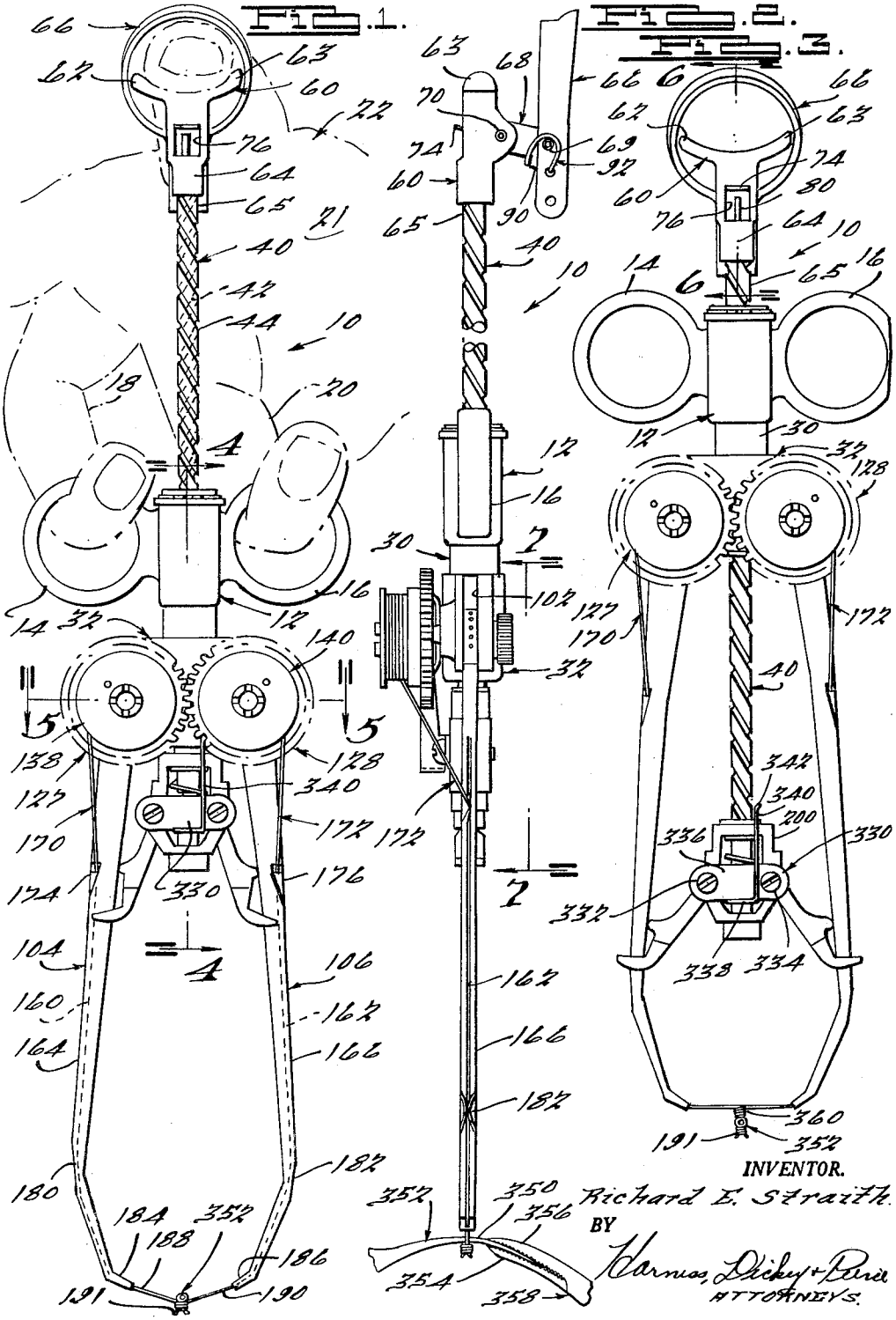
Dec. 11, 1962 R. E. STRAITH 3,067,748

SURGICAL INSTRUMENT

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SURGICAL INSTRUMENT

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