# United States Patent [19]

**Razgulov et al.**

[11] **3,790,057**

[45] **Feb. 5, 1974**


[54] **SURGICAL INSTRUMENT FOR SUTURING BLOOD VESSELS WITH U-SHAPED STAPLES**


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[52] **U.S. Cl.** ..... **227/19**

[51] **Int. Cl.** ..... **A61b 17/12**

[58] **Field of Search** ..... 227/19, 108, 144, 152, 154



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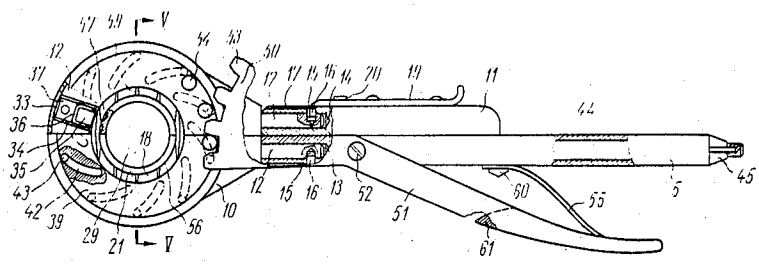
*Attorney, Agent, or Firm*—Holman and Stern



[57] **ABSTRACT**

A surgical instrument for suturing blood vessels with U-shaped staples, has two supporting semibushes whose cylindrical surface has depressions for staples to be deformed, and two staple semibushes that embrace the supporting semibushes from outside so that an annular gap is left therebetween to accommodate the walls of the blood vessel being sutured. The staple semibushes are provided with radial slots, wherein staple-magazines are movably mounted; the magazines have staple recesses and staple ejectors located inside said magazines. The instrument is provided with mechanical actuators to impart radial motion to the magazines and staple ejectors. The end of a blood vessel is everted as a cuff on the assembled supporting semibushes and on the blood-vessel end so everted, the other end of the blood vessel to be sutured on is disposed in overlapping relation, whereupon the staple semibushes are assembled embracing the overlapping region of the blood-vessel ends. Suturing is performed in a single motion by causing U-shaped staples to eject from the staple magazines. The ejected staples penetrate the overlapping walls of the blood-vessel and get deformed by impinging against the depressions on the supporting semibushes. Suturing performed, the semibushes are disassembled and the surgical instrument withdrawn.


