June 28, 1949. J. R. GUARINO 2,474,665

PNEUMATIC BLOOD TREATING APPARATUS

Filed Feb. 26, 1946 2 Sheets-Sheet 1

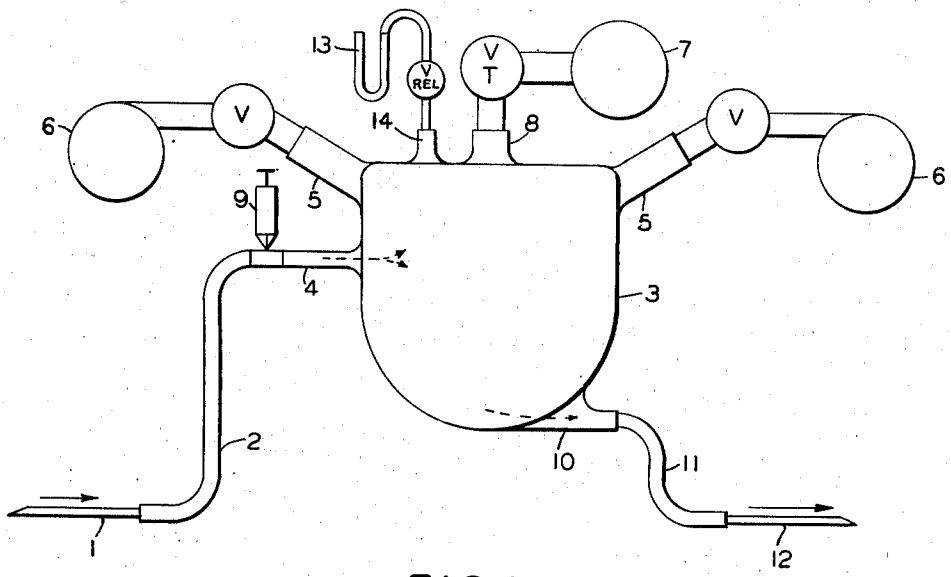

FIG. 1.

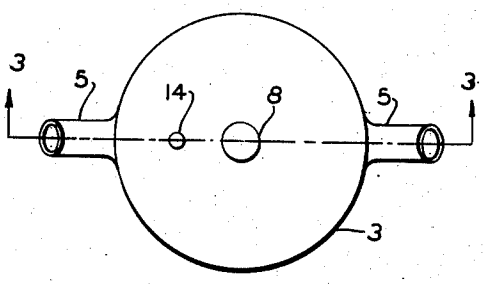

FIG. 2.

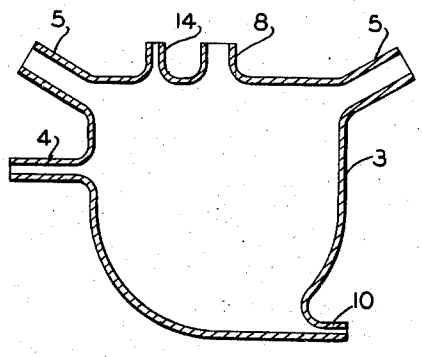

FIG. 3.

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June 28, 1949. J. R. GUARINO 2,474,665

PNEUMATIC BLOOD TREATING APPARATUS

Filed Feb. 26, 1946 2 Sheets-Sheet 2

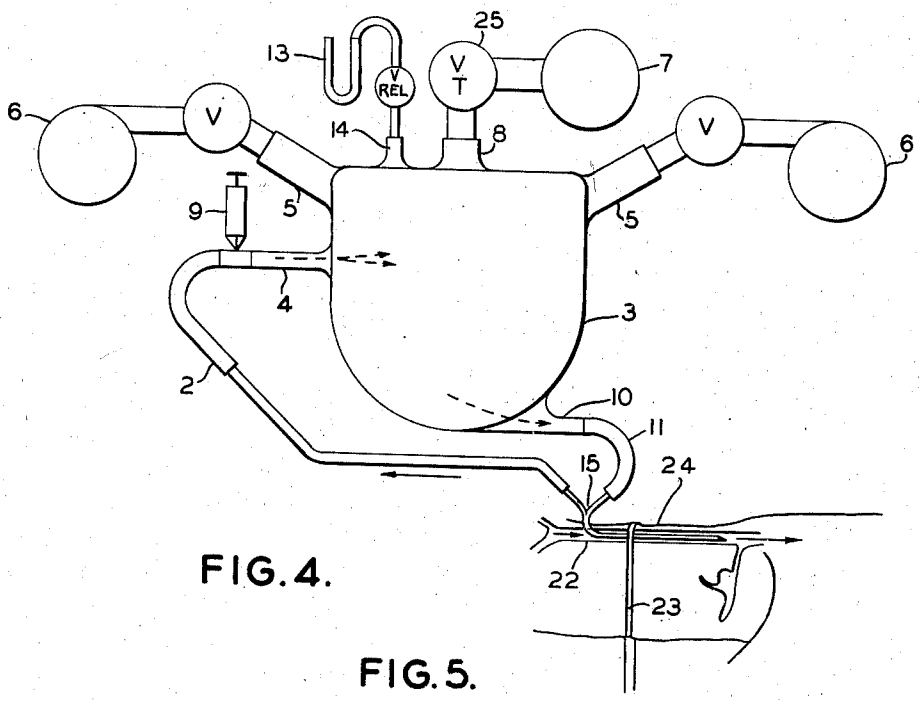
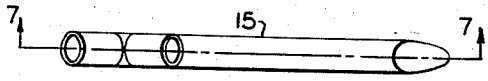


