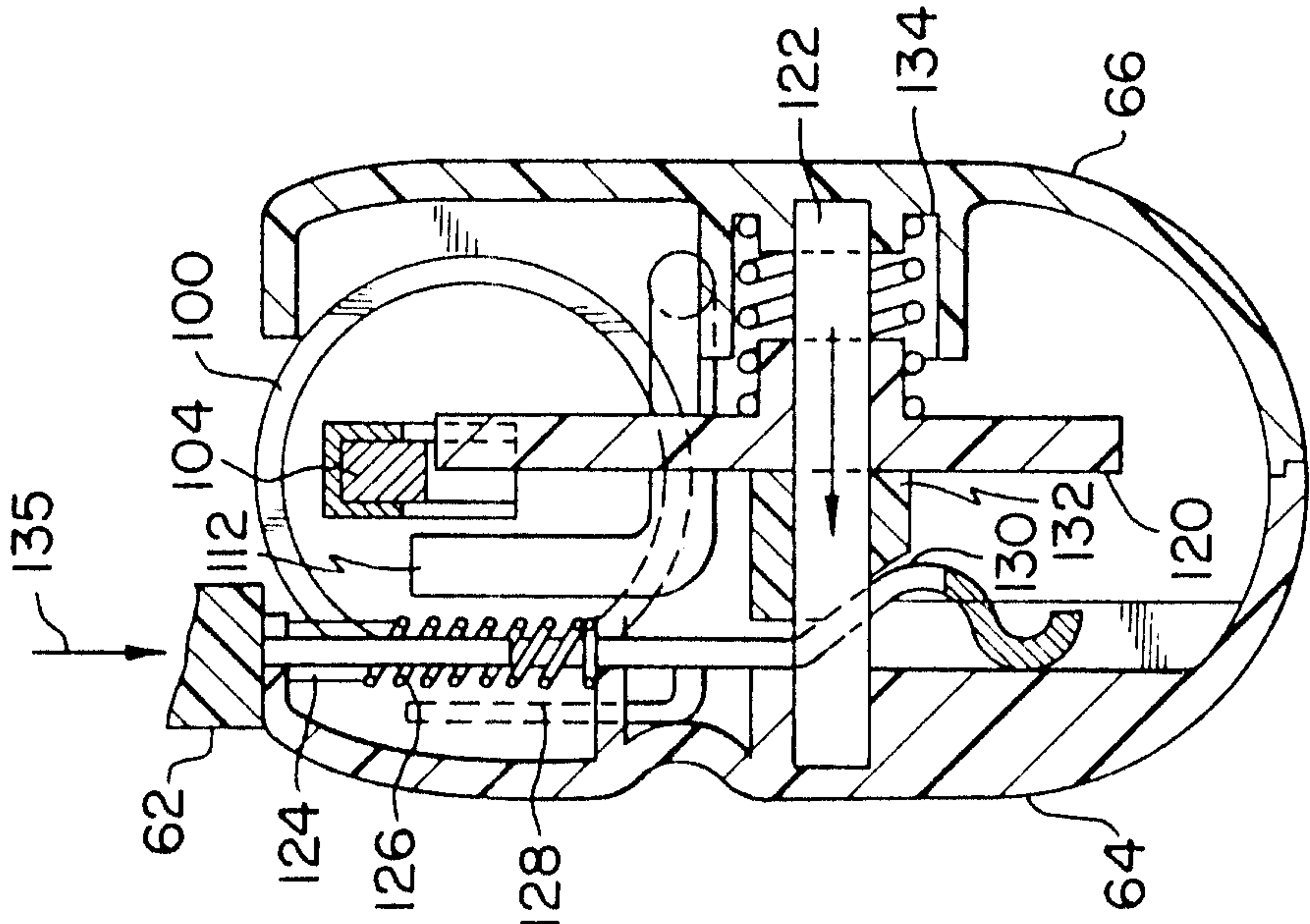


FIG. 7

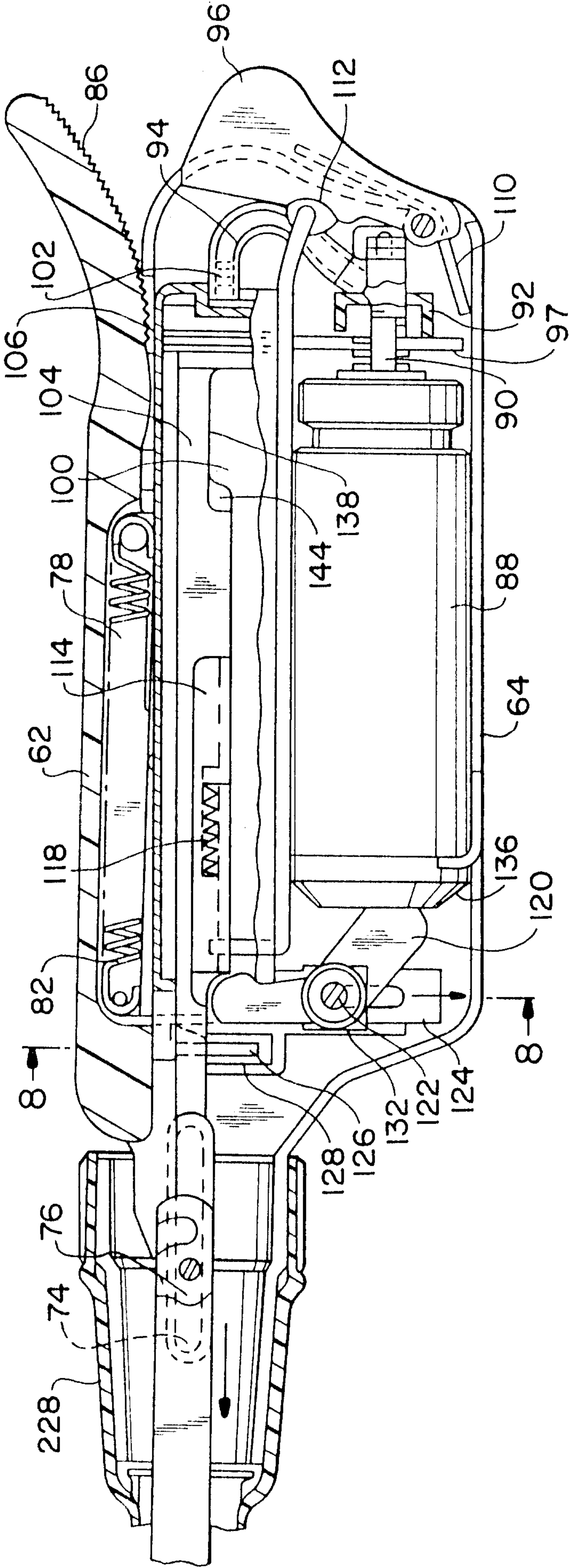


FIG.9

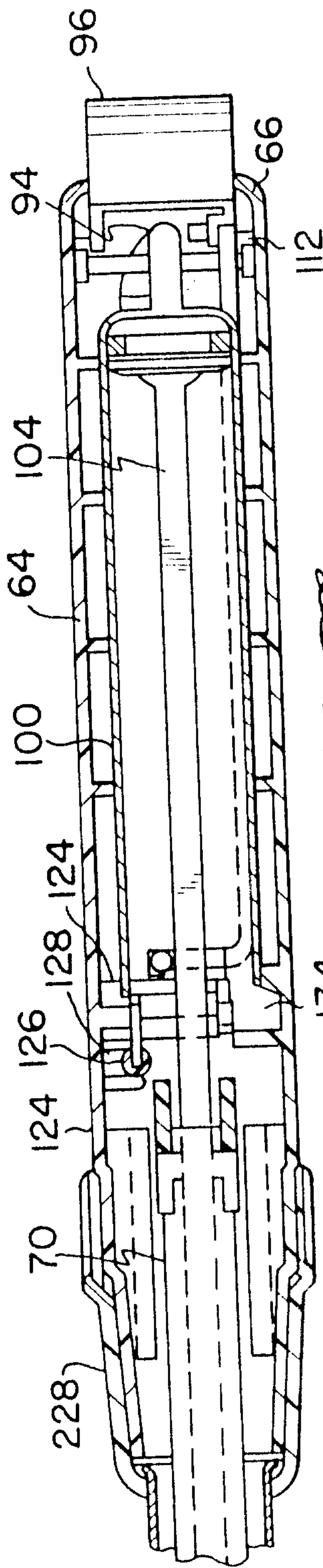


FIG.12

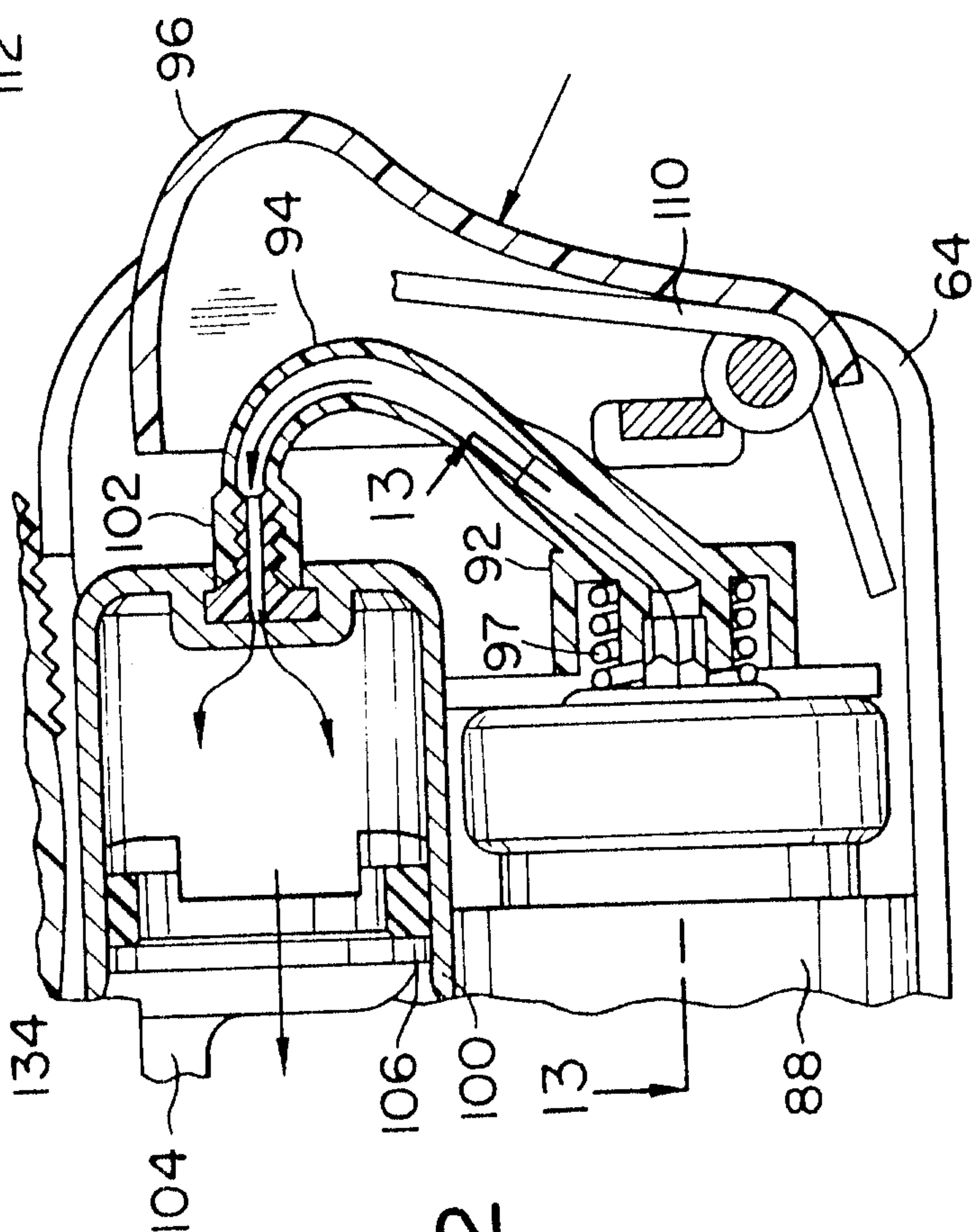


