

[54] APPARATUS FOR CLOSING A CUT END OF A BLOOD VESSEL

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Jan. 20, 1973	Japan.....	48-8878

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[51] Int. Cl. .... B21d 9/08

[58] Field of Search ..... 128/325, 326, 327, 346; 72/409, 410; 227/19, 20, 21, 80; 29/243.56

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[57] ABSTRACT

A method for closing a cut end of a blood vessel comprises the steps of nipping the cut end of the blood vessel between a pair of closing members formed of plastic material, and of fastening the pair of closing members to each other.

An apparatus for carrying out the above method comprises a pair of actuating members for the pair of closing members to press the pair of closing members to each other when the cut end of the blood vessel is inserted between the pair of closing members, and concurrently to fasten the pair of closing members to each other.

16 Claims, 15 Drawing Figures

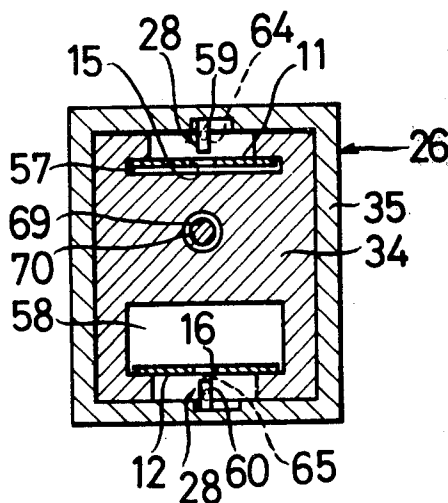


FIG.1A

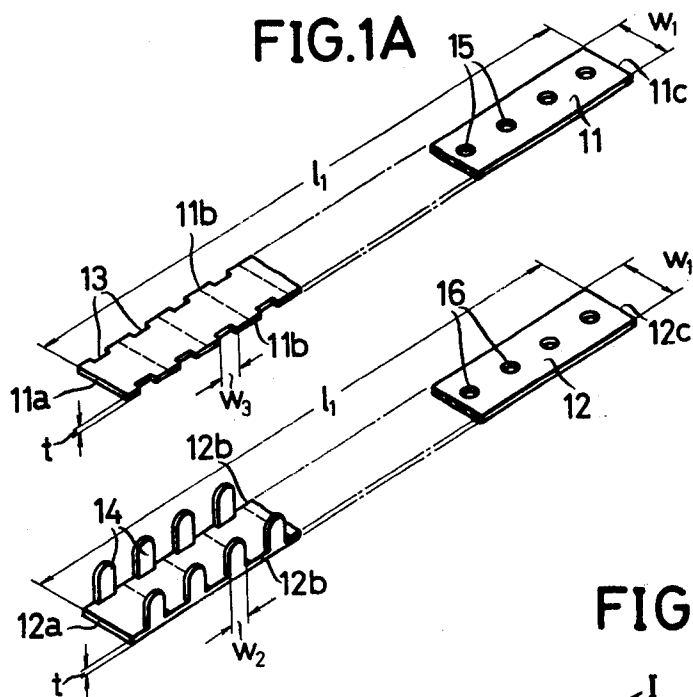


FIG.1B

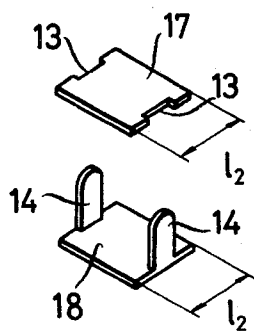


FIG.1C

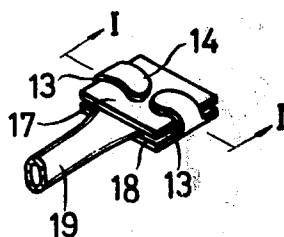
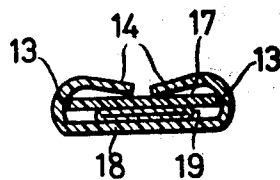
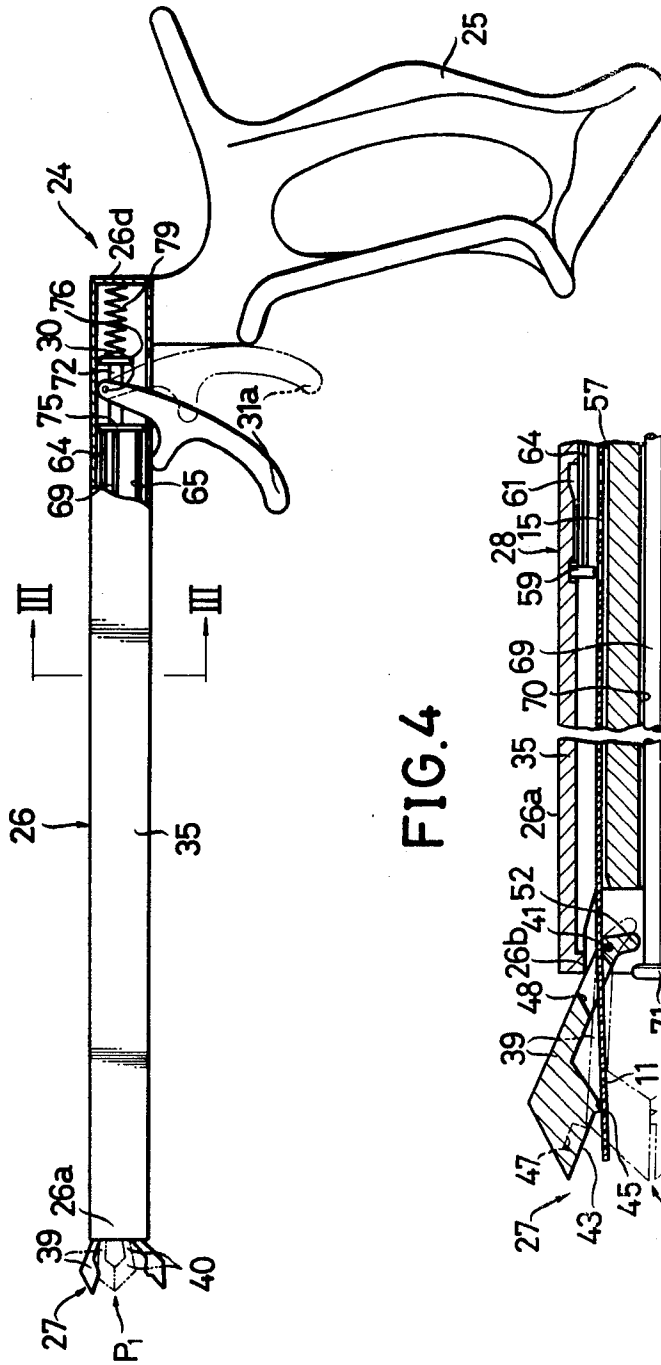


