work was not certain; the laboratory does not operate on a fixed budget, but special appropriations are made as occasion requires.

The laboratory of R.W.K.S. - The laboratory (fig. 1), which is at Syndikatstrasse 3, Essen, was completed in 1936. The main building is of four stories, each of which contained 15 to 20 rooms or laboratories. It is estimated that bomb damage (fig. 2) destroyed 60 percent of the structure, and only the ground floor, which housed the heat-technology department, the sample-preparation room, and laboratories for physical testing of coal and coke, was in use at the time of inspection. Constructional details, floor plans, and photographs of some of the laboratories have been published in two articles.6/7/

In the laboratories for physical testing of coke and coal, most of the equipment was standard. The Micum drum test for coke is accepted as standard, although provision was made to use the ASTM shatter test and the Wolff pressure test. Neither of these tests has wide acceptance in Germany. The Nedelmann drum test was used for determining strength of small experimental samples of coke. A new test was being investigated for determining hardness of coals. The equipment was a sheet-steel cylinder about 20 centimeters in diameter and 50 centimeters long, which was charged from one end and then closed. The cylinder was supported midway by a trunion, and was rotated 180 degrees through a hand-operated gear drive at a speed characteristic of the individual making the test. Fifty such "up-endings" were made, allowing a certain fall of the sample and screen analysis of the product made. The results were reproducible if a single operator was used, and showed a decrease in hardness or strength of coals from anthracite to low-volatile (mager) coals to steam coals. It was recognized that further development was required to standardize conditions of test.

In the sample-preparation laboratory, a special roll crusher (fig. 3) was in use for preparation of coke samples for analysis, which could reduce 200 grams of coke, after being passed through a jaw crusher, to minus 60 mesh in 5 to 10 minutes. The roll and plate were manganese steel; the roll, weighing about 500 pounds, was moved forward and backward over the sample spread on the plate by a reciprocating drive. An illustration of the crusher is contained in reference 7.

An experimental coke oven of 150 kilograms capacity, with silica walls heated by gas, was available for studying the effect on coke quality of blending noncoking coals with Ruhr coals. The oven was 30 centimeters wide and about 1 meter long and 1 meter high. Top charging by hand was employed. The coke was pushed by machine into a water-cooled metal container, thus

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6/ Weidemann, Dr. F., Das feueringstechnische Laboratorium des Rheinische-Westfälischen Kohlen-Syndikats in Essen: Heizung and Lüftung, 1936, Heft 5, pp. 79-83.

7/ Radmacher, Dr., Das neue Chemische Laboratorium des Rheinisch-Westfälischen Kohlen-Syndikats in Essen: Die Chemische Fabrik, 1938, Heft 1/2, pp. 20-27.

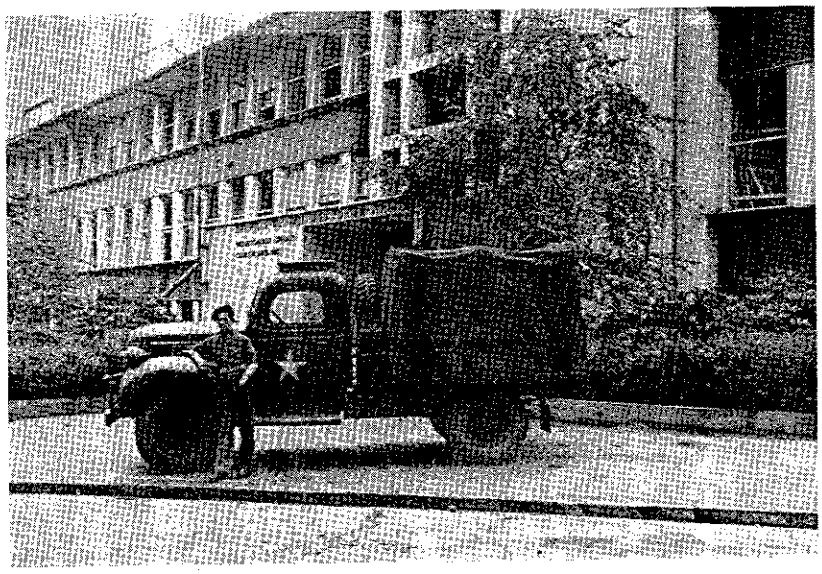

Figure 1. - Front entrance of laboratory of Rheinisch-Westfälisches Kohlen Syndikat at Syndikatstrasse 3, Essen, Germany. (Photo by H. J. Rose.)

