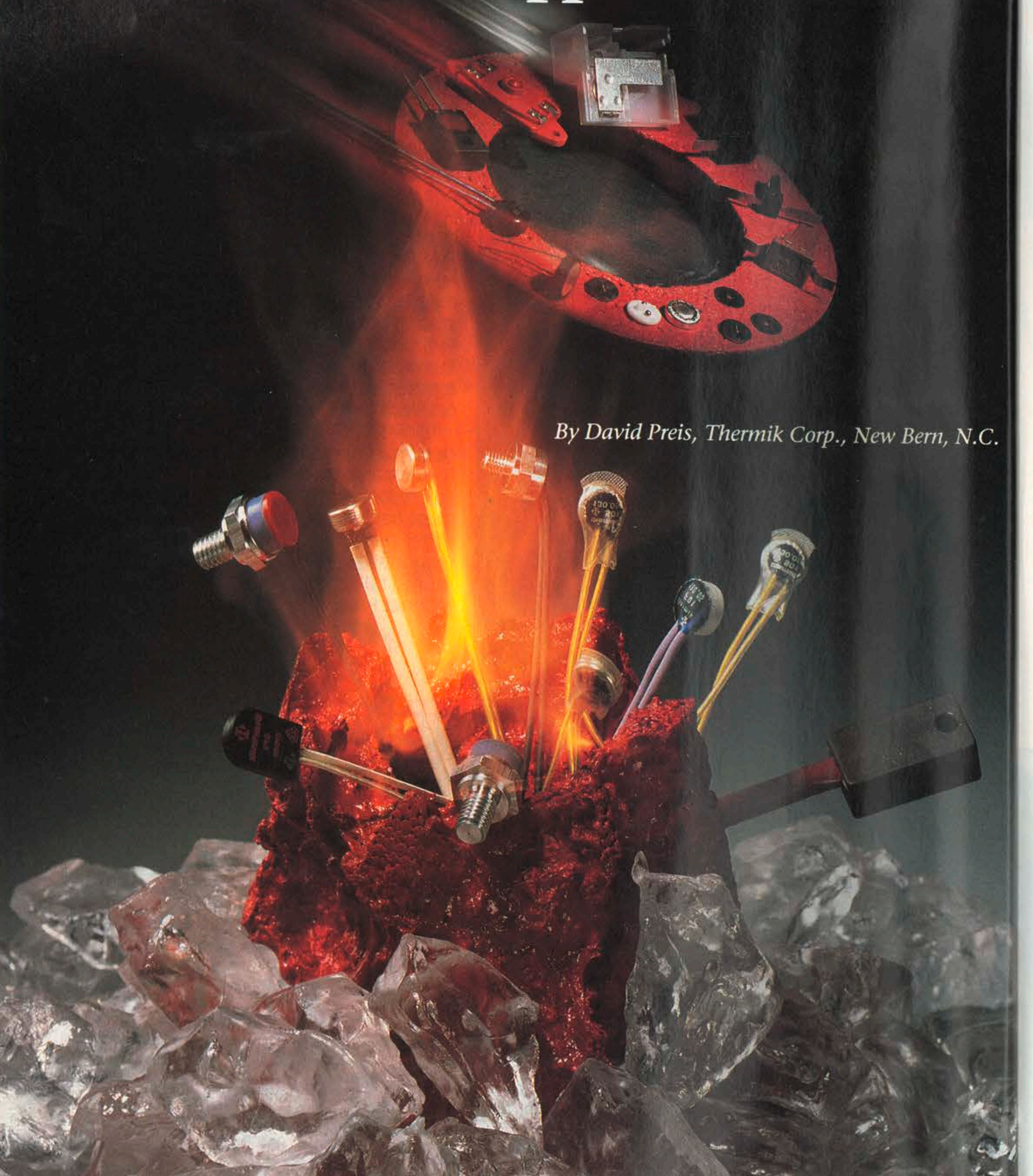
Choosing the Right Thermal Protection Device For Electrical Applications



By David Preis, Thermik Corp., New Bern, N.C.

