United States Patent [19]

Noiles et al.

[11] E **Re. 28,932**

[45] **Reissued Aug. 17, 1976**

[54] **SURGICAL STAPLING INSTRUMENT**

[75] Inventors: **Douglas G. Noiles,** New Canaan; **Graham W. Bryan,** Ridgefield, both of Conn.

[73] Assignee: **United States Surgical Corporation,** Baltimore, Md.

[22] Filed: **May 8, 1975**

[21] Appl. No.: **575,580**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **3,819,100**
Issued: **June 25, 1974**
Appl. No.: **293,470**
Filed: **Sept. 29, 1972**

[52] **U.S. Cl.** **227/19;** 227/121; 227/129

[51] **Int. Cl.²** **B25C 5/02**

[58] **Field of Search** 227/19, 121, 129

[56] **References Cited**

UNITED STATES PATENTS

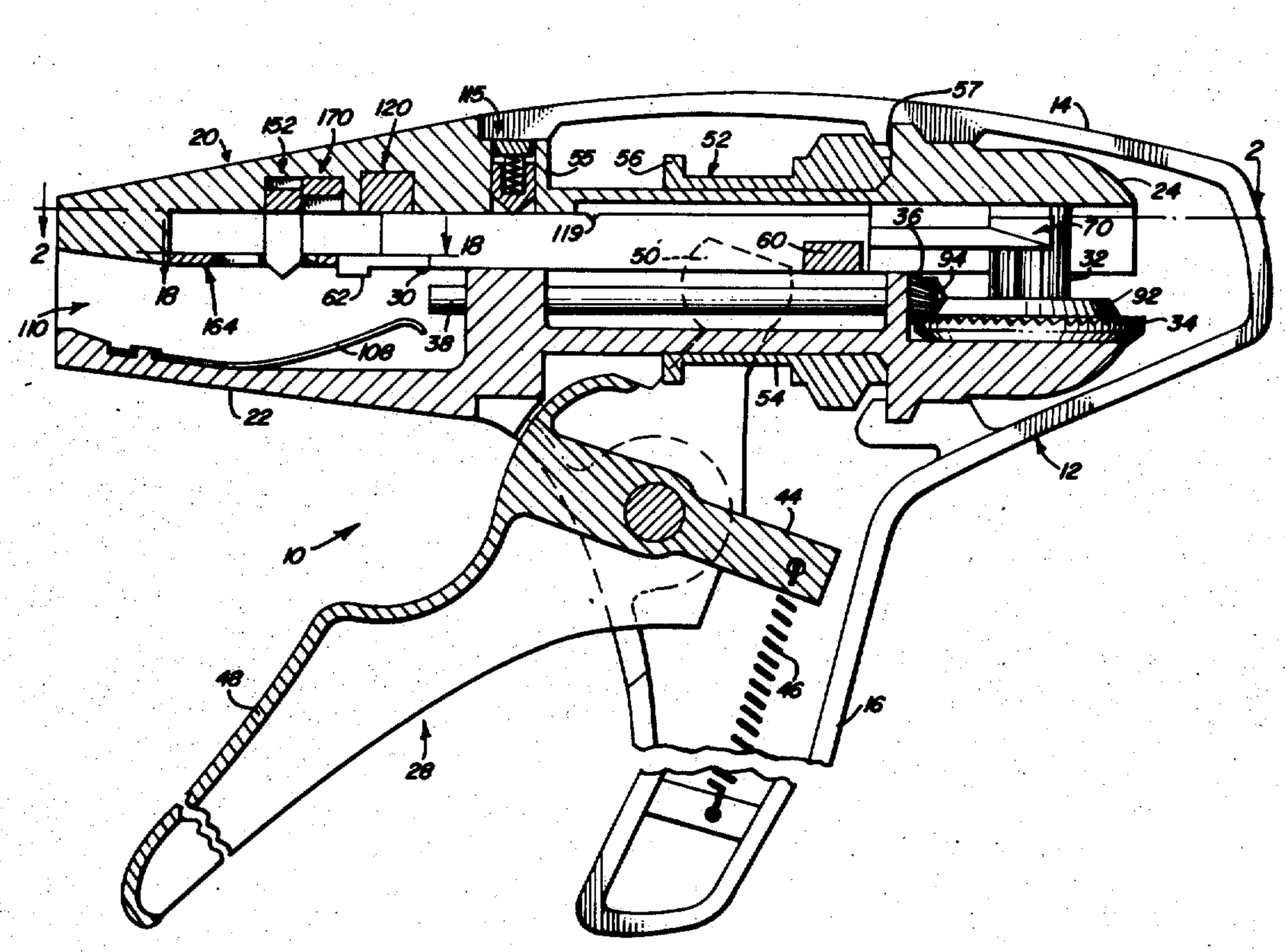
2,275,548	3/1942	Olsen	227/121
2,801,415	8/1957	Jenny	227/130
3,618,842	11/1971	Bryan	227/19

Primary Examiner—Granville Y. Custer, Jr
Attorney, Agent, or Firm—Fleit & Jacobson

[57] **ABSTRACT**

A surgical stapling instrument for applying sterilized staples to the disunited skin or fascia of a patient in order to effect a joining of the skin or fascia. The instrument is adapted to associate with a staple-carrying cartridge having a plurality of staples therein. The instrument is manually powered and includes a nose portion rotatably mounted in a hand-held main body portion and adapted to mount the staple-carrying cartridge so that the stapling angle can be varied without rotating the hand-held portion of the stapler. A clutch means is provided for ensuring that the staple-advancing drive means of the instrument is only activated once per stapling operation. The instrument is further provided with means for preventing the insertion of a fresh staple-carrying cartridge until the instrument is in the readiness position for a driving stroke, and means for maintaining the unloaded instrument in its readiness position until equipped with a cartridge.

22 Claims, 22 Drawing Figures



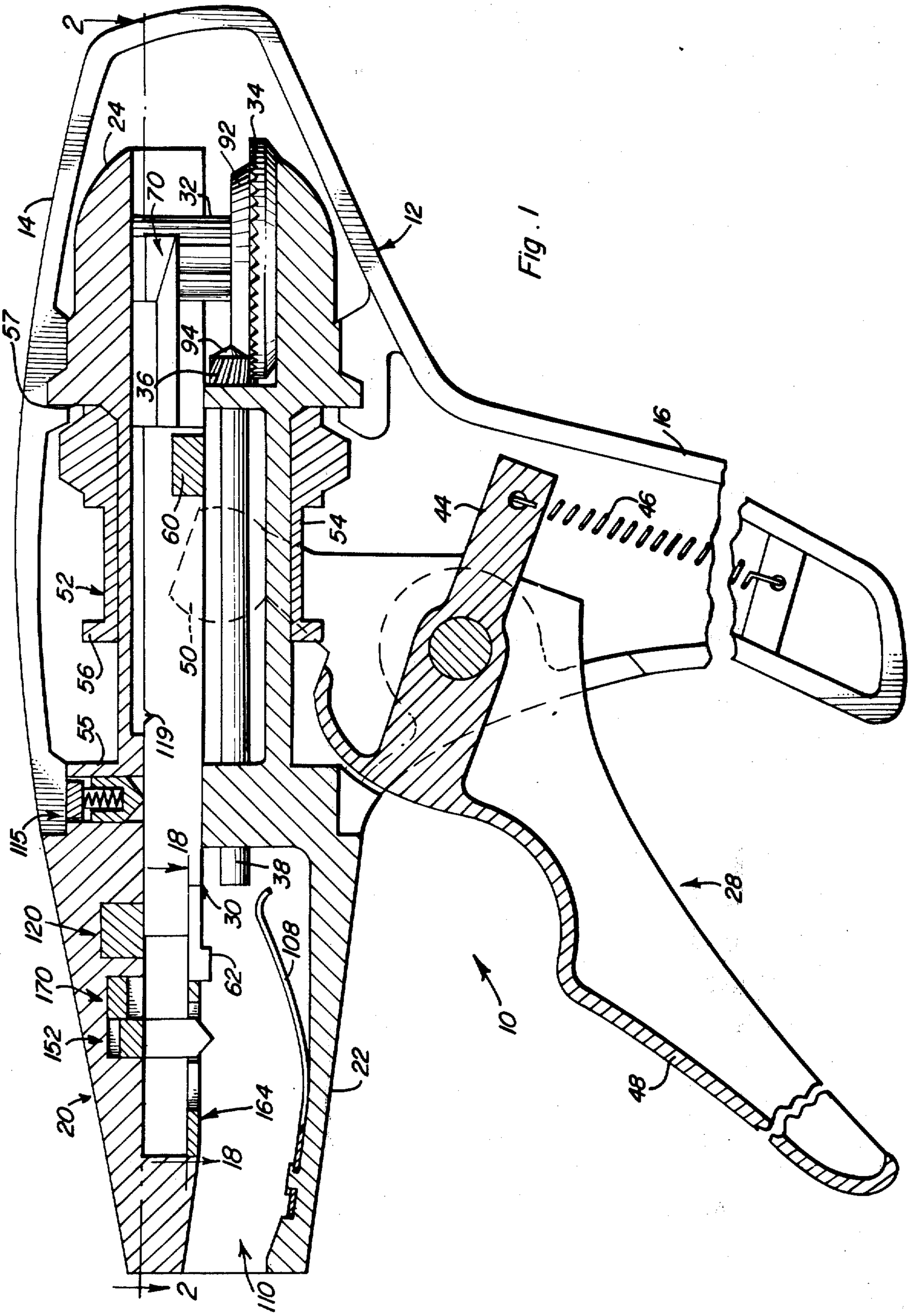

2
24
34
92
70
32
14
12
57
94
36
16
44
46
60
54
52
56
50
55
119
115
18
38
30
120
108
62
170
152
10
22
48
20
164
28
18
2
110

Fig. 1

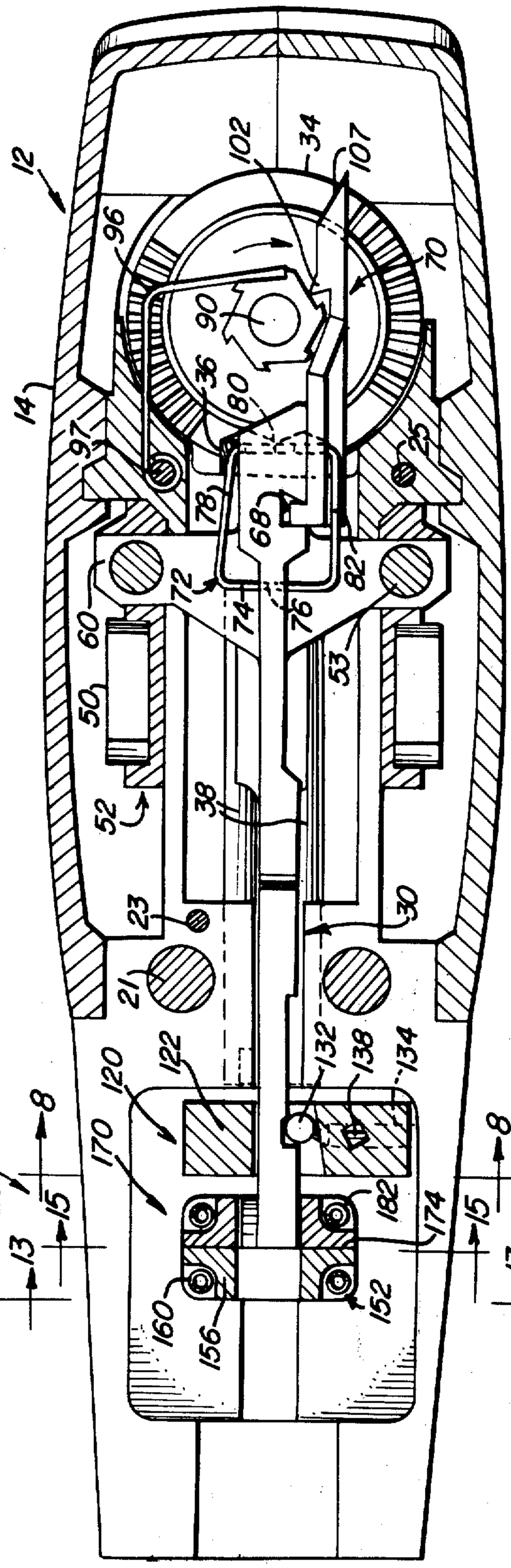

12
102
34
107
96
90
70
36
80
14
97
25
78
68
72
74
76
82
60
50
53
52
38
23
30
21
122
120
132
138
134
8
170
22
15
13
182
174
160
156
152

