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(54) SUTURING APPARATUS

(57) **Abstract:**

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This invention relates to an apparatus for effecting a suturing operation.

When a blood vessel is severed, either as a result of an accident or in the course of a surgical operation, repairs to restore flow through the vessel without delay may be imperative in order to save a limb or the life of a patient.

The usual manner of joining the two parts of a severed blood vessel involves a very slow and difficult operation requiring highly specialized skill on the part of the surgeon. Many surgical operations would be greatly facilitated if it were possible to join severed blood vessels, regardless of their size, in a rapid and convenient manner.

It is an object of this invention to provide a means for effecting a suturing operation in a greatly reduced period of time and in such a manner that its execution is not difficult thereby avoiding strain on the patient and surgeon.

Another object is to provide an apparatus which will make it possible to carry out operations, the performance of which is now substantially impossible because of the necessity of maintaining blood supply to vital organs.

Another object is to provide an apparatus which will enable a surgeon to perform peripheral vascular surgery without the necessity of specialized training in this field and to perform such surgery in a much reduced period of time.

Another object is to provide an apparatus which will permit the suturing of blood vessels as small as approximately two millimeters and possibly even smaller.

Another object is to provide an apparatus which will enable surgeons to produce peripheral vascular sutures of an exceptionally high degree of perfection.

The invention resides in a suturing apparatus comprising a hollow cylindrical clip-driving assembly having two half sections arranged to surround one end portion of a severed blood vessel, a cylindrical anvil member having two half sections arranged to surround the other end portion of said severed blood vessel, a holder having a pair of pivotally mounted jaws for engagement with said two sections of said clip-driving assembly, a second holder having a pair of pivotally mounted jaws for engagement with said two sections of said anvil member, means removably connecting said holders for limited swinging movement with respect to each other in the axial direction of said assembly and anvil member, and means for effecting said limited swinging movement.

The invention will be described with reference to the accompanying drawings, in which

Figure 1 is a longitudinal sectional elevation of the cylindrical members of the apparatus in accordance with the invention, showing such members in operational engagement with a severed blood vessel,

Figure 2 is an end elevation on line 2-2 of Figure 1 of the clip-driving assembly,

Figure 3 is an end elevation on line 3-3 of Figure 1 of the anvil cylindrical member,

Figure 4 is a partial side view, partly in section, on line 4-4 of Figure 3 of the anvil cylindrical member,

Figure 5 is a side elevation of a tubular guide forming part of the clip-driving assembly,

Figure 6 is an end elevation of the complete apparatus in accordance with the invention,

Figure 7 is a side elevation of the apparatus,

Figure 8 is a partial side elevation of a sleeve forming another part of the clip-driving assembly,

Figure 9 is a plan view of a holder locking means,

Figure 10 is a side elevation of a clip suitable for use with the apparatus illustrated,

Figures 11 and 12 are side elevations of the clip in two forms of clinched condition,

Figure 13 is an end elevation of the apparatus showing a modified form of press tool,

Figure 14 is a side elevation of the apparatus and press tool shown in Figure 13,

Figure 15 is a sectional view on line 15-15 of Figure 14,

Figure 16 is a transverse sectional view of the clip-driving assembly, showing a modified form of locking member,

Figure 17 is a partial side elevation of a modified portion of the clip-driving sleeve, and

Figure 18 is a plan view of the modified portion shown in Figure 17.

