Fuel Research in the United Kingdom*

THE latest annual report of the Department of Scientific and Industrial Research, recording the progress of a number of activities of the Fuel Research Board, like the previous numbers, is divided into many sections; and experimental data are included wherever necessary in the form of tables and graphs with a view to throw sufficient light on the work under review. A few photographs and diagrams of special semi-industrial plants are also included.

At the outset, satisfaction is expressed in respect of the voluminous and extremely valuable work carried out by the field laboratories established in the major mining areas by way of undertaking "a survey and classification of the coal seams in the various mining districts by means of chemical and physical tests in the laboratory", which was one of the main lines of research of the Board. This has been achieved with the closest co-operation of the colliery owners, the users of graded fuel and other organisations. The information has been of great value not only for the marketing purposes of the coals, but also to gain an idea of the Nation's potentialities. Several difficulties in conducting the work at a central place—in the nature of proper sampling, transportation of tons of samples, etc.—have been overcome by the establishment of laboratories in the coal-fields, only the correlation and special work being carried out at the central research station.

In view of the experience gained, the previously standardised methods of analysis of coal and ash have been modified. The presence of certain elements—Barium, Titanium, Nickel, Zinc, etc.—have been detected in certain coal samples, and by submitting certain coal ashes to spectroscopic examination the presence of those elements not normally associated with coal ashes, *e.g.*, Vanadium, Chromium, Lead, Germanium, Gallium, Silver and Copper has been revealed.

Some of the University Laboratories have been engaged in special investigations on the oxidation of carbon and the constitution of coal, subjects of considerable technical importance and also of intrinsic scientific interest, and views on the results achieved so far have been recorded.

Owing to the considerable attention paid to the sized grades of coal put on the market, work carried out by the Board has included investigations on the types of 'picks' used in breaking, the avoidance of unwanted breakage and the undue formation of fines, and the wet and dry methods of cleaning coal. They have been able to overcome the dust nuisance commonly attached to the coal conveyers, screening plants, etc., by sprinkling certain fluids in very small proportions on the broken coal. This method of dust-proofing coal has the additional advantage of protecting coal from weathering. A study of the physical structure of coal, employing *inter alia* the X-ray methods, has been of considerable interest in the determination of the absorption properties of certain fluids by different types of coals.

In regard to the work on carbonisation and gasification of coals, attention has been specially directed to the utilisation of low grade coals for metallurgical purposes by studying the characteristics of special blends, and the production of gases of special composition required for the development of synthetic processes for the production of oils and fatty acids. The investigations were carried out on the different types of large-scale retorts and the necessary working conditions have been ascertained for the success of the processes. Interesting results have been recorded with the modified operation of water gas plants fitted with a chamber for the catalytic reduction of carbon monoxide to methane, on the lines suggested by Sebastian. The results have been encouraging and water gas of high calorific value may some day be expected to be supplied to consumers instead of the more expensive coal gas.

Coal tars and oils have been subjected to hydrogenation in order to obtain motor spirit. In this connection, observations on the treatment of low temperature and high temperature tars have been recorded and it is suggested that the latter are not amenable to the treatment to the same extent as the former. Results of a mild hydrogenation treatment of crude benzole have been recorded to show how the process can be successfully worked for desulphurization of the hydrocarbon.

As a result of the cracking of higher boiling 'hydrogenated oils' unsaturated hydrocarbons are obtained which, when polymerised, give oils with lubricating properties. The results of this investigation have been encouraging to such an extent that a semi-technical scale plant has been designed and operated to synthesise olefines from mixtures of carbon monoxide and hydrogen, after the Fischer-Tropsch reaction. The large quantities of synthesised olefines—particularly ethylene—are next subjected to polymerisation in the presence of catalysts. This work has yielded a variety of products, such as lubricating oils, waxes for soaps, and acids for the production of esters.

Besides the continued progress of the process of hydrogenation of coal, steps have been taken to use pulverized coal in internal combustion engines where partial success has already been attained. Designing of long-wearing engine cylinder parts is one of the important items in this investigation.

The Board has been taking keen interest in the design of open fire grates for burning blended cokes, a problem of wide interest.

