

[54] APPARATUS FOR CONTROLLING FLOW OF BLOOD

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[58] **Field of Search**..... 128/2.05 A, 2.05 G, 327,
128/DIG. 20, 297-299, 30-30.2; 137/505,
505.13, 613, 624.14

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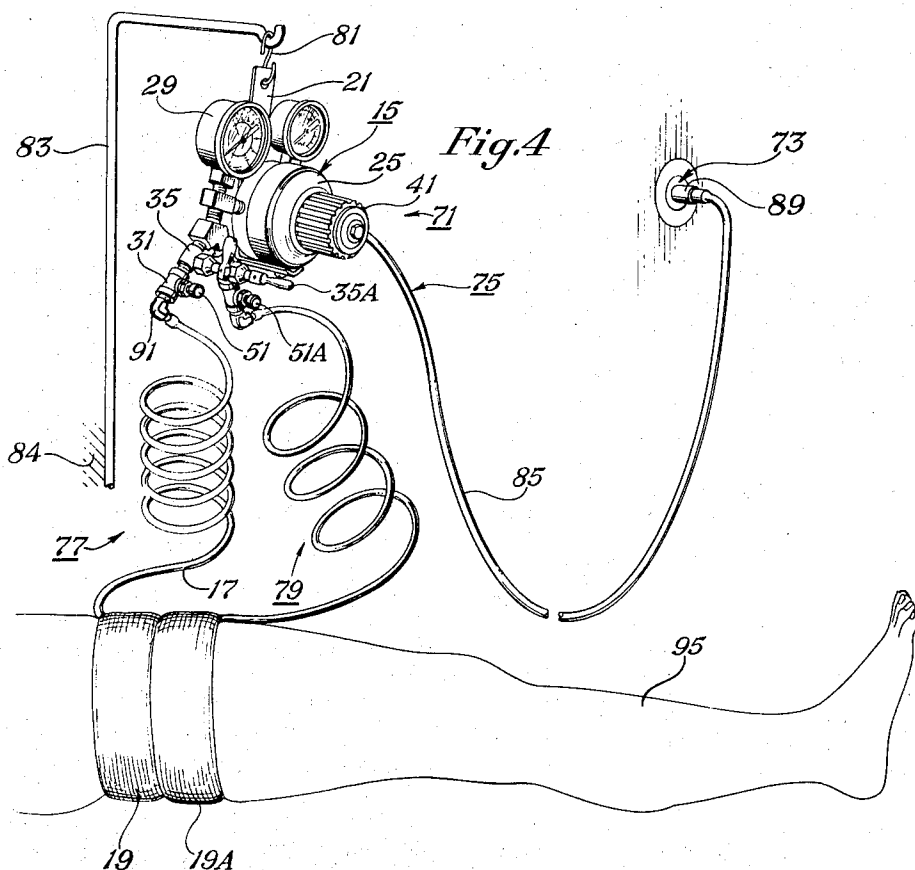
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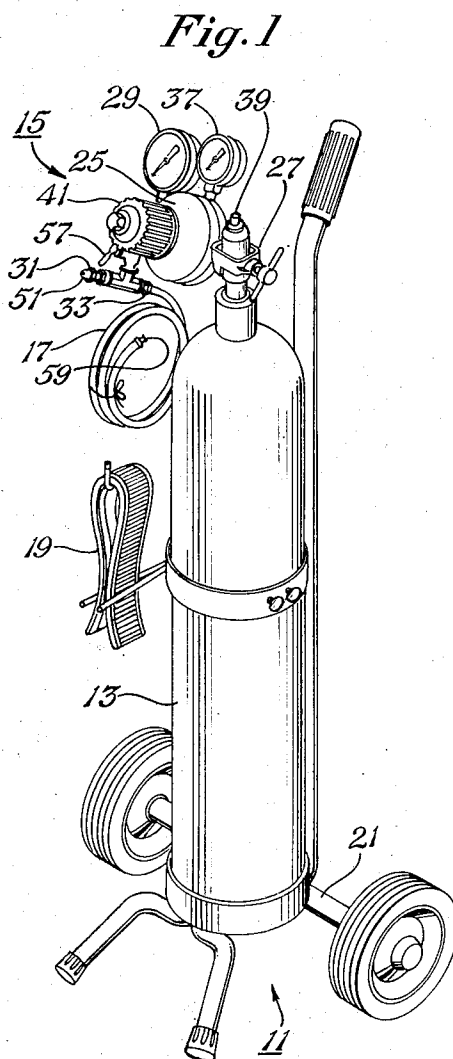
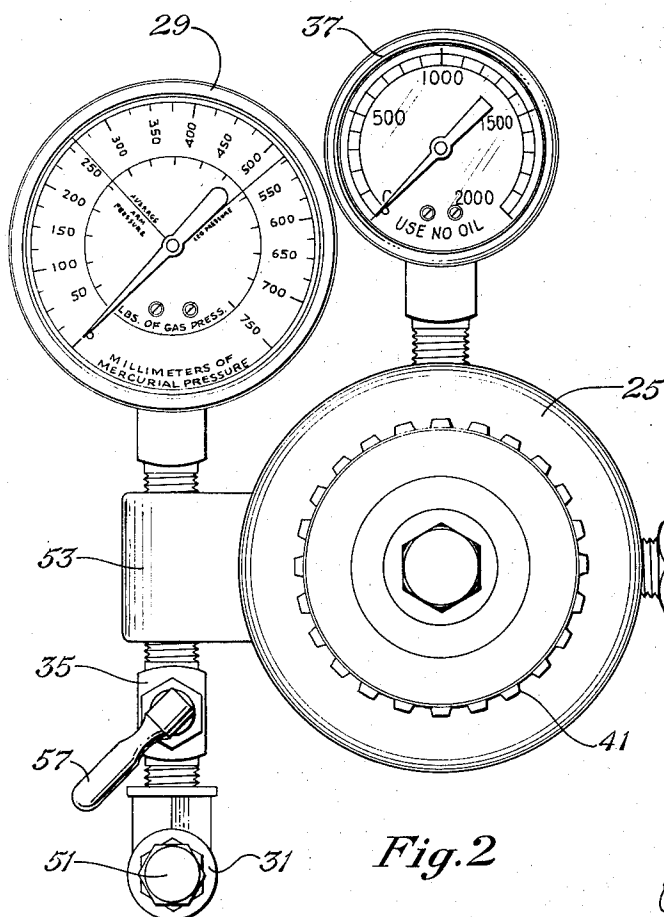
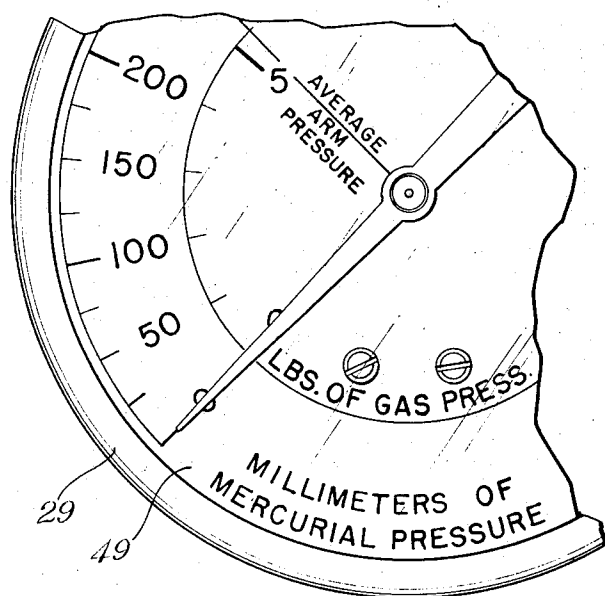
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[57] ABSTRACT