FIG.1D



**FIG. 2**



**FIG. 4**

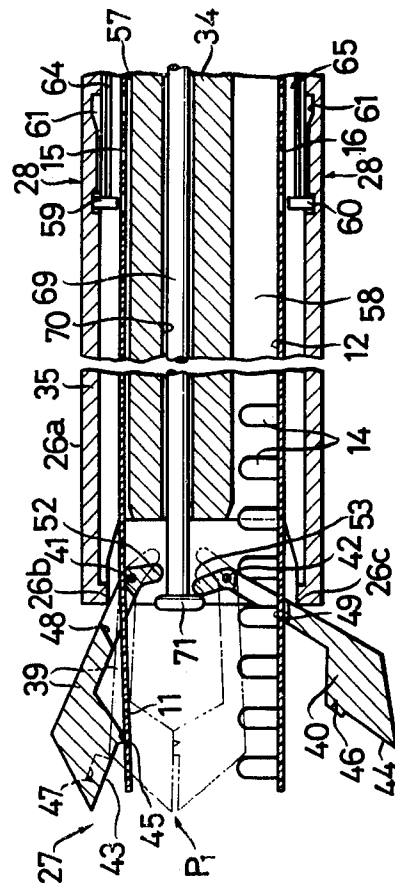


FIG. 5

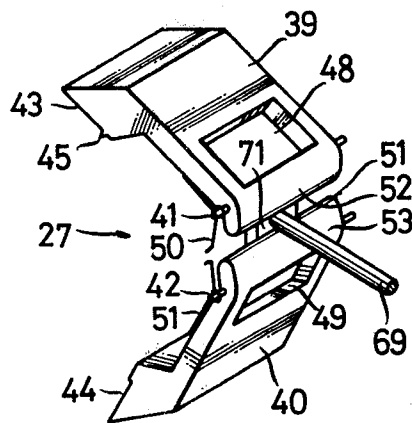


FIG. 3

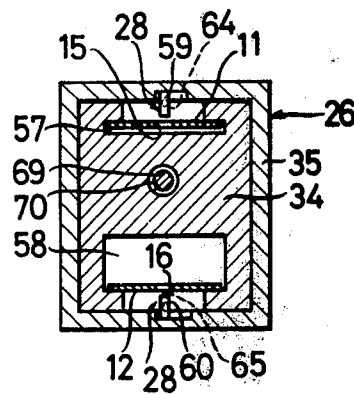


FIG. 6A

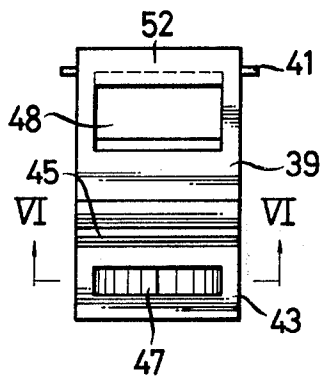


FIG. 6B

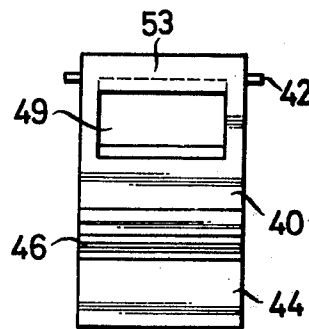
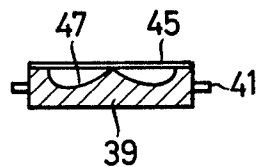


FIG. 6C





# APPARATUS FOR CLOSING A CUT END OF A BLOOD VESSEL

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention:

This invention relates to a novel method and apparatus for closing a cut end or opening of a blood vessel, and more particularly to a method and apparatus for closing a cut end of a blood vessel in use of a pair of closing members.

### 2. Description of the Prior Art:

The conventional method for closing an opening of a blood vessel remains as it was, in which a cut end of the blood vessel is ligatured by a thread. It has often been said that a surgical operation is a struggle against bleeding. Quickness and certainty are required for ligaturing the cut end of the blood vessel. If the surgeon is not skilled, it is difficult for him quickly and certainly to ligature the cut end of the blood vessel by the thread. Moreover, in the conventional method, two operators are required for respectively nipping the cut end of the blood vessel to stop bleeding, and ligaturing it with the thread. When the cut end of the blood vessel is beyond the reach of the operator's hand, it is impossible to ligature the cut end of the blood vessel.

Consequently, the conventional ligaturing is very troublesome and difficult.

## SUMMARY OF THE INVENTION

In practising the present invention a cut end of a blood vessel is closed by nipping the cut end of the blood vessel between a pair of closing members formed for example of plastic material, and fastening said pair of closing members to each other.

An apparatus for carrying out the above method comprises a pair of actuating members adapted to engage said pair of closing members to press said pair of closing members against one another with the cut end of the blood vessel between them, and concurrently to fasten said pair of closing members together.

An object of the present invention is to provide a novel method for closing a cut end of a blood vessel.

A further object of the present invention is to provide a pair of closing members suitable for the method.

A still further object of the present invention is to provide a pair of band plates comprising the respective groups of the closing members which are intermittently advanced to the position of the cut end of the blood vessel to be closed.

A still further object of the present invention is to provide a novel apparatus for closing the cut end of the blood vessel.

A still further object of the present invention is to provide an apparatus for closing the cut end of the blood vessel by which the pair of the band plates are intermittently advanced to the position of the cut end of the blood vessel.

A still further object of the present invention is to provide an apparatus for closing the cut end of the blood vessel by which the cut end of the blood vessel can be closed with the pair of the closing members cut out from the pair of the band plates, synchronously with the advance of the pair of the band plates.

A still further object of the present invention is to provide an apparatus for closing the cut end of the blood vessel which can simply be operated.

A still further object of the present invention is to provide an apparatus for closing the cut end of the blood vessel which is simple in construction.