Fig. 2

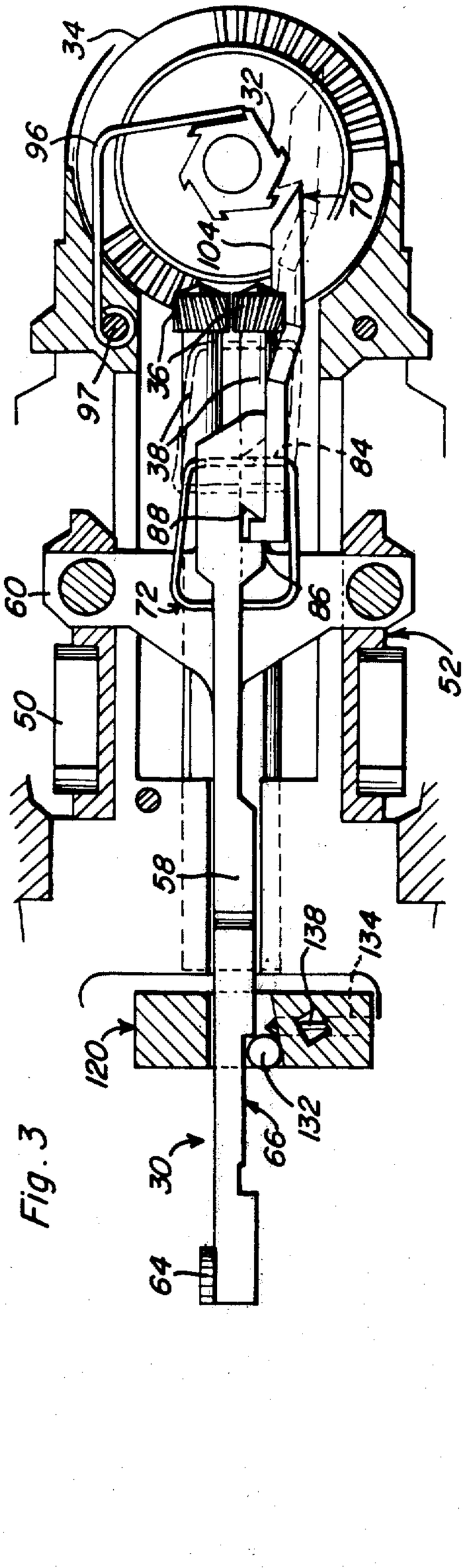

34
32
96
70
104
97
36
38
84
88
60
72
86
52
50
58
138
134
120
132
66
30
64

Fig. 3

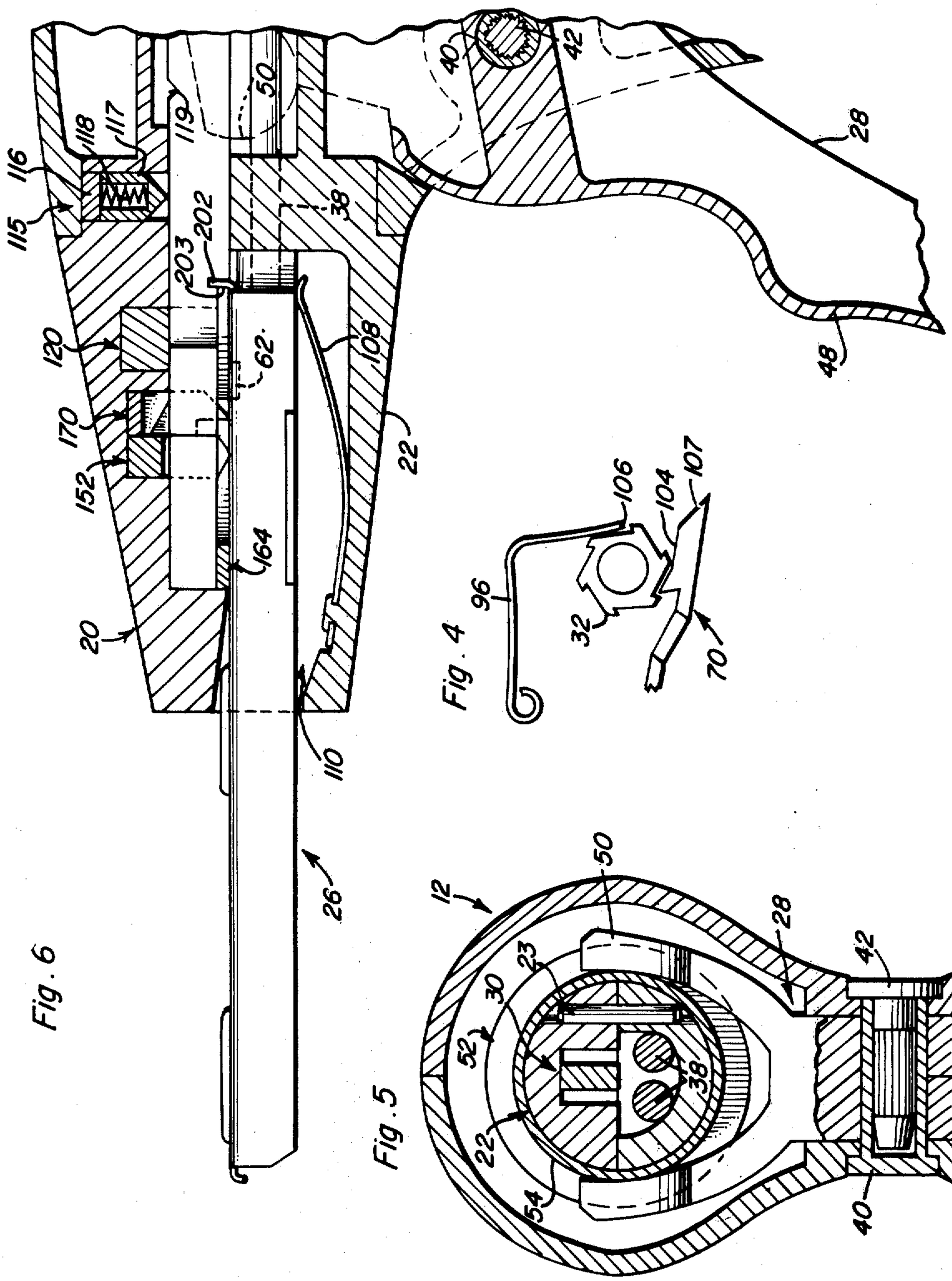


Fig. 6

Fig. 4

Fig. 5

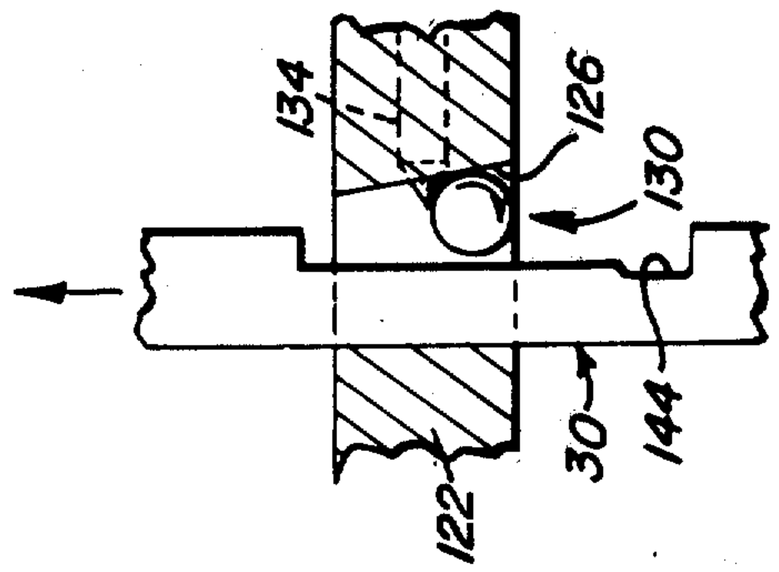


Fig. 12

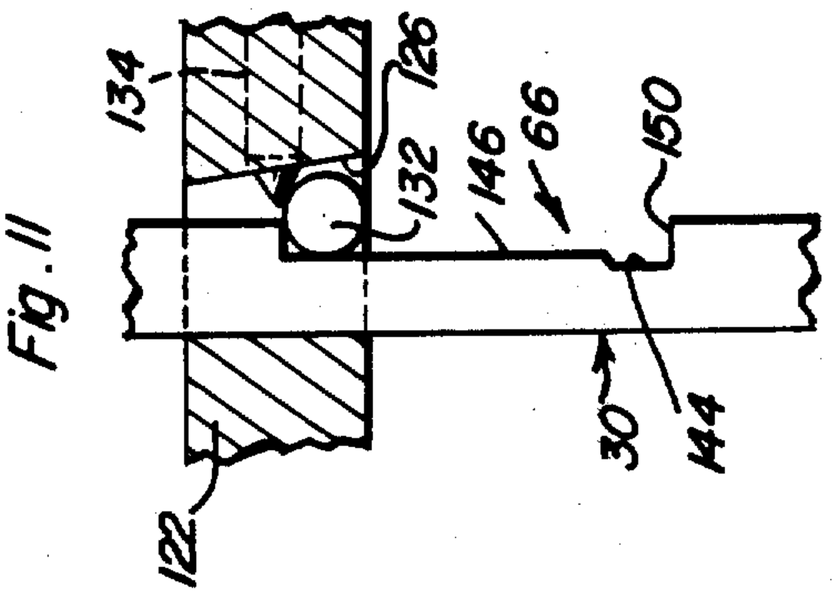


Fig. 11

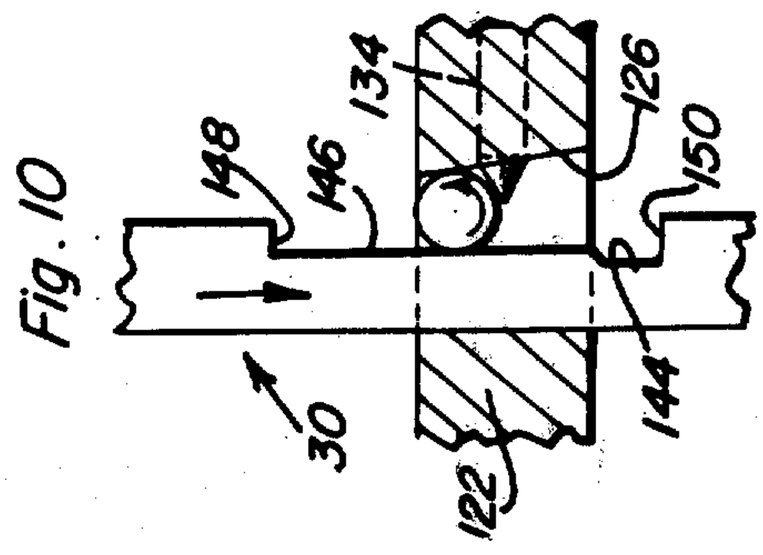


Fig. 10

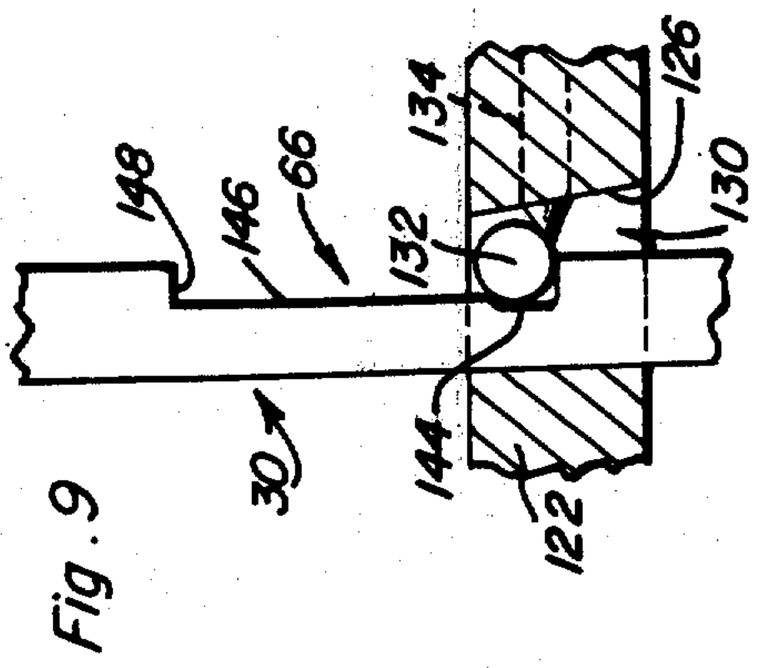


Fig. 9