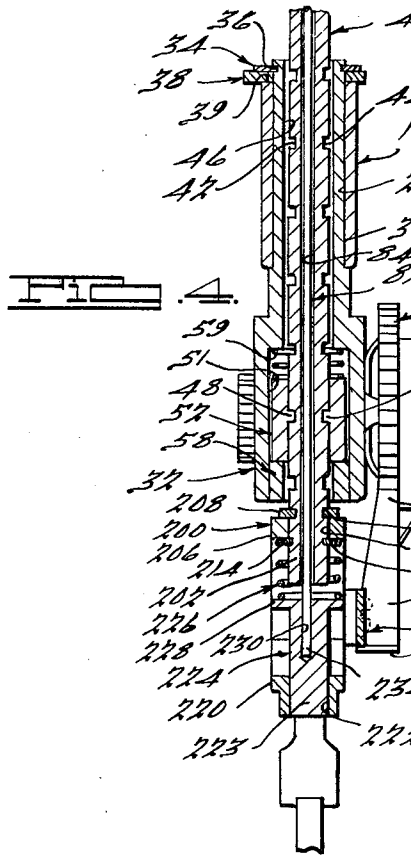


FIG. 4.

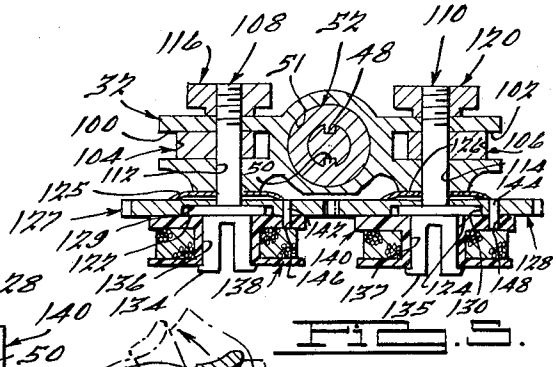


FIG. 5.

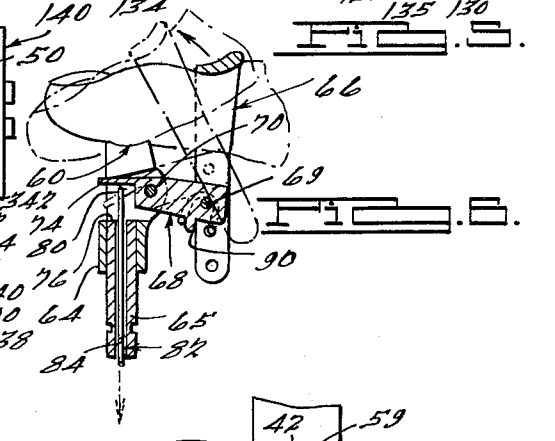


FIG. 6.

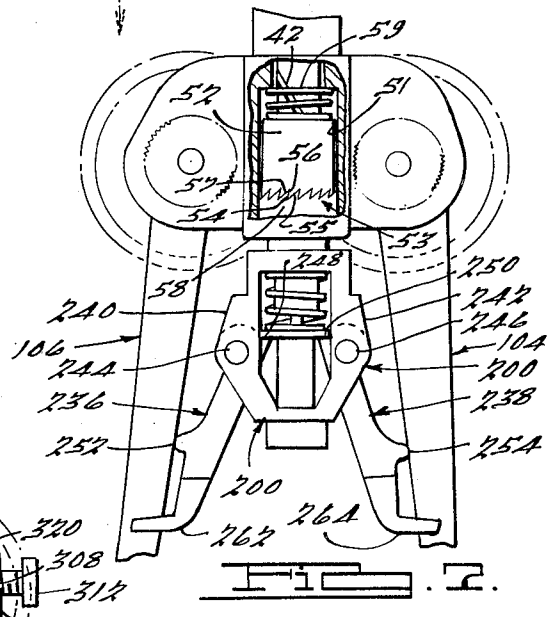


FIG. 7.

