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GERMAN CARBON ELECTRODE MANUFACTURE at GRIESHEIM (I. G. F.)

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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

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GERMAN CARBON ELECTRODE MANUFACTURE AT GRIESHEIM (I.G.F.).

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PERSONNEL OF TEAM

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1. OBJECT OF VISIT

The I.G.F. Carbon Electrode Factory at Griesheim (a suburb of Frankfurt, A.M.) was visited on 19/20th September, 1945. It was a "target of opportunity" selected as a result of information obtained during visits to other Factories.

2. INTRODUCTION AND SUMMARY

(a) The inspection was made by members of the Team which was investigating alumina and aluminium production in Germany. This field included the manufacture of the pre-baked anode and cathode blocks and Soderberg paste carried out in ancillary buildings. It was learned that some Reduction Works obtained some of their carbon blocks from Griesheim, so arrangements were made to investigate the part of the process carried out there which related to this supply. The Carbon Factories directly associated with Reduction Works are covered by the Report dealing with these later; but it seems more convenient to describe this Griesheim Carbon Factory separately.

(b) This Report deals with the raw materials, plant and process for the preparation of the paste which is used for all the Griesheim carbons. It includes a description of an interesting self-firing calciner. The Report also covers the pressing and baking operations for large sections, and includes a description of the largest extrusion press there. This Team did not investigate the plant and process involved in the manufacture of small carbon electrodes and sections.

3. PERSONNEL INTERVIEWED.

Dr. Engelbertz (Manager); Dr. Peter (Process Superintendent); Dr.-Eng. Gesses (Chief Engineer).

4. BOMB DAMAGE

There had been very extensive bombing at Griesheim, but the buildings and plant concerned with carbon manufacture did not seem to have been materially affected. Some of the processes were in actual operation at the time of our visit.

5. GRIST PREPARATION

(a) Raw Materials. The following cokes are used as the raw materials; pitch coke; petroleum oil coke; shale oil coke; and specially treated brown coal cokes known under the names of Baessweiler and 'S coke'. The two last-named cokes are a fairly recent development in German industry. They are manufactured by flotation and/or acid treatment, with, we understand, in one case the addition of pitch before coking. They are characterised by ash contents of 0.9% down to 0.6%.

(b) Preliminary Crushing. The coke is hand-shovelled from rail-trucks to a jaw crusher and reduced to 30 mm. in size in the older train; and in the case of the more recent train reduction is effected to 15/20 mm. in a "three-high claw" mill. This mill takes the form of three fixed-arm hammer mills mounted one above the other, with clearances between the spider arms and the body of the mill decreasing progressively. This crusher was supplied by Klocker Hambold, Deutz, of Cologne, and it was stated that for crushing oil and pitch coke this form of mill required less power and made less dust than the jaw crusher installed in the older train.

The coke is fed to the calciners to a given level from overhead bunkers fitted with segmental feeders. Each type of coke is separately bunkered so that mixtures of coke can be charged to the calciners in the correct proportions and with a view to the overall volatile content.

(c) Calcination

(i) Description of Plant. Two calciner houses were seen, the first containing three calcining units - two for pitch and oil cokes, and one for anthracite - installed in 1937, and the second containing six units for the calcination of pitch coke and oil coke, and installed in 1941 and 1942.

The calciners themselves were supplied by Reidhamer, of Nuremberg, and the conical water-jacketed discharge hoppers sub-contracted to Klocker Hambold, Deutz, of Cologne, and in principle both installations are the same and consist of groups of ovens, each group consisting of six vertical muffle cells working as a unit. Essentially each muffle consists of an oval-shaped fire-brick chamber measuring approximately 5 metres high x 160 cm. x 40 cm., fitted at the top with a charging hopper (directly sited beneath the segmental feeder outlet of an overhead bunker) and offtake pipes for the gas evolved from the coke during calcination, and at the bottom with a conical water-cooled mild steel discharge equipped with a rotary discharge table (drum type in the latter installation) for feeding the calcined material on to a plate conveyor. Each muffle is surrounded by gas-burning flues, the flues of the six muffles comprising a calcining group being arranged in parallel. The gas offtakes from the top of each muffle are led to a main and then introduced to the gas-burning flues at the top of the calciner system together with pre-heated air, piped from a recuperator system below the calciners. The burning gas then follows a downward zig-zag path from top to bottom of the calciners, and is finally passed through the air pre-heating recuperator before being exhausted to atmosphere through cyclones and a wet washer.