The features and advantages of the present invention will be more readily understood upon consideration of the following detailed description of the preferred embodiments of the invention, taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is an enlarged partial cutaway view in perspective, of a pair of strips or band plates comprising the respective groups of closing members according to the invention;

FIG. 1B is an enlarged perspective view of a pair of the closing members cut out from the band plates shown in FIG. 1A;

FIG. 1C is an enlarged perspective view of a cut end of a blood vessel closed by a pair of closing members;

FIG. 1D is a cross-sectional view taken along the lines I—I of FIG. 1C;

FIG. 2 is an elevational partial cutaway view of an apparatus according to the invention for closing the cut end of a blood vessel;

FIG. 3 is an enlarged cross-sectional view taken along the lines III—III;

FIG. 4 is an enlarged fragmentary cross-sectional view, partly cutaway, of the apparatus according to the invention;

FIG. 5 is an enlarged perspective view of a device forming part of the apparatus according to the invention for closing the cut end of the blood vessel;

FIG. 6A and FIG. 6B are enlarged front views of a pair of actuating members constituting the device shown in FIG. 5;

FIG. 6C is a cross-sectional view taken along the lines VI—VI of FIG. 6A;

FIG. 7 is an enlarged cross-sectional view of the actuating means of the apparatus according to the invention;

FIG. 8 is an enlarged top plan view of a guide groove for a feeding means according to the invention;

FIG. 9 is a developed cross-sectional view of FIG. 8; and

FIG. 10 is a cross-sectional view taken along the lines X—X of FIG. 8.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the method and apparatus for closing a cut end or an opening of a blood vessel according to the invention will be described in detail with reference to the drawings.

First, a closing unit or a pair of closing members will be described with reference to FIGS. 1A to 1D. It is formed in such a manner that each member is cut out from two kinds of strips or band plates. FIG. 1A shows the two kinds of the band plates 11 and 12. They are formed of a plastic material such as titanium alloy, tantalum alloy, 18.6 chromium alloy and polycarbonate. The thickness  $t$ , the width  $w$ , and length  $l$ , of the band plates 11 and 12 are about 0.1 to 0.3 mm, about 5 to 10 mm and about 130 to 140 mm, respectively. A plurality of, for instance, twenty cut-out portions 13 are formed on both edges 11b of one band plate 11 in the about half region at the side of one end 11a of the band plate 11, at regular intervals. The cut portions 13 of

one edge 11b oppose those on the other edge 11b. A plurality of, for instance, twenty round-ended projections 14 are formed on both the edges 12b of another band plate 12 in the about half region at the side of one end 12a of the band plate 12, at regular intervals. The projections 14 of one edge 12b oppose those on the other edge 12b. The width  $w_2$  of each projection 14 is equal to or just less than, the width  $w_3$  of each cut portion 13. Moreover, a plurality of, for instance, twenty holes 15 and 16 are formed along the centre lines of the band plates 11 and 12 in the about half regions at the sides of another ends 11c and 12c of the band plates 11 and 12, at regular intervals. The holes 15 and 16 help to advance the band plates 11 and 12 as described below. The spacings of the holes 15 and 16 are equal to those of the cut portions 13 and the projections 14, that is to say about 3 mm ( $l_2$  in FIG. 1B).

A pair of closing members 17 and 18 as shown in FIG. 1B are obtained by cutting the pair of the band plates 11 and 12 at the centre line of the adjacent cut portions 13 and projections 14 in the direction of the width  $w_1$  of the band plates 11 and 12 (shown by dash-line in FIG. 1A). The width and the length of the closing members 17 and 18 are  $w_1$  and  $l_2$ , respectively.

The desired closing of the cut end of the blood vessel as performed by the pair of closing members 17 and 18, is shown in FIG. 1C and FIG. 1D.

The projections 14 are bent to each other and fastened to each other so that the projections 14 are fitted in the cut portions 13.

The apparatus 24 for closing the cut end of the blood vessel will now be described with reference to FIG. 2 to FIG. 10. By this apparatus the pair of the band plates 11 and 12 are cut to give a pair of the closing members 17 and 18 and close the cut end of the blood vessel as shown in FIG. 1C.

The apparatus 24 comprises a body 26 provided with a handle 25, a device 27 attached to the leading end 26a of the body 26 for closing the cut end of the blood vessel with the pair of the closing members 17 and 18, feeding means 28 disposed in the body 26 for feeding the pair of the closing members 17 and 18 to the device 27, actuating means 29 disposed in the body 26 for actuating synchronously the device 27 and the feeding means 28, and a trigger 31 pivoted at an axle 30 fixed to the side wall of the body 26 for operating the actuating means 29.

The body 26 consists of an inner case 34 and an outer case 35 which is open at the top end.

