ELECTRONICS

The Fabulous Midget

Transistors, flecks of germanium with spider-like wire legs, may revolutionize the electronics industry by replacing the vacuum tube. They may even work on body heat alone.

By HARLAND MANCHESTER

➤ IF SOMEONE invented a household light bulb smaller than a pencil eraser which would never burn out, would cut your light bill 99 percent, would not get hot and could be thrown at a brick wall without breaking, you would probably call it an industrial miracle of the first order.

That is about what has happened to the radio tube and its big glass-clad family of electronic brethren. The transistor, a tiny speck of solid germanium metal sprouting hairlike wires, has now gone to work after a seven-year gestation in the Bell Telephone Laboratories, and it is unanimously hailed by the world's scientists as the greatest advance in communication since De Forest invented the radio, or "audion," tube 46 years ago.

The little "spider," so small that you can hold a hundred in one hand, is slated to cut the size and weight of our familiar communication devices to a fraction of their present size, with striking reductions in power consumption and improvements in reliability and length of life. The transistor opens exciting new frontiers in radio, television, radar, guided missiles, automatic gun-sighters and the whole field of military and aviation electronics.

The familiar radio tube—sire of the whole 20th-century electronics industry—is really a glorified light bulb. When Edison found that the heated filament in a light bulb "boiled off" the negative particles called electrons, he put a positive terminal inside the bulb to capture the leaping stream of free electrons and set up a continuous current.

Air Wave Built Up

Then Lee De Forest found a way of piping into the bulb feeble radio-wave vibrations from an antenna; these vibrations impressed their pattern on the much stronger current from the house circuit, thus building up the air-wave whisper into a shout. Since De Forest's epochal discovery, his tube and its electronic cousins have been vastly improved, but they still have the limitations of their light-bulb ancestor: heat makes them eventually burn out.

When Dr. William Shockley and his Bell colleagues started work on the transistor project, it had long been known that certain crystalline metals like germanium could be used in certain limited ways in the control of electric currents.

A research group at Purdue University headed by Dr. Karl Lark-Horovitz made important contributions in purifying germanium for use as a semi-conducting material, and by World War II a few germanium control devices were in use. Then in 1945 Dr. Shockley caught a vision of their great future and started intensified work with nine colleagues at the Murray Hill, N. J., plant of the Bell Telephone Laboratories.

The Bell scientists found that if they took ultrapure germanium and introduced meticulously measured impurities in a certain way, they upset the metal's orderly atomic pattern and created a restless structure full of submicroscopic holes and homeless, wandering electrons. When a current passed through the metal it touched off a complicated game of musical chairs as the holes moved like bubbles in a liquid and the loose electrons rushed to fill the empty places.

Rigging the game by controlling the distribution of holes and electrons, they found that they could make the current perform various stunts. Like De Forest, they could stick in a third wire from a radio antenna and force the current to amplify vibrations which originated in the larynx of Dinah Shore.

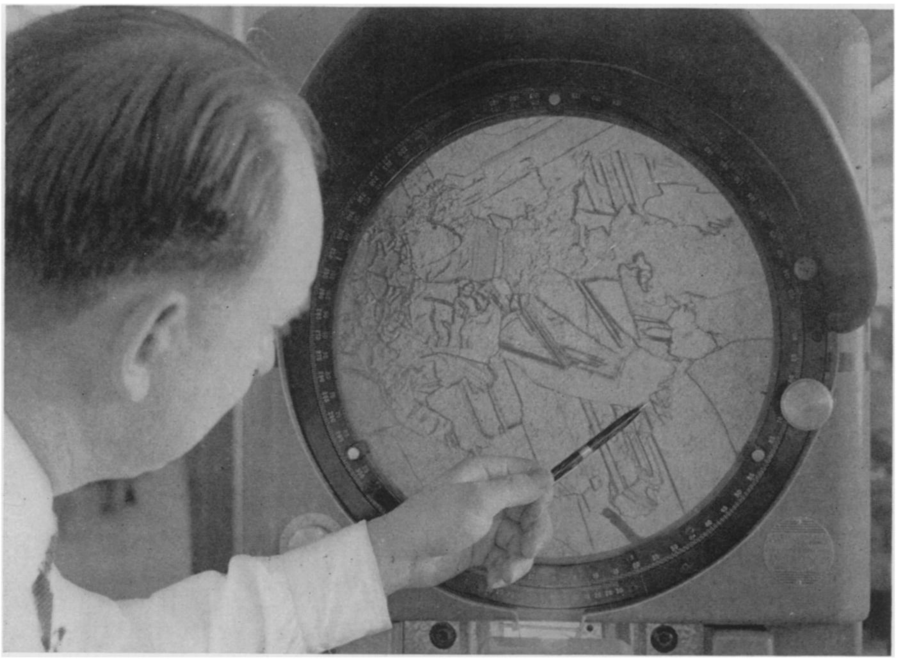
Since you do not have to build a fire, so to speak, to boil the electrons out of the metal, you save a lot of fuel in the form of electric power. You also save money now spent in getting rid of the unwanted heat—often a serious ventilation problem. And since heat and glass are eliminated, you can pack the transistors together like sardines.