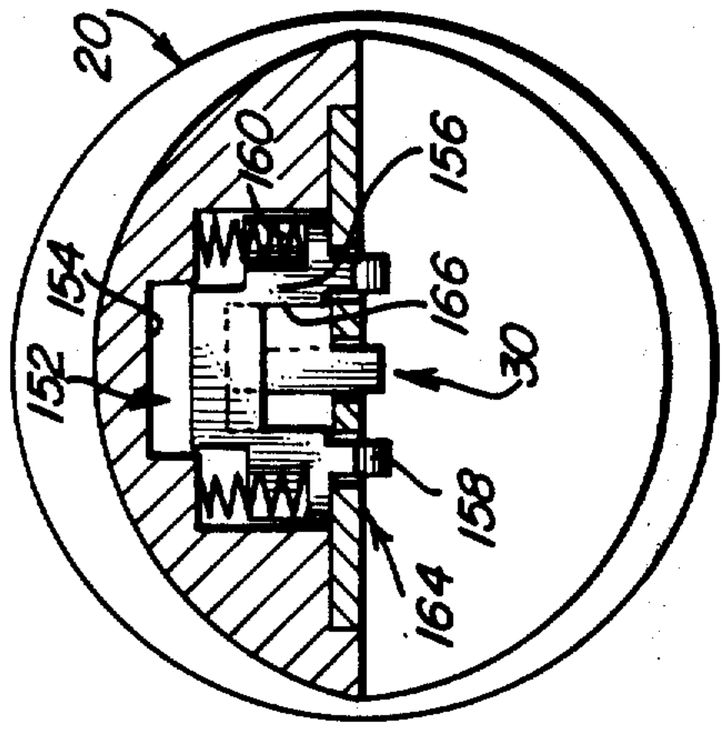


Fig. 13

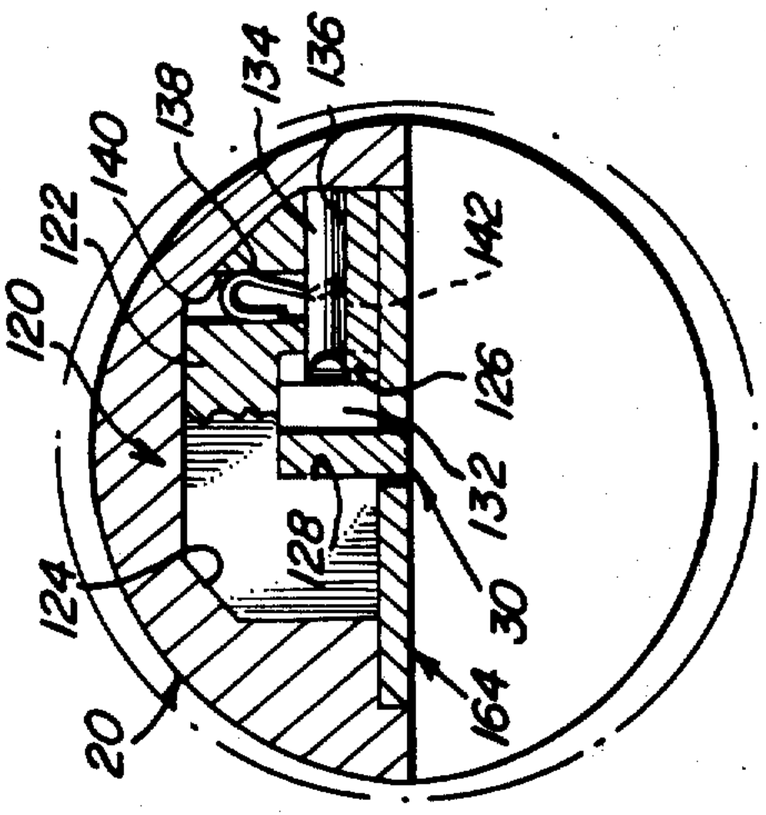


Fig. 8

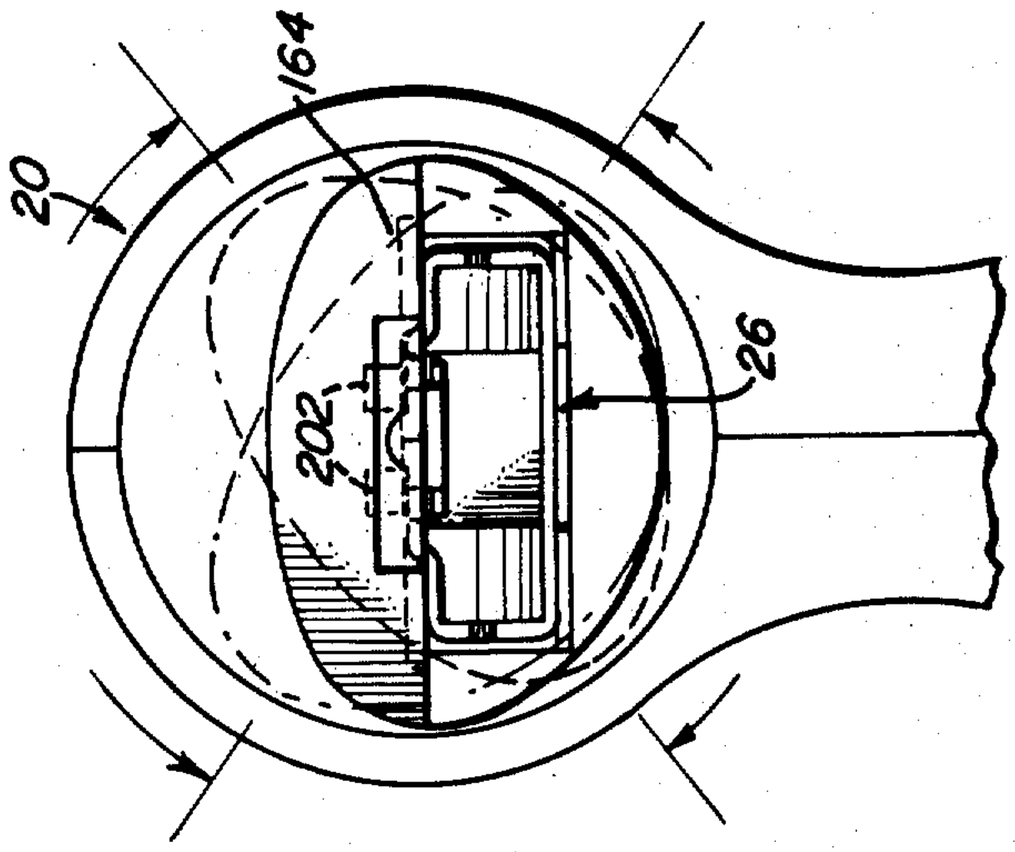


Fig. 7

Fig. 16

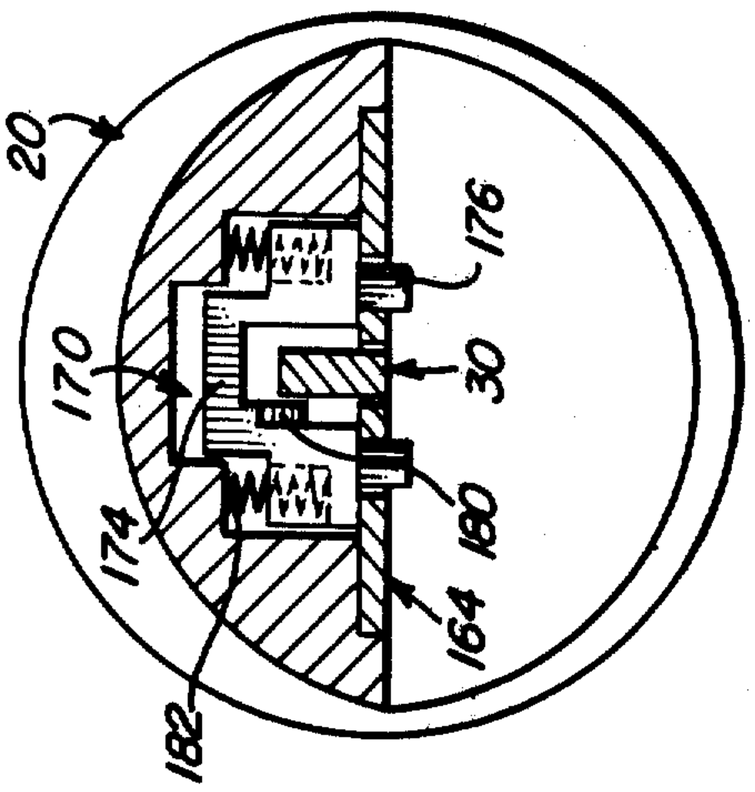


Fig. 18

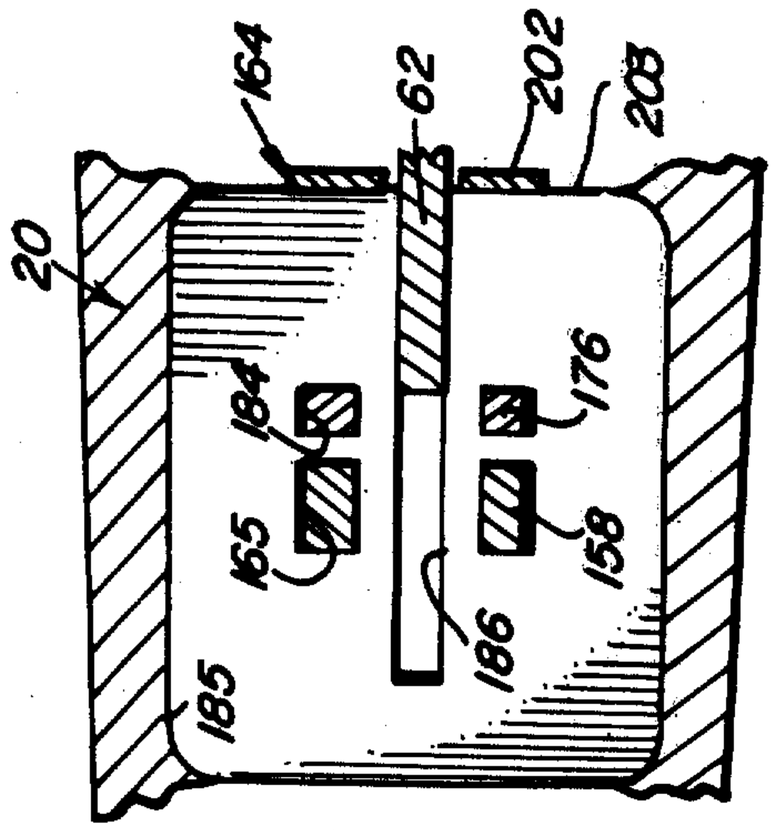


Fig. 15

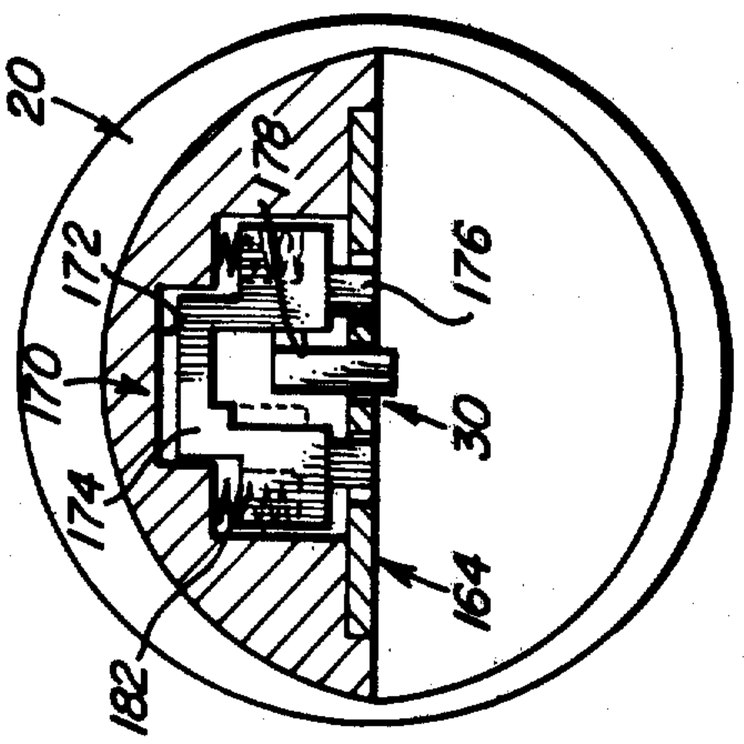


Fig. 17

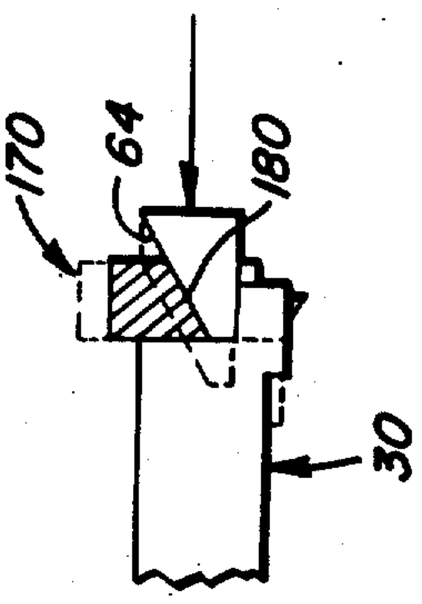
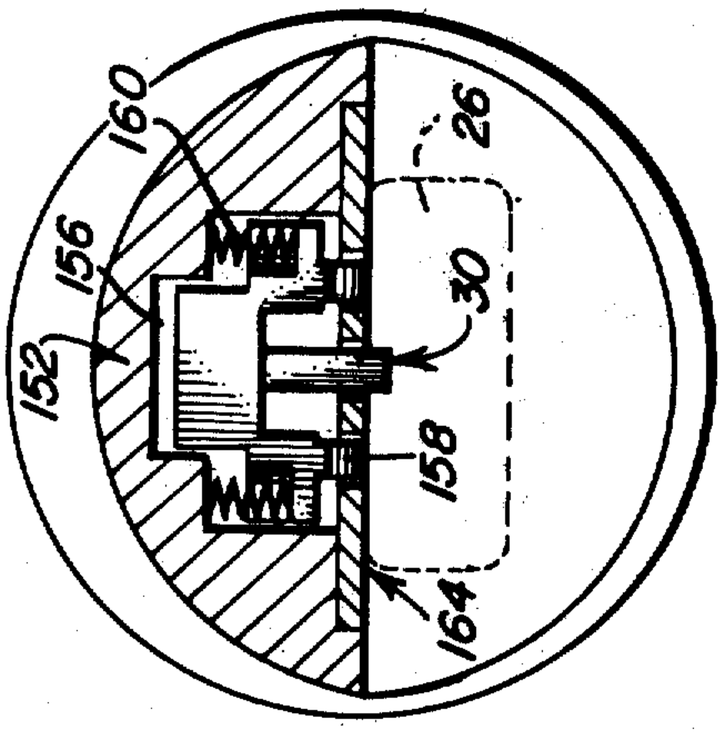


