purposes through the tops of the generators, as the main thrust bearings are located below the rotors. Power is transformed from 11,000 volts to 230,000 volts in outdoor water-cooled transformers, supplied by the Canadian General Electric Co., and is transmitted direct to Trois Rivières by means of an overhead transmission line, 120 miles long. With the addition of this installation, the Shawinigan Water and Power Co. possesses a combination of power plants aggregating 809,200 electrical horse-power and 55,000 hydraulic horse-power.

The enormous importance to Canada of its hydro-electric installations may be gauged from the fact that the investment represented by the present development of seven and a half million horse-power is conservatively estimated at 1,743,000 dollars and, while it is difficult to assign a precise figure to the coal equivalent of developed horse-power, the potential saving of coal through the present utilisation of water power is on a moderate computation equivalent to 36¼ million tons per annum. The realised saving, dependent, as it is, on the actual output of the plants in operation, was during the year 1934, of the order of 17 million tons of coal. The total installation gives a notable ratio of 697 horse-power per 1,000 of the population.

[1] "Water Power Resources of Canada", Paper No. 1813, Department of the Interior, Ottawa.
[2] "Hydro-electric Progress in Canada in 1934", Paper No. 1784, Ottawa.
[3] NATURE, **131**, 788; 1933.
[4] NATURE, **120**, 334; 1927.

The Classification of Coals

By DR. R. LESSING

THE complexity of the heterogeneous conglomerate, coal, can be appreciated if it is considered that it represents the accumulation of vast masses of a large variety of vegetable materials under different climatic and topographical conditions, and their gradual metamorphosis by biological, chemical and physical agencies extending over geological periods which have proceeded to, or are arrested at, varying stages of development. The component portions of a single plant differ widely in their morphological and phytological characteristics and more especially in their chemical composition, that is to say, in the general quantitative relationship of the cellulosic, lignitic, resinic groupings and their quota of normal inorganic plant constituents and accessories, and likewise in the qualitative properties of each of them. Assume this mixtum compositum of raw materials to be subjected to bacterial, enzymatic and chemical decay under varying conditions of wind and water, oxidation, dehydration and carbonisation, rest and disturbance, pressure of superimposed strata and disruptive earth movements, let these phenomena occur in different sequence, at different stages of 'coalification' and with different potency in each region, and you will sympathise with the researcher who attempts to piece the jig-saw puzzle of coal constitution together. He is faced with complexity in the smallest fragment examined under the microscope or by chemical analysis, in any lump taken from the domestic scuttle, when surveying a coal seam throughout its depth and along its bedding plane or a series of seams overlying each other in a single coal pit, when comparing the commercial products of any district or the deposits of the coalfields in different countries and continents.

Such considerations will demonstrate the difficulty of fitting the many hundreds of more or less definite forms in which coal occurs and their transitional modifications into a rigid system of classification. Moreover, classification is required for many purposes. The geologist, the palæobotanist, the chemist, the combustion or carbonisation engineer, the coal miner, and the coal salesman will all view the problem from their particular point of view, and will insist that any methodical grouping shall give the special information that satisfies their own curiosity or is helpful in their limited sphere of activity.

The older classifications of Karsten (1826), Regnault (1832), Gruner (1873), Hilt (1873), Schondorff (1875), and others were originally based on the character, and later the yield, of the coke obtained in the crucible test, and on the length of flame of the burning coal. This method has persisted on the Continent ever since, for commercial purposes, though admittedly deficient unless supplemented by other data. Attempts at correlating various properties led to the adoption of the ratio of 'fixed carbon' to volatile matter, the 'fuel-ratio', as a standard of comparison, particularly in America. In 1900, C. A. Seyler proposed a classification on the basis of the carbon/hydrogen ratio, and elaborated his scheme in recent years by incorporating the graphical representation of Ralston's isovols and isocals, and applying Parr's correction for mineral matter content. Seyler's classification is capable of expansion by plotting other characteristics, such as caking and agglutinating power, oxidisability, oxygen requirement on combustion, hardness and liability to 'slacking' or weathering. He visualises an atlas of the coals of the world in which the carbon and hydrogen axes correspond to longitude and latitude and the iso-functional lines to altitude, isotherms and other features of an atlas of physical geography.

