The invention involves the use of photocells to electrically isolate the control circuit of the adjustable bed from the motor drive circuit so that the person operating the hand held controller is isolated from the high voltage hazard of the drive circuit. The bed frame is not grounded but is maintained at a zero electrical potential and mechanical insulators are used to isolate the bed structure from the electric control and drive circuits and from earth ground. In addition, a monitoring light is used to indicate the presence of a correct grounding of the electrical components of the bed so that a broken or incorrect grounding situation is readily apparent.
ACTUATION MEANS FOR AN ADJUSTABLE BED

BACKGROUND OF THE INVENTION

The present invention relates to adjustable beds of the type wherein an electric drive motor operated by a person reclining on the bed is used to move the movable bed portions to various adjusted positions. More particularly, the invention pertains to means for maintaining the bed frame at a zero electrical potential and for isolating the control circuit and the hand held controller from the motor drive circuit in order to insulate the patient from the high voltage shock hazard of the electric motor drive circuit.

Adjustable beds which utilize an electrically driven motor controlled by the patient are well known in the art. In such beds, there is an ever present hazard of shock resulting from insulation failure, loose connections and similar faults. For example, an ungrounded or "hot" wire may contact the motor housing or metal bed frame. A patient then touching the bed controls or bed frame and at the same time touching any grounded structure or piece of equipment on or alongside the bed will suffer a shock. Therefore, it is necessary for the patient's safety to prevent the patient from becoming part of the electric circuit.

This has been attempted in the prior art by grounding the bed frame structure and connecting the electric drive motor directly to the frame. Insulated mechanical couplings between the circuit of the hand control unit and the electric drive motor circuit are also provided. With this arrangement, the patient manipulating the hand controller should not come into contact with the high voltage circuit of the electric drive motor. However, if this mechanically insulated coupling were to fail and the patient attempted to manipulate the hand controller, the result would be a short circuit and potential shock hazard to the patient. Furthermore, since a relatively high voltage say on the order of 24 volts is required in hand controllers of the prior art to operate the mechanically insulated coupling, a patient manipulating the hand controller and at the same time touching the bed frame or other grounded apparatus on or alongside the bed would be subject to a shock hazard.

With a grounded bed frame now commonly used, there is a potential shock hazard any time the patient comes in contact with operating electrical medical apparatus such as x-rays or heart monitors and at the same time touches the frame of the bed. Cases have even been reported where the patient attached to some electrical medical apparatus has been electrocuted because the mattress on which he was lying was wet through by water spillage or urine. One approach to this problem in the prior art has been to make as much of the bed frame as possible out of a non-conducting material such as plastic.

In the present invention, practically all possibility of shock hazard has been prevented by first completely isolating the patient from earth ground by maintaining the bed frame at a zero electrical potential and mechanically isolating with insulators the complete bed frame from the electrical motor drive circuit and the control system. Since the bed frame is not grounded but "floats", the patient may contact both the bed and a "hot" wire and still not be subject to a shock hazard. Further isolating the patient from earth ground prevents shock hazard from any malfunction in the electrical motor drive circuit as well as malfunction in any electrical or medical apparatus which may be in contact with the patient such as x-ray apparatus, suction or intravenous feeding equipment, bed lights, etc. In addition, the coupling in the present invention between the control circuit in the hand controller and the electric motor drive circuit is provided by an opto-electrical device so that there is no direct electrical or mechanical connection between the motor drive circuit and the control circuit. The control circuit of the present invention is also designed to operate at a 1 volt potential and at very low current so that the shock hazard for the patient is substantially reduced should a double fault occur and the patient does come in contact with ground while manipulating the hand controller. As an additional precaution, the present invention provides for continuously monitoring the ground system to insure that a broken or incorrect grounding situation is readily apparent.

SUMMARY OF THE INVENTION

The present invention may be characterized in one aspect thereof by providing in combination, an adjustable bed structure which is electrically isolated from earth ground and which has movable portions for supporting a patient in various adjusted positions; an electric drive motor connectable to the various movable portions, the electric drive motor circuitry being electrically insulated from the bed frame; an electrical control circuit including a manually manipulated controller, the electric control circuit being electrically insulated from the bed frame; opto-electronic means electrically isolating the control circuit from the drive circuit; and a ground monitor light which is illuminated so long as the ground connection of the drive circuit is intact.

