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Research and Discussion on Fire Extinguishing Devices for Electrical Equipment

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Abstract: *The fire extinguishing device for electrical equipment includes a support mechanism installed between a pair of utility poles to secure the electrical equipment and a fire extinguishing mechanism designed to extinguish fires when the electrical equipment catches fire. The support mechanism consists of a housing and a mounting bracket fixed at the bottom of the housing to connect with the utility poles. Inside the housing, from top to bottom, there are an intake chamber, an electrical equipment placement chamber, and an exhaust chamber. When the electrical equipment catches fire, a triggering component releases a locking component, allowing carbon dioxide from the intake chamber to be injected into the electrical equipment placement chamber to extinguish the fire. Simultaneously, a connecting component pushes a flap to seal the electrical equipment placement chamber, cutting off the oxygen supply. Additionally, the connecting component drives a piston in the exhaust chamber to move, drawing the original gas from the electrical equipment placement chamber into the exhaust chamber, thereby quickly filling the electrical equipment placement chamber with carbon dioxide.*

Keywords: *Electrical equipment, fire extinguishing mechanism, support mechanism*

1. Resarch Background

Electricity refers to the production, transmission, distribution, and use of electrical energy, as well as the manufacturing of electrical equipment. It is a scientific field that utilizes electrical energy, electrical equipment, and electrical technology to create, maintain, and improve living spaces and the surrounding environment. This includes the conversion, utilization, and research of electrical energy, covering fundamental theories, applied technologies, and facility equipment. Electrical engineering is one of the core disciplines in modern technology and a crucial field in high-tech industries. The significant advancements in electrical technology have driven the era of automation and are transforming human lifestyles and work patterns. Therefore, the development prospects for electrical equipment are highly promising. Electrical equipment refers to devices such as generators, transformers, power lines, and circuit breakers within power systems.

Certain electrical equipment mounted on high utility poles along roadsides is often filled with insulating oil to enhance insulation. However, if such equipment catches fire and is not extinguished promptly, it can be extremely dangerous. The insulating oil can intensify the fire and even cause explosions, posing a threat to pedestrians passing by. Therefore, research on fire extinguishing devices for electrical equipment is of great significance[1].

2. Research Content

The purpose of this study is to provide a fire extinguishing device for electrical equipment mounted at high roadside locations to address the issues mentioned above.

The fire extinguishing device for high roadside electrical equipment includes a support mechanism installed between a pair of utility poles to secure the electrical equipment and a fire extinguishing mechanism designed to extinguish fires when the electrical equipment catches fire[2]. The support mechanism consists of a housing and a mounting bracket fixed at the bottom of the housing to connect with the utility poles. Inside the housing, from top to bottom, there are an intake chamber, an electrical equipment placement chamber, and an exhaust chamber. The housing is uniformly equipped with slotted ventilation holes on both sides of the electrical equipment placement chamber, and these holes are hinged with flaps. The hinge shafts of the flaps are equipped with torsion springs, which keep the flaps in an inclined position under normal conditions.

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2.1. Technical Solution of the Fire Extinguishing Device

The fire extinguishing mechanism includes an exhaust component in the intake chamber, an intake component in the exhaust chamber, and a connecting component in the electrical equipment placement chamber[3]. The exhaust component consists of a piston sliding inside the intake chamber, reset springs uniformly fixed at the top of the piston and connected to the top of the intake chamber, an intake pipe connected to the top of the housing and the intake chamber, and exhaust pipes connected to both sides of the housing top and the intake chamber. The intake pipe is equipped with a plug, and the exhaust pipes are sequentially equipped with a switch valve and a one-way valve, with the other end of the exhaust pipes extending into the electrical equipment placement chamber.

The intake component includes a piston sliding inside the exhaust chamber, an intake pipe connected to the bottom of the electrical equipment placement chamber and the exhaust chamber, and an exhaust pipe connected to one side of the top of the exhaust chamber. The intake pipe is equipped with a one-way valve, and the exhaust pipe is equipped with another one-way valve.

