United States Patent [19]

Strekopytov et al.

[11] **3,822,818**

[45] **July 9, 1974**

[54] **SURGICAL INSTRUMENT FOR JOINING OSSEOUS TISSUES BY STAPLES**

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[22] Filed: **June 6, 1973**

[21] Appl. No.: **367,382**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 333,463, Feb. 20, 1973, abandoned, Continuation of Ser. No. 117,981, Feb. 23, 1971, abandoned.

[52] **U.S. Cl.** **227/124,** 227/19

[51] **Int. Cl.** **B25c 5/02**

[58] **Field of Search** 227/19, 124

[56] **References Cited**

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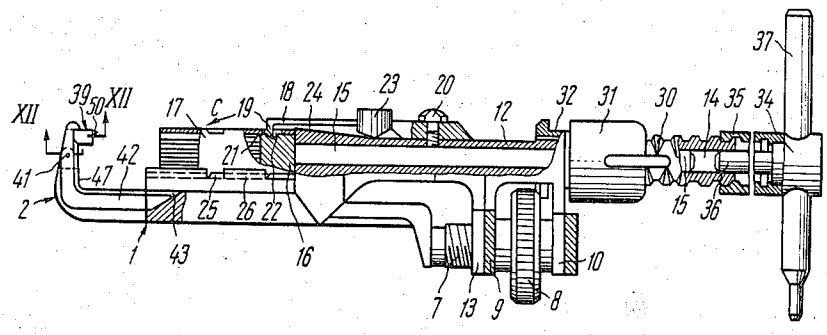
Primary Examiner—Granville Y. Custer, Jr.
Attorney, Agent, or Firm—Holman & Stern

[57] **ABSTRACT**

A surgical instrument for joining osseous tissue by V-shaped staples, comprising a bearing stock with a hook carrying a removable dies with depressions for bending staple legs; a staple carrier accomodating a staple magazine, said staple carrier being mounted in the guideways of the bearing stock so as to be moved freely therealong, and a staple ejector mounted in the staple carrier so as to move freely therealong the hook of the bearing stock comprising two component members movable lengthwise relative to each other permitting them to be disposed at different distances from the staple magazine, the dies likewise comprising two portions fixed respective to one of the respective component hook members and serving as bearing surfaces for the respective legs of the staple when the legs are being bent. whereby dimensional variations between osseous tissue being joined is compensated for while the portions and stabilized while being jointed; and the danger from trauma due to protruding sharp staple-edges is minimized.