Fig. 14



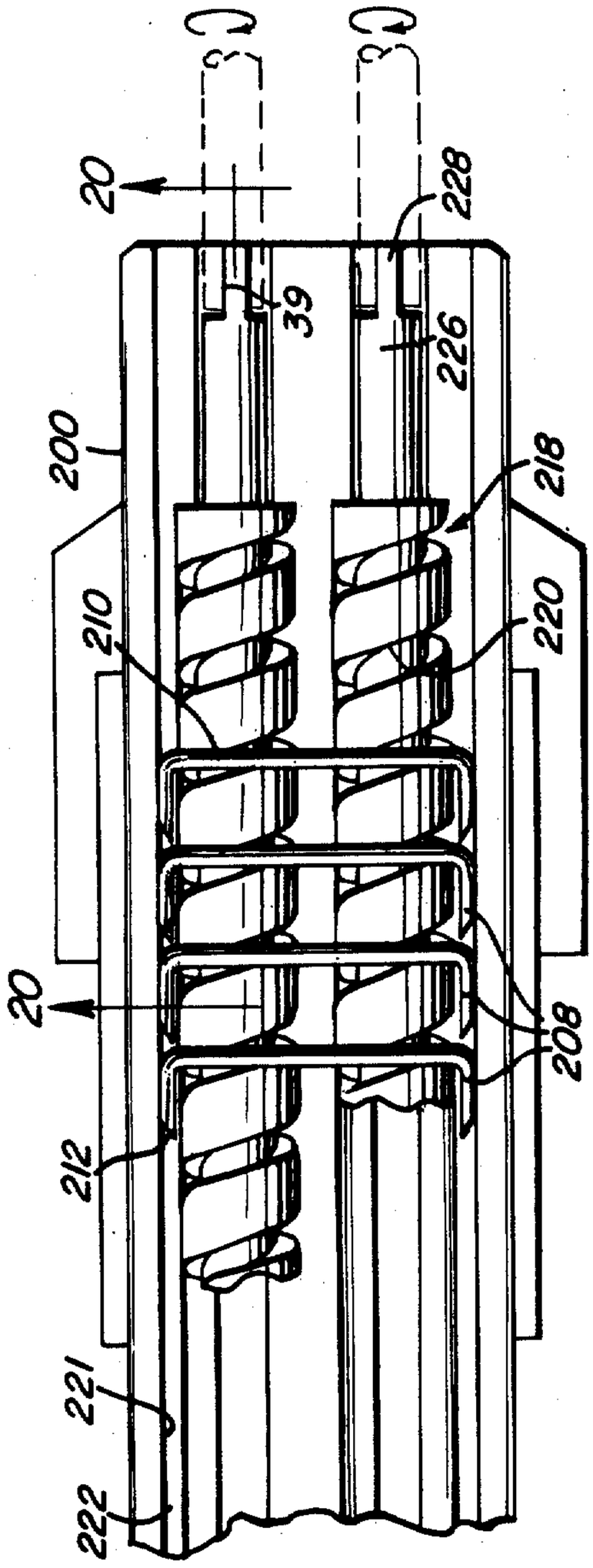


Fig. 19

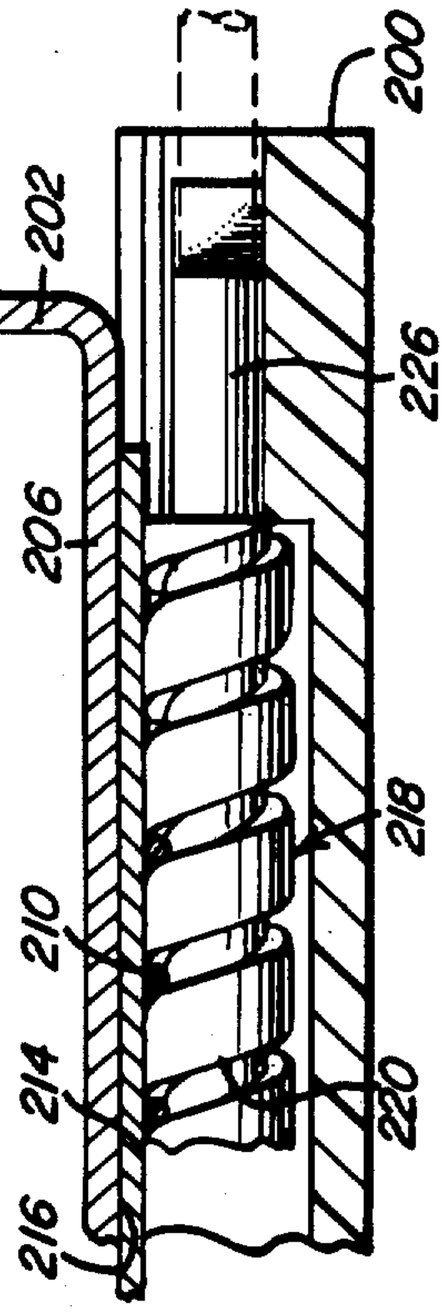


Fig. 20

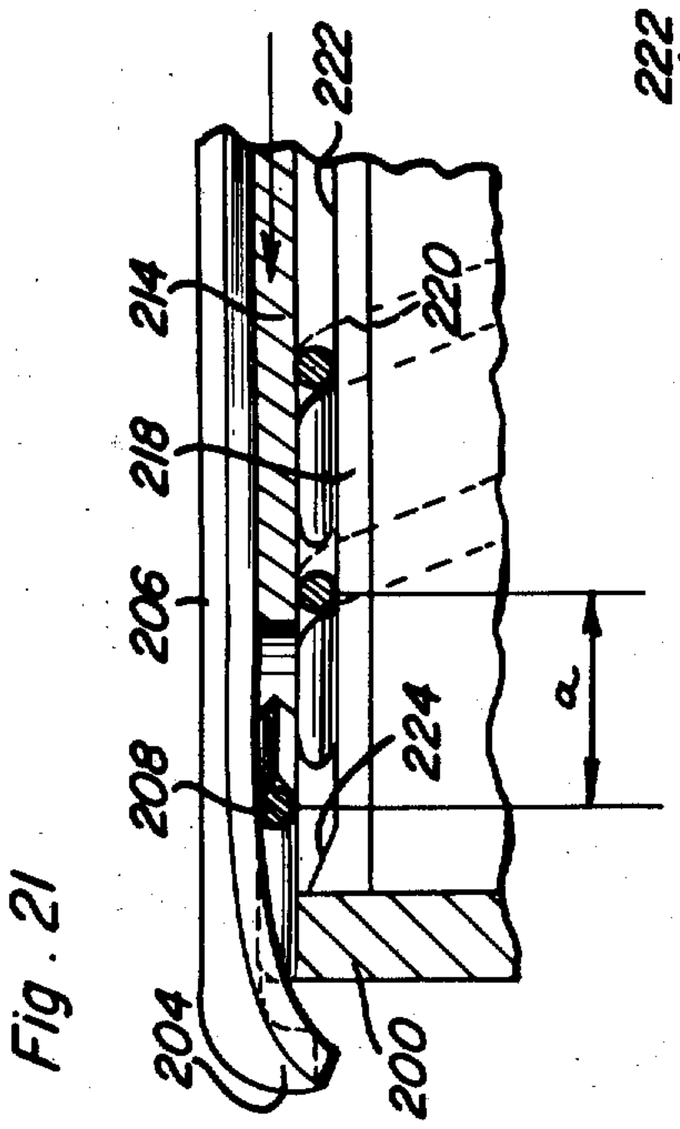


Fig. 21

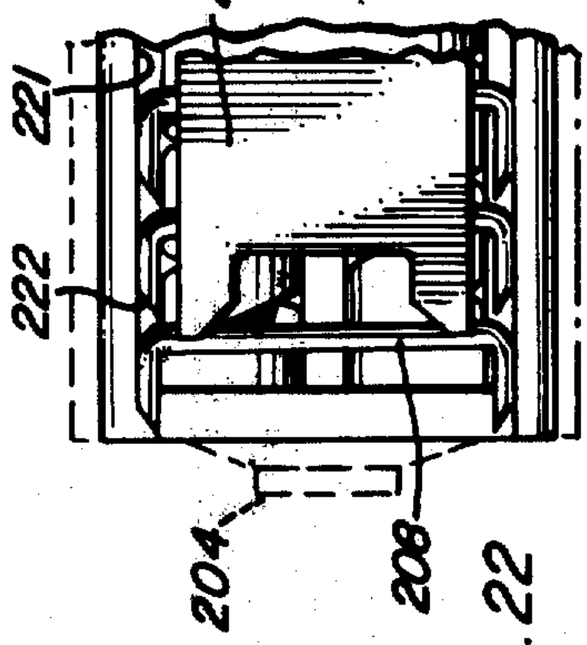


Fig. 22

SURGICAL STAPLING INSTRUMENT

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

In U.S. Pat. No. 3,643,851, assigned to the present assignee and entitled SKIN STAPLER, there is disclosed a surgical stapler for joining the disunited skin of a patient. The surgical stapler disclosed in this commonly assigned patent employs a staple-carrying cartridge comprising an anvil adapted to lie flush with the skin, a plurality of staples which are to be folded around the anvil, and a pusher for ejecting and bending the staples around the anvil. The surgical stapling instrument adapted to accept the staple-carrying cartridge in this commonly assigned patent is powered by a pressurized gas. Later developments of the gas-powered stapler and cartridges for applying surgical staples to external skin and internal fascia are disclosed in U.S. Pat. No. 3,662,939, assigned to the present assignee and entitled "SURGICAL STAPLER FOR SKIN AND FASCIA."

Although these gas-powered instruments represent a marked advance over the state-of-the-art, there are certain disadvantages associated with the use of gas-powered units of this type. One of the obvious disadvantages is the necessity for replacing the gas cartridges after their contents have been exhausted, and a second is the inconvenience associated with storing and maintaining a supply of these cartridges. Also, the powering mechanism is complex, is hence somewhat costly, and comprises numerous close-tolerance elements which tend to be susceptible to malfunction. For these and other obvious reasons, it would be advantageous to have a simple surgical stapling instrument adapted to accept staple-carrying cartridges of the type disclosed in the above commonly assigned patents, but which is powered manually and without the intervention of a gaseous medium and the disadvantages associated therewith.

Accordingly, it is a broad object of the present invention to provide a surgical stapling instrument for stapling the disunited skin or fascia of a patient which is manually powered and wholly operated by mechanical means.

It is another object of the present invention to provide a surgical stapler in which the staple-carrying cartridge is mounted so that it is rotatable relative to the hand-held main body portion of the instrument so that the staples can be applied at any angle without the necessity for rotating the hand-held portion of the instrument.

It is yet another object of the present invention to provide a surgical stapler with means for ensuring that the staple-advancing drive means of the instrument is activated only once in each stapling operation.

Another object of the invention is to provide means for preventing a driving stroke of a surgical stapler absent the association with a staple-carrying cartridge.

It is yet a further object of the present invention to provide means for preventing the insertion of a staple-carrying cartridge into the surgical stapler until the driving mechanism of the stapler has been returned to its initial position.

It is still a further object of the present invention to provide a surgical stapler with means to alert the surgeon when a staple has been advanced into the ready position and is about to be ejected and formed.

These and other objects of the invention, as well as many of the attendant advantages thereof, will become more readily apparent when reference is made to the following description taken in conjunction with the accompanying drawings.

SUMMARY OF THE INVENTION

The present invention relates to a surgical instrument for stapling together disunited segments of the external skin or internal fascia of a patient.

The surgical stapling instrument generally comprises a main body portion having a nose portion rotatably mounted therein and adapted to receive and mount a staple-carrying cartridge. The nose portion of the stapler houses the drive means for advancing and forming the staples. A pusher-activating means for driving the pusher element of the staple-carrying cartridge to eject and form the staples around the anvil means of the cartridge comprises a thrust bar slidably mounted for reciprocative movement in the nose portion of the stapler. The thrust bar is attached to and adapted to move with a collar element slidably mounted on the nose portion of the stapler. A trigger means comprises a handle which is pivotally mounted on the main body portion of the stapler and has means for engaging the collar element so that the thrust bar is moved forwardly by squeezing the trigger. A return spring attached to the trigger and to the main body portion of the stapler functions to return the thrust bar to its initial position after the thrust stroke of the bar has been completed.

The drive means to activate the staple-advancing means in the staple-carrying cartridge for driving the staples toward the anvil comprises pinion gears and pinion shafts also housed within the nose portion of the stapler. The teeth of the pinion gears mesh with the teeth of a main gear which is adapted to rotate in unison with a ratchet. The main gear and ratchet are rotatably mounted in the rear nose portion of the stapler. An index pawl pivotally attached to the thrust bar and operatively associated with the ratchet causes the ratchet, main gears and pinions to rotate when the thrust bar is initially moved forward and thus activates the staple-advancing means in the cartridge.

