

# The Research and Application of Electric Massage Chair with Residual Current Protection Function

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**Abstract.** The electric massage chair is a common instrument in family health care. In addition to health function, to provide safety for the users is also very important. Comparing with the current safety protection technology of electric massage chair, this paper designs a residual current detection function to increase the safety performance, which provides a new way for this field. When the residual current is generated, the power is disconnected in time. It not only can protect the user's personal safety, but also can reduce the occurrence rate of fire.

## 1 Introduction

At present, the composition of a massage chair generally includes a mechanical part and an electrical part which are made of a metallic material with electric conductivity. The two parts are connected by a wire when the power source is used. If the electrical insulation is damaged, the two parts will become exposed conductive body, which leads potential danger. If the electrical insulation of the massage chair is damaged and the power cannot be disconnected in time, the user's life will be dangerous with touching the exposed conductor. If the bare conductor contact with the earth directly, it will produce a larger current and at the same time release much heat, which will likely ignite combustible materials and then cause a fire. So the electricity safety protection is very important to the massage chair. From the perspective of electricity safety analysis, the lack of residual current protection will increase the danger of electricity safety, so it has very practical significance to design a residual current protection (RCP).

According to GB4706.1 and GB 4706.10[1], the scope of massage apparatus is "single-phase appliances for rated voltage not exceeding 250V, other appliances for rated voltage not exceeding 480V". The normal power source of massage apparatus with larger work power is generally from the electric motor, which is used at home and similar places adopting the wall power directly. The general work power is 220V alternating current. For example, in the use condition of 220V, if the user touches the power accidentally, then residual current is produced, it will cause a great risk of injury for user. If the residual current caused by damaged insulation, the heat will be produced continuously, and it is possible to cause fire, so it becomes a hidden danger of fire.

At present, the electric massage chair use 3 to 4 sets of 15-30W permanent magnet DC motor to drive the movement of kneading, knock shaft and also drive the movement up and down. Electric massage is used the RC-260, RC-280 and other small motors to generate vibration. The maximum power of the motor output is limited, if the motor power is designed too small, the load may exceed the nominal output power, the motor may be

overloaded. The overload will make the motor heating, vibration, speed decreases, sound abnormalities and other phenomena. When the overload is very serious, the motor will burn. According to 6.1 in GB4706.1, the motor protection of the standing massage chair is not only dependent on basic insulation but also includes an accessory safety precaution which links the accessible conductive parts to the grounded protective conductor in the fixed wiring. Some non-portable appliances with a weight greater than or equal to 18 kg cannot be grounded, it rely on double insulation or fortified insulation, and at the same time safety special low voltage power supply to achieve anti-shock protection.

So the existing safety precautions of electric massage chair may still produce residual current and cause the risk of electric shock, resulting in excess heat, leading to security incidents. In order to compensate for the shortcomings of the existing technology, this paper puts forward and realizes a massage chair with residual current protection (RCP) function improving the safety of electricity.

## 2 The RCP mechanism

### 2.1 The Design of RCP

This research present the residual current protection technical scheme is summarized as follows: the motor portion connected to a mechanical linkage portion and an air compression device portion connecting an airbag portion through a PVC pipe, and the electronic integrated control remote controller being connected to a motor portion, an air compression unit portion are all connected in parallel with the outgoing end of the residual current detection module through the wire. And the input terminal of the residual current detection module is connected in series with the working power source (see figure.2).

The motor part is composed of motors which belong to each functional unit having an automatic forward

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rotation, a reverse rotation and a limit function. The forward and reverse rotation of the motor drives the mechanical linkage device realizing the lifting and descent of the functional unit in the spatial position, the forward and backward, the front and the rear, and so on.

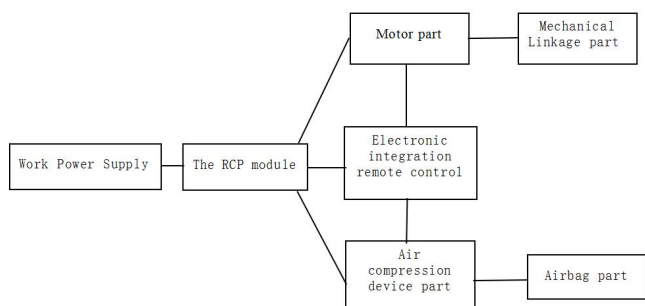


Fig. 1. The frame of RCP

The mechanical linkage part is composed of connecting rod, bearing, push rod and other mechanical parts achieving varieties of mechanical functions through the mutual cooperation of the above device [4]. The air compression device is composed of an air compressor and solenoid valves corresponding to each functional unit, which is connected with each other through a PVC pipe. The control of each solenoid valve enables the each functional unit inflation and aeration. The compressed gas is passed through the PVC pipe to the various functional units, as the driving force of massage. The airbag portion is composed of an airbag of each functional unit. When the airbag is filled with the gas, the body parts of the user are subjected to fasten flexibly. The electronic integrated control remote controller integrates the functions by writing a corresponding program, and the motor part and the air compression device can be operated according to the predetermined program realizing the corresponding function. The working power supply described in the paper is 220V single-phase AC power supply with fire line L and zero line N.

