

Apparatus for heating blood or another physiological fluid

The invention relates to an apparatus for warming blood or other physiological fluids, comprising a conduit through which the fluid can be conducted, and heating means for warming the fluid flowing through the conduit.

5 Such an apparatus is known from the international patent application PCT/US96/04737 (WO 96/32080). The apparatus disclosed therein serves for warming blood and has a transparent conduit so that the blood flowing through the conduit is visible. The blood that flows through the con-
10 duit is warmed due to the fact that the conduit is fabricated from an electrically conductive polymer material, so that resistance heating of the material, and thus indirectly of the blood, can take place. A drawback of this known apparatus is that the heating is relatively ineffi-
15 cient, that there is a rather long response time, and is consequently difficult to control.

 One object of the invention is to realize an improvement with respect to these points, and to realize a more direct warming of the blood or of the physiological
20 fluid to be warmed in general, such as to provide a better controllability of the fluid temperature. A further object of the invention is to provide an apparatus with which the blood or other physiological fluid can be processed hygienically, and with which the development of so-called
25 hot spots in the (blood) stream is avoided, as occurs with direct heating by means of microwave techniques such as, for example, disclosed in the American patent US-A-5,073,167.

 A further object of the invention is to avoid
30 problems inherent to heating by applying electrical energy, in particular the risk of current leaking to a patient receiving the warmed blood or other physiological fluid from the apparatus.

 To this end the apparatus according to the inven-
35 tion is characterized in that the heating means comprise

at least one source of infrared radiation, and in that the conduit is at least partly transparent to the radiation emitted by the infrared source during operation. Surprisingly, such an infrared source provides a very well controllable, direct warming of the blood or the fluid flowing through the transparent conduit. Because there is no direct contact at all, such heating can take place very hygienically, and because there is no electrical contact with the conduit or the fluid flowing through the conduit, the risk of leakage currents is totally absent.

It is observed that WO 97/46271 discloses an apparatus for the sterilization of physiological fluids wherein a conduit is used, which is substantially transparent to radiation from a UV tube. In this apparatus a separately adjustable heating unit is used for the fluid that is conducted through the conduit.

From EP-A-0 138 489 an apparatus is known for the irradiation of somatic cells, in particular the treatment of blood cells, with ultraviolet radiation. To this end a tubular construction is used wherein the radiation source is arranged coaxially. The blood fluid is conducted through the tube wherein the fluid is bordered on one side by the radiation source and on the other side by the wall of the tube in which the radiation source is placed.

Neither WO 97/46271 nor EP-A-0 138 489 gives any indication directed at applying a source of infrared radiation for warming a physiological fluid such as blood that is being conducted through a conduit.

The fluid flowing through the conduit may be warmed very efficiently in a first preferred embodiment of the apparatus, which is characterized in that the conduit defines a space wherein the infrared source is placed, and in that the conduit, at least at the side facing the infrared source, is transparent to infrared radiation.

A very suitable second embodiment of the apparatus is characterized in that the conduit extends substantially in a plane, in that the infrared source is situated next to the conduit, and in that the conduit, at least at the side of the source, is transparent to infrared radiation.

tion. This allows the blood or the fluid to be warmed safely and simply.

The efficiency and controllability is aided in particular by the fact that the conduit extends substantially in the form of a spiral and that its side facing away from the infrared source is provided with an infrared radiation-reflective coating or film. Such an embodiment of the apparatus according to the invention can, moreover, be produced at relatively low costs.

10 It is desirable that the infrared source be adjustable and connected to a control member, and that the conduit, at its discharge, be provided with a temperature sensor that is coupled to, and feeds the control member. It is further advantageous for the apparatus to be
15 equipped with a flowmeter connected with the control member, in order to be able to accurately adjust the widely varying currents of blood or other physiological fluid that flows through the apparatus.

A first embodiment with which this may be realized is characterized in that the flowmeter comprises a
20 heat source, and at least one temperatures sensor.

A second preferred embodiment is characterized in that the flowmeter comprises two temperature sensors and a heat source positioned between said temperature sensors or
25 near the temperature sensors positioned at the discharge side.

The invention will now be further elucidated with reference to the drawings, which

in Figure 1, schematically show a longitudinal
30 section of a first preferred embodiment of the apparatus according to the invention; and

in Figure 2, show a top view of the conduit that may be used in a second preferred embodiment of the apparatus according to the invention.

35 The general workings of the apparatus according to the invention will now first be elucidated with reference to Figure 1.