The connecting component includes two vertical plates fixed at the bottom of the piston on both sides, two vertical plates fixed at the top of the piston on both sides, two connecting rods between the corresponding plates, and crossbars uniformly set between the two connecting rods. The connecting rods are close to the sidewalls of the electrical equipment placement chamber, and the number of crossbars matches the number of flaps. The crossbars are located at the hinge positions of the flaps. One side of the vertical plate is equipped with a rack, and the exhaust chamber has a gear roller that meshes with the rack. The other side of the gear roller is equipped with another rack that meshes with the gear roller, and this rack is fixed to the top of the piston, as shown in Figure 1.

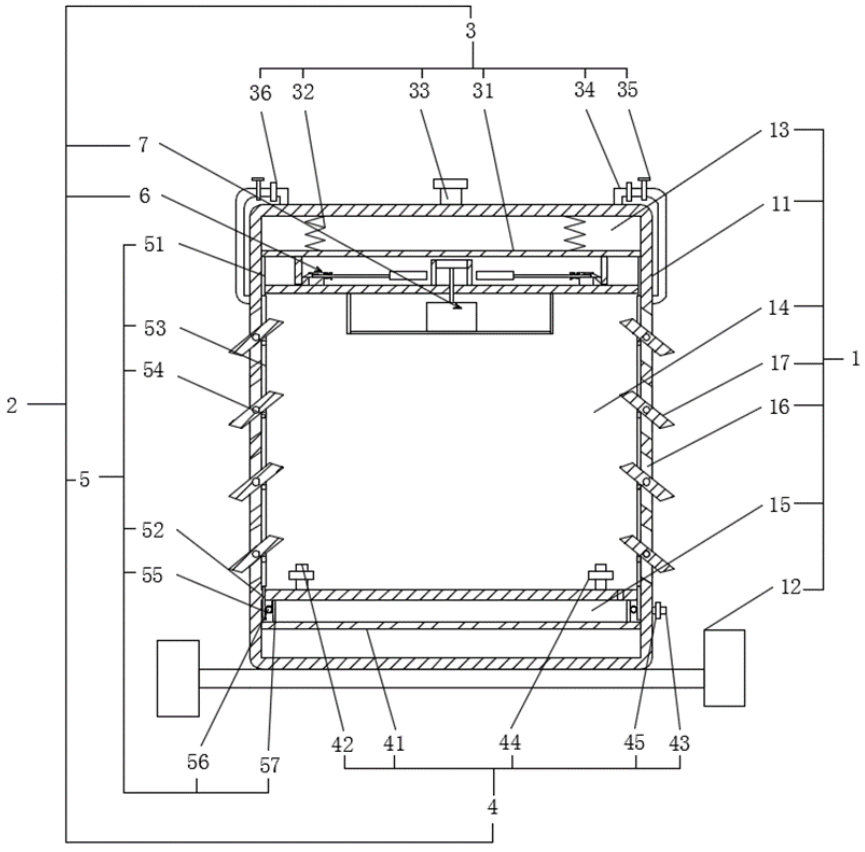

Figure 1: Schematic diagram of the fire extinguishing device structure.

In the figure: 1. Support mechanism; 11. Housing; 12. Mounting frame; 13. Air intake chamber; 14. Electrical equipment placement cavity; 15. Suction chamber; 16. Strip-shaped vent holes; 17. Fan plate; 2. Fire extinguishing mechanism; 3. Exhaust assembly; 31. Piston one; 32. Return spring; 33. Intake pipe; 34. Exhaust pipe; 35. Switch valve; 36. One-way valve one; 4. Suction assembly; 41. Piston two; 42. Suction pipe; 43. Outlet pipe; 44. One-way valve two; 45. One-way valve three; 5. Connection assembly; 51. Movable plate one; 52. Movable plate two; 53. Movable strip; 54. Crossbar; 55. Rack plate; 56. Gear

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roller; 57. Rack; 6. Locking assembly; 61. Vertical plate; 62. Guide inclined block one; 63. Fixed seat; 64. Groove; 65. Guide inclined block two; 66. Sliding rod; 67. Magnet one; 68. Limit block; 69. Compression spring; 7. Trigger assembly; 71. Support plate; 72. Hard partition plate; 73. Guide cylinder; 74. Magnet two; 75. Support rod; 76. Positioning plate.

