Feb. 17, 1959 J. S. DONALDSON 2,873,741

SLIDE FASTENER CLOSURE WITH QUICK-OPERABLE INSTALLATION CONNECTOR MEANS

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Fig. 1

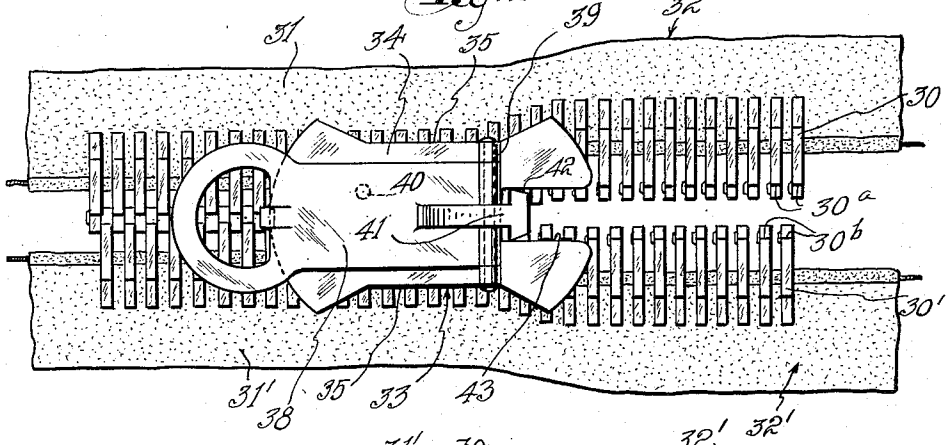


Fig. 2

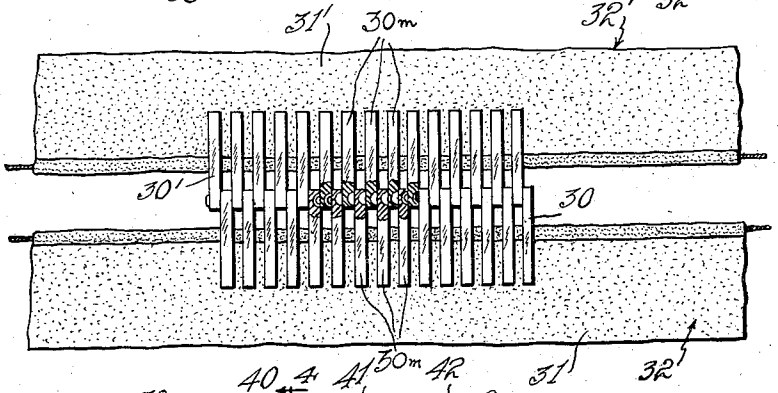


Fig. 3

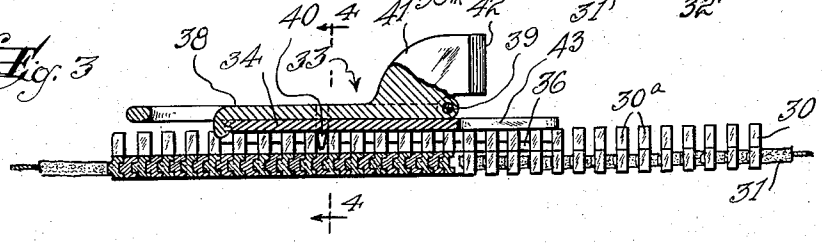
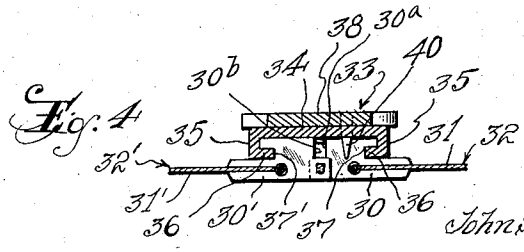


Fig. 4



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SLIDE FASTENER CLOSURE WITH QUICK-OPERABLE INSTALLATION CONNECTOR MEANS

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Fig. 5

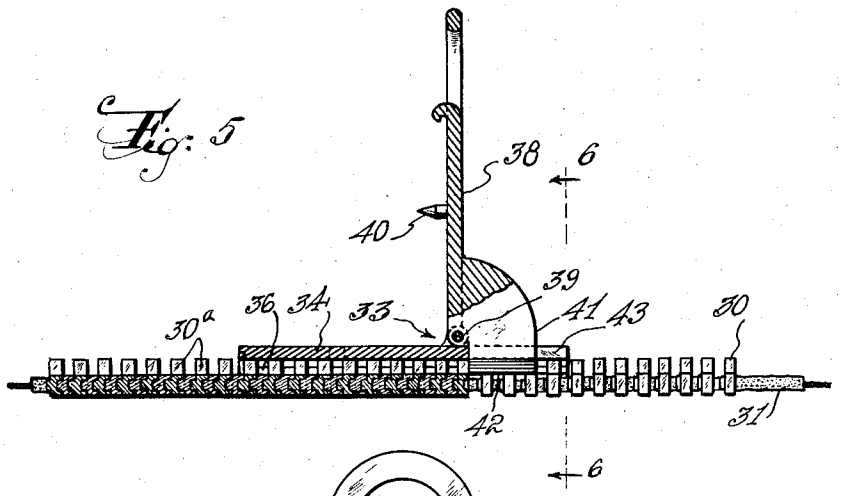


Fig. 6

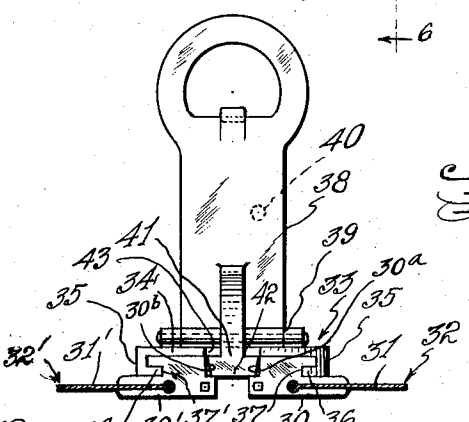
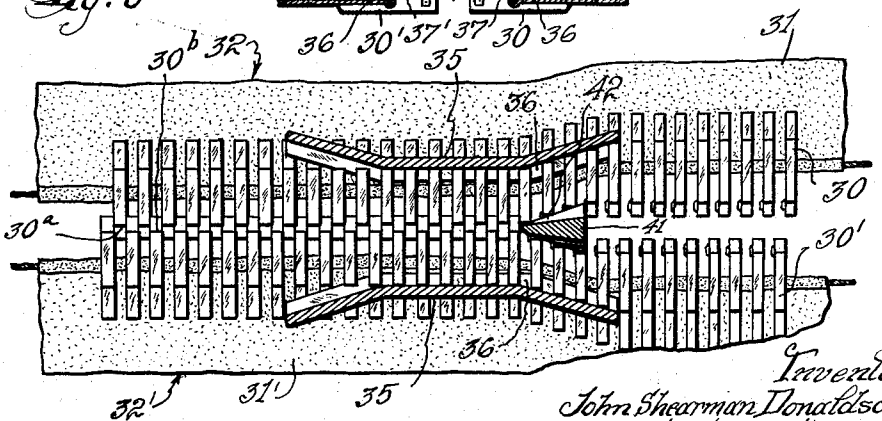