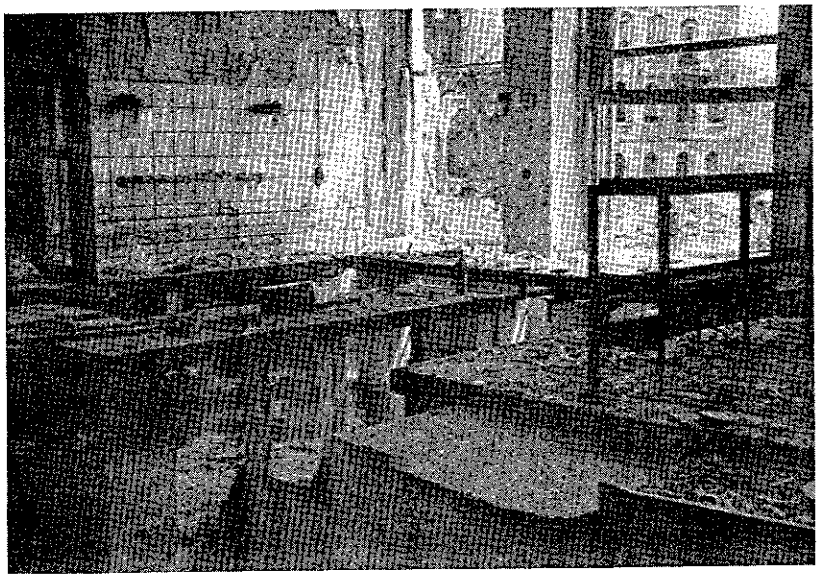

Figure 2. - Typical condition of individual rooms in laboratory of Rheinisch-Westfälisches Kohlen Syndikat at Syndikatstrasse 3, Essen, Germany. (Photo by H. J. Rose.)

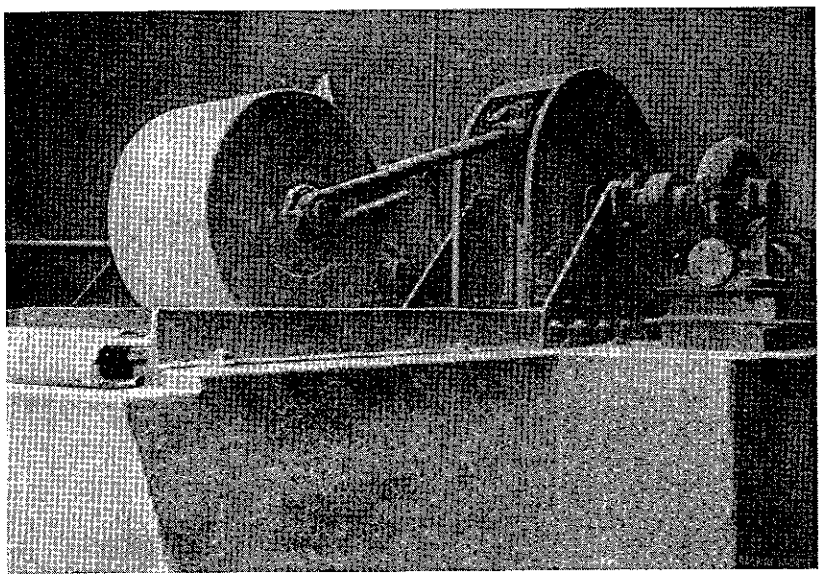

Figure 3. - Roll crusher used for preparing coke samples, laboratory of Rheinisch-Westfälisches Kohlen Syndikat, Syndikatstrasse 3, Essen, Germany. (Photo by H. J. Rose.)