2.2. Preferred Solution

The fire extinguishing mechanism also includes a locking component to lock the piston when it moves to the bottom and a triggering component to release the locking component when the electrical equipment catches fire, as shown in Figure 2.

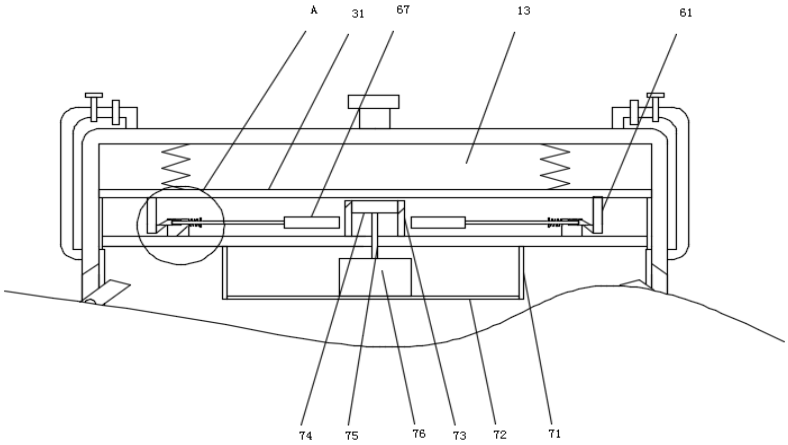

Figure 2: Schematic diagram of the locking mechanism and triggering component structure.

Preferably, the locking component includes two vertical plates fixed at the bottom of the piston on both sides, inclined blocks on the inner sides of the two vertical plates, a fixed base at the bottom of the intake chamber near the inclined blocks, a groove in the fixed base near the inclined blocks, a sliding block inside the groove that matches the inclined blocks, and a sliding rod connected to the sliding block. The end of the sliding rod extends to one side of the fixed base and is equipped with a magnet. The sliding rod is equipped with a limit block, and a compression spring is set between the limit block and the fixed base. The two magnets have opposite polarities facing each other. The inclined block on the vertical plate has a downward slope, and the inclined block in the groove has an upward slope.

Preferably, the triggering component includes two support plates at the top of the electrical equipment placement chamber, a hard partition between the two support plates, a guide cylinder between the two magnets, a magnet sliding inside the guide cylinder, and a support rod vertically fixed at the bottom of the magnet. The bottom end of the support rod extends to the top of the hard partition and is fixed with a positioning plate. Under normal conditions, the magnet is misaligned with the magnet on the sliding rod and is located above it.

Preferably, the top surface of the slotted ventilation holes is inclined toward the electrical equipment placement chamber, and the bottom surface is inclined toward the outside.

Preferably, the one-way valve on the exhaust pipe allows flow from the intake chamber to the electrical equipment placement chamber, the one-way valve on the intake pipe allows flow from the electrical equipment placement chamber to the exhaust chamber, and the one-way valve on the exhaust pipe allows flow from the exhaust chamber to the outside.

3. Research Results

3.1. Structural Characteristics of the Fire Extinguishing Device

The fire extinguishing device structurally comprises multiple critical components that work in coordination to achieve fire suppression functionality. The locking assembly, as one of the primary structures, consists of several parts: two vertical plates arranged perpendicularly on both sides of the bottom of Piston One; Guide Sloping Block One mounted at the bottom of the vertical plates; and a fixed

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base at the bottom of the intake chamber, which is provided with a groove. Guide Sloping Block Two, which matches Guide Sloping Block One, is slidably installed within the groove. One side of Guide Sloping Block Two is connected to a sliding rod, the end of which is fixed with Magnet One. A limit block is positioned outside the sliding rod, and a compression spring is installed between the limit block and the fixed base. The two Magnets One have opposite polarities on their facing ends, while the inclined surfaces of Guide Sloping Blocks One and Two are oriented in a specific direction. These components collectively enable the locking function.