Fig. 6A



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SLIDE FASTENER CLOSURE WITH QUICK-OPERABLE INSTALLATION CONNECTOR MEANS

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Fig. 7

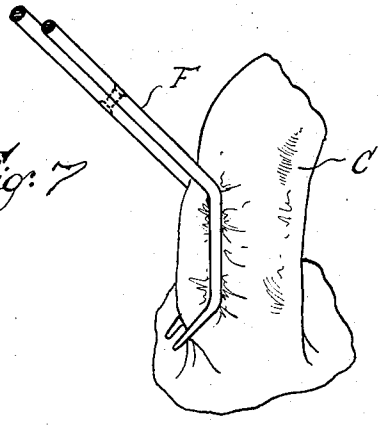


Fig. 8

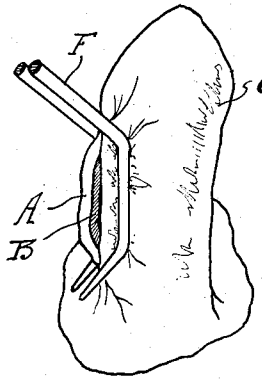


Fig. 9

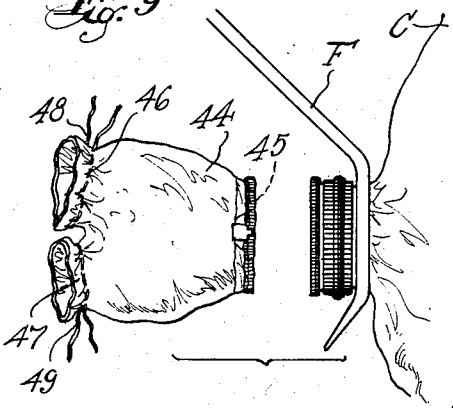


Fig. 10

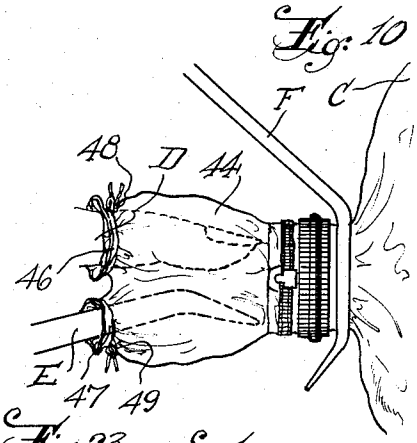


Fig. 23

Fig. 22

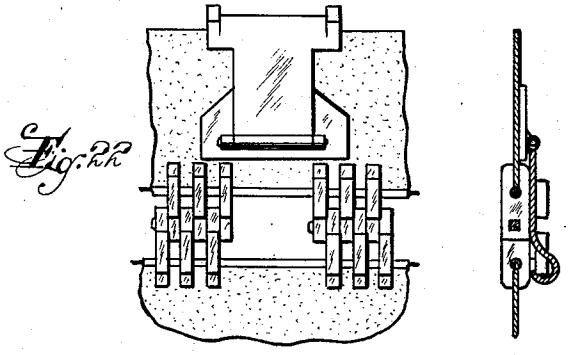
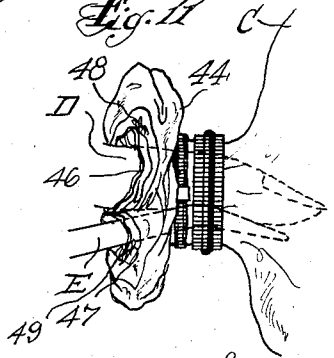


Fig. 11



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SLIDE FASTENER CLOSURE WITH QUICK-OPERABLE INSTALLATION CONNECTOR MEANS