FIG.10

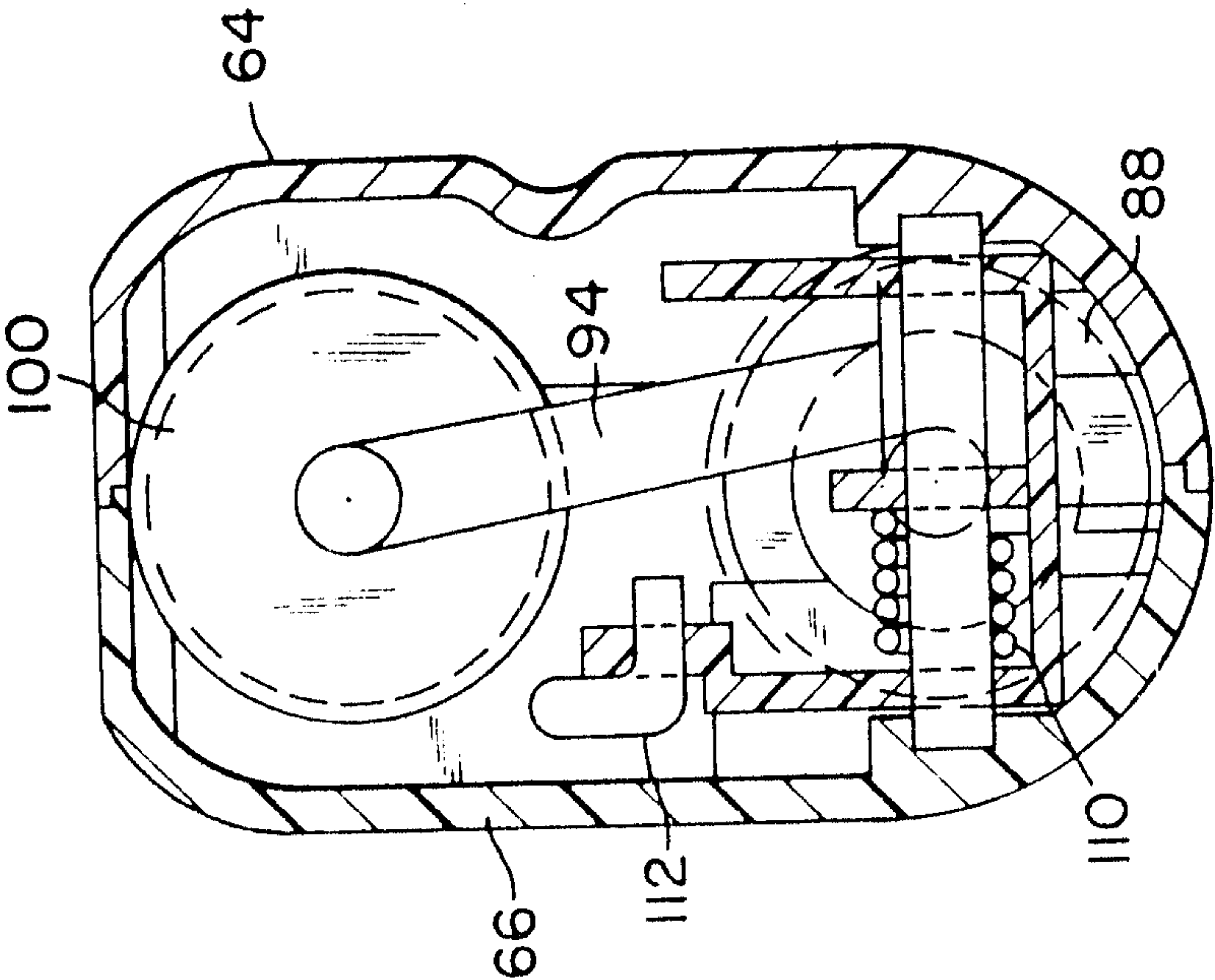


FIG.13

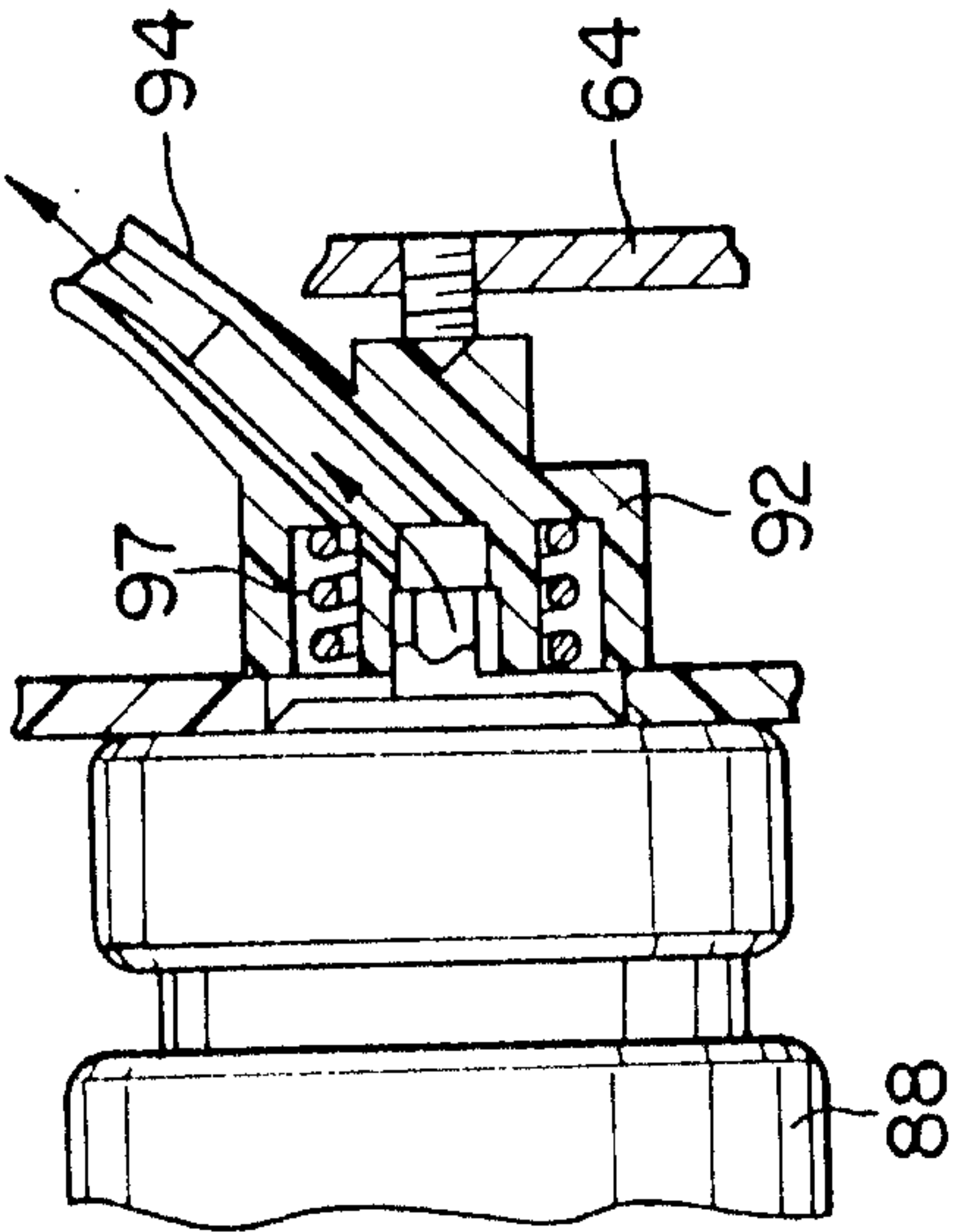


FIG. 11

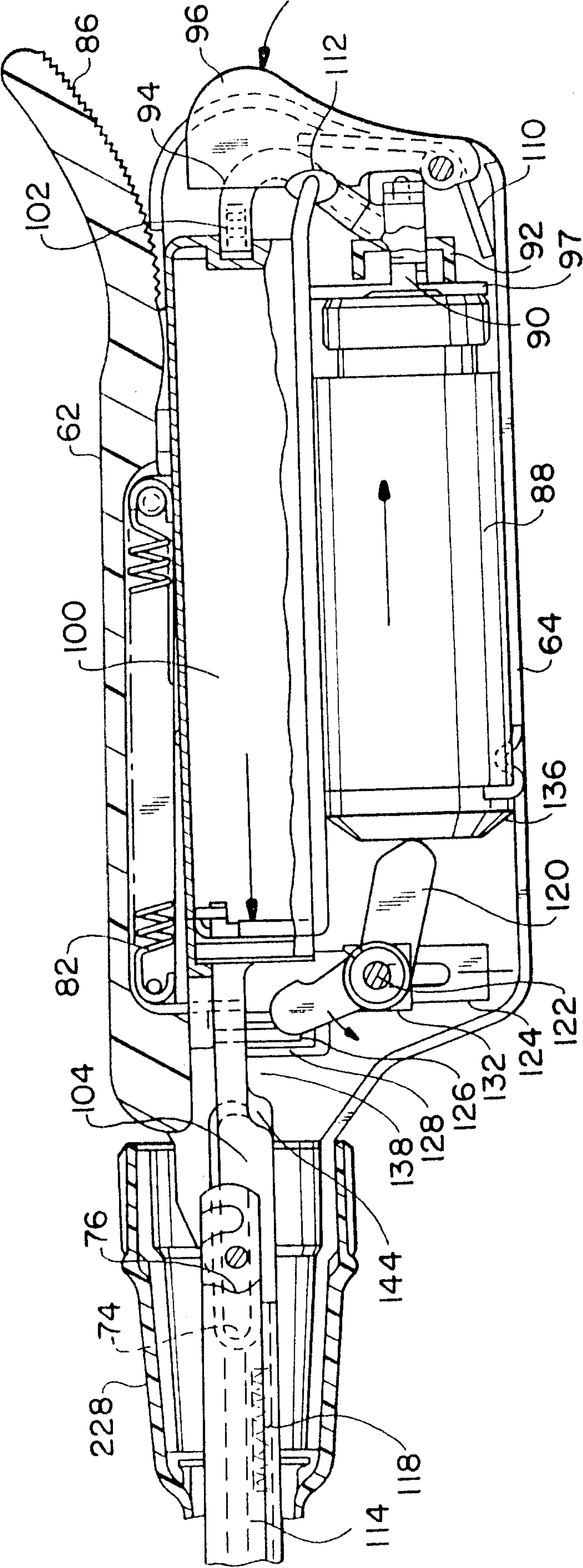


FIG. 14