All attempts at coal classification prior to 1919 had dealt with commercial coals, that is, the mixed product of collieries in certain localities or at best the fuel extracted from individual seams. The values used in drawing up coal charts were obtained by unstandardised methods of analysis, often of doubtful definition or accuracy, whilst the materials examined represented average samples, in most cases containing an undue percentage of adventitious mineral matter apart from the 'inherent' ash.

In that year Dr. Marie C. Stopes described in the *Proceedings of the Royal Society* the four visible ingredients of banded bituminous coal—fusain, durain, clarain and vitrain—isolated mechanically from hand specimens from Hamstead Colliery in Staffordshire. Reference had been made frequently in the literature to the banding of coal, to the dull (matt) and bright (glanz) nature of the laminations, and to the peculiar lenticular inclusions of mineral charcoal (mother-of-coal). This paper constituted the first attempt to consider coal in detail from a petrological point of view. The possibility thus shown, of isolating distinct and identifiable components from any lump of banded coal, has proved a most fruitful factor in the furtherance of coal research during the past fifteen years, and its significance has penetrated even into the realm of industry. The isolated components were shown to be different and typical in their chemical composition and morphological structure, to be associated with mineral matter in characteristic amount and composition, to have different coking values and to contain groups of organic compounds and plant residues in defined ratios.

The subdivision of coal into the four visible Stopes ingredients has been widely accepted in Great Britain and in most European countries. American workers have not felt able to adopt it in its entirety, owing partly to differences in the character of their coals and partly to difficulties in terminology. They are adhering to the subdivision into Thiessen's anthraxylon and attritus, roughly comparable to clarain-vitrain and durain respectively. The fact that vitrain, clarain, durain and fusain are group designations and were put forward by Dr. Stopes as merely representing portions of hand specimens distinguishable macroscopically has not been sufficiently appreciated by subsequent authors; hence new observations on other coals have in some cases been interpreted as contradicting the original descriptions.

In a recent paper "On the Petrology of banded Bituminous Coal"[1] Dr. Stopes re-states her case and sums up the results of research arising from her original paper. She goes further than that; encouraged by the additional knowledge obtained since its publication and in order to clarify the position, Dr. Stopes proposes a much more comprehensive, though perhaps more ambitious, scheme of classification. The new schedule[2], which during the last two years has been discussed in detail by the British and American members of the Coal Research Club and others, provides for the further subdivision of the macroscopic components into smaller groups, to which the generic term 'macerals' has been given, analogous to the minerals composing a rock. These are connotated by the suffix *-inite.* A maceral is named generally according to the kind of tissue from which it is mainly derived and of which in its mummified form the bulk of the unit consists. If wood, cork, cortex, cuticles, spore exines or resin was the raw material, the maceral is called xylinite, suberinite, periblinite, cutinite, exinite or resinite respectively. Completely jellified plant material is ulminite, whilst re-precipitated ulmin compounds form collinite. Fusainised xylem or other lignified tissues are fusinite and the yet little explored matrix of durain or 'residuum' is termed micronite. The combination of individual macerals present in the hand specimen (having suffix *-ain*) are vitrinite, fusinite, clarinite and durinite.

In order to allow for the distinction between vitrains with and without structure, Potonié's terms pro-vitrain for the former and eu-vitrain for the latter are adopted, and in the case of vitrain the sub-groups ulmain, collain, periblain, suberain and xylain have been interposed between the main component and its macerals, to denote their principal characteristics.

The schedule may at first glance appear complicated, and some may gibe at the mass-production of new terms. These are, however, not meaningless words, but signify distinct elements which have been recognised and defined by the microscopist and the chemist. Whilst the technique of identification and isolation of macerals has yet to be developed, the schedule forms a well thought out skeleton into which existing knowledge and future observations can be fitted. The scheme is obviously of a tentative nature and mainly intended for the bituminous portion of the coal range, and not so much for coals of lower rank (peat, brown coal, lignite), but its potential bearing on coal research and practical coal classification should not be underrated.

