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INFORMATION CIRCULAR

REPORT ON THE INVESTIGATION BY FUELS AND LUBRICANTS TEAMS AT THE WINTERSHALL A. G., LÜTZKENDORF, NEAR MÜCHELN, GERMANY

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Reported by H. Hollings[1]

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1/ British Ministry of Fuel and Power.

FOREWORD

In the early part of 1945 as the Allied armies advanced, German laboratories and plants became available for investigation. Since German development work had been hidden from the eyes of the world by the Reich's national policy of secrecy, and by 5½ years of war, it was obvious that much might be learned from such investigation. In particular, this was true in the synthetic-fuel industries deriving oil, gasoline, and a wide variety of chemicals from coal, for owing to the scarcity of domestic petroleum, Germany had been forced into intense development of this field in contrast to the limited amount of similar development by the United States and Great Britain. Before the fighting ended in Europe, the United States and Great Britain organized teams comprised of experts in all fields to investigate the research and industrial operations in Germany. The teams investigating coal, oil, gasification, and allied chemical fields included more than 30 American investigators and about an equivalent number of British investigators during 1945, and functioned with a reduced staff into 1946. German work inthe synthetic-liquid-fuels industries and allied fields was on such a large scale that even such extensive investigation could not possibly cover the subject in all detail. However, a great deal of information possible of direct application, and much information of a fundamental nature to help guide research work in this country for many years was uncovered. Studies of the German industry are continuing, and it is hoped that such gaps in the information as now exist will be filled in by future work.

The primary fields that were covered in the oil and synthetic-fuels investigation were concerned with petroleum refining and the gas-syntheses and coal-hydrogenation processes for producing oil from coal. The related fields of coal gasification, oxygen production, alcohol manufacture, lubricating oil production, and the production of waxes and edible fats, as well as a variety of other chemicals, were an inherent part of the investigation.

This report is one of a series which resulted from the investigations in Germany and other parts of Europe by the Technical Oil Mission, operating under the auspices of the Ministry of Fuel and Power for Great Britain and the Petroleum Administration for War and the Bureau of Mines for the United States. It is being published in accordance with the policy of the United States Government to make available to the interested public the results of the investigations of enemy research and industrial development.

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INTRODUCTION

This report deals with the Schmalfeldt gasification plant for making synthesis gas, the Fischer-Tropsch plant, the hydrogenation plant and the catalyst factory, and includes a report on lubricating oil.

THE SCHMALFELDT GASIFICATION PLANT

The information was obtained on May 9 and 11, 1945, from Dr. Schneeberger (director), Dr. Schneider (director and power plant manager), Herr Dassau (manager of gas plant) and Herr Schultz (manager of Fischer-Tropsch plant). The plant was shut down as the result of very heavy air raid damage to other parts of the works.

The process consists of the gasification of brown coal in the entrained state. The designer, Dr. H. Schmalfeldt, lived at Lutzkendorf from the start-up in 1938 until 1940, and is now believed to be living in the Kassel area. Before this plant was built there had been an experimental unit at Rühlen, but so far as is known, there is no other large-scale installation.

The principles of the process are as follows. Brown coal was obtained from an open mine in the neighbourhood. Typical analyses were:-

As Received	
H_2O	50-54%
Ash	5-6%
Tar	4-5%
Total S	2-2.5%
Volatile S	1-1.5%
Calorific Value	2300-2400 k.cals per kg.

Dry Basis	
C	60%
H	4%
O	18-20%
S	3%
N	1%
Ash	12%

The tar content was rather low for brown coal, and so the coal was not well suited to the normal treatment (carbonization to produce tar for hydrogenation, with use of coke in Winkler generators and in boilers). The raw coal was elevated and crushed in hammer mills to below 20 mm., dropping into a raw coal bunker, from whence it was fed by Redler screw conveyors through star feeders into the side of the bottom of the gas drier. The contents of the bunker were kept under nitrogen pressure. Recycled synthesis gas and steam at a temperature of 1,000° C. flowed upwards in the gas drier (see Fig. 2), and the sudden heating of the raw brown coal caused it to dry and decrepitate, the particles becoming entrained. The gas leaving the drier was passed through a classifier where large lumps of coal were removed, to be crushed and returned to the drier. The gas next passed to a large cyclone separator, and was then divided into two streams, one of which constituted the synthesis gas make while the other was recycled. On each stream there was a small cyclone followed by a washer. The dry coal dust separated in the cyclones was used in the gasifiers (gas generators) and in the producers. The recycled synthesis gas was passed to a hot generator where it was heated to 1,300°C., and then passed through two gasifiers or generators in series, to complete the cycle by entering the drier. Dry coal dust was injected into the top of the first generator and was gasified.