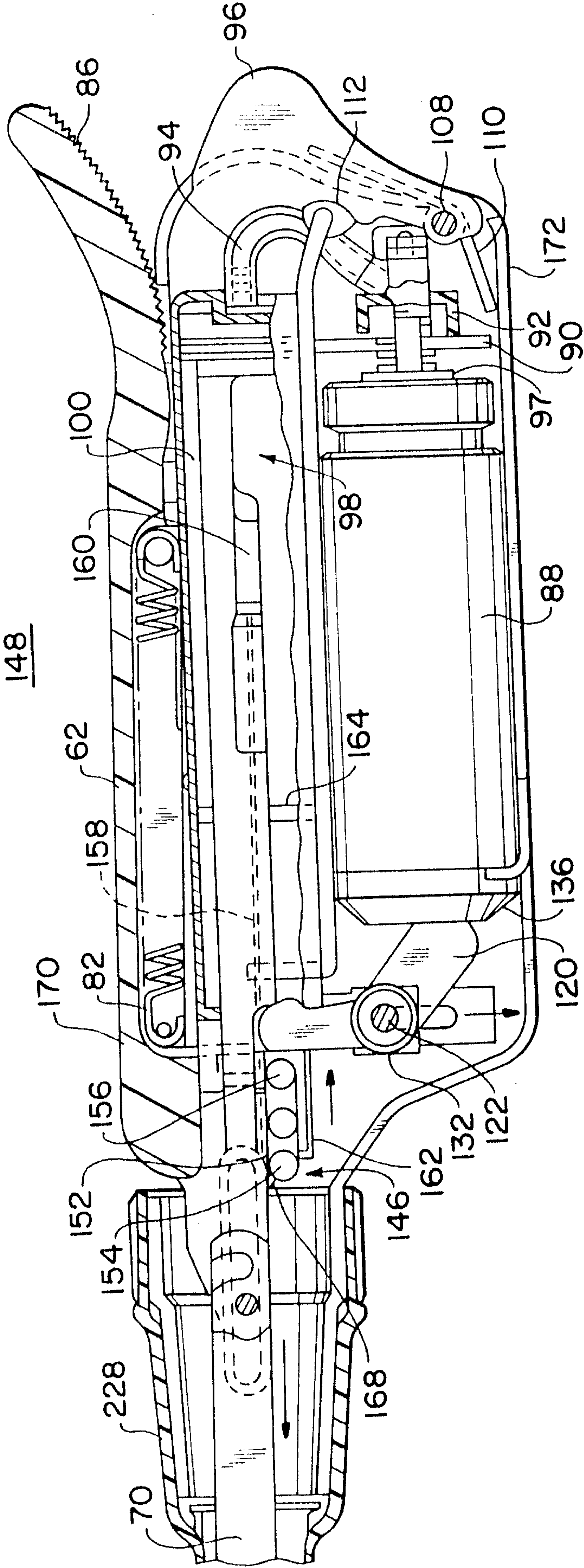


FIG. 15

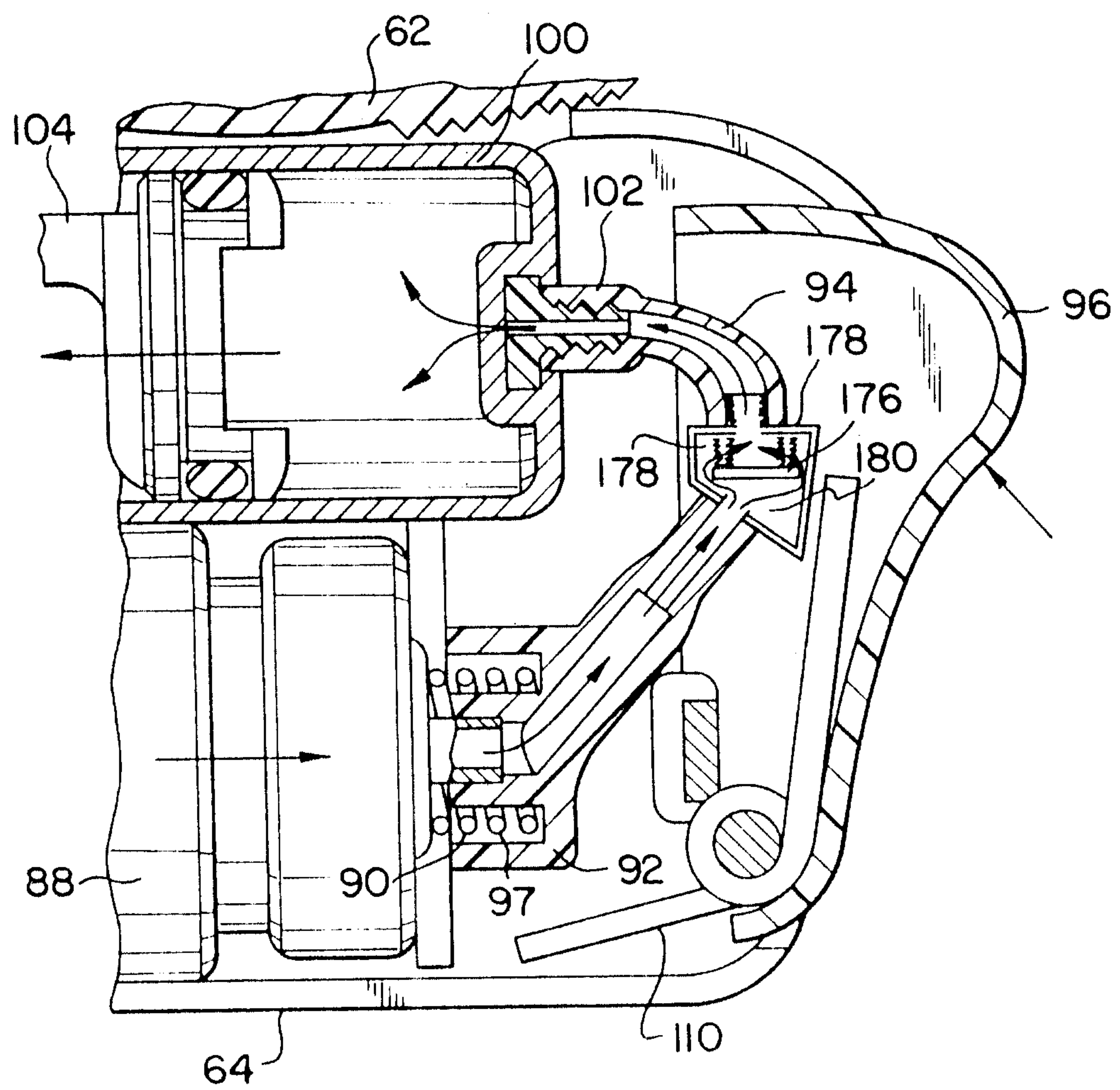


FIG.16

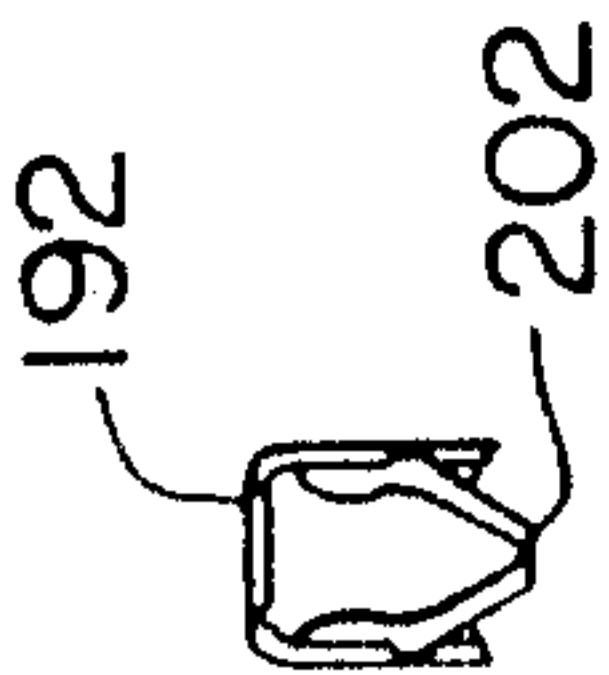
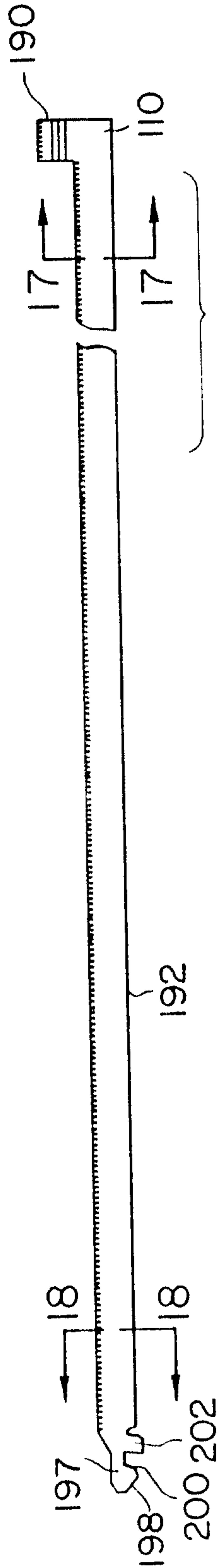