According to Underwriters Laboratory Document 547, a thermal protector for a motor is "an inherent overheating protective device that is responsive to motor current and temperature and that, when applied as intended to a motor, protects the motor against overheating due to overload or failure to start." Naturally, thermal protectors are also used to protect transformers, electronic components and other kinds of electric products where potential failures can lead to critical heat situations.

Protectors are available either with normally closed (NC) or normally open (NO) contacts. They are provided with a fixed, factory preset switching temperature. Each protector is identified by type, temperature, tolerance and manufacturer's identification (figure 1). When reaching or exceeding the factory pre-set switching temperature, the NC-protector will break contact, disconnecting the protected device from its power supply. On the other hand, the NO-protector will make contact, activating an alarm signal, a cooling fan or other such device.

Thermal protectors can be either of the automatic or manual resetting type. Recently, however, semi-automatic or non-automatic resetting types have been developed. In a semi-automatic resetting type, a built-in heating resistor avoids automatic resetting as long as the device is physically connected to its power supply. Only after manual (galvanical) disconnection of the device from its power supply will the protector reset, as does the automatic resetting type. Such protectors are being used increasingly in the transformer and motor industries.

Choosing a thermal protector depends on the intended function of the device to be protected. In most cases, especially when motors may occasionally run hot and when damage to the motor after tripping of the protector is not likely, automatic resetting types are used. On the other hand, where thorough inspection or maintenance work is necessary after tripping, manual resetting types would be most practical.

Thermal protectors are available as current sensitive types, temperature sensitive types or as a combination of both. Depending on the rated current of the motor to be protected, a current sensitive protector may switch at temperatures well below the pre-set switching limit of the protector. This can be advantageous, especially in cases of steep current rises. However, a current sensitive protector with a fixed switching temperature of 130°C may switch in one motor at 120°C, in another motor at 110°C and in yet another motor at 80°C, depending on the rated current of the motor (figure 2).

The user should keep in mind two additional aspects. First, the range between the switching temperature and the resetting temperature of the protector could be smaller than intended, resulting in a more frequent switching cycle, stressing the motor and the protector more than necessary. Second, protectors with different temperature values have to be stocked for different motor sizes within a given insulation class. Here, the advantage of non-current sensitive protectors becomes evident: A 130°C protector always switches at 130°C, requiring only one protector type for different sized motors within one insulation class.

Bimetallic Thermal Protectors

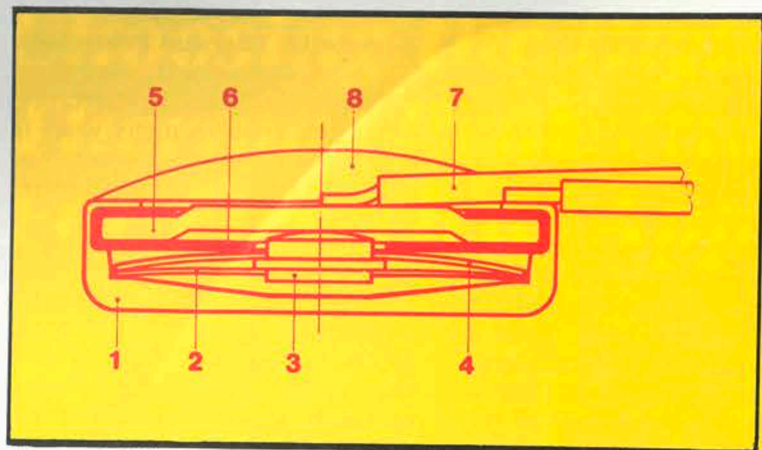
Bimetallic thermal protectors* have been used for many years in the electrical industry for overheating protection. Their features include:

- Direct switching capability — good for rated currents up to 10 A and maximum switching currents up to 25 A.
- Long contact life — due to minimum contact chattering or arching, verified by stringent endurance tests according to UL, CSA, BEAB, SEMCO and VDE.
- Rapid switching speed — with the non-current carrying thermobimetallic disc and a specially designed snap acting disc, the switching performance has been measured at less than 1 ms.
- Reliable contact stability — even with mechanical vibrations equivalent to a force of 10 g's in any direction, the contacts remain stable.
- Responsive to temperature variations — due to its small mass and dimensions, the sensitive side of the protector permits rapid heat transfer, which trips the switch as close to the source temperature as possible.
- Impact resistant — the switching temperature is not influenced by normal mechanical stresses during installation or operation.
- Compact design — only 4 to 7 mm in height and 9 to 10 mm in diameter, depending on the type, allowing many motor manufacturers to use this with little or no product

**The following information describes one such device patented by Thermik Corp., New Bern, N.C.*

To order reprints of this article, mark no. **421** on the reader service card.

Figure 1, thermal protectors are identified by type, temperature, tolerance and manufacturer's identification.



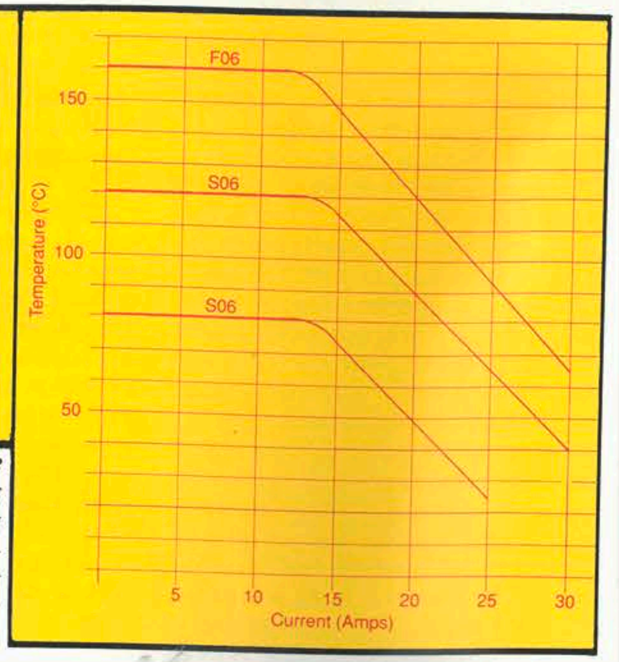


Figure 2, left, is a graph showing the current dependance of the switching point of series "SO6" and "FO6" thermal protectors installed in the winding of a single phase motor. The switching temperature of thermal protectors has to be chosen in conformity with the insulation class of winding wires as well as the short circuit current. Figure 3, above, design of a typical bimetallic thermal protector.

design changes.

• Consistent switching performance — the operating current has only miniscule influence on the switching temperature. Therefore, a given switch will react to the true temperature and allows one temperature rating to be used for many motor variations.

The design of a typical thermal protector**, incorporating the above listed features, is shown in figure 3. Located in the metal housing (1) is a round contact spring (2), a silver contact (3) and a round thermo-bimetallic disc (4). The metal cover (5) with a silver contact is insulated from the housing by an insulation washer (6) encircling the cover. The assembled protector is furnished with connection leads (7) per customer specification. The exposed portion of the cover, including the connection area, is protected and insulated by an epoxy sealant (8).

The switch works as follows: When the temperature of the thermo-bimetallic disc has reached the preset limit it instantaneously changes from a convex to concave state, separating the contact from the cover. The circuit is then opened and the current interrupted. When the temperature in the motor drops to a safe level (generally 30°C +/- 15°C below the switching temperature), the bimetallic disc automatically returns to its initial position and closes the circuit. Due to the specially designed contact spring, the mechanical opening and closing process reaches stability in a matter of milliseconds, with the electrical contact chattering less than 1 ms. The contact system can also be adopted for higher current-carrying capacity.

