New Protection For Telephone Receivers

News of Semiconductor Device Development

A new diffused-germanium varistor, coded 104A, was recently developed by the Semiconductor Device and Electron Tube Laboratory at Reading. The new device replaces the 44A copper-oxide varistor, which has been used for many years as a protective device in telephone receivers, and provides superior performance. In addition, the 104A offers the advantage of improved reliability.

High-quality telephone service depends upon the accurate transmission of speech signals. One of the key links in the telephone-to-telephone chain which provides faithful reproduction of the transmitted voice is the telephone receiver unit. But acoustic disturbances caused by transient electrical effects—chiefly surges of high voltage—in the telephone circuit are also reproduced in the receiver, resulting in loud bursts of noise unless there is suitable protection. To protect the telephone user from these disturbances, and to protect the receiver magnet from being demagnetized by transient currents, protective devices, such as varistors, are shunted across the receiver to drain off the transient current and keep the voltage low, thereby elimininating loud bursts of noise.

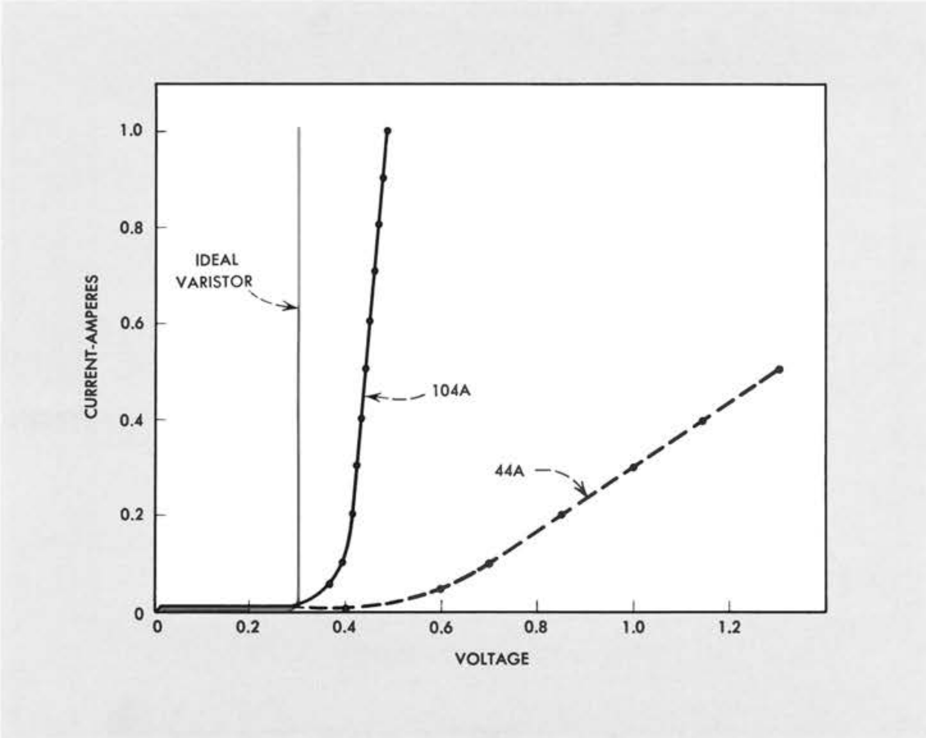
A varistor is a device whose resistance varies nonlinearly with voltage. At speech-level voltages (0.1 to 0.2 volt), its resistance is high compared to the 135-ohm resistance of the receiver; at transient voltage levels (above a few tenths of a volt), its resistance is low. The current-voltage characteristics for an ideal varistor are shown in the chart on page 347.

The new 104A varistor consists of two diffused-germanium wafers (p-n junctions) arranged in parallel and oppositely poled, resulting in an electrically symmetrical unit. The first step in processing the germanium junction elements is to cut a slice from a single-crystal ingot of p-type germanium. The slice, about 0.01 inch thick, is then chemically etched to eliminate damage due to cutting. A p-n junction is formed by diffusing an n-type layer onto the surface of the germanium slice. This is accomplished by heating the slice to a temperature of 600 degrees C in an atmosphere of arsenic vapor and dry hydrogen, followed by a similiar treatment at 900 degrees C in an atmosphere of hydrogen. The arsenic atoms migrate into the bulk germanium, producing an n-type layer about 0.001 inch thick. An n-type layer, formed on the back of the slice in the process, is then removed by chemical etching.

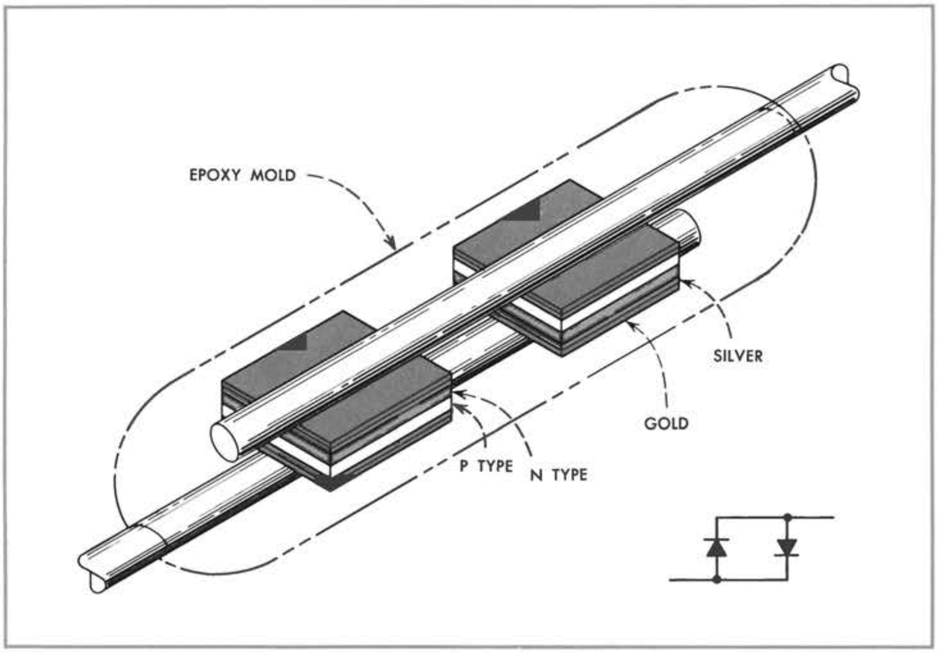
Electrical contact to the germanium wafer is provided by a layer of evaporated silver. A thin layer of gold overlaid on the silver protects it from tarnishing. The slice is then cut into 0.04-inch square wafers, which are also etched to remove germanium damaged in cutting. The wafers are assembled automatically with the proper polarities, and solder-coated leads are fitted in place. The assembly is then passed under a hot gas stream. The hot gas directed over the assembly quickly melts the solder, causing the leads to adhere to the wafer. For mechanical protection and component indentification, the assembly is encapsulated in molded plastic. (See figure on page 347.)

To evaluate its reliability, the new varistor was subjected to a variety of electrical test conditions much more severe than the device will encounter in use. The results of these tests indicate a typical failure rate of 1 percent per 1000 hours at one ampere and 0.01 percent per 1000 hours at normal operating currents.

The new 104A varistor has proven to be a highly reliable device with superior initial and long-term electrical characteristics. It is presently being manufactured by Western Electric for Bell System use at the rate of ten million units per year.



Electrical characteristics of the 44A copper-oxide varistor and the 104A diffused-germanium varistor compared with those of an "ideal" varistor.



Pictorial view of the 104A varistor.