FIG. 4.

FIG. 5.



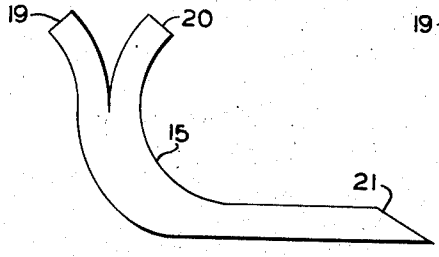


FIG. 6.

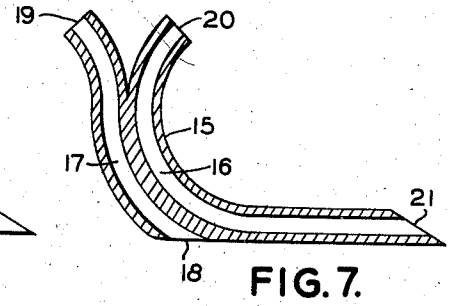


FIG. 7.

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2,474,665

PNEUMATIC BLOOD TREATING APPARATUS

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Application February 26, 1946, Serial No. 650,224

7 Claims. (Cl. 128—214)

1

This invention relates to methods and improvements in blood treating devices.

One object of this invention is to provide an apparatus which may function as a part of the human circulatory system, and permit and control a flow of blood through said apparatus. Another object of this invention is to expose the blood of a given subject to a pneumatic medium which will enable the blood to be treated during its circulation through the apparatus without clotting of the blood or formation of emboli in the circulatory system.

I accomplish these objects by methods and apparatus illustrated in the accompanying drawings, in which

Fig. 1 is an assembly view of the apparatus which may be made of glass, quartz, metal, refractory or plastic material. The interior of this apparatus may be wax lined or wax coated.

Fig. 2 is a plan view of the chamber proper of the apparatus with all attachments removed.

Fig. 3 is a sectional view of the chamber taken along the line 3—3 of Fig. 2.

Fig. 4 is an assembly view of the entire apparatus showing an alternate method in which I use a double passage needle so that only one veni-puncture is necessary. Such double passage needle may be made of glass, metal or plastics. I will refer to this needle throughout this specification as the double passage needle.

Fig. 5 is a plan view of the double passage needle.

Fig. 6 is a side view of the double passage needle.

Fig. 7 is a sectional view of the double passage needle, taken along the line 7—7 of Fig. 5. Similar numerals refer to similar parts throughout the several views.

Following is a detailed description of my process in which this apparatus simulates the function of the human lung. This description will also serve to explain the methods by which I accomplish the aforementioned objects.

In Fig. 1, a veni-puncture needle 1 is inserted into a vein distal to a tourniquet applied to the arm or other anatomical region in order to establish the desired blood pressure gradients, unless it is inserted into an artery where the desired blood pressure gradients already exist. The blood will enter the veni-puncture needle 1 and flow through the conduit 2, thence through the nozzle 4, and thereupon into the chamber 3. Oxygen from the supply vessel 7 may pass through the nozzle 8 into the container or chamber 3 under a pressure regulated by means of a throttle valve,

2

such as the valve 25, when the level of the blood rises to an elevation preferably below the entrance of the nozzle 4 and above the exit to the nozzle 10, the oxygen disposed in the area above the level of the blood will form a controllable pneumatic cushion, thereby providing an elastic medium which will control the flow of blood through the chamber 3. Some of this oxygen is absorbed by the reduced hemoglobin of the blood in the chamber 3 due to the partial pressure difference between the oxygen of the entering blood and the oxygen above the surface of the blood within the chamber 3. As a result thereof, oxygen may be absorbed by the blood to the limit of physiological requirements. Nitrous oxide, nitrous oxide-oxygen or other gases, or gases of volatile liquids such as ether, similarly may be introduced into the chamber 3 to be absorbed by the blood.

