

both thyroxine and thiouracil form complexes with copper.

C. F. Mills's paper on dietary factors influencing copper utilization by the animal was presented by Dr. D. P. Cuthbertson. The greater part of the copper in herbage is in the form of fairly stable organic complexes. Copper in herbage, and in aqueous extracts made from herbage, is more readily available to rats than an equivalent amount of cupric sulphate: the copper complexes present in the extract are not decomposed at ranges of acidity such as occur in the gastric contents of the rat; nor are they decomposed in the digestive tract of the sheep but seem to be absorbed intact. The lower availability of ionic copper may be ascribed to the formation of insoluble compounds. Discussion followed regarding conflicting findings with swayback in sheep. It was noted that in animals excess zinc reduces the activity of cytochrome-c oxidase, whereas copper restores it; in micro-organisms molybdenum has a similar effect to zinc, and the molybdenum-copper interrelationship therefore seemed worth studying in animal enzyme systems.

Copper nutrition in ruminants was further discussed in a paper by Ruth Alleroft and Gwyneth Lewis, who observed that copper deficiency in cattle and sheep in the United Kingdom occurs on pastures with an apparently normal or even high copper content. This is in contrast to parts of Australia and New Zealand, where the disorder is regarded as a simple copper deficiency associated with a low copper content of pastures—usually less than 5 p.p.m. Observations in the United Kingdom indicate the presence of other factors in the herbage which interfere with the utilization and storage of copper in the animal. Australian work has shown that a high molybdenum intake can limit liver copper storage in sheep and cattle, and that the inorganic sulphate content of the diet influences the effect of molybdenum. Evidence obtained so far indicates that the copper, molybdenum and inorganic sulphate contents of the food are not the only factors concerned in the occurrence of copper deficiency in ruminants in Britain. Some of the complexities of copper metabolism were discussed and the possible danger of over-supplementation with copperized mineral mixtures was pointed out. E. J. Butler commented on the gross disparity of pathological symptoms associated with copper deficiency; he agreed that low copper content in pasture does not always lead to swayback. H. A. Robertson mentioned a flock of sheep which was healthy in spite of low levels of blood copper. J. W. S. Reith said there were areas in north-eastern Scotland where crops had responded to application of copper, but animals showed no deficiency in spite of the low level of copper in the pasture.

Classical examples of cobalt deficiency occurring in Connemara were reported by L. B. O'Moore. The disorder occurs with cattle grazing on a calcareous sand of the coastal area and with sheep, especially with recently weaned lambs, pastured on certain acid peats in the inland hill area. On the same peats, cattle are liable to suffer aphosphorosis. The traditional way of avoiding these troubles is to move stock to different grazing areas. However, fortnightly drenching with cobalt sulphate is effective in the coastal sand-blown pastures; top dressing with cobalt is advocated for acid peat land.

A. D. Osborne has found a moderate degree of cobalt deficiency in some parts of north Herefordshire. No severe symptoms appear, but male lambs

gain weight more rapidly when given a fortnightly drench of cobalt sulphate; female lambs benefit less from the treatment. In discussion, J. B. E. Patterson noted that the subclinical deficiency is of financial importance to the farmer. The investigation has been difficult, since analytical data for soil and for pasture do not give a clear picture: limits found acceptable elsewhere are not satisfactory here.

Confirming observations in the United States, D. B. Bellis and J. McL. Philp, by adding zinc to the dry feed of 8-16-week-old pigs, obtained spectacular cures of parakeratosis, a severe disorder of the skin accompanied by reduced growth. In discussion, it was asserted that the syndrome is mainly due to excessive amounts of calcium carbonate incorporated in proprietary pig feeds; the diet quoted by the authors is high in calcium and low in phosphorus. Work is being continued with a range of calcium/phosphorus ratios.

On April 12, symposium members visited the Long Ashton Research Station and the University of Bristol Veterinary Laboratory at Langford and the artificial insemination unit of Horlicks Farms and Dairies, Ltd. The symposium was organized jointly by the Agriculture Group and the Bristol Section of the Society of Chemical Industry. The organizers owed a particular debt to Prof. T. Wallace and his colleagues for the success of the meeting. The papers and discussions of the symposium will appear in a supplementary issue of the *Journal of the Science of Food and Agriculture* later this summer.

SEMICONDUCTORS

THE subject of the Spring (1956) Meeting of the Physical Society, organized with the assistance of British Thomson-Houston, Ltd., was "Semiconductors". The report* of the meeting has now, a little belatedly, been published; it contains all but one of the twenty-three papers read, but not the discussions.

Prof. N. F. Mott opened the meeting with his ideas on the transition to metallic conduction via impurity states in a semiconductor. He sought to show that in an array of monovalent atoms, the overlapping of the wave functions of adjacent atoms, though making electron transfer possible, does not necessarily lead to freely mobile carriers. He contested the assumption that an array of singly charged centres in a semiconductor, containing only donors or only acceptors, can be treated as a half-filled band. Confirmation of his prediction, that transition to metallic conduction with increase of concentration of monovalent dissolved atoms will be sudden, may have to await a sample of a semiconductor with regularly spaced donors or acceptors.

Another speaker introduced the idea of a 'semiconductor bond'. It does not exclude one (*A*) of the two atoms of a compound *AB* having incomplete *s*- and *p*-orbitals, provided there is no bonding together of the *A* atoms. Some predictions of new semiconducting compounds were made, based on a simple relation between the number of valence electrons per molecule, the number of atoms of the molecule lying in Groups IV-VII and any bonding between these atoms.