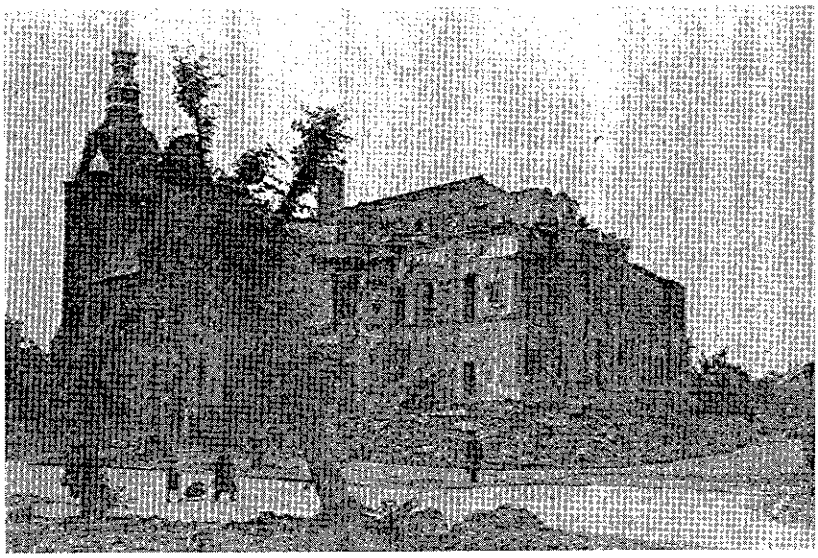

Figure 4. - Damaged office of Bergbau-Verein, Friedrich-strasse 2 (left), Essen, Germany. (Photo by H. J. Rose.)

avoiding quenching with water. Temperatures in the coke were measured by thermocouples and in the flues by optical pyrometers. With a flue temperature of 1,150° to 1,200° C., coking time was 24 hours. This was admitted to be too slow a rate for direct comparison with plant practice, but it was claimed that experience had provided the necessary conversion factors. The equipment had not been used for carbonization of dry or preheated coal. Byproducts were not collected. The equipment in general is much inferior to that built for similar studies elsewhere.8/

Pressures developed during carbonization of coal were measured by a gage designed by F. Ulrich. Experimental work with various coals in the small oven described in the preceding paragraph led to modification in design and full-scale tests at the Helene Steinkohlenbergwerk coke ovens of F. Krupp. The design is described and results of tests are outlined in a published paper.9/ The gage is massive, water-cooled, with the pressure exerted against a small diaphragm transmitted by glycerine to an indicating dial. Temperatures of the steel shell are measured by a thermocouple, and the gage must be withdrawn when the steel temperature reaches about 600° C. The gage seen at the R.W.K.S. laboratory was somewhat oval in cross section, about 3 inches in maximum and 2-1/4 inches in minimum diameters, and about 4 feet long. It required two men to carry it. Although discussion of the gage with other German fuel technologists indicated that the instrument was impractical owing to its obvious physical limitations, at R.W.K.S. it was stated that industrial interest in the gage was such that an instrument maker, Dreyer-Rosenkranz & Droop, in Hannover, had redesigned the gage for production, but had built only two or three before bomb damage made further work impossible.

Dutch-tile ovens (Kachelofen) for house heating received considerable attention during the war. Their construction was such as to require the minimum of steel. R.W.K.S. was especially concerned in its efficiency of fuel utilization in proposed designs and had the authority to stop the manufacture of those that did not meet standards of efficiency. Tests were made of rate of fuel consumption and flue-gas composition and temperature, but no direct observation was made of smoke density. An apparatus was available for recording Ringelmann smoke numbers. Heat absorption in the equipment was stated to be as high as 95 percent,10/ and at least 70 percent was required of wartime stoves. The methods of tests and typical results were described in publications.10/,11/

8/ Reed, Frank H., Jackman, Harold W., and Henline, P. W., Coke from Illinois Coals: Ind. Eng. Chem., vol. 37, June 1945, pp. 560-566.