Carbon dioxide contained in the blood will be liberated in the chamber 3 to the extent of the partial pressure differences between the carbon dioxide of the blood and the carbon dioxide in the chamber 3. The liberted carbon dioxide passing out through the nozzles 5 may be absorbed by a carbon dioxide absorbing agent such as lime water contained in the vessels 6. In this way, the carbon dioxide in the blood may be liberated to the limit of physiological requirements. Other gases or volatile liquids contained in the blood similarly may be liberated from the blood and be absorbed by suitable absorbing agents.

An anti-coagulant such as sodium citrate contained in the vessel 9 may be injected into the blood, if necessary, at nozzle 4. The treated blood passes out from the chamber 3 through the nozzle 10 and conduit 11, thence through the veni-puncture needle 12, which may be inserted into the desired blood channel. A pressure gauge, such as a manometer 13, may be attached to the nozzle 14 for recording the pressure within the chamber 3. The manometer 13 may be calibrated to record the quantity flow of the blood in the chamber 3.

In Fig. 4 there is shown an apparatus according to an alternate method by which the blood may be withdrawn and returned from and to the blood stream by the use of one veni-puncture needle 15, having a double passage way 16 and 17, as shown in Fig. 7, by means of which the blood from a vein or artery enters the needle through the opening 18 and then passes through the passage way 17 out through the opening 19 into the conduit 2, through nozzle 4, and into the chamber 3. The blood after treatment passes out from the cham-

ber 3 through the nozzle 10, thence through the conduit 11, through the opening 20, thence through the passage way 16 and out of the opening 21 into the blood stream. When the double passage needle 15 is inserted into the blood vessel 22, a tourniquet 23 may be applied to the arm 24, or other anatomical region of the subject, along the axis of the double passage needle 15, between the inlet opening 18, and the outlet opening 21, in order to induce the blood pressure gradients desired.

It may be noted here, that although this apparatus would function if the chamber 3 were exposed to the open atmosphere by raising the chamber to such a height that the blood in the chamber would attain its own hydraulic level, I prefer to supply a certain selected gas or gases into the chamber under a regulated pressure in order to make the apparatus more clinically applicable. Also, I wish to point out that with a regulated gas pressure in the chamber, this apparatus could function if one or more nozzles of the chamber 3, were open to the atmosphere. However, I prefer to maintain a closed system in order to measure gaseous exchanges to and from the blood.

It is known to me that heretofore, attempts have been made to inject oxygen gas intravenously for therapeusis. The reports on the failure of these attempts on intravenous oxygen therapy are given by F. S. Grodins, A. C. Ivy, and H. F. Adler, of the Department of Physiology and Pharmacology of Northwestern University Medical School, and published in the Journal of Laboratory and Cinical Medicine, volume 28, 1942–1943, page 1013, entitled, "Intravenous Administration of Oxygen," in which they state: "Intravenous oxygen was not only unable to correct an existing anoxia produced by nembutal anesthesia, but actually increased the anoxemia. That nembutal anoxemia can be corrected by oxygen inhalation has been reported by Schnedorf and McClure and associates and confirmed by us." They also state: "It would appear that if intravenous oxygen therapy will ever prove to be efficient, some way will have to be found so that significant amounts can be administered without causing bubble formation." It is to be noted that in the aforementioned attempts at intravenous oxygen therapy, the oxygen was admitted by needle directly into the blood stream, and without provision for carbon dioxide elimination.

In my apparatus, I expose the blood to the oxygen, and also provide means for carbon dioxide elimination.

The higher the carbon dioxide content of the blood, the greater will be the dissociation of oxygen from oxyhemoglobin. Carbon dioxide, therefore, must be taken out of the blood in measured amounts to accomplish full saturation of hemoglobin, and to prevent premature dissociation of oxygen from oxyhemoglobin.

The influence exerted by carbon dioxide on the affinity of hemoglobin for oxygen is referred to as the Bohr effect. Reference: Physiological Basis of Medical Practice, Best and Taylor, 3rd edition, pages 540–541.

Since in my apparatus, carbon dioxide is eliminated as is physiologically necessary, oxygen can be absorbed by the blood to the limit of physiological requirements, and anoxemia can be corrected without the formation of gas emboli in the blood.

In summation, I wish to state that in my apparatus, the heart is the sole propagating force, thus eliminating all pumping mechanisms, and because of my control of blood flow, a desired rate of flow is maintained. As a result thereof, the prevention of blood clotting is assured. Since I allow the gaseous exchanges to occur with the blood within physiological requirements, gas emboli will not form.

It may be mentioned that additional therapeusis may be administered to the blood by providing an additional nozzle or nozzles, such as nozzle 14, to chamber 3, Figure 3. For example, solutions such as glucose and saline, and drugs such as penicillin and sulfonamides, or other medication may be administered through the chamber.