As was the case in the above-referenced commonly assigned patents, it is desirable to rotate the particular drive screws of the staple-carrying cartridge 360° each time a staple is being ejected by first over-driving and then return-driving the screws. Accordingly, and similar to the gear boxes disclosed in the commonly assigned patents, the drive means for advancing staples of the present invention is adapted to be over-driven and then returned to a position wherein the drive screws of the cartridge are rotated exactly 360°. The return movement of the staple-advancing drive means is accomplished by a spring pawl which cooperates with the above-mentioned ratchet. This spring pawl also functions as a stop preventing excessive return rotation of the ratchet.

Means are also provided for preventing more than one staple from being placed in the ready position of the staple-carrying cartridge during the stapling operation. This means comprises a clutch means which pre-

vents the return of the thrust bar to its initial position until it has completed a full stroke, thereby ejecting a staple from the staple-carrying cartridge. The clutch means includes a cam block mounted in the forward end of the nose portion of the stapler and having an inclined surface facing the thrust bar. The forward end of the thrust bar passes through the cam block and operatively engages a cylindrical roller positioned between the thrust bar and the inclined surface of the cam block. The cam block houses a spring-biased wedge which cooperates with the cylindrical roller. The cooperation between these elements is such that the cylindrical roller prevents the thrust bar from being returned to its initial position until it has completed a full driving thrust movement.

Means are further provided for preventing the forward movement of thrust bar until a staple-carrying cartridge has been mounted on the stapler. This means comprises a cartridge interlock housed in the forward end of the nose portion of the stapler and spring-biased into a position such that it blocks the forward movement of the thrust bar until a cartridge is properly mounted. In its initial position, the forward end of the thrust bar abuts the rear face of the cartridge interlock. When the staple-carrying cartridge is mounted, the cartridge interlock is forced upward by the staple-carrying cartridge thereby registering an opening in the cartridge interlock with the forward end of the thrust bar such that the thrust bar is capable of being moved forward and driving the pusher element of the staple-carrying cartridge to eject and form the staples.

The forwardmost staple in the staple-carrying cartridge is advanced into the ready position during the initial stage of the forward thrust stroke of the thrust bar. At this point and with the thrust bar partially advanced, it is possible to remove the staple-carrying cartridge from the stapler. Under these circumstances, the clutch means prevents the thrust bar from returning to its initial position. Accordingly, the thrust bar must be fully advanced before it will be automatically returned to its initial position. The surgeon or his attendant may not remember to follow this procedure, however, and may attempt to mount a staple-carrying cartridge in the stapler while the thrust bar is in this partially advanced position. This procedure could result in jamming the drive mechanisms of the staple-carrying cartridge or other undesirable mechanical difficulty.

To prevent such jamming, means are provided for preventing a cartridge from being mounted unless the thrust bar has returned to its initial position. This means comprises a cartridge stop lock mounted in the forward end of the nose portion of the stapler. When the thrust bar is in its initial position, the cartridge stop lock is oriented so that a staple-carrying cartridge can be easily locked in the stapler. If the thrust bar is not in its initial position, however, but rather is in a partially advanced position, the cartridge stop lock is spring-biased into a blocking position so that a staple-carrying cartridge cannot be fully mounted in the stapler.

While the initial movement of the trigger advances the staples and the intermediate movement readies the cartridge for the stapling operation, only the final stages of trigger movement effect the ejection and formation of a staple. Accordingly, it is desirable to alert the surgeon to the fact that a staple is about to be ejected so that the surgeon can be sure that the instrument is properly positioned. In fact, the inventive instrument could be operated remote from the patient

until the last stage of trigger movement, and only then oriented in readiness for a stapling operation. As part of the present invention, the stapler is provided with a spring-biased wedge housed in the nose portion of the stapler which snaps into a notch on the top surface of the thrust bar with an audible "click" just before a staple is to be ejected. At the same time, the surgeon will also feel a slight but noticeable change in the force required to squeeze the trigger, thus further alerting him to the fact that a staple is about to be ejected.