## 2.2 The connection of RCP module

The residual current detection module described in the paper is made up of a switch installed on the connection circuit of the incoming and outgoing terminals (see figure.2).

The switch is connected in parallel with the automatic identification unit, the voice alarm and the reset instruction button. The automatic identification unit is connected in series with the voice alarm. The automatic identification unit is used for indicating the presence of residual current. The switch is used to close or connect the connection between the incoming and outgoing terminals of the electric circuit. The voice alarm beeps to indicate the presence of residual current. The resetting indicator button upsprings when the residual current is detected. The reset indicator button and switch is

interlocked with each other. When the reset button recovery original position, the switch can be closed and disconnected properly, otherwise the switch cannot be closed.

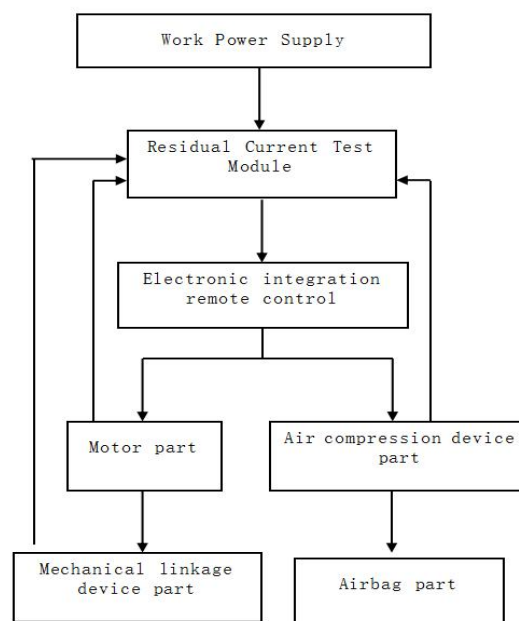


Fig. 2. The Schematic diagram of circuit connection.

When the residual current is generated, the automatic identification unit will identify it automatically. The switch is disconnected within 0.1s automatically, the voice alarm beeps, the reset indicator button bounces. The switch mentioned above is respectively connected with the working power source, the motor part, the electronic integrated remote control and the air compression device part.

## 2.3 The work flow of the RCP module

Work power supply provides power to the residual current detection module, the motor part, the air compression device and electronic integrated remote control.

The electronic integrated remote control makes the motor part, the air compression device part, the mechanical linkage part and the airbag part cooperate complete the corresponding action. The residual current detection module starts at the time when the working power is turned on, and detects whether there is residual current at real-time. When the work power supply is connected, the automatic identification unit monitors whether there is residual current at real-time. Assuming the current which come from the power line L and go into the current detection module is recorded as  $I_1$ . The current which is come from the zero line N and go into the detection module current is recorded as  $I_2$ . The residual current is recorded as  $I_3$ , when the residual current  $I_3$  is generated,  $I = I_1 - I_2, I_1 > I_2$ . The automatic

identification unit records the  $I_3$  value. When  $I_3 \geq 10\text{mA}$ , the voice alarm beep, the reset instructions button bounce, the switch is disconnected within 0.1s automatically, the massage chair stops working; When  $I_3 < 10\text{mA}$ , the switch, the voice alarm, the reset instructions button is in normal working condition, the massage chair works properly. (see figure.3)