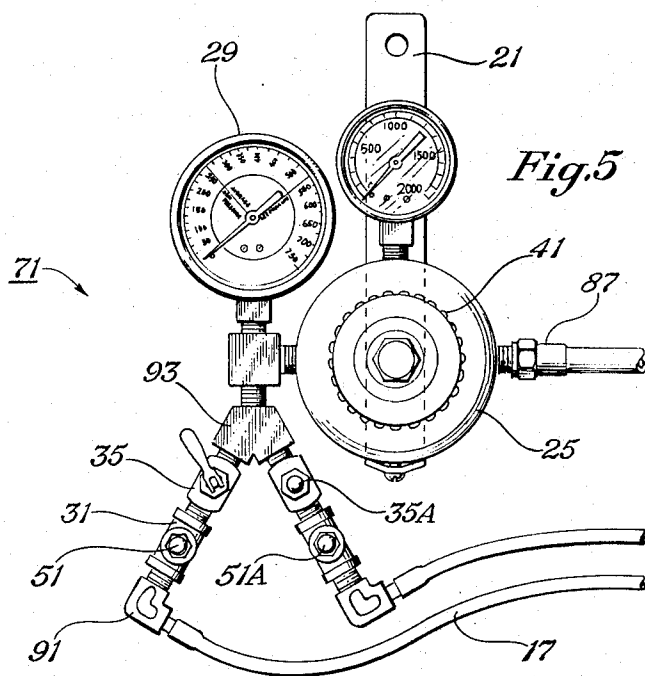
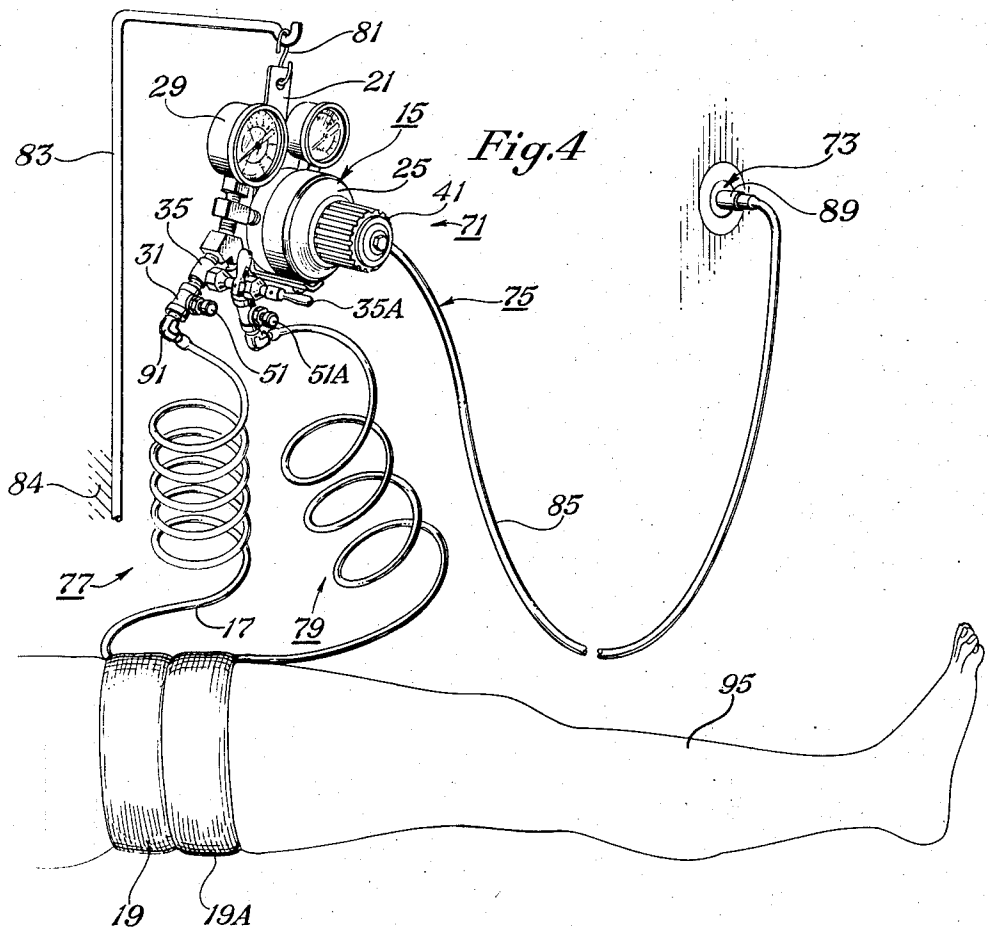
A combination, including pressure regulating apparatus, for controlling the flow of blood in a limb of a patient characterized by a container of a biologically inert gas such as carbon dioxide at a pressure no more than 1,000 pounds per square inch gauge (psig), a pressure regulator means that provides a set downstream pressure without variation even under zero flow conditions and having a convenient means for altering the set downstream pressure, a gauge that reads in both psig and millimeters of mercury for medical use, a pressure relief means for relieving the downstream pressure back to atmospheric pressure, an inflatable tourniquet, and the requisite interconnections. Also disclosed are preferred embodiments; including a Beir block combination having a plurality of inflatable tourniquets for anesthetizing locally; and respective branches connecting with the pressure regulating apparatus, each branch incorporating a toggle valve means for allowing alternate and inverse tourniquet inflation and deflation with immediately responsive operation of the respective inflatable tourniquet in accordance with a doctor's orders without having to alter the setting on the pressure regulator means; as well as other specific structural and advantageous features.