Suction on the calciners is provided by a 30 metre high chimney and this is sufficient without any additional pressure boosting of the gas. The only precaution necessary to maintain the draught is that periodically it is found necessary to clear out the gas escape ports at the tops of the calciners.

(ii) Dust Precipitation. The calciners in each house are provided with a dust precipitating unit, these units being separate and distinct from the Lurgi electrostatic precipitator serving the remainder of the process. The calciner precipitators each take the form of two cyclones followed by a wet washer, and the efficiency of these cyclones and wet washers was stated to be 98%, although it was admitted that the discharge effluent dust from the stack could be seen clearly. The precipitated dust is thrown away.

(iii) Method of Operation. Calcination is carried out whether the cokes are of high or low volatile content. With the calciners described above trouble ensues if the volatile content of the coke to be calcined exceeds 10%, owing to the binding and consequent withdrawal difficulties of the coke within the calciner, and therefore high and low volatile content cokes are mixed. Additionally, there is the insurance that even allegedly low volatile-containing cokes do, in fact, contain only a small amount of volatile matter before being fed to the further processes. In this connection stress was laid on the desirability of attaining uniformity in the volatile contents of the cokes to be processed. As an example of the above, Baessweiler coke (brown coal coke), which by normal standards would not require calcination, is mixed with pitch or oil coke so as to give an over-all mixture with a volatile content of less than 10%. In the event of only high volatile-containing cokes being available then previously calcined material is used as a diluent, and any excess gas still then available is used for steam raising elsewhere; and conversely, if only low-volatile cokes are on hand, insufficient in gas content to effect self-calcination, then means are available for introducing a supplementary supply of coal gas from the Ruhr Grid main. (This supplementary gas supply also provides a means for starting up of the calciners).

The calcination loss is that to be expected theoretically, i.e., the loss amounts to the moisture and volatile contents of the coke as charged.

Given sufficient volatile content in the coke, the calcination process operates at 1200°C., is self-supporting, and is worked continuously. The volatile content of the cokes after calcination was given as .3% maximum, and the output was stated as being at half-a-ton per hour for each calciner group of six muffles.

Temperature measurements during the calcination process are made by direct reading high temperature bulb thermometers inserted through sight holes built into the body of the calciner. (Thermometers of this type are well-known in Germany, and one was evacuated from an Aluminium Reduction Works and is being reported on separately).

There is no doubt that the calciners were looked upon as efficient and easily-worked units, and that in the event of greater calcining capacity being required at Griesheim further units of the same type would be installed.

No repairs had been necessary during the first five years of operation, and thereafter only minor repairs to the linings of the muffles. Four prints giving details of the calciners were evacuated.

(d) Grinding Plant. The grist production plant consists essentially of two pairs of roll crushers, several sieving machines, a fine grinding pendulum-type mill and a Lurgi electrostatic precipitator plant. All the plant appears to have been supplied by Klocker Hambold, Deutz, with the exception of the electrostatic precipitator and the pendulum mill.

The rolls of both the coarse and fine roll crushers were of size 80 cm. long x 40 cm. diameter. Normally the rolls on both crushers have plain surfaces, but for the coarse crusher rolls with serrated faces have been tried. We understand, however, that little advantage was to be obtained from these serrated faces as compared with the plain faces. Rolls were made of manganese steel, and the nominal setting for the distance between rolls was:- for the coarse crusher, 8-10 mm.; for the fine crusher, 1-2 mm.

The output capacities from these roll crushers, and on the types of coke processed at Griesheim, were given as follows:- Coarse crushing, 5/6 tons per hour; fine crushing, 2/3 tons per hour.