9/ Ulrich, F., Bestimmung des Treibdrucks einer Kohle in der Ofenkammer: Gluckauf, Heft 6, 1939, pp. 128-133.

10/ Wiedemann, F., and Schaeffer, H., Steinkohlen in Kachelgrundofen: Das Kachelofen, Heft 12, 1942, pp. 1-8.

11/ Schaeffer, H., Steinkohlen in Kachelgrundofen: Das Kachelofen, Heft 5/6, 1940, pp. 17-23.

Studies were made also on conversion to other solid fuels of domestic heating appliances designed for anthracite.12/

Beginning even before the war, a shortage of the smaller sizes of coal, which in earlier years had been surplus, led to studies of crushing larger sizes of coal with production of a minimum of fines.13/, 14/, 15/

The R.W.K.S. laboratory would appear to have been well on the way to becoming one of the most important centers of coal research in Germany, particularly with its association with the Verein für die Bergbaulichen Interessen (Bergbau-Verein). Wiedemann stated that the Bergbau-Verein had only research problems for future developments, whereas all problems originating with current coal consumers were handled by R.W.K.S. This was not concurred in by Bergassessor Wüster of the Bergbau-Verein. Although covered in separate reports, it may be stated that the Bergbau-Verein had absorbed the Gesellschaft für Kohlentechnik. It was stated that cooperation was not at the organization level, but at personal levels. However, it may be mentioned that the experimental work of Dr. W. Lange of the Gesellschaft für Kohlentechnik on production of organic acids by oxidation of coal were carried out in the laboratory of R.W.K.S.

FUEL RESEARCH AND TECHNOLOGY, BERGBAU-VEREIN, ESSEN-HEISINGEN16/

Conclusions

The Bergbau-Verein and its group at the Gesellschaft für Kohlentechnik form an important center of coal research. Its connections throughout the coal industry make it a most important source of information on developments in coal research and technology. Bergassessor Wüster is very cooperative, speaks English well, and helped materially in arranging interviews with fuel technologists of industrial and other organizations. Temporary quarters were used after heavy bombings (figs. 4 and 5.)

Organization and work of Bergbau-Verein (including Gesellschaft für Kohlentechnik). - In the various lists of targets, the Bergbau-Verein and the Gesellschaft für Kohlentechnik are shown separately. However, the Bergbau-Verein acquired all the equity in the Gesellschaft für Kohlentechnik

12/ Wiedemann, F., Über die Umstellung häuslicher Anthrazit-Feuerstätten auf andere Brennstoffe: Heizung und Lüftung, Heft 10, 1940, pp. 358-362.

13/ Wiedemann, F., "Die Verlagerung im Sortenproblem des Steinkohlenbergbaues" Archiv fur Warmewirtschaft und Dampfkesselwesen, Heft 5, 1938, pp. 113-116.

14/ Wiedemann, F., and Lenhart, K., Über die Verbreiterung der Brennstoffgrundlage bei der Planung von Dampfkesselanlagen: Die Wärme, Heft 13, 1940, pp. 1-6.

15/ Lenhart, K., Untersuchungen über die Vorzerkleinerung grober Steinkohlensorten für Dampfkesselfeuerungen: Elektrizitätswirtschaft, Heft 11, 1941, pp. 186-193.

16/ Prepared from Combined Intelligence Objectives Subcommittee report "Fuel Research and Technology, Bergbau-Verein, Essen-Heisingen," by H. H. Lowry and H. J. Rose, 1945. (C.I.O.S. No. XXXI-25, Item No. 30, Solid Fuels No. 22).

