

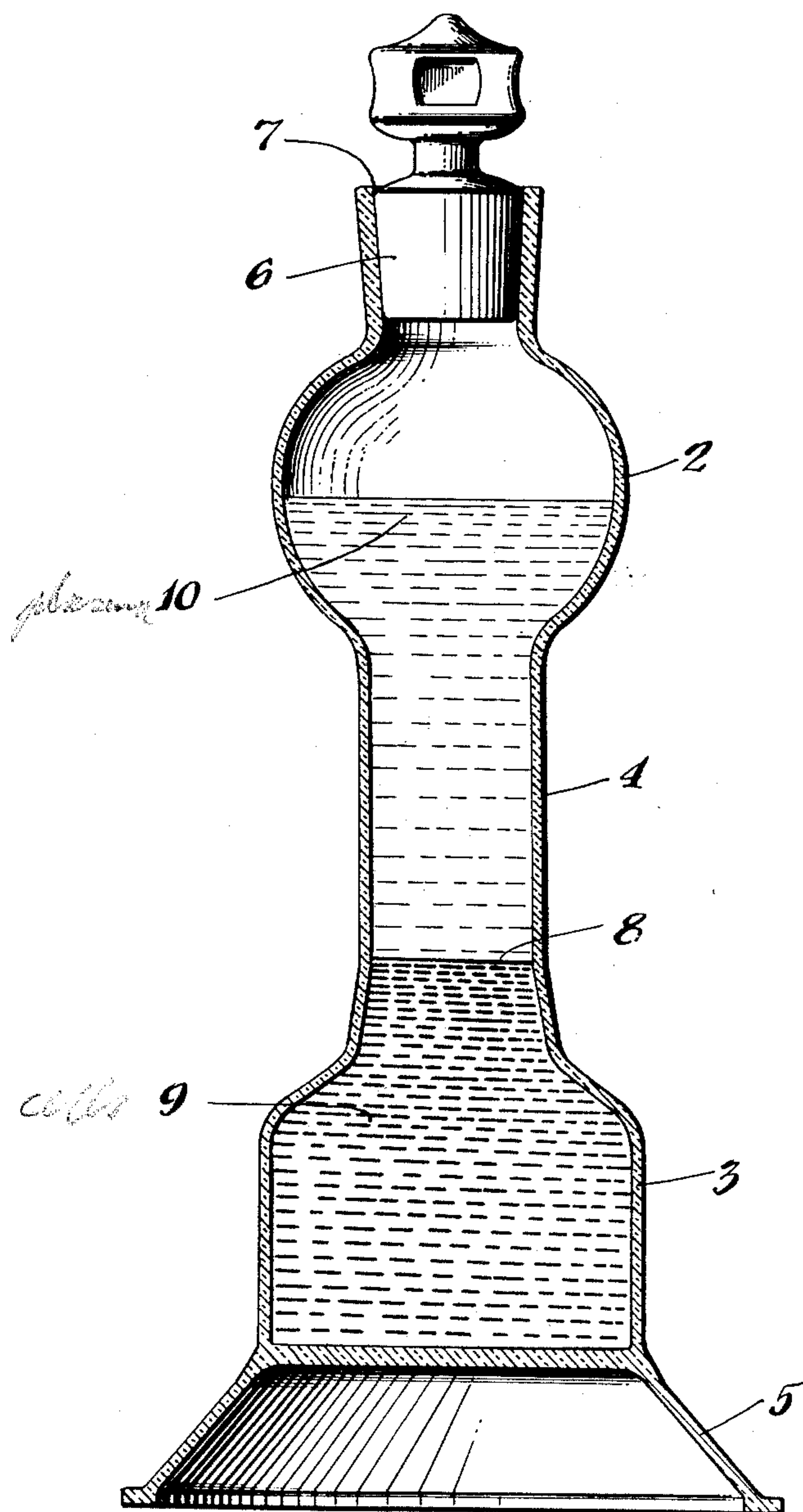
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APPARATUS FOR PRESERVING BLOOD

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APPARATUS FOR PRESERVING BLOOD

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This invention relates to the method of and apparatus for preserving blood and more particularly human blood to be used for transfusions.

