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Leonard

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[54] **SURGICAL SUCTION DEVICE**

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[52] **U.S. Cl.** **128/278;** 417/36

[51] **Int. Cl.**[2] **A61M 1/00**

[58] **Field of Search** ..... 128/276–278; 32/33; 200/81 R, 81.6; 417/35–36

[56] **References Cited**

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[57] **ABSTRACT**

A surgical suction device is provided having a suction tip and a suction motor communicating with the tip by a length of flexible tubing. The improvement of this invention relates to a control for starting and stopping the motor. The control is positioned remotely from the suction tip, while pneumatic pressure varying means, communicating with the control, are positioned adjacent the suction tip. The control is operated in a manner responsive to pressure variations in the pneumatic pressure means.

10 Claims, 6 Drawing Figures

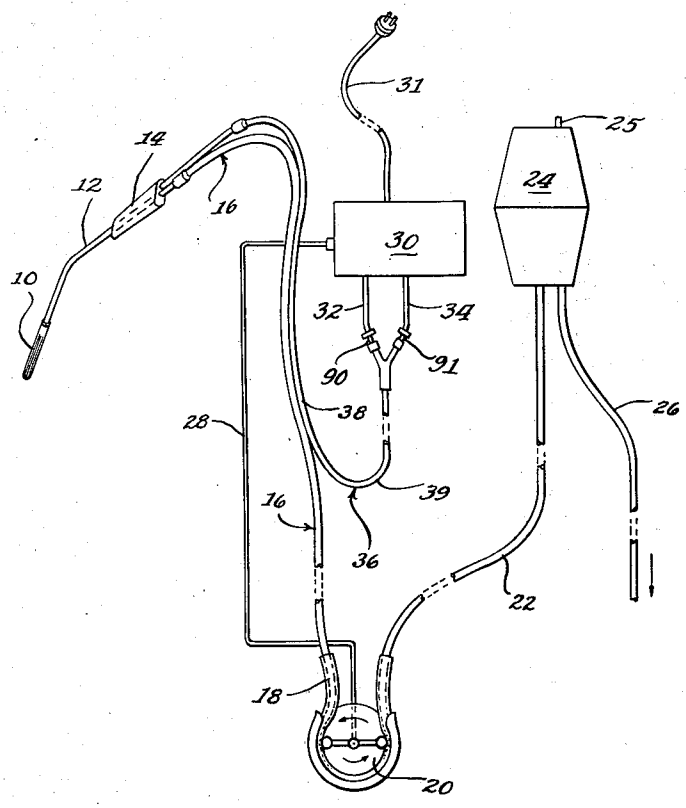


Fig. 1.