10 Claims, 22 Drawing Figures



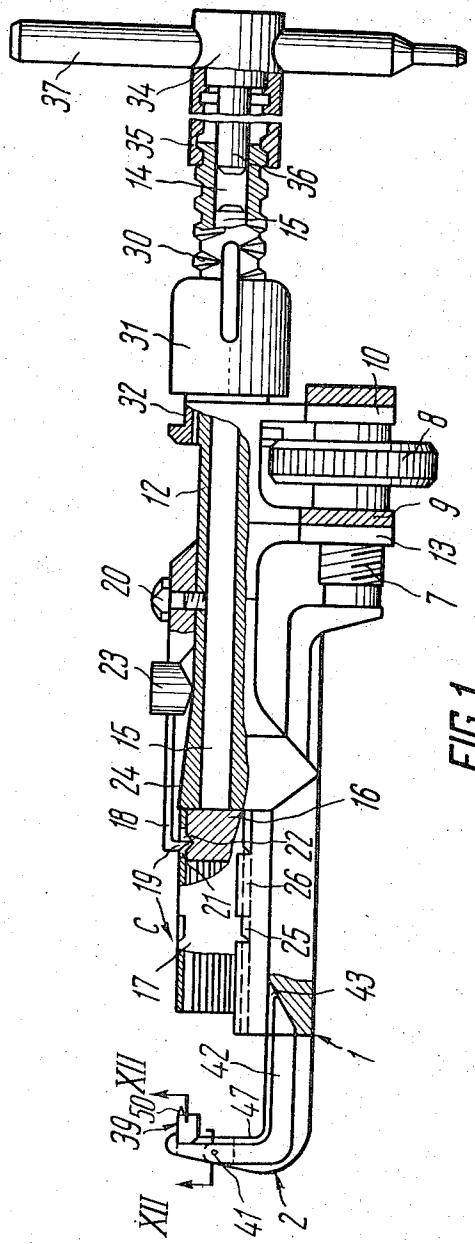

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FIG.1

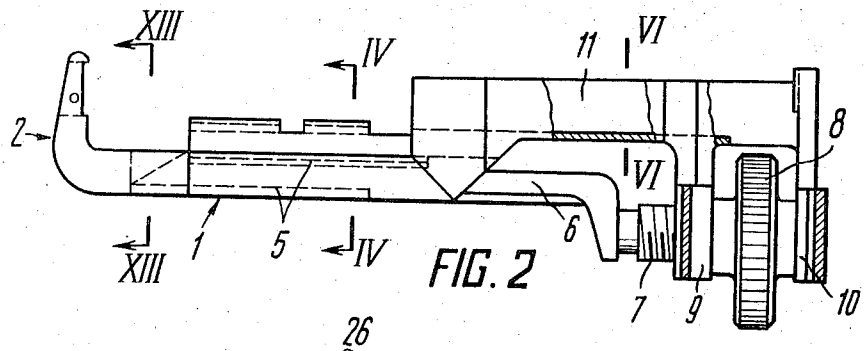


FIG. 2

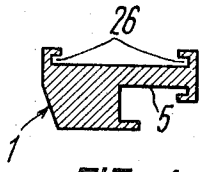
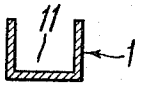


FIG. 4



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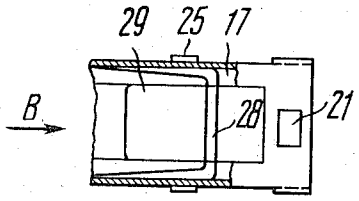