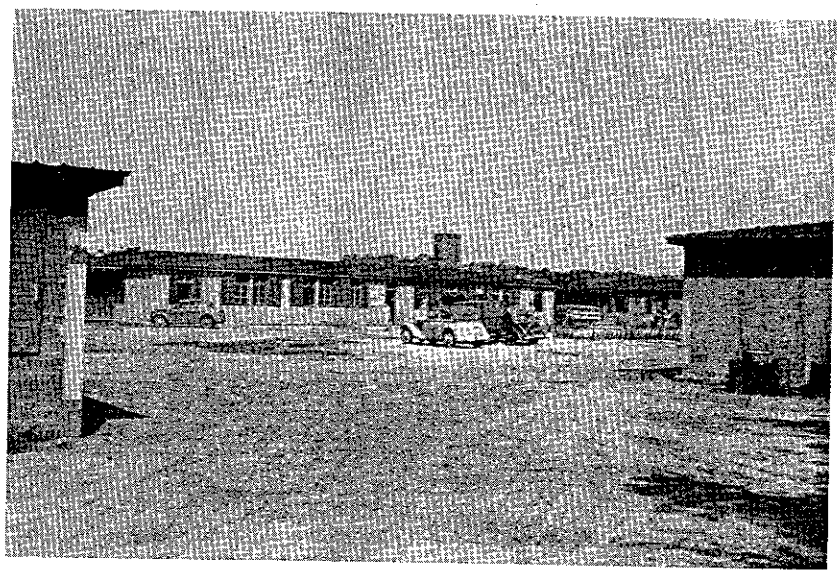

Figure 5. - Temporary quarters of Bergbau-Verein at Essen-Heisingen, Germany. (Photo by H. J. Rose.)

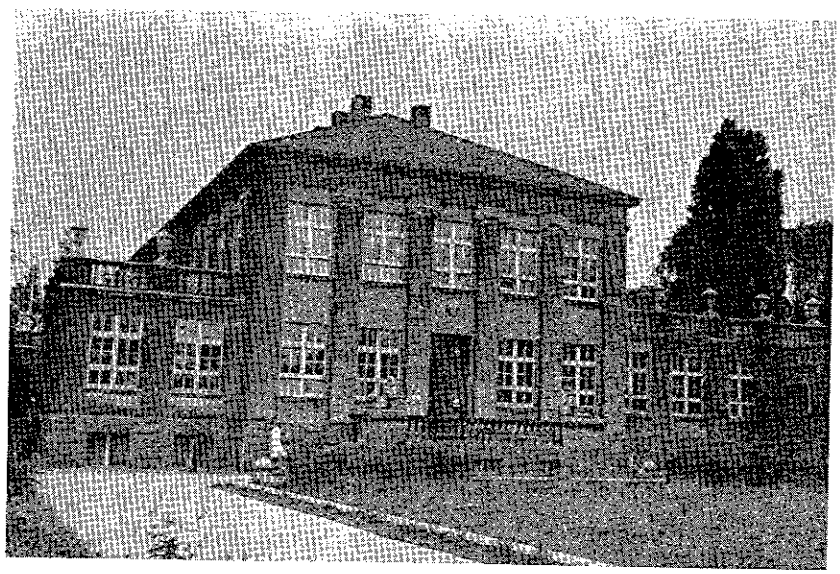

Figure 6. - Kaiser Wilhelm Institut für Kohlenforschung, Kaiser Wilhelm Platz 1, Mülheim, Ruhr, Germany. (Photo by H. J. Rose.)