9 Claims, 5 Drawing Figures





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APPARATUS FOR CONTROLLING FLOW OF BLOOD

CROSS REFERENCES TO RELATED APPLICATIONS:

This is a continuation-in-part of application Ser. no. 163,963, filed July 19, 1971, now abandoned.

BACKGROUND OF THE INVENTION:

1. Field of the Invention:

This invention relates to apparatus for controlling the flow of blood in the limb of a patient. More particularly, it relates to a combination of apparatus employing a pressurized gas and an inflatable tourniquet and pressure regulating and flow control means therebetween.

2. Description of the Prior Art:

The prior art has seen the development of inflatable pneumatic tourniquets such as described in U.S. Pat. No. 3,120,846. These tourniquets have employed pressurized oxygen from an oxygen container, since it is readily available in hospitals. These prior art apparatus have suffered from one or more of the following disadvantages, however:

1. the gas employed in the tourniquet has been dangerous since it would support combustion and has resulted in burns to the patient when cauterizing equipment or the like was employed in conjunction with the inflatable tourniquet, as is sometimes done in operating rooms;

2. the pressure regulator means employed in controlling the pressure to the inflatable tourniquet varied over an intolerably wide range of many millimeters of mercury and even several pounds per square inch (psi) from one time of use to the next, and even with the same time of use under zero flow conditions;

3. attempts to employ bottled gases other than oxygen in which the gas was at a much higher pressure; for example, nitrogen bottles have a pressure in excess of 2000 psi; resulted in intolerable variations in pressure downstream of the pressure regulator means;

4. the connections employed were not leak-free and allowed an intolerable change in pressure if the source pressure were denied the inflatable tourniquet for even a short interval of time;

5. the downstream gauge was not marked in millimeters of mercury so that the nurse could set the pressure ordered by the doctor quickly and readily; and

6. the apparatus did not incorporate a toggle valve that could be readily flicked into the on or off position in accordance with a doctor's orders in an operating room to facilitate releasing the pressure and rapidly reinstating the pressure when needed without altering the setting on the pressure regulator means.

