

Aug. 15, 1967

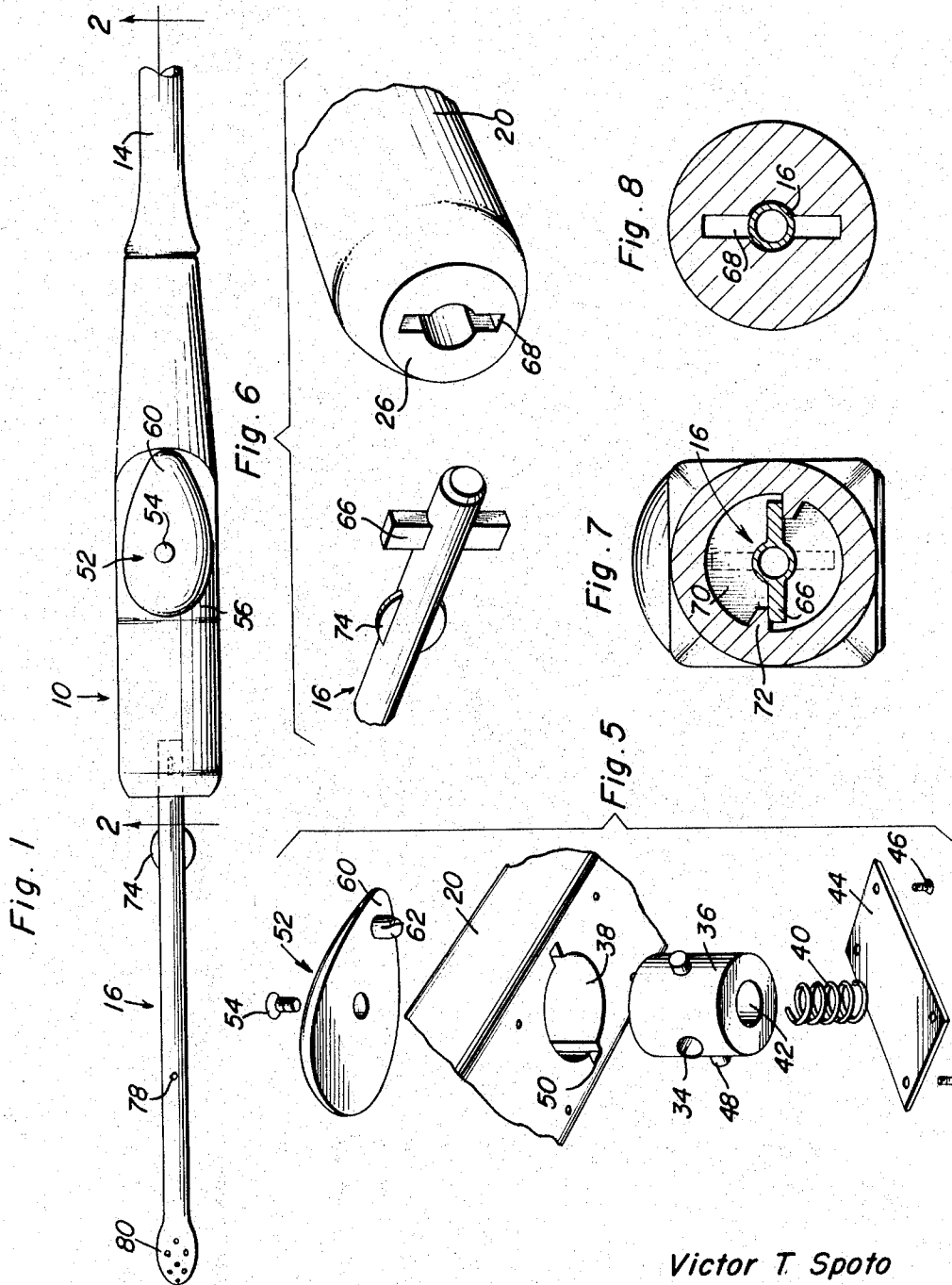
V. T. SPOTO

3,335,727

VALVE CONTROLLED CORONARY PERFUSION SUCTION TUBE

Filed March 2, 1965

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 2

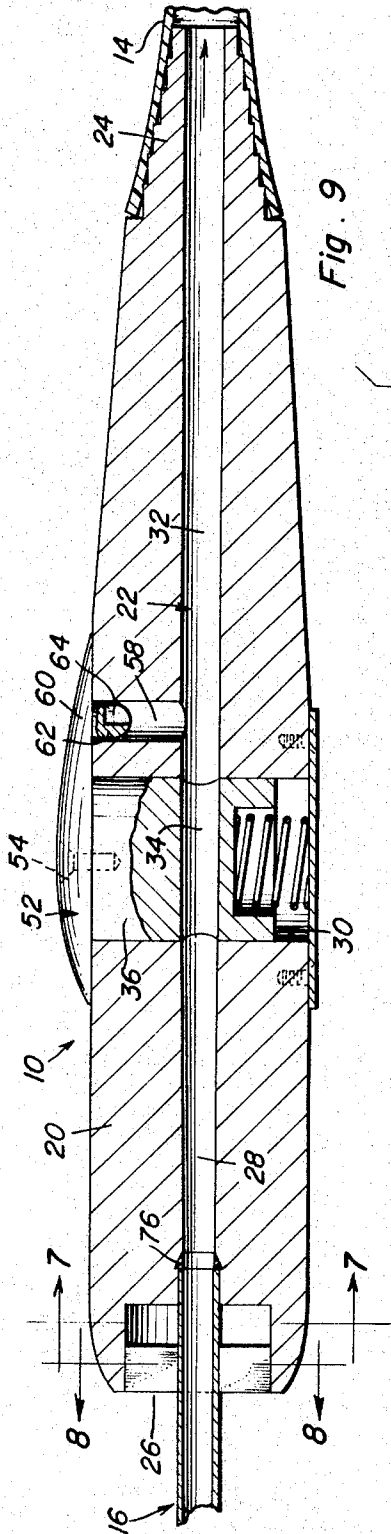


Fig. 9

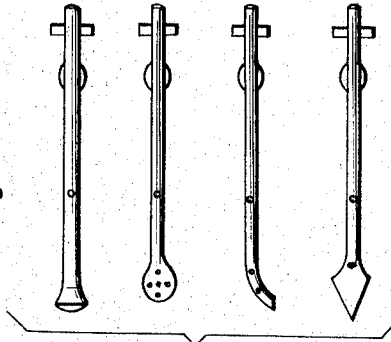


Fig. 4

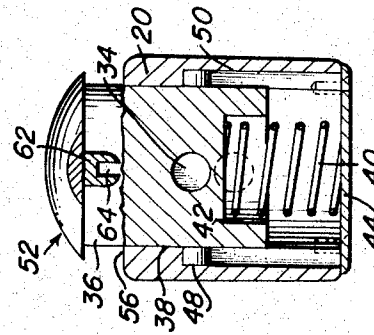


Fig. 3

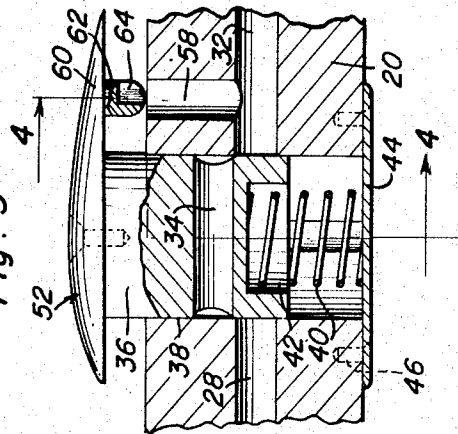
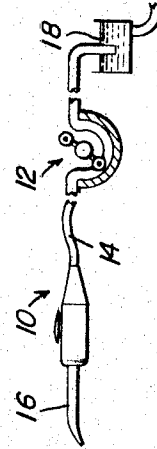


Fig. 10



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## 3,335,727 VALVE CONTROLLED CORONARY PERFUSION SUCTION TUBE

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This invention relates to improvements in surgical apparatus and more particularly to a valve controlled suction device through which the flow of blood may be controlled during open heart surgery.