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Fig. 12

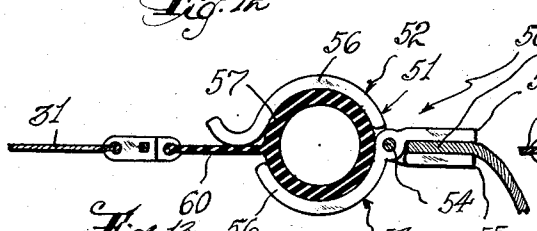


Fig. 14

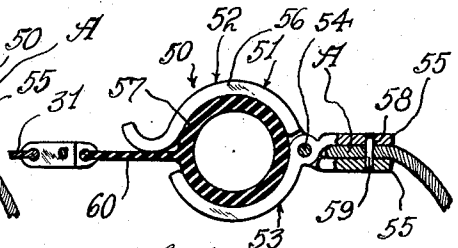


Fig. 13

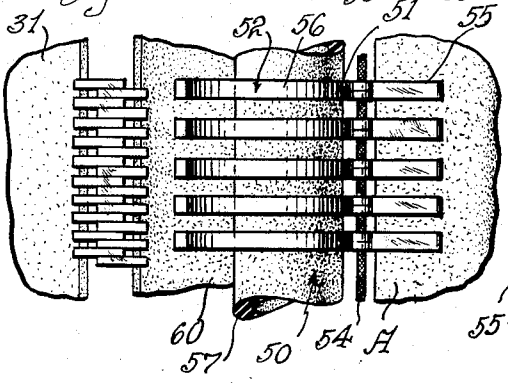


Fig. 18

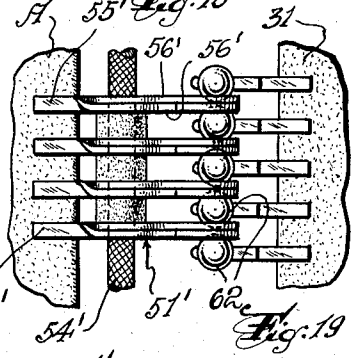


Fig. 19

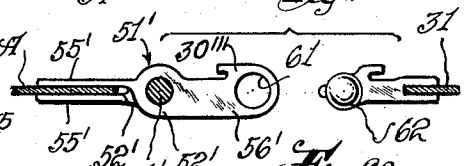


Fig. 15

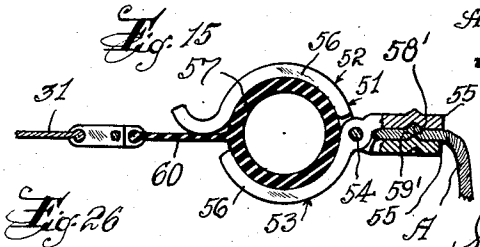


Fig. 20

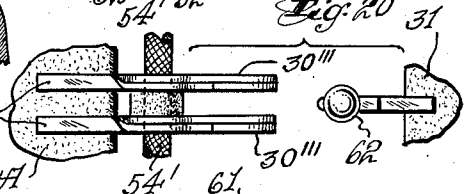


Fig. 26

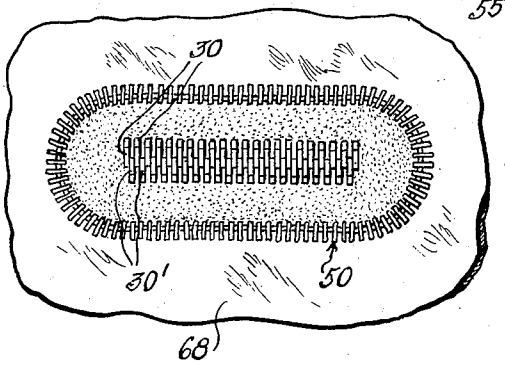
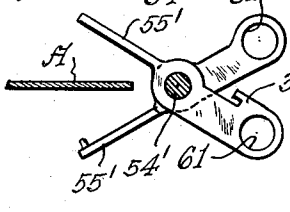


Fig. 21



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SLIDE FASTENER CLOSURE WITH QUICK-OPERABLE INSTALLATION CONNECTOR MEANS

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Fig. 6B

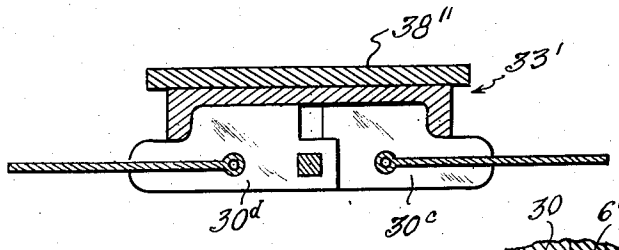


Fig. 24

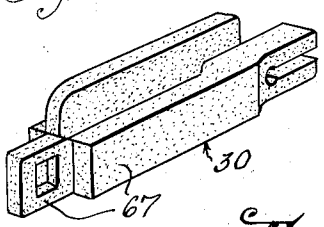


Fig. 25

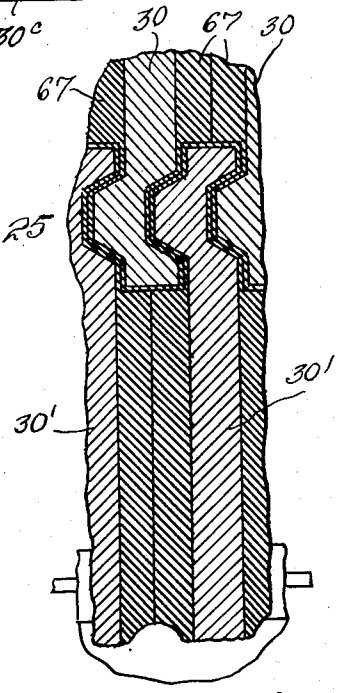
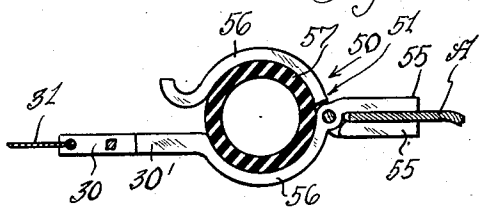


Fig. 16



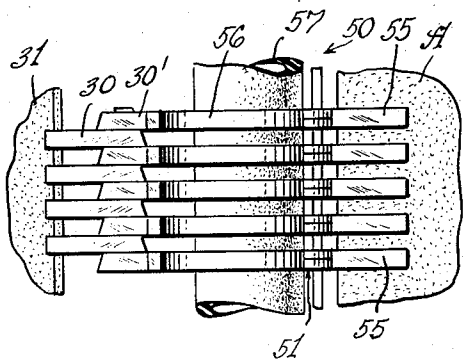


Fig. 17

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United States Patent Office 2,873,741 Patented Feb. 17, 1959

2,873,741

SLIDE FASTENER CLOSURE WITH QUICK-OPERABLE INSTALLATION CONNECTOR MEANS

John Shearman Donaldson, Chatham, N. J.

Application November 23, 1954, Serial No. 470,777

13 Claims. (Cl. 128—303)

The invention relates to slide fastener closure devices such as are used to close the slit-like openings or seams in body apparel or in the flexible walls of traveling bags and other containers.

In the heretofore well known construction of slide fastener closure device, or "zipper" as it is commonly called, there are two coextensive stringers which include tape-form fabric connector elements bearing rows of mated fastener elements, or "scoops," which are affixed to the inner opposed edges of the connector elements. The connector elements serve as means for convenient attachment of the stringers to the respective edges of the opening or seam to be closed, which attachment usually is accomplished by machine stitching. The mated fastener elements of the stringers usually are of the planarly moving, mutually interlocking type and are coupled and uncoupled by means of a manually operable slider mounted for movement lengthwise of the stringers. The conventional slider comprises inner and outer wings, or plates, that embrace the two rows of fastener elements and are rigidly interconnected by an integral neck, or web. This neck serves, in cooperation with the Y-shaped channel through which the fastener elements of the respective stringers extend, to separate or uncouple the said elements by wedging action when the slider is backed up. For its intended purpose the wedging neck is useful, but it frequently is the cause of serious operational difficulties.

In the installation of a slide fastener closure device in connection with an opening in a garment such as a woman's dress, after the connector elements of the respective stringers have been stitched to the marginal edges of the garment opening, there usually are free edge portions of the garment material remaining along the sides of the opening. Quite frequently, these free edge portions of the garment material or threads unravelled therefrom, or even portions of an undergarment, protrude into the garment opening and become caught in the slide fastener. When of conventional prior art construction, the slider will become jammed in operation due to the inclusion of the objectionable neck and inner wing. Moreover, unduly forcible efforts to move the jammed slider in either direction is likely to result in tearing the caught fabric.

In view of the above-mentioned disadvantages of the conventional slide fastener device of the prior art, it is my primary purpose to provide an improved construction of slider which has only one wing that is mounted to slide along the outer side only of the plane of the interlocking fastener elements. The improved slider is operatively united with the fastener elements of the respective opposed rows thereof by sliding engagement of inwardly facing flanges provided on the sides of the slider within laterally facing track grooves, or slots, provided on the outer sides of said fastener elements. Due to this arrangement, the slider will function to couple the mated fastener elements when slid along its track in either direction. In some applications of the device, there will be no need for any slider-incorporated means to uncouple

the interlocked fastener elements, such as a structure equivalent to the wedging neck of the earlier two-wing slider structure, provided that the tape-form connector structures of the stringer extend lengthwise beyond the ends of the rows of fastener elements and are not bound together in such a manner that they cannot be spread apart manually. With such an open-ended zipper device, manual spreading of the stringer connector elements at either end of the rows of fastener elements will break the interlocking engagement of the latter. This uncoupling action may be caused to progress to any desired extent throughout the length of the device by continuing to spread the stringers apart. However, there may be some applications in which mechanical uncoupling by the slider is desirable. To meet that requirement, I have provided spreader means which is adjustable between operative position in which it projects beneath the lone wing of the slider into the gap between vertical inwardly facing shoulders that are formed on the mated fastener elements and inoperative position wherein it is out of the way above the said wing.

