conditions, the test being identical with that used in many laboratory tests on Europeans in varying states of acclimatization. It was found that even the experienced Bantu never quite reach the same state of acclimatization as the European, a result which appears to indicate that the Bantu has no high degree of 'natural' heat tolerance. A serious obstacle to the comparison of Bantu and European workers is the absence of reliable measures of the physical effort made by native workers in hot mines.

A paper by Dr. A. O. Dreosti described investigations carried out at the Central Native Mine Hospital, City Deep, Johannesburg, to determine the reaction of native mine labourers to hard muscular work in hot and humid environments. The tests, consisting of shovelling rock, lasted one hour, and mouth temperature was observed at the beginning, after half an hour, and at the end of the test. The results may be tabulated as shown below.

Mouth temp. after test	Classification	Frequency	Acclimatization recommended
100·8° F.	Heat tolerant	25 per cent	4 days
100·8–102° F.	Normal	60 ,,	7 ,,
102° F.	Heat intolerant	15 ,,	14 ,,

Rise of mouth temperature was assumed to be the best measure of acclimatization. Of the natives subjected to tests for seven days, the majority showed a diminution of rise of mouth temperature after five days. Those who showed no diminution were those whose temperature rose above 102° F. on the first day. These men took longer than the others to acclimatize, and were given fourteen days acclimatization. The degree of acclimatization gained by the men tested by Dr. Dreosti appeared to be lost in a very short period of absence from the mine.

In the seven years 1932–39, there was no single case of heat-stroke among the heat-tolerant group, and Dr. Dreosti suggests that a rather simple test such as he describes will ensure that heat-intolerant men are protected from the danger of being too rapidly promoted to work in hot stopes. The tests were used at the City Deep over a period of years, but were later abandoned as unnecessary, conditions in the mine having been so improved as to remove serious risk of heat-stroke.

A review of the conditions in British mines, by A. E. Crook, F. Edmond, J. Ivon Graham and B. R. Lawton, gave a brief summary of the factors controlling the temperature conditions in underground workings. It was stated that the flow of heat from strata, the oxidation of coal dust, radiation from walls and roofs, and the heat given off by machines, are relatively unimportant in well-ventilated mines. The use of wet-cutting methods to obviate dust leads to considerable evaporation and humidifying of the atmosphere, both at the coal face and during the transit of wet coal to the mine shaft. In a series of appendixes are given extensive series of actual observations in various collieries of temperatures of dry- and wet-bulb thermometers, of air speed and effective temperatures, as well as of readings of dry and wet katathermometers.

Messrs. W. A. Attwood and W. B. Lawrie presented a paper on working conditions during certain melting and smelting processes, and demonstrated very clearly that work in the metallurgical industry can be as severe as in deep mines. In many industrial concerns the work is carried out in very hot buildings with congested plant, while men at times work to the limit of endurance. Improvement is to be looked for in some cases by rebuilding, in others by improvement of natural ventilation or by the installation of forced ventilation.

In the subsequent general discussion, Dr. J. K. Lindsay pointed out that during work in very difficult conditions, the brain is the first organ to suffer, the onset of mental fatigue preceding the onset of physical fatigue, and lasting long after the shift in the mine is ended. The desire to get to a cooler place leads to slipshod work.

Mr. D. G. Malherbe, chief inspector of mines, Union of South Africa, pointed out that the silicosis danger demands wet mining, which leads to rise of wet-bulb temperature at the working stopes. It is difficult to economize wisely in the use of water, since some miners when asked to economize use no water. Mr. Malherbe referred to the possibility of the extension of gold mining to a depth of 10,000 ft. This would best be done by gradually deepening existing mines to 10,000 ft., so as to learn the problems by experience.

Prof. F. B. Hinsley stressed the value of high speed of ventilation, in that the air is thus got into the mine quickly, without being warmed by its environment. He pointed out that in modern mines in Great Britain there is a great increase in the amount of dust, and if this is suppressed by the use of water the wet-bulb temperature is raised. Dr. K. J. Irvine also stressed the importance of high rate of ventilation, and of good food and good personal relations for the worker.

J. D. Farmer, an expert in air conditioning, directed attention to the fact that the mine cooling-plants on the Rand, in the Kolar Gold Field and elsewhere, are all surface plants. We are faced with the prospect of having to deal in British mines with wet-bulb temperatures up to 80–85° F. If this is to be met by the installation of cooling-plant, a decision is required as to whether the plant is to be on the surface or below, and since it will require some years to design a suitable plant, it will be advisable to put the problem to the refrigerating engineer soon.

