extent of migmatite granites is considered, it is clear that sufficient water is available to promote the changes seen in the regionally metamorphosed rocks.

Are there any indications in low- to medium-grade rocks, not visibly associated with igneous activity in the field, which point to solutions from magmatic sources having travelled so far from the locus of migmatization? In my opinion, we see such indications in the presence of tourmaline in rocks of all grades. Admittedly, this opinion is one not generally accepted in Great Britain, but on balance I prefer to regard most tourmaline in metamorphic rocks as due to impregnations from granitization fluids. Tourmaline occurs not only in pelitic derivatives but also in rocks of other compositions. In many examples of high- and medium grade rocks it is clearly introduced, as shown by its relation to the other minerals present. I believe that the ubiquitous tourmaline in regionally metamorphosed rocks is an indicator of the action of 'emanations' throughout all grades.

Whilst I have belittled the role of the dynamic factor in regional metamorphism, it is of course true that in the lower grades it must be of considerable importance. How can this be reconciled with the view that migmatization is the prime cause of regional metamorphism? The reconciliation may be sought, I suggest, in the stresses set up by the increase of volume consequent upon the invasion of the crust by the migmatite front. Relief is obtained in the outer and cooler zones by shearing; in the inner and hotter zones by internal reconstructions. The unity of the zonal series may thus be preserved.

I have shown my predilection for dividing all rock transformations into two groups, one those of dislocation-metamorphism associated with dislocations of the crust, and the other those of regional and thermal metamorphism associated with igneous activity. My remarks, I trust, will receive thorough criticism. I am prepared for this, for, just as things too absurd to be said can yet be sung with perfect propriety, so views too tenuous, unsubstantiated and generalized for ordinary scientific papers can yet appear with some measure of dignity in presidential addresses.

POWDERED FUEL: PROGRESS AND PROSPECTS

THE necessity imposed by the demands of war to make use of any available materials in order to eke out inadequate supplies of the usual commodities is frequently the means of bringing to practical use ideas and inventions which might otherwise languish for years. An example is the introduction in the Napoleonic era of the present method of making soap in consequence of France being cut off from the usual supplies of kelp. The use of powdered fuel in aero-engines may, owing to Germany having difficulty in getting adequate supplies of petrol, be one of the results of the present hostilities; that the Germans have been working in this direction is evidenced by patents covering the use of powdered fuel. Patent literature shows that two distinct methods of operation have been envisaged. One consists in mixing the fuel with air and introducing the mixture into the combustion chamber, thus following the cycle used in petrol engines. The other adopts Diesel practice in injecting the fuel directly into the combustion chamber, though obviously with a fuel in the form of a powder some important modifications at the injection stage would be necessary.

Powdered coal cannot be described as a tractable material for the purpose of being metered out in small quantities for injection into the combustion chambers of a high-speed engine. Freshly pulverized, it is light and fluffy but, in the presence of moisture it readily tends to change its physical characteristics and to pack itself into a dense and rather inert mass. It is necessary, therefore, that it should be well dried before the final pulverization, and it is desirable also that it should not be kept in storage but rather used at once. After a long period of trial, it has now become well established as a boiler fuel, and a brief statement of its history in this connexion may indicate its possibilities.

In 1831, a patent was granted to John Dawes, ironmaster, for a method of introducing fuel into the blast of furnaces. Later patentees include the name of Mushet who, it will be noted, was also interested in steel furnaces. The first to advocate pulverized fuel seems to have been John Bourne, in whose "Treatise on the Steam Engine" of 1861 it is stated that "the fuel and air must be fed in simultaneously and the most feasible way of accomplishing this object seems to be in reducing the coal to dust and blowing it into a chamber lined with firebrick so that the coal dust may be ignited by coming into contact with the red hot surfaces". In 1868, T. R. Crampton experimented on the use of pulverized coal in steam boilers and puddling furnaces, and the views he put forward in a paper read before the Iron and Steel Institute in 1873 have proved to be fundamentally correct. He was strongly insistent on the importance of the size of the fuel particles and of the intimate mixture of air and fuel.