Another object of the present invention is to provide a new kind of connector element for either one or both of the stringers of a slide fastener device, which, instead of being stitched to the material at the edge of the opening to be closed, comprises a row of closely abutting gripper devices which removably engage the edges of the opening in a manner to insure a fluid-tight structure when in closed condition. In order to meet the exacting requirements of a particular application which I have in mind and which will be illustrated and described fully hereinafter, the proposed new connector elements for the zipper stringers are of a construction that permits almost as rapid manipulation in engagement with the edges of the opening to be closed, and in disengagement, as can be effected with the zipper closure itself. Briefly, it may be explained that there is urgent need for such a zipper having quick-operable connector means in heart surgery to replace the slow, tedious suturing heretofore practiced in effecting a fluid-tight connection between the lip of the necessary artery incision and the base opening in the immuring device known as a "surgical well," or "boot," employed to permit non-haemorrhaging access of the surgeon's finger and an instrumental aid into the artery for performance of the operative technique called "finger fracture" in relief of stenosis of a heart valve. Whereas the suturing, which prior to my present invention has been considered to be unavoidable, takes about thirty minutes to perform, a surgical well can be completely installed in about one minute with my improved slide fastener closure means. When it is considered that time is very precious in any operation and particularly in heart surgery, the importance of my present invention should be realized.

In addition to freedom from becoming jammed by fabric material which may become caught between the fastener elements during closing operation of the improved form of zipper device, a further advantage which makes the device peculiarly suitable for use in connection with a surgical well is the practicability of arranging the stringers in a closed curve and at the same time insuring complete coupling of the fastener elements all the way around the circuit, so that there will be no leaky gap such as is practically unavoidable in use of the prior art zipper device having a double-wing slider with intervening neck.

The foregoing and other objects, advantages and features of the invention will be more fully understood as the following specific description is read in connection with the accompanying drawings, in which:

Fig. 1 is a large-scale fragmentary plan view of a slide fastener unit for general use constructed in accord-

ance with the present invention, showing the fastener elements in partially coupled condition and the slider locked to its track; Fig. 2 is a bottom plan view of the coupled portion of the mated rows of fastener elements represented in Fig. 1; Fig. 3 is a longitudinal vertical section of the structure as shown in Fig. 1; Fig. 4 is a transverse section of the same; Fig. 5 is a view similar to Fig. 3, showing the separator detent in depressed operative position; Fig. 6 is a transverse section on line **6—6** of Fig. 5; Fig. 6A is horizontal longitudinal section on line **6A—6A** of Fig. 6; and Fig. 6B is a view similar to Fig. 4 showing a modified form of slider which is held to its track by magnetic attraction.

Fig. 7 is a fragmentary perspective view of the aortic arch at its juncture with a human heart, showing an area thereof pinched into an external ridge or flap by a haemostat preparatory to incision; Fig. 8 is a similar view after the incision has been made in the flap; Fig. 9 is a similar view showing a surgical well about to be applied to the lip of the incision by means of the improved slide fastener closure device; Fig. 10 is a similar view showing the surgical well completely connected in fluid-tight manner to the incision lip with a surgeon's finger and instrument sealed in introductory positions in the well; and Fig. 11 is a similar view showing the haemostat removed and the surgeon's finger and instrumental aid entering the aorta for the valvular relief operation.

Fig. 12 is a large-scale fragmentary transverse section through the improved slide fastener closure device having one embodiment of quick-operable connector element substituted for the conventional tape-form connector element of one stringer thereof, showing plain jaws on the gripper devices; Fig. 13 is a plain view of the same; Fig. 14 is a view similar to Fig. 12, showing one embodiment of lip indenting means provided on the gripping jaws; and Fig. 15 is a similar view showing another embodiment of lip indenting means.

Fig. 16 is a view similar to Fig. 12 representing another embodiment of quick-operable connector element for the slide fastener closure; and Fig. 17 is a plan view of the same.

Fig. 18 is a fragmentary plan view on a less enlarged scale of a slide fastener closure having a still further modified form of connector element on one stringer and correspondingly modified fastener elements on the other stringer to match modified fastener elements incorporated in construction of the modified connector element; Fig. 19 is a transverse section of the slide fastener closure as shown in Fig. 18, but showing the respective fastener elements in uncoupled condition; Fig. 20 is a plan view of the same; and Fig. 21 is a transverse sectional view of the connector element alone of the closure represented in Fig. 20, showing the jaws of the gripper device in open condition.

Fig. 22 is a fragmentary side elevational view of the slide fastener closure device as applied to a surgical well, showing a slider-entrance gap in the encircling rows of fastener elements and a gap-sealing plate hinged to the well-affixed stringer, said plate being represented in inoperative position in full lines and in operative position in broken lines; and Fig. 23 is a transverse section of the same, showing the gap-sealing plate latched in operative position.

Fig. 24 is a perspective view of a fastener element of conventional construction on an enlarged scale, showing an external coating of rubber-like material applied thereto for clearance sealing purposes; and Fig. 25 is a fragmentary cross-sectional view, on a still larger scale, of plural coupled fastener elements of a slide fastener closure, showing the manner in which rubber-like coatings serve to provide a fluid-tight seal at the areas of juncture between contiguous faces of said elements.

Fig. 26 is a plan view of the improved slide fastener closure applied to the marginal edges of an incised opening in the wall of a body cavity to permit periodic inspection of the interior, showing the same with slider removed.

Referring now in detail to the drawings, in which like reference characters designate corresponding parts in the several views, Figs. 1 to 6B, inclusive, illustrate the improved slide fastener structure in combination with stringer connector elements of the conventional fabric tape type. It is to be understood that the new slide fastener structure is capable of incorporation with any desired stringer connector, an alternative example being disclosed later herein for a particular use which needs connector means that may be applied to the marginal edges of an opening far more rapidly than can be accomplished by tedious stitching of a fabric stringer tape thereto.

Referring to Figs. 1 to 6A in particular, it will be observed that rows of fastener elements **30—30′** are affixed to the inner opposed edges of tape-form connector elements **31—31′** in the usual manner to form the pair of interengageable stringers **32—32′** of the slide fastener device, or zipper, as a whole. The fastener elements **30—30′** preferably are of the planarly moving mutually interlocking type shown and are adapted to be coupled together, at least, by the slider **33** which is similar in structure to the outer wing or plate of the conventional two-wing slider of the prior art. Slider **33** has a horizontal top wall **34** of modified plan form, e. g., narrow and parallel-sided medially and widely flaring at its opposite ends. The side edges of top wall **34** are downbent to form side walls **35—35** as in the earlier sliders, but with the difference that the lower edges of these walls are bent laterally inward to form inwardly facing guide flanges **36—36**, which are adapted to cooperatively engage within mated guide slots or grooves **37—37′** provided in the respective fastener elements **30—30′** in laterally facing relation thereto. The cooperative guide flanges and grooves thus provided constitute means to guide slider **33** along the track formed by the mated rows of fastener elements of the two stringers **32—32′** and press the said rows of fastener elements together into coupled condition when the slider is advanced with either flared end leading. In thus guiding slider **33** along its track, the interengaged guide flanges and grooves serve to prevent outward disengagement, i. e., at right angles to the plane of the fastener elements.