**4 Claims, 9 Drawing Figures**



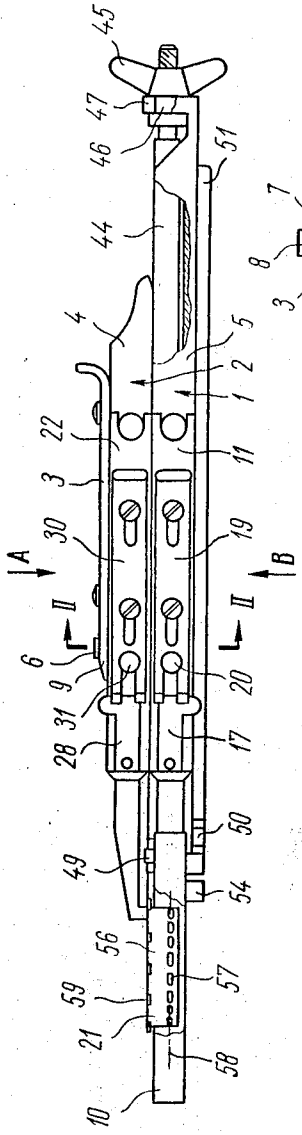


FIG. 1

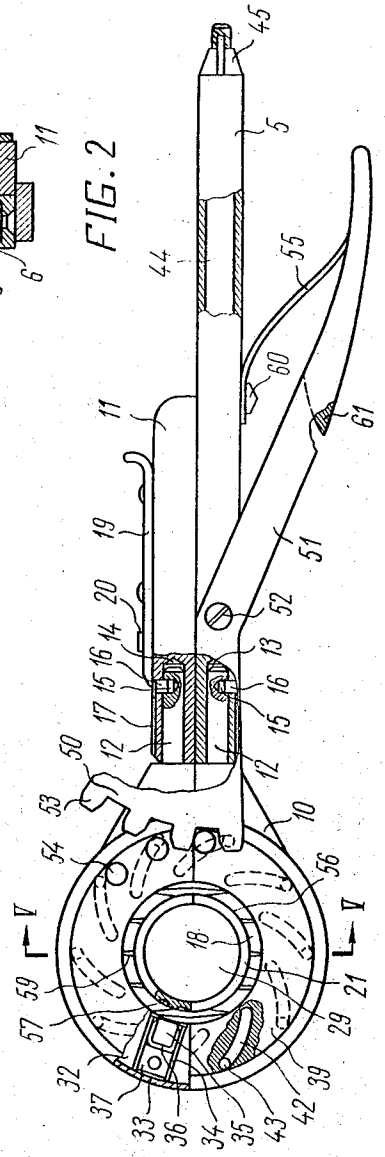


FIG. 2



FIG. 3

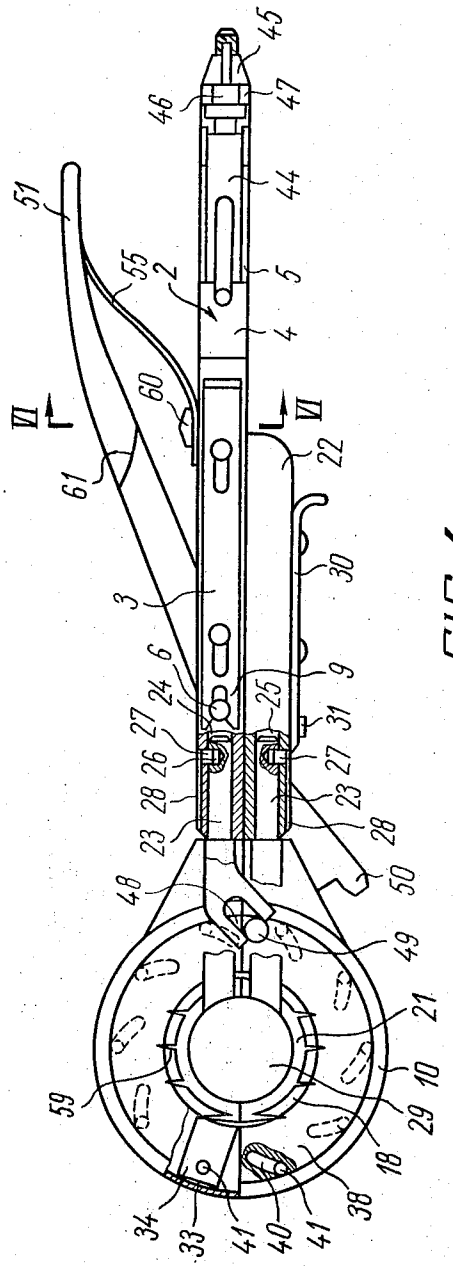

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FIG. 4

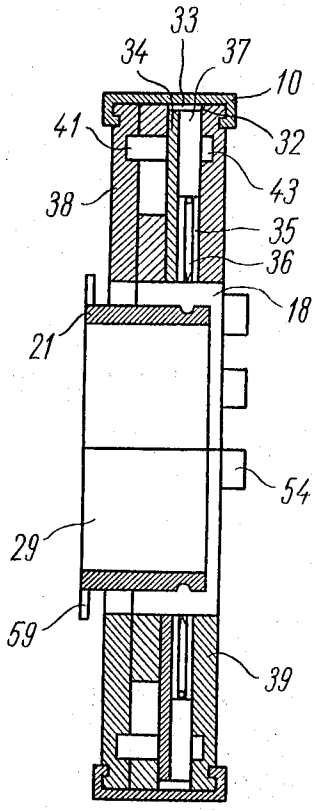


FIG. 5

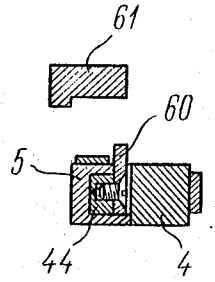


FIG. 6

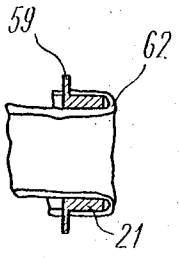


FIG. 7

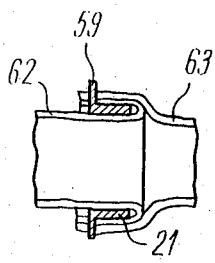


FIG. 8

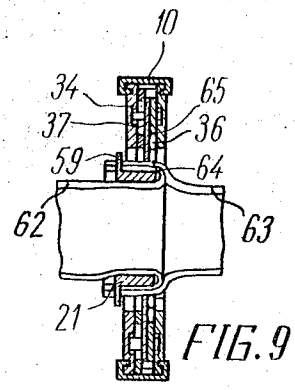


FIG. 9

# SURGICAL INSTRUMENT FOR SUTURING BLOOD VESSELS WITH U-SHAPED STAPLES

## BACKGROUND OF THE INVENTION

### Field of The Invention

The present invention relates generally to medical equipment and has particular reference to surgical instruments for suturing blood vessels using U-shaped staples which are applicable for suturing a variety of blood vessels such as veins, arteries, the aorta, etc., as well as other hollow organs of a living being.

### DESCRIPTION OF THE PRIOR ART

Known in the present-day surgical practice is a surgical instrument for suturing blood vessels.

Said known instrument consists of two parts, viz., a supporting body part and the other comprising staples.

The supporting part accommodates two interchangeable supporting semibushes having depressions adapted for bending the staples. One of the supporting semibushes is fixed on the supporting body, while the other, on a carrier strip. The supporting body and the carrier strip, when brought together, form the supporting part of the instrument, while the supporting semibushes in the assembled position form a cylindrical sleeve or bush, whose bore is adapted to accommodate the vessel being sutured.

The staple part comprises two interchangeable staple semibushes, of which one is fixed on a staple body and the other, on the carrier strip.

The staple body and the carrier strip, when brought together, form the staple part of the instrument, while the staple semibushes in the assembled position likewise form a cylindrical-shaped staple bush whose bore is adapted to accommodate the vessel being sutured.

