shunting of the junction by ionic conduction and to erosion of the germanium at the edges of the junction.

A wide variety of changes of performance can be noted when units are exposed to wet and dry atmospheres, ozone, halides and the vapours of some organic liquids; the effects of high humidity are particularly detrimental when small quantities (for example, $1/10^6$) of salts of nickel or copper are present in the final washing water. Because these metals are often used as connecting stubs or leads, great care needs to be taken in manufacture to prevent their transfer to unwanted places.

Some new designs of transistor have involved new techniques and therefore require new studies of basic phenomena. The surface barrier transistor, made by electrolytically etching two wells opposite one another in a wafer and afterwards electrolytically depositing or evaporating emitter and collector electrodes in the wells, depends for its action on the contact between the metal coating and the semiconductor as left by the electrolytic etch. Platinum, indium, copper, lead and antimony are among the metals used. As with point-contact rectifiers, the work function of the metal seems to have little influence on the overall performance. No satisfactory theory has yet been given to account for the high hole content of the current flow across such metal–semiconductor contacts.

The solar and atomic batteries are recent additions to the possible uses of silicon *p–n* junctions; each converts some of the energy of a radiation, solar or β, respectively, via the production of hole-electron pairs in the vicinity of the junction, into electrical power. Problems of damage to the lattice, with degradation of performance of the battery, may be severe in the atomic unit.

New Semiconductors

Germanium and silicon are not ideal materials for crystal valves for several reasons. Germanium is a comparatively rare element; valves made from it lose much of their performance when operated at ambient temperatures above about 70° C. Silicon presents difficulties of purification; its technology involves accurate control of temperatures around 1,420° C. The mobilities (μ) of carriers in germanium and silicon ($\sim$ 400–4,000 cm.²/sec. V.) limit the speed of response of transistors. Searches continue to be made for other transistor materials less severely limited in the above ways. The compounds of elements of Group III with elements of Group V, for example, indium antimonide and gallium arsenide, were among the first to receive attention. The properties of the constituent elements disappear in the compounds, which have a diamond-like structure and the electrical properties of semiconductors. Values of μ as high as 75,000 cm.²/sec. V. have been reported for electrons in indium antimonide, but the accompanying energy gap is less than 0·3 eV., and the life-time, τ, of minority carriers may be severely limited (perhaps to < 1 μsec.). The small energy gap prohibits useful transistor action at room temperature; for a base region of indium antimonide to be extrinsic it must contain about 10^{17} impurity atoms per cm.³ and may be nearly degenerate. Collector barriers would be very thin and unable to withstand any usable reverse voltage. Reverse currents at *pn* junctions will be large because of the small gap, large μ and small τ. Some other compounds have more appropriate values of energy gap, but only moderate values of μ. The search has extended to other binary compounds (elements in Groups IV and VI and also V and VI) and to ternary compounds—for example, $CuInSe_2$—the structure of which also resembles that of diamond. Some, though not suitable for transistors, have extended the range of other electrical properties. Thus the Peltier effect at the junction between bismuth and bismuth telluride has been made to produce a temperature difference of 26° C., and that between *n*- and *p*-type bismuth telluride a difference of $\sim$ 40° C. Some attention has been paid recently to quaternary compounds having the stannite structure, also akin to diamond.

Problems in applying Crystal Valves

It is now possible to assess more adequately the likely uses of crystal valves. Diodes offer advantages of size, lack of a heater, small capacitance and, sometimes, rapid response. Triodes offer advantages of size, lack of a heater and some additional facilities compared with thermionic valves. The diodes bring few new problems; their noise factors are not well understood, but at radio frequencies are usually tolerable. Minority-carrier storage can set a limit to their speed of operation as switches, for example, in computer circuits; forward current results in an excess of minority carriers near the junction or contact, which prevents the diodes instantaneously becoming of high impedance when a reverse voltage is applied. Recovery times can vary from about 0·01 μsec. to 10 μsec. Triodes set many more, and sometimes severe, problems. The noise factor can be intolerable at audio-frequencies for some uses; here the dominating component at a frequency f is often proportional to f^{-n}, where n is about 0·9–1·2. The equivalent circuits are more involved than those of thermionic valves, and it is not always easy to relate the components of the equivalent circuit which suits the engineer to those preferred by the device designer. Methods of circuit analysis and design both for large-signal and small-signal applications are being evolved, but the limitations of upper working temperature (less stringent for silicon units), of power handling capacity and of frequency response continue to restrict the field of applications.

OBITUARIES

Prof. Albert Michel-Lévy

ALBERT MICHEL-LÉVY was born at Autun on July 3, 1877. His father, Auguste (1844–1911), was a very distinguished geologist and mineralogist, best known for his fundamental work on the relationship of chemical composition to optical properties in the feldspar group, which is still used as the basis for the identification of members of this most important group of rock-forming minerals. Albert at first studied agriculture and forestry at Nancy; but he soon found an opportunity to turn to geology, and in 1901 he entered the Collège de France as a student of Ferdinand Fouqué's. His early work was on the rocks of the central massif of France in Morvan and Le Loire, and his thesis for his doctorate embodied the results of many years work in that region. In 1913 he succeeded to Louis Gentil as a lecturer in petrography at the Sorbonne. Here he carried out many investigations of volcanic rocks and of mylonites, illustrating his papers on these rocks by photomicrographs of remarkable excellence. He was ever ready to lend his special skill with the polarizing microscope to workers in fields other than petrography, and this led, happily, to some work on the birefringence of nitrated cellulose and in turn to work on other explosives. Together with Henri Muraour he studied, and photographed under the microscope, the behaviour of single crystals of explosive substances, observing the products of the explosion, the light flash, and the shock waves. Later they extended their observations to the modifications in the shock waves when explosion took place in one of the heavier gases like argon, comparing these with the effects seen in atmospheres of lighter gases.