To facilitate easy manipulation of slider **33**, it is provided with a pull tab **38**, as is customary. This pull tab **38** preferably is pivotally connected to the top wall **34** of slider **33** substantially at the juncture of the narrow and the front flared portions thereof on a transverse axis, as at **39**. In accordance with common practice, pull tab **38** may be provided with a locking lug or tooth **40** to engage within the spaces between fastener elements when said pull tab is rocked inward against the narrow portion of top wall **34** into the locking position shown in Fig. 2. The opposite face of pull tab **38** from that which bears locking stud **40**, is provided with a curved separator detent **41** having a longitudinally tapered engaging end portion **42** of wedge-shaped cross-section. This separator detent **41** is so located with relation to the pivotal axis of pull tab **38** that it will register with and penetrate the notch **43** provided in the forward edge of top wall **34** when said pull tab is rocked oppositely from the broken line locking position into the slide fastener uncoupling position represented in full lines in Fig. 3. In uncoupling position, the engaging end of separator detent **41** will depend into the gap between shoulders **30*a*—30*b*** of the coupled fastener elements **30—30′** and will operate to wedge the said fastener elements apart when the slider **33** is backed-up along its track.

It should be apparent that slider **33** will operate to couple the fastener elements upon translatory movement in either direction, provided that separator detent **41** is retracted from uncoupling position into the position shown in broken lines in Fig. 3. During the coupling operation,

even though anything such as the free edges of garment material, loose threads, bulging folds of undergarments, and the like, enter the space between closing fastener elements, they will not be likely to jam the slider because, with the separator retracted, there will be no part of the slider to become caught in folds of material that may have entered the space between fastener elements. Instead, the top wall of the slider will pass freely over any such fastener-element-confined material. Later, when the slider is moved in reverse direction and the fastener elements are uncoupled either by manual separation of the stringers or by use of the separator detent in its operative uncoupling position shown in full lines in Fig. 3, the confined material will be released readily.

Fig. 6B represents a modified form of slider 33' which is made of magnetized metal, such as steel, so that it will be magnetically attracted to the track constituted by the mated rows of fastener elements 30*c*—30*d*, which accordingly should be made of similar paramagnetic material. In this way, it is practicable to eliminate the provision of guide flanges and grooves. The depending side flanges of the slider will be sufficient to guide the slider in resistance to lateral displacement from the track and the magnetic attraction which holds it on the track in resistance to pull outward from the plane of the latter will offer negligible resistance to lengthwise translation in the performance of fastener element coupling and uncoupling. By making pull tab 38' of paramagnetic material also, it will be biased toward inswung locking position by magnetic attraction.

As previously stated, the improved slide fastener closure device with its one-wing slider is peculiarly adapted for use in connection with a surgical well to attach the latter to the marginal lip of an incision when the new quick-operable connector element is incorporated in the construction of one of the stringers in substitution for the conventional stitchable tape connector element. Because it is believed that the structural details of the new slide fastener closure with quick-operable connector element will be more readily understood if the surgical well and its mode of use in a heart valve operation are first made clear, that will be done now with reference to the disclosure in Figs. 7 to 11. These views illustrate on a reduced scale the general construction of the well and one embodiment of the connector means and also disclose the sequential steps performed in installation of the well in connection to the lip A of an incision B in the aortic arch C of a patient's circulatory system preparatory to a "finger fracture" operation for relief of stenosis of the tricuspid aortic valve of the heart, in which the well is employed to permit non-haemorrhaging introduction of the surgeon's finger D and a fracture instrument E into the area of the diseased valve.

The typical well comprises a hollow, thin-walled body 44 of flexible, waterproof material, such as rubber latex, which customarily is reinforced with embedded large-mesh fabric of comparatively inelastic thread to prevent ballooning under the influence of the patient's blood pressure. This body 44 for practical reasons is bag-shaped and has one end completely open to form a base opening 45 having free marginal edges to be connected to the lip of an operational incision, in this instance by my quick-operable means for that purpose instead of by the laborious, time-consuming stitching previously practiced. The opposite end of body 44 is provided with a pair of slightly spaced abbreviated sleeves 46 and 47 for introduction of a surgeon's finger D into the interior through one opening and the instrument E to be used through the other. In order to effect a fluid seal after the finger and instrument have penetrated sleeves 46 and 47, respectively, to a sufficient degree, purse-string closure means 48 and 49 are provided in said sleeves. Body 44 should be made large enough in diameter to afford considerable freedom in finger flexing and instrument arrangement with respect to the finger and it should be long enough to permit the desired penetration of the aorta by finger and instrument as the side wall of the body is collapsed in the accordion-pleat manner illustrated in Fig. 11. In order that the side walls of body 44 will become pleated outward instead of pressing inward against the finger and instrument welled-in thereby to obstruct movement, the said side wall is medially bulged as shown. Since the base opening 45 in the wall body 44 is to be marginally connected to the lip of the artery incision, the circumferential dimension of the said opening will determine the extent of the incision. Because it is desirable to make as short an incision as possible, for medical reasons, the diameter of base opening 45, therefore, should not be any larger than absolutely necessary.

At this point, it may be appropriate to explain that my improved connector element of the improved slide fastener closure structure, as at present contemplated, will be manufactured in precisely calculated standard sizes for substantially permanent incorporation in the construction of a surgical well or any one of the other appliances, surgical or in other categories, to which it may be applied. For instance, another application of the invention is in connection with an artificial conduit (not shown) which may be introduced in a patient's circulatory system in terminal connection to any selected arteries or veins in by-passing relation to some vital organ which it is desired to operate in a blood-evacuated condition, such as the heart. Naturally, where the heart is by-passed, artificial blood pumping means will have to be operatively coupled to the artificial conduit to take over the function of the resting heart.

Since the artificial conduit may not need to be as large in diameter as the base portion of a surgical well, the connector element for this application may be of proportionately reduced diameter. As a practical matter, its diameter should be just sufficient to admit one finger into its interior for manipulation of the gripper devices of which the connector element is composed. This size reduction will be favorable to the making of desirably short incisions.

Turning for a moment to Figs. 7 and 8, it will be observed that the two preparatory steps in the surgical operation for which the well is primarily designed that immediately precede application of the latter to the incision B consist in first pinching an appropriate portion of the wall of the aorta outward into a ridge or flap by use of haemostat F and then incising the pinched portion of the said wall lengthwise thereof, whereby a marginal lip A is formed for attachment to the well.

