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 superconducting state must be partially stable in the sense that it requires energy to change the momentum of individual particles and thus to make them collide more with each other, which would decrease superconductivity and superfluidity.

How these condensed phases are formed, in the case of helium, becomes clearer with the recent discovery, discussed in detail at the conference by Lane and Daunt, that He^3 does not take part in the superflow. It is, then, presumably a result of the condensation of He^4 atoms. With superconductivity the mechanism is probably a result of greater stability resulting from a very uniform charge distribution, whereas in the ordinary state random motions of the electrons result in greater charge fluctuations.

Along these lines progress in the theories will probably be made. A further topic discussed, interesting but less controversial than the others, was adiabatic demagnetization and the microwave energy levels of the salts, particularly the alums used for this purpose. J.C.S.

APS at Madison

The summer meeting of the American Physical Society was held in Madison June 21 to 23 during the interval between the spring commencement and the beginning of the summer session of the University of Wisconsin. As the dinner toastmaster happily put it, it had more the character of a peacetime meeting than any of its recent predecessors: only about three hundred attended, no more than three sessions went on simultaneously, plenty of lawn was found to sprawl on, and the pressure of the war years was absent but not missed. Among about sixty contributed papers (almost half of which were on federally supported research) the largest numbers were in the fields of nuclear reactions and nuclear moments. Six invited papers were given in the division of electron physics, and eleven in other fields.

Reporting on nuclear reactions and energy level widths, Wigner began with a simple analogy between a waveguide junction or 'black box' (in ordinary space) and a nuclear reaction as considered in configuration or space: the incoming and outgoing waves in the junction correspond to wave functions of the initial and final states, and each system can be separated into an external region of well-defined waves and an internal region about which we have no detailed knowledge. Experimental data may be used to find the constants (level widths) entering into the actual formalism (derivative matrix) describing the nuclear reaction. He felt that knowledge of the excited states of isobars may lead to a decision as to whether neutron-neutron and proton-proton forces are really symmetric.

Wentzel emphasized that quantum electrodynamics has recently given, for the first time, results unforeseen by correspondence arguments, yet observable (Kusch's anomalous g-values, Lamb-Retherford shift). In disagreement with part of Schwinger's work, he obtained by the same method a finite non-zero rest mass for the photon, instead of zero. He pointed out that since all particle fields interact with the electromagnetic field, e.g., a photon can produce pairs of protons and mesons as well as electrons, ultimately all the theories must interconnect.

Lofgren gave a preliminary description of some high-altitude cloud-chamber studies of cosmic rays. Two particles photographed at about 25 kilometers appear to have atomic numbers between 12 and 20 and energies of about five billion electron volts. Tracks in photographic emulsions show particles with even more surprisingly high atomic numbers, of the order of 70, and energies in the neighborhood of 160 billion electron volts, which extrapolates to 300 billion electron volts at the top of the atmosphere. The apparatus, carried up to 30 kilometers and kept aloft for several hours by open-bottom balloons 30 meters high and 20 meters in diameter, is contained in an aluminum sphere 75 centimeters in diameter, which with its load weighs about 32 kilograms.

In the field of radiofrequency and microwave spectra, Van Vleck discussed the shapes of the absorption lines in gases and crystals arising from electrons and nuclear magnetic moments. He showed that, whereas Lorentz' classical results on line width and pressure broadening are now verified directly for electronic transitions, surprisingly enough for nuclear moments an increase in pressure sharpens the line.

A. Roberts showed that important information on nuclear moments and spins could be gained by a study of the spectra of polyatomic molecules in the radiofrequency region. Jauch showed that discrepancies previously observed in ammonia could be resolved by considering the interaction between the nuclear spin of nitrogen and the molecular rotation. Sachs reviewed recent work on the theory of magnetic moments, showing that it may become necessary to introduce 'exchange currents' in order to describe the observed magnetic moments.

James pictured rubbers as networks of long-chain polymers, essentially liquid but tacked together by occasional cross-bonds, with thermal motion opposing the stretching of the chains; properties of actual rubbers may be expressed in terms of deviations from the equation of state of an ideal rubber. J.E.M. and F.T.A.

Pacific Floor

A continuous profile map of part of the Pacific Ocean basin, made by scientists of the U. S. Navy Electronics Laboratory, San Diego, using war-developed underwater sound apparatus, shows the Pacific floor to be rugged and mountainous instead of smooth and undulating as had been supposed. An especially modified, deep-sea depth recorder operative to depths of more than 2,000 fathoms, was used to plot Erben and West Twin banks, 800 miles off the California coast. Because underwater sound transmission will be used in the proposed SOFAR Air-Sea Rescue System the Navy undertook to investigate the sound-reflecting and sound-absorbing characteristics of these submerged land masses, which for some time had been known to exist.

During the survey evidence was found that the banks are all that is left of prehistoric volcanoes which once formed islands but have been submerged for millions of years. Dredging operations brought up volcanic rock,