

true for any q and hence the total number of defective values is enumerable and the total defect + the branch-index, never exceeds 2. (As mentioned earlier 2 is the best possible constant.) In this connection Nevanlinna has conjectured that the total number of defective values in the case of a meromorphic function of finite order [i.e., if $\frac{T(r)}{r^\rho}$ is finite for some ρ], then the number of defective values also is finite. This is as yet unproved.

From II we can deduce theorems concerning multiple values. a_1 is said to be a multiple value of $f(z)$ if (2) $f(z) = a_1$, has always multiple roots. Its order m_1 is the least possible order of the roots of (2). (It is obviously ≤ 2 .) If a_1, a_2, a_3 are multiple values with multiplicity m_1, m_2, m_3 , respectively we obtain from II,

$$T(r) \leq \sum_1^3 [N(r, a_\nu) - \frac{m_\nu - 1}{m_\nu} N(r, a_\nu)] + O[\log r T(r)]$$

by taking into account $\bar{N}(r)$.

$$\therefore T(r) < T(r) \sum_1^3 \frac{1}{m_\nu} + O[\log r T(r)]$$

$$\text{as } T(r) > N(r, a_\nu).$$

$$\therefore \frac{1}{m_1} + \frac{1}{m_2} + \frac{1}{m_3} \geq 1.$$

(We shall exclude the case of a rational function as direct analysis is possible in that case.)

Similarly we obtain that

$$(3) \quad \frac{1}{m_1} + \frac{1}{m_2} + \frac{1}{m_3} + \frac{1}{m_4} \geq 2 \text{ and}$$

$$(4) \quad \frac{1}{m_1} + \frac{1}{m_2} + \frac{1}{m_3} + \frac{1}{m_4} + \frac{1}{m_5} \geq 3;$$

but $m_\nu \geq 2$. Hence from (4) we deduce that there cannot be more than four multiple values for a meromorphic function. This is really the best possible constant. For the Weierstrassian elliptic function $p(z)$ is such that it takes the values e_1, e_2, e_3 and ∞ always with multiplicity 2.

Conversion of Coal into Oil.*

A REPORT issued by the Department of Scientific and Industrial Research reveals that the process which forms the basis of the big coal-into-oil plant recently opened at the Imperial Chemical Industries Works at Billingham, was first discovered by Bergius in Germany as the result of applying hydrogen under pressure to "Artificial Coal" produced by him from cellulose and peat. The Report makes public for the first time the results of many early experiments on the conversion of British coals into oil and describes how the British Government, acting through the Department of Scientific and Industrial Research and its Fuel Research Board, ensured the development of the process covered by the Bergius patents.

The Report makes it clear that in view of the great importance of securing adequate oil supplies from British coal, the department considers it highly desirable that the knowledge gained in every stage in the development of this epoch-making process should be fully available to British technicians.

Via "ARTIFICIAL COAL" TO OIL.

Bergius, the Report states, as early as 1910 had evolved apparatus for working under high pressures and after studying a number of other reactions he heated cellulose and peat in the presence of water to 340° C. at a pressure of 150 atms. The products were black solids which he considered similar to natural coal and which he called "artificial coal". Later Bergius turned his attention to heavy petroleum oils which, when heated under pressure in hydrogen, gave a quantity of light spirit. On treating his artificial coals in a similar manner, Bergius obtained a 70 per cent. conversion into oil soluble in benzene. Natural coals were then found to behave similarly, and in 1914 Bergius patented the application of the process to coals and other solid carbonaceous substances.

EARLY EXPERIMENTS AT THE FUEL RESEARCH STATION.

Further development was delayed during the War and, owing to the cost of high pressure work, little was done until 1921 when a plant on a semi-industrial scale was erected at Mannheim-Rheinau in Germany for treating oil. Research on the process was also initiated at the Fuel Research Station, Greenwich, in 1923 with a small home-made converter. From the experiments there, it was satisfactorily established that the Bergius process afforded a means of obtaining much higher yields of benzene soluble material from coal than were obtainable by any other known method.

BRITISH COALS TESTED IN GERMANY.

In 1924, the British Bergius Syndicate was formed which obtained an option on the patent rights of the Bergius process covering the British Empire, and experiments were carried out at Mannheim-Rheinau to test the suitability of British coals for the process. The preliminary results obtained were favourable and were communicated to the British Government. In view, therefore, of the importance of any practical means of obtaining liquid fuels from British coals, it was decided that the Department of Scientific and Industrial Research should proceed with the investigations. An agreement was accordingly entered into between the Department, the British Bergius Syndicate, the Internationale Bergin Compagnie and Dr. Bergius whereby the option on the patents which were shortly running out was continued. Further experiments were carried out at Mannheim-Rheinau in Germany on British coals.