This work on explosives suggested to Michel-Lévy a way of synthesizing rock-forming minerals under pressure and in presence of water vapour. The materials for the synthesis were enclosed in a 'bomb' cleverly designed to accommodate also a small explosive charge. The 'bomb' could be heated in an electric furnace at first to a temperature of 200°, at which the explosive detonated, producing the high pressures required in the closed 'bomb'. This was then heated to higher temperatures and could be kept there for days or weeks as desired. The identification of the minerals synthesized in these experiments was made by means of X-rays by Jean Wyart, and in later experiments they had the collaboration of one of Michel-Lévy's daughters, now Mme. Mireille Christophe-Michel-Lévy, by whom the work is still being carried on.

Twice Michel-Lévy's scientific work was interrupted by wars. He came of a family devoted to the service of France. His grandfather had served in the Crimea as a surgeon and became a very distinguished officer in the French Army medical service. In the First World War Albert Michel-Lévy, *Capitaine de chasseurs à pied* and later *Chef de Bataillon*, was twice grievously wounded, and he ended the war as an officer on the General Staff. He was made a chevalier of the Légion d'Honneur, of which he became an officer in 1920, and commander in 1946. In the Second World War, after the fall of France, he was removed from his post at the Sorbonne because of his Jewish ancestry. Protests at his removal were eventually successful in having the interdiction withdrawn in January 1942, and he was able to resume his work, though not in his own laboratory. However, worse was in store. His only son, Roger, fighting in the resistance, was taken prisoner and shot in February 1944. The loss was irreparable. Michel-Lévy's health was never again very good and he retired from his professorship in 1946, though he continued work with Jean Wyart and his daughter until 1948. He died in Paris on May 2, 1955. He was made a professor of the Sorbonne in 1936, and was elected a member of the Academy of France on January 22, 1945.

W. Campbell Smith

Prof. Madison Bentley

Prof. Madison Bentley died in California, U.S.A., on May 30. He was born at Clinton, Iowa, on June 18, 1870. His early training was at the University of Nebraska. He then went to Cornell University where, in 1898, he obtained the Ph.D. degree. At Cornell he remained, first as instructor and then as associate professor of psychology, until 1912. During 1912–28 he was professor of psychology and director of the Psychological Laboratory at the University of Illinois. In 1928 he succeeded Titchener at Cornell as Sage professor of psychology, and there he remained until his retirement from official life. He became president of the American Psychological Association in 1925, he was a Fellow of the American Association for the Advancement of Science, chairman of the Division of Anthropology and Psychology in the National Research Council; and he was editor of the *Psychological Index* (1915–24), of the *Journal of Experimental Psychology* (1926–30) and co-editor for many years of the *American Journal of Psychology*.

Madison Bentley achieved a position of great influence in the relatively early days of experimental psychology in America. He was of a modest and friendly disposition, a man of complete intellectual honesty, yet willing to try to see something good in all the many systematic, and often highly dogmatic, approaches to psychology which characterized the end of the nineteenth and the beginning of the twentieth centuries. This temper of mind made him an admirable editor, and his successful editorial work, as he himself recorded, broadened his knowledge and increased his tolerance. He wrote widely but mostly in journals, or in books of the familiar American 'portmanteau' kind. There were two volumes of his own: "The Field of Psychology", published in 1924, and "The New Field of Psychology", which appeared about ten years later. In the second, Bentley showed himself rather surprisingly sympathetic to practical and applied developments of experimental psychology.

When Prof. Carl Murchison got the excellent idea of producing a series of volumes to be called "History of Psychology in Autobiography", Madison Bentley was naturally one of the people approached for an early contribution. He wrote a beautifully unassuming account of his intellectual development (Vol. 3, p. 53; 1936). He acknowledges his debt to Titchener, and it is characteristic that he should select one item of this debt as most important. He had "submitted a cherished manuscript" for criticism and got it back with these remarks: "Here it is. I don't think that I have ever told you that I thoroughly disliked anything that you had written. I do this. It is decidedly bad. Cut out your figures and have done with your fine writing". This, says Bentley, "was a major operation without anæsthetic. Recovery was slow, but it left my organism saner".

Whether or no this was the reason, it was the sanity and dependability of his judgment, as well as the wide range of his knowledge, that won for Bentley the deep respect and admiration of psychologists everywhere.

F. C. Bartlett

Mr. G. W. Lines, C.B.E.

George William Lines, director of agriculture, Sierra Leone, will be well remembered in West Africa and especially in agricultural circles of Nigeria and Sierra Leone, where he had a long and distinguished career. He died at his headquarters at Njala on February 11 in his fifty-second year.

After graduating from St. Catherine's College, Cambridge, in 1924, he obtained a Cambridge diploma in agricultural science before he joined the Colonial Agricultural Service in 1925. He spent the earlier part of his service in Nigeria, where he was noted for the enthusiasm and energy he put into his work and for his genial personality. He was particularly successful in obtaining the co-operation and confidence of the native farmers to a degree seldom attained by other officers in the Service.