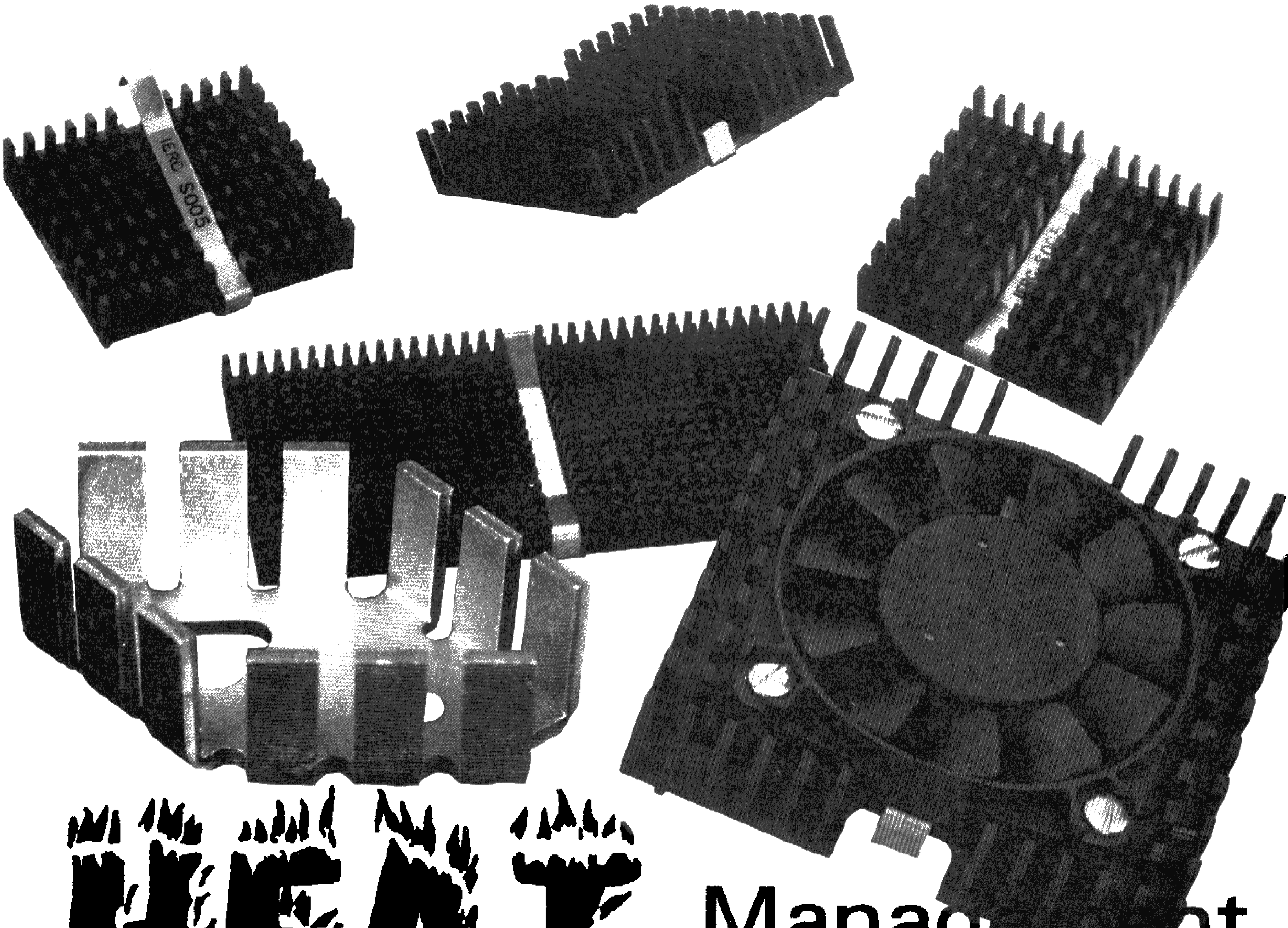

HEAT Management Techniques

Proper heat management ensures that components have a long and healthy life.

