IMPLANTABLE ARTIFICIAL HEART WITH EXTERNALLY WORN FLUID PRESSURE ENERGY TRANSMITTER

Inventor: Heinz Kresse, Erlangen, Germany
Assignee: Siemens Aktiengesellschaft, Erlangen, Germany

Filed: Jan. 8, 1971
Appl. No.: 104,857

Other Publications

Primary Examiner—Richard A. Gaudet
Assistant Examiner—Ronald L. Frinks
Attorney—Richards & Geier

Abstract
An artificial heart has an implanted pneumatic or hydraulic blood pump as well as an also implanted energy receiver serving as a source of energy for the blood pump, energy being transmitted from the outside through the undamaged skin of the patient. The invention is particularly characterized by the provision of at least one compressible elastic bag serving as the energy receiver, filled with liquid or gas, connected with the blood pump and preferably implanted between the peritoneum and the fascia transversalis; it is subjected to pressure change acting from the outside.

1 Claim, 2 Drawing Figures
This invention relates to an artificial heart having an implanted pneumatic or hydraulic blood pump, as well as an also implanted energy receiver serving as the energy source for the blood pump for the energy to be transmitted from the outside through the undamaged skin of the patient.

Existing artificial hearts operate by the use of an implanted electromotor which drives an implanted pneumatically or hydraulically operating blood pump and which receives its energy inductively from the outside through the skin. To operate the artificial heart the electrical primary energy (battery or network) must be therefore transformed initially into magnetic energy which is sent through the skin of the patient and is again transformed into electrical energy inside the body. Then electrical energy is transformed into mechanical energy in the electromotor which drives the pneumatic or hydraulic blood pump. These changes and transfers of energy have substantial losses, so that a substantially large amount of electrical primary energy is required. The required energy can be easily provided from the electric network. However, the heart patient should be able to move freely independently from a network connection. At the present time electrical energy sources which are independent from a network require dimensions which are so large and heavy that they cannot be carried by heart patients. Thus these artificial hearts cannot be used at the present time.

However, the main drawback of existing artificial hearts consists in that a simple emergency operation of the blood pump is not possible. When, for example, the supply of the outer primary energy is interrupted or disturbances take place in the implanted receiving part or the electromotor, it is necessary to carry out servicing operations.

An object of the present invention is to provide an artificial heart of the described type which will not have the above-mentioned drawbacks.

Another object is the provision of an artificial heart wherein energy losses are maintained as low as possible and wherein in case of emergency the blood pump can be also operated by hand.

Other objects of the present invention will become apparent in the course of the following specification.

In the accomplishment of the objectives of the present invention it was found desirable to use as the energy receiver at least one compressible bag filled with liquid or gas, connected with the blood pump and preferably implanted between the peritoneum and the fascia transversalis. The bag is subjected to pressure change acting from the outside.

The implanted bag can be rhythmically compressed and de-aerated by a compression device automatically operating through the undamaged skin, or in case of emergency by hand. In accordance with the present invention it is possible to operate the compression device by compressed air which can be stored in sufficient quantity at low weight. The energy of compressed air does not have to be changed into other forms of energy, but can be used directly to provide pressure changing procedures. For this purpose in accordance with the present invention an outer bag is located opposite the implanted bag at the outer skin side of the patient, which produces the desired pressure change through a regulating and controlling device with the use of compressed air as primary energy. In case of emergency, changes in pressure are produced by hand and are transmitted through the skin to the implanted bag.

So-called two chamber blood pumps are used as a blood pump for artificial hearts. In accordance with the present invention it is advantageous to provide a separate bag for each chamber and to implant the two bags spaced from each other between the peritoneum and the fascia transversalis. In that case two outer bags are also provided and are arranged opposite the implanted ones. If the two bags are alternately actuated, a perfect operation of the two-chamber blood pump is attained. However, in accordance with the present invention it is also possible to use a single bag if an automatically operating switch-over valve is provided between it and the chambers of the blood pump or between means providing compressed air and the outer bag.

Preferably, the outer bag or the outer bags are provided in a belt to be carried around the body. This belt serves at the same time as a carrier for the compressed air bottle, regulating and controlling device and possibly for the switch valve.