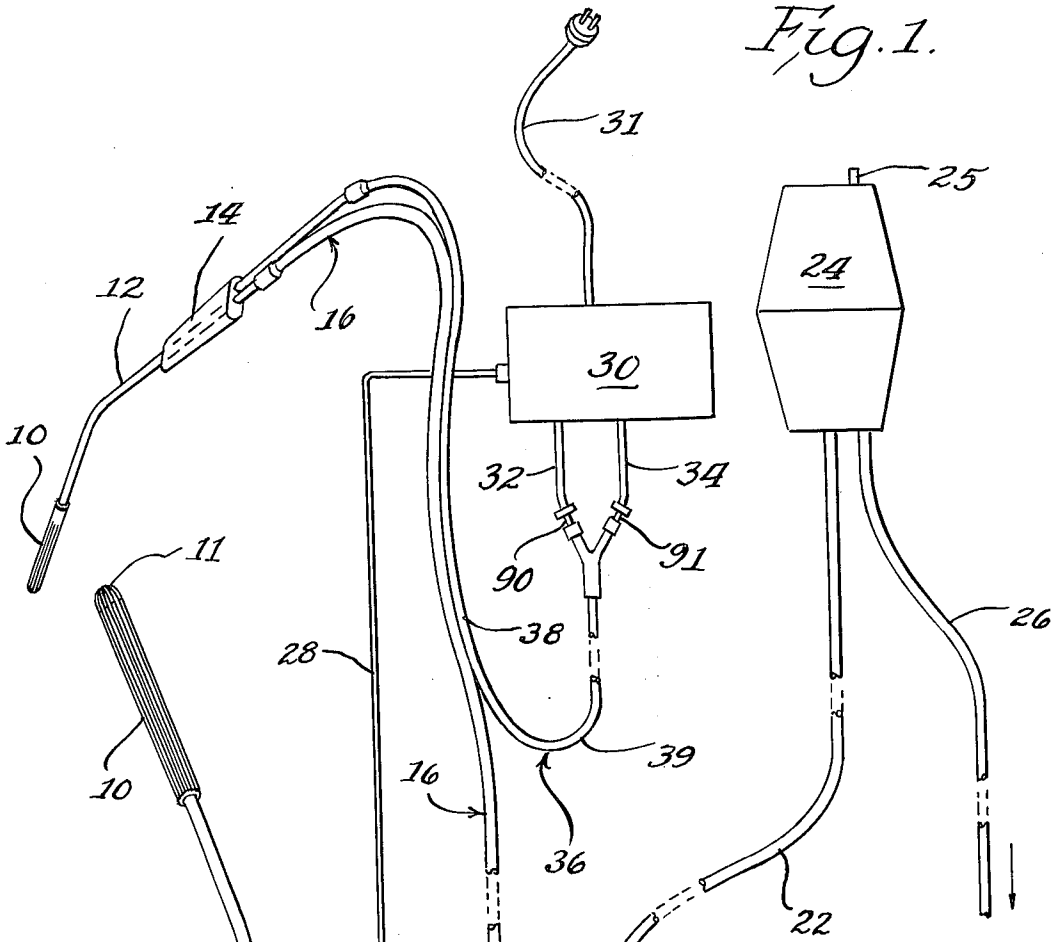


Fig. 2.

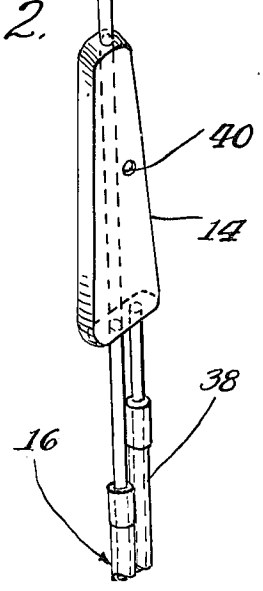
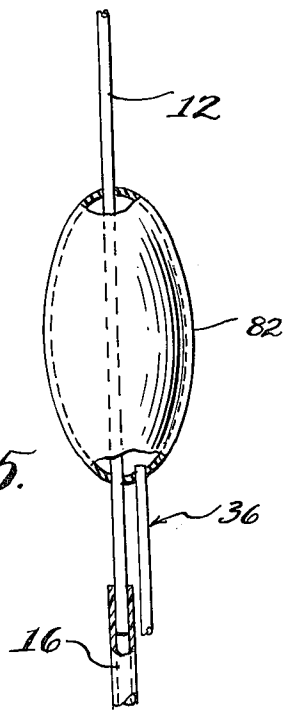


Fig. 5.