The heat of reaction was originally supplied by burning producer gas in one of two regenerators, used alternately, the heat being stored in chequer brick until given up to a mixture of recycled synthesis gas and steam. The gasification plant was intended to supply synthesis gas for the Fischer-Tropsch plant (designed to produce 75,000 tonnes of crude oil per annum), but later a hydrogenation plant was added (designed to produce 50,000 tonnes per annum) and the gas requirement was increased. In order to make more gas, additional heat had been introduced by adding oxygen to the recycled gas. The original designed output per gasifier unit (considering the two generators in series as one gasifier unit) was 20,000 cubic meters per hour (measured at 0°C. and 760 mm.), but in fact the output obtainable without the use of oxygen was only 15,000 cu.m. per hour. When using oxygen, the maximum output was 30,000 cu.m. per hour, although more usually 20-25,000 cu.m. per hour were made.

The producer gas was made by gasification of entrained dry coal dust, but there was no recycling of gas or use of oxygen. Air, steam and dry coal dust were fed into a tower, and the sensible heat in the exit gases was abstracted by waste heat boilers. The maximum output of a producer was 30-35,000 cu.m. per hour.

The plant consisted of four gasifier units each, as shown in Figure 2, and five producers, and usually one of each was out of action for cleaning. The plant was very spacious considering its capacity, although it was made up of relatively simple pieces of equipment. The four gasifier units (2 generators, 2 regenerators, drier, with stocks and washers) occupied an area of about 100 m. x 30 m., the vessels being 20-24 m. high. The gas boasting house was outside this area, while the producers occupied a separate site. Figures 1A and 1B show a rough layout and arrangement of a synthesis gas unit, while Figure 2 is a diagrammatic representation of the flow. Figure 3 is a photograph of one end of the synthesis gas plant. Figure 5 is a rough layout of a producer gas unit, and Figure 6 is a flowsheet for producer gas. The individual items of plant will now be considered in turn.

The gas drier was a vertical brick-lined chimney, 1.2 m. internal diameter and 22 m. total height. The crushed raw brown coal dropped into the drier without any conveying gas, at a point 15 m. below the top of the drier. Two inlets were available, one working and one spare; each was steam-heated to prevent sticking of the coal, but was brick-lined near the drier itself. The feed pipe was at an angle of about 30° to the vertical. No special mixing of coal and gas was attempted; the high turbulence of the gas, which had just passed through a bend of about 2.5 m. radius of curvature, together with the explosion of each particle, was sufficient to give good mixing. The final temperature at the top of the drier was 200-300°C. At full output, the dry gas rate entering the drier is calculated to be about 90,000 cu.m. per hour, so that taking into account the steam present, calculated as 91,500 cu.m. per hour, the average gas velocity in the drier