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WHENEVER CURRENT FLOWS through an electronic component, that component dissipates power. The power that the part dissipates depends on both the current flowing through the part and the voltage across it, and can be expressed by the relationship P=IV. Heat is an unavoidable byproduct of power dissipation.

For many circuits and components, heat generation is negligible or so small that the component can easily shed its heat buildup directly into the air. Some components, however, can not give up heat fast enough, and excessive heat buildup occurs. When that happens, the device can be permanently damaged. Thermal management techniques, such as the two common heatsink arrangements shown in Fig. 1, must be used to improve the component's heat dissipation. This article will explain the concepts of heat management and show you how to use manufacturers' specifications to optimize component operation. You can use these techniques with most semiconductor devices.

Thermal circuits

A *thermal circuit* is a graphic representation of thermal energy's path from its source to ambient air. In many ways, thermal circuits are analogous to electronic circuits as shown in Fig. 2.

Notice that there is resistance to the flow of heat between the heat source and the air. Such thermal resistance is generally defined as the difference in temperature across two points, divided by the power being dissipated between those two points. Thermal resistance is symbolized by the Greek letter theta (θ) and is measured in degrees Celsius per watt (°C/W). As a rule, thermal resistance should be as small as possible between the power-dissipating semiconductor junction(s) and the ambient air. Low thermal resistance between junctions ensures minimum junction temperature.