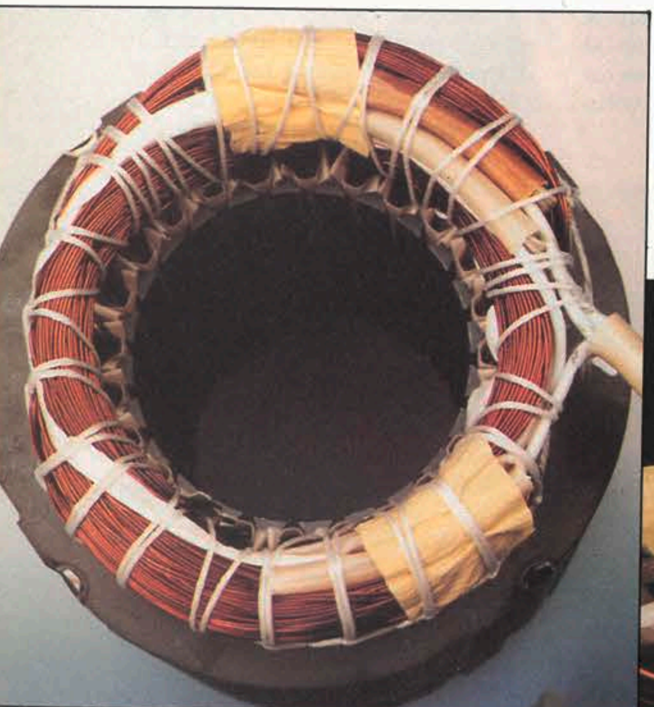


Figure 4, above and to the right, shows a thermal protector used in a single phase motor.

For applications requiring an insulated switch up to 145°C nominal temperature, all protectors are insulated with a "Mylar" shrinking sleeve and, in special cases, the front edge is ultrasonically welded to create a cap to form fit the protector. Above 150°C, an ultrasonically welded sleeve of Mylar-Nomex is used.

Application

Thermal protectors should be designed and tested for overheating protection of electric motors in accordance with UL 547, CSA 22.2 No. 77, IEC 34-11 and VDE 0700; transformers should be in accordance with EN 60742/IEC 742 and electronic components and other devices as per the manufacturer's design.

For optimum protection, thermal protectors are installed as close as possible to the heat source, which is generally within the windings. Good thermal coupling is essential, with the current sensitive side of the protector always facing the potential, critical heat source.

Installation before impregnation of the windings and impregnating the complete winding/protector assembly are important to achieve best results. Since hot spot areas vary with the motor or transformer design, the thermal coupling factor is not easy to determine. Thorough tests by the motor manufacturer are strongly recommended. It is also a distinct advantage to have protectors with sufficient current-carrying capacity that can safely carry the rated current and directly switch the locked rotor or short circuit current.

Figure 4 shows a thermal protector used in a single phase motor. The protector is embedded in the winding coil between the main and auxiliary winding, with the heat sensitive side facing the main winding. This is the area where severe heat build-up is likely.

For smaller wye-connected three phase-motors, special three-phase switches of the Y6-type are available for direct switching (figure 5c). For motors and/or transformers with currents higher than those experienced in the aforementioned single phase application, and especially for three phase units, the protectors are used for indirect switching; for example, activating an auxiliary relay which then switches off the device to be protected. For three phase application and indirect switching, special duplex or triplex protector assemblies are used (figure 5d). For applications in electronic devices, the standard types available are with either threaded housings or prongs. For direct mounting onto heat sinks of electronic devices the threaded type is used (figures 5e and 5f).