FIG. 10

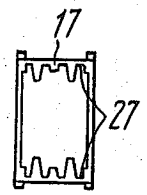

FIG. 11

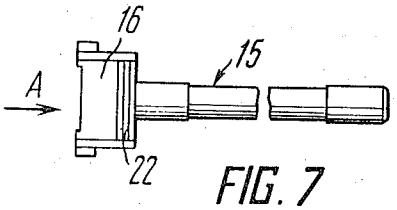

FIG. 7

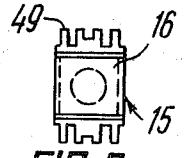

FIG. 8

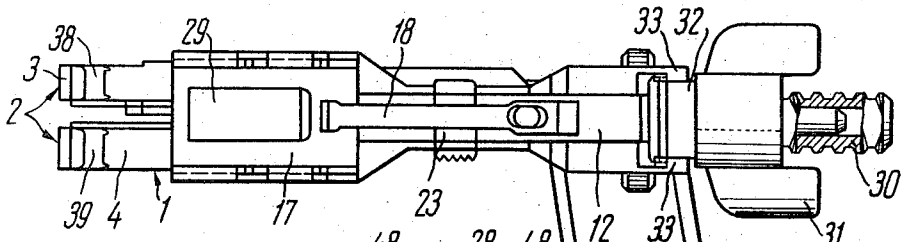

FIG.17

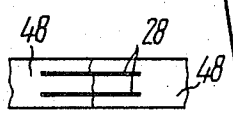

FIG.18

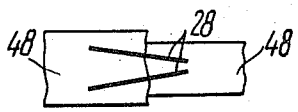

FIG.19

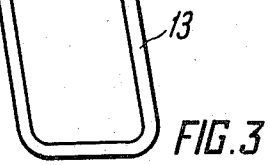

FIG.3

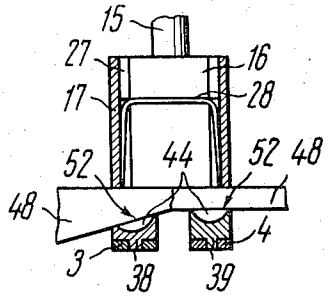

FIG. 9

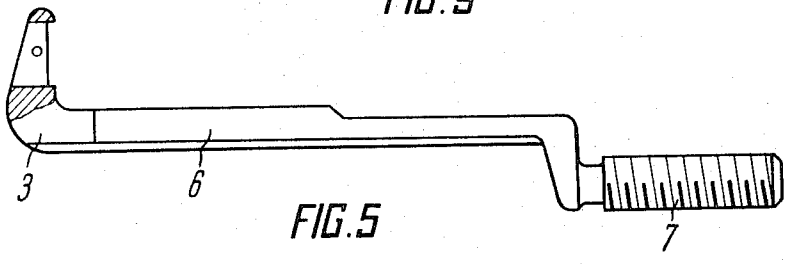

FIG. 5

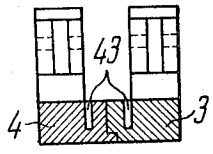

FIG. 13

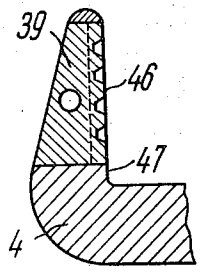

FIG. 16

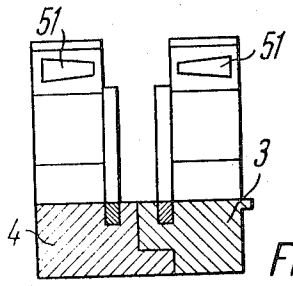

FIG. 20

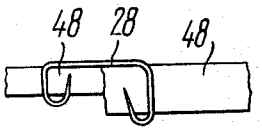

FIG. 21

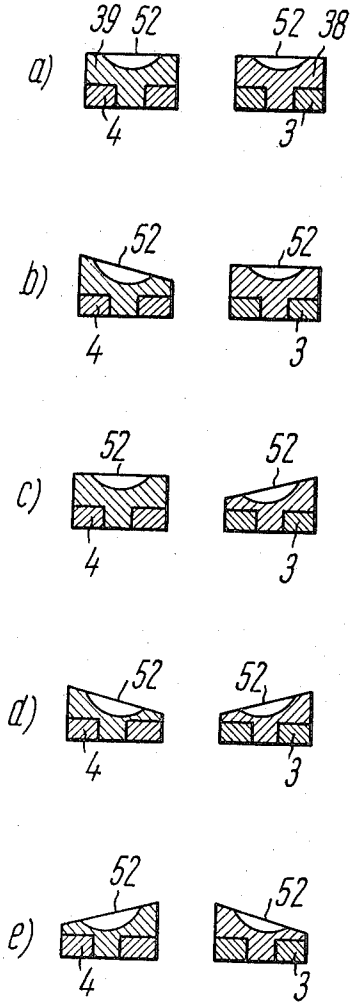

FIG. 22

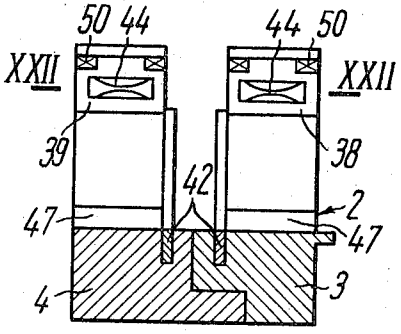

FIG. 14

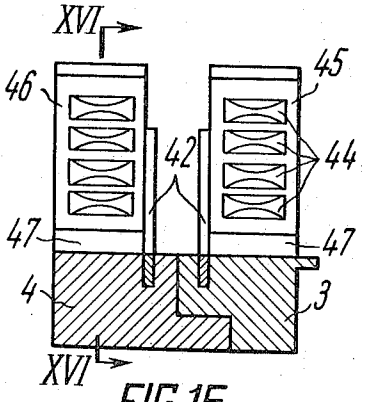

FIG. 15

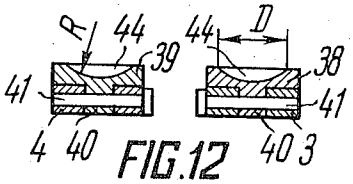

FIG. 12

SURGICAL INSTRUMENT FOR JOINING OSSEOUS TISSUES BY STAPLES

This is a continuation-in-part application of Application Ser. No. 333,463 filed Feb. 20, 1973 which in turn is a continuation of Application Serial No. 117,981, filed Feb. 23, 1971, both now abandoned.

FIELD OF THE INVENTION

The present invention relates to medical equipment, and more particularly to surgical instruments for staple suturing osseous tissues.

The surgical instrument of this invention may be employed as a means of suturing ribs, the collarbone, the mandible and other flat bones.

BACKGROUND OF THE INVENTION

Known in the present state of medical art is a surgical instrument for staple-joining of osseous tissues, comprising a bearing stock with an open longitudinal slot and a hook carrying a die or anvil with depressions for bending staple legs. In an open slot of the bearing stock there is mounted a staple carrier with a threaded tailpiece and a fixed handle. The staple carrier is hollow to accommodate a pusher or ejector with a head, the pusher being adapted to move lengthwise relative to the staple carrier. Mounted on the staple carrier is a replaceable staple magazine with staple slots or recesses, said staple magazine being adapted to receive the pusher head. The staple carrier is provided with a screw-and-nut actuator moving along the bearing stock.