The screens were of the double-deck type and were vibrated mechanically. The following meshes were in use:- 3, 1, .5, .3 and .2 mm. It was stated that they found the screening below .2 mm. to be inefficient on a production scale.

We were told that they had little trouble with wear on the coarser steel sieves, but that with the finer sieves made of bronze occasional replacements were necessary on account of fatigue failures. It was also mentioned that, in order to reduce the wear and to obtain greater accuracy of sieving, all sieves had been enlarged from the supplied size of 2.7 M x 1.1 M. to 4 x 1.5 M.

The fine grinding mill was of the air-swept (classification) pendulum type and was supplied by Meumann and Essen, of Aachen. Although we understood wear-and-tear on this mill was high, we were told that it was considered a satisfactory unit, bearing in mind the duty, and that it consumed less power, had a greater capacity, and produced a more uniform product than a ball mill. Questioned on the point as to whether their comparison of a ball mill against a pendulum mill for the production of fines was on the basis of actual experience with both types, the reply given was that this was so, and that the ball mill used was of the short barrel type. It was confirmed that the ball mill used was not of the multi-stage tube type.

The following working details were given for the pendulum mill:-

Power consumed	27 KW. for the mill itself and 15 KW. for the air classification unit.
Output	500/600 Kg. per hour when fed with pitch/oil cokes of sizes 3/5 mm.
Size of product	96% less than .1 mm. and of this 80% of less than 60 μ 4% between .1 and .2 mm.

For the collection of dust, multitudinous offtake ducts from the various items of plant were first led to four cyclones arranged in series which preceded a Lurgi precipitator. This dust precipitating plant was stated as having an overall efficiency of 99.8%, and it was said that the effluent dust was the merest haze. The cost of the dust-collecting system, including the ducting, was given as 45,000/50,000 Marks.

(e) Processing Procedure. The grist production procedure for the plant described above is that the coke from the calciners is delivered to the first roll crusher via plate conveyors and bunker and table feeder, of feed size 15/20 mm. or 30 mm., depending on whether the coke emanates from the old or from the recently installed calciners. The product from the first pair of rolls is passed through the various sieves enumerated above - the oversize from the first 3 mm. sieve, which is mostly 3/5 mm. in size, being either returned to the mill or passed on to form the feed for the second roll crusher or for the fine grinding mill. The undersize is separated into the various fractions by the remaining sieves and bunkered for ultimate re-compounding into the final grist. Similarly, the product from the second pair of rolls passes through the same series of sieves and the various fractions obtained bunkered in one or other of the five bunkers fed by the screens. The product from the fine grinding mill is fed as discharged (without screening) direct to the sixth bunker, together with the dust collected by the electrostatic precipitator plant.

For grist compounding, therefore, six fractions as follows are obtained:-

a. 1-3 mm.
b. 0.5-1.0 mm.
c. 0.3-0.5 mm.
d. 0.2-0.3 mm.
e. Pass .2
f. 96% Pass .1

and the next stage in the process is the drawing from the six bunkers of the various grist fractions in weighed amounts according to the recipe for the final grist for the particular type of electrode to be produced. Each of the six hoppers is equipped with its own weighing machine and is fitted with motor-driven inlet and outlet valves of the slotted drum type to allow steady flow of the material. The weighers are nowadays manually operated, although previously attempts have been made with automatic weighing devices. Automatic weighing, however, was found to be too complicated to be worth-while. The wieghing machines discharge into a 400 Kg. -capacity travelling hopper via a quickly-fastened canvas jacket which acts as a dust seal, and the travelling hopper is then hand-operated along a rail track to a mixing room. Discharge of the travelling hopper to the mixers is by means of an overhead crane.