The device 27 for actually closing the cut end of the blood vessel is shown in detail in FIG. 4 to FIG. 6C.

A pair of actuating members 39 and 40 are rotatably supported at the end 26a of the body 26 by axles 41 and 42 respectively. Both of the actuating members 39 and 40 have nipping surfaces 43 and 44 at respective front end portions which can press the pair of the closing members 17 and 18 forcibly to each other. A cutter 45 is formed integrally with the actuating member 39 near the rear end of one nipping surface 43 to cut the band plates 11 and 12 in the direction of their width, while a V-shaped groove 46 is formed near the rear end of the other nipping surface 44 to receive the cutter 45. Moreover, an approximately w-shaped recess 47 is formed near the front end of the one nipping surface 43 to bend the pair of the projections 14 opposite to each other, as shown in FIG. 6C. Openings 48 and 49 are formed near the rear ends of the actuating members 39

and 40 to pass the pair of the band plates 11 and 12 therethrough, respectively.

The actuating members 39 and 40 are urged in counter revolution around the supporting axles 41 and 42 by springs 50 and 51 respectively. The upper actuating member 39 and the lower actuating member 40 therefore normally contact with an upper edge 26b and the lower edge 26c respectively of the top end portion 26a of the body 26. Moreover, contact portions 52 and 53 for an actuating shaft as described below are formed integrally with the respective rear ends of the actuating members 39 and 40.

The feeding means 28 is shown in detail in FIG. 3, FIG. 4 and FIG. 7 to FIG. 10.

A pair of paths 57 and 58 are formed along the body 26 between the inner case 34 and the outer case 35. The band plates 11 and 12 pass through these paths. An opening can be provided at the side of the rear end of the paths 57 and 58 for insertion of the band plates 11 and 12. However, in this embodiment, the band plates 11 and 12 are inserted backward into the paths 57 and 58 from the front end 26a of the body 26. Although not shown, leaf springs or the like may be provided in the paths 57 and 58 to press the band plates 11 and 12 against the walls of the inner case 34 to prevent undesirable slipping of the band plates 11 and 12.

The band plates 11 and 12 are fed to the device 27 in the paths 57 and 58 in such a manner that a pair of pins 59 and 60 are engaged with the respective holes 15 and 16 of the band plates 11 and 12. The pins 59 and 60 are guided by guide grooves 61, as shown in FIG. 8 to FIG. 10. The guide grooves 61 are formed on the outer case 35 and consist of a straight forwardly extending path 62 in which the pin 59 or 60 engaged with the hole 15 or 16 moves forward in the direction of the arrow a and a curved backward path 63 in which the pin 59 or 60 free from the hole 15 or 16 moves backward in the direction of the arrow b. An upper face 62a is formed on the bottom of the path 62, on which the pin 59 or 60 is advanced in engagement with the hole 15 or 16 of the band plates 11 or 12. A lower face 63a of the curved backward path 63 is at a lower level than the face 62a. On this lower face the pin 59 or 60 moves backward free from the hole 15 or 16 of the band plate 11 or 12. Further, a slant face 62a' is formed on the bottom of the path 62, on which the pin 59 or 60 is removed from the lower face 63a to the upper face 62a for engagement with the hole 15 or 16 of the band plate 11 or 12. A length  $l_3$  of the band plate 11 or 12 advanced by the pin 59 or 60 on the upper face 62a corresponds to the length  $l_2$  of the closing member 17 or 18, as shown in FIG. 1B and FIG. 9. Elastic rods 64 and 65 are connected to the pins 59 and 60 respectively, by which the pins 59 and 60 can freely move in the upper face 62a, the lower face 63a and the slant face 62a'.

The actuating means 29 is shown in detail in FIG. 4 and FIG. 7.

An actuating shaft 69 is slidably supported at a hole 70 made in the inner case 34. An actuator element 71 connected to the leading end of the actuating shaft 69 contacts with the front faces of the contact portions 52 and 53 of the actuating members 39 and 40. The trailing end of the actuating shaft 69 is inserted slidably into a cylinder 72. An axle 73 projected from the outer side of the cylinder 72 is engaged with an oblong hole 74 made in an actuating arm portion 31a of the trigger 31. A pair of flanges 75 and 76 are formed on the leading

and the trailing ends of the cylinder 72. The trailing ends of the elastic rods 64 and 65 are fixed to the upper and the lower parts of the flange 75. A coil spring 78 is supported between the flange 76 and a disc 77 fixed to the trailing end of the actuating shaft 69. A larger coil spring 79 surrounding the coil spring 78 is supported between the flange 76 and a rear end wall 26d of the body 26 to restore the trigger 31.