While in operation, the instrument is so positioned by the surgeon so that the hook with the die is located under the bone fragments being sutured. Further, the surgeon rotates the nut of the staple carrier actuator to move the staple carrier forward toward the die, causing the magazine to approach the die and the bone fragments are clamped between the magazine and the die thereafter, the surgeon urges the ejector toward the die and the ejector drives the staples out from the magazine into the clamped bone fragments being joined.

The two staple legs pierce the osseous tissue and, upon engagement with die depressions, are deformed, thereby securing the bone fragments being joined.

The foregoing known instrument, however, potentially give use to from the following disadvantages:

When suturing bone fragments, both staple legs may be bent or deformed same length consequently, where the bone fragments being sutured differed in thickness, the staple leg that pierced the thinner fragment formed a hook-shaped projection which protruding beyond the osseous tissue and thus became a potential source of trauma to adjacent soft tissues, when employed to join adjacent bone fragments, the prior art instrument did not rule out the possibility of separation or relative movement, since the design of the instrument component elements failed to provide means for positively clamping the bony tissues while staple legs were driven therethrough and when being bent on the die. As a result, a staple leg might form a hook with a tapered point protruding beyond the surface of the osseous tissue and liable to traumatize the adjacent soft tissues. Moreover, the known instrument failed to provide an effective suturing of bone fragments of intricate configuration, such as those of the mandible.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide an instrument for joining osseous tissues by V-shaped staples of a design that makes it possible to securely join bone fragments, no matter whether their thickness is identical or different, and also to join bone fragments of intricate configuration, with the ends of the staple legs surely stabilizing the osseous tissue after having pierced the bone fragments being sutured when the staple legs are being bent on the die.

Accordingly, there is provided a surgical instrument for stapling osseous tissues by V-shaped staples, comprising a bearing stock, a hook at one end of the bearing stock, which hook is positioned transversely relative to the main portion of the bearing stock, a die for the staple legs to bend, which die is fixed on said hook and has a surface facing the main portion of the bearing stock and intended to be in contact with osseous tissue, depressions on said flat die intended to be in contact with the legs of said staples as the legs are being bent, a staple carrier mounted in the bearing stock and adapted to move therealong, a staple magazine attached to the staple carrier and having a surface facing said surface of the die which is intended to be in contact with osseous tissue, a staple pusher mounted in the staple carrier and adapted to move therealong, which staple pusher is designed to move toward the hook and eject the staples out of the magazine, wherein, the improvement in accordance with the invention, the hook of the bearing stock comprises two component members movable lengthwise relative to each other so that they can be set at different distances from the magazine, and the die is likewise composed of two portions fixed respectively on the different hook members and serving as bearing surfaces for the different legs of a staple as the latter is being bent, and as the staple carrier with the magazine fixed thereon moves along the bearing stock toward the hook one of the bone fragments being joined is clamped between the surface of the magazine and one of the die portions, whereas the other bone fragment being joined is clamped between the magazine surface and the other die portion, the hook members carrying the die portions fixed thereon being adapted to be set at different distances from the magazine.

It is preferred that the die depressions serving to bend the staple legs widen within the zone of their initial contact with the staple legs.

It is further desirable that the die members be replaceable and their surfaces in contact with osseous tissue slope relative to the magazine surface in contact with osseous tissue to provide for the closest possible contact of the die portions with the osseous tissue.

It is also recommended that the die depressions widen or expand from the bottom center toward the edges thereof, and that their longitudinal section be shaped as an arc of the same radius with a chord not longer than half the width of the staple.

It is also prefered that the die portions be fixed in the hook by projections formed on the surfaces thereof that are in contact with the hook so that the projections engage the respective slots on the surface of the hook of the bearing stock and be kept from disengaging therefrom by pins whereof the ends are interconnected with the bearing stock through a spring plate.

The die can be provided with a projection located at the hook end and having a depression for one of the staple leg to bend.

It is preferred that the die surfaces in contact with osseous tissue have lugs.

Each of the die portions may have at least four depressions which enable staple sutures to be obtained featuring different staple spacings and different slope angles of the staples with respect to one another.

The design of the proposed instrument permits joining bone fragments both of identical and different thicknesses as well as those of intricate configuration, with the staple leg ends positively transfixing the osseous tissue at bending after having pierced the bone fragments, thereby ensuring a smooth exposed of the staple suture and ruling out any possibility of traumatizing the adjacent soft tissues.