As just described, the drive means for advancing staples in the staple-carrying cartridge and for ejecting staples therefrom are housed in the nose portion of the stapler which is rotatably mounted in the main body portion. Since the staple-carrying cartridge is mounted in the nose portion and rotatable therewith, it is possible to change the stapling angle of the stapler by merely rotating the nose portion while maintaining the hand-held main body portion in a fixed position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertical cross-section of the surgical stapling instrument of the present invention;

FIG. **2** is a horizontal cross-section taken along line **2—2** of FIG. **1**;

FIG. **3** is similar to FIG. **2** but shows a portion of the stapler during the stapling operation;

FIG. **4** is a horizontal, fragmentary view of a portion of the staple-advancing drive mechanism of the stapler during the stapling operation;

FIG. **5** is a vertical cross-section of the stapler looking rearwardly;

FIG. **6** is a side view, partially in section, of the staple-carrying cartridge mounting portion of the stapler after the cartridge is mounted and ready for use;

FIG. **7** is a front view of the stapler with the staple-carrying cartridge mounted and ready for use;

FIG. **8** is a vertical cross-section taken along line **8—8** of FIG. **2** and showing the clutch means;

FIGS. **9–12** are sequential views showing the operation of the clutch means during a stapling operation;

FIG. **13** is a vertical cross-section taken along line **13—13** of FIG. **2** and showing the position of the cartridge interlock before the staple-carrying cartridge is inserted;

FIG. **14** is similar to FIG. **13** but shows the cartridge interlock after the insertion of the staple-carrying cartridge which is shown in phantom lines;

FIG. **15** is a vertical cross-section taken along line **15—15** of FIG. **2** and showing the position of the cartridge stop lock before the thrust bar has been advanced;

FIG. **16** is similar to FIG. **15** but shows the cartridge stop lock after the thrust bar has been partially advanced;

FIG. **17** shows the cooperation between the inclined surfaces of the thrust bar and cartridge stop lock;

FIG. **18** is a horizontal cross-section taken along line **18—18** of FIG. **1** and showing the location plate for locating the cartridge interlock, cartridge stop lock and pusher-engaging portion of the thrust bar;

FIG. **19** is an enlarged view of the rear portion of a staple-carrying cartridge with its cover removed;

FIG. **20** is a cross-section taken along line **20—20** of FIG. **19**;

FIG. **21** is a vertical cross-section of the front portion of a staple-carrying cartridge; and

FIG. 22 is a view of the front portion of the cartridge during the stapling operation, with the cover removed.

DETAILED DESCRIPTION OF THE INVENTION

With reference first to FIGS. **1–6,** the surgical stapler of the present invention will be described in general terms. The stapler shown generally at **10** comprises housing **12** having main body portion **14** and handle portion **16.** Nose portion **20** of stapler **10** is rotatably mounted in main body portion **14** of housing **12.** Nose portion **20** includes a front section **22** extending out of housing **12** and adapted to mount staple-carrying cartridge **26.** Nose portion **20** further includes a rear section **24** located inside housing **12** and acting to house the driving means for advancing, ejecting and forming staples from the staple-carrying cartridge. Nose portion **20** is conveniently formed in two parts, upper and lower, held together by a pair of screws **21** and held in relative alignment by dowel pins **23** and **25.** Staple-carrying cartridge **26** is shown fitted into nose portion **20** of stapler **10** in FIG. **6.**

The staples in staple-carrying cartridge **26** are advanced, ejected and formed by mechanical means only and without the intervention of a gaseous medium. Accordingly, the power for advancing, ejecting and forming the staples in cartridge **26** comes from the manipulative force supplied to stapler **10** by the surgeon. This force is transmitted to the drive means of stapler **10** by means of trigger **28** which generally comprises a handle pivotally attached to housing **12.** Pivoting of trigger **28** causes a thrust bar **30,** the pusher-activating means, to drive the pusher element of staple carrying cartridge **26** forward to eject and form a staple around the anvil means. At the same time, a [pusher-engaging] *ratchet* **32** and a main gear **34** housed in the rear portion **24** of nose **20** are caused to rotate. Main gear **34** in turn rotates a pair of pinion gears **36** and pinion shafts **38** which associate with the cartridge **26** to advance the staples.

With reference now to FIGS. **1** and **5,** trigger **28** will be described. Trigger **28** is pivotally mounted to housing **12** by means of stud **40** and drive pin **42.** Trigger **28** is of appropriate size and shape to be conveniently gripped by the operating hand of a surgeon. The trigger includes a rearward extending portion **44** to which is attached one end of a return spring **46.** The other end of return spring **46** is attached to housing **12** and functions to return trigger **28** and thrust bar **30** to their initial positions after staple forming has occurred. Trigger **28** is of Y-shape and includes a lower hand-engaging portion **48** and an upper force-transmitting yoke portion **50.** Yoke **50** embraces a collar **52** slidingly mounted around the mid-section of nose portion **20** and adapted to rotate therewith. Collar **52** includes a cylindrically-shaped body member **54** having outwardly and radially extending flange portions **56** at each end. Yoke **50** is positioned around cylindrically-shaped body member **54** and between the flange portions **56.** Shoulder portions **55** and **57** of nose portion **20** limit the forward and rearward movement, respectively, of collar **52.** Pivoting of trigger **28** results in longitudinally directed force being exerted on collar **52** by yoke portion **50** of trigger **28.** Accordingly, when the trigger is activated, collar **52** simultaneously slides along the mid-section of nose **20.** Also, by this arrangement, collar **52** is free to rotate relative to trigger **28.**

As best seen in FIGS. **1, 3** and **17,** the means for driving the pusher element of the staple-carrying cartridge to eject and form staples comprises thrust bar **30** which includes an elongated central section **58** having a wing portion **60** near the rear end thereof. A pusher-engaging extension **62** and an inclined surface **64** are positioned at the forwardmost end of thrust bar **30.** Inclined surface **64** is adapted to engage a stop lock mechanism which will be discussed subsequently. Also located near the front end of thrust bar **30** is an elongated notch **66** which forms a part of the clutch means of the present invention. Located near the rear end of thrust bar **30** is a second notch **68** which engages the forward end of index pawl **70.** Thrust bar **30** is slidingly mounted in nose portion **20** and is adapted to rotate therewith. As illustrated in FIG. **2,** wing portion **60** of thrust bar **30** lies near the mid-section of collar **52,** conveniently formed as two semi-circular parts, and is rigidly attached to collar **52** by means of bolts **53.** Accordingly, thrust bar **30** reciprocates back and forth with collar **52** when trigger **28** is pivoted, and collar **52** rotates with thrust bar **30** when nose portion **20** is rotated.

The staple-advancing drive means of the stapler **10** is arranged so that when thrust bar **30** is moved forward, the elements forming a part of this arrangement are activated. That is, the forward motion of the pusher-activating element causes the rotation of the screws of staple-carrying cartridge **26** thereby advancing the staples. And as will be more fully described below, the staples are slightly over-driven during the forward stroke of thrust bar **30** and are then returned to their proper positions as will be discussed subsequently.

With reference now to FIGS. **1–4,** the staple-drive mechanism will be explained. The index pawl **70** is pivotally attached to the rear end of thrust bar **30.** The transverse base portion **74** of spring **72** passes through aperture **76** in thrust bar **30** and the inturned end of upstanding leg **78** of spring **72** fits into one end of an aperture **80** in the rear end of thrust bar **30** and the inturned end of upstanding leg **82** fits through an aperture **84** in index pawl **70** and then into the other end of aperture **80** in thrust bar **30.** An upstanding leg **86** on the forward end of index pawl **70** fits into notch **68** in thrust bar **30.** Notch **68** is trapezoidal in shape and has inclined surface **88.** The combination of spring **72** and inclined surface **88** of notch **68** allows index pawl **70** to pivot outwardly.

Index pawl **70** rides along on wall of a six-tooth ratchet **32** and engages one of the teeth thereof. The index pawl, pivotally mounted on thrust bar **30,** is biased toward ratchet **32** by spring **72.** Ratchet **32** is attached to, and rotates with, a main gear **34.** Ratchet **32** and main gear **34** are of unitary construction, as illustrated, and are rotatably mounted in the rear end **24** of nose portion **20** by means of shaft **90.** The teeth of main gear **34** mesh with the teeth of two pinion gears **36,** both of which are seen in the drawings. Pinion gears **36** are in turn attached to pinion shafts **38** which are housed in, and extend longitudinally through, the nose portion **20** of stapler **10.** A tapered cylindrical body portion **92** on the ratchet **32** and main gear **34** assembly provides a stop for pinion gears **36** which have a rear portion **94** which abuts body portion **92** of the ratchet **32** and main gear **34** assembly. (See FIG. **1**). This arrangement prevents the pinion shafts from inadvertently being moved out of their proper longitudinal position.

Thrust bar **30,** index pawl **70** and ratchet **32** are arranged in such a manner that the forward stroke of

thrust bar **30** causes ratchet **32** and accordingly main gear **34** to move slightly more than 60°. As noted previously, it is desired to ultimately rotate the screws associated with staple-carrying cartridge **26** precisely 360° for each staple driving operation. The staple-advancing drive means in stapler **10** is arranged so that for each 60° turn of ratchet **32** and main gear **34,** pinion shafts **38** and the screws in cartridge **26** are rotated 360°. However, to ensure that the staples are advanced a proper amount, it has been found desirable to overdrive the screws in cartridge **26** and thus the staples, and then to reverse the rotation of the screws so that ultimately they experience a net 360° rotation. It is for this reason that six-tooth ratchet **32** is rotated slightly more than 60°. It becomes necessary therefore to provide means for returning ratchet **32** to its 60° position. The ratchet return is brought about by means of spring pawl **96** as will be discussed subsequently.

With particular reference now to FIGS. **2–4,** the operation of the drive means for activating the staple-advancing mechanism of the staple-carrying cartridge and for driving the staples toward the anvil will be described. As shown in FIG. **2,** thrust bar **30** is in its initial at rest position. In this position, index pawl **70** is in engagement with ratchet **32.** Tooth portion **102** of index pawl **70,** which is the driving region thereof, is removed from the nearest tooth on ratchet **32** to allow for slight "play" before the ratchet **32** is rotated.