Depressions for deforming and bending staples are located on an end face of the supporting semibushes. Located along the staple semibushes and parallel to the generatrix of the cylindrical surfaces thereof, are staple recesses open from the end face of the semibushes. Each of the stable recesses accommodates a U-shaped staple, whereas located therebehind is a staple ejector. The staple recesses in the staple bush are arranged quite similarly to those located on the end face of the supporting bush.

The supporting and staple parts of the instruments are interconnected through a special lock. With the supporting and staple parts interconnected, the supporting and staple bush are located with their end faces towards each other.

The distance between the end faces of the staple and supporting bushes which distance is essentially a suturing gap adjustable to suit the wall thickness of the vessel being sutured, is varied by means of the aforesaid lock interconnecting the staple and supporting parts of the instrument.

A reciprocating motion is imparted from the staple ejectors lengthwise of a staple recess by means of a a special lever.

The instrument has also two pinchcock clamps (also referred to as haemostatic forceps) to arrest blood flow and two collar clamps to retain the everted vessel ends on the supporting and staple bushes during stitching.

The known instrument operates as follows.

The vessel ends are freed from the surrounding tissues and exposed for a required length which depends upon the height of the supporting and staple bushes



next, one of the exposed ends of the blood-vessel is passed inside this supporting bush and everted thereupon as a cuff so as to lie as far as on the outside surface of the supporting bush, as feasible while the other blood vessel end is placed ina similar way on the staple bush. To prevent the vessel ends from slipping off said bushes, said ends are secured by collar clamps. To arrest hemorrhage, the blood vessel is to be compressed by pinch-cock clamps. At this juncture the supporting and staple parts of the instrument are joined together and closed with the lock which is also adapted to adjust the suturing gap.