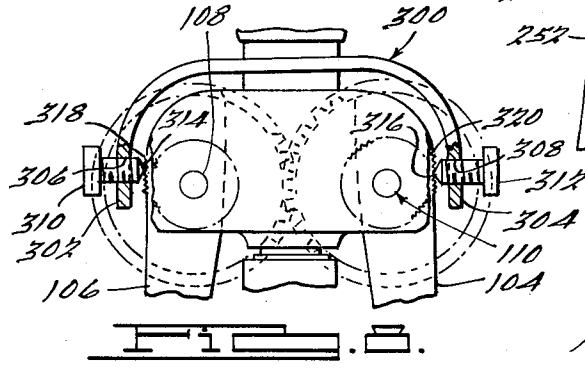


FIG. 8.

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SURGICAL INSTRUMENT

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19 Claims. (Cl. 128—326)

This invention relates generally to a surgical instrument, and more particularly to an instrument for tying off severed blood vessels.

Blood vessels severed during the course of a surgical operation are often tied off by gripping the severed end of the blood vessel between the jaws of a hemostat, drawing a ligature about the blood vessel, and weaving the free ends of the ligature into a knot. However, as frequently occurs in surgery of the abdomen, tonsillectomies and the like, blood vessels must be tied off in relatively inaccessible anatomical parts, thereby requiring that the knot be tied blindly.

The surgical instrument of the present invention materially increases the speed and sterility of a surgical operation by tying off such a severed blood vessel in a new and novel manner. The instrument requires the use of only one hand, thereby freeing the other hand of the surgeon for manipulation of the hemostat or to otherwise aid in providing access to the severed blood vessel. Further, the surgical instrument of the present invention does not require the surgeon to insert or work with his hands adjacent the severed blood vessel, thereby permitting the hands of the surgeon to remain exteriorly of the surgical cavity.

Accordingly, one object of the present invention is an improved surgical instrument.

Another object is a surgical knot-tying instrument.

Another object is a surgical knot-tying instrument that is fully operable by one hand.

Another object of the present invention is a surgical knot-tying instrument that is capable of tying a knot to any desired degree of tightness.

Another object is a surgical tying instrument that permits the tying of a surgical knot without the operator's hand entering into the surgical cavity.

Other objects and advantages of the present invention will become apparent from the following description wherein reference is made to the drawings, in which:

FIGURE 1 is a front elevational view of an exemplary embodiment of the surgical instrument of the present invention, shown in position preparatory to tying a surgical knot;

FIG. 2 is a side elevational view of the surgical instrument;

FIG. 3 is a front elevational view of the surgical instrument after completion of a knot;

FIG. 4 is a cross-sectional view taken substantially along the line 4—4 of FIG. 1;

FIG. 5 is a cross-sectional view taken along the line 5—5 of FIG. 1;

FIG. 6 is a cross-sectional view taken substantially along the line 6—6 of FIG. 3;

FIG. 7 is a fragmentary side elevation of the surgical instrument, enlarged for clarity; and

FIG. 8 is a fragmentary view of an alternative means of biasing the arms of the instrument to an open position.

A surgical knot-tying instrument **10**, in accordance with an exemplary embodiment of the present invention, comprises a handle member **12** having a pair of finger loops **14** and **16** for the acceptance of any two fingers, for example fingers **18** and **20** on a hand **21** of an operator (not shown). The handle member **12** has a vertical central bore **24** therein (FIG. 4) for the acceptance of an upstanding shank **30** on a frame member **32**. The shank portion **30** of the frame **32** is rotatable within the bore **24** in the handle **12** and is restrained from axial movement

with respect thereto as by a conventional key washer **34** that is engaged in a complementary annular slot **36** in the shank **30** of the frame **32**. A suitable thrust washer **38** is interposed between an upper end face **39** of the shank **30** and the key washer **34** to provide a relatively large bearing surface therebetween.