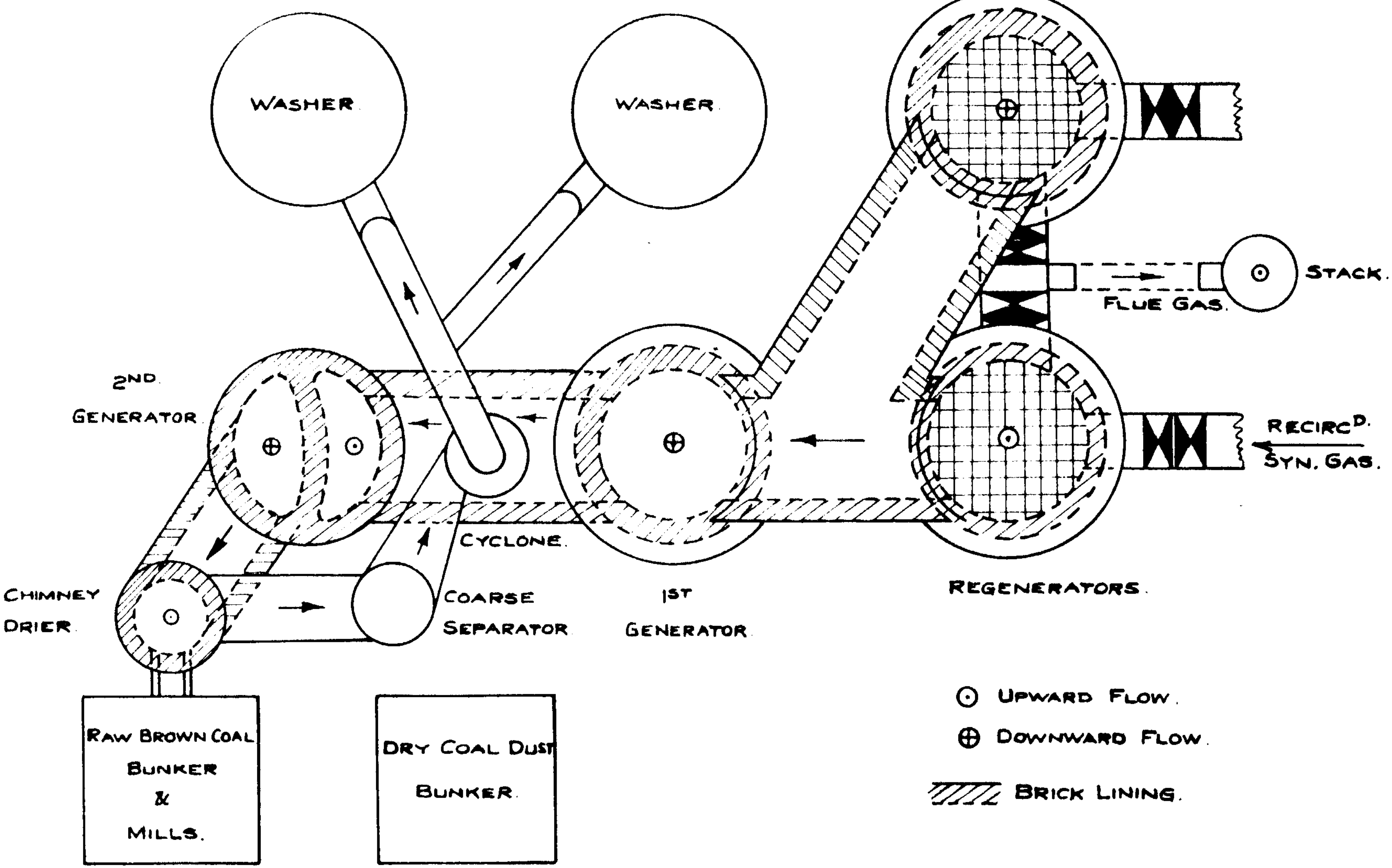

FIG. 1A. PLAN VIEW & ROUGH LAYOUT OF SYNTHESIS GAS UNIT.

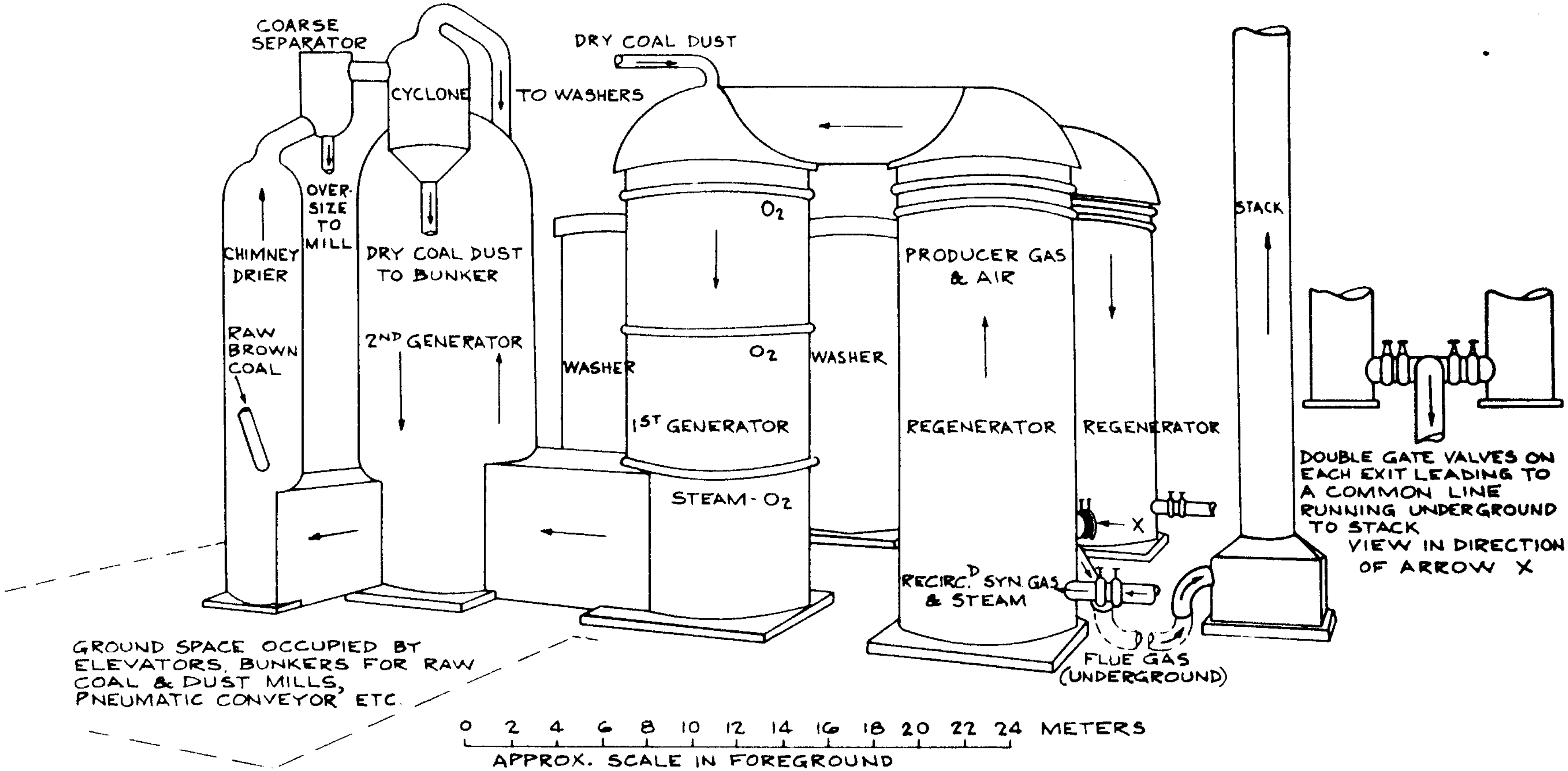

FIG. 1B.- SYNTHESIS GAS UNIT (SIMPLIFIED BUT ROUGHLY TO SIZE-BUNKER BUILDING SHOWN REMOVED).