I watched Jack Morton, who helped to build the transistor, chew a piece of blotting paper to give it acid from his saliva, slap it on a 25-cent piece, and attach wires from a tiny transistor sound-wave broadcaster. The power generated by this impromptu battery—2/100,000,000ths of a watt—was enough to run the device.

This points the way to vest-pocket "survival radios" which would need no batteries or built-in power. Easy to carry, they could be used by campers, hunters, prospectors and ranchers.

Heat Can Run Them

A little heat will run them, possibly even body heat. Morton ran a transistor radio on power obtained from a small thermocouple, made of two thin strips of dissimilar metals to provide a kind of battery. A lighted cigarette held near the device gave enough heat to operate it. Even body heat would do. Or you might get enough from one winding of a watch spring to run a



GERMANIUM WAFER—Magnified 20 times on a special contour projector, a germanium wafer looks like this. The black lines are the boundaries of single crystals of germanium.

powerful eight-transistor receiver for several hours.

One of the most popular uses of the transistor will be in the automobile radio. Such radios can be made one-tenth the size of present ones, and laboratory models use no more power than it takes to run the little light bulb behind the dial—a small fraction of a tube radio's drain on the battery. The present auto radio uses a vibrator, a transformer and a rectifier to step up the battery's six volts to the 130 needed to power the tubes. These devices, which add to cost, weight and size, and can get out of order, are not needed in a transistor radio, which can operate directly from the battery.

No Warm-Up Needed

There need be no tube replacement either. Although the oldest transistors "life tested" by the Bell laboratories have barely passed their fourth birthday, Bell engineers hope that with further development they may run indefinitely. So transistors will not be plugged in, but will be wired in permanently, saving the cost and space of sockets. As a final advantage, a transistor radio comes on full volume the split-second you turn the switch—there is no waiting for tubes to warm up. Such a radio is smaller, lighter, simpler and more reliable than any now in use.

Nine manufacturers of hearing aids are already using transistors in a job where small size and weight, longevity and low operating cost are at a premium.

RCA, which manufactures transistors, has built a portable television receiver which weighs only 27 pounds because it uses transistors, 37 of them, eliminating all tubes except the picture tube itself.

Among other RCA creations is a "roving microphone" which transistors have boiled down to the size of a cigar. Sound is picked up and broadcast by an unconnected transmitter, enabling a speaker or performer to move about a stage or TV or film set without tripping over wires.

Electronic "robot brains" are already performing in a few hours paper work which once took years, but these machines have run into limitations imposed by the power-hungry tubes—hot and bulky and comparatively short-lived. Today's biggest thinking machines are no more complicated than the nervous system of a fish; but a machine duplicating man's nerve structure would be larger than the Empire State Building. The transistor can cut these temperamental dinosaurs down to practical working size, and this job alone may turn out to be its most important contribution to human progress.

A transistor electronic computer built by RCA is one-tenth the size and uses one-thirtieth the power of a similar device using tubes.

Next spring Bell will install in its Pittsburgh telephone office a kind of transistor thinking machine which will "remember" all possible routes a message can take from that city to any point in the country. When a call is blocked on one route by busy lines or local trouble, the robot will detour the call to its goal, mapping the route and giving orders in about a third of a second. Bell has tried to use tubes for this purpose, but they take too much space, power and maintenance. In Englewood, N. J., transistors were installed last fall as a part of the equipment which enables telephone subscribers to dial numbers directly in distant cities. This direct long-distance telephone service will gradually be installed in most large centers.