FIG.18

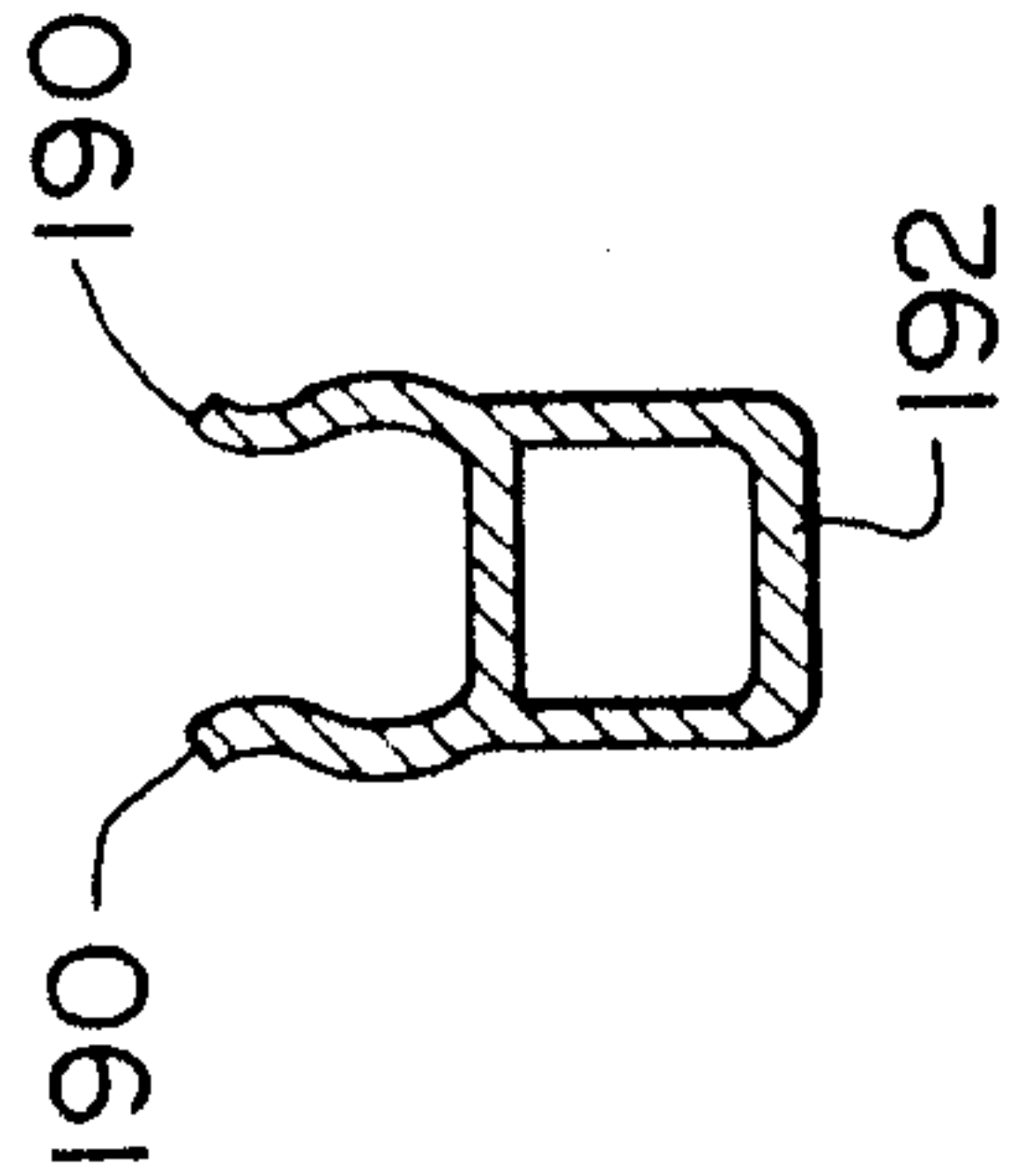


FIG.17

FIG.19

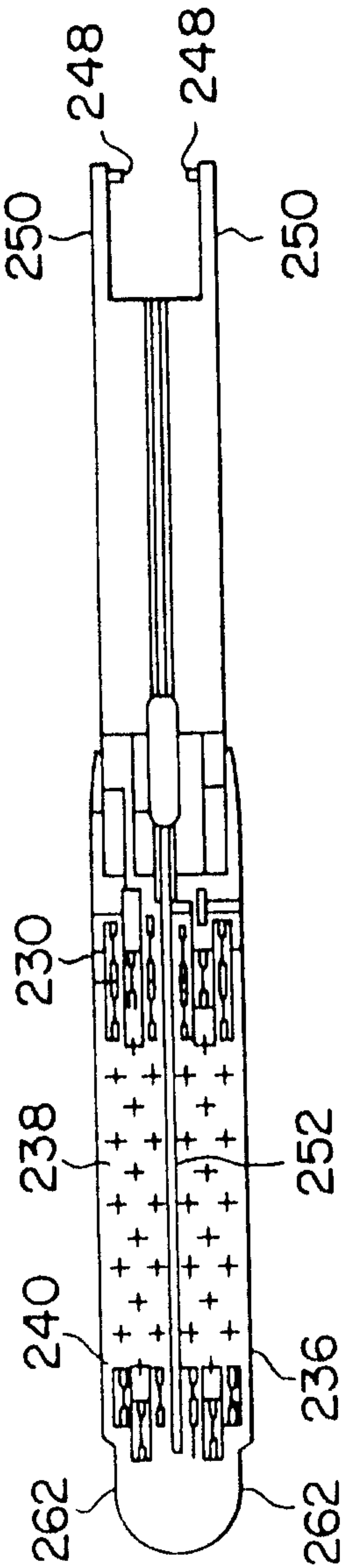


FIG.20

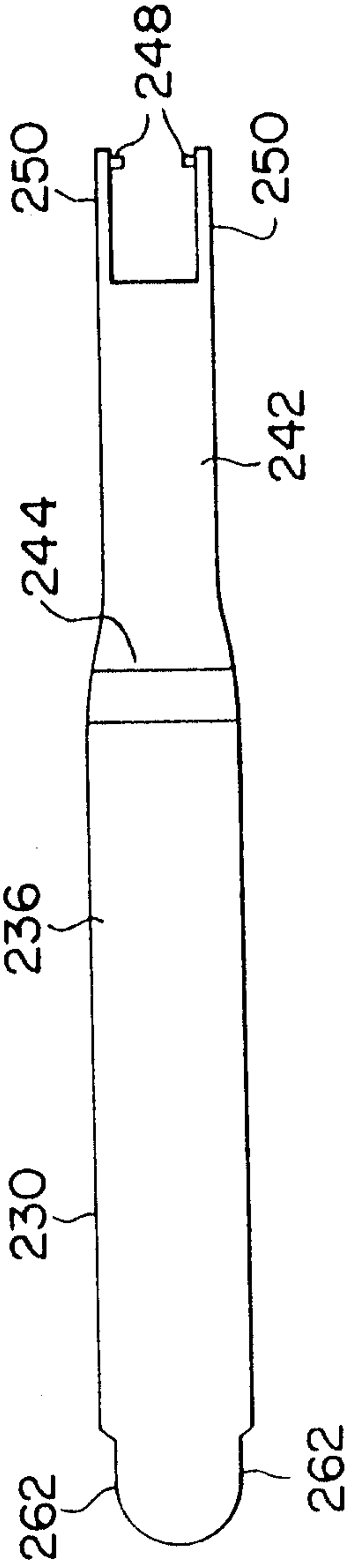


FIG.21

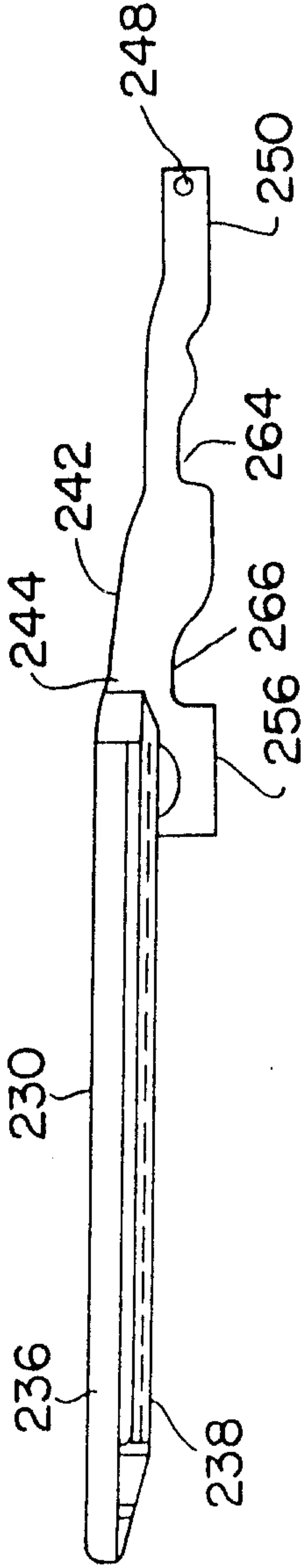


FIG. 22

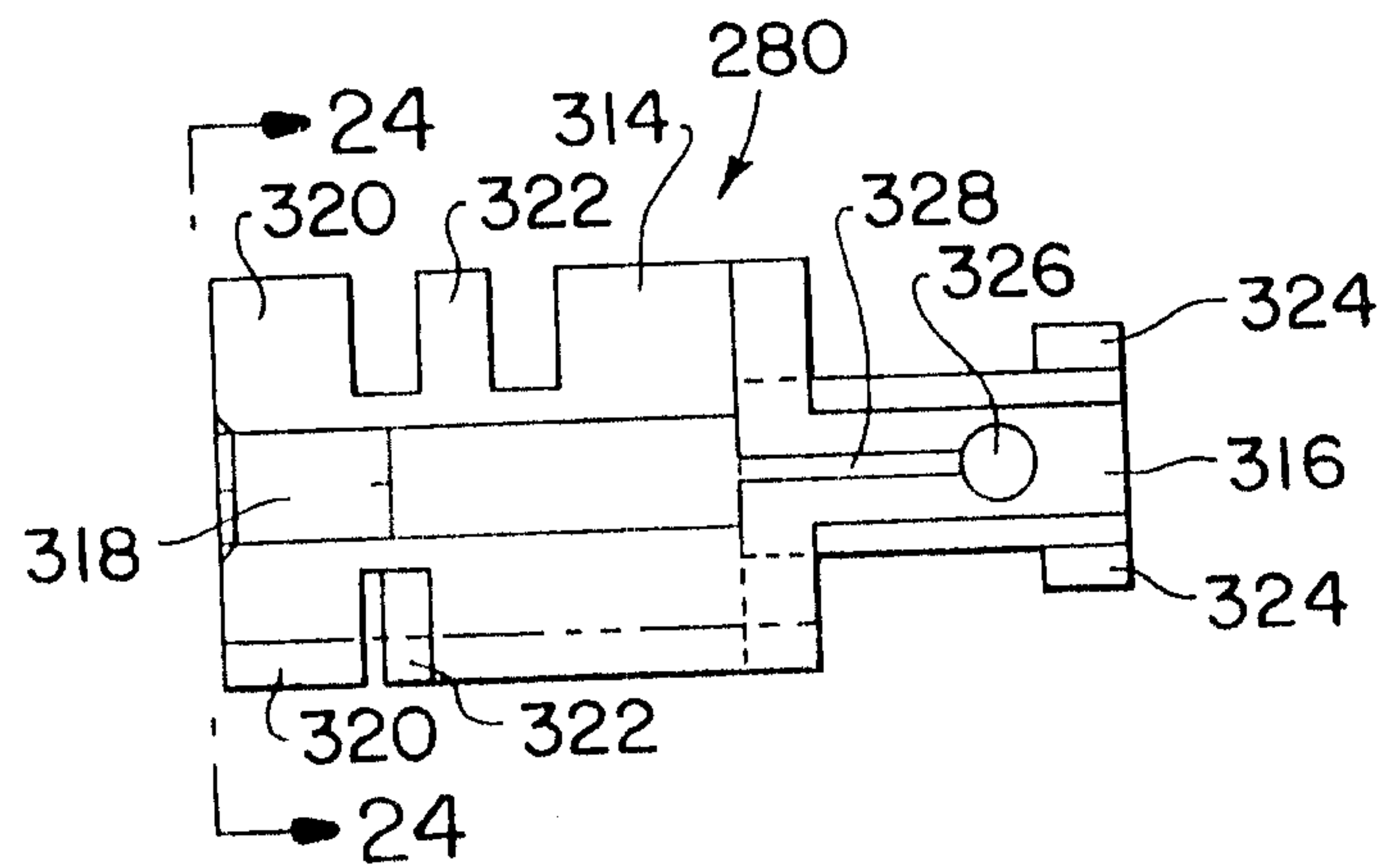


FIG. 23