D. B.

NEW MATERIALS AND THEIR ENGINEERING SIGNIFICANCE

THREE papers read at a meeting on September 1 before Section G (Engineering) of the British Association brought together some interesting information and suggested interesting possibilities in the application of new engineering materials.

The first paper, "New Dielectric and Semi-Conducting Materials", by Dr. R. W. Sillars, began with a discussion of the behaviour of the sulphides and oxides of various elements, and mixtures of these, when carrying an electric current at varying temperature. It is found that oxides and sulphides, such as those of copper, lead, nickel and titanium, have a resistance which is profoundly affected by small changes of composition or of impurity content, and that they all possess a large negative temperature coefficient. Moreover, when they are brought into electrical contact with another material or another piece of the same material, a voltage appears across the contact which is not proportional to the current flowing and may depend upon its direction.

These semi-conductors differ from metallic conductors in that the electrons which carry the current are the few which have escaped from a weak attachment to fixed ions, to which they would have been held if the temperature had been very low. A semi-conductor may, therefore, be regarded as an insulator which is too hot to insulate even at room temperature. The fixed ions from which these conductivity electrons are released do not belong to the lattice structure and are referred to as impurities. Temperature coefficients of -3 per cent to -5 per cent per degree centigrade are obtainable with resistivities varying from hundreds, to hundreds of thousands of ohm/cm., the higher resistance coefficients being generally associated with the materials of higher resistivity, while in a given material the temperature coefficient varies inversely as the square of the absolute temperature. The materials used commercially are nickel, cobalt and manganese oxides and mixtures of these fused or sintered into small beads and provided with two fine platinum wire electrodes, or manganese oxides sintered into disks, rods or thin flakes, and provided with deposited metal film electrodes. It is possible to give these semi-conductors rectifying qualities under suitable conditions by bringing them into contact with a dissimilar conductor; if the surfaces of two pieces of similar semi-conductor are placed in contact, a fault-current curve of a similar type of more or less symmetrical shape may be obtained. Both silicon and germanium have good rectifying properties and may be used with advantage in radio work, as the capacity across the rectifier barrier layer is very small. Rectification is, indeed, found to be effective only when contact is made over a very small area, of the order of 0·0005 cm. diameter.

Germanium is also used in the 'Transistor' amplifier which was announced from the Bell Laboratories last year. This consists of two point contacts very close together, on the surface of a piece of germanium, but not necessarily on the same surface, and a large base electrode which corresponds with the cathode of a thermionic valve, except that it is biased positive and not negative with respect to the other output terminal. The input point is biased slightly in the direction of easy conduction, that is, positive. The germanium used is the same as that for high back-voltage rectifiers, that is, with the highest possible resistance. The main features of this rectifier are an input impedance of 100 or 200 ohms, an output impedance of several thousand ohms and a maximum output of a few tens of milliwatts from a pair in push-pull. Operation is satisfactory up to 10 megacycles per second. The noise-level at audio frequencies is, however, high as compared with the thermionic valve.

Dr. Sillars next directed attention to recent progress in the production of insulation, and pointed out that organic substances consisting only of carbon and one other monovalent element have very low dielectric loss, as exemplified in the polymers of styrene and ethylene. The main limitation of polyethylene is, however, its low softening point; in this respect the polymer of tetrafluorethylene, the molecules of which have a mutual attraction so strong that the substance tends to decompose before it has softened and is insoluble in all liquids, offers some possibilities. Its very stability, however, tends to make it intractable in manufacturing processes.

For the insulation of electrical machines, materials are required which will withstand the higher temperatures of operation now employed. Glass fibres in combination with organic varnishes are often used, but the brittleness of the glass may cause trouble. Recently, asbestos paper has become available, and this, impregnated with heat-resisting varnish, has been found useful where ability to withstand high temperature is of greater importance than high breakdown strength. The new fibre made from terephthalic esters, known as 'Terylene', promises to be useful as it will withstand a temperature of 180° C. Among ceramics, the low loss steatites and the oxide – zirconium oxide – titanium dioxide are now in common use; but others may be obtained by sintering together the oxides of barium, strontium and titanium in various proportions, resulting in materials of permittivities up to several thousand. These high-permittivity materials are, however, rather sensitive to temperature changes, and this fact, together with the difficulties of handling very thin ceramic sheets, may prove an obstacle to their general use for large capacitors.