OBJECTS OF THE PRESENT INVENTION

One object of the present invention is to provide an adjustable, electrically driven bed wherein the electrical components are electrically isolated from the bed structure to maintain the bed structure at a zero electrical potential.

Another object of the present invention is to provide optoelectrical isolation between the control circuit and the drive circuit of an electrically adjustable bed.

A further object of the present invention is to provide a safe-ground monitoring system for an adjustable hospital bed.

These and other objects, advantages and characterizing features of the present invention will become more apparent upon consideration of the following detailed description thereof when taken in connection with the accompanying drawings depicting the same.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view partly broken away of a typical electrically operated hospital bed; and FIG. 2 is a block diagram of the electrical circuitry of the hospital bed.
DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, FIG. 1 shows a typical adjustable hospital bed generally indicated at 10. The bed includes head and foot ends 12 and 14, respectively, and side rails 16. The side rails support by conventional means the spring frame of the hospital bed which may have two or more movable sections. The bed as shown in FIG. 1, for example, has three movable spring frame sections, being the head, leg and foot portions 18, 20 and 22 respectively. The dotted line illustrates a typical position to which the spring frame may be adjusted. These portions may be moved independently from one another by any suitable linkage means which are conventional in the art, a typical linkage being illustrated, for example, in U.S. Pat. No. 3,216,026. Since such linkages are known, they have been omitted from the drawing as shown in FIG. 1 in order to simplify the description.

The bed frame itself is not grounded; instead, the electrical system of the bed as described hereinbelow is grounded with this system being electrically insulated from the bed frame. With this arrangement the bed is maintained at a zero or neutral electrical potential.

Carried by the frame member of the bed is an electric drive motor 24 which supplies the motive power for moving the various sections of the spring frame. Motor 24 is insulated from the frame of the bed by any suitable means such as an insulator pad 26. The drive from motor 24 is connected to a gearbox 28 which contains the gear mechanism and various solenoids (not shown) for connecting the drive motor to a selected one of the adjustable sections. Motor 24 is also insulated from the drive within gearbox 28 by an insulating member 30 in the motor coupling. With this arrangement then, the motor is electrically insulated from all the components of the bed frame. Located alongside the bed on a flexible support 32 is a hand control unit 34 which contains the various push buttons for activating drive motor 24 and selectively engaging the gears within gearbox 28 for adjusting the movable spring frame members.

Referring to FIG. 2, the electric circuit for operating the bed is shown connected to the standard three prong outlet wherein the "hot" "neutral" and "earth ground" terminals are represented by the references 1, 2 and 3 respectively. The motor drive circuit is connected directly to these outlet terminals and includes a first portion for supplying power to the reversible motor 24 and a second portion for supplying power to magnetic clutches 36 and 38 disposed within the gearbox 28. Motor 24 has a forward winding 40 and a reverse winding 42 connected at 43 to the neutral terminal 2. The circuit through forward winding 40 and reverse winding 42 is completed through solid state switches 44 and 46 respectively to the hot terminal 1. The housing of motor 24 is connected directly to the ground terminal 3. As set forth hereinabove, the motor is mounted in a fashion to electrically insulate the motor from the bed frame.

The second portion of the drive circuit includes solid state switches 48 and 50 for operating the magnetic clutches 36 and 38 respectively. It should be appreciated that while only two magnetic clutches are shown, there should be one magnetic clutch associated with each movable portion 18, 20 and 22 of the bed.

Associated with each of the solid state switches, 44, 46, 48 and 50 is a photocell 52, 54, 56 and 58 respectively. Thus, the first portion of the electric drive circuit including the drive motor contains two photocells and two solid state switches and the second portion of the electric drive circuit including the magnetic clutches contains one photocell and one solid state switch associated with each magnetic clutch employed.

The control circuit portion of the circuitry associated with hand controller 34 derives its power from a power supply which includes a shielded transformer 60 and diode rectifier 62. The secondary winding 64 of the transformer is connected to the control circuit with the primary 66 being connected across the hot and neutral terminals 1 and 2. The transformer shield is connected to ground terminal 3.