For a long time in medical and surgical practice it has been customary to inject blood into a patient's veins to take the place of his own which has either been lost or has become altered. Formerly this transfusion of the new blood was done within a few minutes or a few hours after the new blood had been taken from the person giving it. The reason for this prompt transfusion is that blood, when taken from one person soon becomes unfit for injection into another, since it quickly deteriorates unless properly preserved. So long as there is a donor ready to supply blood for injection into a patient or there is time to obtain a donor when needed, there is no special demand for a store or a bank of blood ready to be used. However, it is often the case that blood of the right type is needed immediately in order to save the patient's life. He may be brought into a hospital after losing blood in an accident or he may, being already in a hospital, take a sudden turn for the worse and can be saved only by prompt blood transfusion. In instances such as these it becomes imperative that a supply of typed blood be kept on hand for immediate use.

The larger hospitals have of late years been accustomed to keep a bank or store of blood, which has been typed or classified, on hand for emergency use. This has been accomplished by means of refrigeration, keeping the temperature at about four degrees centigrade. By this method human blood can be kept fit for use only a short period of time, after which it is discarded, as it has deteriorated so much as to be harmful for sick individuals if used.

It is an object of this invention to preserve blood much longer than was formerly possible.

Blood is composed of red cells, white cells and plasma which latter is a liquid in which the blood cells, both red and white, are suspended. Blood contains potassium in the form of various salts of potassium and the plasma contains about 20 milligrams of potassium per hundred cubic centimeters of plasma, the red cells about 400 milligrams of potassium per hundred cubic centimeters of red cells and the white cells slightly more. The disintegration of blood, when stored in containers, which makes it dangerous for rapid transfusion into a living animal such as a human, is in part caused by the diffusion of the potassium salts from the cells, especially the red

cells, into the plasma of the blood. There are so very few white cells in the blood that the small amount of potassium salts which is given off by their disintegration is negligible. Potassium, even in salt form, in the plasma is toxic to animals and humans and acts as a cardiac poison and also inhibits respiration when a certain concentration is exceeded. Potassium contained within the blood cells has little or no such effect upon the human system.

It is the object of this invention to retard this diffusion of potassium from the cells, especially from the red cells, into the blood plasma. I can retard this diffusion enough so that blood can be stored with the usual refrigeration, much longer than formerly.

It is to be understood that the length of time blood can be stored is comparative depending upon the amount to be used in the transfusion, the rapidity with which it is to be injected, and the condition of the patient into whose veins it is to be injected. As stated above, excessive amounts of potassium in the blood plasma acts as a poison, but the body normally maintains potassium concentration within certain limits, by eliminating the excess from the circulating body fluids. The danger lies, however, in increasing the potassium contained in the patient's blood plasma to such an extent and in such a short space of time that his body can not eliminate it fast enough. If this should occur, the patient's life would be endangered by the high content of potassium in the plasma. It has been estimated that about 3 to 4 grams of potassium is the utmost that may safely be given an average healthy man by way of infusion in one rapid dose; factors such as the speed of the injection, resistance of the individual, efficiency of the excretory organs are, however, some of the limiting conditions. It is, however, the fact that this amount may be safely given if the injection is done very slowly or if injections are given with intervals of time between each. This is because the body is given an opportunity of eliminating the potassium from the circulating body fluids. It is thus apparent that small quantities of blood, the plasma of which is high in potassium content, can be given a patient from time to time without injurious effect, but large quantities of such blood cannot be given at one time without endangering his life. Thus, when large quantities of blood are to be injected rapidly, the plasma thereof must contain but small quantities of potassium; in other words, the diffusion of potassium from cells to plasma must be small.

When blood is allowed to stand, as when stored, the cells, which are heavier, gravitate to the bottom, and the lighter plasma floats on top of them. Thus the surface of the two liquids meet and are in contact with each other at what is called the interface. It is usually best to allow the settling to take place under refrigeration. The old way of storing blood and keeping it under refrigeration, as described above, was to place it in containers of comparatively wide diameters such as common mason jars or Erlenmeyer flasks. Such vessels permitted the area of the interface to be great in relation to the quantity of blood. I have discovered that if blood is stored in vessels of narrow diameters, it can be preserved longer than it could be formerly. This is because, as I have discovered, the area of the interface is small in relation to the quantity of blood. From tests I have ascertained that within limits, if the same amount of blood is stored in vessels of different diameters, the length of its preservation varies inversely as the interface area varies to the constant quantity of blood, i. e., the smaller the interface area is as compared to the constant quantity the longer can the blood be preserved and vice versa. Thus, a quantity of blood will be preserved longer in a long cylindrical tube, than will the same quantity in a common mason jar or Erlenmeyer flask, because the interface area in the former is smaller in relation to the quantity of blood. I have discovered that when the interface is small in relation to the quantity of blood the diffusion of potassium from the red cells to the plasma is retarded.