The present invention features a manually operated suction device adapted to be utilized in connection with a blood circulating pump system utilized during cardiac surgery. Pump systems of this type are available whereby blood may be withdrawn from the patient during surgery and stored or recirculated externally of the patient for return and reuse by the patient. One of the serious problems encountered in connection with such external flow of blood, is a condition known as hemolysis, wherein a breakdown of red blood cells occurs because of abrupt changes in environmental flow conditions. It is therefore a primary object of the present invention to provide a manually controlled suction device through which blood is withdrawn from a patient under control of the cardiac surgeon in such a manner as to minimize hemolysis.

An additional object in accordance with the preceding object, is to provide a valve controlled suction device adapted to be connected to a flexible tube or conduit through which blood is to be conducted, with facilities for preventing collapse of the flexible tube in response to intermittent stoppage of flow through the suction device. By preventing the intermittent collapse and expansion of the flexible tube through which the blood flows, turbulence is avoided. Thus, the suction device of the present invention will prevent flow conditions which often contributes to the development of hemolysis.

A further object of the present invention is to provide a valve controlled suction device which is easy to handle and operate and which is provided with facilities for facilitating replacement of interchangeable tips through which the suction pressure of the external blood circulating system may be selectively directed by the cardiac surgeon to the source of blood within the patient.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a top plan view of the valve controlled suction device of the present invention;

FIGURE 2 is an enlarged partial sectional view taken substantially through a plane indicated by the section line 2—2 in FIGURE 1;

FIGURE 3 is a partial sectional view of a portion of the device illustrated in FIGURE 2 showing the device in a closed condition;

FIGURE 4 is a transverse sectional view taken substantially through a plane indicated by section line 4—4 in FIGURE 3;

FIGURE 5 is a perspective view of some of the disassembled parts of the valve controlled suction device;

FIGURE 6 is a perspective view of other disassembled parts of the suction device;

FIGURE 7 is a transverse sectional view taken substantially through a plane indicated by the section line 7—7 in FIGURE 2;

FIGURE 8 is a transverse sectional view taken substantially through a plane indicated by section line 8—8 in FIGURE 2;

FIGURE 9 illustrates several different types of interchangeable tips to be utilized with the valve controlled device of the present invention; and

FIGURE 10 is a diagrammatic view of a portion of the blood circulating system with which the suction device is utilized.

The suction device of the present invention generally referred to by the reference numeral 10 is adapted to be utilized with an external blood circulating system as aforementioned which is diagrammatically illustrated in FIGURE 10, the system including, for example, a roller-type of pump unit 12 constituting a source of suction pressure communicating with the suction device 10 through a flexible conduit 14 so that blood from its source may be withdrawn from the patient through the tip 16 upon actuation of the suction device 10. Thus, the blood may be conducted by the flexible conduit and collected within a suitable container or reservoir 18 which forms part of the circulating system.

Referring now to FIGURES 1 and 2 in particular, it will be observed that the suction device 10 embodies an elongated passage 22 formed within the valve body. The valve body 20 is formed adjacent one end with a grip surface portion 24 adapted to anchor one end of the flexible conduit 14. The forward end 26 of the valve body on the other hand, is adapted to receive the tip 16. Fluid communication between the tip 16 and the conduit 14 is therefore established through the elongated passage 22 which includes a forward portion 28 located on the upstream side of a valve assembly 30 and a rear portion 32 on the downstream side of the valve assembly. The passage 22 is formed by a bore of constant cross-section between the opposite ends of the valve body so that there will be no abrupt changes in flow as blood passes through the suction device. Toward this latter end, the valve assembly is provided with a valve passage 34 equal in cross-sectional flow area to the passage 22 and disposed parallel thereto so that when it is aligned with the passage 22 in the open position of the valve assembly as illustrated in FIGURE 2, unrestricted fluid communication will be established between the tip 16 and the conduit 14.

Referring now to FIGURES 2, 3 and 4, it will be observed that the valve assembly includes a cylindrical valve member 36 which is slidably mounted within a transverse bore 38 formed in the valve body intersecting the elongated passage 22. The valve member is continuously biased to the closed position illustrated in FIGURE 3 by means of a spring element 40 the upper end of which is received within a socket 42 formed in the lower axial end of the valve member. The lower end of the spring element 40 reacts against a plate member 44 which is fastened to the valve body by the fasteners 46 so as to close the lower end of the transverse bore 38 formed in the valve body.