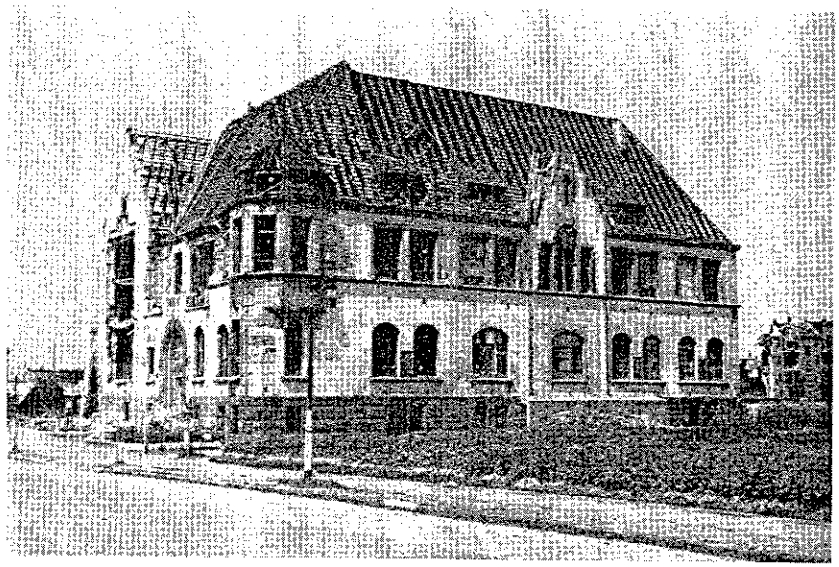

Figure 7. - Gesellschaft für Kohlentechnik, Dortmund-Eving, Germany. (Photo by H. J. Rose.)

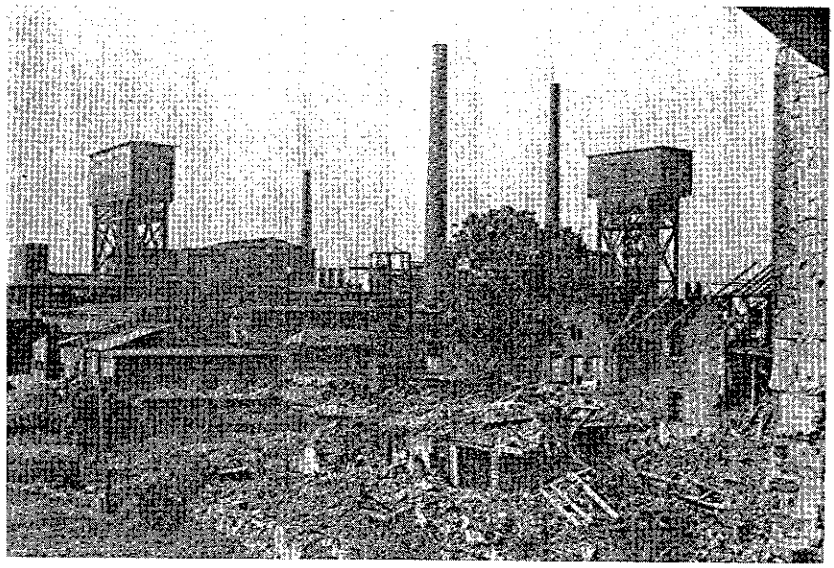

Figure 8. - Minister Stein colliery as seen from library of Gesellschaft für Kohlentechnik, Dortmund-Eving, Germany. The extensive library and records of the research laboratory were said to have been evacuated to a mine in this colliery. (Photo by H. J. Rose.)

on January 1, 1941, and it is not feasible to discuss the activities separately. The following report is based upon notes made from outlines prepared by Wuster for Lt. Col. Starr, British SHAEF G-4 Solid Fuels RCD 4, Essen-Heisingen, and on notes taken during interrogation of personnel.

The Bergbau-Verein receives its support from the mines in the Ruhr in the form of a royalty of four pfennigs per ton of production. From 30 to 35 percent of the income is spent on research (from the mines' point of view) on practical objectives. Long-range fundamental research, from the purely scientific viewpoint, is carried out at the Kaiser-Wilhelm Institut für Kohlenforschung (fig. 6), whereas the Rheinisch-Westfälisches Kohlen-Syndikat does research for customers only. The research work previously done by the Verein für Uberwachung der Warmewirtschaft zur Ruhrzechen on combustion and carbonization is now carried out by the Bergbau-Verein and R.W.K.S., whereas responsibility for inspection, safety, and boiler acceptance tests, formerly held by the Verein für Uberwachung, has been extended from the coal industry to all industry under the Technischen Uberwachungs-Verein, Essen. The Westfalische Berggewerkschaftkasse in Bochum had been active in chemical and physical coal research. Dr. F. K. L. Kuhlwein is at present working for Bergbau-Verein; Dr. P. Kukuk, well-known geologist of the Ruhr, does require chemical assistance, which is furnished by the chemical laboratory of the Berggewerkschaftkasse, which otherwise does little research. Studies have been made by Drs. Reerink and Grosskinsky and their associates of the Bergbau-Verein with the object of planning a combined research institute for coal utilization and coal refining, which would provide facilities for experimentation on both laboratory and experimental-plant scale.