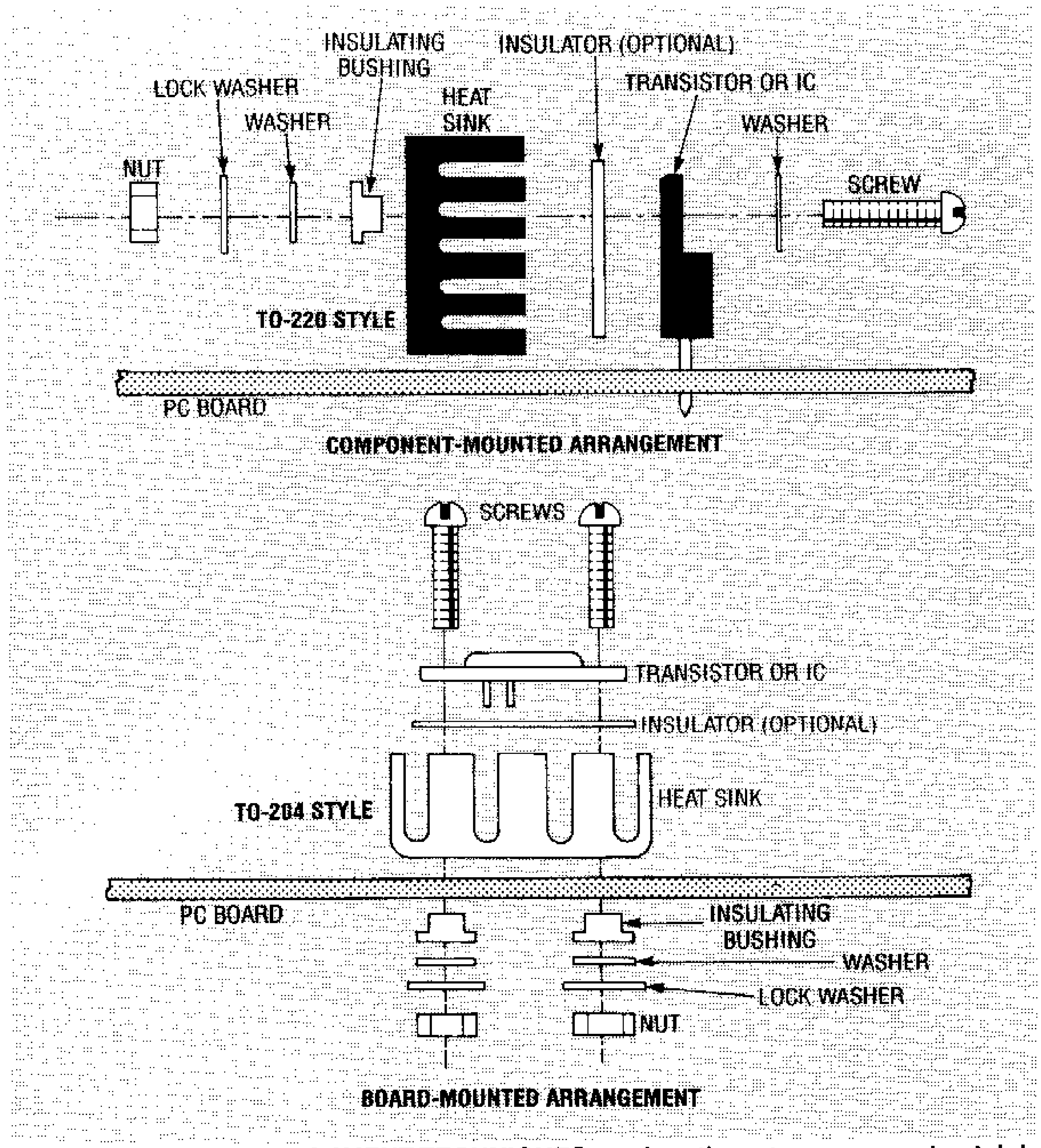

FIG.1—THERMAL MANAGEMENT TECHNIQUES, such as these two common heatsink arrangements, must be used to improve a component's heat dissipation.

Heat sources

Heat is generated by a semiconductor device when it dissipates power. A diode dissipates power at its anode-cathode junction. Junction power can be defined as the current through the junction multiplied by the voltage drop across the junction (typically 0.6 volt DC for a silicon diode). Power dissipated by a transistor is the voltage drop between the collector and emitter multiplied by the collector current. The power dissipated by an integrated circuit is the total power dissipated by all of the integrated circuit's transistors.

Thermal resistance

The heat generated in a semiconductor junction does not dissipate directly to the ambient air. Instead, a number of thermal resistance factors must be taken into account. The use of an external heatsink typically involves three major thermal resistances: (1) between the semiconductor junction and the device's case, (2) between the case and the attached heatsink, and (3) between the heatsink and the ambient air. Additional thermal resistance might be encountered if an electrical insulator is included between the case and heatsink.

For components that do not use an external heatsink, two thermal resistances must be considered: (1) between the semiconductor junction and the case, and (2) between the case and the ambient air. The total thermal resistance of a semiconductor arrangement can be summarized as shown in Table 1.

The junction-case resistance (θ_{JC}) represents the flow of heat from a device's junction(s) to its outer case. The value of θ_{JC} is specified by the manufacturer in his data sheet. A smaller number represents better heat flow. Junction-case thermal resistance is dependent on a number of physical characteristics. These include the size and shape of the semiconductor die and its mount, the quality of the die-to-mount bond, and the thermal conductivity of the die, mount, bond, and any interconnecting wires.

Although you have no control over θ_{JC}, you can select a particular case style that minimizes the thermal resistance. Figure 3 shows what the different case styles look like. For example, a transistor in a TO-220 case has better (lower) θ_{JC} than a similar device in a TO-92 case. Table 2 shows a selection of typical θ_{JC} values for a variety of case styles. If you do not have access to manufacturer's data, Table 2 can provide a good approximation.

The use of a heatsink can have a tremendous impact on a component's operating temperature. For some devices, a good heatsink can mean the difference between a successful project and a failure. The goal of a heatsink is to move as much heat as possible away from the device's junction, and that's accomplished through the choice of heatsink, mounting arrangement, and mounting materials.