Then, levers are pressed down to actuate the staple ejectors to drive out the staples from their recesses.

The legs of the staples penetrate the walls of the vessels being sututed and, while thrusting against the bottom of the depressions made in the supporting bush, are bent to assume the B-shape, thus firmly uniting the vessel ends.

A suture is applied in a single motion throughout the vessel circumference, and this cuts down the suture application time by 15–30 minutes. After having been sutured, the vessel ends are released from the pinchcock and collar clamps, and the staple and supporting bushes are disassembled into semibushes by removing the corresponding carrier strips, whereupon the entire instrument can be taken off the sutured vessel.

However, the above-described instrument suffers from the following disadvantages.

The staple recesses are arranged lengthwise of the generatrix of the bush, i.e., square with the end face thereof, with the result that the height of the staple bush is determined by the height of a staple and the length of the staple ejector, and, therefore, cannot be reduced with the given design particularities of the instrument.

This results in a relatively large height of the staple and supporting bushes of the known instruments, which requires that the vessel ends to be exposed for a considerable length, viz., up to 50–60 mm which in some cases proves to be impracticable.

Moreover, the known instruments fail to stitch vessels in excess of 20 mm in diameter, since further increase in the diametral size of bushes under the adapted design of instrument will result in a higher stitching forces to be applied which, in turn, would result in an impermissible increase in the overall dimensions of the instrument.

## SUMMARY OF THE INVENTION

It is an essential object of the present invention to provide an instrument for suturing blood vessels with U-shaped staples the instrument being simple in design, able to perform single-motion suturing and having the staple and supporting bushes adapted to stitch blood vessels which need be separated from the surrounding tissues as little as possible. The instrument besides, is capable of suturing vessels in excess of 20 mm in diameter and feature relatively small overall dimensions.

Said object is accomplished due to the fact that a surgical instrument for suturing blood vessels with U-shaped staples in accordance with the invention, comprises two supporting semibushes having depressions for causing staples to bend, one of said supporting semibushes being fixed to a supporting body, while the other, to a carrier strip, the two semibushes being adapted, when assembled together, to form a support-

ing part of the instrument having a cylindrical bore for the vessel accommodating being sutured; the instrument further includes two staple semibushes adapted to accommodate staples and staple ejectors, one of the staple semibushes being fixed to the staple body and the other, to the carrier strip, the two staple semibushes, when assembled and brought together, forming a staple part of the instrument with a cylindrical bore for the vessel being sutured. According to the invention the staple semibushes embrace the supporting semibushes from outside so that an annular gap is left in between the staple and supporting semibushes, said gap being adapted to accomoodate the walls of the vessel being sutured, staple bending depressions being provided on the outside cylindrical surface of the supporting semibushes; in said staple semibushes radial slots located against the respective depressions in the supporting semibushes are provided, said radial slots accommodating movable holders or magazines provided with staple recesses and staple ejectors located inside said magazines. The magazines and staple ejectors are provided with mechanical actuators to impart radial motion thereto, said actuators being made as the magazine and staple semirings, respectively which can swivel relative to the staple semibushes and are interconnected with the actuating mechanisms thereof; said semirings have sloping grooves adapted to receive shanks provided on the magazines and staple ejectors so that swivelling motion of the magazine and staple semirings are transformed into radial reciprocating motion of the magazines and staple ejectors, respectively.

The actuating mechanism of the magazine semirings may be made as a rod movable lengthwise the staple body, said rod having a thread cut on one of its ends, the thread being adapted to interact with a sliding nut, whereas a sloping groove is made on the other end of said rod to interact with a projection made on one of the magazine semirings.

It is desirable that the actuating mechanism of the staple semirings be made as a swivel toothed segment provided with an actuating lever, said segment being adapted to interact by means of its teeth with the projections provided on the staple semirings.