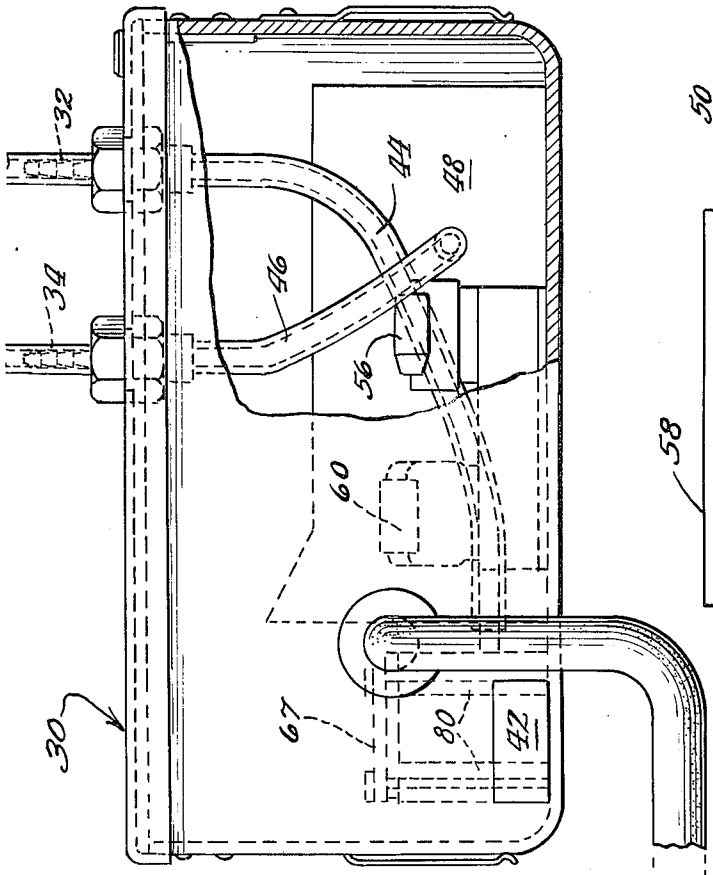


Fig. 3.

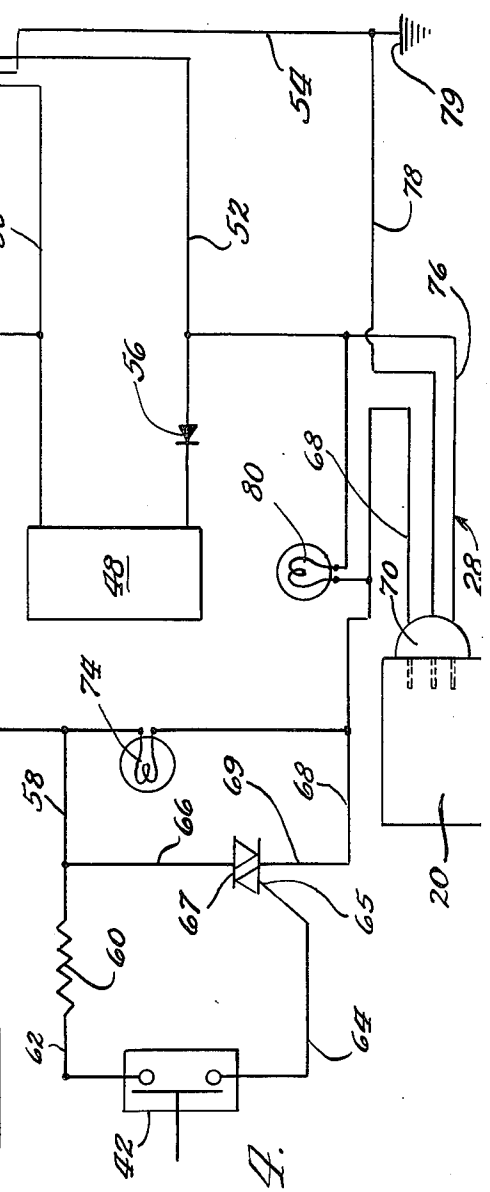


Fig. 4.