The second paper, "Magnetic Materials for Electrical Power Plants", by Dr. F. Brailsford, began by indicating the magnetic properties important to the designer of electrical machines. A low hysteresis loss is desirable, together with high permeability at flux density of some 15,000 gauss. There followed a general review of the theory of ferromagnetism, and it was shown that theoretical work by Becker, Kirsten and others had demonstrated that low hysteresis loss is to be expected in a material in which there is easy movement of the domain boundaries, and that all sources of internal stress producing lattice distortion should be eliminated. There appears to be little doubt that the chief causes of poor magnetic properties are associated with impurities present in the material, carbon and sulphur being particularly harmful. The work of Honda and Kaya, on large single crystals of iron, and silicon–iron, indicate further that magnetization is more easily accomplished along a cube edge than across a cube diagonal or a face diagonal. In the case of hot-rolled iron, and silicon–iron polycrystalline sheets, there is a more or less random arrangement of the crystals, so that the magnetization curve is a mean of that for all magnetization directions, giving a knee point at 13,500 gauss for a 4 per cent silicon–iron; but the experimental work of Yensen, Cioffi and others has shown that if processes of manufacture are controlled to keep impurities to a minimum and to produce a large grain size, a considerable improvement in magnetic quality is possible. In some of the better grades of hot-rolled material produced in the United States, the carbon is reduced by a decarburizing treatment, and large grain size is obtained by special rolling. This has resulted in the production of American steel of a better magnetic quality than the material of similar composition produced in Great Britain. A further improvement may be obtained by a process of cold rolling, which is now standard practice for certain steels in America. Cold work on the steel tends to orient the cube edges in the direction of rolling, and therefore to give a higher permeability in this direction than a direction across the plate, or a direction normal to its surface, which contain the diagonals of two cube faces. There seems to be a possibility, if rolling methods can be evolved which would orient the cube edges along the direction of rolling and at right angles to it, that a still further increase in permeability could be obtained.

An account was given of the alloys of iron and nickel; but it was pointed out that, in spite of their very low hysteresis loss, the use of these alloys is restricted to instrument and communication work on account of their high cost and low saturation flux-density. In this class of materials the ferrites were mentioned, certain oxides upon which research work has been in progress in Holland and which show initial permeabilities as high as 4,000 and saturation values of about 5,000 gauss.

The paper concluded with a short account of the work of Martindale and Langford in producing, under laboratory conditions, large crystals of silicon–iron in sheet form.

In his paper on "Metals for High Duty", Dr. R. W. Bailey first gave an account of the improvements which have been achieved in the quality of the carbon steel used for structural parts. Greater strength has been obtained without undue sacrifice of other properties by modification of the normal elements of composition, principally by increasing the manganese and silicon contents beyond their usual amounts. Such steels have found application in structural work such as bridges and high-duty railway rolling stock. A further improvement in the quality of steel by the development of alloy steels began with the addition of nickel, and later the usefulness of chromium was appreciated; this element is extensively used for low-alloy steels of high reliability and moderate cost. High-duty steels for structural purposes should also resist atmospheric corrosion, and the addition of about 0·5 per cent of copper has been found advantageous in this respect. A structural steel made by the United States Steel Co. has used silicon and chromium to raise the yield point and tensile strength, and copper and high phosphorus to improve corrosion resistance, giving a steel of approximately the following percentage composition:

Carbon	0·08	Silicon	0·7
Manganese	0·3	Chromium	1·0
Phosphorus	0·13	Copper	0·4
Sulphur	0·03		

Such a steel has been used extensively in the United States for railway carriages. It has a yield point of 26 tons per square inch, a tensile strength of 34 tons per square inch and an elongation of 25 per cent on 8 inches. A further increase in the yield point and tensile strength is obtained by the addition of nickel up to 0·5 per cent, and plates for structural work having a yield point of 28 tons per square inch and a tensile strength of 40 tons per square inch are obtainable.

For high-duty forgings, nickel–chromium and nickel–chromium–molybdenum steels have been used for some time. In small parts, such as bolts, a tensile strength of 100 tons is attained, and quite large forgings may have a tensile strength of 70 tons per square inch. High duties, however, necessitate a high degree of freedom from defects, and a type of defect which made its appearance in nickel steels and became more apparent in nickel–chromium and nickel–chromium–molybdenum steels was the hair-line crack, upon which a large amount of research work has been carried out. The major factors concerning its cause and prevention have become known, but it still appears sporadically.