The operation of the apparatus 24 for closing the cut end of a blood vessel 19 will be now described.

Before the cut end of the blood vessel 19 is closed, or the trigger 31 is drawn, the pair of actuating members 39 and 40 are open, as shown by solid lines in FIG. 4.

The ends 11a and 12a of the band plates 11 and 12 passing through the paths 57 and 58 are positioned at P<sub>1</sub> or at the front ends of the actuating members 39 and 40 when they are closed, as shown in FIG. 2 and FIG. 4. At that time, the pin 59 or 60 is positioned at P<sub>2</sub> or the front end of the straight forward path 61 of the guide groove 61, where it is free from the hole 15 or 16 of the band plate 11 or 12.

In such a condition, as soon as the cut end of the blood vessel 19 is inserted between the pair of the actuating members 39 and 40 immediately after the blood vessel is cut, the trigger 31 is drawn so as to rotate around the axle 30 and the axis 73, so that the cylinder 72 is pushed backward through the oblong hole 74 and the actuating shaft 69 slides backward through the coil spring 78. The actuator element 71 connected to the top end of the actuating shaft 69 pushes the contact portions 52 and 53 of the actuating members 39 and 40 backward, so that the actuating members 39 and 40 are rotated about the supporting axles 41 and 42 against the springs 50 and 51. Consequently, the actuating members 39 and 40 nip the pair of the band plates 11 and 12 at the nipping surfaces 43 and 44 between which the cut end of the blood vessel 19 is inserted. In the action of nipping, the pair of the band plates 11 and 12 are cut by the cutter 45 formed on the nipping surface 43 to give the pair of members 17 and 18 of FIG. 1B. The pair of the projections 14 are then bent opposite to each other in the recess 47, so that the cut end of the blood vessel 19 is closed by the pair of the closing members 17 and 18, as shown in FIG. 1C and FIG. 1D.

Furthermore when the trigger 31 is drawn the pins 59 and 60 are moved backward with the backward movement of the cylinder 72 through the elastic rods 64 and 65 in the curved backward path 63 of the guide groove 61, so that the pins 59 and 60 are positioned at P<sub>3</sub> or the rear end of the straight forward path 62.

When the trigger 31 is released, it returns to the original position by the coil spring 79. At that time, the cylinder 72 and the actuating shaft 69 return forward to the original positions, so that the actuator 71 is separated from the contact portions 52 and 53 of the actuating members 39 and 40, and the actuating members 39 and 40 are rotated about the axles 41 and 42 to the original positions by the springs 50 and 51.

The band plates 11 and 12 are automatically advanced a distance l<sub>2</sub> in the following manner. With the forward movement of the cylinder 72, the pins 59 and 60 are moved forward in the path 62 of the guide groove 61 by the elastic rods 64 and 65. In the forward movement, the pins 59 and 60 climb the slant face 62a' to move from the lower face 63a to the upper face 62a

and to engage with the holes 15 and 16 of the band plates 11 and 12. The pins 59 and 60 move forward on the face 62a in engagement with the holes 15 and 16 to advance the band plates 11 and 12 by the spacing l<sub>2</sub>. When the pins 59 and 60 reach the P<sub>2</sub>-position (i.e. the front end of the path 62) they move from the upper face 62a to the lower face 63a to become free from the holes 15 and 16 of the band plates 11 and 12. Consequently, while the pins 59 and 60 are circulated once through the guide groove 61 consisting of the straight forwardly extending path 62 and the curved backward path 63, the band plates 11 and 12 are intermittently advanced by the spacing l<sub>2</sub>. The pins 59 and 60 are engaged with the holes 15 and 16 of the band plates 11 and 12 and the band plates 11 and 12 are intermittently advanced for the same number of times as the number of the holes made in the band plates, that is to say, the number of the pair of the closing members intermittently fed to the closing position P<sub>1</sub> is equal to that of the holes made in the band plates 11 and 12.

Although the pair of the band plates 11 and 12 are advanced in order, and the pair of the closing members 17 and 18 are produced by cutting the band plates 11 and 12, in the above-described embodiment, it is possible that a number of the pair of the closing members 17 and 18 are prepared, and the pair of the closing members 17 and 18 are set at the pair of the actuating members 39 and 40 every time the cut end of the blood vessel is closed.