It is expedient that the instrument be provided with a self-acting limiter of the staple ejectors, to coordinate the movement of the staple ejectors with that of the magazines, said limiter being made as a stop fixed on the movable rod and adapted to interact with a curvilinear surface of a projection provided on the actuating lever.

The herein-proposed design of the instrument makes it possible to reduce the axial dimension of bushes several times, whereby the instrument disclosed herein is rendered much more versatile and its capabilities are much higher as compared to the heretofore known suturing instruments, mainly since the instrument of the invention requires that the ends of the vessels being sutured be exposed only for short lengths viz., 5–10 mm as against 50–60 mm, in the case of prior art instruments. This advantageous feature makes the present instrument applicable for suturing especially the inferior vena cava which has hitherto been impracticable due to too short ends of the latter.

Another advantageous feature of the herein proposed instrument resides also in the fact that it involves the evertion of only one vessel end which is of special importance when badly sclerotic vessels are to be sutured.

Besides, the construction of the proposed instrument is sturdy enough to make use of bushes having such a size that enables vessels of 2 to 40 mm in diameter to be sutured.

The instrument is simple in operation and maintenance and features the suture application time equal to 1–2 min., a sutured being applied in a single-motion procedure.

## BRIEF DESCRIPTION OF THE DRAWINGS

Given below are a number of exemplary embodiments of the present invention to be considered in conjunction with the appended drawings, wherein:

FIG. 1 is a schematic, partly sectional view of a surgical instrument for suturing blood vessels with U-shaped staples, according to the invention;

FIG. 2 is a section taken along the line II—II in FIG. 1;

FIG. 3 illustrates the surgical instrument as viewed in the direction the arrow A in FIG. 1;

FIG. 4 illustrates the surgical instrument as viewed in the direction of the arrow B in FIG. 1;

FIG. 5 is an enlarged-scale in section taken along the line V—V in FIG. 3;

FIG. 6 is a section taken along the line VI—VI in FIG. 4;

FIG. 7 illustrates the manner of fixing a cut end of a blood vessel to the supporting semibushes, according to the invention;

FIG. 8 shows two ends of blood-vessels to be sutured, assembled on the supporting semibushes, according to the invention; and

FIG. 9 diagrammatically illustrates the application of the staple semibushes to the supporting semibushes carrying the ends of the blood vessel fixed thereto, according to the invention.

Now referring to the Figures, the instrument described herein consists essentially of two major components, viz., a staple part 1 (FIG. 1) and a supporting part 2. Both the instrument parts are interconnected through a locking strip 3 movably mounted on a supporting body 4 of the supporting part 2 so as to be free to reciprocate lengthwise of the supporting body 4.

A rod 6 is made fast and secured on a staple carrying body 5.

When the staple and supporting parts of the instrument are brought together the rod 6 enters a hole 7 (FIG. 2) in the supporting body 4 so that the end of the rod 6 having grooves 8 provided therein, is free to extend beyond the supporting body 4.

A bifurcated end 9 (FIG. 1) of the locking strip 3 enters the grooves 8 (FIG. 2), thus locking the staple part 1 (FIG. 1) and the supporting part 2 together.

The staple part 1 comprises two interchangeable staple semibushes 10 (FIG. 3), of which one is fixed on the staple body 5 and the other, on a carrier strip 11. The staple semibushes 10 are fixed by means of shanks 12 which enter holes 13 and 14 in the staple body 5 and in the carrier strip 11 respectively. Each shank 12 has grooves 15 adapted to interact with a projection 16 of a blade spring 17.

The staple body 5 and the carrier strip 11 together with the staple semibushes 10 when brought together, form the staple part 1 of the instrument having a cylindrical bore 18 formed by the staple semibushes 10 and

adapted to accommodate the vessel being sutured. The interchangeable staple semibushes **10** may have any suitable outside diameter and a required size of the bore **18** so that their size is to be selected to suit the cross sectional dimensions of the vessel being sutured.