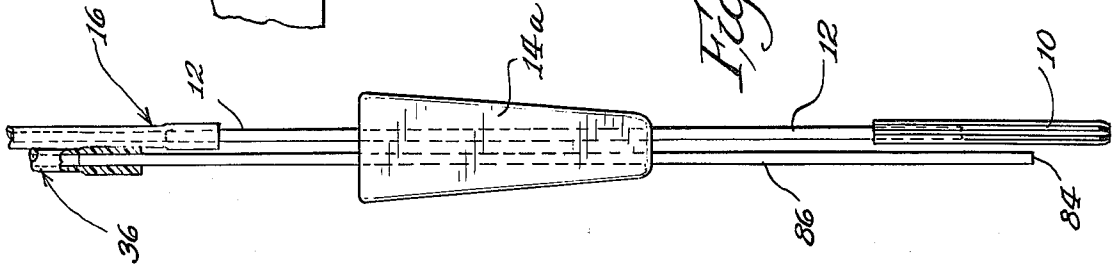


Fig. 6.

SURGICAL SUCTION DEVICE

BACKGROUND OF THE INVENTION

Surgical suction devices are primarily used in such medical procedures as cardiotomy operations and the like, which are serious operations involving a heavy loss of blood. In this type of operation, a surgical suction device is used to keep the operating field clear of blood, and thus visible to the surgeon. Usually, the blood is recycled through the suction device into a so-called cardiotomy reservoir, which serves as a blood storage and filtering means, so that the blood may be re-infused to the patient during or after the operation. This reduces the amount of donated blood which has to be administered to the patient.

Membrane and bubble type blood oxygenators are used in many of the major surgical procedures in which surgical suction is used and the sucked blood is recirculated. The hemolysis reduction in these oxygenator devices has advanced to the point where the hemolysis of blood in the surgical suction apparatus has become a significant percentage of the total hemolysis of blood during the entire operation.

It is believed by many skilled in the art that the best method of reducing the amount of blood hemolysis created by the surgical sucker is by careful control of the suction pump, to prevent it from operating while the suction device is not immersed in blood. When the pumps do so operate without the suction tip being immersed in blood, the residue of blood remaining in the suction lines is bubbled and foamed due to the rush of air through the lines. This causes a great deal of hemolysis, as well as clotting and other undesirable effects.

However, in the heat of surgery, the frustrated surgeon's cry for more suction usually causes the already overburdened pump technician to merely turn the suction pump on, and allow it to run constantly. As a result, the hemolysis of the blood takes place, as well as the creation of clots and other blood debris, and the formation of air microbubbles, which are difficult to remove from the blood, and which are distinctly undesirable for re-infusion to the patient.

Solutions to this problem have been attempted in Jackson U.S. Pat. No. 3,469,582, and Halligan U.S. Pat. No. 3,319,628, in which the suction at the tip of a surgical suction device is halted by the use of venting pipe bypass techniques, so that, although the pump continues to run, the suction device does not operate until the bypass is occluded by the thumb or some other means. However, this arrangement does not protect the blood already in the surgical suction line from damage by foaming, since the pump continues to operate. Also, this air tends to overburden filters, and reservoirs used to separate the blood and air before the return of the blood to the patient.

Also, it is definitely undesirable to utilize spark-forming electrical connections anywhere in the vicinity of the surgical field, because of the presence of the pure oxygen being administered to the patient. Additionally, protection must be made against leakage of electrical current, since the device may be in contact with the heart, which can be fibrillated by even very low electrical stimulation. Furthermore, all of the equipment in the vicinity of the surgical field is desirably sterilizable and disposable, for maximum protection against infection.

This invention provides a device which avoids the above disadvantages, and provides a conveniently operable, disposable device for controlling a surgical suction pump from a location adjacent the suction tip in the surgical field, without requiring electrical equipment in the surgical field area.

DESCRIPTION OF THE INVENTION

In accordance with this invention, a surgical suction device is provided having a suction tip, and a suction pump communicating with the tip by a length of flexible tubing. The improvement of this invention comprises, in combination, control means for starting and stopping the pump, the control means being positioned remotely from the suction tip, away from the surgical field and the pure oxygen; and pneumatic pressure varying means adjacent the suction tip, communicating with the control means, to operate the control means in a manner responsive to pressure variations in the pneumatic pressure varying means.