While a long cylindrical vessel of small diameter will accomplish the results sought, yet such a vessel is unwieldy and inconvenient for storing in a refrigerator by reason of its necessarily great length in comparison to its capacity for holding blood. Therefore I prefer to use a container which has reservoirs of comparatively large capacities connected by a narrow waist where it is intended that the interface will come.

The drawing is a vertical section of my preferred container showing the blood cells separated from the plasma.

The vessel or container is divided into an upper reservoir 2 and a lower reservoir or settling chamber 3 which together are of sufficient capacity to hold a convenient amount of blood for storing purposes. The two reservoirs are connected by restricted passage 4 which as shown has substantial length. The vessel has base 5 and any convenient closure such as stopper 6 fitting snugly in opening 7. As pointed out above the cells of blood being heavier, settle to the bottom and plasma rises and floats on the cells with the surfaces of the two liquids meeting at 8, which is called the interface. As shown the blood cells 9 are contained in the bottom reservoir 3 and the lower part of the restricted passage 4 and the plasma 10 is contained in the top reservoir 2 and the upper part of the restricted passage 4 with the meeting surfaces of the two liquids at 8. The average normal blood by volume contains about 45% cells and about 55% plasma although these amounts are subject to a variation of about 10%. Thus some bloods may consist of about 40% cells and 60% plasma or 50% cells and 50% plasma. The reservoirs of my container are made of such a size that after the blood has settled the lower reservoir will be completely filled with cells and the lower part of the restricted passage will also contain cells; the upper reservoir will contain plasma alone and no

cells, as will also the upper part of the restricted passage. Thus the interface, the meeting of the surfaces of the two liquids, will be in the somewhat restricted passage and the area of the interface will be small in relation to the quantity of the fluid in the flask no matter what the variation of plasma to cells within the above stated limits. The passage 4 is made of substantial length so as to allow for the variation in proportion of cells to plasma in different bloods, and still have the interface come at said passage with the usual addition of an anti-coagulant. The diameter of the restricted passage should be as small as its cubic content in relation to the capacity of the reservoir will allow, also allowing for the 10% variance in proportion of cells to plasma found in different human bloods and the usual addition of an anti-coagulant.

The restricted passage 4 may, if desired, be made of such capacity in relation to the top and bottom reservoirs, that during the process of settling, and before all the cells have separated from the plasma, the interface will always be within its length. This will help retard diffusion of potassium from the cells to the plasma during the process of settling.

What I claim is:

1. A container for storing blood including a bottom reservoir for storing the blood cell content of the blood, a top reservoir for storing the plasma content of the blood, said container including an elongated and relatively restricted neck portion connecting the bottom and top reservoirs for restricting the meeting area of the plasma and blood cells to retard diffusion of potassium from the blood cells to the plasma, said restricted neck being proportioned to provide a liquid containing capacity which is within the limits of normal variation of the cell to plasma ratio of the blood components stored in the lower and upper reservoirs.

2. A container for storing blood comprising in combination, a bottom reservoir for storing the blood cell content of the blood, a top reservoir for storing the plasma content of the blood, and an elongated and relatively restricted neck portion connecting the bottom and top reservoirs, said restricted neck being of such length as to embrace the interface between said plasma and said blood cells during their separation within said container, and proportioned to provide a liquid containing capacity which is within the limits of normal variation of the cell to plasma ratio of the blood components stored in the container, and also of relatively small capacity in relation to the capacity of the bottom and top reservoirs, said bottom reservoir being closed except for said neck portion so that it can be emptied only when all of the blood content in both reservoirs is emptied.

3. A container for storing blood including a bottom reservoir for storing the blood cell content of the blood, a top reservoir for storing the plasma content of the blood, said container including an elongated and relatively restricted neck portion connecting the bottom and top reservoirs for restricting the meeting area of the plasma and blood cells to retard diffusion of potassium from the blood cells to the plasma, said restricted neck having a liquid containing capacity of about ten percentum of the capacity of said container.

4. A container for storing blood comprising in combination a bottom reservoir for storing the blood cell content of the blood and a top reservoir for storing the plasma content of the blood, both

reservoirs being so proportioned to the whole container as to hold respectively most of the blood cell and plasma content of the blood, and an elongated and relatively restricted neck portion connecting the bottom and top reservoirs, said 5 restricted neck being of such length as to embrace the interface between said plasma and said blood cells during the latter part of their separa-

tion within said container, and proportioned to provide a liquid containing capacity of about ten percentum of the liquid containing capacity of said container, said bottom reservoir being closed except for said neck portion so that it can be emptied only when all of the blood content in both reservoirs is emptied.

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