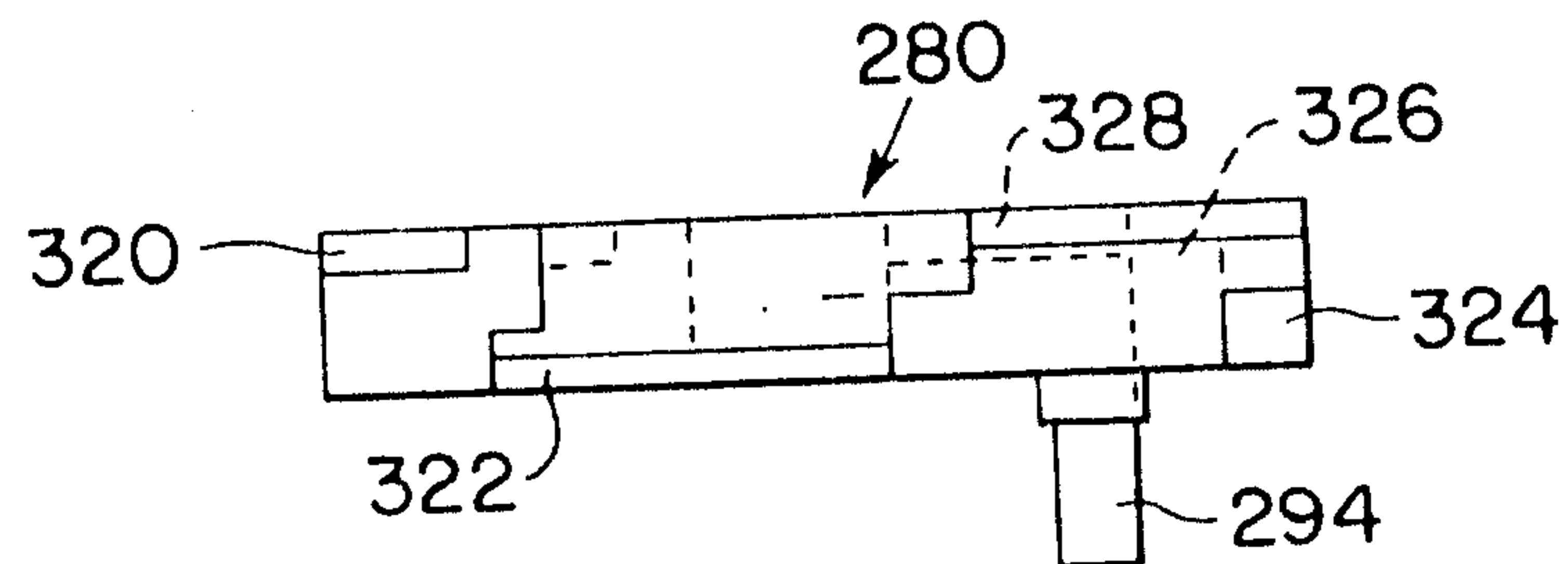


FIG. 24

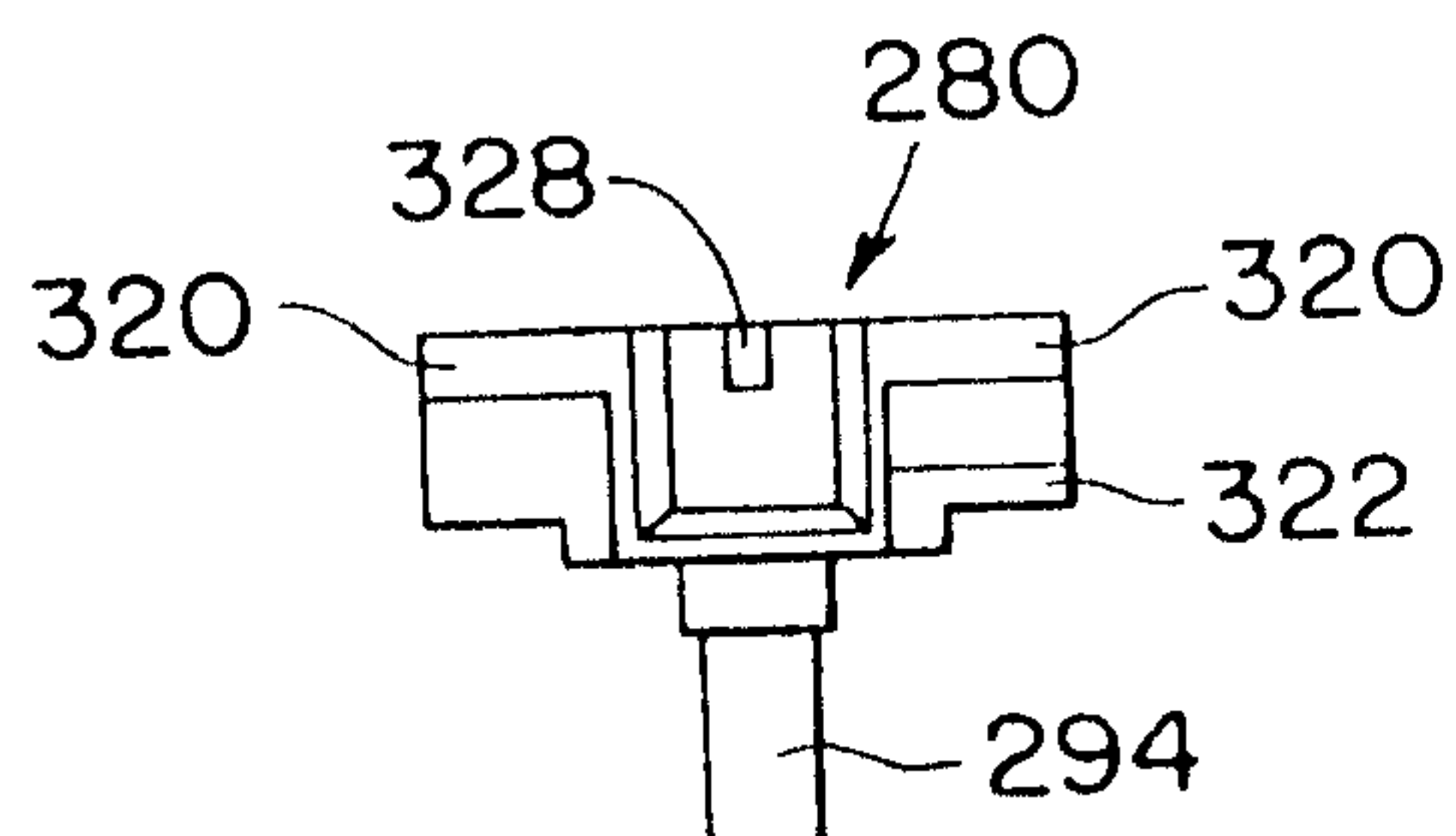


FIG. 25

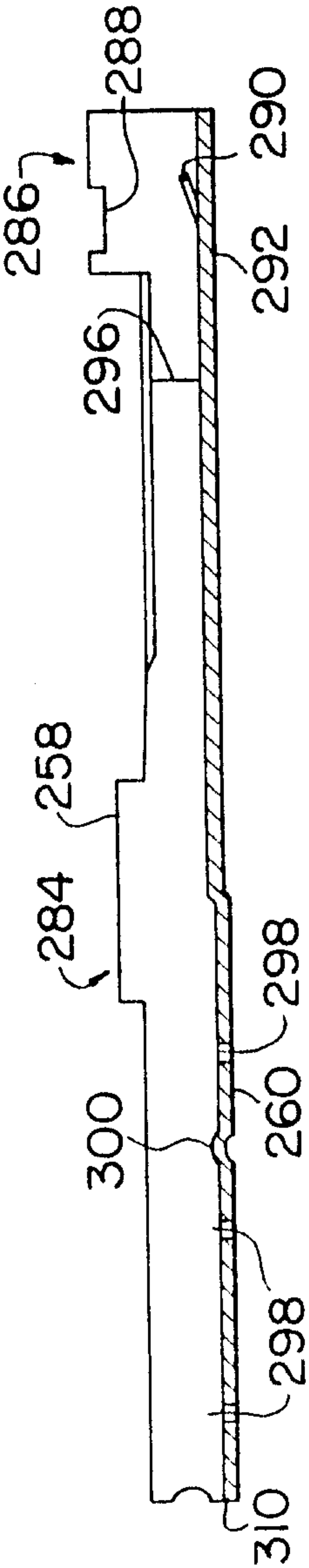


FIG. 26

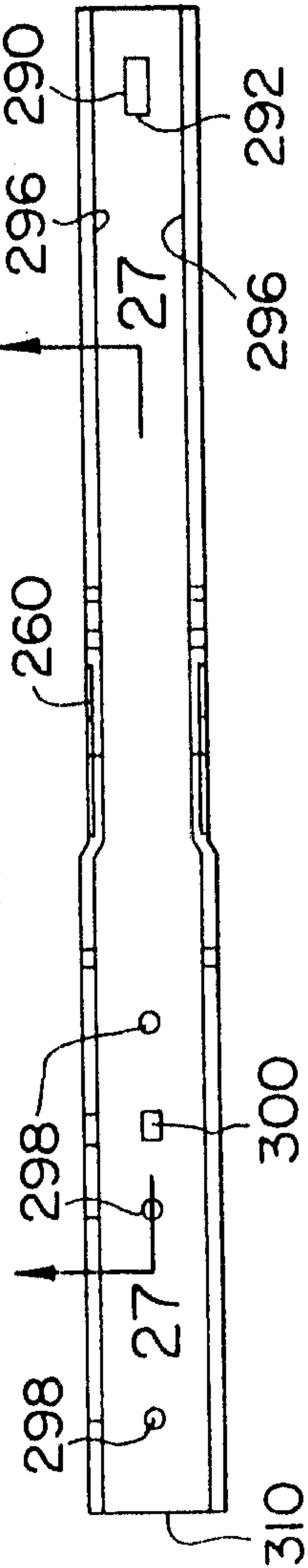


FIG. 27

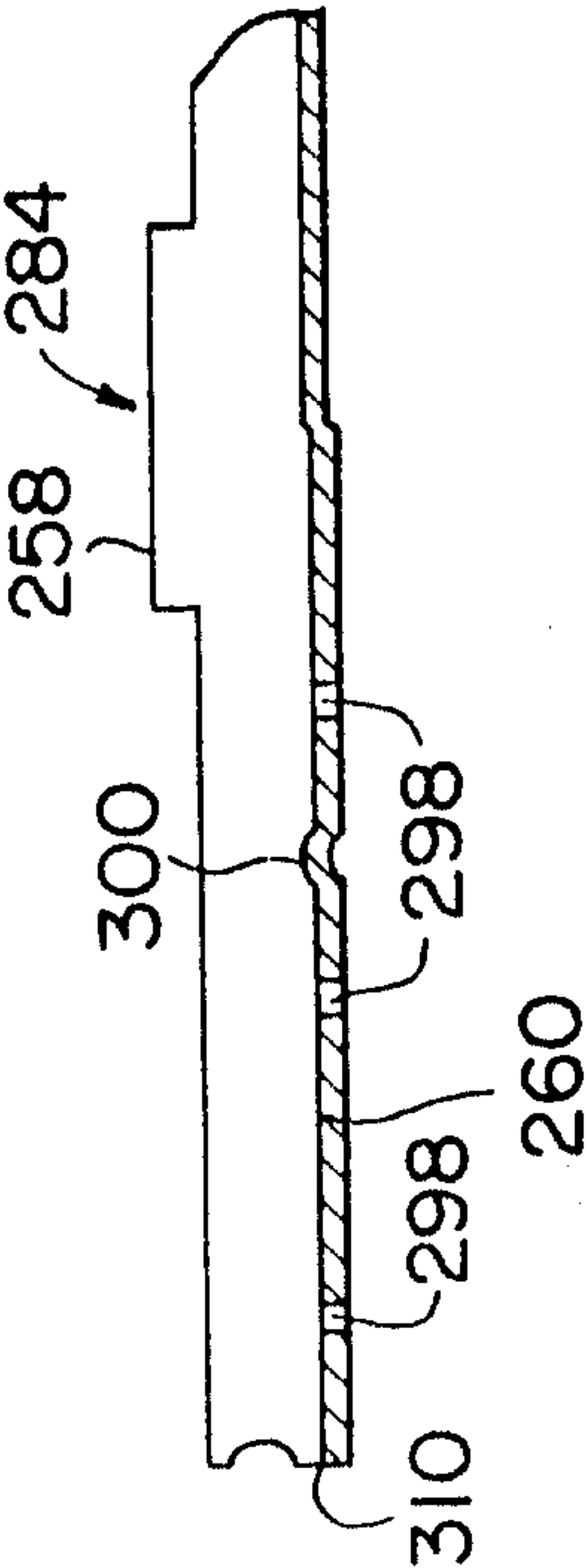
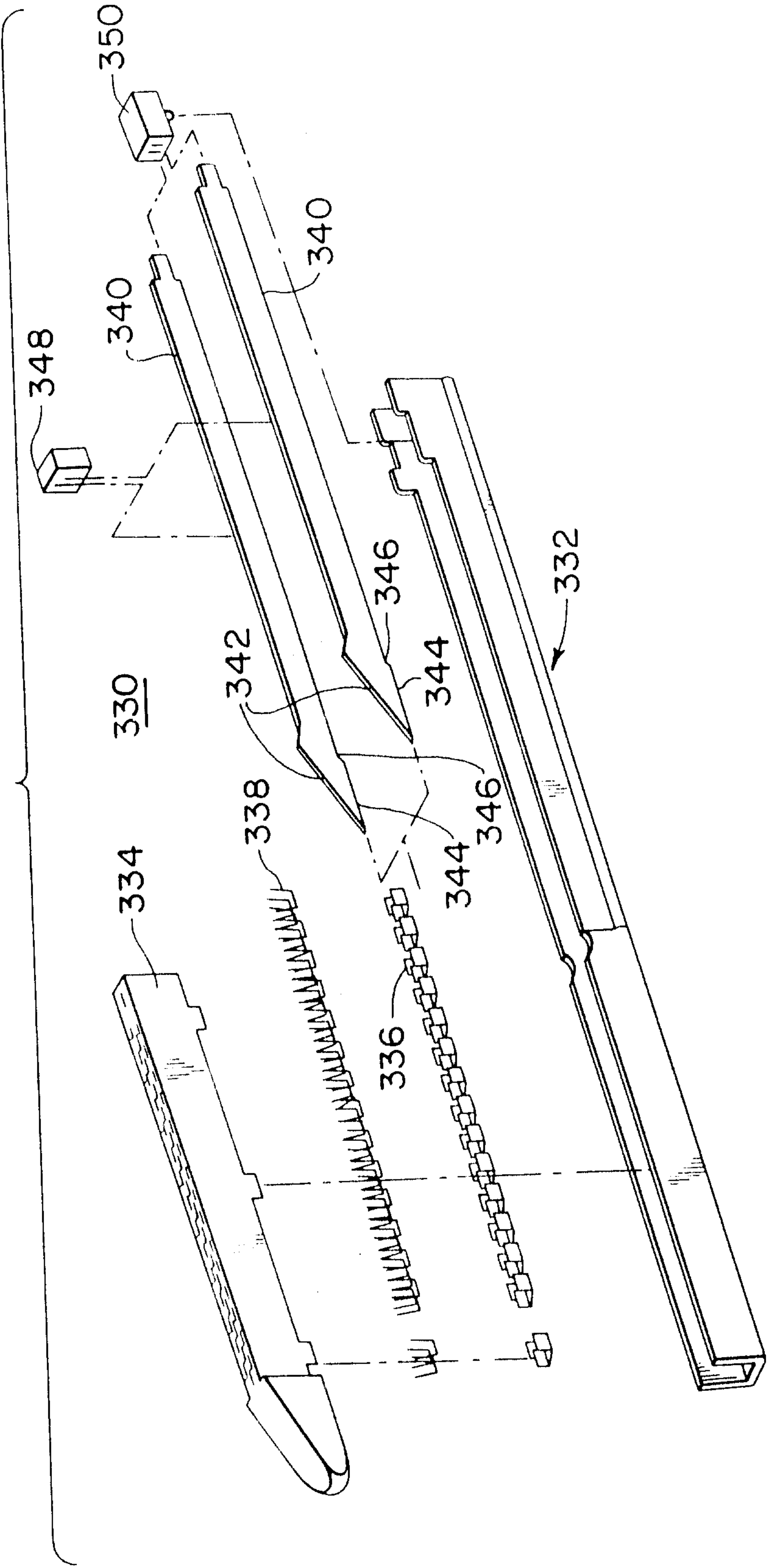


