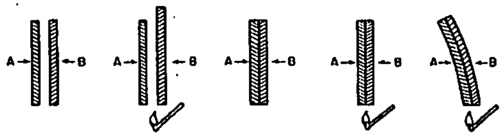
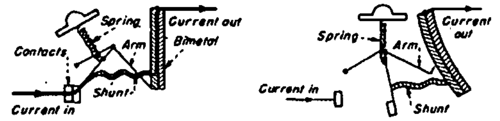
THERMAL AND MAGNETIC DEVICES

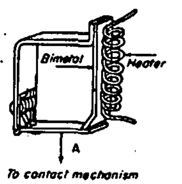
HOW THERMAL ELEMENTS WORK

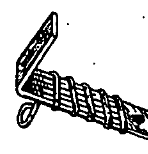


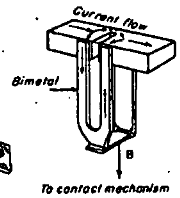
1 Bimetallic principle is illustrated above. Two metals with unequal coefficients of expansion, A and B, are welded. When heat is applied the combination strip will bend, operating a circuit-opening mechanism



2 Heat to the bimetallic strip is generally supplied by a coil connected in series with the load. Time required to operate decreases as load increases. Strip returns to normal position after it has cooled



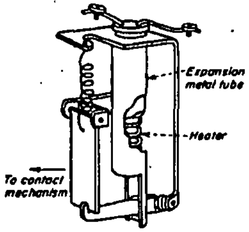




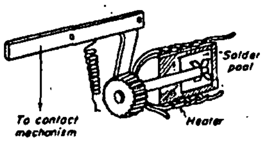
3 When bimetal strip bends, trip latch moves up and operates mechanism that opens contacts in load line

4 Heaters used with bimetallic element can be replaced with one of different rating if load changes

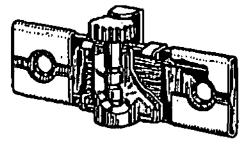
5 Part of current to load passes through bimetal element. Heat generated by overload current deflects strip



6 Heater is inserted in manganese alloy tube. When connected motor draws overcurrent, heat developed within tube causes it to expand. A lever mechanism trips relay



7 Heat developed within coil melts solder allowing ratchet to trip. Can reset relay after solder cools



8 Cutaway view of alloy-pool type relay showing heating grid and alloy pool. Ratchet wheel engages a spring-held tripping mechanism

Protecting a circuit against overcurrent consists essentially in providing (1) a device to detect flow of excess current and (2) a means of interrupting the circuit. Methods commonly used in opening the circuit were discussed in the last few pages under the heading, "Circuit Breakers." We will now take up fundamental principles in detecting excess current, as well as typical overcurrent detectors.

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Thermal Devices. Flow of current through a resistor generates heat, the value of which varies as the square of the current *flowing.* For a motor, the maximum current that can be safely drawn, and hence the greatest output the unit can deliver, is limited by the temperature rise within its winding. The thermal overload device was developed to permit short-time overload, while still protecting against overload that would injure the insulation of the motor's winding.

The thermal relay consists essentially of three parts: a *heat-producing* means, a *heat-responsive* device, and a *contact mechanism.* Generally speaking, thermal relays may be divided into two classifications according to the type of heat-responsive device: *bimetallic* and *solder pool.* Several forms are illustrated in the panel to the left. The heat-producing means is generally a heater coil. Thermal devices are connected in series with the load; hence the current flowing, which produces heat within the motor's windings, will generate a proportional amount of heat within the thermal device.

Referring to *Fig. 1,* we see illustrated the fundamental principle in the operation of a bimetallic strip. Metals with a different coefficient of expansion are bonded together. When heat is applied, each strip will expand at unequal rates, resulting in a bending action of the whole. The heat is supplied to the bimetallic strip by a heater coil, which surrounds the element and is connected in series with the load. The bimetal thermal relay is widely used today.

The solder-pool type of thermal protector *is illustrated in Fig. 7.* This relay consists of a container filled with a specific amount of solder. As with the bimetallic strip, a heater surrounds the cylinder holding the solder. A ratchet arm is connected to radial vanes in the solder pool. The device is so calibrated that upon flow of excess current sufficient heat is generated within the coil to melt the solder. The vanes are now free to turn, and since they are under spring tension the ratchet arm will move. This movement operates a tripping mechanism that opens the circuit.