A reciprocable tubular shaft **40**, having a pair of helical grooves **42** and **44** therein, is disposed within a central bore **46** in the frame member **32**. The helical grooves **42** and **44** slidably accept complementary keys or detents **48** and **50** in a rotatable clutch member **52** that is journaled in a bore **51** in the frame member **32**. Therefore, movement of the shaft **40** axially with respect to the clutch member **52** effects relative rotation therebetween. Because the shaft **40** is restrained from rotation with respect to the handle **12**, as will be discussed, axial movement of the shaft **40** effects rotation of the clutch member **52** with respect to the frame **32**.

The lower edge face of the clutch member **52** has a plurality of ratchet teeth **53** thereon, each of which has an axially extending surface **54** and a transverse sloping surface **55**. The surfaces **54** and **55** are engageable with complementary surfaces **56** and **57** on a fixed clutch member **58**. The fixed clutch member **58** is held within the bore **51** as by a press fit.

The rotatable clutch member **52** is normally biased against the fixed clutch member **58** as by a helical compression spring **59**. Upon upward movement of the shaft **40** with respect to the frame member **32**, the complementary surfaces **55** and **57** on the clutch members **52** and **58**, respectively, coact to permit rotation of the clutch member **52** with respect to the clutch member **58** by camming the clutch member **52** axially upwardly against the spring **59** with a ratcheting action, thereby permitting the shaft **40** to move longitudinally of the bore **46** without effecting rotation of the frame **32**. Upon downward movement of the shaft **40** within the bore **46**, rotation of the clutch member **52** is transmitted to the clutch member **58** by engagement of the surfaces **54** and **56** thereon, respectively, thereby effecting relative rotation between the shaft **40** and the frame **32**.

A thumb yoke **60** comprising a pair of oppositely directed thumb supports **62** and **63** and a downwardly extending tubular portion **64**, for the acceptance of an upper end portion **65** of the shaft **40**, is secured to the shaft **40**, as by welding.

A thumb ring **66** is pivotally supported on a radial arm **68** as by a transverse pin **69**. The arm **68** is supported for rotation with respect to the thumb yoke **60** by a transverse pin **70**. An end portion **74** of the arm **68** extends into a central cutout portion **76** in the thumb yoke **60** for engagement with an upper end portion **80** of a cam rod **82**. The cam rod **82** is disposed within a hollow central portion **84** in the shaft **40** and is slidable axially thereof for a reason to be discussed. It is to be noted that counterclockwise rotation of the arm **68** as seen in FIGURE 2, about the pin **70** effects downward movement of the cam rod **82** due to engagement of the end portion **74** of the arm **68** with the upper end **80** of the cam rod **82**. The thumb ring **66** is normally biased to an index position against a stop **90** on the arm **68** as by a spring **92**.

The frame member **32** has a pair of vertically oriented slots **100** and **102** (FIG. 5) on opposite sides of bore **46** therein for acceptance of a pair of downwardly extending arms **104** and **106**. The arms **104** and **106** are supported for rotation within the slots **100** and **102** by a pair of transverse arm support pins **108** and **110**, respectively, that extend through suitable aligned bores **112** and **114** in the frame member **32**. The pins **108** and **110** are retained within the bores **112** and **114** as by a pair of knurled pin retainers **116** and **120**. The pins **108** and **110** have radial flanges **122** and **124** there-

on, respectively, that, in conjunction with suitable spring washers 125 and 126, function as clutch surfaces to restrict rotation of a pair of gears 127 and 128. The flanges 122 and 124 are accepted in complementary recesses 129 and 130 in the gears 127 and 128.

The pins 108 and 110 have axially split end portions 134 and 135 that are acceptable in the central apertures 136 and 137 of a pair of wire spools 138 and 140. The gears 127 and 128 are provided with index pins 142 and 144, respectively, that are engageable in complementary apertures 146 and 148 in the spools 138 and 140, respectively, thereby to effect positive rotation of the spools 138 and 140 upon rotation of the gears 127 and 128. It is to be noted that the gears 127 and 128 are meshed for simultaneous opposite rotation for a reason to be discussed.