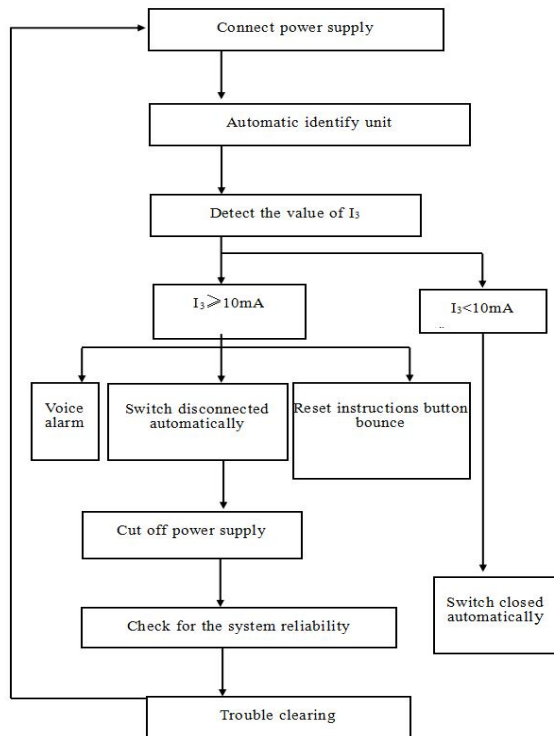


Figure.3. The working principle diagram of residual current detection

**2.4 The actual case**

Case1: As shown in Figure 2, work process of the residual current test module: Connect power supply → Automatic identify unit → Detect the value of  $I_3$  →  $I_3 \geq 10\text{mA}$  → Voice alarm, Switch disconnected automatically, Reset instructions button bounce → Check for the system reliability → Trouble clearing → Connect power supply. Connect power supply → Automatic identify unit → Detect the value of  $I_3$  →  $I_3 < 10\text{mA}$  → Switch closed automatically. More specifically, as show in Figure.4. Residual current test module is made up of four parts such as automatic identify unit 8, switch 9, voice alarm 10 and reset instructions button 11. The four parts cooperate with each other to complete the function of residual current test the residual current module.

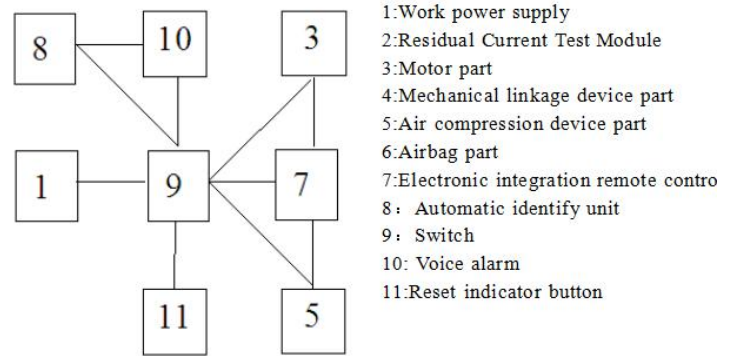


Figure.4. The relation between each part of case1

First turn on the power supply 1, then residual current test module began to work, automatic identify unit 8 detect the value of residual current  $I_3$ . In fact, there are two cases: the first case is when detect  $I_3 \geq 10\text{mA}$ , voice alarm 10 just beeps to indicate residual current fault occur, switch 9 automatically disconnected within 0.1s to ensure that the existence of the residual current won't cause dangerous accident in a short time. Reset instructions button 11 bounce indicates the presence of residual current. Maintenance personnel cut off power supply and check for the above mentioned faults, after ruling out possible faults connect power supply 1, the automatic identify unit 8 in residual current test module 2 began to detect residual current and restart the workflow. The second case is when  $I_3 < 10\text{mA}$ , switch 9 close automatically, the massage armchair work properly. Switch 9 and reset instructions button 11 is interlocked. When reset instructions button 11 bounce, press to restore manually, so the switch 9 can close automatically when  $I_3 < 10\text{mA}$  and vice versa.

Case2: As shown in Figure 5, the work process of massage armchair module: Work Power Supply → Residual Current Test Module → Electronic integration remote control → Motor part → Mechanical linkage device part; Electronic integration remote control → Air compression device part → Airbag part; Motor part, Mechanical linkage device part, Air compression device part → Residual Current Test Module.

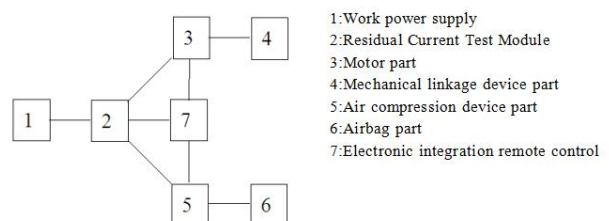


Figure.5. The relation between each part of case2

More specifically, as show in Figure 5, the connection from power supply 1 to single-phase 220V alternating current power supply makes the massage Chair can work

properly; Switch inside residual current test module 2 closed automatically; Electronic integration remote control 7 is used to select the corresponding function. Motor part 3 and air compression device part 5 began to work according to the functional requirements. Motor part 3 drives mechanical linkage device part 4; Air compression devices part 5 drives airbag part 6; In the normal work, the failures of electrical insulation damage might happen on motor part 3, mechanical linkage device part 4, and air compression devices part 5, this can lead to residual current; Residual Current Test Module 2 obtains the feedback of residual current value, so residual current test module 2 can play the corresponding protection function according to the residual current value. Throughout the course of the work, it achieves closed cycle automatic control for residual current test of massage chair, and further achieves protection function for residual current.

### 3 Conclusion

Compared with the prior technology[5][6][7], our research has the residual current protection function, which increases the electrical safety performance of the massage chair. When the residual current is generated, the power supply can be disconnected in order to protect the user's personal safety and can also prevent the occurrence of fire. When the residual current is generated, the voice alarm beeps prompting the existence of residual current, it's easy to find the problem and repair. When the residual current accident is not resolved, the reset indicator button bounces. And the reset indicator button interlock with the switch of residual current detection module making the massage chair cannot work. The residual current detection module will eliminate the existing safety risks and make the massage chairs work with strong security.

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