The prior art apparatus has been particularly deficient in providing equipment facilitating a Beir block. In the Beir block, a dual tourniquet cuff, or two closely spaced inflatable tourniquets are employed on a limb, such as an arm or leg, that is to be anesthetized locally. The Beir block is employed where the patient is physically unable to sustain a general anesthetic or the like. A local anesthetic, such as xylocaine, is injected several times with alternate and inverse inflation and deflation of the respective tourniquets to anesthetize the arm or leg of an operation without imposing intolerable strain; for example, on the patient's heart. The Beir has

been found so effective when properly used by employing the apparatus of this invention, that it is much easier than a general anesthetic and is coming into more widespread use. Heretofore, the Beir block with the prior art apparatus required difficultly controllable systems, including dual pressure regulating means, cuffs and separate valves that were difficultly openable or closeable such that normal operating room personnel, without help, could not operate a Beir block satisfactorily. Thus, the Beir block required, before this invention, additional circulating nurses, requiring more people in the operating room and increasing the likelihood of infection in an incision or the like.

Thus, it can be seen that the prior art apparatus did not provide totally satisfactory equipment for controlling the flow of blood in the limb of a patient; and, particularly, was deficient when it came to performing a Beir block for anesthetizing locally.

Accordingly, it is an object of this invention to provide apparatus which obviates the disadvantages of the prior art apparatus and provides the desirable features antithetical to the disadvantages delineated hereinbefore.

It is also an object of this invention to provide apparatus that is ideally suited for performing a Beir block for locally anesthetizing a limb of a patient and obviating the deficiencies of the prior art in this respect.

These and other objects will become apparent from the descriptive matter hereinafter, particularly when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING(S):

FIG. 1 is a perspective view of the combination in accordance with one embodiment of this invention.

FIG. 2 is a front elevational view of the pressure regulating apparatus of the embodiment of FIG. 1.

FIG. 3 is a partial plan view of the face of the gauge for downstream pressure in the embodiment of FIG. 2.

FIG. 4 is a partial isometric view of another embodiment of this invention that is ideally suited for performing a Beir block.

FIG. 5 is a partial front elevational view of the apparatus of FIG. 4.

DESCRIPTION OF PREFERRED embodiment(s):

Referring to FIG. 1, the combination 11 includes a container 13 of carbon dioxide at a super atmospheric pressure of no more than 1,000 pounds per square inch gauge (psig); pressure regulating apparatus 15 for effecting controlled inflation of an inflatable tourniquet for use on the limb of a patient; flexible conduit 17; and an inflatable tourniquet 19. The combination 11 may be suitably supported and transported on a mobile support frame 21 to facilitate movement to the desired location.

As indicated, the container 13 contains carbon dioxide at a super atmospheric pressure of no more than 1,000 psig. The carbon dioxide is illustrative of a medically inert gas which does not react with tissue of a patient so is safe for use in the operating room, and is commercially available in the desired pressure range; for example, in the class "E" cylinders of CO₂. I have found that commercially available containers of carbon dioxide at pressures of from 600 to 900 psig effect optimum results and comprises the preferred embodiment of this invention. Other medically inert gases could be

specially bottled and would be the equivalent. For example, nitrogen could be specially bottled for the desired pressure range. The present bottles of nitrogen contain too high a pressure; for example 2,250 psig; so are not equivalent in terms of obtaining the desired static downstream pressure from a pressure regulator means. As indicated hereinbefore, the containers of medically reactive gases such as oxygen are not satisfactory because of the dangers posed in case there is a leak. Other well known bottled gases such as acetylene pose medical reaction dangers, have too high pressure and are explosive when admixed with combustion supporting gases; and, accordingly, are not suitable for use with the inflatable tourniquet.

The pressure regulating apparatus 15 comprises the major essential elements of a pressure regulator means such as pressure regulator 25 for maintaining a set downstream pressure; a first connection means such as connector 27 for connecting the regulator 25 with container 13; a gauge means such as gauge 29 for monitoring the downstream pressure; a pressure relief means such as relief valve 31 for relieving the downstream pressure back to atmospheric pressure; and a second connection means such as sealing connector 33 for connecting the relief valve 31 with the inflatable tourniquet. In the preferred embodiment illustrated in FIGS. 1 and 2, the pressure regulating apparatus 15 also includes a toggle valve means such as toggle valve 35 for allowing rapidly relieving the downstream pressure on the inflatable tourniquet without altering the set downstream pressure on the regulator 25. Preferably, also, an inlet gauge 37 is provided for monitoring the content, or quantity of gas remaining in container 13.