Most transistors are now earmarked for national defense, and production bottlenecks must be broken before they can be made in the great quantities needed to fill civilian demands. The metal must first be superrefined to a fantastic degree of purity—more than one part of foreign matter to 100,000,000 parts of germanium makes it unfit for use. "Doping" it with controlled impurities is equally fussy business. Workers who assemble transistors peer through microscopes and use delicate electronic "feelers" to guide them when vision is useless. But the best brains in American industry, backed by unlimited funds, say that mass production problems can be licked.

The first transistor was announced in 1948, and since then scientists and engineers have been improving it. The industry has already spent $10,000,000 on development, and 37 foreign and domestic corporations, among them industrial giants, like IBM, IT&T, General Electric, Westinghouse and Raytheon, licensed to manufacture the mighty midget, are strongly competing to put it in harness.

No one can state with certainty when transistor radios and television sets will be on the market, but some engineers pick 1956.

Great numbers of electronic tubes, now manufactured at the rate of half a billion a year, will still be needed for jobs the germanium spider cannot do—in shortwave therapy, radio nailing and welding, where heat is needed, for TV picture tubes. And the transistor will expand the horizons of communications and industry to create new demands for tubes.

In less than half a century the electronic tube has changed the world, and the effect of the transistor on all our lives may be equally potent.

This article was prepared for SCIENCE NEWS LETTER *in cooperation with the Reader's Digest. It will appear shortly in that magazine.*

Science News Letter, March 14, 1953

INVENTION

Design Diving Bell for Underwater Prospecting

➤ GEOPHYSICISTS PROSPECTING for oil beneath the surface of the Pacific and Gulf will have to go underwater if an invention patented by Clemille F. Sellers, El Banco, Colombia, South America, comes into general use. He has invented a diving bell which can carry a geophysicist and his prospecting instruments down to the bottom for use. Patent number is 2,627,727 and it is assigned to Robert H. Ray, Inc., of Texas.

Science News Letter, March 14, 1953

• Books of the Week •

For the editorial information of our readers, books received for review since last week's issue are listed. For convenient purchase of any U. S. book in print, send a remittance to cover retail price (postage will be paid) to Book Department, Science Service, 1719 N Street, N. W., Washington 6, D. C. Request free publications direct from publisher, not from Science Service.

ALLAN AND TRISHA VISIT SCIENCE PARK—Caroline Harrison and Bradford Washburn — *Little, Brown,* 59 p., illus., $2.00. In this book for children, a small boy and girl with their mother visit the Museum of Science and learn a great deal from the exhibits which they could work themselves.

ANIMAL MICROLOGY: Practical Exercises in Zoological Micro-technique—Michael F. Guyer—*University of Chicago Press,* 4th rev. ed., 331 p., illus., $4.75. This classic text for beginners in animal microscopy has again been revised to include recent advances in technique.

ANTHROPOLOGY TODAY: An Encyclopedic Inventory—A. L. Kroeber, Chairman—*University of Chicago Press,* 966 p., $9.00. Fifty papers by the world's leading anthropologists constituting a summary of the knowledge obtained to date in all phases of anthropology.

ARCTIC SOLITUDES—Admiral Lord Mountevans — *Philosophical Library,* 143 p., illus., $4.50. The author, himself a well-known Arctic explorer who has been taking part in expeditions since the beginning of the century, tells here the story of trips that have been made to the top of the world. Excellent photographic illustrations.

ASTRONOMY FOR EVERYMAN—Martin Davidson, Ed.—*Dutton,* 494 p., illus., $5.00. A popular presentation of all phases of astronomy, including instrumental equipment, aims and methods of the astronomer, a study of the heavens and a brief history. Excludes, for the most part, mathematics.

THE ATOM STORY: Being the Story of the Atom and the Human Race—J. G. Feinberg—*Philosophical Library,* 243 p., illus., $4.75. The history of atomic development is traced from Democritus of 500 B.C. to the day of the hydrogen bomb.

BUILDING AMERICA'S HEALTH: Volume 4, Financing A Health Program for America—President's Commission on the Health Needs of the Nation—*Government Printing Office,* 363 p., paper, $1.50. Presents some of the basic facts on health expenditures. Includes statements by the members of the Commission's Panel on Financing a Health Program.