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J. L. N. BESSELING ET AL

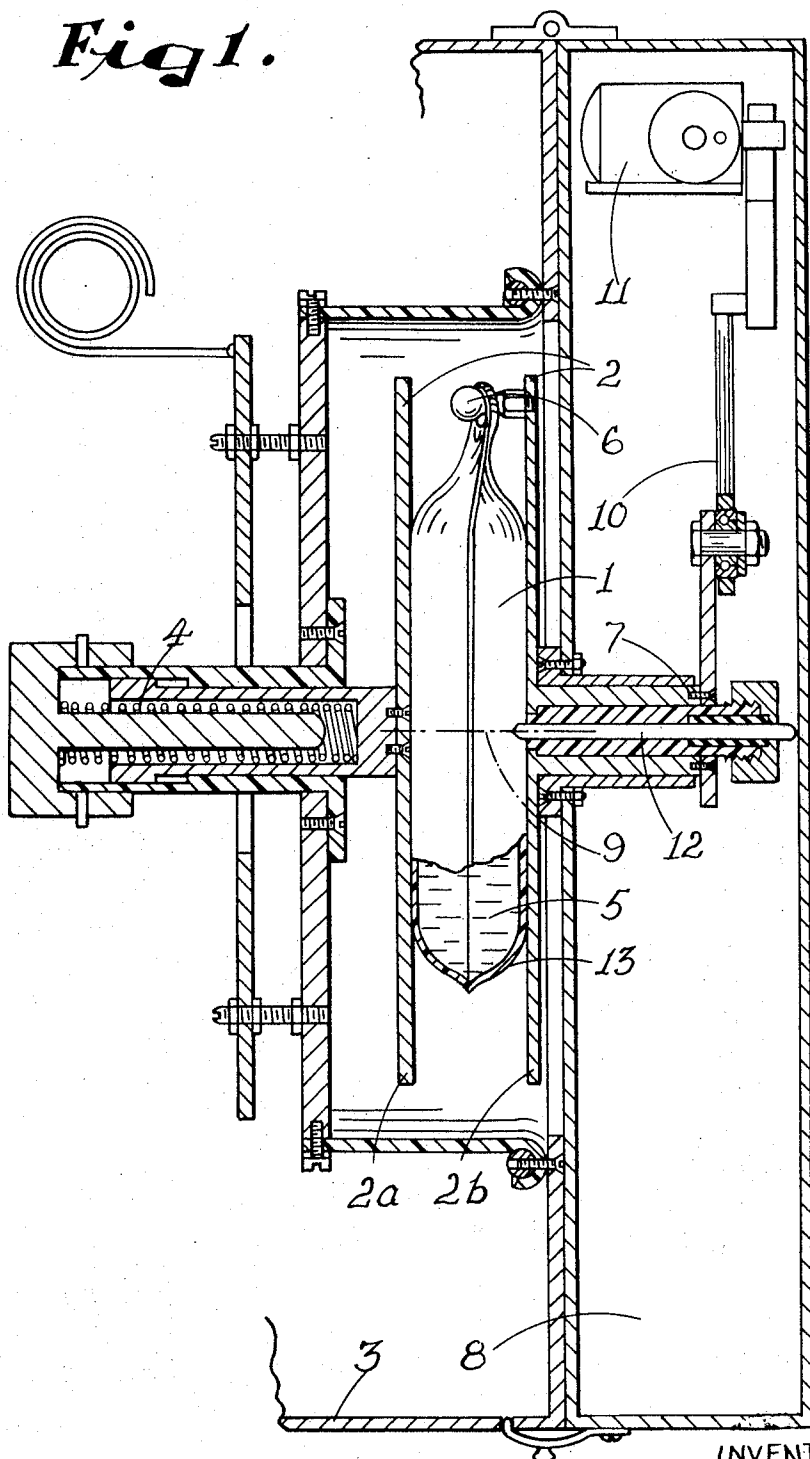
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BLOODWARMERS

Filed Nov. 19, 1968

2 Sheets-Sheet 1

Fig 1.



INVENTOR

JOHANN LODEWYK NAUDE BESSELING

by hTs Attorney
Robert A. Howson

June 30, 1970

J. L. N. BESSELING ET AL

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Fig 2.