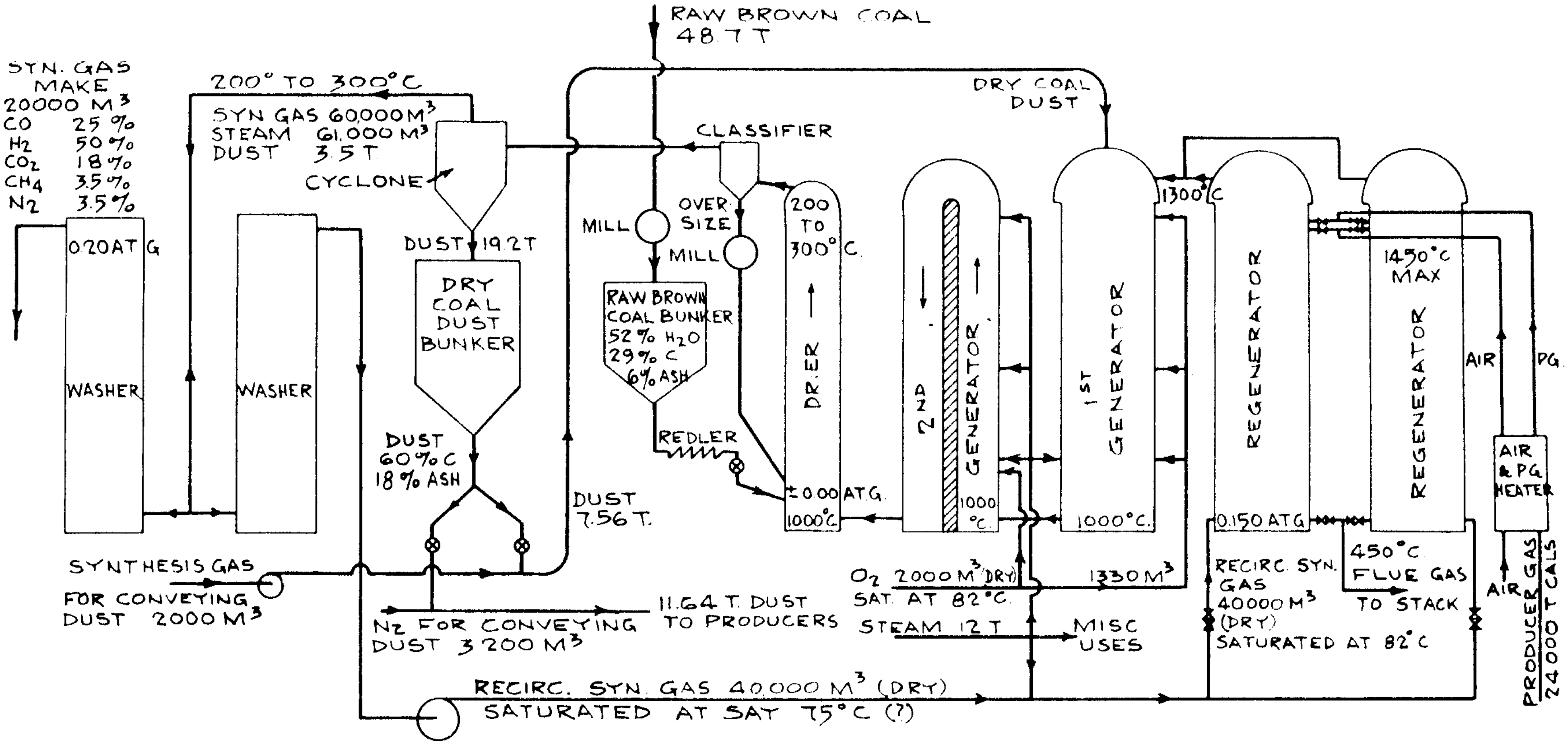

FIGURE 2: FLOWSHEET FOR SYNTHESIS GAS UNIT MAKING 20,000 M^3/HR. - MAX. OUTPUT 30,000 M^3/HR.

Figure 3. - One end of the synthesis gas plant.

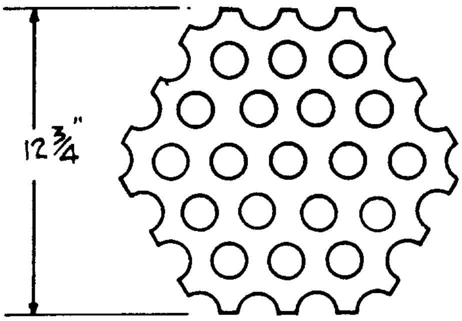

FIGURE 4A.- PLAN OF DIDIER BRICK FOR REGENERATORS.

