Correspondence

A Junction Transistor for Kilowatt Pulses*

While it has long been recognized that the transistor is a very useful device for the fast switching of currents, applications have usually been at relatively low current levels. It is the purpose of this note to describe a transistor which has been developed to switch currents of 40 amperes in times of the order of a microsecond. Since the transistor can operate on voltages up to 30 volts, pulses with powers in the kilowatt range can be produced.

The theory of large signal switching behavior of transistors has been developed by Ebers, Moll, and Miller.[1–3] For our purposes the design requirements may be summarized: 1) high α at the operating current; 2) low extrinsic base resistance, and 3) high α cutoff frequency.

These objectives have been achieved using the design theory proposed by the present author,[4,5] in which the emitter is in the form of a thin bar, flanked by parallel bars making ohmic base connection. In the present transistor the configuration has been distorted to annular shape, since for this particular size, this allows a more economical use of germanium. The transistor element is shown in Fig. 1.

To increase emitter efficiency an alloy of 0.5 per cent gallium in indium was used for the emitter.[6] Traditional alloying methods were used, but a special effort was made to achieve a uniform thin base layer over the large area involved. This was done by reducing the thickness of the germanium and indium to about 0.005 inch and using very carefully machined graphite alloying jigs.

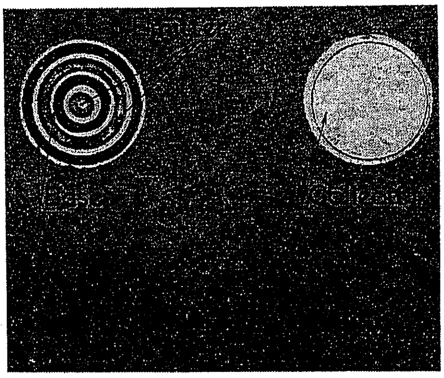

Fig. 1—The transistor element. Base rings show up black, emitters grey. The collector covers most of the back surface.

Relatively few transistors have been made, but the results reported below indicate what can reasonably be attained with this design. Collector currents as high as 45 a have been obtained with as little as 3-a base current, though average transistors require rather more drive than this. Rise times are fastest[2] when a constant current pulse is applied to the emitter in a grounded base configuration.

Rise time for a collector current of 40 a is as little as $\frac{1}{2}$ microsecond for some transistors, even without collector "bottoming," and overdrive could reduce this somewhat without appreciable storage. Rise times for other pulsing arrangements are much longer[2] (several microseconds typically) but greater power gains can be realized and overdrive is more economical. Extrinsic base resistances are less than 1 ohm so that input impedances are very low and power gain is quite high.

The mechanical structure of the transistor is shown in Fig. 2. The collector junction has a low thermal resistance path to the chassis and the unit can dissipate considerable power, though it was designed principally for low duty cycle pulsing systems where dissipations of only a few watts are involved.

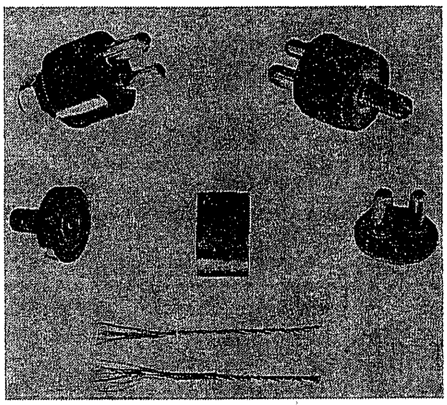

Fig. 2—An exploded view of the transistor, with two completed units above. Araldite type D is used to fill the case.

The author is specially indebted to H. Flood of this Laboratory who made the alloying jigs and other fittings as well as the transistors themselves.

NEVILLE H. FLETCHER
Division of Radiophysics
C.S.I.R.O.
Sydney, Australia

* Received by the IRE, November 13, 1956.

[1] J. J. Ebers and J. L. Moll, "Large-signal behavior of junction transistors," PROC. IRE, vol. 42, pp. 1761–1772; December, 1954.

[2] J. L. Moll, "Large signal transient response of junction transistors," PROC. IRE, vol. 42, pp. 1773–1784; December, 1954.

[3] J. J. Ebers and S. L. Miller, "Design of alloyed junction germanium transistors for high speed switching," *Bell Sys. Tech. J.*, vol. 34, pp. 761–781; July, 1955.

[4] N. H. Fletcher, "Some aspects of the design of power transistors," PROC. IRE, vol. 43, pp. 551–559; May, 1955.

[5] N. H. Fletcher, "Self-bias cutoff effect in power transistors," PROC. IRE, vol. 43, p. 1669; November, 1955.

[6] L. D. Armstrong, C. L. Carlson, and M. Bentivegna, "PNP transistors using high-emitter-efficiency alloy materials," *RCA Rev.*, vol. 17, pp. 37–45; March, 1956.

Contributors

For a photograph and biography of Howard Boyet, see page 558 of the April, 1956 issue of PROCEEDINGS.

❖

Bobby J. Duncan (M'54) was born in Carrollton, Ga., on February 1, 1930. He received the B.S. degree in physics from Berry College, Rome, Ga., in 1950 and the M.S. degree in physics from Emory University, Atlanta, Ga. in 1951. While at Emory he performed research in microwave spectroscopy.

He continued research in this same field while performing graduate work toward a doctorate in physics at the University of Florida, Gainesville, Fla. until December 1952, at which time he joined the Sperry Gyroscope Company as a project engineer.

B. J. DUNCAN

At Sperry he initially performed research in applied microwave spectroscopy. Subsequently, he was associated with research and development projects on microwave ferrites, special radar systems, radar countermeasures techniques, and obstacle avoidance equipment. More recently he has worked almost exclusively in the field of microwave ferrite research and components applications. At present he is a senior engineer and group leader of the microwave ferrite research and advanced development group in the Applied Physics Section of the Microwave Electronics Division of Sperry.

❖

Lawrence Gould was born in Boston, Mass., on November 28, 1930. He received the B.S. and Ph.D. degrees in physics from