The staple sutures obtained with the instrument of this invention provide for a secure fixation of the bone fragments being joined and obviate any possibility of their disjunction or movability relative to each other, which cuts down the post-operative period considerably.

Depending on the width of the bone fragments being sutured, the design of the proposed instrument enables a variety of sutures to be applied, viz., single-staple; two-staple with various staple spacings; two-staple with the staples inclined to each other.

Additionally, the use of replaceable and interchangeable dies and various combinations thereof enables the surgeon to employ the instrument of this invention to carry out diverse surgical suture procedures on the collarbone, ribs or intricately configured mandible.

DESCRIPTION OF THE DRAWINGS

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. **1** is a general generally schematic side elevation view, partially broken away, of a surgical instrument for joining osseous tissues by V-shaped staples, according to the invention;

FIG. **2** is a view, partially cut away, of the bearing stock of the instrument of FIG. **1**, according to the invention;

FIG. **3** is a general plan view of the surgical instrument, according to the invention;

FIG. **4** is a section through the bearing stock taken on the line IV—IV of FIG. **2**;

FIG. **5** is an elevation of movable member of the hook of the bearing stock, according to the invention;

FIG. **6** is a section through the staple carrier slot taken on the line VI—VI in FIG. **2**;

FIG. **7** is a pusher of the surgical instrument, according to the invention;

FIG. **8** is a front elevational view taken along the arrow A of FIG. **7**;

FIG. **9** is a fragmentary, horizontal sectional view of the mutual arrangement of a die, a pusher head osseous tissues being joined and a staple magazine in the surgical instrument, according to the invention;

FIG. **10** is a fragmentary, partially broken away, horizontal section of the staple magazine of the surgical instrument, according to the invention;

FIG. **11** is an elevational view taken along the arrow B in FIG. **10**;

FIG. **12** is a section through the hook-dies at the bearing stock taken along the line XII—XII in FIG. **1**;

FIG. **13** is a section through the bearing stock taken along the line XIII—XIII in FIG. **2**;

FIG. **14** illustrates an on an enlarged scale embodiment of a die of the surgical instrument with one pair of depressions, according to the invention;

FIG. **15** is similar to FIG. **14** and illustrates an alternative embodiment of a die of the surgical instrument with four pairs of depressions, according to the invention;

FIG. **16** is a section through one die taken on the line XVI—XVI in FIG. **15**;

FIGS. **17, 18 19** illustrate different types of staple sutures obtained with the surgical instrument according to the invention;

FIG. **20** is similar to FIG. **14** and shows a modification of the die of the surgical instrument with one pair of depressions, according to the invention;

FIG. **21** shows diagrammatically in plan the joined bone fragments with a staple using a surgical instrument, according to the invention;

FIG. **22** (*a, b, c, d, e*) respectively are sections taken along the line XXII—XXII in FIG. **14** showing various combinations of dies in the surgical instrument, according to the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The proposed surgical instrument for joining osseous tissues by V-shaped staples comprises a bearing stock **1** (FIGS. **1, 2**) with a hook **2** at the end thereof, the hook **2** being positioned transversely relative to the main portion of the bearing stock **1** (see FIG. **3**). The hook **2** is composed of two members, viz., a movable member **3** (FIG. **3**) and a fixed member **4**. The movable member **3** is free to move lengthwise relative to the bearing stock and, inter alia, the fixed member **4**, in guideways **5** (FIGS. **2, 4**) of the bearing stock **1**.

The movable member **3** (FIG. **5**) has a stem **6** with a threaded tailpiece **7**. The threaded tailpiece **7** interacts with a nut **8** (FIGS. **1, 2**) located between projections **9** and **10** of the bearing stock **1**, which projections **9** and **10** prevent the nut **8** from moving lengthwise. Rotation of the nut **8** causes the movable member **3** (FIG. **3**) to move along the bearing stock **1** relative to fixed member **4**.

The bearing stock **1** also has an open longitudinal slot **11** (FIGS. **2, 6**) in which a staple carrier **12** (FIG. **1**) is mounted.

A lateral handle **13** is attached to the bearing stock **1** (FIGS. **1, 3**)

The staple carrier **12** has a longitudinal through hole **14** (FIG. **1**) housing a pusher **15** (FIGS. **1, 7**). The pusher **15** is free to move lengthwise along the staple carrier **12** (FIG. **1**) in the longitudinal through hole **14**.