The control circuit includes a plurality of manually operative switches illustrated at 68 and 70 contained within the hand controller 34. Switches 68, 70 are preferably a double acting type, the operation of which will be described in greater detail hereinbelow. In addition, the control circuit includes lights 72, 74, 76 and 78 associated with photocells 52, 54, 56 and 58 respectively. The circuit to each light is opened and closed by an associated solid state switch 80, 82, 84 and 86. Two solid state switches 80 and 82 are associated with both the manual switches 68 and 70 while each switch 84 and 86 is associated with one of the manual switches 68 and 70 respectively. With this arrangement, operation, for example, of switch 68 will cause solid state switch 84 and either solid state switches 80 or 82 to close whereas operation of manual switch 70 will cause solid state switch 86 and either switch 80 or 82 to close.

It should now be readily apparent that the control circuit and the hand controller 34 are electrically isolated from the drive circuit by the opto-electrical means consisting of the paired photocell and light sources and by the power transformer 60. In addition, since solid state switches are employed at 80, 82, 84 and 86, very little voltage is required in the control circuit to operate the switches. The actual hand controller 34 is itself electrically isolated from the frame of the bed by constructing the hand held controller 34 and flexible support 32 of an electrically insulating material.

OPERATION

The operation shall be described for purposes of illustration as if the patient desired to raise the head portion 18 of the bed from the position shown in solid line in FIG. 1 to the position shown in dotted line. To accomplish this, switch 68 is closed to contact its movable terminals 5 and 8 against its fixed contacts 4 and 9 respectively. The closing of contacts 4 and 5 completes a first circuit through solid state switch 80 to close the switch and illuminate light source 72. The illumination of light 72 energizes photocell 52 which in turn closes solid state switch 44. Closing switch 44 completes a circuit through the forward winding 40 of drive motor 24 so that the motor begins to turn in a forward direction.

In the meantime, closing of contacts 8 and 9 completes a circuit through solid state switch 84 in order to illuminate light source 76. This in turn energizes its associated photocell 56 which closes solid state switch 48. Closing switch 48 completes a circuit
through coil 36 of magnetic clutch 36 which engages the gearing to connect the drive motor to the head portion 18 of the movable bed. So long as switch 68 is held in this position, motor 24 will be connected through the gearing to elevate the head portion of the bed.

If the patient desires to lower the head portion 18, switch 68 is thrown to bring movable terminals 5 and 8 against fixed contacts 6 and 7. Closing contacts 5 and 6 then completes the circuit through solid state switch 82 to illuminate light source 74. Light source 74 in turn energizes its associated photocell 54 which closes solid state switch 46. Closing solid state switch 46 completes a circuit through the reverse winding 42 of drive motor 24, so that motor 24 is now energized to rotate in reverse direction. However, since contacts 9 and 7 are connected in series, closing contacts 8 and 7 result in illumination of light source 76 as described hereinabove to operate the magnetic clutch associated with the head portion 18 of the bed.

In the same fashion, switch 70 may be manipulated to raise and lower the foot portion 22 of the bed, that is, throwing the switch to contact movable terminals 5' and 8' against the fixed contacts 6' and 7' causes the illumination of light sources 74 and 78 whereas throwing the switch to engage the movable terminals 5' and 8' against fixed contacts 4' and 9' illuminates light sources 72 and 78. The illumination of light source 78 energizes its associated photocell 58 to close solid state switch 50 and complete a circuit through coil 38 of magnetic clutch 38. Activating magnetic clutch 38 in turn engages the gearing necessary to connect drive motor 24 to the foot section 22 of the bed.

While controls for moving only the head and foot portion of the bed are shown, it should be appreciated that similar controls may be provided for each movable bed section and for raising and lowering the entire bed frame.

In addition, the circuitry includes a pilot light 88 which is connected between the hot and ground terminals 1 and 3 respectively. With this arrangement, the pilot light is illuminated so long as the ground at terminal 3 is intact. Thus, the light would not be illuminated if the ground is disrupted, the electrical plug connections are faulty, the polarity of the electrical socket is incorrect or if any fault develops in the earth ground connection of the hospital. Such safe ground monitoring light cannot be used on prior art beds which are grounded because with such a bed, the light itself becomes a safety hazard. For example, should a patient on the grounded bed touch the filaments of the bulb, the patient may be shocked, that is, only a single fault such as touching the filaments of a broken bulb will shock the patient. However, in the present invention, the bed is not grounded so that the single fault of touching the filaments of a broken bulb will not shock the patient.