Thermal resistance at the case-sink barrier (θ_{CS}) is a function of many factors: (1) the cross-sectional contact area be-

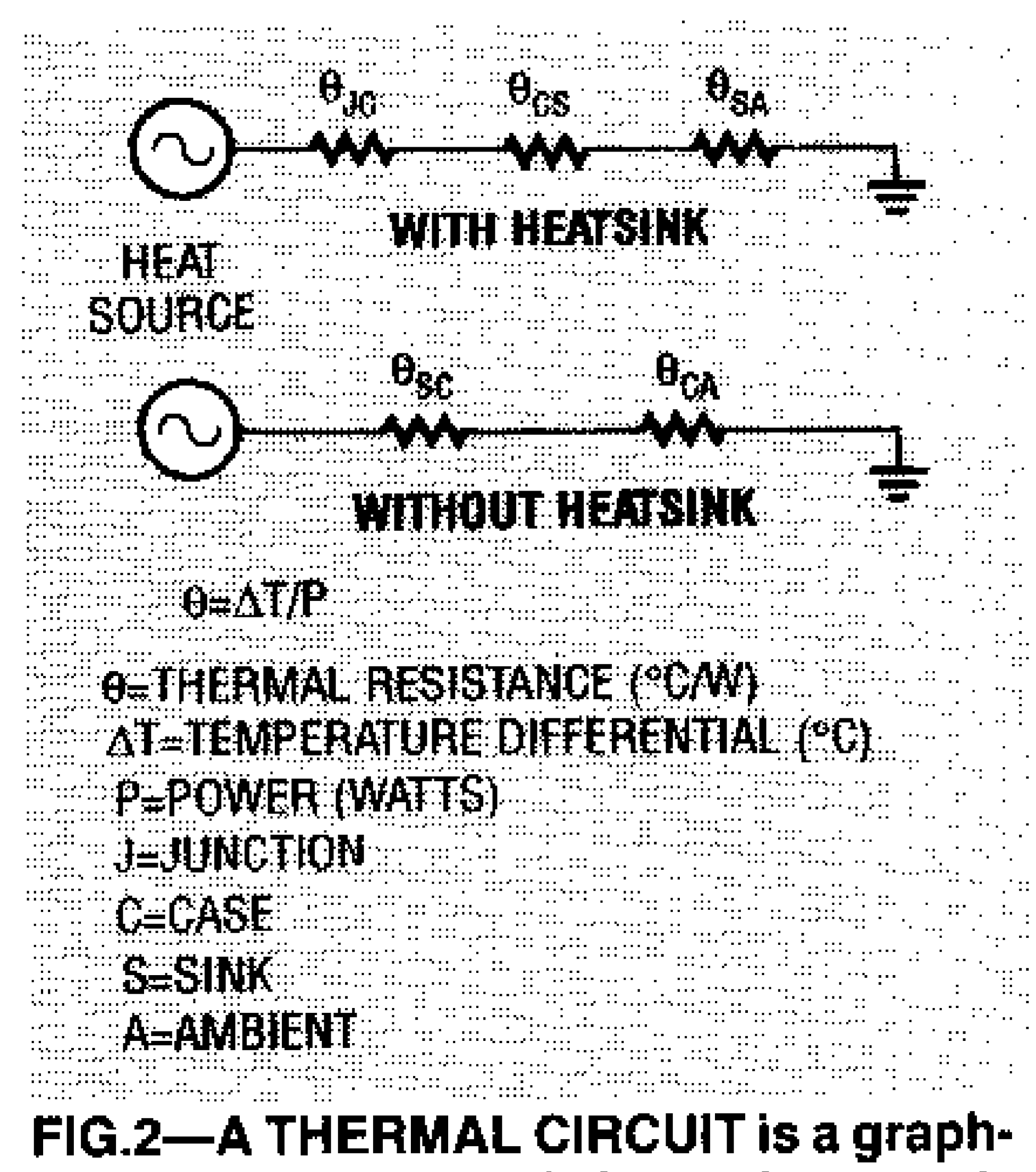

FIG.2—A THERMAL CIRCUIT is a graphic representation of thermal energy's path from its source to ambient air. Thermal resistance is defined as the difference in temperature across two points, divided by the power being dissipated between those two points. Thermal resistance should always be as small as possible.