NEWS and VIEWS

New Amplifier

A semi-conductor has been used for electronic amplification in the Bell Telephone Laboratories. For years the only flexible amplifier available, the vacuum tube, has been an important tool, not only in radio, telephony, and industrial control but in physical research as well. Now a fundamental study of certain problems of solid state physics has provided a new amplifier which seems suited for a variety of practical applications. Developed by John Bardeen and Walter H. Brattain under a general research program initiated and directed by William Shockley, the Transistor, as it is called, is a semi-conductor triode which can be used as an amplifier, an oscillator, and in other ways in which vacuum tubes perform.

This device, about the size of an automobile fuse, has no vacuum, no glass envelope, no grid, no plate. No warm-up time is needed to make it operate; it uses less power than a vacuum tube, can pass 25 milliwatts, operates in a range up to 10 megacycles (in the present state of the art), and is expected to have excellent life and wear resistance.

At a press conference given at the Laboratories, on West Street in New York City, the use of the device was demonstrated in amplifying telephone and television signals. It satisfactorily replaced all tubes in a standard table model radio, and it was used to generate a standard frequency tone in an oscillating circuit.

Extraordinarily simple mechanically, the small cartridge contains and supports two leads which terminate in spring contacts resting on a germanium block. The leads are about two-thousandths of an inch apart. A third lead is attached to the base on the opposite side of the block. A signal introduced between one lead and the base appears in amplified form between the other lead and the base.

It has been known for some time that electrons in a semi-conductor, such as germanium or silicon, can carry current in two distinctly different ways. Most of the electrons in a semi-conductor are held in fixed positions in which they act as a rigid cement to bind the atoms together into a solid, and do not contribute to carrying the current at all. It is only if one of these electrons gets out of place, or if another electron is introduced in one of a number of ways, that current can be carried.

If an extra electron is added to the material it can move and carry current. If, on the other hand, one of the electrons normally present in the cement is removed, then the place left behind it can move like a bubble in a liquid. Conduction of the current by motion of such 'holes' in the electron cement is referred to as hole conductivity. While the excess electrons are negatively charged, the holes behave in all respects as positive carriers of electricity. Carriers of both types are involved in Transistor action.

The germanium used in the Transistor is the same type used in point contact rectifiers, which carry current easily in one direction but withstand high voltages in the reverse direction. Now the main body of the germanium conducts electricity by excess electrons, but there is a very thin surface layer in which the conduction is by positively charged holes. The input electrode is biased positively, which is the direction of easy flow. A current of holes flows from the electrode and spreads over the surface. The output electrode is biased negatively with a large voltage, which is the direction of difficult flow. If the output electrode is placed very close to the input electrode, a large part of the input current, the 'hole' current, flows to and enters the output electrode. As the output circuit is of higher resistance than the input, there is a large voltage amplification of an input signal. It is found that there is current amplification as well. The resultant power amplification is about 100 times or 20 decibels.

The device has not yet been put into pilot production so that no estimates have been announced in regard to cost. The noise limit is still somewhat higher than that for vacuum tubes, but it was said that there is no apparent reason why this cannot be pushed down with further work.

Low Temperatures

The Shelter Island Conference on Low Temperatures, May 31–June 2, tried to interpret low temperature theory, and make some sense out of superconductivity and liquid helium. London, Onsager, Tisza, Van Vleck, Slater, and various other theorists all had things to say, as did a number of experimentalists. There were arguments, but no violent fights; and there was progress toward understanding, though nothing spectacular.

Superconducting metals, and superfluid He II, show close resemblances. Both have states, stable at the lowest temperatures, in which a continuous flow of electricity can occur almost without dissipation. As they are warmed up, they have transitions to more normal phases, the amount of the normal material increasing as the transition point is approached. The mixed phase below the transition shows itself in the existence of finite resistance of superconductors at microwave frequencies, and in second sound in He II, two experimental fields discussed at the conference.

The real puzzle is the nature of these superconducting or superfluid particles; and the general result of the conference was that in both fields we have good theories (London's theory of superconductivity, Tisza's of helium) which agree well with experiment; and in both fields we can see in general what is needed of a detailed molecular theory, though it will take more elaborate treatment of the many-body problem than anyone has given yet to tie the theories down. There is good reason for thinking that there will be steady progress in the theories, rather than spectacular new ideas.

The general idea is that the superconducting electrons and the superfluid helium atoms form condensed phases where there is a correlation between velocities of the various particles rather than a correlation between their positions, as in a lattice. It was thought that the super-