The regulator 25 is a single stage compensated regulator that is designed for less than 1,000 psi inlet pressure and for maintaining the set downstream pressure within a few millimeters of mercury regardless of whether or not there is flow through the regulator and regardless of whether or not the regulation is continuous or is interrupted by turning on and off a master valve 39 on the cylinder 13. The regulator 25 also has a convenient manually operable means such as the knurled handle 41 for altering the set downstream pressure. These requirements on regulator 25 are stringent and not readily met. I have not been able to accomplish these results with an inlet pressure in excess of 1,000 psig. Moreover, I have found that the regulator 25 requires a resilient neoprene seat to effect the desired sealing at zero flow rate. It is imperative that the regulator employed in my pressure regulating apparatus regulate at the desired pressure and return to the same pressure each time it is used. To accomplish this, not only is it necessary to employ a resilient seat such as of neoprene to effect sealing of the inert gas, and to employ gas at a pressure of less than 1,000 psig, but the resiliency and size of the diaphragm is significant, as is the resiliency and shape of the needle seat and the shape of the needle that is employed in the regulator. For example, I have found that (1) a 3½ inch diaphragm is advantageous and (2) two springs, a main regulating spring, and a resistance spring should be employed in conjunction with the pressure on the diaphragm to effect the desired duplicate regulation of zero flow rate. A suitable gauge that meets the foregoing stringent requirements is commercially available from Air Products and Chemical Company, Medical Division, Allen-

town, Pennsylvania. Accordingly, the correlation setting forth the interaction of the recited elements in the regulator need not be described in detail herein, since the regulator is not being claimed, per se.

The connector 27 is a conventional connector that encompasses the master valve 39. The connector 27 has a suitable resilient sealing means such as an o-ring (not shown) adjacent the passageway leading to regulator 25 via bushing 45. The connector 27 has suitable biasing means such as threaded bolt 47 for forcing engagement of the sealing means with the master valve 39 such that they effect fluid-impermeable sidewalls that define a passageway and connection between the cylinder 13 and the regulator 25.

The gauge 29 has a dial face having the equivalent markings of pressure in psi and in millimeters of mercury (mm Hg); as well as showing other convenient markings; such as, the average pressure required for shutting off the flow of blood through a limb such as an arm and a leg; to facilitate medical use. As is well known, the pressure in millimeters of mercury is the height of a column of mercury in vacuo as measured in millimeters that is equivalent to the pressure. A typical dial face 49 for the gauge 29 is illustrated in FIG. 3. Therein the pressure in millimeters of mercury are indicated as "millimeters of mercurial pressure." Any other recognized nomenclature may be employed. As illustrated, the gauge 29 is screwed into a downstream body 53 that is connected with the downstream side of regulator 25.

The relief valve 31 is a conventional push button type relief valve having a relieving passageway and aperture that are normally sealed by a poppet seating on a suitable seat. The poppet may be pushed inwardly to open the effluent passageway to vent the downstream pressure that is employed to inflate the inflatable tourniquet. The venting is accomplished exteriorly by depressing inwardly on a suitably biased push button 51. Such relief valves are conventional and need not be described in detail. It is sufficient to note that pressure is readily relieved by inward depression of the spring biased push button 51. Other forms of relief valves may be employed as long as they are rapidly and conveniently operable so that the nurse or other technician may rapidly carry out the doctor's instruction in an operating room. As illustrated, the relief valve 31 is connected with the body 53 via toggle valve 35.

The toggle valve 35 is interposed intermediate the pressure regulator 25 and the relief valve 31. The toggle valve 35 is a quick-opening valve having a two position toggle 57 for effecting respective "on" and "off" operation so as to be rapidly responsive to operation in accordance with the doctor's orders in an operating room. That is, the toggle 57 may be flipped into the indicated "off" position to block pressure from regulator 25 and allow the relief valve 31 to be opened by inward depression of push button 51, immediately relieving the pressure on the tourniquet. In the "off" position, however, the pressure downstream of the regulator 25 and upstream of toggle valve 35 is maintained such that the toggle 57 may be flipped to the straight out, or "on" position, to immediately restore pressure to the inflatable tourniquet. These variations in pressure are effected without altering the setting of the regulator 25; and, therefore, does not require time-consuming subsequent adjustment to obtain exactly the desired setting. The quick-opening feature of the toggle valve 35 is ef-

fectured by a relatively large area of poppet, in accordance with well recognized principles of construction for quick-opening valves. The quick-opening type toggle valves are commercially available; for example, from the supplier, delineated hereinbefore, of regulator 25.

The sealing connector 33 comprises a conventional "quick-connect" connector employing suitable o-ring and mating recess and protrusion means that are biased to effect the desired seal. The sealing connector 33 is intimately associated with the mating portion on the flexible conduit 17. The flexible conduit 17 has a sufficient length so that the container 13 of carbon dioxide can be placed at a desired location in an operating room, and the inflatable tourniquet placed on the desired limb of the patient. Ordinarily, a length of several feet is adequate. The flexible conduit 17 terminates at its other end in a mating portion 59 for a suitable sealing connector such as sealing connector 33. The second sealing connector is emplaced on the inflatable tourniquet 19.