When in the closed position, the valve passage 34 will be parallel to but spaced from the passage 22 so as to completely block the flow of fluid from the upstream portion 28 of the passage into the downstream portion 32 of the passage. In order to ensure that the valve passage 34 will be perfectly aligned with the upstream and downstream portions of the passage 22 when the valve assembly is displaced to the open position against the bias of the spring element 40, a pair of projections 48 extend laterally from the valve member 36 and are received within guide slots 50 formed within the valve body 20 in order to prevent angular displacement of the valve member.

A valve actuating member 52 is secured by fastener 54 to the upper end of the cylindrical valve member 36, the shape of the valve actuating member being such in relation to the elongated shape of the valve body as to facilitate depression of the valve member against the bias of the spring element 40 by the operator's thumb while the hand grasps the valve body. Further, the valve actuating member extends longitudinally beyond the valve member 36 to which it is connected so as to abut a relatively flat portion 56 on top of the valve body as more clearly seen in FIGURE 1 in order to limit downward displacement of the valve member to the open position shown in FIGURE 2.

An important feature of the suction device is the provision of a vent passage 58 on the downstream side of the valve assembly which intersects the passage portion 32 so as to expose the passage to atmospheric pressure when the valve assembly is in the closed position as shown in FIGURE 3. The valve actuating member 52 is therefore provided with a rearward extension portion 60 which overlies the vent passage 58 so as to seal it when the valve actuating member 52 is displaced into abutment with the surface 56 on the valve body as aforementioned. A vent closing plunger element 62 is connected to the extension portion 60 in alignment with the vent passage so as to be received therewithin for closing the same as illustrated in FIGURE 2. The closing plunger element is further notched so as to provide a restricted passage 64 whereby atmospheric pressure is gradually cut off from the passage portion 32 as the valve member 36 is displaced downwardly to its open position. By the same token, venting of the passage portion 32 to atmosphere is made more gradual in response to release of the valve assembly and movement thereof to its closed position.

Referring now to FIGURES 2, 6, 7 and 8, it will be observed that flow of fluid is introduced to the upstream portion 28 of the passage by means of the tip 16 which is provided at a connecting end thereof with a pair of laterally projecting lock flanges 66. The lock flanges are therefore adapted to be received through the slots 68 formed at the end 26 of the valve body, the slots communicating with a cylindrical chamber 70 formed in the valve body adjacent the end 26. A pair of stop flanges 72 project inwardly of the cylindrical chamber 70 as more clearly seen in FIGURE 7 so that after the connecting end of the tip is inserted, it may be rotated until the locking flanges 66 engage the stop flanges 72 and prevent withdrawal of the tip through the slots 68. So as to facilitate locking and unlocking of the tip by rotation thereof, a pair of grip formations 74 are formed on the tip closely spaced forwardly of the locking flanges 66. When fully inserted, the end of the tip engages a sealing ring 76 as more clearly seen in FIGURE 2 in order to prevent leakage of blood conducted through the tip into the valve body passage 22. The tip is also provided with a release pressure vent 78 as shown in FIGURE 1 so as to facilitate withdrawal. Also, the tip is provided with an inlet end portion 80 through which suction pressure is applied to a source of blood in order to induce its flow into the tip and through the valve body when the valve assembly 36 thereof is displaced to its open position. Depending upon the location of the source of blood, inlet end portions of different shapes may be provided on different tips as illustrated in FIGURE 9. Accordingly, each type of tip is constructed in a similar fashion except for the shape of the inlet portion thereof. Further, it will be apparent that replacement of the tip is facilitated so that the same suction device may be utilized by the surgeon with a supply of sterilized tips for interchange purposes.