The triggering mechanism is equally crucial and includes two support plates at the top of the electrical equipment compartment, with a rigid partition plate positioned between them. A guide cylinder is installed between the two Magnets One, inside which Magnet Two slides. A support rod is vertically fixed at the bottom of Magnet Two, extending downward to the top of the rigid partition plate and connected to a positioning plate. Under normal operating conditions, Magnet Two is offset from Magnet One and remains positioned above it. The triggering mechanism plays a pivotal role in activating the fire extinguishing device.

Additionally, the top surface of the elongated ventilation slots is designed in an inclined shape, facing toward the electrical equipment compartment and the external environment respectively, facilitating proper gas circulation. One-Way Valve One, One-Way Valve Two, and One-Way Valve Three regulate the unidirectional flow of gas between the intake chamber, electrical equipment compartment, suction chamber, and the external environment, ensuring rational internal gas distribution. This guarantees stable and efficient operation of the fire extinguishing device, ultimately achieving effective fire suppression for elevated roadside electrical equipment.

3.2. Application Characteristics of the Fire Extinguishing Device

When the electrical equipment catches fire, the hard partition is easily burned, causing it to break. The magnet then moves downward due to gravity, aligning with the magnet on the sliding rod, which attracts the sliding rod and moves it toward the guide cylinder. This releases the sliding block from the groove, unlocking the piston. The piston then moves upward under the force of the reset spring. As the piston moves upward, it injects gas from the intake chamber into the electrical equipment placement chamber and drives the connecting component to push the flaps, sealing the electrical equipment placement chamber. Simultaneously, the connecting component drives the gear roller to rotate, which in turn drives the piston in the exhaust chamber to move downward, drawing the original gas from the electrical equipment placement chamber into the exhaust chamber. (When injecting gas into the intake chamber, the switch valve must be closed to allow the piston to move downward. After the locking component locks the piston, the switch valve is opened to complete the gas injection process).

3.3. Research Results

Research on fire extinguishing devices for high roadside electrical equipment is of great significance. Fires in such equipment can lead to explosions, electric leakage, and other dangers, posing threats to pedestrians, vehicles, and nearby buildings. An effective fire extinguishing device can quickly control the fire, reduce the risk of fire, and protect public life and property. Timely fire extinguishing can minimize damage to electrical equipment, reduce repair and replacement costs, shorten equipment downtime, ensure the normal operation of power supply and communication systems, and avoid greater economic losses and social impacts caused by equipment damage[4]. Relevant regulations and standards require necessary fire prevention measures for electrical equipment. Research and installation of appropriate fire extinguishing devices can help relevant departments and companies comply with regulations, avoid legal risks, and administrative penalties. Without waiting for firefighters to arrive, the device can save valuable time, improve emergency response efficiency, and reduce the workload of fire departments. Especially in the early stages of a fire, dedicated fire extinguishing devices can automatically or quickly respond. Given the limited space, weather conditions, and special environments of high roadside locations, research on targeted fire extinguishing devices can better adapt to these conditions, ensuring reliable operation and effective fire suppression in various complex environments[5].

The housing of this device is internally divided into an intake chamber, an electrical equipment placement chamber, and an exhaust chamber from top to bottom. The electrical equipment is placed inside the electrical equipment placement chamber, and its sides are equipped with slotted ventilation holes. The holes are hinged with flaps, and the hinge shafts are equipped with torsion springs. Under normal conditions, the flaps are inclined due to the torsion springs, allowing air intake and heat

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dissipation for the electrical equipment placement chamber. The intake chamber is filled with carbon dioxide. When the electrical equipment catches fire, the triggering component releases the locking component, allowing carbon dioxide from the intake chamber to be injected into the electrical equipment placement chamber to extinguish the fire. Simultaneously, the connecting component pushes the flaps to seal the electrical equipment placement chamber, cutting off the oxygen supply. The connecting component also drives the piston in the exhaust chamber to move, drawing the original gas from the electrical equipment placement chamber into the exhaust chamber, thereby quickly filling the electrical equipment placement chamber with carbon dioxide. This ensures timely fire extinguishing and guarantees the safety of electrical equipment mounted on high roadside utility poles, demonstrating reliable application results.

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