Department for coal refining and utilization. - This department at Dortmund-Eving (fig. 7), is headed by Dr. Ing. W. Reerink, and the planning is done jointly with Dr. Grosskinsky, chief chemist and manager of the Gesellschaft für Kohlentechnik, with the assistance of committees on Raw Coal Research, Briquetting, Coal Preparation, Thermal Refining, Chemical Refining, and Coal Utilization.

Coal cleaning and petrography. - Dr. Kuhlwein is in charge of work on coal cleaning and petrography. This work was carried out at Bochum until bombing necessitated its withdrawal to the Clausthal Mining School. The team includes five qualified assistants - Drs. Krupe, Abramski, Riener, Makowsky, and Notzold - and six other assistants. Their work has been mainly concerned with the following programs:

1. Development of processes for producing very clean coal for carbon electrodes, etc. The principle of dense-medium separation followed by froth flotation, as used at Zeche Koenigin Elisabeth (Mannesmannrohren-Werke A.G.) in Essen-Frillendorf, is patented in Dr. Kuhlwein's name.

2. Dry-cleaning of fine coal by electrostatic methods, which was being studied on a small scale at Clausthal, on an intermediate scale at Zeche Osterfeld (Gutehoffnungshütte A. G., Oberhausen), and on a commercial scale at Zeche Koenigin Elisabeth. Drs. Schnitzler and Stieler of Metallgesellschaft

A. G., Frankfurt-Main, have also been in Clausthal working on more general applications of the process.

The electrostatic process is at present only capable of treating coking coals, but recent work had shown that coals of both higher and lower rank are more amenable if oxidized at 110° C.

3. Recovery of coal pyrites from washery refuse. Ten plants, consisting either of standard jigs or of high-speed pulsator jigs, had been installed in the Ruhr, where the maximum output of pyrites from this source was 12,000 tons in 1943. About 50 percent of the pyrites present was recovered as a product that met the specification: Sulfur, 42 percent; carbon, 6 percent; moisture, 4 percent. The process cost was 15 to 20 marks per ton.

4. Coal survey and seam registry. It was not possible to make much progress during the war, although the information would have been very useful. The methods involve the use of physical-petrographic techniques as well as chemical procedures. Cooperation is maintained with the laboratories of the Westfälische Berggewerkschaftskasse and the R.W.K.S.

5. Improvement of coking coal. There has been no recent progress with this program, which involves mainly the separation of the petrographic constituents.

Dr. Meyer is in charge of large-scale tests of new coal-preparation techniques, including the following colliery projects for producing very clean coal:

1. Carl Alexander (Gewerkschaft Carl Alexander) at Baesweiler near Aachen. Froth flotation followed by treatment with acids.

2. Koenigin Elisabeth (Mannesmannröhren-Werke A. G.) at Essen-Frillendorf. Heavy-medium separation, froth flotation, electrostatic cleaning.

3. Auguste-Victoria (I. G. Farbenindustrie) at Hüls. Froth flotation.

4. Beuthen Ober-Schlesien. Acid treatment.

Projects 1 and 2 were actually operated; 3 and 4 were not completed.

Briquetting. - Work on coal briquetting is under the supervision of Dr. Meyer, who has associated with him Dipl. Ing. Müller, and is done largely at the laboratories and plants of the collieries and equipment manufacturers. There are several objectives, such as improvement of the quality of the briquets, standardization of test methods and briquetting presses, and improvement, hygienically, of working conditions. A problem of immediate concern is the matter of supply of suitable binders.