In the drawings, 1 is a cylindrical clip-driving assembly which may be formed of suitable metal, combination of metal and plastic composition or the like and comprises a tubular guide 2 having a plurality of axially extending raised portions 3 on the external surface thereof. Each portion 3 is of generally T-shaped cross-section to provide a groove 4 in each side surface thereof. It will be observed that each portion 3 extends from one end of the guide 2 to a point intermediate the ends of the guide. In the embodiment shown, each portion 3 extends to a point somewhat less than half the length of the guide. It will also be observed that each space between each adjacent pair of portions 3 forms with the grooves 4 a T-shaped slot 5. The assembly also includes a sleeve 6 having a radial flange 7 extending outwardly therefrom and a plurality of axially

ending fingers 8 of T-shaped cross-section and each arranged for reception in a respective slot 5. The sleeve 6 is thus arranged for longitudinal sliding or reciprocal movement on the guide 2 but is restrained from rotative movement by the fingers 8. The sleeve 6 on guide 2 with fingers 8 in slots 5 slides freely but with substantially little play with respect thereto. The guide 2 and sleeve 6 are formed in two separate complementary half sections, as shown.

The guide 2 is adapted to receive a plurality of clips 9, one in each of the wider portions of slots 5 (sleeve 6 with fingers 8 being withdrawn sufficiently to permit insertion of the clips).

Each clip 9 is preferably formed from round section wire, which may be of a material which is neutral with respect to the body, such as tantalum, whereby it can be left permanently in the patient's body without ill effects. The clip, as shown, is U-shaped with legs 10 and a connecting part 11 hereinafter referred to as the head. The head 11 is preferably slightly arched in the plane of the legs thereof and is also slightly arched in a direction at right angles to such plane whereby it may fit the arcuate wall of the slot 5. Each leg 10 is preferably also slightly arched outwardly in the plane of the legs and the end of each leg is sharpened to a knife edge preferably in the plane of the legs, as shown. The free end of the broader part of each finger 8 may be slightly concave as indicated at 51 for engagement with the arched head of a clip 9 and the free end of the narrower part of the finger may overhand such concave surface to provide a retaining and supporting lip 52 for the clip. Alternatively, the same retaining and supporting effect may be obtained by concave bevelling

entire end face of the free end of each finger 8 to suit the arch of the head of the clip, as indicated at 66 in Figures 17 and 18.

Each clip is placed in a slot 5 with the pointed ends of its legs adjacent to, but not protruding beyond the end of the slot coinciding with the end of the guide 2. The normal maximum width of the clip, which occurs near the mid-length of the legs, is slightly greater than the width of the under portion of slot 5 whereby it is necessary to spring the legs 10 slightly towards each other in order to place the slip in the slot. Thus, the slightly flexed legs exert a light spring load on the walls of the slot, and the clip is thereby held in position in the guide 2.

A cylindrical anvil member 12 comprises two complementary half sections formed of a suitable metal, combination of metal and plastic composition, or the like. The member 12 has a radially outwardly extending flange 13 adjacent one end thereof and a plurality of sets of anvil recesses 14 in the other end edge thereof. Each set of recesses shown comprises a pair of adjacent arcuate grooves 15, the bottom walls of which are curved towards a common apex 16. It will be apparent that a set of anvil recesses 14 is adapted to be provided opposite each of the slots 5 for reception of the ends of a clip 9 in such slot 5.

A holder 17 is provided for the clip-driving assembly 1, such holder being of the pincer type and comprising a pair of arms 18 pivoted together at 19 to provide a pair of gripping jaws 20. Each jaw 20 has an arcuate groove 20a to receive a portion of radial flange 7 of the clip-driving assembly 1. Means for locking the holder 17 in closed or gripping position comprises a toggle mechanism 21 of conventional form and having, as shown, a pair of

votally connected toggle links 22 and 23 pivoted to the free ends of arms 18. Link 22 has a handle portion 24 whereby the toggle mechanism may be opened or closed as desired.

A holder 25 is provided for the anvil member 12, such holder being closely similar to holder 17 and comprising a pair of arms 26 pivoted together at 27 to provide a pair of gripping jaws 28. Each jaw 28 has an arcuate groove 28a to receive a portion of radial flange 13 of anvil member 12. The holder 25 is also provided with locking toggle mechanism 29.

Aligning means for the clip-driving assembly 1 and anvil member 12 comprises a boss 53 on one of the gripping jaws 20 arranged to enter one of a pair of complementary notches 54 in radial flange 7, and boss 55 on one of the gripping jaws 28 arranged to enter one of a pair of complementary notches 56 in radial flange 13.