The inflatable tourniquet 19 may take any of the present commercially available forms of tourniquet, such as described in the hereinbefore referenced U.S. Pat. No. 3,120,846. On the other hand, the inflatable tourniquet may be disposable cuffs such as the Zimmer or Kidde disposable cuffs having the strips of adhesive over the outside instead of the more expensive Velcro type fasteners employed with the conventional inflatable tourniquets. Since the inflatable tourniquets 19 are commercially available and the details are not claimed, per se, herein, no further detailed description is necessary. It is sufficient to note that the inflatable tourniquets operate to restrict the flow of blood through the arteries and veins at respective pressures in response to the downstream pressure effected by the regulator 25. It will be readily apparent that conventional blood pressure determining bands may be employed advantageously with the pressure regulating apparatus of this invention, as well as the other inflatable tourniquets.

The inlet gauge 37 is screwed into a suitable body (not shown) and in fluid connection with the inlet passageway for the regulator 25 in order to monitor the pressure and, consequently, the contents of the cylinder 13. This allows ensuring that there is a sufficient supply of gas in the container 13 to carry out the desired manipulations of the inflatable tourniquet for any desired operation or the like.

I have found that it is imperative that the connections downstream of the regulator 25, and particularly downstream of toggle valve 35, be leak-free such that the toggle 57 may be operated into the "off" position and the pressure on the inflatable tourniquet will be maintained. This requires a high degree of care and testing in assembly. Otherwise, the downstream pressure that is locked into the flexible conduit 17 by the toggle valve 35 will be lowered by leaks.

In operation, the inflatable tourniquet 19 is applied in the conventional manner to the limb of the patient. The mating portion 59 of the flexible conduit 17 may be connected with the sealing connector of the inflatable tourniquet 19 before or after it is emplaced. Preferably, it is pre-connected and pre-tested for leaks, as indicated hereinbefore. The knurled handle 41 is turned to increase the downstream pressure, as indicated on gauge 29, to effect the desired pressure in the inflatable tourniquet 19. In the event that the doctor

desires to temporarily relieve the pressure, the toggle 57 may be moved to the illustrated off position and the push button 51 depressed to relieve the pressure from the inflatable tourniquet. For example, a doctor might desire to provide a flow of oxygen to prevent damaging cells during a protracted operation. When pressure is again desired on the tourniquet, the toggle 57 is flipped to the straight out, or on position and pressure is immediately restored. The regulator may be adjusted to provide a new downstream pressure by adjusting the knurled handle 41. If the pressure is lower, a momentary relief of pressure via relief valve 31 may be provided by depression of push button 51.

Another embodiment of this invention is illustrated in FIGS. 4 and 5. Therein, a combination 71 comprises a source 73 of medically inert gas at a superatmospheric pressure of no more than 1,000 psig; pressure regulating apparatus 15 for effecting controlled inflation of a plurality of inflatable tourniquets employed on the limb of a patient; first connection means 75 connecting the pressure regulating apparatus 15 with the source 73; gauge means 29; and a plurality of branches 77 and 79 for controlling the flow of blood in the limb of a patient at different locations. Each of the branches 77 and 79 include a serially connected toggle valve 35 for connecting and disconnecting an inflatable tourniquet with the inert gas at the downstream pressure set on the pressure regulating apparatus 15; pressure relief valve 31 for relieving the downstream pressure back to atmospheric pressure; fittings and conduit means, such as flexible conduit means 17, for connecting an inflatable tourniquet with the pressure regulating apparatus 15, and an inflatable tourniquet means 19 for putting pressure on veins and arteries within a limb of a patient for controlling the flow of blood therein. The combination 71 may be suitable supported and transported on a mobile support frame 21 to facilitate movement to the desired location. As illustrated, the mobile support frame 21 comprises a bracket that may be hung by suitable means, such as hook 81, on suitable support, such as the intravenous (IV) support pole 83. As is known, the IV support pole 83 is connected to any suitable support in an operating room or the like, illustrated generically by the support lines 84. Thus, the combination 71 is readily transportable into any operating room or to any table within a large operating room.

The source 73 of medically inert gas may comprise any source delineated hereinbefore, such as the carbon dioxide container. As illustrated, it comprises a source of carbon dioxide or nitrogen that is piped into an operating room at a regulated pressure of about 160 psig. Specifically, containers of the carbon dioxide or nitrogen are located at a remote point, such as the basement. High pressure regulators are connected with the containers and the piping to supply the medically inert gas at the desired pressure. As described hereinbefore, the medically inert gas has a pressure less than 1,000 psig; and observes the caveats described hereinbefore with respect to the source of high pressure fluid.

The pressure regulating apparatus 15 is, in principle, the same as described hereinbefore. Mainly, it employs the same pressure regulator 25. The pressure regulating apparatus 15 is not connected with a cylinder by means of the connector 27, FIG. 1, and, consequently, that portion of the descriptive matter is not pertinent.