FIG. 28



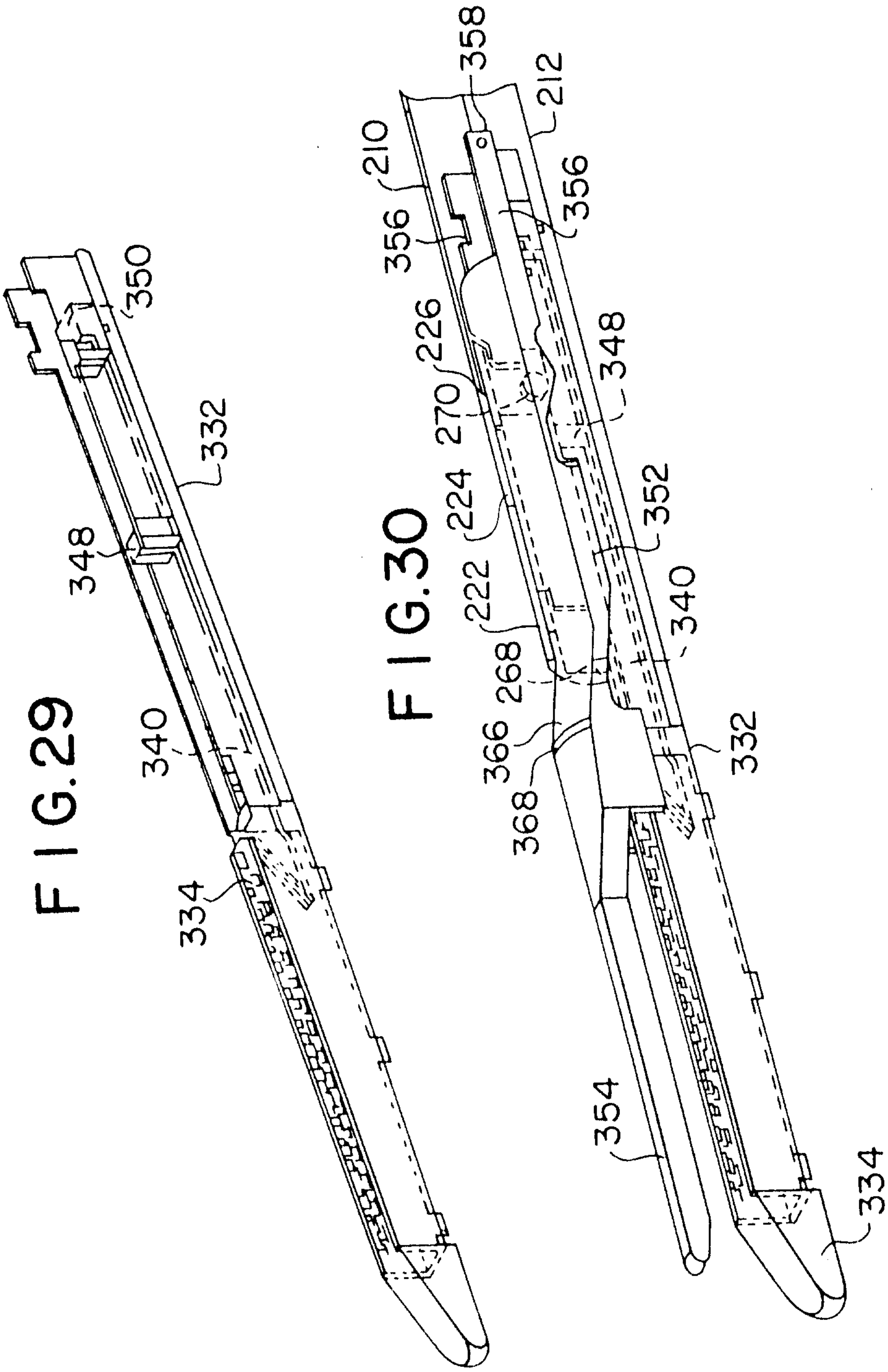
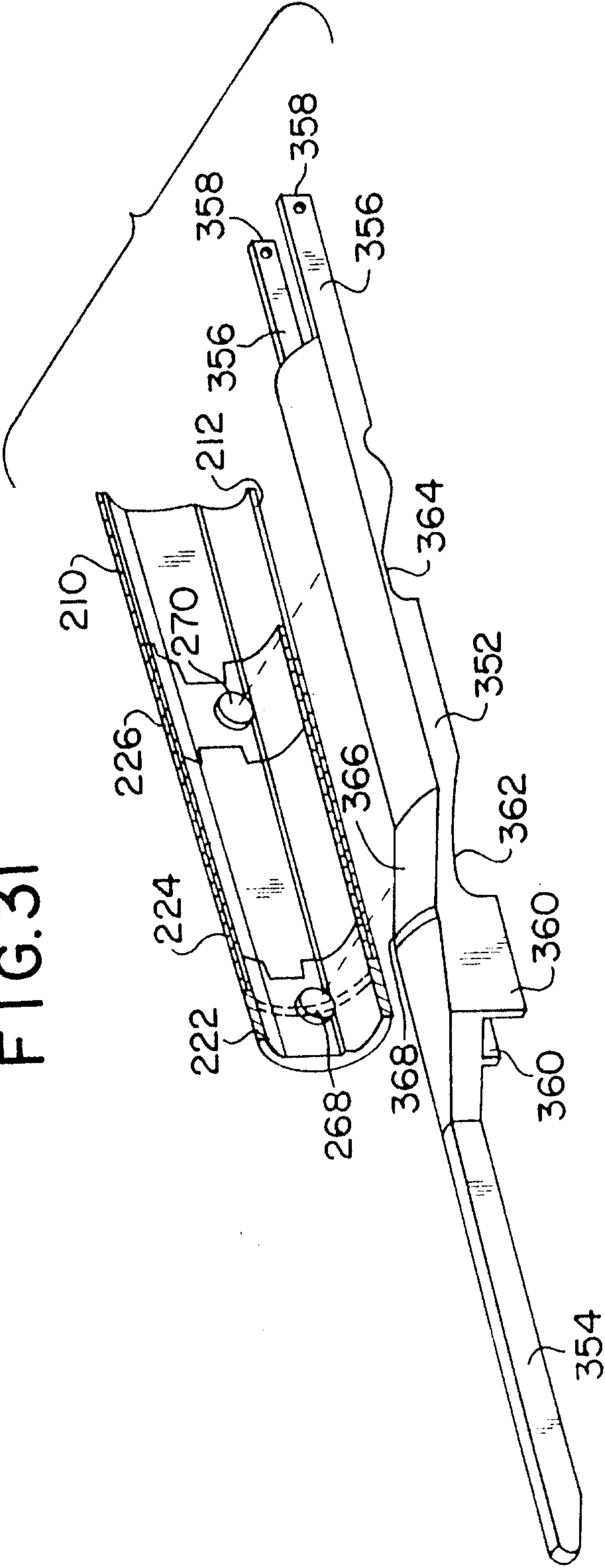
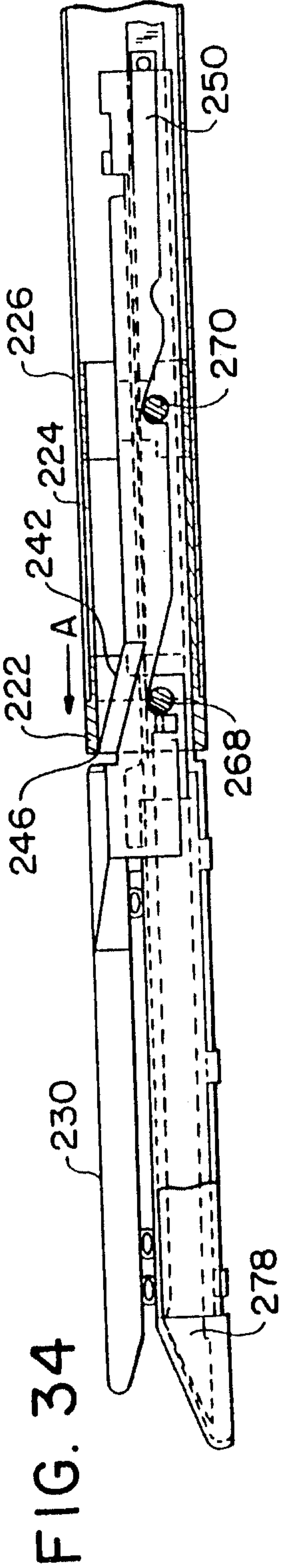
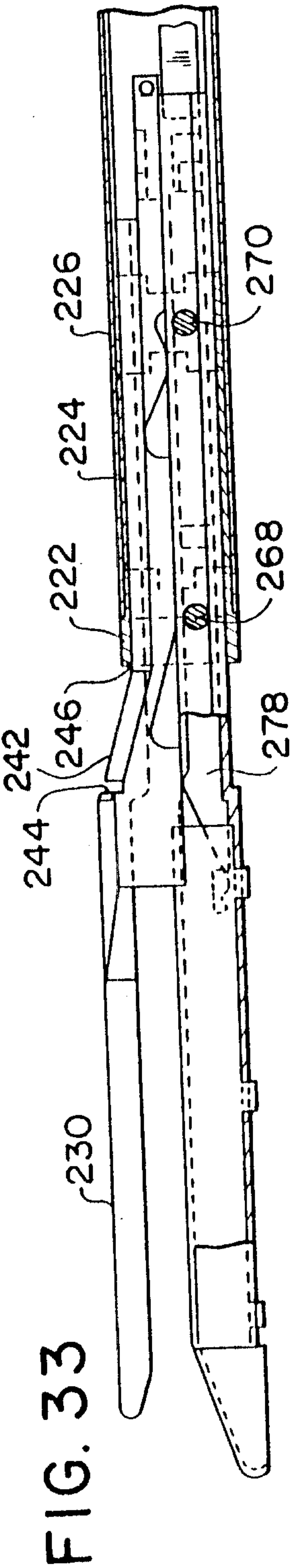
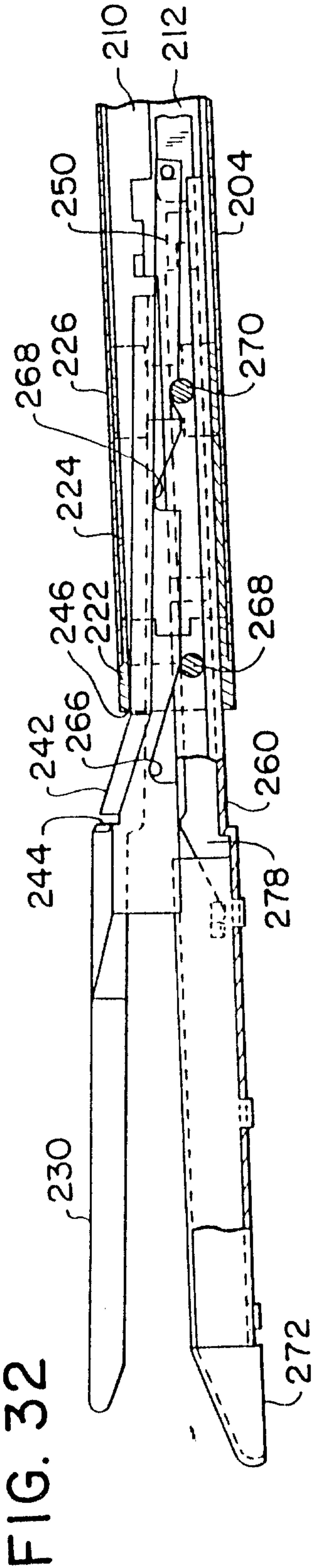