Means are provided for separably connecting holders 17 and 25 in accurate alignment and for limited swinging movement towards and away from each other comprises a pair of connectors 30. Each connector 30 comprises a pin 31 fixed to an arm 26 adjacent its free end and having, as shown, a partly spherical head 32 and, adjacent to the head, a conical neck section 33. Each arm 18 has a complementary socket 34 to receive the head 32 of a respective pin 31, such head being releasably retained in the socket by means of a flat spring member 35 mounted on each arm 18 by a retainer plate 36 and having a pair of opposed spring fingers 37 arranged to be forced apart to permit passage therebetween of the head 32 and to thereafter spring together to engage the conical neck 33 and force the head 32 of the pin to seat tightly in socket 34. The connectors described, while

..ving to releasably connect the holders, restrain the holders from undesirably side play.

It is important that, when the holders 17 and 25 are locked in gripping position by means of the toggles 21 and 29, the center to center distance of the two pins 31, and of the two sockets 34, be substantially equal.

Means for applying an inward stroke to connected holders 17 and 25 to move the clip-driving assembly 1 and anvil member 12 towards each other comprises a press tool 38. Tool 38 comprises a pair of arms 39 rockably connected together intermediate their ends by means of a pair of links 40. One end of each arm 39 has a pair of laterally extending jaws 41 for engagement with one or the other of a pair of shoulders 42 on arms 18 and 26. Means for moving said jaws 41 towards each other comprises a screw 43 carried by the other end portion of one arm 39, such screw having an operating handle 44 and an end portion 45 engageable in a socket 46 in the corresponding end portion of the other arm 39. Means for limiting the stroke applied to jaws 41 comprises a pin 47 carried by the latter arm 39 and extending through an opening 48 in the first arm 39. Pin 47 carries a stop or head 49 engageable with such first arm 39 to limit outward movement thereof. Pin 47 has screw-threaded mounting in arm 39 whereby its length may be adjusted thereby to adjust the length of stroke of jaws 41 and consequently jaws 20 and 28. Head 49 is preferably provided with an indicating dial 50 to facilitate the setting of pin 47.

Referring to Figures 13 and 14, an alternative and preferred form of press tool is therein illustrated. The tool is indicated generally at 67 and includes a pair of arms 68 and 69 pivoted together at 70. One end of each arm 68 and 69 has a pair of laterally extending jaws 71 for engagement

.ch one or other of the pair of shoulders 42 on arms 18 and 26. It will be apparent that the tool is operable in the conventional manner of a plier type of tool. The hand gripping portions 72 and 73 of the arms are preferably somewhat offset from the pivot 70 and jaws 71, as clearly shown in Figure 14. It will be apparent that, since the tool is operable directly by the hand of the user, it is unnecessary to provide a stroke-limiting stop since the operator will be able to "feel" the progress and conclusion of the stroke. However, a stop 74 may be provided on the arm 68 for engagement by the other arm to define an extreme limit of the stroke.

Means are preferably provided for defining the normal open or "at rest" position of the tool and comprises, in the embodiment shown, a coil spring 75 located in recesses 76 and 77 in the engaging inner surfaces of arms 68 and 69, respectively adjacent the pivot 70. It will be observed that the spring 75 will urge the arms 68 and 69 into open position wherein the recesses 76 and 77 are in registry, as shown in Figure 15. When the gripping portions 72 and 73 are moved towards each other, the recesses will move out of registry and compress the spring. When the gripping portions 72 and 73, are released the spring will move the arms 68 and 69 (with jaws 71) back to the position shown in Figure 14.