The staple body **5** and the carrier strip **11** are interlinked by means of a locking strip **19** mounted on the carrier strip **11** and adapted to interact with a rod **20** which is fixed on the staple body **5** and passes through a hole (not shown) in the carrier strip **11**.

Interlocking of the staple body **5** with the carrier strip **11** occurs in a way similar to that described above with reference to the interlocking of the staple part **1** and the supporting part **2** of the instrument.

Two interchangeable supporting semibushes **21** are fixed on the supporting part **2** (FIG. 4) of the instrument. Of these, one interchangeable supporting semibush **21** is fixed on the supporting body **4** and the other, on the carrier strip **22**.

The supporting semibushes **21** are fixed by means of shanks **23** which enter holes **24** and **25** in the supporting body **4** and the carrier strip **22**, respectively. Each of the shanks **23** has a groove **26** adapted to interact with a projection **27** of a blade spring **28**.

The supporting body **4** and the carrier strip **22** with the supporting semibushes **21**, when brought together, form the supporting part **2** of the instrument with a cylindrical bore **29** formed by the semibushes **21** and adapted to accommodate the blood vessel being sutured.

The interchangeable supporting semibushes **21** may have any suitable outside diameter and a required size of the bore **29** so that their size is to be selected to suit the diameter of the blood vessel being sutured.

The supporting body **4** and the carrier strip **22** are interconnected by a locking strip **30** mounted on the carrier strip **22** and adapted to interact with a rod **31** which is fixed on the supporting body **4** and passes through a hole (not shown) in the carrier strip **22**.

Interlocking of the supporting body **4** and the carrier strip **22** occurs as the afore-described interlocking of the staple part **1** and the supporting part **2** of the instrument.

When the staple part **1** and the supporting part **2** of the instrument get interlocked, the staple semibushes **10** embrace from outside the supporting semibushes **21** so that an annular gap is formed in between the staple semibushes **10** and the supporting semibushes **21**, said gap being adapted to accommodate the walls of the blood vessel being sutured. Provision is made on an end face **32** (FIGS. **3, 5**) of the staple semibushes **10** for radial slots **33**, which accommodate movably mounted magazines **34** with recesses **35** for staples **36**, said magazines incoproating thereinside ejectors **37** to eject the staples **36**.

The magazines **34** and the staple ejectors **37** are provided with mechanical actuators for being moved in radial directions. Said mechanical actuators are made as magazIne semirings **38** (FIGS. **4, 5**) and staple semirings **39** (FIGS. **3, 5**), both being made swivel with respect to the staple semi-bushes **10**. The magazine semirings **38** (FIG. **4**) have sloping grooves **40** adapted to receive shanks **41** provided on the magazines **34**, whereas the staple semirings **39** (FIG. **3**) have sloping spiral grooves **42** adapted to receive shanks **43** provided on the staple ejectors **37**. Swivelling motion of the magazine semirings (FIG.4) results in radial motion of the magazines **34**, while swivelling motion of the staple semirings **39** (FIG. **3**) causes radial motion of the staple ejectors **37**.

The mechanical actuator of the magazine semirings **38** (FIG. 4) is made as a rod **44** movable lengthwise the staple body **5** and mounted in a slot thereof.

One end of the rod **44** is provided with a helical thread adapted to interact with a sliding nut **45** (FIGS. **1, 4**) having an annular recess **46**, whereby said nut gets engaged with an edge **47** of the staple body **5** and is thus prevented from moving lengthwise of the latter.

The other end of the rod is provided with a sloping groove **48** (FIG. 4) adapted to interact with a projection **49** provided on the magazine semiring **38**.

The mechanical actuator of the staple semirings **39** (FIG. 3) is made as a swivel toothed segment **50** provided with an actuating lever **51** rotatable about a pivot pin **52**.

The toothed segment **50** is adapted to interact by its teeth **53** with projections **54** which are affixed on the staple semirings **39**. To bring the staple semirings into the initial position, provision is made for a return spring **55**.

