Ross, who stressed the importance of the larger scale 'ripples' which appear to occur, especially on region *F*. Mr. G. Millington discussed the question of 'long-distance scattered' signals, and whether they were produced by the irregularities in region *E* or on the ground. M. R. Rivault gave examples of some diffuse and scattered echoes observed near the critical penetration frequency for region *F*, and it was again questioned whether these echoes were incident vertically or obliquely.

Finally, Dr. A. C. B. Lovell summarized the effects which would be expected to be produced by the 450 kgm. of meteoric material which burn up each day in the atmosphere near the level of region *E*. Although there is a relation between the number of meteors and the presence of sporadic *E*, he gave reasons for supposing that meteors cannot be assumed to be responsible for all sporadic *E*.

J. A. RATCLIFFE

PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS OF HIGH TEMPERATURE AND HUMIDITY IN MINING AND METALLURGICAL WORKS

AT the Fourth Empire Congress on Mining and Metallurgy, a discussion on "The Physiological and Psychological Effects of High Temperature and Humidity on Workers in the Mining and Metallurgical Industries" was held at Oxford on July 14. In the opening paper, by Sir David Brunt, the factors which determine the thermal equilibrium of the human body were enumerated and discussed briefly. These factors are:

(*a*) The rate at which heat is generated in the body, this rate depending on the rate at which work is being done.

(*b*) The dry- and wet-bulb temperatures of the air.

(*c*) The temperatures of radiating surfaces, such as walls and roofs, in the immediate environment.

(*d*) The rate of movement of the air.

Attention was directed to the fact that whenever work is done there is a rise of body temperature. This should be borne in mind in the interpretation of observations of working conditions. A moderate rise of body temperature is not harmful. Both these points were later emphasized by Dr. A. Caplan.

The ability to sweat is the body's chief protection against a continuous rise of body temperature; but the losses of water and of salt in the sweat must be replaced if health and efficiency are to be maintained.

It was shown that when the skin is completely wetted with sweat, the rate of loss of heat from the body is determined largely by the wet-bulb temperature of the air, the dry-bulb temperature having no direct effect, except in so far as it may control the temperature of the radiating surfaces. In these conditions the rate of loss of heat by convection and evaporation from the nude skin is proportional to $\sqrt{v}(I_s - I_w)$, where v is the rate of air movement, and I_s and I_w represent the total heat content of saturated air at the temperature of the skin and at the temperature of the wet bulb respectively. From the above considerations it is possible to represent the conditions of heat balance in the *nude* body by a tractable equation; from this equation the limiting conditions in which the body temperature can be guarded against continuous increase can be deduced for any given rate of work and of air movement. These limiting conditions are the heat-stroke limits for a nude man. A diagram was shown giving these limiting conditions for a range of rates of work and of air movement.

While an increase of ventilation from a few feet per minute up to 200 feet per minute produces a very marked rise in the limiting temperatures, further increase of ventilation is followed by relatively slight rise, and it may be concluded that in hot, humid mines an improvement in working conditions is to be looked for by the drying and cooling of the air, rather than by an increase of ventilation.

From the diagram referred to above it was inferred that air with a wet-bulb temperature of 83° F. represents a limit beyond which a continuous shift would be impossible without a rise of body temperature. The same limit was laid down by Dr. Caplan on the basis of his experience in the Kolar Gold Field.

Dr. A. Caplan, in a paper on the effects of high environmental temperatures on underground workers on the Kolar Gold Field, emphasized the complexity of the heat-regulating mechanisms of the human body. He stressed the rise in body temperature which always accompanies work, stating that a rise above 102° F. is a sign of heat intolerance, indicating a need for artificial acclimatization. In 80 per cent of cases of heat collapse, an individual predisposing factor, such as unacclimatization, loss of acclimatization or disturbances of health, contributed to the collapse. The first sign of impending heat collapse is a fall of blood pressure, reducing the blood supply to brain, heart, muscles and skin, and resulting in fatigue, giddiness, headache and nausea.

In his discussion of water metabolism, Dr. Caplan pointed out that there is an increasing diminution of the total body fluids as the shift progresses, aggravated by the fact that in hot environments blood is diverted from the alimentary tract to the skin and muscles, so that the absorption of fluids is diminished, and may be entirely absent. No serious danger arises unless reserve tissue fluids are low, as would happen after vomiting or diarrhœa.

Dr. Caplan discussed briefly some important psychological factors. He pointed out that the strain on the whole organism produced by hard work in hot atmospheres leads to mental fatigue, which makes the worker apathetic and neglectful, reducing his working efficiency and making him prone to accidents. The workman becomes resentful and dissatisfied, and is easy prey for the agitator; labour unrest and all its implications will follow.

On the basis of his experience on the Kolar Gold Field, Dr. Caplan gave a wet-bulb temperature of 83° F. or lower as prescribing favourable conditions for comfortable and unimpaired output, and 90° F. as the crucial wet-bulb temperature above which conditions are dangerous to health.

The need for acclimatization of native workers in hot and humid mines was discussed in two of the papers presented at this session. Dr. J. S. Weiner, of the Medical Research Council Climatic and Working Efficiency Unit, discussed the effects of acclimatization on the working efficiency of Bantu workers, as observed in the City Deep Mine, Johannesburg. Tests were made on a group of eight unacclimatized Bantu, and on another group of eight acclimatized Bantu, doing a standardized task in hot humid 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