To facilitate handling of the clip-driving assembly 1, the two half sections thereof may be temporarily connected together by means of a locking member, such as a spring clamp 61. The spring clamp is provided with a projecting piece 62 which, by means of its engagement with notches 63 in the sides of the fingers 8 and with opening 64 in the guide 2, is adapted to temporarily lock the sleeve 6 in its initial position on the guide 2,

as shown in Figure 1, and thus preclude premature ejection of the clips from the slots 5. The spring clamp is also provided with a lug 65 which serves as a means to facilitate removal of the spring clamp in order to unlock the sleeve at the appropriate time during the suturing operation. Another suitable form of temporary lock is shown in Figure 16 and consists of a removable short length of wire 78 threaded through small holes 79 in the sleeve 6 and corresponding holes in the guide 2.

To facilitate handling of the anvil member, the two half sections thereof may be temporarily connected together by means of a spring clamp of any conventional form.

In operation, and referring to Figure 1, a suitable length of the severed vessel 57 is first made free of surrounding tissue, and the two ends of the vessel are temporarily sealed by applying hemostatic clamps as indicated at 58.

The clip-driving assembly 1, locked in the initial position by the spring clamp and loaded with a complete set of clips, is mounted in holder 17, and the holder locked in gripping engagement therewith. Similarly, anvil member 12 is mounted in holder 25 which is locked in gripping engagement therewith. At this point the spring clamp is removed from the anvil member only. The ends of the severed vessel 57 are then respectively threaded through the clip-driving assembly and the anvil member, a short end portion of the vessel, as indicated at 59, being doubled back on the outer surface of the respective clip-driving assembly and anvil member.

In order to retain the everted ends of the vessel on the assembly 1 and anvil member 12 sharpened projections 60 are provided on the outer surfaces thereof.

The holders 17 and 25 are now connected together by means of the connectors 30 and the ends of the vessel brought into engagement as shown in Figure 1. At this point the spring clamp is removed from the clip-driving assembly 1. After the stop 49 has been adjusted to suit the wall thickness of the vessel, the press tool 38 is placed in the position shown in Figures 6 and 7 with jaws 41 in engagement with shoulders 42. The operating screw 43 is actuated to impart an inward driving stroke to assembly 1 and member 12. The clip ends thus pierce the contacting ends of the vessel and are clinched by engagement with the walls of anvil recesses 14 to fasten together the vessel ends. It will be understood that the holders 17 and 25, and their operating relation to each other, are such that, at the end of the clip driving stroke, when the assembly 1 and member 12 are separated by a distance slightly less than twice the thickness of the vessel wall, the adjacent faces thereof are closely parallel and concentric.

The apparatus is then withdrawn by first removing the press tool 38. The toggle mechanisms 21 and 29 are released and the holders 17 and 25 removed as a unit. The two parts of the anvil member 12 are then removed and the everted end of the vessel rolled off the driving assembly 1 and over the other everted end of the vessel. The two sections of the assembly 1 and the two hemostatic clamps 58 are now removed, thus completing the suturing operation.

It is important that the clips 9 adequately clamp, but do not crush, the vessel walls. It has been found that a clip, such as illustrated, with suitable control of its pressure stroke into the anvil recesses 14, and with use of a recess wall profile as illustrated, will be deformed into a clinched form such as shown in Figures 11 and 12, wherein

..e legs 10 do not exert an undue crushing action with respect to head 11 of the clip. However, it will be apparent that various other shapes of clips and of anvil recess profiles may be employed to achieve the desired purpose.

It is within the contemplation of the present invention to provide a series of clip-driving assemblies 1 and anvil members 12 of various sizes in order to meet varying conditions of use as normally encountered in suturing operations of the type described. The holding flanges 7 and 13 of such series may be of standardized dimensions in order to fit the jaws of holders 17 and 25 and the positioning bosses thereon.

It will be understood that, while the apparatus shown has been designed to employ a series of six clips, it would be a simple matter to design an apparatus for use with any desired numberof clips.