6. BINDER

Soft pitch was employed for the larger type of electrodes, whether of the pressed or extruded kind. Specification of the pitch was as follows:-

S.P.	50° - 55°C. (K. & S.)
Coking residue	35 - 50%
Solubility in benzole	25 - 30%
Solubility in anthracene	12 - 13%

An additional empirical test is to coke the material insoluble in benzole, and then to examine this visually for structure. For a good pitch, a fine-pored structure is expected - contrariwise, the structure with coarse pores is taken as indicative of a poor binder. This test was one agreed upon some two years ago as the result of the pooling of the experiences of the Association of Carbon Electrode

Manufacturers and in their endeavour to standardise tests for binders. The test was not found to be 100% infallible at Griesheim but we were told that, generally speaking, they had come to look upon it with favour. For smaller carbons, such as brushes, binders with a somewhat lower softening point were used, and they were compounded from pitch and tar, sometimes with the addition of anthracene oil.

7. MIXING

Four mixers of the tilting Werner Pfleiderer type were seen. All were electrically heated and were equipped with 'Sigma' blades. It was confirmed that Griesheim had no experience with blades other than of the 'Sigma' type.

Large side dust offtake ducts were fitted, and as seen on similar mixers at other German Carbon Factories.

After mixing, the green mixture is discharged into a steam-heated hopper, and is then either carried direct to the extrusion plant tamping machine, or, if it is to be made into pressings, is lifted by crane to a second steam-heated vessel equipped with a table feeder serving a 60 Kg. auto-weigher.

8. PRESSING

The weighed green mixture is next passed on to the table of the three-container "Hydraulik" press supplied by Wien. The press is of the fixed anvil floating cylinder type, and is capable of pressing blocks of cross section 30 x 30 cm. and with a pressure of up to 1200 atmosphere. Pressing is single-ended and follows the normal cycle of filling, pressing, and discharging.

We were told that, in the case of anode blocks for Aluminium Reduction Factories, the shapes of the block head and of the contract recess were made to the particular whim of the customer. The anode blocks actually seen were approximately 14" deep, were dome-topped, and equipped with screw-type contact recesses. It was noted that the screw recesses were not undercut. The extraction of the die head was by means of a hand block and tackle, although the blocks themselves were fully discharged and were swept from the table on to roller conveyor by means of a hydraulically-operated arm swinging horizontally across the table. The rotation of the press table itself was accomplished electrically.

9. EXTRUSION

(a) Description of Press. The range of extrusions at Griesheim extends from dry-battery carbons to electrodes of 14" diameter. They have a number of presses of both horizontal and vertical type. The largest is a horizontal press of 2,800-tons capacity, though they had on order at the time of the German collapse a vertical 5,000-ton unit of which part of the foundation work had been done. We confined our attention to the 2,800-ton horizontal press, which we saw at work on some small sections.

The motions of the press are hydraulic. It was made by Eumeco, with Ardelt, of Berlin, as sub-contractors for the tamping gear. It provides (a) continuous preliminary tamping during filling; (b) pre-pressing; (c) extrusion; (d) cutting off.

There are two electrically-heated containers which traverse independently and tilt from vertical to horizontal. In addition, they can float against hydraulic "springs" in the direction of the axis of the press. These containers measure 800 mm. internal diameter and 1.8 m. long, to hold a normal charge of 1,050 Kg. Over them is a structure in which are two filling funnels. This structure which is itself mounted on rail-tracks on the floor to permit its complete removal for repairs or servicing to the main press, carries the tamping machine, which can traverse from one funnel to the other to permit the alternate filling of the containers. A movable pressure plate is provided in front of the die entry to allow for pre-pressing.

The die is electrically-heated, and, of course, can be changed to suit the section. The discharge runs on to a roller conveyor over sliding plates, and there are flying shears. There is no provision for for cooling the extrusions, but they told us that they had planned to instal water sprays.

(b) Operation of Press The mixture is brought from the Werner Pfleiderer mixers by bucket hoist to a steam-heated hopper which runs on gantry rails fixed to the roof above the tamping platform. The discharge is off-set to feed under the body of the tamping machine into the filling funnels. (They planned eventually to feed the hopper by belt elevator conveyor direct from the mixers). The mixture temperature at this stage is 90°C.