Referring now to Figs. 12 to 15, the quickly operable annular connector element 50 which I have provided in substitution for the lengthy and tedious process of suturing the lip A of incision B to the marginal edge of the opening in base portion 45 of the well preferably includes plural closely spaced gripper devices 51, which are arranged in a row following the outline of a closed curve (Figs. 10 and 11). The row of gripper devices 51 for each standard size well should be proportioned to be coextensive with the lip of an incision of predetermined length. Naturally, the several gripper devices must be held together against too great a separation at their adjacent side faces so as to insure a fluid-tight joint. This I have accomplished by means which will be described in detail presently.

Each gripper device 51 comprises two relatively movable members 52 and 53 which are medially pivoted in the preferred embodiment of the invention, as by annular pivot wire 54, which also serves as means to hold the gripper devices together. It is to be understood that it is within the scope of the invention to utilize other equivalent pivotal means, or means for uniting the entire ring of gripper devices. Each gripper member 52 or 53 has a gripping jaw 55 at one side of the pivotal axis and a manipulatable lever arm 56 at the opposite side. The two mated members 52—53 have their respective

jaws 55—55 operatively opposed to each other and adapted to straddle and grippingly engage the lip of a body incision when in closed condition. Instead of being crossed at their pivotal axis, gripper members 52—53 are arranged so that the jaws 55—55 will be opened when lever arms 56—56 are pressed toward each other.

In the embodiment of connector element 50 represented in detail in Figs. 12 to 15, inclusive, means to close the jaws 55—55 of the several gripper devices 51 is provided and is in the form of an annular member 57, which is made of flexible and resiliently compressible, elastic material such as rubber or a rubber substitute. This jaw closing member 57 may be either tubular in construction as shown or may be solid (not shown), in which latter case it should be made of softer, more easily compressible material. The several gripper devices 51 have their lever arms 56—56 formed to provide concave, relatively opposed inner faces which unite to provide an annular groove or channel in which closing member 57 may be seated. The diameter of closing member 57 should be such in its normal uncompressed state that it will maintain the lever arms 56—56 of each gripper device 51 at a maximum degree of separation, whereby jaws 55—55 will be pressed together. Consequently, it will be necessary to press lever arms 56—56 toward each other against the elastic resistance of closing member 57 in order to open jaws 55—55 for the purpose of receiving therebetween in straddled relation the marginal lip A of body incision B. Then, when the compression of member 57 is released, it will expand and bias the jaws 55—55 toward each other into tight gripping engagement with the lip A of the incision. The thickness of incision lip A will prevent complete expansive return of compressible jaw-closing member 57 to normal width, so lever arms 56—56 will be maintained under constant outward tension, which will insure a firm grip of jaws 55—55 on said lip.

In order to prevent the jaws 55—55 of the several gripper devices 51 from slipping in their engagement with lip A of the incision, the jaws of some of the gripper devices, preferably alternate ones, have been provided with lip piercing or indenting means, whichever may be preferred. Fig. 14 shows one jaw provided with a recess 58 in the form of a complete perforation and the coacting jaw provided with a mated pin-like tooth 59 to be received in the aligned recess 58 after piercing the incision lip A. An optional structure is illustrated in Fig. 15, wherein one jaw has a shallow notch-like recess 58' opposed to blunt tooth 59' of the coacting jaw. The alternate gripper devices 51 are provided with plain inner jaw faces as shown in Fig. 12 in order that lip A of the incision will not become weakened and in danger of tearing loose from connector element 50 due to too many and too closely spaced perforations or indentations.

Incorporation of the new connector element 50 in the structure of one stringer of the slide fastener closure involves integration of a row of fastener elements with said connector element for interlocking cooperation with the mated fastener elements of the other stringer, which latter has a connector element of tape-form adapted to be united in permanent manner with the marginal edge of base opening 45 in surgical well 44 and preferably by machine stitching. One mode of such integration is illustrated in Figs. 12 to 15 and includes uniting jaw closing member 57 in fluid-tight manner with the outer marginal edge of a short tubular sleeve 60 by any practicable manufacturing process, such as molding or cementing. Sleeve 60, which is to be considered part of the special connector element 50, may be made entirely of waterproof or water-resistant fabric or of the same reinforced rubber latex material that is used in fabrication of surgical well 44. The choice of material may determine the manufacturing process employed in uniting sleeve 60 with jaw closing member 57. At the opposite end of sleeve 60 with respect to jaw closing member 57, the series of fastener elements 30' are affixed coextensively to the free inner edge thereof in appropriately spaced relation for interlocking engagement with fastener elements 30 of stringer 32.

In Figs. 16 and 17, an alternative mode of integration of the improved connector element 50 of stringer 32' with the fastener elements 30' is disclosed. In this instance, the fastener elements are directly affixed to, or made integral with, corresponding lever arms 56 of respective gripper devices 51 of said connector element. In the illustrative example, the fastener elements are shown integral with the outer lever arms, i. e. those which will be exposed to view when the slide fastener is closed, which at present is the preferred arrangement.

When jaw closing member 57 is tubular in structure and therefore not solid, it is entirely practicable to insure tight gripping action and greatly increased security against accidental opening of jaws 55 by injecting air or other compressible fluid under relatively high pressure into the interior of said member immediately after the incision lip has become engaged between the jaws of all gripper devices of the series. This may be accomplished by use of a needle-type inflation device (not shown) such as is used to inflate basketballs and footballs. There will be an annular area of jaw closing member 57 located between lever arms 56—56 of the whole series of gripper devices 51 that will be exposed when the slide fastener closure is open and thus available for penetration by the needle of the inflation device, regardless of whether said device be directly incorporated in the construction of a hand pump or remotely connected by tubing to a source of compressed fluid, such as a power pump or a pressurized bottle. It may even be preferred and practicable to inject a comparatively incompressible liquid into member 57 instead of a gaseous fluid. At the end of the operation, of course, it will be necessary to utilize the inflation device in reverse manner to release the gas pressure or to evacuate the liquid, as the case may be.

Figs. 18 to 21 show a modified form of slide fastener closure in which quick-operable connector element 50 has gripper devices 51' comprising modified pivoted members 52'—52' which are preferably stamped out of flat sheet metal. The medial pivoted portions and lever arms 56'—56' have their abutting flat faces arranged at right angles to the axis of pivot wire 54', whereas the portions which form jaws 55'—55' are bent on their major axes through an angle of 90 degrees to the planes of arms 56'—56' so that their inner flat faces will closely abut in closed jaw condition. Lever arms 56'—56' have been provided with circular apertures 61—61 which are adapted to register when the jaws are closed, but it is to be understood that any other equivalent structural formation of said arms, such as hook-formation, depressed sockets, or the like, may be utilized to convert them into component parts of a fastener element 30''' for mated engagement with the modified fastener element 30'' of the other stringer. In this embodiment, each fastener element 30'' has a spherical head 62, or equivalent structure, for partially penetrating fit within the registering apertures 61—61 of the mated fastener element 30'''.