It will also be apparent that various forms of the press tool 38 or 67 may be employed to carry out its functions.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A suturing apparatus comprising a cylindrical clip-driving assembly having blood vessel-surrounding sections, a cylindrical anvil member having blood vessel-surrounding sections, a holder having a pair of pivotally mounted jaws removably engaging said clip-driving assembly, a second holder having a pair of pivotally mounted jaws removably engaging said anvil member, a connector releasably connecting together said holders to place said clip-driving assembly and said anvil member in axial alignment, said holders having limited swinging movement with respect to each other in the axial direction of said clip-driving assembly and anvil member, and a pressure-applying device removably engaging said holders to effect said limited swinging movement.

2. A suturing apparatus as defined in claim 1, said clip-driving assembly comprising a tubular guide, a sleeve reciprocally mounted on said guide, and a plurality of axially extending raised portions on the external surface of said guide forming a groove between each adjacent pair of said raised portions, said sleeve having a plurality of axially directed fingers each arranged to extend into one of said grooves, each said groove being arranged to receive a clip for driving engagement by one of said fingers.

3. A suturing apparatus as defined in claim 1, said clip-driving assembly comprising a tubular guide having on the external surface thereof a plurality of axially extending raised portions of T-shaped cross-section forming a T-shaped groove between each adjacent pair of said raised portions, and a sleeve reciprocally mounted on said guide

and having a plurality of axially directed fingers each arranged to extend into one of said grooves, each said groove being arranged to receive a clip for driving engagement by one of said fingers.

4. A suturing apparatus as defined in claim 2, said anvil member having a plurality of clip-receiving recesses in one end thereof, each said recess having a bottom wall for engagement with the ends of a clip to impart a clinching movement thereto.

5. A suturing apparatus as defined in claim 1, each said holder having a pair of arms swingable to open and close said jaws, and mechanism connecting the free ends of said arms to lock said jaws in closed position.

6. A suturing apparatus as defined in claim 1, each said holder having a pair of arms swingable to open and close said jaws, and means for locking said arms in jaw-closing position, said connector comprising a snap fastener on each of the arms of one of said holders, each of the arms of the other of said holders having a socket receiving said snap fastener.

7. A suturing apparatus as defined in claim 5, said pressure applying device comprising a pair of arms pivotally connected together intermediate their ends, and jaws mounted on adjacent ends of said pivotally connected arms and each engageable with one of said holders to swing said holders towards each other, each said arm having a gripping portion for manual application of an inward stroke thereto and to said holders.

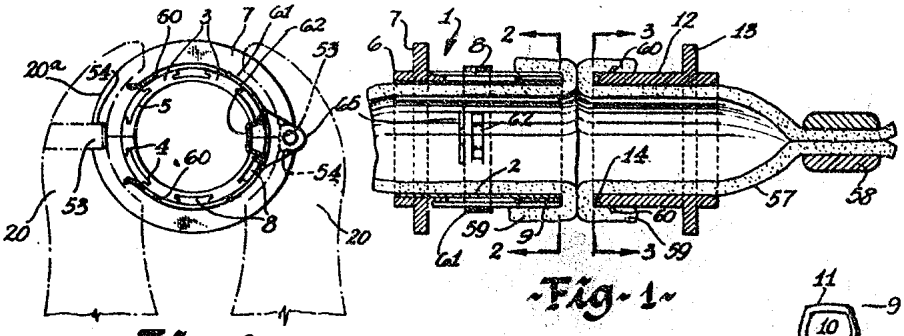
8. A suturing apparatus as defined in claim 7, including spring means mounted in said arms for urging said arms into open position.

9. A suturing apparatus as defined in claim 5, said pressure applying device comprising a pair of arms rockably connected together intermediate their ends, jaws mounted on adjacent ends of said rockably mounted arms and each engageable with one of said holders to swing said holders towards each other, an operating screw carried adjacent the other end of one of said rockably mounted arms and engaging the other of said rockably mounted arms to impart an inward swinging stroke to said holders, and a stop carried by one of said rockably mounted arms to limit the extent of said stroke.