The downwardly extending arms 104 and 106 have longitudinally extending grooves 160 and 162 in the outer faces 164 and 166 thereof, respectively, for the acceptance and guidance of suitable wires 170 and 172. The wires 170 and 172 are normally coiled on the spools 138 and 140, respectively, and are guided into the grooves 160 and 162 after being unwound from the spools 138 and 140 by a pair of wire guides 174 and 176 that are bent inwardly of the grooves 160 and 162, respectively. The grooves 160 and 162 have crimped portions 180 and 182, respectively, that positively retain the wires 170 and 172 therein.

The lower end portions 184 and 186 of the arms 104 and 106 are folded toward one another for the guidance of the end portions 188 and 190 of the wires 170 and 172, respectively. It is to be noted that the end portions 188 and 190 of the wires 170 and 172 are initially twisted into a knot 191 at a point approximately midway between the end portions 184 and 186 of the arms 104 and 106, thereby to join the wires 170 and 172 into what is effectively a continuous wire, opposite end portions of which are supported by the arms 104 and 106 and spools 138 and 140, respectively.

A cam frame 200 is mounted for rotation on a lower end portion 202 of the shaft 40 (FIG. 4). The lower end portion 202 of the shaft 40 extends through a bore 204 in an upper end wall 206 of the frame 200 and is secured thereto as by a pair of spring retainers 208 and 210 that are seated in complementary annular grooves 212 and 214 in the end portion 202 of the shaft 40.

A lower end wall 220 of the cam frame 200 has a central bore 222 therein for the acceptance of a lower end portion 223 of a tubular cam member 224. The cam member 224 is slidable axially of the bore 222 and is normally biased downwardly therein by a helical compression spring 226 that extends between the upper end wall 206 of the cam frame 200 and a radial flange 228 on the cam member 224. The cam member 224 has a central bore 230 therein for the acceptance of a lower end portion 234 of the cam rod 82.

A pair of cam fingers 236 and 238 are mounted for rotation on the opposite side walls 240 and 242 of the cam frame 200 as by a pair of transversely extending pins 244 and 246. The cam fingers 236 and 238 have cam surfaces 248 and 250, respectively, that are engageable with the bottom side of the radial flange 228 on the cam member 224. Because the cam member 224 is normally biased downwardly, as seen in the drawings, the cam fingers 236 and 238 are normally biased in the clockwise and counterclockwise direction, respectively, as seen in FIGURE 3.

The cam fingers 236 and 238 have cam lobes 252 and 254 thereon, respectively, that are engageable with the arms 106 and 104, respectively, to normally bias the arms 106 and 104 apart. The cam fingers 236 and 238 are retained in transverse engagement with the arms 106 and 104, respectively, by forked end portions 262 and 264 thereon, respectively.

Upon axial movement of the shaft 40 with respect to the frame 32, the frame 200 and cam fingers 236 and 238 move longitudinally of the arms 104 and 106. Because the spring 226 maintains a normal downward bias on the cam member 224, the fingers 236 and 238 normally tend to bias the arms 104 and 106 apart.

As shown in FIG. 8, the arms 104 and 106 may be additionally biased apart as by a spring member 300 having downwardly depending arms 302 and 304. The arms 302 and 304 have threaded bores 306 and 308 therein for the acceptance of a pair of suitably threaded thumb screws 310 and 312. The thumb screws 310 and 312 have sharpened points 314 and 316, respectively, that are engageable in suitable ones of a plurality of detents 318 and 320 on the arms 104 and 106, respectively. Because the opposed pairs of the detents 318 and 320 are at different distances radially of the pins 108 and 110, respectively, the effective bias of the spring 300 can be varied by engaging the pointed end portions 314 and 316 of the screws 310 and 312 in any desired ones of the detents 318 and 320, respectively. Additionally, the effective bias of the spring 300 can be varied by advancement of the thumb screws 310 and 312.