The production of steels which would maintain their characteristics at high operating temperatures in steam and chemical plants was helped by the investigations of J. H. S. Dickenson, on the creep testing of alloy steels. The work soon disclosed the limits of usefulness, in steam plant, of carbon steel, and the existing nickel–chromium–molybdenum steels with a low nickel content also left much to be desired. Dr. R. W. Bailey's creep-test data indicated that although this steel offered good resistance at temperatures up to 450° C., it fell off rather rapidly at higher temperatures; the nickel present was suspected as being responsible for this. The results obtained by Promper and Pohl in Germany had indicated the stiffening effect of molybdenum upon carbon steels, and it was thought that advances might be made by reducing, or even eliminating, the nickel and increasing the molybdenum content. These anticipations were realized, and the chromium–molybdenum steels now widely used for bolts working at high temperatures were introduced. A further advantage of eliminating the nickel was a virtual immunity from embrittlement, and a greatly reduced risk of hair cracks, and of cracking during manufacture. Although this steel met the requirements of steam plant; working at high pressures and temperatures, a call for a steel which would withstand more severe conditions was anticipated by experimental work undertaken on a basic 0·5 per cent molybdenum steel, in order to determine the influence of a second added element, and also of tertiary elements. It was concluded from this work that a molybdenum–vanadium steel offered the best possibilities. The turbine cylinder, its bolts and turbine diaphragms, plating, the rotor and steam piping of Battersea Power Station Set 4*a* were ordered in this material in 1937. The developments which have been described were inspired by the need to maintain stress-carrying capacity and permissible deformation at increased operating temperatures. Increasing the temperature reduces the permissible stress for a particular steel until a stress is reached where parts would be too massive, and another steel becomes necessary. As temperatures rise, therefore, the problem of finding a steel to keep the working stress within satisfactory limits is largely a metallurgical one. The question of surface oxidation is bound to arise as temperatures are raised, and these increased temperatures are likely to compel the use of high-alloy or austenitic steels.

The development of gas turbines for aircraft forced the production of new and improved alloys for operating temperatures well above those reached in steam plant; but the desired life of the turbine being only about a three-hundredth of that expected of a normal steam power plant, working stresses could be used which would have been quite inadmissible in the steam set. For this reason and because a degree of cooling could be introduced, it was found possible to use ferritic-steel disks. For blading, however, materials of the highest capacity for duty at elevated temperatures are necessary. Extensive investigation and development work both in Great Britain and in the United States have led to the production of alloys the chemical compositions of which fall conveniently into the groups shown in the accompanying table.

It is of interest to note that the alloys which have the highest performance, namely, those in Groups 3, 4 and 5, are either free, or nearly free of iron.

Alloys which resist deformation at high temperatures require special techniques in manufacture, and processes of precision casting and sintering have been introduced. The factors of cost and availability are both important in the selection of alloys, the first in the industrial possibility of gas turbines and the second in connexion with military and naval requirements. In industrial gas turbines a range of alloys would be used, chosen as those which would meet most economically the conditions occurring at different

Group	Typical Alloy
(1) Chromium-nickel-iron + small additions of molybdenum, tungsten, columbium and titanium.	Firth-Vickers *F.C.B.* (*T*). C, 0·12; Si, 0·6; Mn, 1·6; Ni, 12·5; Cr, 18·0; Cb, 1·45. Firth Vickers H.R. Crown Max. C, 0·25; Si, 1·5; Ni, 12·0; Cr, 24·0; W, 3·0.
(2) Similar to (1) but with nickel exceeding chromium.	S. Fox and Company. Red Fox 33. C, 0·1; Si, 0·8; Ni, 31·0; Cr, 20·0; Ti, 1·0.
(3) Nickel-chromium + small additions of aluminium and titanium.	Mond Nickel Company's Nimonic 80. C, 0·05; Si, 0·70; Mn, 0·4; Fe, 3·0; Ti, 2·4; Al, 0·5; Cr, 21·0; balance, Ni.
(4) Nickel-chromium-cobalt-iron + small additions of molybdenum, tungsten, columbium and titanium.	Jessop and Company's G18*b*. C, 0·4; Si, 1·0; Ni, 13·0; Cr, 13·0; Co, 10·0; W, 2·5; Mo, 2·0; Nb, 3·0. Allegheny Ludlum Steel Corp., U.S.A. *S*816. C, 0·4; Ni, 20·0; Cr, 18·0; Mo, 4·0; W, 4·0; Cb, 3·0; Fe, 3·5; Co (balance), 45·0 approx.
(5) Cobalt-chromium with additions of molybdenum and tungsten.	Vitallium (U.S.A.). C, 0·2; Cr, 28·0; Mo, 6·0; Co (balance), 65·0 approx.

stages of the expansion; but experience with complex alloys has shown that an increase in size may multiply manufacturing difficulties unexpectedly, and therefore in the development of new alloys an early exploration of the influence of size should be made. It must be remembered also that, in all high-duty alloys for elevated temperatures, heat treatment plays an important part in creating the maximum endurance, and experiment is usually needed to determine the treatment appropriate in a particular case. In designs in which high-duty alloys are to be used, account must be taken of the modes of failure of these materials. The more resistant materials which usually have good ductility at atmospheric temperatures frequently show poor ductility under conditions of sustained stress and high temperature. This is because the mode of failure under these conditions is by intergranular fracture, and for this reason permissible deformations may appear to be unnecessarily small and the working stresses correspondingly low. Intergranular cracking may be caused by steep fluctuating temperature gradients, and tests show that different materials vary widely in their ability to withstand repetition of thermal shock.

