Taillight Transistor Protector

An ordinary 6-volt automotive taillight lamp prevents thermal runaway in the common-emitter ouput stage because its positive temperature coefficient provides d.c. degeneration with minimum power sacrifice.

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PERHAPS ONE OF THE MAIN design considerations in high power transistor circuits is the limitations imposed by temperature. The temperature problems of transistors are inherent due to the electrical considerations of their construction. At high temperature, control of the transistor current is necessary to avoid development of a runaway condition which can lead to destruction of the device. The power transistor has a maximum collector-junction temperature rating which has been assigned by the manufacturer and observance of this limit can extend the useful life of the unit indefinitely. Exceeding this limit can lead to permanent loss of gain or early failure of the transistor. Adequate heat sinking of the transistor and stabilization of the d.c. operating point of the device will control the transistor current so as to prevent a rapid rise in junction dissipation as temperature rises.

In the common-emitter circuit, stabilization can be obtained by d.c. degeneration or by thermistor control of the bias circuit. The first method can easily be obtained by inserting resistance into the emitter lead of each transistor, as in the case of R_1 and R_2 of Fig. 1. The larger the value of R_1 and R_2 the greater the degeneration and the greater the temperature control and stability. On the other hand maximum power capabilities are seriously curtailed.

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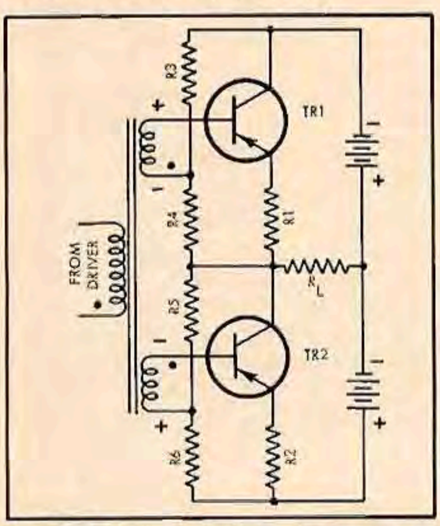

Fig. 1. Common emitter power output stage. R_1 and R_2 provide temperature control as they get larger in value.

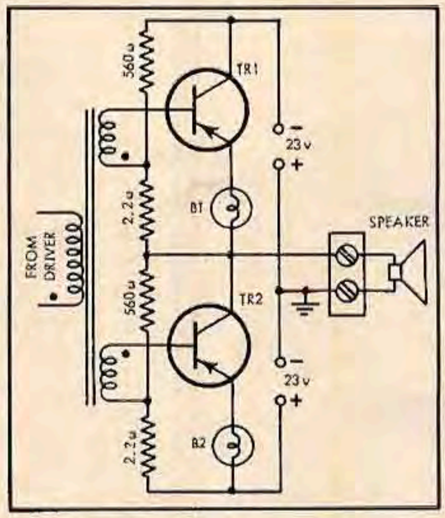

Fig. 2. Power output stage with 6-volt lamps instead of R_1 and R_2. This design is used in the Knight-Kit KX-60 50-watt stereo amplifier.

However, if a resistor of positive temperature coefficient is used for R_1 and R_2 the ultimate in stabilization can be obtained without great sacrifice of total power. It was found that the resistance characteristics of a tungsten filament bulb were ideally suited for this application. The bulb chosen in the amplifier (Knight-kit KX60) is similar to the kind used in a 6-volt automotive taillight. This not only provided the necessary d.c. stabilization but it also provided the speaker the protection of an extremely quick-blow fuse. The tungsten lamp is extremely sensitive to applied voltage since the life varies inversely as the 12th power of applied voltage. In this way the normal 200-hour life at 6 volts would be reduced to $\frac{200}{(23/6)^{12}}$ hours in the circuit, if a wiring error or component failure placed the full 23 volts on the lamp. This corresponds to approximately 70 milliseconds and provides adequate protection for both speaker and transistor. By the same formula, since the lamp is normally only exposed to a few tenths of a volt, its life is extended thousands of hours beyond its normal 200 hour life at 6 volts. In addition to the stabilization and protection afforded by the emitter lamps there is a measure of self balancing afforded to the output circuit since they are sensitive to the current through them and seek an equilibrium with the transistors in which they are in series balancing the bridge and keeping any d.c. from flowing through the speaker.

Several 6-volt automotive lamps were investigated for their characteristics before this lamp was chosen. The life-*versus* over-voltage characteristic is virtually the same for all the lamps examined, therefore, they would all provide the desired speaker protection. However, a lamp with a design current rating in the range of the maximum load current in the 4-ohm load condition would cut the 4-ohm power capability approximately in half. On the other hand, a lamp with maximum design current far greater than the load current encountered at rated power in the 4-ohm load condition would provide only marginal d.c. stabilization on 4-ohm loads and virtually no protection for 8- and 16-ohm load connections where far less load current normally flows.

Hence, having selected the proper bulb and having provided stabilization on 4-, 8-, and 16-ohm loads the amplifier tends to approach a constant-power device rather than the more typical constant-voltage device since the 4-ohm load current will be limited more than the 16-ohm load current. This is evident by the fact that the maximum continuous sine wave power is 36 watts for 4-ohm loads and more than 30 watts for 16-ohm loads. *Figure* 2 shows the output circuit modified for use with the emitter bulbs. Æ