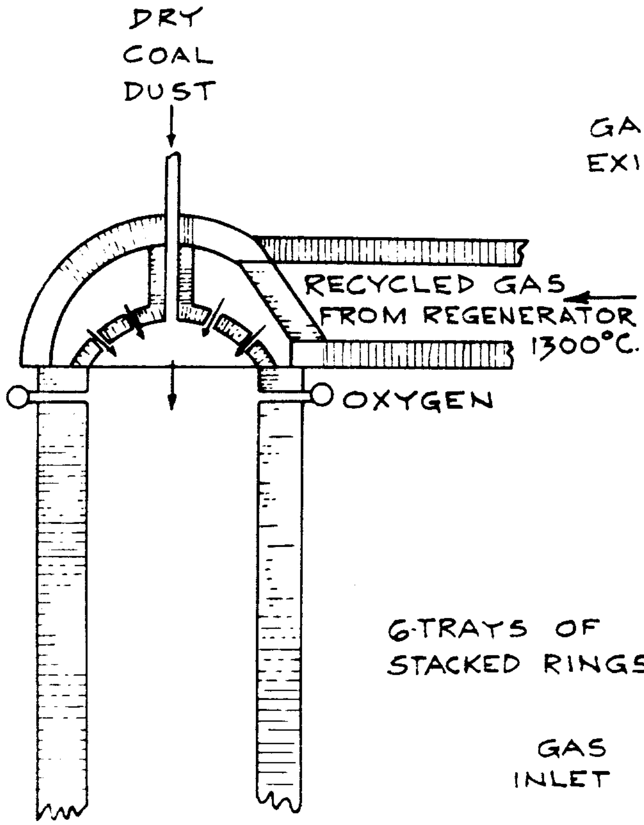

FIG. 4B.- TOP OF FIRST GENERATON (SECTION)

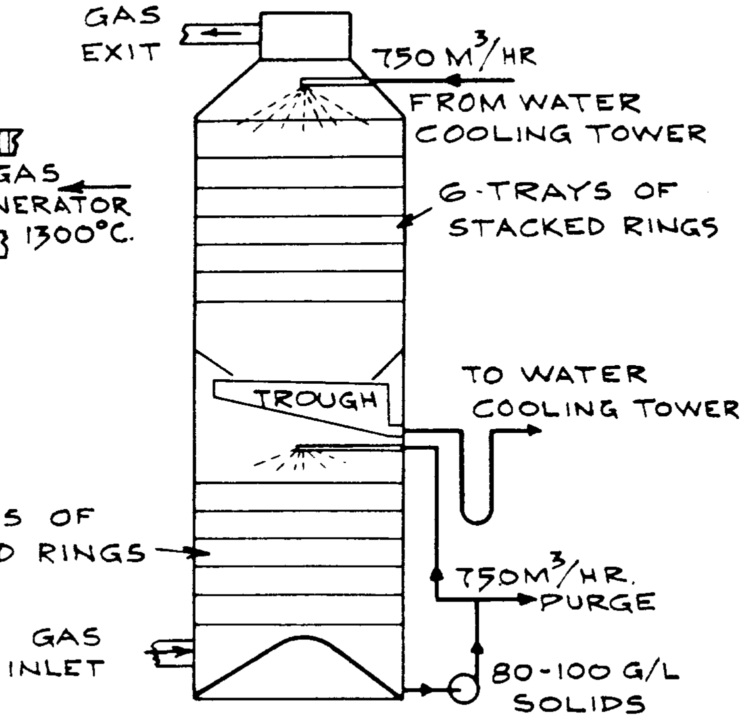

FIG. 4C.- SECTION OF WASHER.