The interchangeable supporting semibushes **21** (FIGS. **4, 6**) are of the following design:

On a cylindrical surface **56** (FIGS. **1, 3**) of the supporting semibushes **21** are provided depressions **57** for staples to bend so that a centre line **58** (FIG. **1**) thereof makes right angles with the generatrix of the cylindrical surface **56**.

When the staple part **1** and the supporting part **2** (FIG. 3) of the instrument are interlocked, the supporting semibushes **21** (FIG. 3) enter the stable semibushes **10**, with the result that the depressions **57** are positioned exactly against the radial slots **33**.

To fix the end of the blood vessel being sutured the supporting semibushes **21** are provided with lugs **59**.

To avoid breakage of the staple ejectors **37** (FIG. 3) which might result from an unlimited travel of the actuating lever **51**, as well as to coordinate the movement of the staple ejectors **37** with that of the magazines **34** which are advanced towards the supporting semibushes **21** when the suturing gap is to be varied to suit the wall thickness of the tissues being sutured, provision is made in the instrument for a self-acting limiter of the movement of the staple ejectors **37**, fashioned as a stop **60** (FIGS. **3, 4, 6**) fixed in position on the movable rod **44** and adapted to co-operate with the curvilinear surface of a projection **61** provided on the actuating lever **51** (FIG. 4).

The herein-proposed surgical instrument operates as follows.

The supporting semibushes **21** and the staple semibushes **10** corresponding thereto, are selected to suit the dimensions of the blood-vessel to be sutured, whereby the outside diameter of the joined semibushes **21** be approximately equal to the vessel inside diameter.

Then one of the supporting semibushes **21** is mounted on the supporting body **4** and the other, on the carrier strip **22** so that the shank **23** of the supporting semi-bushes **21** enters the holes **24** and **25**, and, the projections **27** of the blade springs **28** engage the grooves **26**.

Further, the carrier strip **22** gets interlocked with the supporting body **4** and fixed in that position by the locking strip **30**.

As a result, the supporting semibushes **21** form the cylindrical bore **29** for the blood vessel being sutured to be accommodated.

One of the staple semibushes **10**, like the supporting semibushes **21**, is mounted on the staple body **5**, while the other semibush **10** is mounted on the carrier strip **11**.

Thereupon, an exposed vessel end **62** (FIG. 7) is passed inside the supporting semibushes **21** and everted as a cuff whose edges are pinned down on the lugs **59**.

The other vessel end **63** (FIG. **8**) is folded back over the previously formed cuff and is pinned down on the same lugs **59**.

The staple body **5** (FIG. 1) is interlocked with the supporting part **2**.

After that, the carrier strip **11** is brought together with the staple body **5** and locked by means of the locking strip **19**.

The vessel ends **62** and **63** (FIG. 9) approximated by their inner membranes (intima-to-intima), are arranged in between the supporting semibushes **21** and the staple semibushes **10**.

An extent of gap required for suturing is set by rotating sliding nut **45** (FIG. 4) which causes the rod **44** to move towards the staple semibushes **10**. As a result, the projection **49** made fast on the magazine semiring **38**, slides along the sloping groove **48** of the rod **44**, thus making a rotational movement with respect to the staple semibushes **10**.

At the same time the magazine semirings **38** acting through the sloping grooves **40**, cause the shanks **41** of the magazines **34** to move in radial directions along the radial slots **33**. Rotation of the sliding nut **45** is not ceased until an edge **64** (FIG. 9) of the magazine **34** gets in touch with the vessel wall. At this moment the staple ejector **37** is to be advanced to such a position that its edge **65** coincides with the edge **64** of the magazine **34** which is necessary for the staple to be completely driven out to obtain good-quality suture.

When setting the suturing gap, the stop **60** fixed on the rod **44** is moved along with the rod **44** (FIG. 4) towards the staple semibushes **10**, to assume a difinite position with respect to the body **5** which depends upon the adapted suturing gap.