Generally, the pressure varying means communicates with the pressure responsive pump control means for actuating the suction pump upon sensing a first pressure level and for shutting the pump off upon sensing a second pressure level. A pressure conduit generally provides the communication described above.

Various specific embodiments of the above-described device are shown in the drawings below:

In the drawings,

FIG. **1** is a diagramatic view of a typical surgical suction device in accordance with this invention.

FIG. **2** is a fragmentary perspective view, substantially enlarged, of the sucker portion of FIG. **1.**

FIG. **3** is an enlarged, elevational view, with portions broken away, of the power and control unit of FIG. **1.**

FIG. **4** is a schematic circuit diagram of the power and control unit of FIG. **1.**

FIG. **5** is a fragmentary perspective view of the sucker portion of a modified version of the device of FIG. **1.**

FIG. **6** is a fragmentary perspective view of the sucker portion of another modified version of the device of FIG. **1.**

Referring in particular to FIGS. **1** and **2,** a cardiotomy suction system is disclosed which comprises a conventional suction tip **10,** which may be inserted into a surgical site for removing excess, pooled blood from the site, to permit the surgeon to work. Suction tip **10** generally has a plurality of suction holes **11** at different positions to prevent blockage of all of the holes at any one time during the surgical operation.

Tip **10** is carried on a suction tube **12,** typically made of steel, which, in turn is carried by handle **14** with which the operator can grasp the device. Suction tip **10** and tube **12** constitute an extension of suction line **16,** which communicates with tube **12** at the rear of handle **14,** and is generally made of flexible, plastic tubing.

Suction line **16** is shown to comprise an enlarged section **18,** which fits in the track of a conventional medical roller pump and motor **20,** such as is commercially available from Sarns, Inc. of Ann Arbor, Mich. Accordingly, the operation of the roller pump and motor **20** provides suction within line **16,** tube **12** and tip **10.**

Blood which is expelled past roller pump **20** typically passes in line **22** to a cardiotomy reservoir **24,** which is a commercially available item. There, the blood is filtered and stored until the surgeon determines to rein-

fuse the blood to the patient through line **26.** Air which is pumped into reservoir **24** by pump and motor **20** is vented through port **25.**

In accordance with this invention, a control means for pump and motor **20** is provided so that it can be easily actuated and shut-off as often as desired, to prevent hemolysis of the blood in blood lines or conduits **16** and **22,** for example, and to prevent the creation of microbubbles of air and small clots, which are not easily filtered.

Electrical control cable **28** is shown in the specific embodiment of FIG. **1** to provide electrical power to pump and motor **20** for its operation. The electrical power is supplied from power and control unit **30,** which may be attached to a conventional electrical power outlet by plug and cable **31,** and operates in a manner to be described below.

Power and control unit **30** also provides a stream of air to conduit **34,** which communicates in a Y-connection with conduits **34** and **36** respectively. Both lines contain bacterial filters **90, 91** (preferably less than **1** micron pore size) which prevent any possibility of contamination of the surgical field by the communicating air stream. Typically, conduits **32, 34, 36** are made of vinyl plastisol or the like as a single unit, which unit is separably connected to power and control unit **30,** so that the conduits, and the blood flow lines, may be sterilized before use, and disposed of after use, for maximum insurance of sterility.

Conduit **36** defines a tubular section **38,** which may be a flexible plastic tube attached at its outer periphery to blood flow line **16.** Alternatively, a double lumen tubing may be extruded to serve as both blood flow line **16** and tubular section **38.** However, distal portion **39** of conduit **36** is preferably separate from blood flow line **16,** to permit convenient assembly of the device.

Tubular section **38** communicates with the interior of hollow handle **14,** where it terminates, allowing the pressurized air or other fluid from power and control unit **30** to pass through the hollow interior of handle **14.** Aperture **40** in handle **14** normally permits the exit of the pressurized air or other fluid.