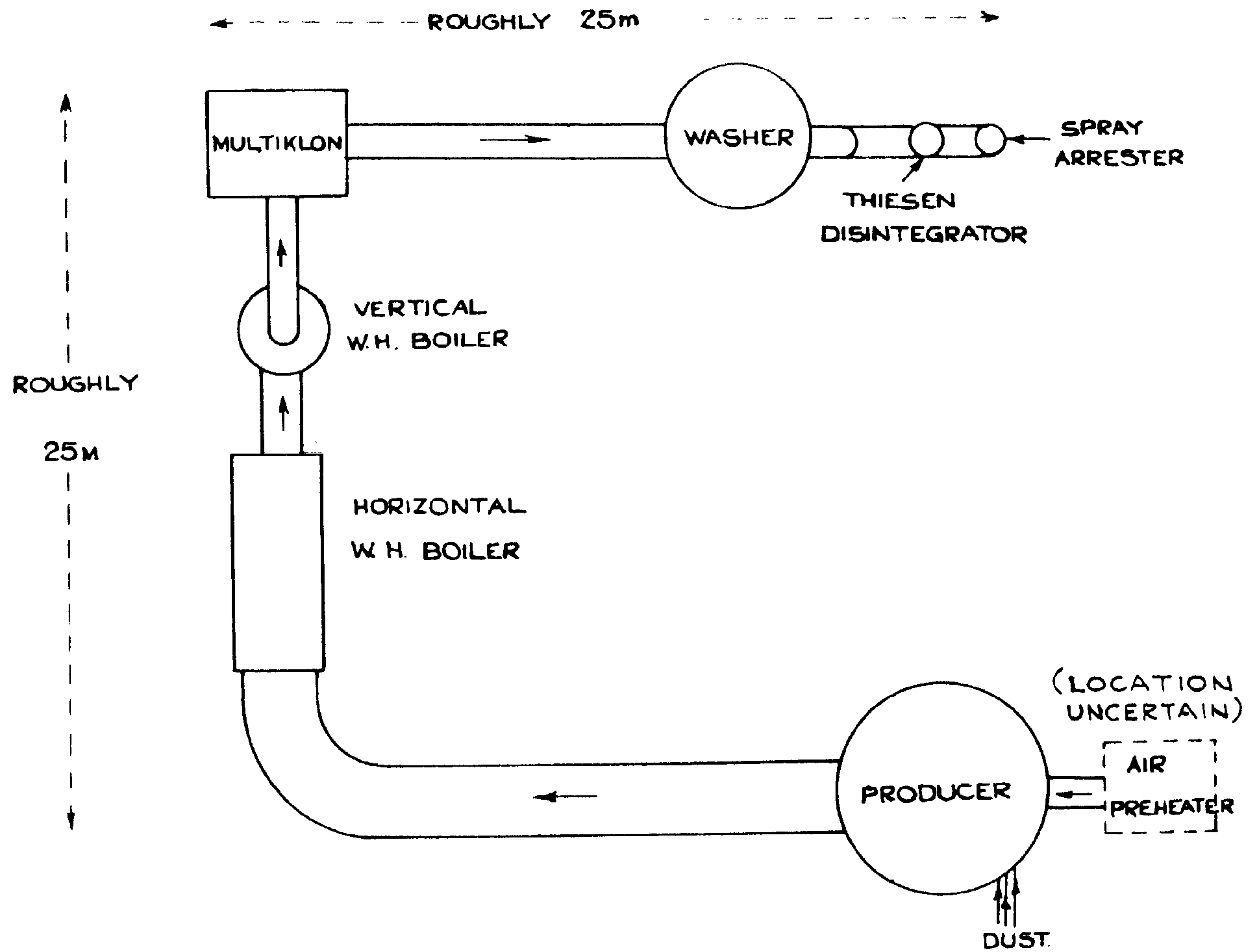

FIG 5 ROUGH LAYOUT OF RRODUCER GAS UNIT

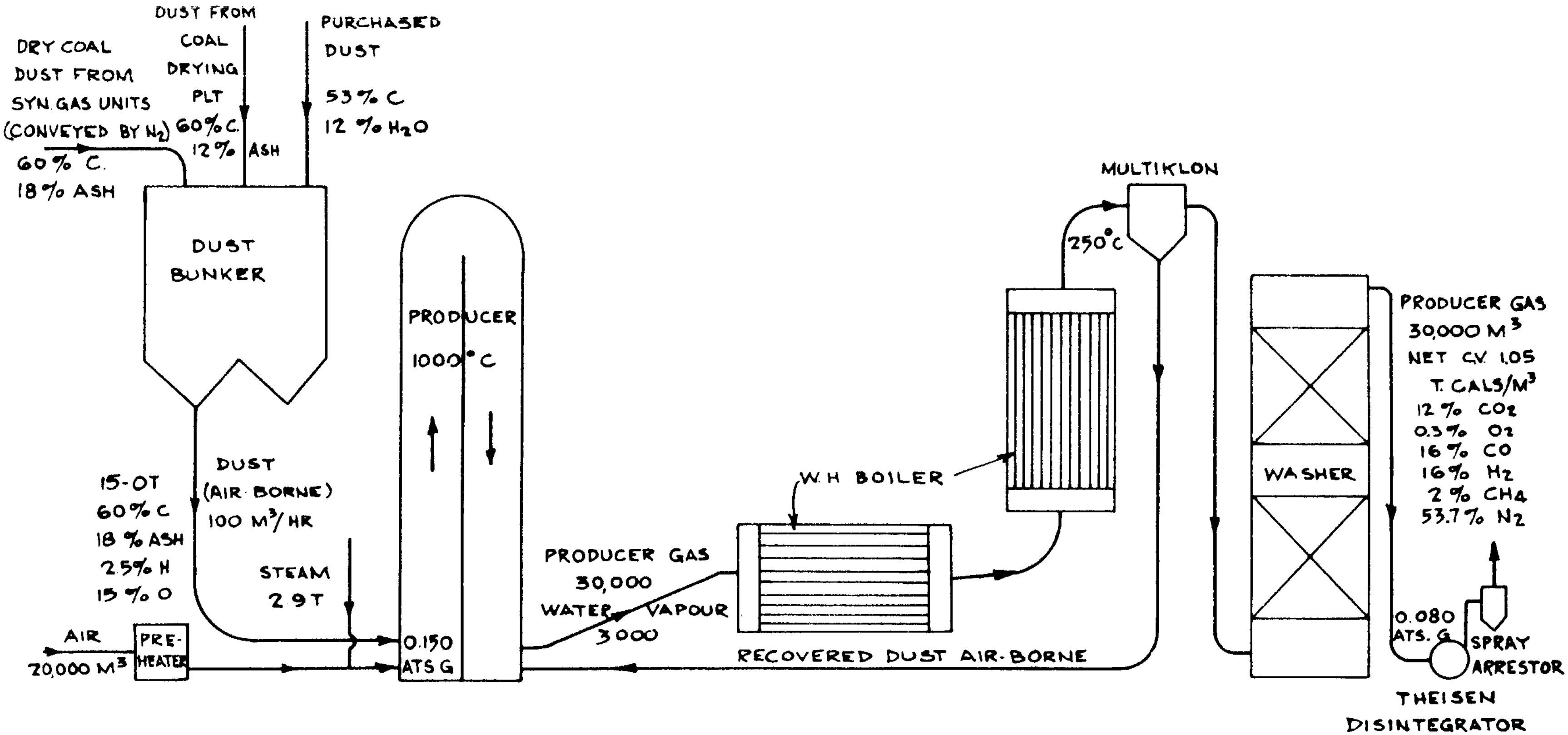

FIG. 6. FLOWSHEET FOR PRODUCER GAS UNIT

was about 100 m. per second, the time of drying being 0.15 seconds. Usually the velocity was about 70 m. per second, and the time of drying 0.20 seconds.

The synthesis gas and dry dust mixture leaving the top of the drier passed through a rough classifier, where any large pieces of coal were separated. These were sent to a separator hammer mill and returned to the drier. The gas then passed through a cyclone to effect the main separation of dust. It was stated that the dust concentration of the wet gas leaving the drier was 150 g. per cu.m., but it is calculated that it should be nearer 200 g. per cu.m. It is also calculated that the dust content of the gas entering the washers was about 20-30 g. per cu.m., so that the overall efficiency of the two cyclones in series was about 85 to 90%, indicating a loss of 10-13% of the carbon in the raw coal as slurry from the washers. In 1942 it had been planned to install Multiklons to reduce the dust content of the gas to 6 g. per cu.m., but this project had not been carried out.

The dry coal dust contained 18 to 20% of ash and 60% carbon. The ash content was higher than that of dry raw brown coal because the dust contained nearly all the ash remaining from the gasification of the dust fed to the generators. The carbon content was however the same, presumably because some oxygen and hydrogen were given up in the drier. There was of course a large ash purge from the generator system in the sending of dry coal dust to the producers. No figures were available for the grading of the dust. The dust from the cyclones fell into a bunker, at the bottom of which were star feeders, passing dust into pneumatic lines working on the ejector principle. Nitrogen was used for conveying dust to the producer gas bunkers, and synthesis gas for conveyance to the generators. This conveying synthesis gas, amounting to about 10% of the make, in effect recirculated through the generator system. Rather more dust was sent to the producers than to the generators, the exact proportion depending on output.