My apparatus points to uses and applications in the fields of clinical medicine and surgery that are not mentioned in my specifications, nor provided for in my drawings, but fall within the scope of my invention.

I claim:

1. The combination of an enclosed container, a discharge conduit in communication with the lower end of said container, a supply conduit in communication with said container above the lower end thereof and below the upper end thereof, the free ends of said conduits connected to the blood stream of a subject to by-pass blood from the subject through the supply conduit, container and discharge conduit, back to the subject, relying in part upon the propagating force of the heart of the subject to effect the flow of the blood through the container, and a gas supply in communication with the upper end of said container above the supply conduit to form a pneumatic cushion above the surface of the blood in the container, the pressure of the gas supply exceeding the pressure of the oxygen entering through the supply conduit to supplement the heart in effecting the flow of the blood from the subject through the container and back to the subject.

2. The combination of an enclosed container, a discharge conduit in communication with the lower end of said container, a supply conduit in communication with said container above the lower end thereof and below the upper end thereof, the free ends of said conduits connected to the blood stream of a subject to by-pass blood from the subject through the supply conduit, container and discharge conduit, back to the subject, relying in part upon the propagating force of the heart of the subject to effect the flow of the blood through the container, and an oxygen supply under pressure connected to the upper end of said container to form a pneumatic cushion above the surface of the blood in the container, the pressure of the oxygen above the surface of the blood in the container exceeding the pressure of the oxygen in the blood entering through the supply conduit to supplement the heart in effecting the flow of the blood from the subject through the container and back to the subject.

3. The combination of an enclosed container, a discharge conduit in communication with the lower end of said container, a supply conduit in communication with said container above the lower end thereof, the free ends of said conduits connected to the blood stream of a subject to by-pass blood from the subject through the supply conduit, container and discharge conduit, back to the subject, relying in part upon the propagating force of the heart of the subject to effect the flow of the blood through the container, an oxygen supply in communication with the

upper end of said container to form a pneumatic cushion above the surface of the blood in the container, and a gas absorbing agent in communication with the upper end of said container to absorb obnoxious gases liberated by the blood while passing through said container and facilitate the absorption of the oxygen from the supply formed by the pneumatic cushion.

4. The combination of an enclosed container, a discharge conduit in communication with the lower end of said container, a supply conduit in communication with said container above the lower end thereof, a double passage veni-puncture needle connected to the free ends of said conduits to enable the needle to be inserted into a blood vessel of the subject with the free ends of the needle exposed to the blood stream in one and the same blood vessel, the free ends of the needle being spaced from one another to enable the tourniquet to interrupt the flow in the bleed vessel between the two free ends of the needle and thereby enable the blood to be withdrawn from and return to one and the same blood vessel through one puncture in such vessel.

5. The combination of an enclosed container, a discharge conduit in communication with the lower end of said container, a supply conduit in communication with said container above the lower end thereof and below the upper end thereof, the free ends of said conduits connected to the blood stream of a subject to by-pass blood from the subject through the supply conduit, container and discharge conduit, back to the subject, relying in part upon the propogating force of the heart of the subject to effect the flow of the blood through the container, and a supply of an extraneous gas under pressure in excess of the pressure of the gas in the blood entering through the supply conduit, the upper end of the container above the surface of the blood being closed and containing, and being in communication with said supply of an extraneous gas to supplement the heart in effecting the flow of the blood from the subject through the container and back to the subject.

6. The combination of an enclosed container, a discharge conduit in communication with the lower end of said container, a supply conduit in communication with said container above the lower end thereof and below the upper end thereof, the free ends of said conduits connected to the blood stream of a subject to by-pass blood from the subject through the supply conduit, container and discharge conduit, back to the subject, relying in part upon the propogating force of the heart of the subject to effect the flow of the blood through the container, a gas absorbing

agent, an extraneous gas supply under a pressure in excess of the pressure of the gas in the blood entering through the supply conduit, and a closed gas exchange chamber formed in the upper end of the container above the supply conduit and in communication with said gas absorbing agent to absorb obnoxious gases liberated by the bleed while passing through said container and also in communication with said extraneous gas supply to form a pneumatic cushion above the surface of the blood in the container to supplement the heart in effecting the flow of the blood from the subject through the container and back to the subject.

7. The combination of an enclosed container, a discharge conduit in communication with the lower end of said container, a supply conduit in communication with said container above the lower end thereof, the free ends of said conduits connected to the blood stream of a subject to by-pass blood from the subject through the supply conduit, container and discharge conduit, back to the subject, relying in part upon the propagating force of the heart of the subject to effect the flow of the blood through the container, a fluid supply in communication with the upper end of said container to form a pneumatic cushion above the surface of the blood in the container, and a gas absorbing agent in communication with the upper end of said container to absorb obnoxious gases liberated by the blood while passing through said container.

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