When thrust bar **30** moves forward, during a stapling operation, index pawl **70** rotates ratchet **32.** Ratchet **32** is rotated in a clockwise direction as index pawl **70** is moved forward with thrust bar **30.** When ratchet **32** has been rotated through approximately its desired maximum angle of slightly greater than 60°, the back surface of an advancing tooth of ratchet **32** engages planar portion **104** near the end of index pawl **70** and forces tooth portion **102** of index pawl **70** out of engagement with ratchet **32** (See FIG. **4**). The maximum angle through which ratchet **32** is rotated is greater than that needed to advance each staple one "staple unit." Thus, the staple-advancing drive means is momentarily overdriven; however, this condition is automatically corrected by spring pawl **96.**

Referring now to FIGS. **2** and **4,** it can be seen that spring pawl **96** is attached to the rear end **24** of nose portion **20** by means of a pin **97** and comprises an arcuate section terminating at end **106.** Spring pawl **96** contacts ratchet **32** at two points in its initial position. First, end **106** of spring pawl **96** contacts one of the teeth of ratchet **32.** Second, a point on spring pawl **96** partially between end **106** and the arcuate section contacts the back surface of the adjacent tooth. Accordingly, when ratchet **32** is momentarily over-driven, spring pawl **96** is cammed outward as shown in FIG. **4;** however, ratchet **32** is then immediately returned to an exactly 60° rotation by the biasing action of spring pawl **96.** It will be noted that the counterclockwise rotation of ratchet **32** terminates when end **106** of spring pawl **96** contacts a tooth on ratchet **32.** Accordingly, when thrust bar **30** and index pawl **70** are in the fully advanced position, shown in solid lines in FIG. **3,** spring pawl **96** has the same relationship to ratchet **32** as it did when thrust bar **30** and index pawl **70** were in their initial positions illustrated in FIG. **2.**

After the forward thrust of thrust bar **30** has been completed and a staple ejected from the cartridge and formed in the patient, return spring **46** returns thrust bar **30** to its initial position. During this phase of operation, the end portion **106** of spring pawl **96** prevents counterclockwise rotation of ratchet **32.** At the stage of the thrust bar return stroke when sloped surface **107** on index pawl **70** contacts a tooth on ratchet **32,** the index pawl begins to be cammed against the force of spring **72.** Further camming action then occurs when the tooth portion **102** of index pawl **70** contacts the backside of a tooth of ratchet **32.** At this stage, index pawl **70** is pivoted outwardly into the position shown in phantom lines in FIG. **3.** This outward pivotal movement is permitted by spring **72** and the inclined surface **88** of notch **68** of thrust bar **30.** Finally, index pawl **70** reassumes the position shown in FIG. **2.** At this point, stapler **10** is ready for another firing.

As previously stated, it is desirable to alert the surgeon to the fact that a staple is about to be ejected and formed so that the surgeon can be sure that cartridge **26** is properly positioned to effect a neat suture. This is accomplished by means of spring-biased means **115** housed in nose portion **20** of stapler **10.** Spring-biased means **115** comprises an upper U-shaped member **116** which bears against housing **12** and a lower member **117** terminating in a V-shaped point which rides along the top of thrust bar **30.** Members **116** and **117** are spring-biased apart by a coil spring **118.** A notch **119** is provided on the top surface of thrust bar **30,** in alignment with member **117,** and is adapted to receive the V-shaped pointed end of member **117** at a stage of the stapling operation just before a staple leaves the cartridge. At this stage, member **117** is snapped into notch **119** on the top surface of thrust bar **30** by spring **118** with an audible "click." Further movement of thrust bar **30** in the forward direction forces member **117** upward against the force of spring **118** so that thrust bar **30** can continue its forward movement. This sequence of events will also cause the surgeon to feel a slight but noticeable change in the force required to squeeze the trigger, thus further alerting him to the fact that a staple is about to be ejected. Member **116** also functions to provide additional frictional resistance between housing **12** and nose portion **2** to avoid uncontrolled rotation between nose portion **20** and housing **12** during normal handling and use.

Turning now to FIG. **8,** there is illustrated an end view of a clutch means **120.** Clutch means **120** includes a cam block **122** mounted in an opening **124** in forward end **22** of nose portion **20.** Cam block **122** has an inclined surface **126** facing thrust bar **30** which passes through an opening **128** in cam block **122.** Inclined surface **126** is positioned relative to thrust bar **30** such that the spacing **130** between inclined surface **126** and thrust bar **30** increases in the forward thrust direction of the thrust bar. A cylindrical cam roller **132** is positioned between inclined surface **126** of cam block **122** and thrust bar **30.** An elongated wedge pin **134** is housed in an aperture **136** in cam block **122.** The forward end of wedge **134** is V-shaped and extends into opening **130** between inclined surface **126** and thrust bar **30.** The wedge pin **134** is spring-biased toward thrust bar **30** by means of a spring **138** housed in a recess **140** in cam block **122.** Recess **140** lies perpendicular to aperture **136** and the end of spring **138,** which is hook-shaped, is seated in a bore **142** through wedge **134.** Cam roller **132** lies adjacent elongated notch **66** in thrust bar **30** and its movement is confined by notch **66** as will be discussed subsequently. The cooperation between these elements is such that cylindrical roller **132** prevents thrust bar **30** from being

returned to its initial position until completion of a full thrust stroke.

FIGS. **9–12** are sequential views showing the operation of clutch means **120** during a stapling operation. Turning first to FIG. **9,** thrust bar **30** is shown in its initial position. In this position, cam roller **132** lies in a shallow cut-out **144** positioned at the forwardmost end of notch **66.** Cam roller **132** is positioned in the narrowest part of opening **130** and at the rear of clutch means **120.** Spring-biased wedge pin **134** maintains the cam roller **132** toward the rear end of clutch means **120.**

Turning now to FIG. **10,** the clutch means **120** is illustrated during the forward stroke of thrust bar **30.** Cam roller **132** is shown rotating in a counterclockwise direction. During this stage of thrust, the surface of cam roller **132** contacts base **146** of notch **66** and inclined surface **126,** and is rotated by the movement of thrust bar **30.** This rotational movement is permitted since cam roller **132** is in effect rotating "downhill" toward the widest part of opening **130.** At the same time, cam roller **132** bears against spring-biased wedge **134** which restrains the longitudinal forward movement of cam roller **132** so that the cam roller is kept in the narrowest part of opening **130.**

Still referring to FIG. **10,** it can be seen that an attempted return movement of thrust bar **30** to its initial position from its partially advanced position would cause cam roller to rotate in a clockwise direction. This movement is not permitted by clutch means **120,** however, since clockwise rotation of cam roller **132** causes cam roller **132** to "lock" itself between thrust bar **30** and inclined surface **126** of cam block **122** thereby preventing all but the slightest movement of thrust bar **30** toward its initial position. This occurs because cam roller **132** is in effect rotating "uphill" toward the narrowest part of opening **130.** Furthermore, cam roller **132** would no longer be bearing against spring-biased wedge **134.**

Turning now to FIG. **11,** clutch means **120** is seen at the forward end of the stroke of thrust bar **30.** In this position, cam roller **132** has been forced to the other side of wedge pin **134** by shoulder porton **148** of notch **66** and lies in the widest region of opening **130.** Once cam roller **132** has so passed wedge **134,** it is housed in an area wider than its diameter and hence is free to rotate in any direction. Accordingly, cam roller **132** permits thrust bar **30** to move rearward toward its initial position. A portion of this operational sequence is shown in FIG. **12** illustrating thrust bar **30** during its return stroke. Here, base portion **146** of notch **66** of thrust bar **30** may still lightly contact cam roller **132.** However, cam roller **132** can freely rotate since opening **132** is sufficiently wide at this location. Near the end of the return movement of thrust bar **30** to its initial position, cam roller **132** is moved into cut-out **144** in notch **66** and is then forced past wedge **134** by shoulder portion **150** of notch **66.** Cut-out portion **144** allows cam roller **132** to be moved past wedge **134** and back to its initial position shown in FIG. **9,** without "locking" before the completion of the return stroke.

Turning now to FIG. **13,** there is shown an end view of a cartridge interlock **152** in its initial blocking position which prevents the initiation of a thrust stroke until a cartridge is properly installed on the stapler. Cartridge interlock **152** lies in blocking and abutting relationship with the forwardmost end of thrust bar **30** when thrust bar **30** is in its initial position. Cartridge interlock **152** is positioned in an opening **154** in the

forward end **22** of nose portion **20** and comprises a body portion **156** and leg portions **158.** As shown in FIG. **13,** cartridge interlock **152** is spring-biased into its initial blocking position by a pair of coil springs **160.** In this position, leg portions **158** of cartridge interlock means **152** extend through openings **165** in a location plate **164.** When a cartridge **26** is mounted on the stapler **10** as shown in FIG. **6,** cartridge interlock **152** is forced upward against the action of springs **160** and into the position illustrated in FIG. **14.** In this position, opening **166** in cartridge interlock **152** registers with thrust bar **30** and allows thrust bar **30** to pass therethrough. Accordingly, cartridge interlock **152** is in the position shown in FIG. **13** when a cartridge is absent and thrust bar **30** is in its initial position, and is in the position shown in FIG. **14** the remainder of the time.

Referring now to FIG. **15,** there is shown an end view of a cartridge stop lock **170** in its initial position. Cartridge stop lock **170** is adapted to prevent the mounting of a staple-carrying cartridge **26** in stapler **10** unless thrust bar **30** is in its fully retracted initial position. Cartridge stop lock **170** is mounted in an opening **172** in forward end **22** of nose portion **20.** The cartridge stop lock **170** comprises a body portion **174** and leg portions **176.** Opening **178** in cartridge stop lock **170** registers with thrust bar **30** when thrust bar **30** is in its initial position. In the position shown in FIG. **15,** leg portions **176** are retracted above the bottom of location plate **164.** Accordingly, staple-carrying cartridge **26** can be easily mounted on stapler **10.**

As best seen in FIG. **17,** the cartridge stop lock **170** is held in its initial position by the inclined surface **64** of thrust bar **30** which engages a correspondingly inclined surface **180** of cartridge stop lock **170** when thrust bar **30** is in its initial position. After thrust bar **30** has left its initial position and is in the thrust or return portion of its stroke, cartridge stop lock **170** is spring-biased downward by a pair of coil springs **182** and into the position shown in FIG. **16.** In this position, leg portions **176** extend through openings **184** in location plate **164** and below the bottom thereof to prevent the mounting of staple-carrying cartridge **26** until thrust bar **30** has been returned to its initial position. The return of thrust bar **30** to its initial position. The return of thrust bar **30** to its initial position causes cartridge stop lock **170** to be forced upward against the action of springs **182** as best shown in FIG. **17,** wherein the initial position of thrust bar **30** and stop lock cartridge **170** are shown in phantom lines.

FIG. **18** shows a top view of the location plate **164,** with thrust bar **30** in its initial position. Location plate **164** is housed in an opening **185** in the forward end **22** of nose portion **20.** As previously described, location plate **164** has openings **164** and **184** therein for receiving leg portions **158** and **176** of cartridge interlock **152** and cartridge stop lock **170,** respectively. Location plate **164** also has a longitudinally extending opening **186** which receives pusherengaging extension **62** and thereby allows thrust bar **30** to reciprocate.

With reference now to FIGS. **6, 7, 19** and **20,** the association of the staple-carrying cartridge **26** with the stapler **10** will be explained. Staple-carrying cartridge **26,** as can be seen in the figures, is detachably mounted on nose portion **20.** Staple-carrying cartridge **26** is elongated and has a pair of upwardly extending spaced tabs **202** at its rear end. The spacing between tabs **202** is sufficient to allow pusher-engaging extension **62** to freely slide therebetween and tabs **202** are dimensioned

and positioned so as to engage surface **203** at rearmost end of location plate **164.** Therefore, when tabs **202** engage surface **203,** staple-carrying cartridge **26** cannot be inadvertently pulled out of the nose, and cartridge **26** is fixed against forward movement during the stapling operation.

Staple-carrying cartridge **26** is mounted in stapler **10** by inserting the end of cartridge **26** into opening **110** in nose portion **20.** The rearward end of staple-carrying cartridge **26** engages a leaf spring **108** which urges the cartridge **26** upwardly until tabs **202** are positively locked into their associated indentations in the body of nose portion **20.** With cartridge **26** in this position, the rearward ends **228** of the drive screws **218** forming a part of staple-carrying cartridge **26** are engaged by slots **39** of pinion shafts **38.** The cartridge **26** is removed from the stapler **10,** when exhausted of staples, by reversing the insertion steps.