A wire feeding mechanism 330 (FIG. 3) is secured to the cam frame 200 as by a pair of machine screws 332 and 334. The feeding mechanism 330 comprises a base portion 336, a lower upstanding portion 338, and a finger 340 that extends generally parallel to the shaft 40. An upper end portion 342 of the finger 340 is engageable with the gear 128, upon retraction of the shaft 40, to effect rotation of the gear 128. Because the gears 127 and 128 are meshed, rotation of the gear 128 effects a similar rotation of the gear 127 in the opposite direction. In this manner, upon each retraction of the shaft 40, the gears 127 and 128 are rotated one angular increment, thereby feeding an increment of wire from the spools 138 and 140.

The surgical instrument 10 of the present invention is prepared for use by initially twisting the end portions 188 and 190 of the wires 170 and 172, respectively, to form the initial twist 191. As best seen in FIG. 2, a severed end portion 350 of a blood vessel 352 is gripped between the jaws 354 and 356 of a hemostat 358 and drawn between the arms 104 and 106 of the instrument 10 so that the initial twist 191 underlies the end portion 350 of the blood vessel 352.

To accomplish the tying operation, the shaft 40 is retracted or moved upwardly as seen in the drawings with respect to the frame 32. This retraction is accomplished without effecting rotation of the frame 32 and its associated structure due to free-wheeling of the clutch member 52 with respect to the clutch member 58. The blood vessel 352 is then tied off by biasing the shaft 40 downwardly, as by the surgeon moving his thumb 22 downwardly with respect to his fingers 18 and 20. Due to locking engagement of the clutch members 52 and 58 upon downward movement of the shaft 40, the frame 32 and arms 104 and 106 are rotated with respect to the handle portion 12. Rotation of the arms 104 and 106 effects a twisting of the portions 188 and 190 of the wires 170 and 172 to form a twist 360 on the opposite side of or above the blood vessel 352 (FIG. 3). Each downward movement of the shaft 40 increases the number of coils in the twist 360. Any desired number of reciprocable movements of the shaft 40 may be effected to give additional turns to the twist 360.

Control of the tension on the portions 188 and 190 of the wires 170 and 172 is provided so that the surgeon can control the tightness of the twist 360 formed about the blood vessel 352. Controlled tensioning of the twist 360 is effected by flexing the thumb 22 upwardly in the counterclockwise direction (FIG. 6) about the thumb yoke 60. This movement of the thumb 22 effects counterclockwise rotation of the arm 68, as seen in FIGURE 2, about its pin 70, whereupon the end portion 74 of the arm 68 biases the cam rod 82 downwardly. Upon down-

ward movement of the cam rod **82**, the lower end portion **234** thereof biases the cam member **224** downwardly. Downward movement of the cam member **224** biases the cam fingers **236** and **238** apart through engagement of the radial flange **228** on the cam member **224** with the cam surfaces **248** and **250** on the cam fingers **236** and **238**, respectively. Divergence of the cam fingers **236** and **238** biases the arms **106** and **104** apart through the cam lobes **252** and **254**. In this manner the surgeon can control the tightness of the knot tied about the blood vessel **352** by controlling tension in the portions **188** and **190**.

Upon completion, the twist **360** is preferably cut in half, leaving a plurality of coils to secure the knot about the blood vessel **352** and preparing the instrument for the next knot-tying operation.

While it will be apparent that the embodiments of the invention herein disclosed are well calculated to fulfill the objects of the invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. A surgical instrument for tying off a severed blood vessel comprising a handle, a frame rotatable with respect to said handle, means on said frame for supporting the end portions of a wire so as to expose an intermediate portion of the wire for placement on one side of the blood vessel, means on said frame for tensioning the wire, the spacing of said handle, frame and wire supporting means longitudinally of the axis of rotation of said frame being relatively constant, and means for effecting rotation of said frame with respect to said handle to reverse the end portions of said wire with respect to said intermediate portion thereof to effect a twist in said wire on the side of the blood vessel opposite to said one side.