FIG. 31





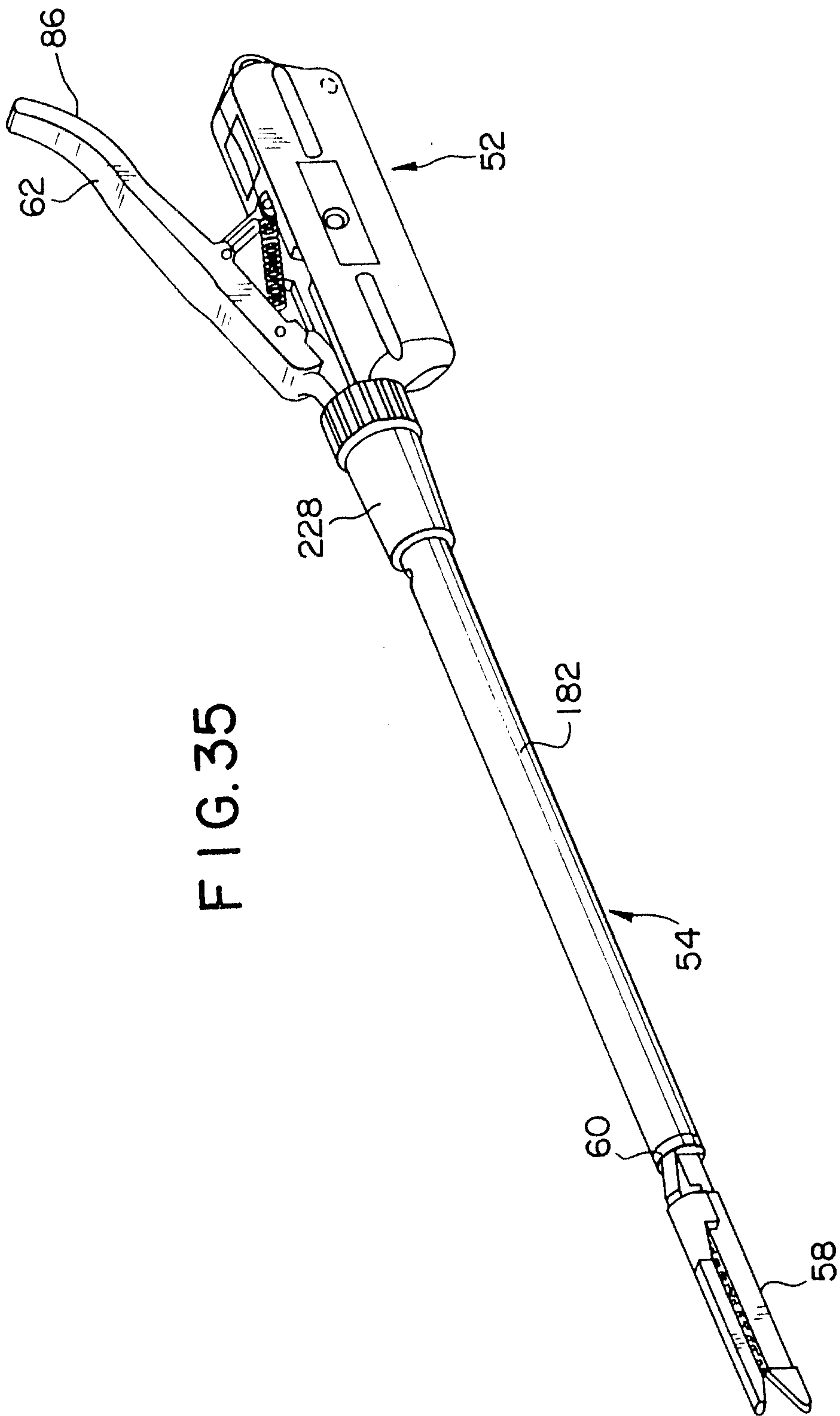


FIG. 36

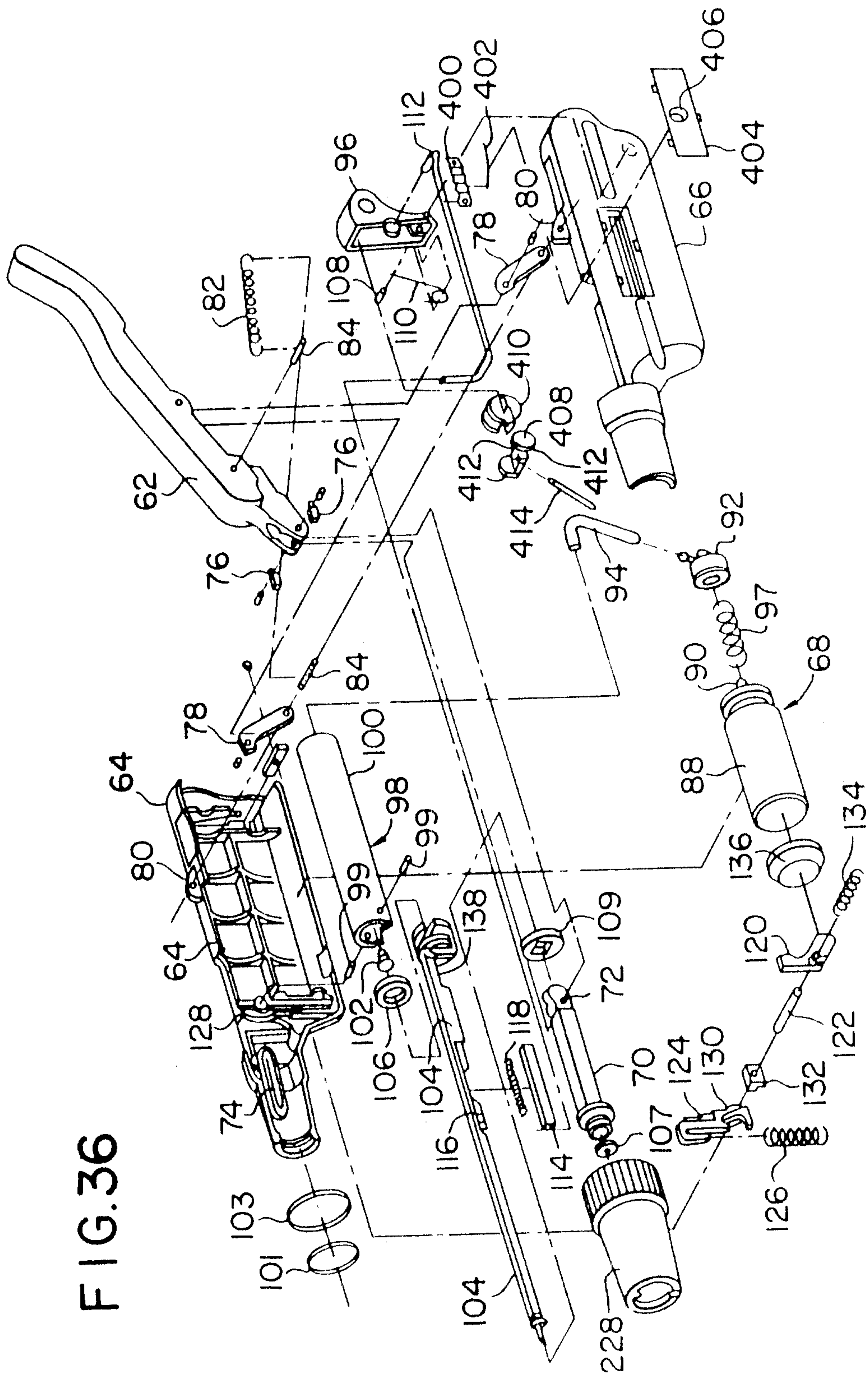


FIG. 37

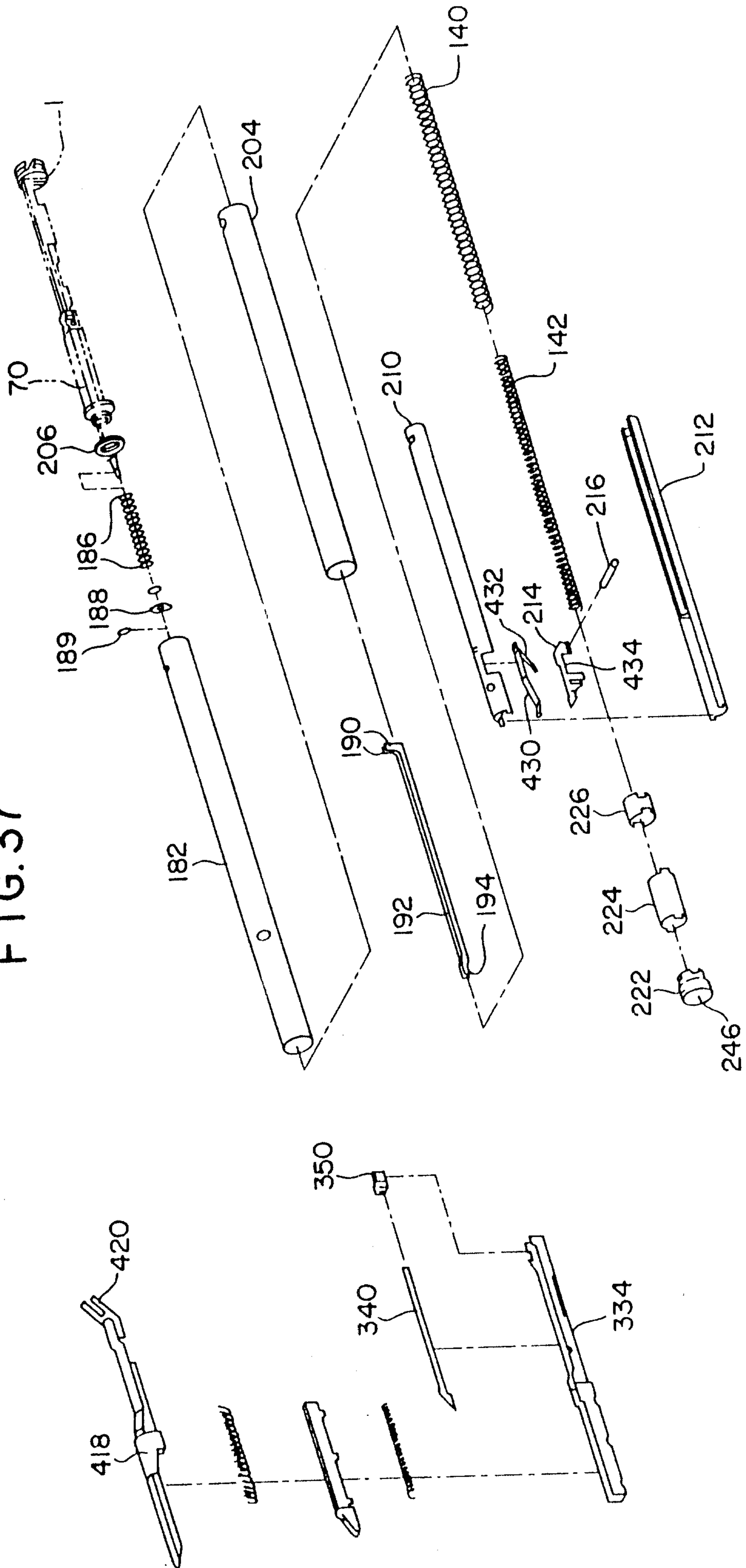