10. A suturing apparatus comprising a cylindrical clip-driving assembly having blood vessel-surrounding sections, a cylindrical anvil member having blood vessel-surrounding sections, a holder having gripping jaws removably engaging said clip-driving assembly, a second holder having gripping jaws removably engaging said anvil member, a connector connecting together said holders to place said clip-driving assembly and said anvil member in axial alignment, said holders having limited movement with respect to each other in the axial direction of said clip-driving assembly and said anvil member, and a pressure-applying device removably engaging said holders to effect said limited movement.

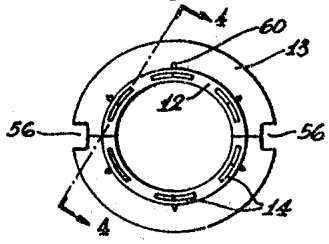
11. A suturing apparatus comprising a cylindrical clip-driving assembly having blood vessel-surrounding sections, a cylindrical anvil member having blood vessel-surrounding sections, a holder having gripping jaws engaging said clip-driving assembly, a second holder having gripping jaws engaging said anvil member, a connector connecting together said holders to place said clip-driving assembly and said anvil member in axial alignment, said holders having limited movement with respect to each other in the axial direction of said clip-driving assembly and said anvil member, and

a pressure-applying device engaging said holders to effect said limited movement.