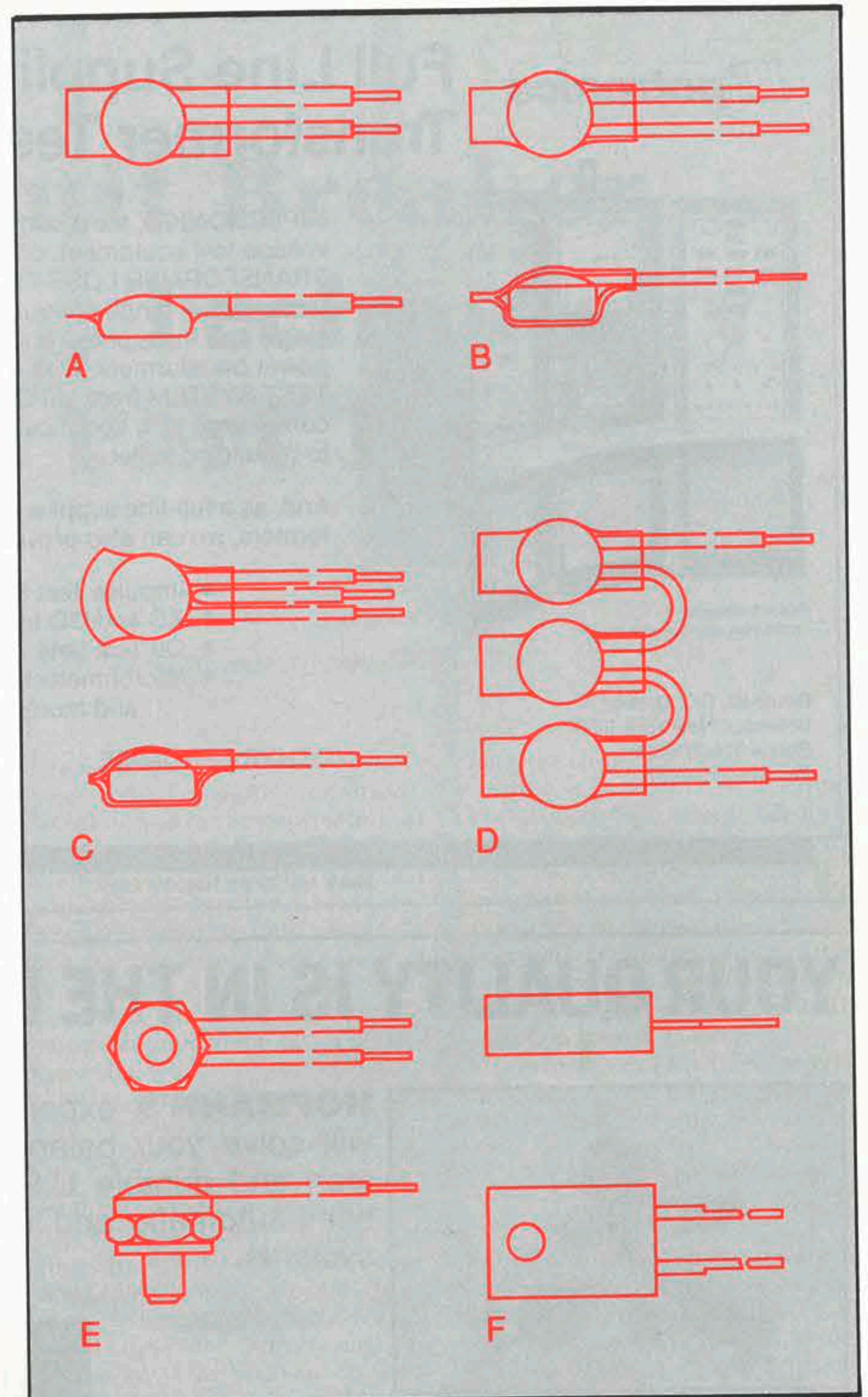


Figure 5, various thermal protector designs.

*** The "01-Series," from Thermik Corp.*

Was this article of interest to you? Mark the proper number on the reader service card.
Yes. . .402 **No. . .403**