As previously stated, the new one-wing slider, which moves on a track located entirely on the outside of the mated fastener elements of both stringers and has no separator neck or equivalent structure permanently penetrating the space between uncoupled fastener elements, is peculiarly adapted for use in connection with a slide fastener closure to unite a surgical well with the lip of an artery incision. This is because it is now possible to run the slider along the complete series of fastener elements comprising the closed curve arrangement thereof disclosed in Figs. 9 to 11 of the drawings. With the earlier conventional type of slide fastener device, complete coupling of all fastener elements in the continuous circuit cannot be accomplished. After the slider has been started from any selected point, it can move only through

part of the circuit. As it approaches the starting point, the slider will become blocked by laterally deflected and obliquely arranged fastener elements close to those which were initially coupled. The slider cannot couple those deflected fastener elements and there will be a large area gap therebetween which it is impractical to close to render the closure properly fluid-tight for its intended use. However, with the new one-wing slider, it is entirely practicable to move the slider clear around the circumference of the closure device and to do so in either direction. In this way, there will be avoidance of any uncoupled condition of the fastener elements and consequent creation of an unsealed gap, but, in this condition, the slide fastener device cannot be opened at the end of the operation, so it became necessary to devise means to permit subsequent uncoupling.

In order to uncouple the fastener elements of the closed circuit, it must be made possible to rock some of them at a selected starting position in the plane of their interlocked organization to disengage their mating scoops. This has been provided for by creation of an intentional gap of rectangular form which can conveniently be sealed by means disclosed in Figs. 22 and 23. The intentional gap, which is designated by the numeral **63** in Fig. 22, is provided by removing a number of the fastener elements **30—30′** of both stringers at the selected location. This gap should be of such width in the direction of the rows of fastener elements that the straight medial portion of slider **33** may be lowered into the gap for engagement with the guide grooves of the terminal fastener elements at either side of said gap, when applying the slider to its track, or may be slid off the guide means into the gap for complete disengagement under appropriate conditions. In other words, gap **63** forms an entrance and an exit for the slider whenever attachment or detachment becomes necessary or desirable while the fastener elements are all in coupled condition.

Due to provision of gap **63**, the connector elements on opposite sides thereof may be pulled apart (at right angles to the center line of the rows of interlocked fastener elements) manually to rock the terminal fastener elements at either side of the gap (in the direction of said center line) into uncoupled condition. Thereafter, uncoupling can be accomplished progressively around the entire circuit by manual operation or by depressing the separator detent of slider **33** into the space between shoulders **30*a*** and **30*b*** of the selected terminal fastener elements after the said slider has been engaged with its track.

In order to maintain a fluid-tight seal for gap **63** after the surgical well **44** has been completely installed in connection with the incision lip A and slider **33** has either been released from its track or is still retained in operative engagement therewith, whichever is desired by the surgeon, a sealing flap **64** has been provided to fill the gap. This flap **64** preferably is in the form of a flat elongated plate of metal, plastic, or other suitable comparatively rigid but resilient material, and should be of sufficient width to close the gap with its side edges in close contiguity with the terminal fastener elements and of a thickness that will obstruct accidental detachment of slider **33** from the guide grooves of its track when said slider has been left in operative track-engaged position during the operation. Flap **64** preferably is mounted for adjustment between the inoperative and operative positions of Figs. 22 and 23, respectively, by being hinged as at **65** to base plate **64′** which is affixed to tape-form connector element **31** of stringer **32**. Other equivalent ways of movably mounting flap **64** may be employed within the scope of the invention, as well as ways to secure the said flap in operative position in closing relation to gap **63**. One means to secure flap **64** in operative position is suggested in Figs. 22 and 23, in accordance with which yieldable latching detents **66—66** are stamped from the side edges of the flap at or near its free end for snap-lock engagement within the guide grooves **37** of the fastener elements **30′—30′** that define the opposite sides of gap **63**.

Regardless of which embodiment of connector element **50** is employed in construction of the improved slide fastener closure for surgical uses, as in uniting a surgical well with the lip of an artery incision, there will be interstices between numerous proximate faces of the fastener elements and the gripper devices which will permit fluid leakage unless sealed in some way. In Figs. 24 and 25, there is illustrated the means which I have devised to seal the normal clearance spaces between the relatively movable parts just mentioned. For example, the fastener elements may be provided, at least on all external surfaces that do not rub together, with a coating **67** of rubber-like elastic material. The thickness of coating **67** should be slightly in excess of one-half the clearance space in any area of proximity. Therefore, since the widths of the several clearance spaces will vary considerably, the coating **67** will be thicker in some areas than in others as shown in Fig. 25. Although not illustrated in the drawings, it is to be understood that it is within the scope of the present invention to extend the coating treatment with elastic sealing material to the gripper devices **51** of quick-operable connector element **50** and to sealing flap **64** for entrance and exit gap **63**.

Concerning the operational use of my improved slide fastener closure in heart valve surgery to connect a surgical well to the lip of an artery incision, the two preparatory steps have been described already with reference to the disclosure in Figs. 7 and 8. To continue now with the subsequent steps involved in installation of the surgical well, the new sutureless connector element **50** constituted by the circular organization of gripper devices **51**, regardless of the particular inventional embodiment of the latter, is introduced into the thoracic cavity and held closely adjacent to the artery incision B. At this stage, the surgical well **44** may be detached from zippered connection to connector element **50** as indicated in Fig. 9, or it may be united thereto at one point only by application of slider **33**, whichever is preferred by the surgeon. In either case, the surgeon has free access to the interior of connector element **50** for manipulation of the lever arms **56—56** of each gripper device **51** of said element. While holding the lip A of incision B erect at a selected area by use of one hand, the surgeon then opens the jaws **55** of all the gripper devices **51** that can be included in the grasp of the thumb and forefinger of his other hand and causes the said jaws to straddle the erected portion of the incision lip. Upon release of compression of the lever arms **56** of these gripper devices, the resilient jaw closing member **57** will automatically cause the jaws to close on the incision lip and tightly grip the same therebetween. This operation is then conducted all the way around the connector element. Then, slider **33** is brought into operation to unite surgical well **44** with connector element **50** by coupling the mated fastener elements **30—30′** from one side of entrance and exit gap **63** to the other (Fig. 22). After slider **33** has been removed from engagement with its track through gap **63**, or has been retained on the track, sealing flap **64** is adjusted from the open or inoperative position shown in Fig. 22 into the closed or operative position disclosed in Fig. 23 and is latched therein by snapping detents **66—66** into engagement with the guide grooves **37—37** of the terminal fastener elements **30′—30′** alongside gap **63**.