A little of the mixture is dropped into the container through the funnel to form a preliminary footing, and then the tamper is adjusted. This tamper is a complicated piece of apparatus, electrically driven, working on the "lazy pile-driving" principle at about 60 strokes per minute with a travel of 6" to 8". It also rotates at about 4 r.p.m. The head of the tamper weighs about a ton, and the tool itself is composed of a ring with harrow teeth arranged radially, alternately in pairs and triplets.

The mixture is added continuously over about ten minutes, tamping being carried on all the while. When all the mixture is in, the tamping tool is lifted by an idle rope clear not only of the container but the filling funnel also, so as to allow the whole tamping gear to traverse and serve the opposite container.

The containers are worked at a temperature of 80° internally though temperature is gauged by outside thermometer. As soon as it is full, the container is swung to the horizontal and traversed to the axis of the press, with the pre-pressing plate down in front of the die. A pre-pressing pressure of about 100 tons is applied, and under the influence of this the container floats to bear hard against the pressure plate, and the pressure is held for a minute or so. This pressure is released and the main ram withdrawn. The container floats back and allows the pre-pressing plate to be swung up clear. All is then set for the extrusion operation.

The total extrusion pressure varies with the sections, the smallest taking up to 300/400 atmospheres. For the full-size section of 14" they use a pressure of the order of 300 Kg. per cm^2.

The die is electrically-heated to a temperature 10/20° above the container - again measured by outside thermometer. Generally speaking, no lubrication is used, although sometimes a little oil is added to the mixture when small and difficult sections have to be made.

As the section comes out of the mouth of the die, it picks up the moving plate and is carried on to the conveyor. The flying shears are operated to cut the lengths needed. We saw the extrusion of a small triangular section with a 3" side and a central hole, which was to be used for a tram bow collector. It was noted that normally this section would be made in a smaller press, but the advantage of this particular installation was its adaptability to a wide range of sections.

We were told that extrusion was carried to within 1 cm. of the end of the container, and that all mixture remaining in the die was left in place and pushed out by the next charge. Care was taken to cut the extrusion at the joint, and all the old mixture was "scrapped", i.e., removed and taken back for re-mixing.

They design their own dies, and have been doing so for twenty years. It was admitted to be a matter of experience rather than theory. They have the die rough cast by an outside Firm - usually Eumeco - in steel, and then dress it up themselves.

There was no wide departure in the preparation of a mixture from normal anode paste practice, but they have been trying to reduce porosity by the use of binders treated with organic chlorides. They also reduce porosity by impregnating the baked section in hot tar and then re-baking. They claim that by this means they can get down to 12/13%.

10. BAKING

Both extruded and pressed electrode blocks are baked in a sunk ring furnace in muffle cells measuring 5' x 2'9", with dome-shaped heat-resistant refractory lids covering each group of four cells. The furnace was fired by producer gas, derived from brown coal briquettes, to a temperature of 1250/1300°C. The firing cycle is three weeks. Petroleum oil coke was used as a packing powder and a suction apparatus was installed for moving powder out of the cells on discharge.

APPENDIX 1.

Testing Methods.

We were told that the following routine tests were used:-

On the Green Mixture

(a) Density; (b) examination of polished sections to ascertain the distribution and arrangement of the various grain fractions.

Samples for this test were polished under water with polishing powder.

On the Baked Product

(a) Density; (b) porosity; (c) crushing strength; (d) electric (d) electrical conductivity.

APPENDIX 2.

SCREEN ANALYSES OF PITCH COKE FINES FROM PENDULUM MILL

	Fraction No:	Size	Kgms. Percentage
1.	1 - 2	0.3	4.5
2.	2 - 5	2.15	32.0
3.	10 - 20	1.40	21.0
4.	30 - 40	0.90	13.5
5.	40 - 70	1.70	25.4
6.	60 - 90	0.10	1.5
7.	Circa 100	0.05	0.8
8.	150 - 250	0.085	1.3

Whilst elutriation apparatus was not available at Griesheim, investigations into the size distribution and particle shape of the combined pendulum mill and electrostatic precipitator products had been undertaken by microscopic examination.

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