2. A surgical instrument for tying off a severed blood vessel comprising a handle, a frame rotatable with respect to said handle, means on said frame for supporting the end portions of a wire so as to expose an intermediate portion thereof, the spacing of said handle, frame and wire supporting means longitudinally of the axis of rotation of said frame being relatively constant, means for applying tension to said intermediate portion of wire, and means for reversing the end portions of said wire with respect to said intermediate portion to effect a twist in said wire.

3. A surgical instrument for tying off a severed blood vessel comprising a handle, a frame member, supported by and rotatable with respect to said handle, a pair of elongated arms pivotally supported on said frame member for rotation about spaced generally parallel axes, means on said arms for supporting the end portions of a wire so as to expose an intermediate portion thereof, the spacing of said handle, frame and wire supporting means longitudinally of the axis of rotation of said frame being relatively constant, means for tensioning said intermediate portion of wire, and means for rotating said frame member with respect to said handle thereby to rotate one end portion of said wire about the other end portion of said wire to effect a twist in said wire.

4. A surgical instrument for tying off a severed blood vessel comprising a handle, grippable by one hand of an operator, means supported by said handle and rotatable with respect thereto for supporting the end portions of a wire so as to expose an intermediate portion thereof for placement on one side of the blood vessel, the spacing of said handle, frame and wire supporting means longitudinally of the axis of rotation of said frame being relatively constant, and means reciprocable with respect to said handle for rotating said supporting means with respect to the intermediate portion of said wire to effect a twist in said wire on the side of the blood vessel opposite from the one side.

5. A surgical instrument in accordance with claim 4 wherein said reciprocable means is movable with respect to said handle by movement of one digit with respect to another digit on one hand of an operator.

6. A surgical instrument for tying off a severed blood vessel comprising a handle, pair of generally parallel arms supported by said handle and rotatable with respect thereto, said arms including means for supporting the end portions of a wire so as to expose an intermediate portion thereof, the spacing of said handle and wire supporting means being relatively constant longitudinally of the axis of rotation of said arms upon rotation thereof, means for biasing said arms away from each other to tension said intermediate portion of wire, and means for rotating one end portion of said wire about the other end portion thereof and with respect to said handle to effect a twist in said wire.

7. A surgical instrument for tying off a severed blood vessel comprising a handle, pair of generally parallel arms supported by said handle and rotatable with respect thereto, said arms including means for supporting the end portions of a wire so as to expose an intermediate portion thereof for placement on one side of the blood vessel, and means for rotating said arms about a common axis and with respect to said intermediate portion of wire and handle to effect a twist in said wire on the side of the blood vessel opposite from the one side, the spacing of said handle and intermediate portion of wire being maintained relatively constant upon rotation of said arms.

8. A surgical instrument for tying off a severed blood vessel comprising handle means, a pair of arms rotatably coupled to said handle at one end, and having means at the other ends thereof, respectively, for supporting the end portions of a wire so as to expose an intermediate portion of the wire for placement on one side of the blood vessel, the spacing of said handle and intermediate portion of wire being maintained relatively constant upon rotation of said arms and means movable with respect to said handle for rotating said arms with respect to said handle and the intermediate portion of said wire to effect a twist in said wire on the side of the blood vessel opposite from the one side.

9. A surgical instrument for tying off a severed blood vessel comprising a handle, a pair of generally parallel arms having means at one end for supporting an end portion of a wire so as to expose an intermediate portion of the wire for placement on one side of the blood vessel, frame means rotatably coupled to said handle for supporting the other end of each of said arms, means restraining said frame from axial movement with respect to said handle, and means for rotating said frame and said arms with respect to said handle about a common axis generally normal to the intermediate portion of said wire to effect a twist in said wire on the side of the blood vessel opposite from the one side.

10. A surgical instrument for tying off a severed blood vessel comprising a pair of arms for supporting the end portions of a wire so as to expose an intermediate portion of the wire for placement on one side of the blood vessel, and means for rotating one end portion of said wire about the other end portion thereof to effect a twist in said wire on the side of the blood vessel opposite from the one side comprising a frame member for the support of said arms having a central bore therein for the acceptance of a reciprocable shaft, said shaft having a helical groove therein, and means within the bore acceptable in said helical groove for effecting rotation of said frame and arms upon movement of said shaft axially of the bore in said frame member.

