I. INTRODUCTION

Objective

The present investigation of work by H. Koppers G.m.b.H. in the field of powdered coal gasification was conducted under the auspices of FIAT with headquarters in Karlsruhe, Germany. The objective was to get complete information about the Koppers process for making fuel gas or synthesis gas from powdered bituminous coal or lignite. Several previous investigators had reported the existence of such a process and some had obtained and published meagre information regarding its operating characteristics. No previous investigation or report had been sufficiently comprehensive to permit an appraisal of the value of the process for the gasification of coal in the United States.

Evaluation

The FIAT investigators succeeded in obtaining a fairly detailed statement of the course of Koppers experimental work and the conclusions reached. Koppers officials could not be shaken in their contention that all experimental data and reports had been destroyed by bombing and fire. Thus documentary proof of statements made from memory is completely lacking. A limited number of original drawings of experimental units and proposed commercial units were obtained.

The largest unit built by Koppers had a powdered coal capacity of about six metric tons per day and the longest run made on such a unit was about five hours. The latest modification of this unit did not give entirely satisfactory operation because of excessive cooling of the reaction zone by its water jacket. Nevertheless the Koppers officials believed that they had a commercially operable process, and from 1941 to 1943 they were making proposals for commercial units. Such units were never built because of the exigencies of war.

The present writer does not feel that the Koppers experimental work justified their confidence as to the commercial operability of their process. However the more complete picture which we now have regarding the course of this experimental work may be a very useful foundation for further research and development in the United States.

II. NUMBER AND SCOPE OF INVESTIGATIONS

The Koppers offices in Essen were visited by CIOS investigators on 15 April, 1945 and the information then obtained was summarized in CIOS

report XXVIII-36, Item 30, by E. B. Peck and A. Parker[1]. The data therein on powdered coal gasification relate only to a proposed unit for Brabag at Schwarzheide. Documents obtained in this connection are reproduced on Technical Oil Mission Microfilm Reel 43 frames 209 to 278 inclusive.

Representatives of the U.S. Navy Technical Mission in Europe interrogated Koppers officials in May 1945 and obtained documents which are reproduced on Technical Oil Mission Microfilm Reel 188 beginning with frame 20951. These include five pages of heat and material balances dated 4 June 1945, as well as undated flow diagrams, graphical representations of heat balances and reproductions of blueprints. So far as can be determined no report on these documents has been published.

About September 1946 the Koppers officials were interrogated by FIAT investigators Johnson and Bushow but no report on powdered coal gasification has been issued as a result of this investigation. According to Dr. Koppers the material given to these investigators included a copy of an unpublished address by Totzek summarizing the Koppers experimental work, which he said was not given to the U.S. Navy investigators.

The present investigation was conducted during the period from 10 April to 27 May, 1947. The conferences were initiated by Dr. W. F. Faragher, Chief of the Fuels and Lubricants Unit, Industry Branch, FIAT. Most of the interrogations were conducted by B. M. Rosenthal and the writer. During the later stages of the investigation French interests were represented by Mr. D. deReseguier, of the Institut du Petrole, Paris. Various representatives of the British Military Government, including Messrs. Shaw and Follett of the North German Coal Control and Dr. Eskreyss of the British Chemical Industry Control, were very helpful in issuing permits and orders which made it possible to obtain the desired documents and information from Koppers officials.

Frequent visits were made to the Koppers offices in Essen for the interrogation of Messrs. Koppers and Totzek, and written answers were obtained to a formal questionnaire regarding various aspects of their work, which is reproduced in Appendix 5, page 49. Persistent questioning failed to shake their story that all original data had been destroyed by bombing and fire, and therefore all statements as to the actual and expected performance of Koppers powdered coal gasification units must be accepted with some reservations.

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[1] Peck, E. B., and Parker, A., Report on H. Koppers G.M.&H., Essen. CIOS Item No. 30, File No. XXVIII-36. 28 June 1945.

All documents obtained from Koppers during the present investigation are being reproduced on Technical Oil Mission Microfilm reel No. 238 for future reference. Prints or copies therefrom may be obtained through the Library of Congress. The documents themselves are being returned to the Office of Technical Services, U.S. Department of Commerce.

III. OUTLINE OF KOPPERS EXPERIMENTAL WORK

Recognizing the importance of being able to gasify lignite or non-coking bituminous coal the Koppers Company built a unit for gasifying lignite briquettes in the plant of Brabag at Schwarzheide-Ruhland in 1935. This process was started to be successful but left a considerable residue of fine coke which could not be gasified in any available generators. Therefore an experimental unit for the gasification of this fine coke was built in the Schwarzheide plant in 1938. This unit was not successful but it indicated the most promising lines for further research.

Studies of coal dust gasification were continued in a unit built by Koppers in the plant of Rheinpreussen at Homberg in 1940. Eventually the performance of this unit was stated to be very satisfactory and on the basis of data obtained there proposals were made for the erection of commercial units. Due to exigencies of war the experimental work at Rheinpreussen was discontinued in 1944 and no commercial unit was ever built.

The general course of this work was reviewed by Totzek in an unpublished paper read at a meeting of the Power Committee, in Essen. 12 June, 1942.