The regenerators were brick-lined towers, 7.1 m. ext. dia. and 5.5 m. int. dia. by 24 m. high. Two were provided for each gasifier unit, and they were changed over automatically every 11 minutes. The design was obviously based on that of air preheaters for blast furnaces. The towers were filled with chequer of high quality brick, such as sillimanite or silica, to a depth of 17-18 m. Two designs of chequer had been tried; one was a Brassert type and the other, which had given better results, a type made by Didier of Berlin. The Didier type known as Schieffer-Strack consisted of hexagonal blocks, about 12-3/4 " across and 7" deep, each having about 20 1-1/2" dia. vertical holes spaced at 2-3/4" centers. A plan view is shown in Figure 4A. These bricks were carefully stacked so that the holes came into line. The lining bricks were well finished, so that the minimum amount of cement was used. It was stated that there was no trouble due to dust deposition in the chequer and that the bricks withstood the conditions very well. No figures were available for the dust content of clean producer gas or recycled synthesis gas.

Preheated air and producer gas were fed into the top of the regenerators through ring mains. Flue gases left the bottom of the regenerators and entered on underground line, common to the two generators, leading to a stack; no waste heat boiler was used but it was intended to install one.

Recyclod synthesis gas, saturated with water vapour at 82°C., entered the bottom of the regenerator and left it through the cupola at the top at 1,300°C. on its way to the first generator. The maximum brickwork temperature was 1,450°C. at the top; the average exit flue gas temperature was 450°C. Double isolation valves were used on each flue gas and recycled gas line, with the portion between the valves automatically vented to atmosphere when the valves were shut. The isolation valves on the air and producer gas were not seen, but may also have been double. Details were not obtained of the method of isolating the top of a regenerator while heating it on alternate cycles; it is possible that no valves were used, reliance being placed on pressure control to prevent more than a slight flow of synthesis gas into the regenerators. At first there had been trouble with erosion at the top of the cupola, but this had been cured by constructional changes aimed at making the linear velocities of the gas in the cupola and off-take pipe more nearly equal.