However, when one wishes to operate pump and motor **20** in order to obtain suction at tip **10,** one simply manually obstructs aperture **40** with the thumb or the like, which consequently causes the pressure in conduit **36** to build up. Accordingly, the pressure of conduit **32** builds up as well, which actuates a pressure switch **42** (see FIGS. **3** and **4**), which in turn causes the operation of pump motor **20.** When one releases the obstruction to aperture **40,** the pressure in conduits **32,** 34 and **36** correspondingly drops, and pump motor **20** is shut off by the opening of pressure switch **42.**

Referring more particularly to FIGS. **3** and **4,** further structure, and details of the electrical operation of the apparatus of this invention are disclosed.

As previously stated, the function of power and control unit **30** is to provide electric power to pump motor **20** in a manner responsive to the sensing of a predetermined air or fluid pressure, which is controlled in conduit **32,** leading to pressure switch **42,** by the simple and convenient manual blocking or unblocking or aperture **40.** Because of this simple technique for operating pump **20,** the surgeon can exert better control over operation of the surgical sucker than has been previously possible, resulting in less hemolysis and other undesirable effects as described above, and with no electrical components near the surgical field.

FIG. **3** shows conduit **32** as conventionally connected to control unit **30,** in fluid flow communication with internal flow tube **44,** which communicates with pressure switch **42** for the actuation thereof. Conduit **34** is likewise conventionally connected to flow tube **46** within control unit **30,** which, in turn, is connected to the output of a simple fluid pump **48.** In the specific embodiment shown, the pump can be an inexpensive, commercially available vibratory air pump for an aquarium, manufactured by the Metaframe Corporation of Maywood, N.J.

Accordingly, upon operation of the apparatus, a continuous outflow of air is provided to conduits **46** and **34,** and accordingly to conduit **36,** for providing a continuous outflow of pressurized air through aperture **40.** Upon blockage of aperture **40,** pressurized air passes into conduit **32,** and from thence to flow line **44,** where the increased pressure actuates pressure switch **42** to operate pump motor **20.**

A suitable pressure switch **42** is manufactured by the Fairchild Hiller Corporation under the nomenclature PSF 100A-6C. This particular switch can be actuated at an overpressure of 3 to 6 inches of water, and has electrical contacts rated for 0.1 ampere current flow.

As shown in the circuit diagram of FIG. **4,** normal line alternating current (approximately 110 v.) is provided to conductor lines **50** and **52,** which may each be connected to opposite terminals of plug and cable **31.** Lines **50** and **52** provide an operating circuit for air pump **48,** for continuous operation of the pump, while the circuit is energized. Line **54** connects plug **31** to ground.

Rectifier diode **56** is provided in line **52** to cut the electrical current received by pump **48** by one-half wave per cycle, so that the electrical power received by the pump is reduced to a value desired for use in the specific device shown herein. This arrangement permits the use of an inexpensive, off-the-shelf pump, rather than an especially made pump of the desired power.

Line **58** is connected to 10 kilohm, 1 watt resistor **60** at one end and to line **50** at the other.

Line **62** connects resistor **60** to one terminal of pressure switch **42.** The other terminal of pressure switch **42** is connected by line **64** to gate **65** of a triac **67,** which controls the current through triac **67** between lines **66, 69** in a manner responsive to a voltage in line **64.** When the pressure switch **42** is closed, triac **67** is closed to permit current flow through line **66.** A suitable triac component is available from Motorola under the stock number MAC 1-4.

It may be appreciated that the use of switch **42** and triac **67** to control the suction device minimizes sparking and unwanted electromagnetic interference, which could be encountered with mechanical switches. Triac **67** controls the power current flowing between lines **66** and **69.** Switch **42** controls the action of triac **67.** Triac **67** only shuts off when switch **42** is opened and the current flow through triac **67** is zero, which occurs twice per cycle with conventional alternating current as is used here.

Resistor **60** limits the potential at switch **42,** and hence the likelihood of arcing when switch **42** is opened.