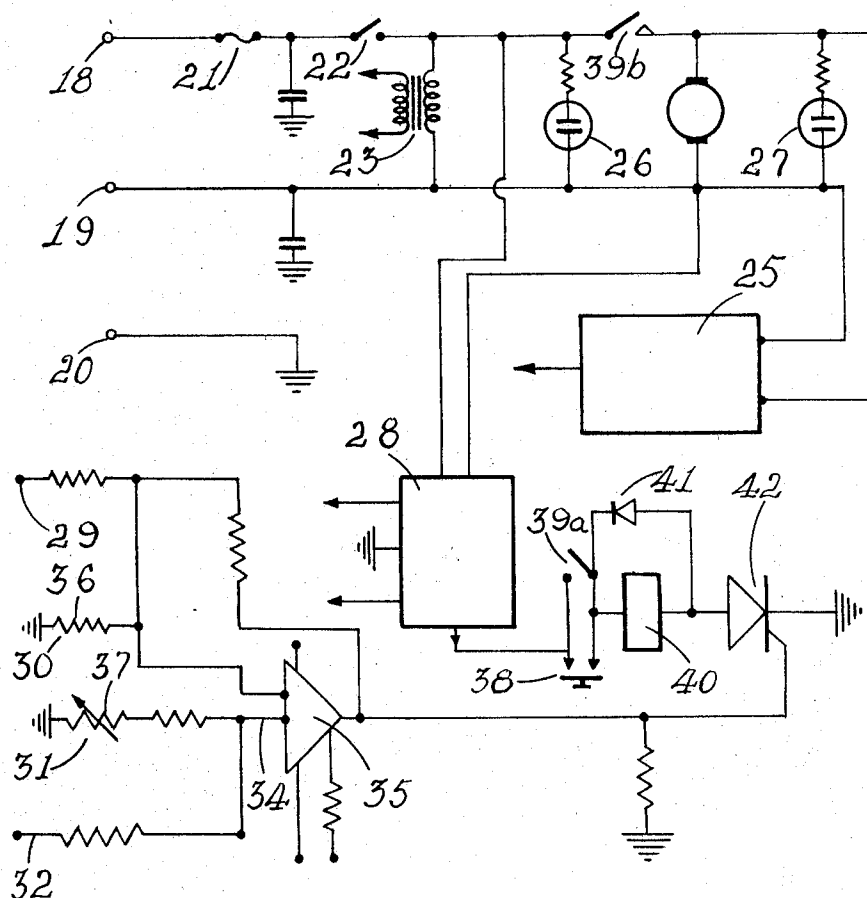
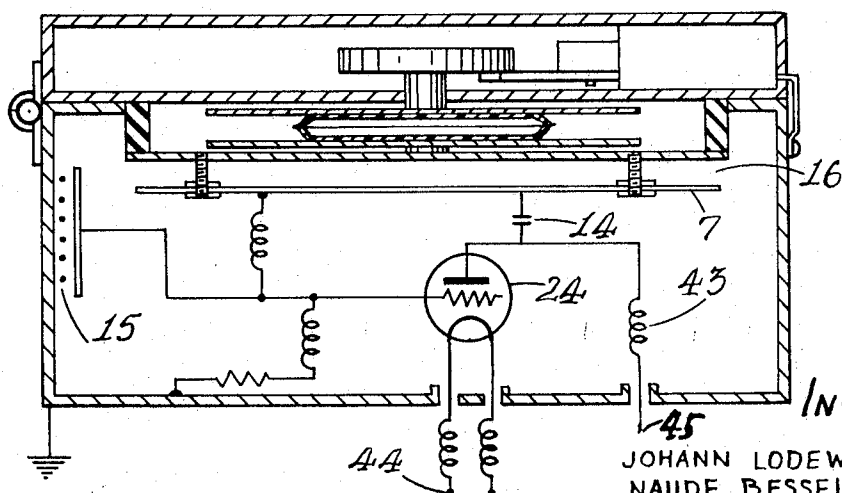


Fig 3.