To provide an exchange of bottles without friction the supply conduit to the outer bag terminates in two separate joints capable of being closed for attaching two compressed air bottles. Due to the flexibility of the thorax and the softness of the abdominal section there is a limit to forces which can be effectively used and to maximum forces which can be transmitted. However, pressures are transmitted to the blood pump which correspond to blood pressure of healthy persons. To attain these pressures the surfaces of at least the inner bags are made as large as possible. The limit to the size of the bags (surface and volume) is provided by the anatomical conditions and by the medical requirement that a foreign body to be implanted should be as small as possible. In accordance with the present invention an increase in pressure produced by the bags is attained by the use of hydraulic or pneumatic pressure changers to increase pressure upon the side of the pump.

An operating, regulating and controlling device is connected to the outer pneumatic system for the setting and maintaining of pump frequency, pump pressure and the like.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings showing by way of example only, a preferred embodiment of the inventive idea.

In the drawings:

FIG. 1 shows in top view partly in section an artificial heart constructed in accordance with the principles of the present invention.

FIG. 2 illustrates diagrammatically the application of the artificial heart to a human body.

Broken lines in FIG. 1 illustrate diagrammatically the stomach muscles of a human body. A pneumatic two chamber blood pump 1 has chambers 2 and 3 connected by pressure transmitting conduits 4 and 5 with elastic bags 6 and 7. The bags are imbedded between the peritoneum 8 shown by broken lines and the fascia transversalis 9 within a human body 10 the stomach muscles of which are indicated at 11. Pressure changers
12 and 13 are switched into the pressure conduits 4 and 5 to supply to the pump side a higher pressure corresponding to the requirements. The patient 10 carries around his waist a belt 14 provided with two outer rubber blow up bags 15 and 16 which, when the belt is carried, are located precisely opposite the implanted bags 6 and 7. Furthermore, the belt 14 carries an operating, regulating and controlling device 17 which also includes an automatically operating pneumatic flip-flop serving as switch for the bags 6 and 7. The device is provided with pneumatic outlets 18 and 19 for the bags 15 and 16 which are connected with them by connecting conduits 20 and 21. Furthermore, the belt serves as a carrier for the compressed air bottle 22 which provides the energy supply for the artificial heart. The device 17 has a pneumatic inlet 23 to which the compressed air bottle is connected by a conduit 24.

Preferably the conduit can be closed directly in front of its connection to the bottle and can be provided with another side conduit (not shown) adapted to be closed and to be connected to a second compressed air bottle. This makes possible an easy exchange of bottles which does not require the interruption of the operation of the artificial heart.

The belt 14 consists of two parts 14a and 14b at least within the range of the outer bags, whereby the part 14a lying against the skin consists of an elastic material while the other part 14b consists of a non-elastic material. The outer bags 15 and 16 and possibly also their connections 20 and 21 are located between these belt parts.

The operating, regulating and controlling device 17 operates by alternatively blowing up and emptying the outer bags in the desired rhythm and with the desired pressure in a manner similar to that of bellows. The pressure change which is thus produced is transmitted through the uninjured skin to the inner bags which actuate correspondingly the blood pump. The device can raise an alarm if pressure drop in the compressed air bottle becomes dangerous. Obviously the implanted bags constitute a closed system with the pump chamber, while compressed air of the outer system expands the outer bags for a short time period to produce the pressure change, whereupon air is immediately withdrawn. The outer bags themselves can be provided with means opening them to outer air. However, it is also possible to operate the pressure transmitting conduit for the bag in the device 17 by a switching device so that the conduit will be alternately connected to compressed air and then deaerated. In that case the device 17 is provided with deaerating openings (not shown). Devices of this type are well known in prior art compressed air drives.

The present invention provides the advantage that a pneumatic energy source which, as is known, has an advantageous output-weight, can be used from the outside without it being necessary to cut the surface of the human body, thus eliminating the danger of infection. A further advantage of the present invention consists in that the entire device has an advantageous degree of efficiency, since when the usual pneumatic or hydraulic pumps are used no consumption of energy is required. Furthermore, it is advantageous that should the outer system break down, for example, by drop in energy or errors in the outer bags or actuating device, it is possible to maintain by hand an emergency operation. There is also the further advantage that the implanted system can be provided additionally with an artificial heart wherein, for example, the energy source (atomic battery, chemical transformers) the pump drive and the blood pump are jointly embedded, so that in this case also if there is any breakdown an emergency operation by hand is possible.

I claim:

1. An artificial heart, comprising a two-chamber blood pump, two spaced compressible inner bags, separate conduits connecting each chamber of the pump to a separate bag, said pump, said bags and said conduits constituting an implantable closed system, a belt adapted to be worn upon the body of a patient, two outer bags carried by said belt and located opposite said inner bags to produce pressure changes therein, a compressed air bottle carried by said belt, and means connecting said bottle with said outer bags.