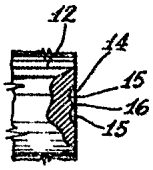


~Fig-1~

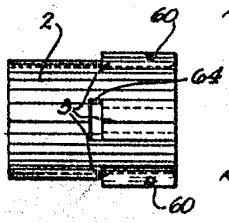
~Fig-2~



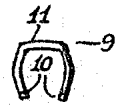
~Fig-3~



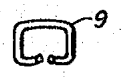
~Fig-4~



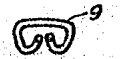
~Fig-5~



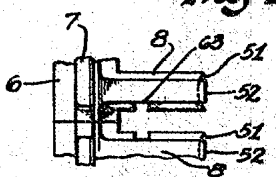
~Fig-10~



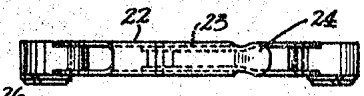
~Fig-11~



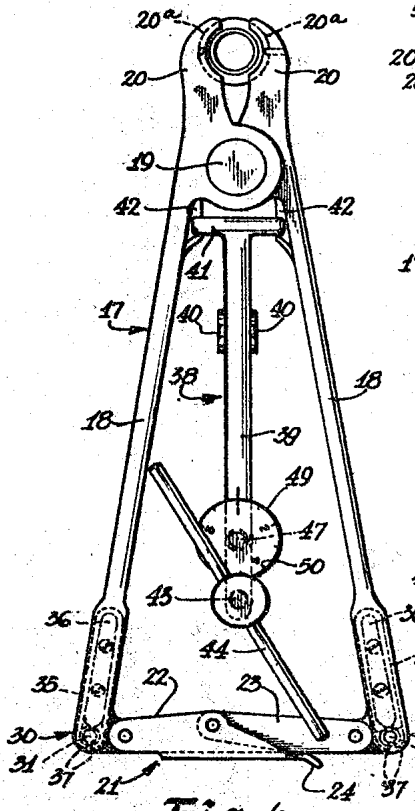
~Fig-12~



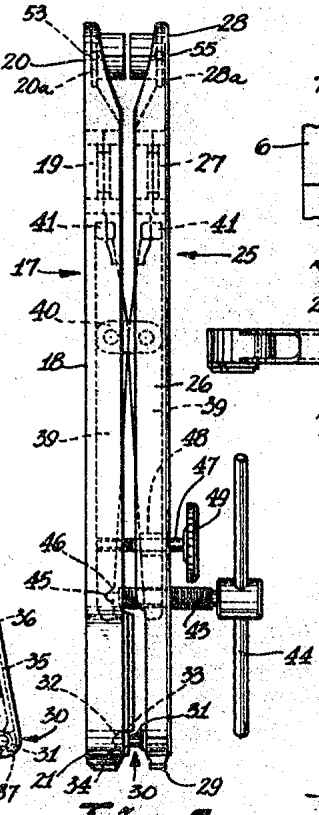
~Fig-8~



~Fig-9~



~Fig-6~



~Fig-7~

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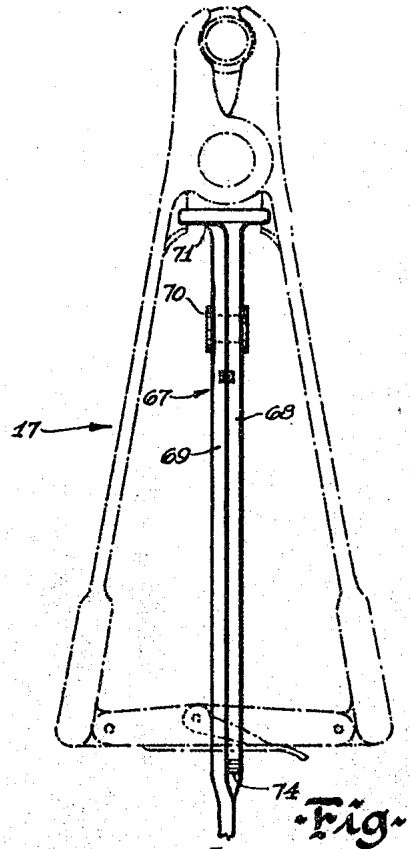

Fig. 13

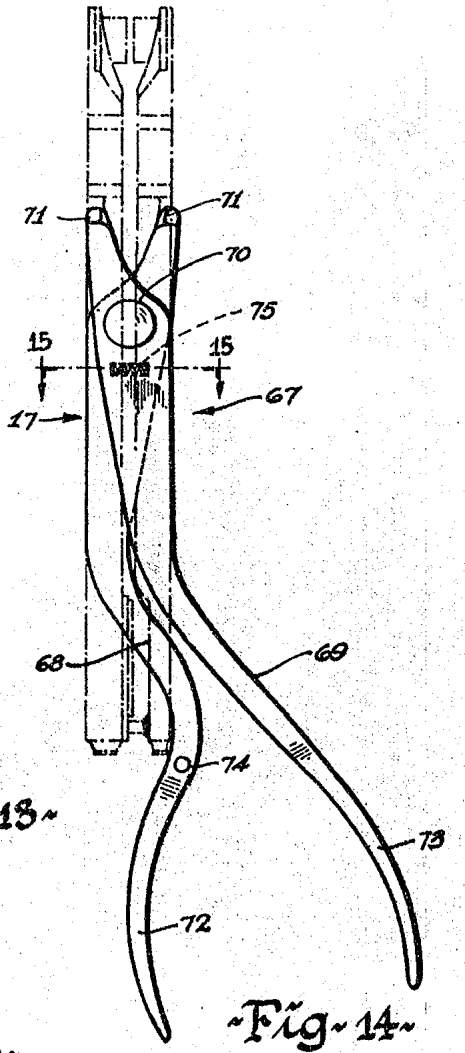

Fig. 14

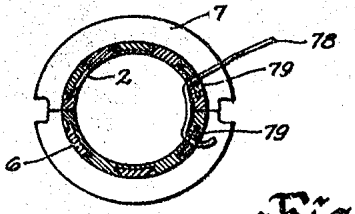

Fig. 16

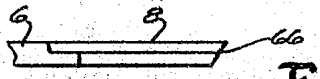

Fig. 17

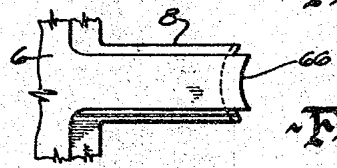

Fig. 18

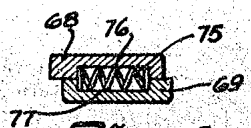

Fig. 15

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