In this invention, since the cut end of the blood vessel is inserted between the pair of the closing members formed of the plastic material and the pair of the closing members are fastened to each other to close the cut end of the blood vessel, the closing operation of the cut end of the blood vessel, is very simple, quick and certain. Moreover, since the pair of the closing members are pressed to each other by the pair of the actuating members and at the same time the pair of the closing members are fastened to each other, the invention has the advantage that the cut end of the blood vessel can be closed in one action.

Moreover, while in the above embodiments band plates are used, a pair of rolls may be used instead. These would unwind intermittently to obtain the pair of closing members.

While preferred embodiments have been described, variations thereto will occur to those skilled in the art within the scope of the present inventive concepts which are delineated by the following claims.

What is claimed is:

1. An apparatus for closing a cut end of a blood vessel with a pair of closing members, comprising means for supporting and guiding a pair of strips with each strip being formed of a series of closing members, a pair of actuating members to press successive pairs of closing members against one another with the cut end of a blood vessel therebetween, said actuating members operating to concurrently fasten said pair of closing members together, feeding means for feeding intermittently said strips to provide successive pairs of closing members at said actuating members, and cutting means for automatically cutting one pair of closing members from said pair of strips during each pressing and fastening operation.

2. An apparatus according to claim 1 including means interlocking the action of said pair of actuating members with said feeding means, and an actuator for



said interlocking means, operation of said actuator achieving said pressing, fastening and cutting operations and then automatically feeding a succeeding pair of closure members to said actuating members.

3. An apparatus according to claim 2, wherein said actuator is a trigger.

4. An apparatus according to claim 2, wherein said pair of actuating members are about L-shaped in section and have openings to pass said strips therethrough, nipping surfaces for nipping said pair of closing members and means on one of said nipping surfaces to fasten said pair of closing members together.

5. An apparatus according to claim 4, wherein said pair of actuating members are rotatably supported by supporting axles at the top end of a body containing said feeding means and said actuating means and are urged by springs.

6. An apparatus according to claim 5, wherein said body consists of an inner case and an outer case between which a pair of paths are formed for feeding said pair of strips.

7. An apparatus according to claim 6 wherein said actuator comprises an actuating shaft slidably supported in a hole extending through said inner case, an actuator element connected to the leading end of said actuating shaft and contacting with contact portions formed integrally with said actuating members, a cylinder slidably supporting the trailing end of said actuating shaft, a disc connected to the trailing end of said actuating shaft, a trailing flange fixed at the trailing end of said cylinder, a spring supported between said trailing flange and said disc, and a larger spring surrounding said first mentioned spring and supported between said trailing flange and the trailing end wall of said body.

8. An apparatus according to claim 7, wherein said feeding means comprises a pair of pins at the leading ends of a pair of elastic rods connected to a flange fixed to the leading end of said cylinder, said pins engaging

with holes in the centres of the closing members forming the closing member strips.

9. An apparatus according to claim 8, wherein said pair of pins are guided by a pair of guide grooves formed on said outer case.

10. An apparatus according to claim 9, wherein said guide groove consists of a forwardly extending straight path having an upper face, and a curved backward path having a lower face.

11. An apparatus according to claim 10, wherein said straight path has further a slant face for moving said pins from said lower face to said upper face.

12. An apparatus according to claim 7 wherein an axle is fixed at the side wall of said cylinder, said axle being engaged with an oblong hole in an arm of said actuator pivoted at a supporting axle fixed to said outer case.

13. Apparatus according to claim 1 in combination with a pair of closing members formed of plastic material and adapted to nip said cut end of a blood vessel between them and to be fastened to each other.

14. Apparatus according to claim 1 in combination with a pair of closing members wherein one of said closing members is rectangular with a pair of cut-out portions on one pair of opposing edges, and the other of said closing members has a similar rectangular base with a pair of projections on opposing edges corresponding with said opposing edges of said one closing member for engagement of said projections with said cut-out portions.

15. Apparatus according to claim 1 in combination with closing members made of a plastic material selected from the group consisting of a titanium alloy, a tantalum alloy, an 18.6 chromium alloy, and a polycarbonate.

16. Apparatus according to claim 1 wherein a plurality of holes are formed in the strips corresponding with the centers of the closing members.

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