Fig. 6 illustrates the expansion-tube thermal relay. The element that responds to temperature in this relay is a manganese-alloy tube. A heater is inserted in the tube supplying sufficient heat on overcurrent to cause elongation of the tube. This movement releases a latch mechanism, which in turn operates the relay contact. As the movement of the alloy tube is very small, a large multiplication of lever ratios in the latch mechanism must be used. It is essential in this type relay that all parts be held to close tolerance.

The relay shown in Fig. 13 uses the heating effect created by a current induced in a copper tube. As in previous relays, the coil is connected in series with the load. A copper tube is inserted in the coil and through transformer action, current is induced within the tube, generating heat. This heat in turn is transferred to a solder-ratchet relay. Since the heat generated depends upon transformer action, this relay is used in alternating-current circuits only.

Thermal relays are most commonly used to protect motors against overload. They are particularly suited for this application because they not only have time-lag characteristics, but, in addition, thermal relays are available which act to sum up the heating effect of a series of minor overloads.

To illustrate this point, let us consider the action of the thermal-overload device connected to a motor which is subjected to periodic overloads. Each period of overload contributes to the temperature rise within the motor. Hence, it is easy to understand how a motor could be damaged if subjected to a sufficient number of these short-time overloads. Since the thermal device *operates on the temperature-rise* principle, each period of motor overload will act to raise the temperature of the thermal relay. In this instance, although each short-time overload did not draw sufficient current to operate the relay, the device will, nevertheless, operate before the resulting temperature of the motor winding reaches a dangerous limit.

Most thermal relays may be designed to reset manually or automatically. Automatic reset may be an advantage if the relay is some distance from the connected motor, and the motor is subjected to few overloads. It is good practice to use manually reset thermal relays to reduce motor overloading by the machine operator.

A combination starting switch and thermal-overload relay is shown in Fig. 11. The device is well suited to operate and protect small motors. A thermal device incorporated in the switch consists of a small heater coil connected in the motor circuit. The coil surrounds a steel ratchet fastened to a fixed shaft. A solder-pool device operates the ratchet arm. Fig. 12 shows overload relay with melting alloy element in place. Overcurrent of sufficient duration allows ratchet of element to turn opening circuit. Pressing button resets relay after cooling.

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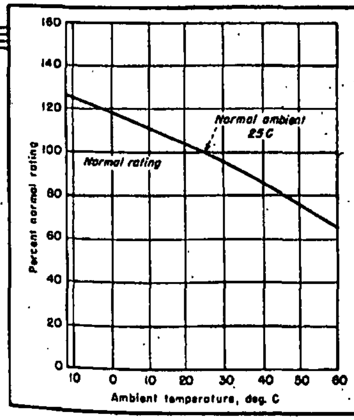
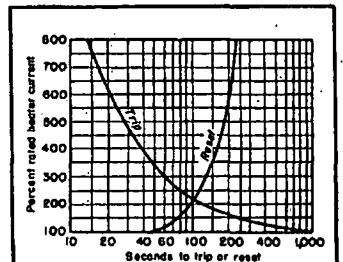
Thermostatic Protection. Another type of thermal protective device designed to protect motors consists of a bimetallic strip, which is near the motor winding. Should the stator winding overheat, the bimetallic element will expand and open the motor circuit. Note in this case the heat supplied to trip the relay is the actual heat generated within the motor winding. The device may be designed to reset automatically when the temperature of the motor returns to normal, or it may be reset manually. In protecting small motors the tripping mechanism is connected directly in the motor circuit. When used with large motors, it operates to open the connected circuit breaker or motor starter. Such relays are often used to operate an indicating device, warning the machine operator

TYPICAL CHARACTERISTICS OF THERMAL ELEMENTS



9 Tripping point of most thermal devices changes with temperature of surrounding air. Elements with automatic compensator are available



10 Trip and reset time is shown. Resetting may be automatic or manual. Automatic reset often used if motor to control distance is large