The pusher **15** has a head **16** (FIGS. **1, 7, 8**) designed to drive the staples out from a magazine **17** (FIG. **1**), the latter mounted on the head **16** of the pusher **15** (FIGS. **1, 9**).

The surface of the magazine **17** which faces the hook **2** (FIG. **1**) is intended to be in contact with osseous tissue while the suturing proceeds.

The magazine 17 is also fixed on the staple carrier 12 by means of a flat spring 18 with a clamp 19 at the end thereof.

The flat spring 18 is anchored on the staple carrier 12 by a screw 20. The terminal lip 19 of the flat spring 18 enters through a hole 21 (FIGS. 1, 10) in the magazine 17 into a recess 22 (FIGS. 1, 7) formed in the head 16 of the pusher 15, thereby clamping together the magazine 17 (FIG. 1), the pusher 15 with the head 16 and the staple carrier 12.

A slide 23 is fitted onto the flat spring 18 (FIGS. 1, 3), which slide 23 is free to move along the spring 18, interacting, while moving, with a sloping cam surface 24 (FIG. 1) of the staple carrier 12, with the result that either the flat spring 18 is lifted, drawing the lip 19 out of the recess 22 and the aperture 21 of the magazine 17 to release the magazine 17 and the pusher 15, or to permit the flat spring 18 to lower, causing the lip 19 to clamp together the pusher 15 with the head 16, the staple carrier 12 and the magazine 17 in a manner described above. The magazine 17 has projections 25 (FIGS. 1, 10) intended to be in contact with grooves 26 (FIGS. 1, 4) of the bearing stock 1, which grooves 26 serve as guideways for the magazine 17 (FIG. 1) as it moves along the bearing stock 1.

The magazine 17 has slots 27 (FIGS. 9, 10) to hold V-shaped staples 28 (FIGS. 9, 10).

The magazine 17 has a hole 29 (FIGS. 3, 10), so that the magazine 17 can be visually observed for the presence of staples therein and the fracture zone is observed when osseous tissues are being sutured. The suturing zone is observed at an angle to the instrument as indicated by the arrow C in FIG. 1.

The staple carrier 12 incorporates a tailpiece 30 provided with both a right-hand and a left-hand thread over the entire length thereof. Screwed onto the tailpiece 30 is a nut 31 (FIGS. 1, 3) with a left-hand thread, which nut 31 has a stem 32 interacting with the flanged edges 33 (FIG. 3) of the bearing stock 1, said flanged edges 33 preventing the nut 31 from moving lengthwise along the bearing stock 1. Rotation of the nut 31 urges the staple carrier 12 along the bearing stock 1 in the longitudinal slot 11 (FIG. 2). Also screwed onto the tailpiece 30 (FIG. 1) is a handle bar 34 having a bush 35 with a right-hand inside thread. The handle bar 34 has a stem 36 attached to a handle 37 of the handle bar and disposed in coaxial relation to the bush 35 of the handle bar 34. The stem 36 is inserted into the longitudinal through hole 14 of the staple carrier 12. As the handle 37 of the handle bar 34 is turned the handle bar 34 is screwed onto the tailpiece 30, urging with its stem 36 the pusher 15 toward the hook 2 of the bearing stock 1 along the staple carrier 12.

The instrument of this invention also comprises a die for bending the staple legs, which die is composed of two portions 38 and 39 (FIG. 3). The die portion 38 is held on the movable member 3 of the hook 2 of the bearing stock 1, whereas the die portion 39 is held on the fixed member 4.

The die portions 38 and 39 are replaceable and are held on the fixed member 4 and the movable member 3 by means of projections 40 (FIG. 12) engaging the respective slots formed in the movable member 3 and fixed member 4. The die portions 38 and 39 are secured in the slots of the movable member 3 and the fixed member 4 by means of pins 41. The pins 41 are attached to the hook 2 (FIG. 1) by spring plates 42, whereof one end of each is attached to the respective pin 41 and the other end engages the respective slot 43 (FIGS. 1, 13). The die portions 38 and 39 (FIGS. 12, 14) have depressions 44 (FIGS. 12, 14) on the surfaces thereof which face the main portion of the bearing stock 1 (FIG. 1) and which are intended to be in contact with osseous tissue, said depressions 44 serving to bend the staple legs so that the depression 44 on the die portion 38 serves to bend one staple leg, while the depression 44 on the die portion 39 serves to bend the other leg of that same staple.