The first generator was a brick-lined vessel, 5.5 m. int. dia. by 24 m. high. The special design of the cupola, with its false roof, is shown in Figure 4B. Dry coal dust, conveyed by synthesis gas at 2-1/2 atm. pressure, was fed down through a passage in the center of the cupola. The hot recycled gas and steam mixture from the regenerator was fed through ports in the false roof. Oxygen, saturated at 82°C., was introduced from ring mains through ports near the top and middle of the generator; near the bottom steam as well as oxygen was admitted to avoid slagging. The temperature fell from 1,300°C. at the top to 1,000°C. at the bottom.

The oxygen was supplied by three Linde-Fränkl units, two working and one spare, each producing 4,000 cu.m/hr.

The second generator was a brick-lined vessel, 5.5 m. int. dia. by 24 m. high. On three units it was divided internally by a vertical wall, but on the fourth (and latest) unit it had no such division wall. The division wall was shaped as shown in Figure 1A, the two portions having approximately the same area of cross section. In the unit with no division wall the gas was brought down to the bottom of the drier by an external pipe. One third of the total oxygen used was added near the bottom inlet of the generator, while steam was added as required at various points, the aim being to maintain the temperature at 1,000°C. It was stated that the division wall was not necessary; the unit without it worked just as well. It was further stated that the second generator was not needed at all except for high outputs, such as were obtained by the use of oxygen.

From the data given, it is calculated that the gasification period (time of contact of coal in generators) was 4.5 seconds at 30,000 cu.m. per hour, and 6.0 seconds at 20,000 cu.m. per hour.

Each unit had two washers, one for recycled gas (50-60,000 cu.m. per hour) and one for synthesis gas (25,000 cu.m. per hour). The washers were the same size and were fed with water at the same rate, despite the differences in gas load. A typical arrangement is shown in Figure 4c. Each washer was about 6 m. diam. by 22 m. total height. The washer was divided into two sections with separate water circulation systems, each section being packed with 6 trays of stacked 80 mm. spiral Raschig rings. About 750 cu.m. of water per hour were circulated through the bottom section to remove the bulk of the dust. A purge was taken from this system to keep the concentration of solids at 80-100 g. per liter. 750 cu.m. of water per hour were circulated through the top section and through a water cooling tower. The high water rates were necessary to prevent choking the packing with dust; but at each six monthly shut-down the rings were removed and washed, the work on 8 washers for the generator plant and 5 washers for the producers providing continuous employment for 14 day men.

The gas pressure at the bottom of the regenerator was 0.150 ats. gauge. Since the pressure at the point of entry of coal into the drier had to be kept very close to atmospheric, to prevent gas leaking back up the coal feed pipe, the drier and washer had to be run at a pressure below atmospheric. The pressure at the top of the washers was - 0.020 ats. gauge.

There were 5 producer units, each making at most 30,000 to 35,000 cu. m. of producer gas per hour, although normally making less. Each unit consisted of the producer followed by waste heat boilers, Multiklons, washtower and Theisen disintegrator. The producer was a brick-lined tower, 5 m. int. diam. by 24 m. high, with an internal division wall, very similar to the second generator. Dry coal dust was blown into the bottom of the tower with steam and air, the mixture passing up one side and down the other. The maximum temperature reached was 1,000°C. The gasification time was about 11 seconds when making 30,000 cu.m. per hour. The dry coal dust (18% ash, 60% C) was conveyed from the generator units to a bunker by means of nitrogen, but it was conveyed from the bunker to the producers by means of air. About 15 tonnes per hour were conveyed by 1,000 cu.m. of air per hour, through three pipe-lines each of 125 mm. int. diam. Assuming atmospheric pressure, this corresponds to a velocity of 7.5 m. per second and a dust content of 15,000 g. per cu.m. It was also stated that the dry coal dust fed to the producers amounted to 0.5 tonnes per 1,000 cu.m. of producer gas. Gases from the producers passed through a horizontal and a vertical waste heat boiler in series, which reduced the temperature to 250°C. Erosion at the inlet of the first boiler limited the running time of a unit to six months before overhaul. Multiklons followed the boilers, and the dust recovered was blown back by compressed air into the bottom of the producer.

The wash tower was 5-5.5 m. int. diam. by 22 m. high, filled with ordinary 2" Raschig rings. In design it was very similar to the washers on the synthesis gas, but the water rate was only 500 cu.m. per hour. It was said to be too small and to pass too much dust. A Theisen disintegrator removed most of the remaining dust, and after passing through a spray arrestor, the gas was pumped into the factory fuel gas system. The amount of gas used for heating a single gasification unit was 24,000 cu.m. per hour, consisting of 3,000-4,000 cu.m. of rest gas from the Fischer-Tropsch plant (2,400 Kcals/cu.m.) and 21,000-20,000 cu.m. of producer gas (1,075 Kcals/cu.m.)

The pressure was 0.150 ats. gauge at the bottom of the producer and 0.080 ats. gauge before the Theisen disintegrator.

Three of the boilers installed in the power plant could use only dry coal, and a plant fired by coal and producer gas was installed to provide this dry coal. This plant was also used to a certain extent to supply dry