Suturing is performed in a single stage by pressing down the actuating lever **51** (FIG. 3).

This results in the swivel toothed segment **50** turning around the pivot pin **52**, thereby causing the teeth **53** of the segment **50** to act upon the projections **54** of the staple semirings **39**, thus causing the latter to turn with respect to the staple semibushes **10**.

The staple semirings **39** act through the sloping grooves **42** upon the shanks **43** of the staple ejectors **37**, thus causing the latter to move lengthwise of the staple recesses **35** of the magazines **34**.

The ejectors **37** drive out the staples **36** the prongs of which penetrate the vessel walls and, upon thrusting against the bending depressions **57**, get bent to assume the required B-shape, thus firmly securing the vessel ends.

The actuating lever **51** (FIG. 4) keeps moving until the projection **61** provided on the actuating lever, engages the stop **60** located on the movable rod **44**.

The curvilinear surface of the projection **61** is so selected that the stop **60** should meet the projection **61** just at the moment when the edge **65** (FIG. 9) of the staple ejector **37** coincides with the edge **64** of the magazines **34**. As a result, the staple **36** will thus be driven out completely from the magazine **34**, whereby high-quality single-motion suturing of the vessel blood vessel ends is performed round the entire circumference of the assembled ends of the blood vessels.

What is claimed is:

**1.** A surgical instrument for suturing to join cut ends of a blood-vessel with U-shaped staples, comprising: a supporting part of the instrument; a carrier strip on said supporting part; first and second supporting semibushes, said first supporting semibush being fixed to said supporting body and said second semibush being fixed to said carrier strip, said first and second semibushes, when assembled forming a cylindrical bore for accommodating the blood-vessel being sutured; depressions for deforming free ends of the U-shaped staples being formed on an outside cylindrical surface of each said supporting semibush; a staple part of the instrument comprising a staple body and a carrier strip; first and second staple semibushes of which the first one is fixed to said staple body and the second secured to said carrier strip, said first and second staple semibushes when assembled concentrically of said supporting semibushes from outside forming an annular gap in between said supporting and said staple semibushes to accommodate the walls of the blood-vessel being sutured; radial slots in said staple semibushes located opposite said respective depressions in said supporting semibushes; magazine means located in said radial slots for storing and holding U-shaped staples; staple recesses in said magazines; staples ejectors accommodated in said magazines; two magazine semirings formed to swivel with respect to the staple semibushes; sloping grooves in said magazine semirings; shanks on said magazines adapted to interact with said sloping grooves so that swivelling motion of said magazine semirings results in radial reciprocating motion of said magazines, manually actuated means for imparting swivelling motion to said magazine semirings; and means to impart radial motion to said staple ejectors comprising two staple semirings made to swivel with respect to the staple semibushes; sloping grooves in said staple semirings; shanks on said staple ejectors adapted to interact with said grooves in the staple semirings so that swivelling motion of said staple semirings results in radial reciprocating motion of said staple ejectors, and manually actuated means for imparting swivelling motion to said staple semirings.

**2.** A surgical instrument as claimed in claim **1**, wherein said means for imparting swivelling motion to said magazine semirings comprises: a rod movable lengthwise of said staple body: threading provided on one end of said rod; a sloping groove at the other end of said rod; a nut provided to co-operate with said threading; and a projection formed on one of said magazine semirings and adapted to interact with said sloping groove at said other end of said rod.

**3.** A surgical instrument as claimed in claim **1**, wherein said means for imparting swivelling motion to said staple semirings comprises: a manually actuated pivoted lever having a toothed segment; and projection means on said staple semirings for co-operating with said toothed segment.

**4.** A surgical instrument as claimed in claim **2**, further provided with a self-acting limiter of motion of said staple ejectors to coordinate the motion of said staple ejectors with that of said magazines, said limiter comprising a stop fixed on said rod and a projection having a curvilinear surface and located on the actuating lever, said projection being adapted to engage said stop.

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