Line 68 provides electrical communication through cable 28 between triac 67 aand plug 70. Line 68 connects through plug 70 with a terminal of pump motor 20.

Light 74 is energized when triac 67 is in open mode, since, under those circumstances, approximately a 110 volt potential exists between opposite terminals of triac 67, and between lines 58 and 68. Thus, light 74 functions as a power light, indicating the readiness of the device to operate.

When pressure switch 42 is closed, allowing a voltage to reach line 64 to open triac gate 67, the electrical potential between lines 58 and 68 is greatly reduced, and light 74 is accordingly extinguished during the time that pressure switch 42 is closed. Simultaneously, however, an electrical potential is applied across line 68 and line 76. Line 76 communicates through cable 72 with the opposite terminal of pump motor 20 from line 68, the potential being created by the resistance of pump motor 20. This potential is sufficient to cause light 80 to light, indicating that motor 20 is receiving power.

Thus, the operator of the device of this invention can use lights 74 and 80 as indicators of the operating status of the device of this invention.

Ground line 78 to plug 70 communicates with ground line 54. Both lines may be connected to the casing of unit 30 at 79.

In FIG. 3, triac 67 is shown to be separated from the inner wall of the casing of power and control unit 30 by insulating posts 80.

If desired, a suitable pump 48 can be arranged to provide suction to conduits 34 and 36 rather than pressure, and the fluid communication arrangement to the pressure switch 42 can be appropriately modified with a diaghragm means or the like so that the pressure switch is actuated to permit current flow upon the sensing of a reduced pressure rather than an increased pressure. However, one disadvantage of this is that there may be suction of blood or the like into aperture 40. It is possible that conduits 34, 36 could thus be somehow plugged, and accordingly pump motor 20 would continuously operate, and could only be shut off by deenergizing the circuit.

Alternatively, a circuit can be easily designed in which the pump motor operates only when the pressure switch 42 is in the "off" position, rather than the "on" position. This might be conveniently utilized in conjunction with the mode in which suction is provided to conduits 34, 36, rather than a positive pressure.

Turning to FIG. 5, a modification of the suction tip of this invention is disclosed. Basically, handle 14 and aperture 40 are shown to be replaced with a resilient squeeze bulb member 82, without significant change in the remaining parts of the device. Accordingly, manual depression of squeeze bulb 82 creates a pressure in conduit 36, which is analogous to the pressure in the same conduit in the embodiment of the previous figures, and which has the same effect of closing pressure switch 42 for actuation of pump motor 20. When manual pressure is removed from squeeze bulb member 82, its natural resilience causes it to re-expand and to reduce the pressure in conduit 36, causing pressure switch 42 to open again, cutting off the supply of power to pump motor 20.

FIG. 6 discloses another closely related embodiment, a tip for a sump-operated suction member. It is contemplated that a single surgical suction apparatus may include a suction unit plus pump motor and circuitry in accordance with FIGS. 1 through 4, but shall also include an additional suction unit with a separate, similar pump motor and circuitry, having a suction tip in accordance with FIG. 6.

The suction tip of FIG. 6 is adapted to be positioned at the lowest part of the surgical incision or the body cavity from which drainage is desired. Thus, as blood or the like pools in the bottom of the incision, and its level rises, a pressure head against the exiting air is created at the mouth 84 of elongated tube 86, which in turn communicates with pressure conduit 36. Accordingly, when a sufficient pressure head of blood or other liquid has accumulated at mouth 84, the pressure in conduit 36 will correspondingly rise to a value equal to the pressure head. This increased pressure will be sensed by the pressure switch 42, to actuate a suction pump motor in the manner similarly described until the blood-created pressure head falls. Pressure switches are commercially available at the present time which are capable of sensing fluid overpressures as low as one-half to one inch of water, so the pressure upon which the embodiment of FIG. 6 operates can be selected as desired from a wide range of pressures.

Thus, this embodiment can operate automatically, to keep a fluid level as low as desired.