INVENTOR

JOHANN LODEWYK
NAUDE BESSELING

by his Attorney
Hubert A. Hansen

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BLOODWARMERS

Johann Lodewyk Naude Besseling and Arthur Barclay
Bull, Rosebank, Cape Town, Cape Province, Republic
of South Africa, assignors to South African Inventions
Development Corporation

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4 Claims

ABSTRACT OF THE DISCLOSURE

Method and apparatus for heating blood which is contained in a flexible bag which entails snugly locating the bag between spaced electrode plates and passing an electromagnetic field through the blood. The snug location of the bag is essential to effect uniform heating of the blood and to prevent burning of the blood with the consequent dangerous effects. A probe is provided for measuring the blood temperature, and an arrangement is provided for agitating the blood to assist in the uniform heating of the blood.

This invention relates to method and apparatus for the heating of blood. In particular it is concerned with heating blood in an electromagnetic field.

In order to prevent the deterioration of stored blood which is to be transferred into living bodies it is necessary that the blood be stored at a temperature substantially lower than the normal body temperature of blood. However, before this stored blood can be rapidly transfused into a living body with safety it is again desirable to raise its temperature substantially near to the body temperature of blood.

When heating blood to this required temperature, care has to be taken that the method of the heating process and method does not cause deleterious effects on the blood, and for this reason controlled methods only for blood heating are employed.

Probably one of the most common methods used is the simple immersion of the blood container in a bath of warm water which causes the blood temperature to increase gradually to the required level. Although this has for a long time doubtless been a reliable method an important disadvantage arises from the fact that it is a relatively slow process and when large volumes of blood are required in a short space of time the blood cannot be heated sufficiently quickly and carefully to comply with the demand.

Another, and more developed, method of heating blood is by locating the blood container in an electromagnetic field. However, a problem which has arisen with this method is the difficulty of determining accurately the temperature of the blood in the container. This is especially the case if the container is rigid and of a relatively non-conducting character thereby increasing the difficulties of using probes to determine the temperature of the container contents. The advantages of employing rigid containers, however, is that a substantially uniform injection of energy into the whole of the blood mass is possible.

With modern developments in the container field it has been found possible, and indeed advantageous in some respects, to store blood in plastic containers, especially container of the resiliently flexible kind. However, this has resulted in a relatively major problem as far as heating of the blood therein is concerned, because the container cannot be maintained in a regular or permanent

shape, and as a result non-uniform heating of the blood often results. This non-uniform heating can rise to serious and even dangerous levels when blood is overheated or burned in various parts of the container, thus rendering the container contents unsafe for transfusion.

It is accordingly an object of the present invention to provide an arrangement for heating blood contained in flexible bags, which arrangement overcomes or at least minimizes the problems set out above, and which has further useful advantages over known arrangements for heating blood.

According to the present invention a method of heating blood includes the steps of providing at least two spaced electrodes defining or being associated with plates constituting collectively a holder, locating a quantity of blood in a flexible bag-like container, snugly sandwiching the container between the plates and exposing the blood to an oscillating electromagnetic field developed between the electrodes.

Further according to the invention a substantially uniform temperature is obtained throughout the blood mass in the bag by imparting a mechanical motion thereto which is adapted to create an agitation and mixing action in the blood.

Preferably the mixing action is provided by rocking the plates about a suitable axis.

A further aspect of the invention, if desired, is an arrangement involving electrode plates which are disposed relative to each other in such a way that at least one field density gradient exists over the area of the plates, the gradient facilitating the non-uniform injection of energy into the blood mass. With this latter optional aspect, temperature gradient/s is or are developed in the blood mass, the gradients acting to create convection currents in the blood mass which assist, albeit in a small way, the achievement of a substantially uniform temperature throughout the blood mass.

The apparatus adapted for carrying out the method, preferably, includes two plate-like electrodes arranged for movement between an open position and an operative position, the plates in operative position defining between them a zone for the snug accommodation of a bag containing blood, and electrical means to warm the zone. Preferably, one of the plates is fixed and the second plate is movable between the open and operative positions, one or more bag supporting elements being located between the plates. The movable plate is, preferably supported through a suitable hinge structure.

In another embodiment of the invention the supporting element is a peg from which the bag may hang.