With specific reference now to FIGS. **19–22,** the construction and operation of the staple-carrying cartridge **26** will be explained. The cartridge **26** is defined by a main body **200** and has an anvil **204** at its forwardmost region projecting out as an extension of the top of cover plate **206.** Staple-carrying cartridge **26** houses a plurality of staples **208** whose cross bars **210** lie transverse to the length of cartridge **26** and whose points **212** face anvil **204.** A pusher element **214** covers staples **208** and is slidingly mounted within indentations **216** in cover plate **206.** Pusher element **214** is adapted to be engaged by pusher-engaging extension **62** of thrust bar **30** and serves both to eject staples **208** from the cartridge **26** and to form the ejected staples around anvil **204.**

The means for advancing staples **208** along the length of cartridge **26** comprises a pair of drive screws **218.** Screws **218** are provided with threads **220** for guiding and propelling staples **208** along main body ledges **222** between the lateral walls **221.** The pusher element **214** is guided between the tops of screws **218** and the bottom of cover plate **206,** and serves to hold each of the staples **208** against ledges **222,** except during the driving operation. Then, the forwardmost staple **208** is advanced out of the screw guiding threads **220** by means of inclined surfaces **224,** at the forward ends of ledges **222,** into the plane of pusher element **214,** and is propelled forward, out of the main body portion and against anvil **204.**

Each screws **218** is provided at its rearwardmost end with an extension **226** fitted at its extremity with a flat projection **228.** Screws **218** are threaded so that when they, by means of projections **226** associating with pinion shafts **38** are rotated through 360°, each staple **208** moves one staple unit. A "staple unit" is defined as that distance which is required to move the second staple from its readiness position into a position ready to be fired. Thus, in FIG. **21,** one staple unit is shown at a.

In operation, while pusher element **214** is moving forward by thrust bar **30,** and after the forwardmost staple has been raised into the plane of the pusher, pusher element **214** makes contact with the staple as illustrated in FIG. **22.** Then, the staple is ejected and formed in the disunited skin or fascia of the patient as is more fully described in the above-referenced commonly assigned patents, the pertinent disclosures of which are expressly incorporated herein by reference.

Above there have been described specific embodiments of the present invention. It should be noted, however, that the above description was given for illustrative purposes only and that many alterations and modifications may be practiced by those skilled in the art without departing from the spirit or the scope of the present invention. It is the intent therefore that the present invention not be limited to the above but be limited only as defined in the appended claims.

What is claimed is:

1. A surgical stapling instrument for applying sterilized staples to the disunited skin or fascia of a patient for effecting a joining of the skin or fascia, the instrument adapted to associate with a staple-carrying cartridge having anvil means at one end thereof and adapted to house a plurality of staples therein, a pusher element slidably mounted therein for ejecting staples from said cartridge and for forming said staples around said anvil means, and means for advancing said staples in said cartridge, said surgical stapling instrument comprising: a main body portion; means for mounting said staple-carrying cartridge on said main body portion; drive means to activate said staple-advancing means for driving the staples toward said anvil means **[**; **]** and **[** pusher-activating means **]** for driving the pusher element forward to eject a staple from the staple-carrying cartridge and to form said staple around said anvil means; said instrument being manually powered, and further comprising trigger means for transmitting a manually applied force to said drive means **[** and said pusher-activating means **]** to power said drive means **[** and said pusher-activating means **]**.

2. The instrument defined in claim **1,** wherein said **[** pusher-activating **]** *drive* means comprises a thrust bar slidably mounted in said main body portion and said trigger means comprises a handle pivotally mounted to said main body portion and having a lower hand-engaging portion and an upper force-transmitting portion associated with said thrust bar.

3. The instrument defined in claim **2,** wherein means are associated with said thrust bar for initiating the advancement of staples, said initiating means comprising an index pawl pivotally mounted to said thrust bar and adapted for sliding movement therewith.

4. The instrument defined in claim **3,** wherein said thrust bar has a notch formed therein and wherein said index pawl has an upstanding leg formed thereon and cooperating with said notch to permit the pivotal movement of said index pawl, and wherein said index pawl is pivotally mounted to said thrust bar by means of a resilient member.

5. The instrument defined in claim **1,** wherein said drive means comprises a ratchet and main gear mounted in said main body portion for rotation in unison, at least one pinion gear rotatably driven by said main gear, and a pinion shaft rotatably driven by each said pinion gear.

6. The instrument defined in claim **5,** wherein said drive means is adapted to be over-driven and thereby advance each staple but the first in said staple-carrying cartridge more than one staple unit for each thrust of said thrust bar; and further including means to reverse the direction of rotation of said drive means so that said drive means ultimately advances each staple one staple unit, said reversing means comprising a spring pawl biasing said drive means in said reverse directon when said drive means is in the over-driven state.

7. The instrument defined in claim **1,** and further comprising means for alerting the surgeon that a staple

has reached a readiness position for ejection and formation.

8. The instrument defined in claim **7,** wherein said alerting means comprises a notch associated with said pusher-activating means and a spring-biased wedge housed in said main body portion and adapted to cooperate with said notch to provide said alerting function.

9. A surgical stapling instrument for applying sterilized staples to the disunited skin or fascia of a patient for effecting a joining of the skin or fascia, the instrument adapted to associate with a staple-carrying cartridge having anvil means at one end thereof and adapted to house a plurality of staples therein, a pusher element slidably mounted therein for ejecting staples from said cartridge and for forming said staples around said anvil means, and means for advancing said staples in said cartridge, said surgical stapling instrument comprising: a main body portion; a nose portion; means for mounting said staple-carrying cartridge on said nose portion so that said cartridge is rotatable therewith; drive means housed in said nose portion and rotatable therewith for activating said staple-advancing means for driving the staples toward said anvil means [;] and [pusher-activating means housed in said nose portion and rotatable therewith] for driving the pusher element forward to eject a staple from the staple-carrying cartridge and to form said staple around said anvil means, wherein said instrument is manually powered, and further comprising trigger means for transmitting a manually applied force to said drive means [and said pusher-activating means] to power said drive means [and said pusher-activating means].

10. The instrument defined in claim **9,** wherein said [pusher-activating] *drive* means comprises a thrust bar slidably mount in said nose portion and said trigger means comprises a handle pivotally mounted to said main body portion and having a lower hand-engaging portion and an upper force-transmitting portion, and wherein said instrument further comprises collar means housed in said main body portion and slidably mounted on and rotatable with said nose portion for transmitting force from said trigger means to said [pusher-activated] *drive* means.

11. The instrument defined in claim **10,** wherein said collar means comprises a cylindrically-shaped body member having outwardly and radially extending flange portions at each end thereof, and wherein said upper force-transmitting portion of said trigger means is formed in the shape of a yoke and is positioned around said cylindrically-shaped body member and between said flange portions of said collar means so that said collar means can rotate relative to said trigger means.

12. A surgical stapling instrument for applying sterilized staples to the disunited skin or fascia of a patient for effecting a joining of the skin or fascia, the instrument adapted to associate with a staple-carrying cartridge having anvil means at one end thereof and adapted to house a plurality of staples therein, a pusher element slidably mounted therein for ejecting staples from said cartridge and for forming said staples around said anvil means, and means for advancing said staples in said cartridge, said surgical staple instrument comprising: a main body portion; means for mounting said staple-carrying cartridge on said main body portion; drive means to activate said staple-advancing means for driving the staples toward said anvil means [; pusher-activating means] *and* for driving the pusher element

forward to eject a staple from the staple-carrying cartridge and to form said staple around said anvil means; and clutch means for preventing said drive means from activating said staple-advancing means more than once in each stapling operation, said clutch means comprising two surfaces movable relative to one another with one of said two surfaces being sloped relative to the other, a roller positioned between said two surfaces, and a wedge member in one of said two surfaces, said wedge member adapted to permit said roller means to move therepast only at the respective ends of the drive means stroke.

13. The instrument defined in claim **12,** wherein said [pusher-activating] *drive* means comprises a thrust bar slidingly mounted for reciprocative movement in said main body portion and wherein said clutch means prevents said thrust bar from returning to its initial rest position until said thrust bar has completed its forward thrust movement.

14. The instrument defined in claim **13,** wherein the sloped surface is inclined relative to said thrust bar and defines an opening therewith which increases in size in the direction of the forward thrust movement of said thrust bar, and wherein said roller is positioned between and cooperating with said sloped surface and said thrust bar.

15. The instrument defined in claim **14,** wherein said wedge member cooperating with said roller is spring-biased.

16. A surgical stapling instrument for applying sterilized staples to the disunited skin or fascia of a patient for effecting a joining of the skin or fascia, the instrument adapted to associate with a staple-carrying cartridge having anvil means at one end thereof and adapted to house a plurality of staples therein, a pusher element slidably mounted therein for ejecting staples from said cartridge and for forming said staples around said anvil means, and means for advancing said staples in said cartridge, said surgical stapling instrument comprising: a main body portion; means for mounting said staple-carrying cartridge on said main body portion: drive means to activate said staple-advancing means for driving the staples toward said anvil means [; pusher-activating means] *and* for driving the pusher element forward to eject a staple from the staple-carrying cartridge and to form said staple around said anvil means; and locking means associated with said [pusher-activating] *drive* means and adapted to cooperate with said staple-carrying cartridge for ensuring that said [pusher-activating] *drive* means is in its initial rest position when said staple-carrying cartridge is mounted on said main body portion.

17. The instrument defined in claim **16,** wherein said locking means is adapted to lock said [pusher-activating] *drive* means in its initial rest position until said staple-carrying cartridge is mounted on said main body portion.

18. The instrument defined in claim **17,** wherein said [pusher-activating] *drive* means comprises a thrust bar mounted for reciprocative movement in said main body portion, and wherein said locking means comprises a movable cartridge interlock member adapted to lie in blocking and abutting relationship with the forwardmost end of said thrust bar when said thrust bar is in its initial rest position and adapted to move out of said blocking relationship with said thrust bar when said staple-carrying cartridge is mounted on said main body portion.

19. The instrument defined in claim **18,** wherein said cartridge interlock member comprises a body portion spring-biased toward a blocking relationship with said thrust bar and having an opening therein through which said thrust bar can pass when moved out of said blocking relationship, said cartridge inter-lock member further having a leg porton adapted to contact said staple-carrying cartridge when said staple-carrying cartridge is mounted on said main body portion such that said cartridge inter-lock member is moved out of said blocking relationship.

20. The instrument defined in claim **16,** wherein said locking means comprises a movable cartridge stop lock member adapted to prevent the mounting of said staple-carrying cartridge in said main body portion unless said **[** pusher-activating **]** *drive* means is in said initial rest position.

21. The instrument defined in claim **20,** wherein said **[**pusher-activating**]** *drive* means comprises a thrust

bar mounted for reciprocative movement in said main body portion and wherein said cartrige stop lock member is adapted to block the mounting of said staple-carrying cartridge when said thrust bar is not in said initial rest position, and is adapted to be moved into a non-blocking position by said thrust bar when said thrust bar is in said initial rest position.

22. The instrument defined in claim **20,** wherein said cartridge stop lock member comprises a body portion and a leg portion, said leg portion being spring-biased into a position adapted to block the mounting of said staple-carrying cartridge when said thrust bar is not in said initial rest position, and wherein each of said cartridge stop lock member and said thrust bar have correspondingly inclined surfaces such that said cartridge stop lock member is moved into a non-blocking position by said thrust bar when said thrust bar is in said initial rest position.

* * * * *