The discussion was opened by Dr. W. G. Radley, who directed attention to the extensive use to which new materials have been put in tele-communications work, instancing the application of "Permalloy" alloys for the loading of submarine cables, of polythene for the insulation of high-frequency cables, and the ferrites for small transformer cores. Dr. A. T. Bowden, discussing Dr. Bailey's paper, said that austenitic steels must be used in gas turbines, and that these steels can be worked, up to their temperature of oxidation.

OBITUARIES

Prof. P. E. Newberry, O.B.E.

Percy Edward Newberry, who died at his home at Hascombe, near Godalming, on August 7, was the *doyen* of British Egyptologists. The youngest son of H. J. Newberry of Ealing, he was born on April 23, 1869, and educated at King's College School and King's College, London. While still at school, at the age of fifteen, he came under the spell of Ancient Egypt, which was to dominate all the rest of his long life.

When only twenty-one, in 1890 (having already reprinted, in two volumes, essays by Carlyle), he became officer-in-charge of the newly founded Archæological Survey of the Egypt Exploration Fund (as it then was), a branch of the Fund's activities which was to prove highly fruitful in publishing accurate records of the already known rock-tombs of Egypt. His first work for the Survey was two volumes (1892–93) on the very important group of tombs at Beni Hasan; these were followed by two more (1893–94) on those of El-Bersheh; all the scenes and inscriptions were copied by him single-handed.

In 1895–1901 he was engaged on a survey of the Theban Necropolis, during which he cleared a number of tombs, and with R. de P. Tytus he excavated the Palace of Amenophis III there until 1902; in that year he joined the staff of the great "Catalogue Général of the Cairo Museum", contributing, as time went on, volumes on the contents of the tomb of Tuthmosis IV, on scarabs and scarab-shaped seals, and on funerary statuettes.

In 1900 he edited the papyri in the collection of Lord Amherst of Hackney and also much of the famous tomb of the Vezier Rekhmirê. His book on scarabs, which appeared in 1905, was for long the leading authority on the subject. He was the first holder of the Brunner chair of Egyptology in the University of Liverpool, to which he was elected in 1906, resigning in 1919 to make way for a younger man, T. Eric Peet. In 1908 he published a volume on the Timins Collection.

Much of Newberry's literary output was in the form of collaboration: together with, or in works by, Petrie, Garstang, Maspero, T. M. Davis, Lord Northampton, Lord Carnarvon, Howard Carter, Hall, Peet and others, he published much valuable work, especially on excavation and antiquities, history, ancient botany and art; and his contributions to various British and Continental journals embrace almost every branch of Egyptology.

During the First World War he took part in the national effort by undertaking the highly skilled work of gauge-making, somewhat to the detriment of his eyesight; later he became assistant secretary of the London and South-Eastern Region of the Ministry of National Service. In 1923 he was elected president of the Anthropological Section of the British Association; his address in that capacity, "Egypt as a Field of Anthropological Research", opened up new perspectives of investigation. During 1926–27 he was vice-president of the Royal Anthropological Institute. The winter of 1927–28 was devoted to an exploration of the Gebel Elba region of the Red Sea Province of the Sudan, from which he brought back a harvest of botanical and other specimens. Thereafter for four years (1929–33) he was professor of Ancient Egyptian history and archæology in the Fouad I University, Cairo. In 1933 the Saxon Academy of Sciences made him a corresponding member. Other distinctions were the O.B.E., in recognition of his war services, an honorary readership in Egyptian art in the University of Liverpool, and a vice-presidentship of the Egypt Exploration Society.

Throughout his career Newberry was an ardent researcher, and collected immense stores of notes on many aspects of ancient Egypt, bearing especially on history, early religion, botany and zoology. His zeal for amassing information (which led him to visit many out-of-the-way sites rarely visited by Egyptologists) outran his urge to publish the results; it is greatly to be hoped that other scholars will be able to make use of his rich material, which he was always