11. A surgical instrument for tying off a severed blood vessel comprising a handle, a frame member supported by said handle for rotation about a first axis and restrained from axial movement with respect to said handle, a pair of elongated arms on said frame member having opposed end portions for supporting a wire generally normal to said first axis, and means engageable with said

frame member to effect rotation thereof with respect to said handle to twist said wire.

12. A surgical instrument for tying off a severed blood vessel comprising a handle, a frame member supported by said handle for rotation about a first axis, a pair of elongated arms supported by said frame member for rotation about spaced parallel axes generally normal to said first axis, means engageable with said frame to effect rotation thereof with respect to said handle, means on said engageable means for normally biasing said arms apart, and means on said arms for supporting a wire with a portion thereof exposed, the spacing of the exposed portion of said wire and said handle being relatively constant longitudinally of the axis of rotation of said frame upon rotation thereof.

13. A surgical instrument for tying off a severed blood vessel comprising a handle having a central bore, a frame member supported for rotation about the axis of the bore in said handle and restrained from axial movement relative to said handle, a pair of elongated arms on said frame extending generally parallel to the axis of the bore in said handle and supported for rotation about spaced axes extending generally normal to the axis of the bore, means reciprocable within the bore in said handle for effecting rotation of said frame member with respect to said handle, means on said reciprocable means for normally biasing said arms apart, and means on said arms for supporting a wire with a portion thereof exposed for placement on one side of the severed blood vessel, reciprocation of said reciprocable means effecting a twist in said wire on the side of the blood vessel opposite from the one side.

14. A surgical instrument for tying off a severed blood vessel comprising a handle, a pair of elongated arms supported by said handle for rotation with respect thereto, means on said arms for supporting a wire so that an intermediate portion of the wire is exposed for placement on one side of the severed blood vessel, the spacing longitudinally of the axis of rotation of said arms of said handle and intermediate portion of wire being maintained relatively constant upon rotation of the wire portion relative to said handle, means for reversing the end portion of said wire with respect to the intermediate portion thereof to effect a twist in said wire, and means operable simultaneously with said reversing means for biasing said arms apart thereby to tension the twist in said wire.

15. A surgical instrument for tying off a severed blood vessel comprising a handle having a central bore and a pair of finger grips on opposite sides of the bore, a frame member extending into the bore and supported for rotation by said handle about the axis of the bore therein, said frame member having a bore therein coaxially related to the bore in said handle, a pair of elongated arms on said frame extending generally parallel to the axis of the bore in said handle and supported for rotation about spaced axes extending generally normal to the axis of the bore, an elongated shaft having a helical groove therein reciprocable within the bore in said frame, detent means on said frame engageable with the helical groove in said shaft for effecting rotation of said frame member with respect to said handle upon axial movement of said shaft in one direction with respect to said handle, means on said shaft for normally biasing said arms apart, selectively operable means on said shaft for supplementing the normal bias on said arms, and means on said arms for supporting a wire with a portion thereof exposed for placement on one side of the severed blood vessel comprising a pair of wire spools mounted for rotation coaxially with said arms, and a longitudinally extending groove in said arms for guiding said wire.

16. The instrument of claim 15 wherein said detent means includes a plurality of ratchet teeth to permit movement of said shaft opposite to said one direction without effecting rotation of said frame member.

17. The instrument of claim 15 wherein said spools are mounted on meshed gears for simultaneous opposite rotation.

18. The instrument of claim 17 wherein said shaft includes means engageable with one of said gears for effecting a predetermined rotation of each of said gears.

19. The instrument of claim 15 wherein said selectively operable means comprises a thumb yoke on said shaft, a cam rod disposed centrally of said shaft, and means cooperable with said thumb yoke for biasing said shaft axially of said shaft to increase the normal bias on said arms.

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