It was not until 1895, when powdered fuel began to be successfully used in rotary cement kilns, that the system can be said to have become established. In this branch, however, its success has been so marked that it can be claimed to account for about four fifths of the world's output of portland cement. In this same year a remarkable result was obtained from tests carried out by Bryan Donkin in Berlin. A Cornish boiler was operated for one day by hand-firing on the ordinary grate; two days later, after being fitted with the Wegener apparatus, it was given a day's run on powdered coal. On the first occasion the thermal efficiency was 54 per cent, whereas on the second it was 77 per cent, the total duration of smoke in the two tests being 105 minutes and 6 minutes respectively.

In view of these figures, it is remarkable that the development of this method of firing has been so retarded and that in England, even now, the number of plants in operation is very limited. This is not explained by any inherent difficulty, as the crushing, drying, pulverizing and delivery plant are of robust construction and generally reliable in operation. The risks associated with the use of pulverized coal can be controlled by strict attention to cleanliness in the boiler house and to the cleaning of all pipes when closing down. The powdered fuel is entrained in a limited blast of air which, before entering the furnace, is enabled to carry with it the additional amount of air requisite for combustion. As the carbon dioxide percentage may be as high as 15, it can be seen that the proportion of excess air is lower than that needed for ordinary coal firing, where 12·5 per cent is the normal figure for carbon dioxide. The ash produced is a very finely divided flocculent powder, and the amount which escapes to the atmosphere can be reduced to any desired degree by suitable interceptors.

The history of the efforts made to use coal dust directly in internal combustion engines is in strong contrast to the record just given, as the main problems have not been satisfactorily solved. It is an interesting fact that when Diesel, about 1890, was planning the type of engine which now bears his name, his primary idea had been to employ coal dust as fuel. After several years of experimental work, the engine which he constructed proved to be adapted to oil fuel but not at all to coal or even gas, and so for this as well as economic reasons its ultimate development was directed toward the utilization of oil. At the Glasgow Exhibition of 1901 there was shown an engine made to the patents of 1894 and 1900 of P. F. MacCallum, which developed 100 B.H.P. at 150 r.p.m., using coal dust as fuel. The difficulty of completely consuming the solid particles was never fully overcome, no matter how finely the coal was pulverized, and this continues to be one of the chief problems to be solved. The ash is also troublesome and inevitably so, for the limited combustion space offers little scope for devising means of interception and control.

These considerations suggest that, instead of the direct use of coal dust in the engine cylinders, some indirect or semi-direct method might be developed. The use of a special form of gas producer is an indirect method, but so much so as to come under a different classification, the engine becoming a gas engine supplied by gas from an individual gas generator. The term semi-direct is intended to suggest an arrangement whereby the processes of combustion are isolated from the cylinder, but in which the working substance is the gas formed by combustion. The indirect method, on the other hand, would be one in which the products of combustion do not enter the cylinder but are enabled through another medium to do work on the piston. It is never possible to forecast how practical conditions may modify theoretical suggestions, and it will be interesting to see by what means the coal-firing of engines, if indeed it is practicable, will be realized.

OBITUARIES

Dr. W. B. Wright

DR. W. B. WRIGHT, lately of the Geological Survey of Great Britain, died on October 11 at the age of sixty-three years. Wright received his university training at Trinity College, Dublin, which in 1928 honoured him with the Sc.D. He approached geology through mathematics, being attracted by Croll's astronomical theory of ice ages. He joined the Geological Survey of Great Britain and Ireland in 1901, and to begin with had the good fortune to work in the Dublin, Belfast, Cork and Limerick districts under the inspiring leadership of the great glacialist Lamplugh. During these early years Wright's most original contribution was a joint account with Maufe, published in 1904, of a low pre-Glacial raised beach preserved at many points