The sequential steps just described must be performed while haemostat F is still tightly engaged with the incision lip A. While the haemostat is still in place, the surgeon inserts his forefinger D and instrument E into the well body **44** through sleeves **46** and **47**, respectively, to the desired degree of penetration and the said sleeves are sealed in connection with said forefinger and instrument by the purse-string closure means **48** and **49**. It is now safe to release haemostat F and proceed with the

heart valve operation by further penetration of finger and instrument through the slide fastener closure and incision into artery C. The patient's blood will well-up into well **44** but cannot leak therefrom during the operation. Upon completion of the latter, the haemostat is reapplied to the incision lip and all the preliminary steps of installing the surgical well are repeated in reverse order. The final step before again releasing the haemostat obviously consists in suturing the incision.

In Fig. 26, a still further application of the improved slide fastener closure in surgery is illustrated. In this example, quick-operable connector element **50** is connected temporarily, but longer than for the duration of a surgical operation, to the marginal edge of any incised opening in a body wall, membrane, or other anatomical structure, for the purpose of sealing the incision during intervals between treatments or periodic inspections of operated areas within the body cavity defined by the wall, membrane, or the like. With this type of closure, it is not necessary to suture the incision immediately following each treatment or inspection. In the illustrative example, the fastener elements are shown with the slider removed and with no provision for an entrance and exit gap for the slider. While it is contemplated that such a gap usually will be provided, there is shown in Fig. 2 a modification of the required number of fastener elements, when of conventional scoop construction, to permit them to be uncoupled by simply pressing them manually outward from the plane of adjacent coupled fastener elements of unmodified construction in rocking motion about their points of attachment to the respective connector elements. The proposed modification consists in grinding off, or otherwise removing, the scoop projections that ordinarily matingly engage within indentations of adjacent scoops. As a result, the modified fastener elements, when pressed down into the plane of coupled unmodified fastener elements, will effectively seal the gap previously created by the upward rocking movement. The modified fastener elements are designated by the reference character **30***m*.

It will be observed in several of the views (Fig. 2 for instance) that the spacing of various structural parts or elements is greatly exaggerated, which could not very well be avoided in such large scale illustration adopted in the interest of clear disclosure. Ordinarily, the several parts or elements are quite minute in size and the clearance spaces therebetween may be sealed in fluid-tight manner by a comparatively thin coating of rubber-like material. Obviously, the thickness of the coating illustrated in Fig. 25 also is greatly exaggerated by the large scale employed.

It will be understood that it is intended to cover all changes and modifications of the examples of the invention herein chosen for the purpose of illustration which do not constitute departures from the spirit and scope of the invention.

Having thus described the invention, I claim:

1. A closure device comprising: a pair of substantially coextensive stringers adapted to be arranged in coplanar parallelism; a longitudinal row of regularly spaced fastener elements arranged along the inner side of each stringer for mutually interlocking engagement with the fastener elements of the other stringer, the fastener elements of each stringer being provided with guide grooves therein facing laterally outward and being in longitudinal alignment with respect to said stringer and having inwardly presented spaced vertical shoulders; and a slider for cooperative operational engagement with the rows of mated fastener elements of both stringers, said slider including a single wing to slide longitudinally outside the plane of the rows of fastener elements and side walls depending from said wing and having guide flanges facing laterally inward therefrom to engage slidably within the guide grooves of the respective rows of fastener elements as a track, said side walls and guide flanges of the slider being spaced apart at least at the rear end thereof sufficiently to couple the slidably engaged fastener elements as they enter the space between said walls and being flared apart toward the front end of said slider, and a separator detent of wedge-shaped cross-section mounted for vertical adjustment on the slider and adapted to be moved into the space between the flared wall portions thereof to enter the space between shoulders of the fastener elements to wedge the latter apart and uncouple the same when the slider is moved rearwardly along its track.

2. A closure device as defined in claim 1, wherein the slider is provided with a pivoted pull tab, and wherein the separator detent is mounted on said pull tab.

3. A closure device as defined in claim 2, wherein the pull tab is pivoted on a transverse axis.

4. A closure device as defined in claim 3, wherein the separator detent is tapered in form outward from the pull tab to facilitate penetration of the space between shoulders of the fastener elements.

5. A closure device as defined in claim 1, wherein the fastener elements of both stringers have their external faces covered with a coating of elastic rubberlike material having a thickness equal to slightly more than half the normal clearance between the mated fastener elements when coupled to form a fluid-tight joint therebetween.

6. A surgical well comprising: an elongated bag-shaped body of thin-walled flexible impervious material open at one end for finger and instrument penetration and with the opposite end open to form a base opening having free circumferential edges; an annular connector element including gripping means arranged in a circumferential closed curve for detachable fluid-tight engagement with the lip of a surgical incision; and annular fluid-tight quickly-operable means to connect said connector element communicably in fluid-tight manner to the circumferential edge of the base opening in the body of the surgical well.

7. A surgical well as defined in claim 6, wherein the quickly-operable means to connect the connector element to the surgical well body is a slide fastener device including parallel stringers united respectively to the surgical well body and to the connector element.

8. A surgical well as defined in claim 6, wherein the connector element comprises a circumferential row of interconnected and closely abutting gripper devices, each gripper device including a pair of medially pivoted members having gripping jaws at their outer ends and manipulating lever arms extending oppositely with respect to said jaws from the pivotal axis, and yieldable means to close the jaws of the gripper devices.

9. A surgical well as defined in claim 8, wherein the jaw closing means is in the form of an annular member of compressible elastic material interposed between the manipulating lever arms of the gripper devices of the connector element, and wherein the surgical well body has the marginal edge of its base opening united in a fluid-tight manner to the jaw closing member.

10. A surgical well as defined in claim 8, wherein the respective lever arms of the connector element gripper devices on one side of the pivotal axis are formed integral with the marginal edge of the base opening in the surgical well body.

11. A surgical well as defined in claim 8, wherein the gripper devices of the connector element have their external faces covered with a coating of elastic rubberlike material having a thickness equal to slightly more than half the normal clearance between contiguous faces thereof when the jaws are closed to form a fluid tight joint.

12. A closure device as defined in claim 8, wherein the pivoted members of each gripper device of the connector element are made of sheet metal and are arranged side by side with flat faces thereof abutting in a plane substantially at right angles to the pivotal axis, the jaw

portions of said members being bent around the axes of said members to arrange the abutting flat faces of said jaws in a plane in which the pivotal axis lies; wherein the lever arms of both gripper device members have circular apertures adapted to register when the jaws are closed whereby said lever arms unite to form a fastener element; and wherein fastener elements having substantially spherical portions to lockingly engage the apertures of the mated fastener elements are affixed in a coextensive circumferential row to the marginal edge of the base opening of the surgical well body.

13. A closure device as defined in claim 8, wherein the lever arms of the respective gripper devices of the connector element are oppositely bowed to form an annular seating channel therebetween; and wherein the jaw closing means is in the form of an annular member of elastic material adapted to lie in the said seating channel.

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