* Report of the Meeting on Semiconductors held by the Physical Society, in collaboration with British Thomson-Houston, Ltd., Rugby, in April 1956. Pp. 153. (London: Physical Society, 1957.) 20s. (12s. 6d. to members).

Almost all the other papers dealt with practice—technology and measurements—or with the properties of junctions. In the main they consolidated or clarified earlier work, or directed more detailed attention to outstanding problems; some contained comprehensive measurements. Only a few of the many points made can be reviewed here.

Improved trace-analysis has been needed to assist the purification of silicon. The common donor elements can now be estimated to 1 part in 10^7 by methods using radioactivation; equally sensitive methods are still lacking, however, for two acceptor elements, boron and aluminium. The rates of evaporation of donor and acceptor elements from molten silicon have been measured; when proper attention is paid to them, as well as to segregation constants, control of resistivity of single crystals grown from the melt is much improved. Carrier life-time in silicon is markedly dependent on injection-level; values for very low levels, obtained in part by extrapolation, have enabled a study of dependence on temperature to be commenced.

It has been suggested that most of the carriers responsible for the reverse current of a $p-n$ junction in silicon are generated, not in the n - or p -regions, but in the depletion layer. New measurements, showing the current to have an activation energy of only 0.7 eV., point to the current arising in a surface channel. An analysis of a model of a $p-n$ rectifier, intermediate between the one-junction ($p-n$ -ohmic) and two-junction ($p-n-n^+$) models, was presented; it, too, predicted a two-component forward current-voltage relationship, $I \propto \exp(qV/kT)$ at small voltages and $I \propto \exp(qV/2kT)$ at large voltages.

The non-ohmic conductivity of n -type germanium has been measured for fields less than, as well as greater than, 10^8 V./cm. For fields between 10^4 and 6×10^4 V./cm. it is so pronounced that the electron drift-velocity changes very little; thereafter avalanche multiplication sets in. Many of the properties of small-area diodes can be explained by these phenomena alone.

There were contributions on noise—an endeavour to detect shot-noise—surface conduction and the Eettinghausen effect, all in germanium.

Compound semiconductors also received attention. Extensive measurements were reported for indium antimonide and indium arsenide—for both of which some degeneracy remained at all temperatures even in the purest samples—and for gallium arsenide of improved purity, many donors having been removed by zone-refining. Measurements of photo-effects in indium antimonide were used to deduce carrier mobilities, μ_e and μ_h , and life-time. There was marked dependence of μ_e on hole-concentration in p material; life-times were short, less than 0.1 microsec., at room temperature. The spectrum of recombination radiation from indium antimonide has now been measured; because the absorption spectrum of thin specimens enables a value of radiation life-time of about 0.8 microsec. to be deduced, which is little more than some experimental values of carrier life-time, it was concluded that recombination in indium antimonide may be mainly radiative.

The electron contribution to the thermal conductivity, at room temperature, of an impure sample of indium antimonide (Hall constant 2×10^{-4} cm.³/coulomb) was calculated to account for the observed increase above the value for a purer sample (5×10^{-3} cm.³/coulomb). However, whereas the electronic contribution in extrinsic bismuth telluride conformed

with existing theory, the contribution in intrinsic material was more than expected, probably due to the transfer of ionization energy down a thermal gradient.

The nuclear resonance of indium-115 in highly degenerate n -type indium antimonide was shown not to differ in frequency from that in intrinsic material (that is, the Knight shift was absent); an adequate explanation lies in the very small effective mass of conduction-electrons in indium antimonide. The size and shape of the resonance are sensitive to cold working of the crystals and to the addition of tellurium as a donor.

The many informal discussions, possible because the audience was in residence, continually stressed the need for more frequent, similar, meetings. The subject has entered so many fields of science and technology, and so quickly finds new applications of effects, that the workers in the field, many of them young, have difficulty in keeping themselves adequately informed.

J. R. TILLMAN

THE WHISTLED LANGUAGE OF LA GOMERA

LA GOMERA is one of the Canary Islands, lying in the Atlantic off the west coast of North Africa. It is inhabited by some 30,000 Spanish-speaking people, scattered over the island in many tiny hamlets and four little towns. The island, volcanic in origin, is distinguished by a rugged and peculiar topography. It has the general shape of a big tent; from a central peak some 4,500 ft. high it slopes down on all sides to sheer cliffs at the sea's edge. Deep gorges radiating from the centre cut up the terrain. It is a difficult, mountainous country where two points only 500 yards apart as the crow flies may be as much as an hour apart in walking time. Apart from a single road, which links San Sebastian, the capital, with the other three towns, the only means of travel between most points on the island is by rough paths which are little better than goat tracks; communication on the island is a great problem.

But the Gomeros do communicate freely, across their ravines and from the valleys to the mountain-tops. The method of communication has been described in an article by André Classe (*Sci. Amer.*, 196, No. 5; May 1957). Long ago the Gomeros contrived an elegant solution to their problem: namely, a whistled language by which they speak to each other across miles of disjointed terrain. The *silbo*, as this language is called, is not a mere code or signal system but a version of Spanish. It has extraordinary carrying power: it can be heard and understood clearly over far greater distances than shouted talk. On a windless day any practised *silbador* can be heard more than a mile away. A good performer can whistle messages three miles or more.

On La Gomera, goatherds on widely separated hills carry on *silbo* conversations merely to pass the time. They whistle long sentences and even make jokes. During the Spanish Civil War in 1936–39 Gomeros were used occasionally for communication at the front; but the practice was discontinued when it was discovered that there were *silbadores* on both sides, so that the degree of secrecy was not high.