FIG. 38

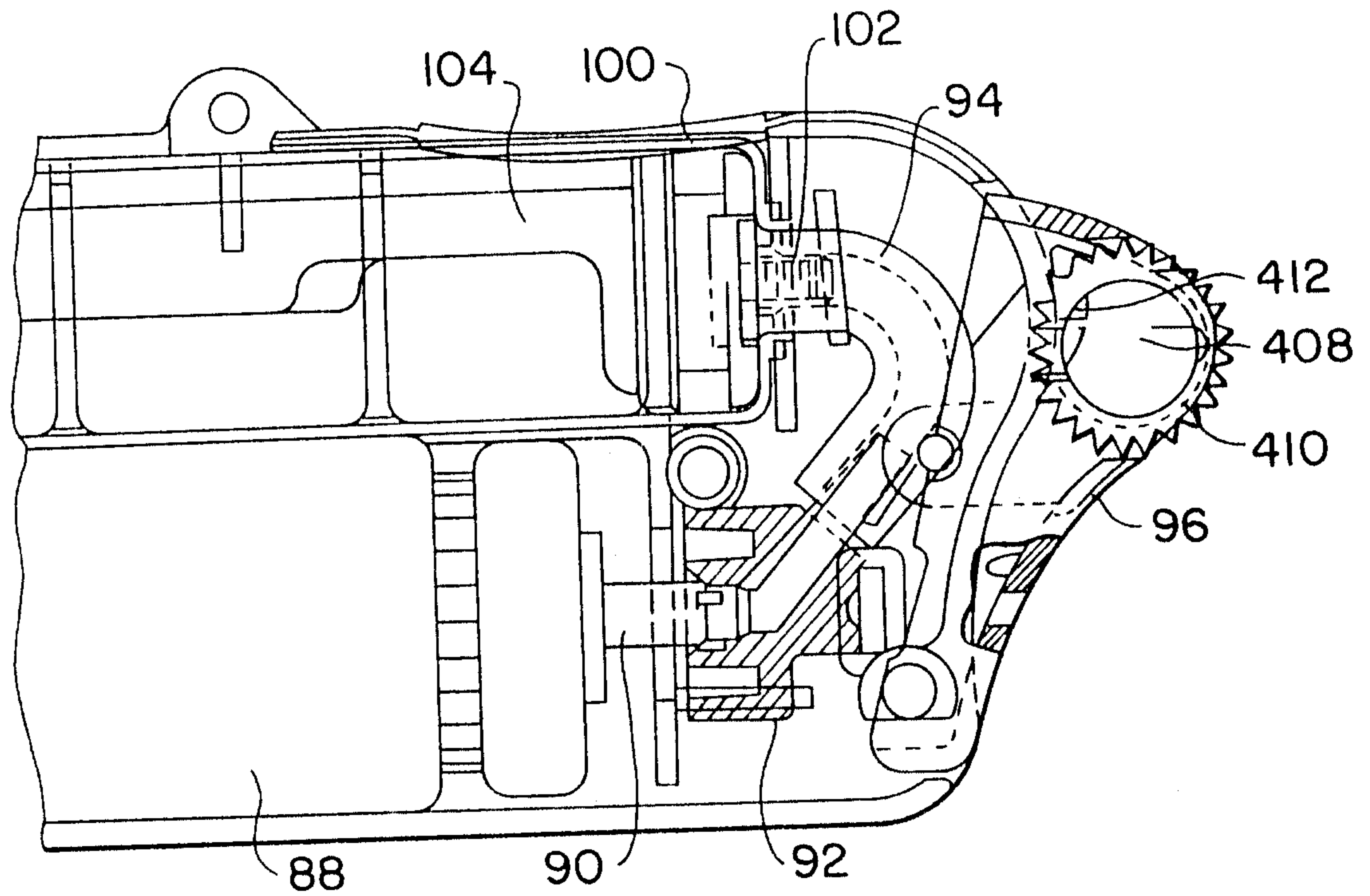


FIG. 39

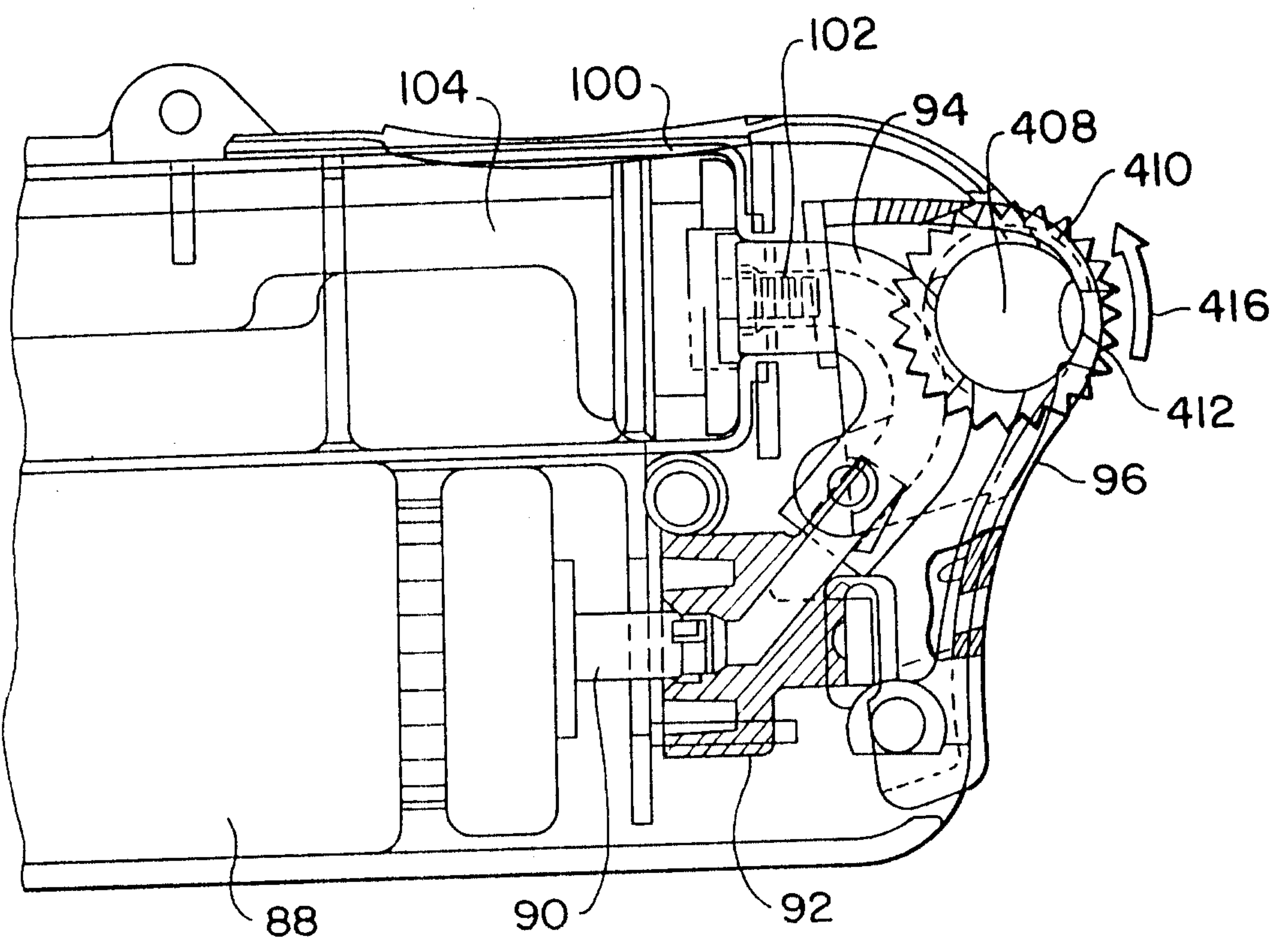


FIG. 40

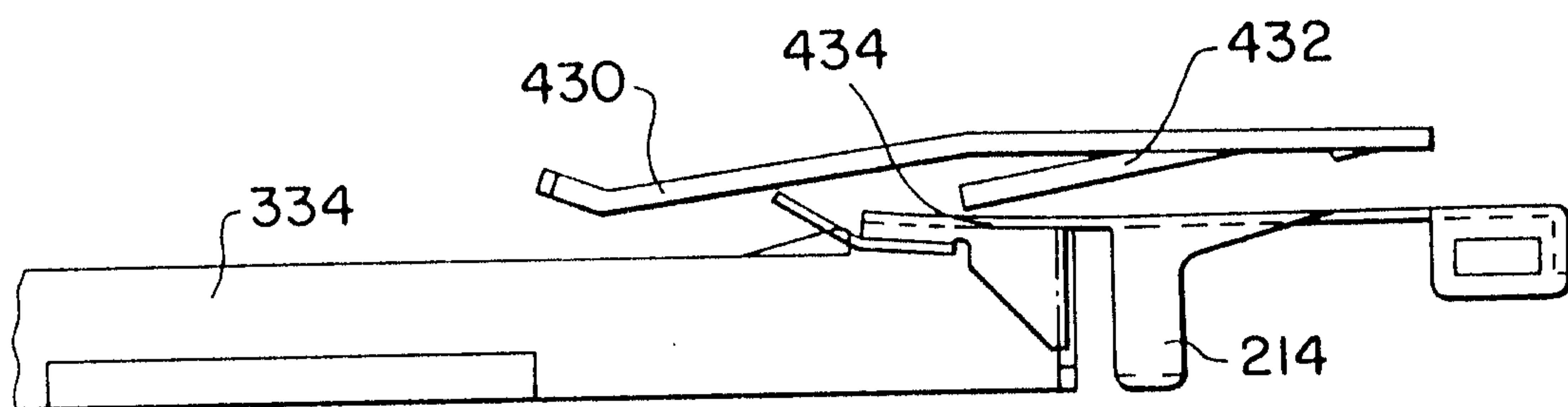


FIG. 41