They have investigated briquetting dry 0.1 mm. bituminous coal at 80° C. without a binder at pressures up to about 5,000 atmospheres in laboratory

tests. They are of the opinion that this process is justified only for production of small briquets for subsequent carbonization at low temperatures, to be used as fuel in automobile gas-generators. Conventional briquets made with pitch binder after carbonization are not as dense, hard, and suitable for this particular application. It was claimed that the cost of briquetting without binder was about the same (3.5 to 4 marks/ton) as when using the usual 6 to 8 percent pitch at conventional pressures. Briquetting has been done at intermediate pressures with 2 to 3 percent sulfite liquor binder (dry basis) and then carbonized at 600° C. with good results.

Dr. Kuhlwein claimed that coals of about 13 percent volatile matter were best for briquetting without binder at high pressures. For making a briquet without binder, which is to be carbonized, it is very important to use the right mixture of coking (e.g. 50 to 70 percent) and noncoking coals to give hard, nonswelling briquets.

They said that Gutehoffnungshütte at Zeche Osterfeld in Osterfeld, north of Oberhausen (Ruhr), had an experimental briquetting plant employing the Ten Bosch process without a binder on coal ground to 4,900 mesh per square centimeter (about 175 mesh per linear inch) at 2,000 to 3,000 atmospheres pressure. The G. H. H. had constructed a large unit for this process but it had been damaged by bombs and had been returned some months ago to the G. H. H. shops at Dusseldorf for repairs. It was intended for the production of briquets for automobile gas-generators.17/

Kuhlwein and Meyer referred to two types of Ringwalzenpresse. One is the original Apfelbeck press with a single groove for the coal being briquetted. The other type has two grooves and about twice the capacity. It has been developed cooperatively by Fried. Kruppgrusonwerke A. G., Magdeburg-Buckau; Lurgi of Frankfurt; and Herglotz Company of Falkenau near Carlsbad. It has been used without binder for brown coal at 1,500 to 2,000 atmospheres and with only 2 to 3 percent-pitch binder for bituminous coal.

A description of the Apfelbeck press and process has been published.18/

In the following table, obtained from Dr. Kuhlwein, the figures for the Apfelbeck process are from this paper by Holik, whereas the figures for the Ten Bosch process were supplied by Bergbau-Verein.

17/ Yancey, H. F., Hendricks, T. A., and Schmidt, L. D., Briquetting Bituminous Coal Without Binder at the Gutehoffnungshütte, Osterfeld, Ruhr: (Available from Office of Technical Services, Dept. of Commerce).

18/ Holick, J., Die bindenmittelfreie, Brikettierung nach Apfelbeck: Glückauf, 1934, vol. 70, pp. 385-93.

TABLE 1. - Comparison of coal and briquets by different methods of briquetting without binder

Kind of press	Apfelbach ring roll	Ten Bosch
Experimental coal	Rtanj	Alter Hellweg
Kind of coal	Fettkohle	Esskohle
Analysis of the prepared coal		
	Percent	Percent
Water	6.6	1.3
Volatile matter	23.2	14.5
Ash	13.8	10.2
Net calorific value		7419
Grain size, in mm.	About 3-0	Below 0.2 (10% over 178 mesh per linear inch)
Coking properties of the coal	Good, coke swollen and coked.	Noncoking
Working information on the presses		
Pressure duration, seconds	About 1	0.8
Briquetting pressure, atmospheres	1500-1600	4,500
Briquetting temperature of the coal, °C.	80-100	80-85
Specific power employed, kwh/t	7.5	About 35
Press output, tons per hour	5	2
Strength characteristics of the briquets		
Lever press strength, kg/cm^2	About 110	250
Bending strength, kg/cm^2	14-18	?
Compressive strength, kg/cm^2	?	40-50
Tensile strength, kg/cm^2	Up to 4	50-60
Trommel strength, percent	88-94	77
Water taken up after 4-1/2 months storage in the open during winter, percent	0.35 to 0.69	
Combustion behavior		
Ignition	Very rapid	Very rapid
Soot and smoke formation	None	None
Disintegration at high temperature	No	No
Degree of burning out	Good (3% unburned fuel	Burn out clean (0.8% unburned)
Clinker formation	None	None
Heating efficiency - useful heat as percent of heat in fuel	High	71.25