The apparatus 1 according to the invention for warming blood or other physiological fluids comprises a

conduit 2, wherein the entrance is indicated by arrow A and the exit by arrow B. Through this conduit 2 the blood or the physiological fluid to be warmed is conducted by means of propulsion, which in itself is known to a person skilled in the art, and which requires no further elucidation at this point. The Figure shows that the conduit 2 is formed like a spiral, and that in the interior of the spiral shape an infrared source is provided, for example, an infrared lamp 3, which serves to warm the blood or another physiological fluid flowing through the conduit 2. For this purpose the conduit 2 is transparent to infrared radiation, at least at the side facing the infrared lamp 3. It is preferred, however, for the side of the conduit 2 facing away from the infrared lamp 3 to be transparent also, and for this latter side to be provided with a heat-reflective coating or film 4. The infrared lamp 3 is preferably adjustable, being connected to a control member 5. Also connected with the control member 5 is a temperature sensor 6, positioned at the discharge side of the conduit 2. In this way the power supply of the adjustable infrared lamp 3 is rendered dependent on the temperature values of the blood or another physiological fluid that leaves the conduit at the discharge side near arrow B. Conveniently there is also a flowmeter 7, 8, 9 connected to the control member 5, to allow the control member 5 to adjust the power supply of the infrared lamp 3 subject to the amount of blood or other physiological fluid being conducted through the conduit 2. A possible embodiment of the flowmeter 7, 8, 9 is one in which a heat source 7 is used, together with one single temperature sensor 8. The flow rate of the blood or fluid can be determined by, with the aid of the heat source 7, supplying the blood or the other physiological fluid entering the conduit 2 near arrow A with heat pulses at a predetermined known frequency, and by measuring these with the aid of the temperature sensor. The Figure shows another embodiment wherein the flowmeter 7, 8, 9 comprises two temperature sensors 8 and 9, and wherein the heat source 7 is positioned between the temperature sensors 8 and 9. The measured temperature differ-

ence between the temperature sensors 8 and 9, together with the amount of heat introduced by the heat source 7, determine the flow rate of the blood or the fluid entering the conduit 2 near the arrow A. It should be noted that
5 the heat source 7 may also be positioned near (opposite to) the temperature sensor 8 near the discharge side.

The foregoing description is to be understood as being a non-limiting exemplary embodiment of the apparatus according to the invention without limiting the protection
10 merited by the appended claims. The example given merely serves to elucidate said claims.

It is, for example, also possible not to embody the conduit 2 as a cylindrical spiral defining a space for housing the infrared lamp 3 but to embody the spiral of
15 the conduit 2 in a plane. A top view of this spiral form of the conduit is shown in Figure 2. Blood or another physiological fluid to be warmed is introduced into the conduit 2 at the entry indicated with arrow A, and leaves the conduit 2 at the exit marked with arrow B. In this em-
20 bodiment the infrared lamp or lamps are positioned next to the conduit 2 in a manner that is completely obvious to the person skilled in the art, and requires no further elucidation.

In correspondence to the afore-described first preferred embodiment, the conduit 2 is, at least at the side of the lamp 3 or lamps, transparent to infrared radiation, and at the side facing away from the infrared lamp or lamps a heat-reflective coating or film may be provided. The infrared lamp or lamps are adjusted in accordance with the manner described for the first preferred embodiment shown in Figure 1. In practice, said second preferred embodiment, in which the conduit 2 is arranged in a plane is for production technical reasons preferred. The blood or the other physiological fluid conducted through said conduit can be warmed safely and the thus embodied apparatus is mechanically simple to realize.

CLAIMS

1. An apparatus (1) for warming blood or other physiological fluids, comprising a conduit (2) through which the fluid can be conducted, and heating means (3) for warming the fluid flowing through the conduit (2),
5 **characterized** in that the heating means comprise at least one source (3) of infrared radiation, and in that the conduit (2) is at least partly transparent to the radiation emitted by the infrared source (3) during operation.

2. An apparatus according to claim 1 **characterized**
10 in that the conduit defines a space wherein the infrared source is placed, and in that the conduit, at least at the side facing the infrared source, is transparent to infrared radiation.

3. An apparatus according to claim 1, **characterized**
15 in that the conduit (2) extends substantially in a plane, in that the infrared source (3) is situated next to the conduit (2), and in that the conduit (2), at least at the side of the source (3), is transparent.

4. An apparatus according to one of the claims 1-3,
20 **characterized** in that the conduit (2) extends substantially in the form of a spiral and that its side facing away from the infrared source is provided with an infrared radiation-reflective coating or film (4).

5. An apparatus according to one of the preceding
25 claims, **characterized** in that the infrared source (3) is adjustable and connected to a control member (5), and that the conduit (2), at its discharge, is provided with a temperature sensor (6) that is coupled to, and feeds the control member (5).

30 6. An apparatus according to claim 5, **characterized** in that the same is equipped with a flowmeter (7, 8, 9) connected with the control member (5).

7. An apparatus according to claim 6, **characterized**
in that the flowmeter (7, 8, 9) comprises a heat source
35 (7) and at least one temperature sensor (8).

8. An apparatus according to claim 6 or 7, **characterized** in that the flowmeter (7, 8, 9) comprises two temperature sensors (8, 9) and a heat source (7) positioned between said temperature sensors (8, 9) or near the temperature sensor (8) positioned at the discharge side.