The design of energy-saving intelligent escape clothes hanger device

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Abstract. Due to the rapid development of economy and technology, floor molding of modern building are different, interior and exterior circuit design are more complex. Therefore, the fire also increases sharply, causing huge losses to the national economy and people's life safety. The survival rate of personnel in serious fires has become the focus of the whole society. We take the clothes hanger as the research object in the paper, refit the clothes hanger, and provides an intelligent escape device to speed up the escape time. The device mainly includes Single-Chip Microprocessor control module, communication module, detection module, alarm module and solar panel module. The device has simple structure and convenient installation, which solves the timeliness of personnel escape in the fire and avoids secondary casualties in the fire.

1. Introduction

With increasing building floor, hidden danger of high-rise building is increasing daily, the fire breaks out every year at home and abroad\cite{1-2}. When there is the fire in the building, the problem of personnel escape is particularly special.

They have strong sense of fire protection in foreign families, fire escape equipment was popularized earlier, so disaster emergency products are highly marketable\cite{3}. There are many escape devices in foreign countries, such as escape ladder, escape slide, escape cabin, stair transfer chair, escape wheel and descent device, etc. However, most of the equipment is used to help firefighters to rescue trapped people in the fire, which is not suitable for family\cite{4}. Because some product technology is not mature, it can not play a protective role in the fire, which may aggravate the disaster.

In our country, fire protection products develop lately. The ministry of public security revise code for fire protection design of tall buildings in 2005, which promote the development of building fire protection products. However, the research for fire protection products mainly focuses on public fire protection in the market, and few fire products are designed specifically for family\cite{5-6}. In daily life, there are public fire protection products, such as fire hydrant, fire nozzle, smoke alarm, fire extinguisher, etc. However, the use of public fire protection products is highly professional, which has great limitations for family use. It is inconvenient to operate in the treatment of sudden fire, with poor response ability.

By analyzing existing fire escape devices at home and abroad, the energy-saving intelligent escape clothes hanger device suitable for families is proposed. The device mainly includes Single-Chip Microprocessor(\texttt{SCM STC89C52}) control module, communication module, detection module, alarm module and solar panel module. When the fire breaks out, the device can realize the alarm function...
and communicate with the fire department. At the same time, the clothes hanger works in the escape ladder mode. The device is simple in structure, easy to operate and suitable for residential building.

2. Design idea
The device is usually used as the clothes hanger[7]. When the fire occurs, clothes hanger is rotated into escape ladder, which can meet family escape. The device is powered by solar panels, and can help people escape, so the device is energy-saving and practical. The device includes mechanical startup mode and electronic startup mode. When the power is not cut off in the fire, the electronic function can be realized, on the contrary, the device can be started by hand.

The device mainly includes central processing unit, communication module, detection module, alarm module, solar panel module, motor drive module, clothes hanger escape ladder module. The central processing unit uses Single-Chip Microprocessor to process signal, the communication module transmits fire information to fire department remotely. The detection module includes temperature sensor and smoke sensor, which feed back detected signal to the central processing unit. After receiving fire signal, alarm module will alarm and inform residents in time. The solar panel module provides power for device[8], the motor drive module is mainly used to control motor and connect clothes hanger into escape ladder. The overall design diagram of the system is shown in Figure 1.

![Figure 1. The overall design diagram of the system.](image)

3. System design
The intelligent escape clothes hanger device is powered by solar panels. When the detection module detects the combustion gas, smoke particles and temperature signals caused by the fire, the signal is transmitted to Single-Chip Microcomputer(STC89C52). The Single-Chip Microcomputer sends the signal to the communication module and notify fire department, fire alarms alarm and inform the people in the room. At the same time, clothes hanger driven by the motor is automatically connected to escape ladder.

3.1. Hardware design
The hardware circuit of the system includes the SCM minimum system, the power supply circuit of solar panel, temperature monitoring circuit, smoke monitoring circuit, stepper motor control circuit, alarm circuit, liquid crystal 1602 display circuit[9]. The hardware circuit of the system is shown in Figure 2.
3.2. **Software design**

The function of energy-saving intelligent escape clothes hanger device is to alarm the fire and help people escape. When the sensor detects fire signal, the system will alarm, meanwhile the communication module transmits fire information to fire department until fire department receives the signal. The control module controls stepper motor to rotate clothes hanger device, and form effective escape channel. The software flow diagram of system is shown in Figure 3.

3.3. **Simulation debugging**

In the system, the temperature and smoke state value are collected by Single-Chip Microcomputer and displayed on LCD 1602. During debugging, the temperature displayed on LCD1602 screen is consistent with that of temperature sensor DS18B20. Because there is no smoke sensor in Proteus software device library, adjustable resistance and LM393 are selected to replace it, according to theory of smoke sensor MQ-135[10]. Smoke monitoring status is simulated by adjusting the size of adjustable resistance. In the program, we set the temperature exceeds threshold value 40 °C, or smoke is monitored, the buzzer starts to alarm, and the motor starts to run. Through debugging the system, the system can meet design requirement. The simulation diagram of the system is shown in Figure 4.

![Figure 2. The hardware circuit of the system.](image-url)
3.4. **Physical debugging**

The system is verified to be feasible by debugging with Proteus simulation software and Keil software in Section 3.3. Because Single-Chip Microcomputer minimum system can not be debugged in simulation circuit, we first debug it in physical debugging, then assemble components according to hardware circuit. The physical picture is shown in Figure 5. The solar panel module provides power for device. In testing temperature, temperature threshold is set to 20 °C, and the actual measured temperature is 28 °C, the system alarm and the motor starts to rotate. In detecting smoke, we keep the smoke on the smoke sensor, and the system also starts to alarm. After debugging, the required functions can be realized completely.
Figure 4. The simulation diagram of the system.

Figure 5. The physical picture.
4. Model design of escape clothes hanger device
The device usually is used as common clothes hanger, the model is shown in Figure 6. In the model, the installation positions of solar panels, alarms and clothes hangers are given. The smoke and fire sensor are array all over the house in order to detect the fire as soon as possible. The system is powered by solar panels, when the alarm receives the signal from alarm circuit, it will start to alarm. At the same time, clothes hanger on the balcony is connected into the escape ladder, and residents start to escape with escape ladders. The clothes hanger escape ladders model is shown in Figure 7. In order to further ensure the escape safety, the system is equipped with escape ropes and the speed limiting device, which is installed on the hand-held shaft. The escapee can adjust the descent speed during the descent process.

Figure 6. The clothes hanger model.

Figure 7. The clothes hanger escape device model.
5. Conclusions
Energy saving intelligent escape clothes hanger device has the characteristics of energy saving, simple structure, convenient use, real-time communication, automatic alarm and so on. If there is the fire in the building, the residents can escape through the clothes hanger device to save themselves. The device provides the escape way for the residents living in high-rise buildings, and effectively solves the problems of insufficient escape channels, crowded corridors and secondary injury in escape. The device usually is used as common clothes hanger, which does not affect building appearance and is convenient for users. In case of the fire, the clothes hanger is connected into the escape ladder, which can help residents escape quickly. Therefore, the device has good application prospect.

At present, we verify the device effectiveness through simulating model and debugging physical methods, but it has not really been used in high-rise buildings. Next, we will promote the equipment in buildings to further confirm its practical value.

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