Temperature sensing means is provided to sense the temperature in the zone between the plates, the sensing means, preferably, being a probe projecting from one of the electrode plates with the projecting portion of the probe being adapted to engage and locally deform the blood container without puncturing it.

In yet another embodiment of the invention at least one of the plates is floatingly mounted on the structure to ensure snug engagement of the plates with the container in operative position, the floating plate being biased to a state of minimum separation from the fixed plate in operative position.

In order to illustrate the invention an example is described below with reference to the accompanying drawings in which:

FIG. 1 is a sectional plan view of the apparatus showing in detail the housing zone for the bag of blood;

FIG. 2 is a diagram of the oscillator circuitry;

FIG. 3 is a diagrammatic sectional view of the apparatus showing the connection and disposition of some of the electrical components relative to the housing for the apparatus.

An arrangement for heating blood in a flexible bag-like container consists basically in apparatus for sandwiching the bag 1 snugly between two plate-like electrodes 2, which collectively constitute a holder for the bag 1 and in providing circuitry for generating an electromagnetic field between the electrodes 2.

The plate-like electrodes 2 are conveniently constituted by the plates of a capacitor, and the capacitor is preferably part of the oscillating field generating circuitry. The oscillator in this example of the invention takes the form of a well-known Colpitts Oscillator circuit.

By making the capacitor plates 2 movable relative to each other a convenient holder adapted to facilitate the simple insertion and removal of the bag 1 is provided for the apparatus. This arrangement is achieved by causing the capacitor plate 2a to form at least part of a side for a housing 3 that is provided to locate the oscillation circuitry. The mating earthed capacitor plate 2b is then suitably hinged for access to the space where the blood is to be located.

A tight or snug location of the container between the capacitor plates 2 is achieved by spring loading at least one of the capacitor plates so as to provide a suitable pressure on the container or bag 1 and so distort the container 1 to contact the maximum area of the capacitor plates 2. In this manner the arrangement is prevented from developing isolated "hot spots" or areas of high field intensity which could result in the establishment of high temperature zones and even burning of the blood. In the present example of the invention plate 2a is spring loaded through spring and housing arrangement 4.

In addition, this snugly arranged location of the container between the plates 2 prevents the plastic bag 1 itself being subjected to high field intensities with the consequent heating causing high temperatures. This is further prevented by causing cooling air to flow around the blood container 1 to keep the container walls relatively cool.

Substantially uniform heating of the blood mass 5 in the bag is achieved by mechanically agitating the blood mass 5. This is preferably effected by a rocking action imparted to at least one of the plates 2 between which the bag 1 containing the blood is sandwiched. A particularly suitable method of rocking the blood mass 5 is to provide an instrument having spaced plates 2 between which the blood bag is located, preferably hanging vertically from a peg 6 associated with the plate 2b which is in turn rotatably mounted at 7 on a hinged door arrangement 8. In this example both plates 2a and 2b are adapted for oscillatory movement about coincident axes 9 and the plates are suitably associated with the electrical circuitry for developing the required temperature in the blood. Plate 2b is linked through crank means 10 to an oscillating device or motor 11 adapted to rock the plate 2b through ninety or more degrees while the plate 2a is spring biased towards the rocking plate 2b. When the bag 1 is snugly located between the plates 2 the frictional grip between the elements ensures that the bag 1 and plates 2 rock in unison. The disturbance created in the blood mass 5 acts to ensure a substantially uniform heating of the blood mass 5.

Clearly other suitable methods may be used mechanically to agitate the blood 5 but the apparatus set out above is of considerable apparent utility and is part of the present inventive concept.

The sensing of the blood temperature in the example under consideration is accomplished through a probe device 12 which penetrates the surface of the plates 2b and projects into the heating space a small degree. The probe 12 is preferably pencil thin and is coaxial with the oscillatory axis 9 of the plate 2b with which it is associated. The probe 12 is arranged to abut firmly with, and even push slightly into, the bag wall 13 and in this manner accurately sense the temperature of the blood mass 5. A suitable electrical circuit is arranged to translate the temperature sensed into temperature readings

and to switch off the heating means when the desired temperature is reached.