From the foregoing description, the construction, operation and use of the suction device of the present invention will be apparent. It will therefore be appreciated that the device is operative in response to displacement of the valve assembly to the open position against the bias of the spring 40, to gradually close off the atmospheric

vent in order to prevent the occurrence of turbulence in the ensuing flow of blood through the passage portion 32 into the flexible conduit 14. Further, upon release of the valve element in order to cut off the flow of blood, gradual opening of the atmospheric vent passage 58 occurs in order to prevent the collapse of the flexible conduit which would still be conducting blood therethrough. Accordingly, the action of the suction device in preventing the collapse of the flexible conduit and the avoidance of any abrupt changes in flow conditions, will operate to minimize hemolysis as aforementioned. Further, the shape of the valve body, the valve actuator member and the facilities for rapidly effecting an interchange of the tip, will substantially facilitate the use and handling of the suction device.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. In combination with a flexible conduit adapted to be connected to a source of suction pressure for inducing flow of blood therethrough, a valve controlled suction device for selectively applying suction pressure to a source of fluid to induce flow thereof into the flexible conduit comprising a valve body connected at one end to said flexible conduit, a replaceable tip removably connected to the other end of the valve body, said valve body having an elongated passage of constant cross-sectional flow area extending between said tip and the flexible conduit, a valve member slidably mounted by said valve body intermediate said ends thereof intersecting the elongated passage, said valve member having a valve passage equal in flow area to said elongated passage and disposed parallel thereto, valve actuating means connected to said valve member for displacing said valve member to an open position with said valve passage in alignment with the elongated passage to establish unrestricted fluid communication between the tip and the flexible conduit, and vent means mounted by the valve body between the valve member and the flexible conduit for supply of air under atmospheric pressure to the elongated passage in response to movement of the valve member to a closed position blocking flow from the tip to prevent collapse of the flexible conduit whereby hemolysis of blood conducted through the flexible conduit is minimized.

2. The combination of claim 1 wherein said vent means comprises a vent passage intersecting the elongated passage upstream of the valve member, and vent closing means mounted on the valve actuating means for closing the vent passage in response to displacement of the valve member to said open position.

3. The combination of claim 2 wherein said vent closing means includes a plunger element received within said vent passage, and restricted passage means formed in said plunger element for reducing abrupt closing and opening of the vent passage in response to movement of the valve member between said open and closed positions to avoid development of turbulence in the flow of fluid through the flexible conduit.

4. The combination of claim 3 wherein said actuating means comprises spring means continuously urging the valve member to the closed position, and a finger operated element connected to the valve member having extension means engageable with the valve body in overlying relation to the vent passage to limit movement of the valve member to said open position and seal the vent passage, said extension means mounting said plunger element in alignment with the vent passage.

5. The combination of claim 1 wherein said actuating means comprises spring means continuously urging the

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valve member to the closed position, and a finger operated element connected to the valve member having extension means engageable with the valve body in overlying relation to the vent means to limit movement of the valve member to said open position and close the vent means.

6. The combination of claim 1 wherein said valve body is provided with a slot at said other end thereof, a cylindrical chamber in communication with said slot and the elongated passage, and stop flanges projecting into the chamber, said tip having locking flanges closely spaced from one end thereof and received through said slot into the chamber, and grip formations mounted on the tip spaced from the locking flanges for rotation of the locking flanges into engagement with the stop flanges after insertion thereof through the slot.

7. In combination with a flexible conduit adapted to be connected to a source of suction pressure for inducing flow of blood therethrough, a valve controlled suction device for selectively applying suction pressure to a source of fluid to induce flow thereof into the flexible conduit comprising a valve body connected at one end to said flexible conduit, said valve body having an elongated passage of constant cross-sectional flow area, a valve member movably mounted by said valve body in intersecting relation to the elongated passage, valve actuating means connected to said valve member for displacement thereof to an open position establishing unrestricted fluid flow through said elongated passage, and vent means mounted by the valve body between the valve member and the flexible conduit for supply of air under atmospheric pressure to the elongated passage in response to movement of the valve member to a closed position blocking flow from said source of fluid to prevent collapse of the flexible conduit.

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8. The combination of claim 7 wherein said vent means comprises a vent passage intersecting the elongated passage upstream of the valve member, a plunger element received within said vent passage, and restricted passage means formed in said plunger element for reducing abrupt closing and opening of the vent passage in response to movement of the valve member between said open and closed positions to avoid development of turbulence in the flow of fluid through the flexible conduit.

9. The combination of claim 8 wherein said actuating means comprises spring means continuously urging the valve member to the closed position, and a finger operated element connected to the valve member having extension means engageable with the valve body in overlying relation to the vent passage to limit movement of the valve member to said open position, said extension means mounting said plunger element in alignment with the vent passage.

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