Instead, the first connection means 75 comprises an elongate flexible conduit 85 that has a regulator con-

nection fitting 87, FIG. 5, connecting it with the pressure regulator 25 at one end and a male quick disconnect fitting 89 for stabbing within the quick disconnect receptacle at the outlet to the source 73 of the medically inert fluid. The flexible conduit 85 may be of any length. Ordinarily, a length of about 25 feet is satisfactory to reach between a convenient outlet of the source 73 and the pressure regulator 25 at the IV support pole 83 at the patient's operating table (not shown) in the operating room. Any of the conventional types of flexible conduit 85 that will sealingly hold the medically inert fluid against its pressure; for example, up to 1,000 psig; may be employed.

The gauge 29, the relief valve 31 and the toggle valve 35 have been described hereinbefore. As can be seen, the respective toggle valve 35 and relief valve 31 are serially connected together and with the pressure regulator 25 by conventional fittings such as threaded connections or the like. As illustrated, each pressure relief valve 31 is connected via an elbow 91 with the flexible conduit 17. Each of the respective flexible conduits 17 and their sealing connectors have been described hereinbefore and need not be repeated.

Similarly, each of the inflatable tourniquets 19 have been described hereinbefore.

The same high degree of care is employed in connecting together the plurality of branches with their respective Y-fitting 93, gauge 29 and pressure regulator 25, as has been described hereinbefore with respect to the single branch of FIGS. 1 and 2.

In operation, the pressure regulator 25 is connected with the source 73 of high pressure, medically inert fluid by way of first connection means 75. The frame 21 is hung on the IV support pole 83, or other suitable support. Inflatable tourniquets 19 and 19A are employed at the desired points on the limb, such as leg 95, of the patient. The tourniquets 19 and 19A of the respective branches 77 and 79 are sealingly serially connected with the single pressure regulator 25. As indicated hereinbefore, it is preferable that the tourniquets have been pre-connected and pre-tested for leaks. The knurled handle 41 is turned to effect the desired downstream pressure as indicated on gauge 29. As illustrated in FIGS. 4 and 5, first one tourniquet and then the other is inflated with the opposite tourniquet being deflated at the same time. Thus, the tourniquets are alternately and inversely inflated and deflated for effecting the Beir block. As illustrated, the toggle valve 35A is "on," allowing the downstream pressure to be supplied to the inflatable tourniquet 19A while the toggle valve 35 is turned "off" by having its toggle flipped laterally into the horizontal, or "off" position. In the first branch 77, pressure is relieved by having depressed the push button 51 on the relief valve 31, deflating tourniquet 19. Next, the toggle valves 31 and 31A will be reversed to inflate the inflatable tourniquet 19; and by depressing push button 51A, deflate the inflatable tourniquet 19A. By this alternate and inverse inflation and deflation, in combination with injection of a local anesthetic, the limb may be anesthetized locally without giving the patient a general anesthetic with the attendant strain on the heart or the like. This combination 71 has been found doubly beneficial, since it allows use of only a single pressure regulator means without the expense of a plurality of pressure regulators; and it eliminates the work and the difficulty of achieving the same pressure in the respective inflatable tourniquets.

Moreover, the usual operating room personnel can be employed to rapidly flick the respective toggle handles of the toggle valves 35 and 35A into their respective "on" and "off" positions for effecting the alternate and inverse inflating and deflating of the tourniquets 19 and 19A. Since fewer personnel are required in the operating room, there is less problem with sterilizing the atmosphere and there are, consequently, less infections that result from use of the combination 71 than with conventional apparatus.

Thus, it can be seen that this invention has wide usefulness and accomplishes the objects set out hereinbefore, and has great practical utility and commercial importance. Moreover, this invention has become a significant tool in the fight to improve health care and reduce complications from operations on patients.

The materials of construction which are ordinarily employed in this art may be employed herein, and no exotic new materials are necessary. A degree of care, as indicated, is necessary in assembly and in the construction of the regulator 25.

Although this invention has been described with a certain degree of particularity, it is understood that the present disclosure is made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of this invention.

What is claimed is:

1. A combination for controlling the flow of blood in a limb of a patient comprising:
 - a. a container of carbon dioxide at a super atmospheric pressure of no more than 1,000 pounds per square inch gauge (psig);
 - b. a pressure regulator means for maintaining a set downstream pressure, said pressure regulator means being a single stage compensated regulator that is designed for less than 1,000 psig inlet pressure and for maintaining said set downstream pressure within a few millimeters of mercury pressure and without variance even under no flow conditions; said pressure regulator means also having a convenient manually operable means for altering said set downstream pressure;
 - c. first connection means connecting said pressure regulator means with said container of carbon dioxide;
 - d. gauge means connected with the downstream side of said pressure regulator means for monitoring the downstream pressure, said gauge means having a dial face being marked in pounds per square inch and in millimeters of mercury for medical use;
 - e. pressure relief means connected with the downstream side of said pressure regulator means and adapted for relieving said downstream pressure back to atmospheric pressure;
 - f. a toggle valve means interposed intermediate said pressure regulator means and said pressure relief means and connected therewith for allowing rapidly relieving the pressure on an inflatable tourniquet without altering the downstream pressure set on said pressure regulator means;
 - g. inflatable tourniquet means for putting pressure on veins and arteries within the limb of the patient for controlling the flow of blood therein; and

h. flexible conduit means connected with and extending between said pressure relief means and said inflatable tourniquet means.