Classification hitherto had to be applied to complex mixtures. It could be based with advantage even to-day on the characteristics of the main components of coal. If, however, in future by the combination of petrological and analytical data, the physical and chemical properties of the small units of the coal complex can be ascertained, the composite value of the fuel will be assessed with much greater accuracy than is possible at present. What may, therefore, appear to-day as a somewhat academic problem, may to-morrow have a very definite effect on practical coal politics. The coal producer, knowing that he can only sell the coal which he happens to find in his pit, usually stands aloof from attempts to codify coals in anything but a 'use' classification. In Great Britain, even schemes for grading coal by size and freedom from ash and moisture have so far been regarded with disfavour. The modern requirements of the industrial consumer, however, make more rigorous demands on the properties of coal used in his processes and indicate the necessity of defining these in terms different from the non-descript 'Derby Brights' beloved by the British householder in the past.

[1] "Fuel in Science and Practice", Jan. 1935, **14**, 4–13.
[2] Copies can be obtained from Dr. M. C. Stopes, Norbury Park, nr. Dorking, England.

Obituary

Prof. Ganesh Prasad

We regret to announce that Prof. Ganesh Prasad died on March 9, with unexpected suddenness. Born in Ballia, a small town in the United Provinces, India, on November 15, 1876, Prasad took the D.Sc. degree of the University of Allahabad at the age of twenty-two years, and then studied at Cambridge and Göttingen as a Government of India scholar. After serving for ten years as a professor of mathematics in his native province on his return from Europe, in 1914 he joined the University of Calcutta as the Ghosh professor of applied mathematics. He left this post four years later to join the Benares Hindu University as its University professor, but came back to Calcutta in 1923, this time as the Hardinge professor of pure mathematics, which post he occupied until the time of his death. While he was in the Benares Hindu University, he was also the principal of the Arts and Science College for about two years.

Prof. Prasad was the first in India to create a school of mathematical research. Many of the papers on mathematics published by young Indian investigators in the last twenty years bear an acknowledgment of indebtedness to him for guidance and help. He founded the Benares Mathematical Society in 1918, and was its life-president. He had been for many years the president also of the Calcutta Mathematical Society.

One of the earliest contributions made by Prof. Prasad was his dissertation entitled "The Constitution of Matter and Analytical Theories of Heat" (1903), in which he dealt with the difficulty of interpreting differential coefficients when the molecular constitution of matter is taken into account. His papers on applied mathematics, published in various journals, dealt likewise with problems in which he skilfully applied his knowledge of the theory of functions of a real variable to potential problems in which the differential coefficients became infinite or did not exist. His later researches were on the theory of Fourier series and other branches of the theory of functions of a real variable. At the time of his death he had in hand the completion of a long memoir on "The Expansion of Zero", which he had promised to contribute to the first issue of the journal of the newly created National Institute of Sciences, India, of which he was a member of council.

Prof. Prasad was well known as a teacher, and his textbooks on the differential and integral calculus are still in use in many Indian universities. His Patna University readership lectures on "The Place of Partial Differential Equations in Mathematical Physics" were published in 1924, and since 1928 he had devoted a good deal of his time to the writing of books on higher mathematics and on the history of the subject.

Prof. Prasad was much loved and admired by his numerous pupils, to whom he was always a source of great inspiration. He was a man of wonderfully simple habits, and remarkable energy and powers of endurance. He had a marvellous memory. When he was a principal—to mention but one example—he recognised all the students (more than one thousand in number) and remembered not only their names but also numerous details about them.

GORAKH PRASAD.

Dr. Shepherd Dawson

By the death of Dr. Shepherd Dawson on March 26 at a relatively early age, experimental psychology in Great Britain has suffered a great loss. For a period of many years, his experimental contributions have been published in the technical journals (mostly in the *British Journal of Psychology*). All have been marked by careful attention to the requirements of scientific method. In later years his attention was directed towards the statistical problems of psychology, and a few years ago he published a book on statistics.

Shepherd Dawson's earliest published work on various problems of vision already showed his quality as an accurate and painstaking experimentalist. After he succeeded H. J. Watt as principal lecturer in psychology, logic and ethics at Jordanhill Training College, Glasgow, he did not lose his interest in experimental research. At meetings of the British Association he had generally some original investigation to report. Probably the best known of his later contributions to experimental psychology was his