*Fuel Research Technical Paper, No. 42—"The Action of Hydrogen on Coal. Part II. Early Experiments with the Bergius Process." Published by H. M. Stationery Office. 1/3d. net.

These experiments were supervised by a Committee consisting of two representatives of the Department, two representatives of the British Bergius Syndicate and Dr. Bergius and in them trials were made with coals from various parts of the country in small converters while "Orgreave Washed Slack" obtained from South Yorkshire was selected as a suitable coal for tests in a continuously operated plant. The results were again promising and a plant embodying the latest improvements resulting from the work in Germany was supplied to the Fuel Research Station. This plant was installed towards the end of 1926 and in 1927, the small-scale experiments carried out at Rheinau were terminated by agreement and the work continued at the Fuel Research Station.

DESCRIPTION OF THE EARLY EXPERIMENTS.

The *Report* in describing the process as evolved originally by Bergius states that his converters were at first glass lined, and then made of plain steel. They were rotated about a horizontal axis, with pebbles within to assist stirring; about 100 atms. was the working pressure, and they were heated externally, either by gas or electricity, for about one hour. After removal, the products were distilled and treated by benzene extraction, the material so recovered being known as "oil". At a later stage in the evolution of his process, Bergius added oil to the charge, at first to avoid local overheating, and later to help in the working of a continuous plant into which a mixture of coal and oil could be pumped in the form of a paste. A further modification was the addition of a proportion of luxmasse, which consists largely of iron oxide with some alumina and titanium, to the charge in order to fix the sulphur in the form of iron sulphide. From subsequent researches at the Fuel Research Station, it was established that the luxmasse had also a definite catalytic effect in hastening the hydrogenation of the coal, contrary to the statements of Bergius.

Other British coals from the Nottingham and Derby, South Yorkshire and Durham coalfields were then tried, generally with satisfactory results. In the course of the work at the Fuel Research Station, the early stages of the reaction were studied and it was discovered that below the temperature of 450° C. normally employed by Bergius, the coal underwent marked changes. Thus, at about 370° C. in the case of a bituminous coal, reaction between the coal and hydrogen took place rapidly and resulted in the formation of a plastic material. If the products were allowed to cool immediately after reaching this temperature a solid product was obtained which had every appearance of having been through a fluid condition. This solid product, which was almost equal in weight to the original coal, had higher coking properties than the coal used in the experiment.

The continuously operated plant at Mannheim-Rheinau consisted of two horizontal reaction vessels in series, contained in baths of molten lead, heated by gas, and fitted with simple mechanical stirrers. A paste consisting of tar, coal and luxmasse was forced through these vessels, with hydrogen, at 150 atms. pressure. Various modifications were tried and numerous tests carried out with varying success, details of which are given in the *Report*.

The equipment which was installed at the Fuel Research Station as a result of the work is also fully described. It provided a continuously operating plant capable of dealing with a ton of coal a day, embodying all features of the latest practice, at the time of erection, of the Bergius Research Institute, together with an adequate plant for making hydrogen.

This plant was used originally for studying Parkgate coal from South Yorkshire and later coals containing less ash, namely, coal from the virgin Seam, Lanark, and finally Beamshaw coal from Wakefield.

The Classification of the Archæan Rocks in India.

A SYMPOSIUM on the Classification of the Archæan Rocks in India was held at a meeting of the Geology and Geography Section of the Indian Science Congress (Indore, 1936) under the Chairmanship of Mr. B. Rama Rao, M.A., D.I.C., F.G.S., the President of the Section.

The President in his introductory remarks pointed out that there was no general agreement among the several workers in the Archæan tracts of India regarding the classification and correlation of these ancient rocks. He stated this disagreement was in no small measure due to the fact of the scattered occurrences of the Archæan rocks in widely separated areas with the intervening distances between them being so large as to make it almost impossible for any single field geologist to get a personal acquaintance with the typical characteristics of each of such separate regions. He requested Sir Lewis Fermor who had devoted more than 30 years of his life for an intimate study of many of the

Archæan tracts of India, to lead the discussion by giving an account of his views on the subject.

SIR LEWIS FERMOR opened his observations by a reference to his *Memoir* on the Archæans of India, which he said was in the Press and would be issued soon. He stated that he had divided therein the Archæans of the Peninsular India into two main provinces: the Charnockitic and the non-Charnockitic and had brought together the various formations of the different regions under that grouping. These major provinces were further sub-divided into minor provinces on the strength of lithological characters and associated ore deposits. Thus, in the non-Charnockitic Province, 10 sub-divisions, viz., 3 iron ore Provinces of Singhbhum, Mysore, etc., 3 marble Provinces of Nagpur, Balaghat, Narbada and Son Valleys, etc., and 4 Igneous Provinces of Hyderabad, Bundelkhand, Shillong, etc., were grouped. In the Charnockitic Provinces, 18 sub-divisions were grouped under the Garnet, Iron ore and Manganese Provinces.