2. The combination of claim 1 wherein said flexible conduit has sufficient length so that said container of carbon dioxide can be placed at a desired location in an operating room and said inflatable tourniquet emplaced on the desired limb of the patient, and said toggle valve means is a quick-opening valve having a two position toggle for effecting respective on and off operation so as to be rapidly responsive to operation in accordance with a doctor's orders in an operating room.

3. The combination of claim 1 wherein the elements connected with the downstream side of the pressure regulator means are pre-assembled and pre-tested to have leak-free connections such that when said toggle valve is shut off, the pressure in said inflatable tourniquet is maintained.

4. Pressure regulating apparatus for effecting controlled inflation of an inflatable tourniquet for use on the limb of a patient comprising:

- a. a pressure regulator means for maintaining a set downstream pressure, said pressure regulator means being a single stage compensated regulator that is designed for less than 1,000 psig inlet pressure and for maintaining said set downstream pressure within a few millimeters of mercury pressure and without variance even under no flow conditions; said pressure regulator means also having a convenient manually operable means for altering said set downstream pressure;
- b. first connection means for connecting said pressure regulator means with a container of carbon dioxide at a super atmospheric pressure of no more than 1,000 psig;
- c. gauge means connected with the downstream side of said pressure regulator means for monitoring the downstream pressure thereof, said gauge means having a dial face marked in pounds per square inch and in millimeters of mercury for medical use;
- d. pressure relief means connected with the downstream side of said pressure regulator means and adapted for relieving said downstream pressure back to atmospheric pressure;
- e. a toggle valve means interposed intermediate said pressure regulator means and said pressure relief means and connected therewith for allowing rapidly relieving the pressure on said inflatable tourniquet without altering the downstream pressure set on said pressure regulator means; and
- f. second connection means for connecting said pressure relief means with an inflatable tourniquet.

5. The apparatus of claim 4 wherein said toggle valve means is a quick-opening valve having a two position toggle for effecting respective "on" and "off" operation so as to be rapidly responsive to operation in accordance with a doctor's orders in an operating room.

6. The apparatus of claim 4 wherein the elements connected with the downstream side of the pressure regulator are pre-assembled and pre-tested to have leak-free connections such that when said toggle valve is shut off, the pressure in said inflatable tourniquet is maintained.

7. A combination of apparatus for controlling flow of blood in a limb of a patient and facilitating anesthetizing the limb locally, comprising:

- a. a source of medically inert gas at superatmospheric pressure of no more than 1,000 pounds per square inch gauge (psig);
 - b. a pressure regulator means for maintaining a set downstream pressure, said pressure regulator means being a single stage compensated regulator that is designed for less than 1,000 psig inlet pressure and for maintaining said set downstream pressure within a few millimeters of mercury pressure and without variance even under no flow conditions; said pressure regulator means also having a convenient manually operable means for altering said set downstream pressure;
 - c. first connection means connecting said pressure regulator means with said source of medically inert gas;
 - d. gauge means connected with the downstream side of said pressure regulator means for monitoring the downstream pressure, said gauge means having a dial face being marked in millimeters of mercury for medical use; and
 - e. a plurality of branches connected with the downstream side of said pressure regulator means, each branch including:
 - i. a toggle valve means connected with the downstream side of said pressure regulator means; said toggle valve means being a quick opening valve and having a toggle handle that is easily flipped into either the "on" or the "off" position for rapidly and easily connecting and disconnecting an inflatable tourniquet with the inert gas at the downstream pressure set on said pressure regulator;
 - ii. pressure relief means connected with the downstream side of said toggle valve means; said pressure relief means having externally accessible, manually operable means for facilitating immediately relieving pressure manually for deflating a tourniquet means;
 - iii. inflatable tourniquet means for putting pressure on veins and arteries within the limb of the patient for controlling the flow of blood therein; and
 - iv. flexible conduit means connected with and extending between said pressure relief means and said inflatable tourniquet means;
- whereby the inflatable tourniquet means in the branches can be alternately and inversely inflated and deflated with only one pressure regulator and gauge and only normal operating room personnel without requiring additional personnel in the operating room and attendant increase in the likelihood of infection.

8. The combination of claim 7 wherein said gauge means, said toggle valve means and said pressure relief valve means are connected with the downstream side of said pressure regulator means and are preassembled and pre-tested at the factory to have leak-free connections when distributed to hospitals.

9. The combination of claim 7 wherein an inlet gauge is provided in communication with the inlet to said pressure regulator means for monitoring the pressure of said source of medically inert gas.

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