The die may have both a single pair of depressions 44 ensuring the bending of the legs of a single staple, as indicated in FIG. 14, or a plurality of pairs of depressions 44 ensuring the bending of a plurality of staples. In the latter case, as illustrated in FIG. 15, the depressions 44 are formed in die portions 45 and 46 held on the members 3 and 4. The die portions 45 and 46 are mounted flush with surfaces 47 of the members 3 and 4, as indicated in FIG. 16. The die portions may have projections, if same is required, which projections, located at the end of the hook 2, extend outward beyond the surface 47 (the die portions 38 and 39 in FIG. 14), which will be seen with respect to the die portion 39 in FIG. 1. In such a case the depressions are formed in the protruding portions of the dies.

Such a design of the die ensures tight adherence of the die depressions to the surface being joined if the latter has an intricate configuration, such as a jaw.

Ribs and the collarbone should be preferably sutured with the use of the die modification of FIG. 15 having at least four pairs of depressions 44. This particular embodiment of the die affords a variety of sutures (FIGS. 17, 18, 19) and permits variations in both the number of staples 28, which join bone fragments 48, and their spacing and slope angle relative to one another, depending on the size and shape of the bone fragments 48.

To this end, a required number of staples are loaded in the magazine 17 (FIG. 11), the slots 27 with sloping guiding walls providing means for the staples to be positioned both parallel and at an angle relative to one another, which affords the types of sutures shown in FIGS. 17, 18 and 19.

The head 16 (FIG. 8) of the pusher 15 may be fitted with projections 49 engaging the respective slots 27 (FIG. 11) of the magazine 17 as the staples are being ejected. Alternatively, the pusher head may be made without these projections (not shown in the drawings), in which case, while the staples are being ejected, the pusher head is in contact only with the middle portion of the staple back edge.

To fix the die in position relative to osseous tissue, it is expedient to provide lugs 50 on the surface thereof intended to be in contact with osseous tissue (FIGS. 1, 14).

It is expedient that within the zone of initial contact with the staple legs the depressions should be widened at their outer ends, such as depressions 51 in FIG. 20, which ensures that the staple legs do not miss the depressions in suturing.

To make the die portions 38 and 39 (FIG. 14), as well as the die portions 45 and 46 (FIG. 15), interchangeable, their depressions 44 should be made widening from the bottom center toward the edges thereof,

which ensures that the staple legs do not miss the depressions in suturing.

The depression **44** have the shape of an arc in the longitudinal section thereof, said arc having the same radius R (FIG. **12**) with the chord D whose length does not exceed half the width of the staple, which ensures that in suturing the leg ends of the staple **28** positively transfix the bone fragments **48** when the staple legs are being bent, as indicated in FIG. **21.**

Surfaces **52** (FIG. **9**) of the die portions **38** and **39,** that are in contact with the bone fragments **48,** may be made both straight or sloping so as to ensure that the die portions **38** and **39** tightly adhere or clamp to the bone fragments **48.**

Since the die portions **38** and **39** are replaceable, various combinations of configurations of their surfaces **52** in contact with the bone fragments **48** may be selected, as is shown in FIG. **22** (*a, b, c, d, e*), which feature enables one and the same instrument to be employed for suturing bone fragments of a variety of configurations.

OPERATION

The operation of the proposed surgical instrument for staple-suturing of osseous tissues is as follows:

The corresponding combinations of the die portions **38** and **39** (FIGS. **3, 14**) or **45** and **46** (FIG. **15**), depending on the configuration of the bone fragments to be sutured, are set on the movable member **3** (FIG. **3**) and the fixed member **4** of the hook **2** of the bearing stock **1** of the instrument.

The magazine **17** (FIG. **1**) loaded with a required number of staples, is set on the instrument and fixed thereon by the flat spring **18** and the grooves **26** of the bearing stock **1.**

The fixed member **4** (FIG. **9**) is brought under one of the bone fragments **48** to be sutured, which is then fixed in position by being clamped between the die portion **39** and the magazine **17.** To this end, the nut **31** (FIG. **1**) is rotated to urge the staple carrier **12** with the pusher **15** and the magazine **17** fized thereon forward toward the hook **2** of the bearing stock **1.**

Then the other bone fragment is brought to the bone fragment **48** (FIG. **9**) clamped in the instrument, the two fragments are juxtaposed and then the former fragment is forced against the magazine **17** by the die portion **38** fixed on the movable member **3.** The movable die portion **3** is moved by rotating the nut **8** (FIG. **1**). What with two hook members movable relative to each other, viz., the movable member **3** (FIG. **9**) and the fixed member **4,** bone fragments differing in thickness may be juxtaposed and fixed in the instrument.