In the oscillator circuit account has to be taken of the fact that the one capacitor, namely, the heating capacitor 2, has between its plates 2a and 2b a material formed by the blood 5, whereas the other capacitors 14 and 15 may be normal air or other commonly used capacitors. In addition, it has been found necessary to consider the effect of the plastic material forming the walls 13 of the blood container 1 as the container is also disposed between the capacitor plates 2a and 2b.

It is an important aspect of blood warming in terms of this invention that the plates 2a and 2b cause the blood container 1 to be snugly and firmly sandwiched between them so as to prevent the creation of extremely high field intensities in any particular area of the plates 2a and 2b, which might overheat the blood or container wall 13 located in the area of the electrode.

The capacitor formed by plates 2 has in adjacent parallel relationship a second capacitor 16 which has plate 2a in common with capacitor 2 and plate 17 constituting the other. Plate 17 is provided with threaded support means 18 to permit its location relative to plate 2a to be altered. In this manner the frequency of oscillation of the oscillator may be correspondingly varied.

Referring to the electrical circuitry of the heater as illustrated in FIG. 2, conductors 18, 19 and 29 represent the line, neutral and earth supplies from the main power source. Element 21 represents the fuse in the circuit and element 22 the main switch of the circuit. Transformer 23 provides for a low voltage a.c. supply to the valve 24 of the oscillator circuitry.

The supply is then fed to the motor 11 of the apparatus and to a high voltage power pack 25 for supplying a D.C. voltage to the oscillator valve 24. In the circuit there are provided two neon lamps 26 and 27 which act as indicating means for the circuit. Leads are also taken from the supply to a low voltage power pack 28 which provides supply voltages to the temperature translator circuitry.

The circuitry is constituted by input terminals 29, 30, 31 and 32 which feed through leads 33 and 34 to a differential operational amplifier 35 which has an open loop gain higher than 50,000. Element 36 represents the temperature sensitive resistor of the apparatus and by varying the value of resistance 37 the settings of temperature may be altered.

Switch 38 represents the "start" control of the circuit and this operates through contacts 39a and 39b of relay 40, silicon diode 41 and silicon controlled rectifier 42 in conjunction with the amplifier 35.

In the oscillator circuit coil 43 represents the R.F. choke, and the leads 44 are for connection to the output of transformer 23, and lead 45 to the output from power pack 25.

What is claimed is:

1. A method of heating blood including the steps of housing the blood in a deformable bag, locating the bag between spaced plate-like electrodes by means of which an electromagnetic field is established in the space occupied by the bag, urging the electrodes into engagement with the bag so as substantially to eliminate air pockets between the electrodes and the engaging bag walls, energizing the electrodes and simultaneously oscillating at least one of the electrodes to set up currents in the blood mass to minimize electro-magnetic gradient in the mass.

2. Apparatus adapted for carrying out the method claimed in claim 1 including two relatively movable plate-like electrodes which in closed position act to nip a flexible blood-carrying bag between them, the bag engaging surfaces of the electrodes being such as to eliminate air pockets between the bag and electrodes, means to establish an electro-magnetic field in the space between the electrodes and means to oscillate at least one of the elec-

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trodes to set up currents in the blood mass during heating thereof.

3. The apparatus claimed in claim 2 including a structure defining a cavity in which one electrode is situated, a cap for the cavity mouth which is hinged to the structure and to which the second electrode is anchored, means in the cap to oscillate the second electrode, biasing means adapted to urge the plates into a position of minimum relative separation thereby to effect the nipping action on a bag disposed between the plates, and a temperature sensing probe projecting from the second plate, the projecting portion of the probe being adapted to engage and locally deform the blood container without puncturing it.

4. The apparatus claimed in claim 3 wherein bag supporting means on the oscillating plate electrode acts substantially to anchor the bag relative that electrode such that electrode oscillation causes similar bag movement.

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References Cited

UNITED STATES PATENTS

2,508,382	5/1950	Gard	219—10.81	X
2,608,638	8/1952	Daiger	219—10.81	X
2,807,697	9/1957	Pircon	219—10.81	X
3,154,663	10/1964	Halvorsen	219—10.49	

FOREIGN PATENTS

933,046 3/1955 Germany.

JOSEPH V. TRUHE, Primary Examiner

L. H. BENDER, Assistant Examiner

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