Accordingly, a surgical suction pump is provided in which the blood suction motor can be started and turned off by simple manual manipulation from a location near the suction tip, or by other pressure responsive means, without the use of electrical componentry near the surgical field. As a result, the improvement of this invention can be used to substantially reduce the hemolysis of blood during the surgical operation, and disposable components can be used near the surgical field, for greater patient safety and more rapid recovery.

The above has been offered for illustrative purposes only, and is not intended to limit the invention of this application, which is defined in the claims below.

That which is claimed is:

1. In a surgical suction device which comprises a tubular suction member having a suction tip, and a mechanically-operated blood suction pump, the improvement comprising: pressure responsive pump control means for actuating said suction pump upon sensing a first pressure level, and for shutting said pump off upon sensing a second pressure level, a pressure conduit, other than said suction member, communicating with said pressure responsive pump control means for providing pressure for sensing by said control means, said pressure conduit extending to a position adjacent said suction tip; and means for varying and controlling, from a position adjacent said suction tip, the pressure within said pressure conduit to correspondingly control the operation of said suction pump.

2. The device of claim 1 in which said pressure controlling means comprises a source for providing pressurized fluid to said pressure conduit, and a manually obstructable aperture, communicating with the exterior, in said pressure conduit adjacent said suction tip, whereby obstruction of said aperture elevates the pressure in said pressure conduit, to actuate said pump control means to operate said pump, and removal of said obstruction causes said fluid pressure to fall back toward essentially ambient pressure, actuating said pump control means to shut said pump off.

3. The device of claim 2 in which said fluid is air.

4. The surgical suction device of claim 2 in which said mechanically-operated blood suction pump is an electrically operated roller pump.

5. The device of claim 1 in which said pressure controlling means comprises a suction source communicating with said pressure conduit, and a manually obstructable aperture communicating with the exterior in said pressure conduit adjacent said suction tip, whereby obstruction of said aperture causes a reduction of the pressure in said pressure conduit, to actuate said pump control means to operate said pump, and removal of said obstruction causes said pressure to rise back toward essentially ambient pressure, to actuate said pump control means to shut said pump off.

6. The device of claim 1 in which said pressure control means comprises a squeeze bulb connected to an aperture of said pressure conduit adjacent said suction tip, said pressure conduit being pneumatically sealed from the exterior, whereby manual pressure on said squeeze bulb elevates the pressure in said pressure conduit, to actuate said pump control means to operate said pump, and removal of said manual pressure on said squeeze bulb causes pressure to fall back to essentially ambient pressure, actuating said pump control means to shut said pump off.

7. The device of claim 1 in which said pressure control means comprises a source for providing pressurized gas to said pressure conduit, said pressure conduit being essentially co-extensive with said suction tip and having an open aperture positioned next to said suction tip, whereby immersion of said suction tip and open aperture to a predetermined depth into a pool of liquid to be removed by suction will create a liquid pressure head against said open aperture, to correspondingly elevate the pressure within said pressure conduit, to actuate said pump control means to operate said pump, while lowering of said liquid pressure head causes the gas pressure in said pressure conduit to be reduced, actuating said pump control means to shut said pump off.

8. In the method of removing fluids from a surgical incision or the like by means of a suction tip and a mechanically-operated blood suction pump communicating with said tip through a length of tubing, the improvement which comprises: providing a flow of pressurized fluid through a conduit and through an aperture in said conduit adjacent said tip; and altering said pressure in said conduit by restricting flow through said aperture, to actuate pressure switch means communicating with said conduit and positioned remotely from said suction tip, to correspondingly actuate said suction pump by said pressure switch means when said suction is desired.

9. The surgical suction device of claim 8 in which said mechanically-operated blood suction pump is an electrically operated roller pump.

10. The method of claim 9 which comprises thereafter removing the restriction of flow from said aperture, to permit the opening of said pressure switch means to halt the operation of said pump.

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