From the foregoing description, it should be appreciated that the control circuit including the hand held controller 34 is electrically isolated from the high voltage electric drive circuit, on the one hand, by power transformer 60 and, on the other hand, by the opto-electrical means which connect the control circuit to the drive circuit. Further, since the solid state switches 80, 82, 84 and 86 in the control circuit require very little power for operation, there is very little current flowing through the control circuit. Since the bed frame itself is not grounded and is at a neutral or zero electrical potential, there should be no potential shock hazard resulting from manipulating the hand controller 34. However, should the control circuit be faulty and the patient come in contact with ground through a source other than the bed frame, the low operating voltage and current in the controller would not be sufficient to cause serious shock to the patient.

By the same token, grounding the electric drive circuit and insulating the circuits from the bed, to permit the bed to remain at a zero electrical potential, also greatly eliminates shock hazard. For example, the patient lying on the bed can contact any hot wire and still not suffer shock and two faults must occur before a potential shock hazard can develop. That is, not only must the patient touch a hot wire, he must also touch a grounded connection.

Thus, it should be appreciated that the present invention accomplishes its intended objects providing a control and drive system for electrically operated adjustable hospital beds which greatly reduces the potential of shock hazard to the patient. Electrically isolating the control circuit which the patient may contact directly through the hand unit 34 from the high voltage components of the drive circuit insures that the high voltage in the drive circuit will not be applied to the hand controller. Electrically isolating the high voltage drive circuit from the bed structure and allowing the bed to maintain a neutral or zero electrical potential greatly reduces the potential of shock hazard by requiring a double fault to occur before the patient will be shocked. The use of the safe-ground monitoring light insures instant notice of an incorrect grounding situation or reversal of the polarity of the electric system.

Having thus described the invention in detail, what is claimed as new is:

1. A hospital bed comprising in combination:
   a. a patient support having movable sections for supporting a patient in various adjusted positions, said patient support being electrically isolated from earth ground and maintained at a zero electrical potential;
   b. a electric drive motor and gearing for moving said movable sections, said motor being electrically isolated from said patient support and having a connection to ground;
   c. clutch means for selectively engaging said gearing to move one or another of said movable sections;
   d. an electric drive circuit electrically isolated from said patient support, said drive circuit having a first circuit part including said clutch means and a second circuit part including said electric drive motor;
   e. an electric control circuit electrically isolated from said patient support including manual operative means for opening and closing said control circuit; and
   f. opto-electrical means coupling said control and drive circuits including a light source in said control circuit which is illuminated by closing said control circuit and a photo cell switch means in both parts of said electric drive circuit, said photo cells switch means being energized on illumination of said light source to close said first and second circuit parts.
2. A hospital bed as set forth in claim 1 comprising:
   a. a plurality of clutch means, each associated with one of said movable bed portions;
   b. said electric drive circuit having a plurality of first circuit parts each including a photo cell switch means and one of said clutch means; and
   c. a plurality of said electric control circuits each having a manually operated means for opening and closing each control circuit and a light source, the operation of one or another of said manually operated means causing said second circuit part and a selected one of said first circuit parts to close, whereby a selected one of said movable portions is adjusted.
3. A hospital bed as set forth in claim 1 comprising:
   a. said drive motor having a forward and reverse drive windings in said second circuit part;
   b. said control circuit having motor forward and reverse drive portions;
   c. said opto-electric means having a light source in both of said control circuit forward and reverse drive portions and a photo cell switch means in said second drive circuit part associated with each of said forward and reverse windings; and
   d. said manual operative means being selectively operated to energize one or another of said light sources to drive said motor forward or in reverse.

4. A hospital bed as set forth in claim 1 including a ground monitor comprising a monitoring light mounted on said patient support, the terminals of said light source being connected between said hot wire and said ground connection to create a potential across said monitoring light and maintain said monitoring light illuminated so long as said ground connection is unbroken.
5. A hospital bed comprising:
   a. a patient support having movable sections for supporting a patient in various adjusted positions;
   b. an electric drive motor for moving said movable sections, said motor having a connection to ground;
   c. an electric circuit for supplying power to said motor including a hot and neutral wire; and
   d. a ground monitoring light carried by said bed, said light being connected between said hot wire and said ground connection to create a potential across said light and maintain said light illuminated so long as said ground connection is unbroken.
6. A hospital bed as set forth in claim 5 wherein said patient support is isolated from earth ground and maintained at a zero electrical potential, said electric drive motor and electric drive circuit being connected to ground and electrically insulated from said patient support.

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