IV. GENERAL CONSIDERATIONS IN POWDERED COAL GASIFICATION

Totzek[1] points out that the gasification of powdered coal with air involves first the combustion of part of the coal and its distillation products with all available oxygen, which is an exothermic reaction and quite rapid. Subsequently the resulting CO_2 and H_2O must undergo reaction with unburned carbon, which is endothermic. Not only must the required heat be available in the system but it must be transferred to the coal particles so that they will remain at an active reaction temperature, which was indicated by Koppers experiments (not further specified) to be 300-400°C. above the values usually stated in the literature.

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(1) Totzek; Arbeiten der Heinr. Koppers G.m.b.H. über restlose Vergasung; Vortrag vor dem Energieausschuss. (Essen) 12 June 1942 (Unpublished Address).

It was concluded that the provision of long contact times to attain heat transfer and the desired completeness of reaction was impractical. As an alternative the use of an excess of carbon would probably give desired gas compositions but would be objectionable because of the difficulty of recovering and recycling the unconverted carbon. However by the use of oxygen or enriched air as the combustion medium it was concluded that complete gasification of powdered coal could be accomplished. Furthermore by thus avoiding or limiting the amount of nitrogen charged to the generator the concentration of CO and H_2 in the product gas could be raised, which is important in the production of synthesis gas. For this purpose Totzek stated that the concentration of CO + H_2 in the product gas should be at least 82%, in which case the concentration of CO_2 would be so low that it need not be reduced further by scrubbing. Furthermore the use of oxygen gives considerable flexibility in the ratio of CO to H_2 which can be attained in the product gas. Assuming the use of oxygen to be essential, Totzek points out that preheating of the gasifying medium and using very finely ground coal as for powdered coal combustion will keep the oxygen consumption at a minimum.

With respect to the production of synthesis gas in particular Totzek pointed out that it is important to minimize the content of resin forming materials which will foul the synthesis catalyst and are costly to remove, and also it is desirable to insure the conversion of sulfur in the coal to compounds in the gas of a type readily removed by conventional rough and fine purification procedures.

V. BRABAG-SCHWARZHEIDE LIGNITE BRIQUETTE GASIFICATION

In an attempt to accomplish the production of synthesis gas directly from lignite or non-caking bituminous coals Koppers started the construction of a unit in August 1935 for the gasification of brown coal briquettes in the Schwarzheide-Ruhland plant of Braunkohlenbenzin A.G. This unit involved carbonization and partial gasification of the briquettes by a recirculating stream of gas and steam heated in a Cowper stove to 1250°C. The heat requirements were met by converting the carbonized residue from the briquettes to fuel gas in a rotating grate convertor. The latter operation was successful only if the coke retained sufficient mechanical strength, and this was not always the case. Thus the problem arose of making fuel gas from the relatively fine char resulting from the crumbling of these lignite briquettes.

The original briquette gasification unit started operation in April 1936 and had a capacity of 25,000 m^3 of normal synthesis gas per hour to be used in the Brabag Fischer-Tropsch plant. The operation of this unit was stated by Totzek to be entirely successful and within one year the construction of additional units was begun to give a capacity of 4,320,000 m^3 of

synthesis gas per 24 hours. The consumption of briquettes was to be 3600 metric tons per day and the gas production was 1200 m^3 per ton. No report on the performance of this unit by American or British technical investigators has been found but a flow diagram was included in CIOS report No. XXVIII-36 Item 30 and is reproduced herewith as Figure 1, page 7. Koppers gave to the FIAT investigators a print of their drawing IOS 111 860 dated 29 July 1936 showing details of the Cowper stove and combustion shaft, presumably associated with this unit, but this drawing is not suitable for reproduction in this report. A drawing obtained by the U.S. Navy Technical Mission reproduced on Tech. Oil Mission Microfilm reel 188 section 36-U apparently relates to the same unit but is difficult to identify with certainty.

VI. BRABAG-SCHWARZHEIDE COKE DUST GASIFICATION

In 1938 an experimental unit was set up at the Brabag Schwarzheide plant to study the production of fuel gas from finely divided lignite coke. The design of the reaction chamber used in this unit is shown by Figure 2, page 8, taken from Koppers drawing IOS 92,915. Another Koppers drawing, IAK 112,745, shows the general arrangement of the Schwarzheide powdered coke unit but is not suitable for reproduction in this report. The following comments on the performance of this unit are essentially a translation of statements by Totzek in answer to the FIAT questionnaire.

"The Brabag reaction chamber was intended to give an accentuated relative motion between the gas and coke particles. In a powdered coal burner part of the coke was to be burned in admixture with steam. At a second point additional powdered coke was to be introduced and agitated with the hot flue gas mixture to reduce the flue gases and steam. The results were unsatisfactory. Only about 30% of the coke was gasified and the rest settled out in the dead spaces. The heating value of the gas was only about 800 kcal/m^3."

"Instead of using powdered coke in the burner, butane from the plant residue gas was burned with the hope of reducing the resulting combustion gases with coke dust. This was based on the following reasoning. In the combustion of coke dust the principal product is CO_2. Steam is admixed cold and reduces the temperature considerably. However in the combustion of butane considerable water vapor is produced in addition to CO_2 and at a higher temperature level. The results of operation with butane fuel were somewhat more favorable. However, continuation of experiments along this line did not seem advisable since even here extensive conversion of the added coal dust was not obtained."

"In order to completely gasify a particle of coal dust it is necessary for the gasifying atmosphere to have a certain relative motion and furthermore the path through which the particle travels must be sufficiently long so that the particle is brought to reaction temperature and is then