The bone fragments having been fixed in the instrument, the handle bar **34** is screwed onto the tailpiece **30** (FIG. **1**) of the staple carrier **12,** said handle bar, while rotating, urging with its stem **36** the pusher **15** toward the hook **2.**

While moving forward, the pusher **15** forces the back edges of the staples **28** (FIG. **9**) loaded into the magazine **17** and drives them forward toward the bone fragments **48** being sutured, said bone fragments **48** being positioned between the die portions **38** and **39** and the magazine **17.**

The staples **28,** while moving along the slots **27** of the magazine **17,** pierce the bone fragments **48** with their ends and, having thrusted against the die depressions **44,** get bent.

When being bent, the leg ends of the staples **28** come out of the die depressions **44** and transfix the bony tissue from the reverse side, as is shown in FIG. **21,** thus providing a staple suture with the parts of the staple protruding from the bony tissue having a smooth surface free from any sharp irregularities, that is to say, the staple suture has a smooth contour, which prevents injuring or irritating the adjacent tissues and organs.

Finally, by rotating the nut **31** (FIG. **1**) counterclockwise, the magazine **17** is drawn off the sutured osseous tissues, and the surgical instrument is withdrawn from the operation zone.

What is claimed is:

1. A surgical instrument for joining osseous tissues by staples comprising a back and two legs, comprising: a bearing stock; a hook at one end of said bearing stock, said hook being disposed transverse relative to said bearing stock and comprising two members movable lengthwise relative to each each other; a die consisting of two portions fixed on the different members of said hook for respectively bending a staple leg, a surface of said dies facing the main portion of the bearing stock for contacting osseous tissue to be stapled, depressions formed in said surface of said dies, said depressions engaging and contacting the respective legs of said staples as the same are being bent; a staple carrier freely mounted on said bearing stock for movement therealong; a staple magazine fixed on said staple carrier and having a surface facing said die surfaces, said surface of the staple magazine including portions for contacting osseous tissue to be stapled in opposition to said die surfaces; a staple ejector mounted in said staple carrier and adapted to move therealong, said staple ejector including means for driving out the staples from said magazine as said ejector moves toward said hook and as said staple carrier with said magazine fixed thereon moves along said bearing stock toward said hook whereby one of the bone fragments to be sutured is clamped between said magazine surface and one of said die surfaces, while another bone fragment to be sutured is clamped between said magazine surface and the other said die portion, means connected to one of said hook members carrying said die portions fixed thereon for orienting it at different distances from said staple magazine portions engaging the osseous tissue being sutured, said die portions comprising bearing surfaces for the different legs of the same staple when the legs of said staple are being bent and said staple is driven out by movement of said ejector relative to said staple carrier.

2. A surgical instrument according to claim **1,** in which said die depressions have widened portions for insuring initial contact with the said staple legs.

3. A surgical instrument according to claim **1,** in which said hook member includes means replacably mounting the die portions, said die surfaces contacting the osseous tissue being inclined relative to said magazine surface contacting the osseous tissue for providing the closest possible adherence of said die surfaces to the osseous tissue.

4. A surgical instrument according to claim **1,** in which said die depressions widen from a bottom center portion toward edges thereof.

5. A surgical instrument according to claim **3,** in which said die depressions widen from a bottom center portion toward edges thereof.

6. A surgical instrument according to claim 1, in which said depressions have a longitudinal section shaped as an arc of the same radius with a chord, the length of the chord not exceeding half the width of said staples.

7. A surgical instrument according to claim 3, in which said means for replaceably mounting said die portions in said hook comprise slots in said hook members, projections on said die portions removably received in said slots, pins extending through said projections and said slots, and spring plates operatively connected to said pins and said bearing stock for retaining the pins in a locking position.

8. A surgical instrument according to claim 1, in which said die portions have projections located at the end of said hook and extend toward said magazine and include depressions for respectively receiving one leg of a staple.

9. A surgical instrument according to claim 8, in which on said die surfaces for contacting the osseous tissue include projecting lugs for fixing said dies in position with respect to the osseous tissue.

10. A surgical instrument according to claim 1, in which at least one of said die portions includes at least four depressions.

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