The report is a record of the multifarious activities in which the Board is engaged. The necessity for establishing such an institution in India has been stressed from time to time by all those having some kind of interest in the country's fuel problems. At present, investigations even of a preliminary nature are in progress in a few laboratories only, and there are evidently numerous difficulties in undertaking extensive research schemes whereby the coal

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resources could be properly surveyed and classified; but then alone can a proper control be obtained on the economic utilisation of fuels in general. The Geological Survey of India have issued a number of bulletins from time to time embodying the preliminary work of an analytical character regarding some coalfields. The fuel laboratories of the Universities of Bombay and Calcutta and the Indian School of Mines have been adding to the meagre information on most of the coal deposits from time to time; but the work will have to be much wider in scope to enable the mining proprietors and coal users to profit by it. The outstanding results achieved by the Fuel Research Board in England, which have been partly recorded in the report, should be enough to stress the importance of an organisation of that kind to this country.

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Modern Tendencies in Mathematics*

DURING the last hundred and fifty years, not only an immense advance has been made in the direction already indicated by the old masters like Descartes, Newton, Leibnitz, Euler and Lagrange but entirely new branches of mathematics were created such as Projective Geometry, Functions of Complex Variables and the whole vast subject of mathematical physics. Sometimes, the development in mathematics went hand in hand with the progress of the natural sciences, and new methods of attack were developed in order to solve the problems set by these sciences. At other times the trend of events has been in the opposite direction. Many subjects in mathematics were developed purely for their own sake, and it was only at a later date that most of these abstruse ideas found applications in practical problems. Complex Variables, Differential and Integral Equations, Tensors, Quaternions, Matrices and Groups have become powerful tools in the hands of the physicist. Having conquered the domain of the natural sciences, mathematics continues in its triumphal march into the realm of the biological and sociological sciences as well. It is thus becoming more and more indispensable for all knowledge and the conviction is gaining ground that the formulation of all the fundamental laws of nature requires its use.

Another characteristic development of modern times is the rise of the deductive method. In mechanics, for example, it has become customary to start with Hamilton's variational principle and deduce Newton's Laws. This tendency has resulted in the unification of various theories and various branches of knowledge.

Dr. Siddiqi pointed out that the progress of mathematical sciences up to the nineteenth century was mainly in the constructive direction, that is, in the direction in which we start from familiar conceptions and then advance in a synthetic way towards gradually increasing complexity. But with Gauss, the critical discipline was also introduced. Gauss and Cauchy were the first mathematicians to realise the insecure foundations on which mathematics was built, and they turned their attention to a critical examination and rigorous formulation of the whole subject. This work was carried on by Abel, Riemann, Weirstrass, Dedikind and Cantor. This process led to the great and important movement called "the Arithmetisation of Mathematics", started by Kronecker and Weirstrass. The greatest achievement of the late nineteenth century was Cantor's theory of sets, and his first mastery over the world of infinity. It has had a far-reaching influence both on pure mathematics and its applications. The theory of sets contributed a great deal towards clearing the foundations of mathematics, but the theory itself was not founded on a secure basis, as it led to many paradoxes. Investigations connected with these difficulties have thrown much light on many of the most fundamental problems of human knowledge. The solution has been attempted in three different ways by different schools. The difference is not only methodical; it consists mainly in the whole mathematical outlook.

The Intuitionistic School, led by Bronwer and Weyl, considers pure existence theorems as illegitimate. For this school existence in mathematics means constructability. It also rejects the age-old "Principle of Excluded Middle", *i.e.*, the principle that out of two opposites one must hold. It applies this to the Decision-problem, and says that contrary to the general belief, every mathematical problem is not necessarily soluble.

The Logistic School of Bertrand Russell forbids the use of non-predicative definitions. It has revived the old idea that mathematics is a part of logic. This conception of logicism has had a sequel in the modern tendency to do away with the ordinary language, with its uncertainties and confusion, and to use a purely symbolical language.

The Axiomatic or Formalistic School has been founded and developed by David Hilbert. The axiomatic method, as distinguished from the genetic method, tries to build up a subject on a system of suitably chosen axioms. The fundamental problems then are those of proving the independence, completeness and self-consistency of the axioms.

The controversy between these different schools of thought is still raging, and it is not yet possible to forecast the direction to which mathematics of the future will tend.

* From an Extension Lecture delivered by Prof. R. Siddiqi on 10th January 1939, under the auspices of the Aligarh Muslim University.