Item #2
Ammonia-Laboratory Oppau
Dr. Sachsse Laboratory report #1662
July 27, 1941

The Removal of Carbon Black and Dust from Gases with the Oppauer Shaft-filter

Summary--

In connection with the process for the manufacturing of acetylene from hydrocarbons by an incomplete combustion with oxygen applying a flame, the problem arose of how to liberate the obtained split gas from carbon black. The content of carbon black is between 100 and 500 mg. per. cu. m. It was requested to treat the warm gas near its dew point at 80°C. in order to preserve the water vapors which are present in the gas and which shall be utilized for the following reaction of the gas, i.e. for the conversion of the acetylene into acetone.

The problem was solved by an arrangement which is filled with a packing material (coke or pumice stone) and through which the gas to be purified is passed. The packing which adsorbs the carbon black is continuously discharged at the bottom of the shaft, refreshed and fed in at the top of the apparatus. Experiments of different scale carried out with the filter proved its adaptability. The same design could be successfully employed for the purification of split gases which originated from the splitting of coke oven gas by means of oxygen using a shaft kiln and a nickel catalyst. Since the experiments have been finished and since the shaft filters will be employed for commercial purposes it seems appropriate to submit a detailed report of the experiments. Dipl. Ing. Altsaecot was in charge of the design and the construction of the filter. Dr. Bartholome and Dr. Moritz contributed to the performance of the experiments. The author is indebted to chief engineer Lampe for helpful advice.

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Known purification Methods

Experiments were made to extract the carbon black from the gases by means of known methods. Even if the experiments did not solve the problem the results will be mentioned. The experiments were carried out with the following types of gases:

1) Split gas from acetylene burners.
2) Split gas which was obtained when hydrocarbons containing gases were subjected to an incomplete combustion by a deficiency of air or oxygen. The burned gases all immediately led over a nickel catalyst at temperatures of 1000°C. in order to obtain a gas mixture free from hydrocarbons which serves for synthesis purposes.

Both of the two gases contained 100 to 500 mg/m³ of carbon black. The carbon black of the acetylene split gas contains higher amounts of empyreumatic substances which hinder the wetting due to a more rapid cooling of the gases, whereas the carbon black of the Synthesis gas is of a graphitic nature. The removal of both kinds of carbon black was equally difficult.

a) Water wash, Theisen-scrubber

By scrubbing with water it was possible to extract the coarse particles of the carbon black but at least 100 mg. per m³ of the undesirable carbon black remained in the gas. Hot water has a better efficiency than cold. The best efficiency is obtained if the water is carefully distributed in the gas by injecting it by means of Schlick-jets. At the same time, the gas should be cooled causing a partial condensation of the water vapors which are present in the gas. With high amounts of carbon black present in the gas, a pretreatment with hot water is recommended. For the final purification, Theisen-washers were employed. Two Theisen-washers were connected in series, the output was approx. 80 m³ per hour of gas. Scrubbing was performed by means of hot water near the dew point of the gas. The content of carbon black in the gas after the first washer was 50-70 mg., after the second one 10-20 mg per cu. m. An addition of "Nekal" to facilitate the wetting of the carbon black particles did not improve the purifying effect. The efficiency of a Theisen-washer is unsatisfactory and its power consumption is too high.

b) Bag-filter

A bag (made of wool? cotton?) 15 cm. wide and 2.50 m. long was inserted into a small filter box and 15 m³ per hour acetylene split gas at a temperature of 95-105°C. was passed through the filter. The dew point of the gas was 83°C. The purifying effect was very good (not more than 1 mg. of carbon black in the treated gas), but the durability of the bag did not exceed 8-14 days. Experiments which were carried out in the acetylene factory of Merseburg showed that the high water vapor content of the gas was responsible for a certain degree of hydrolysis of the wool (cotton?). The experiments were therefore abandoned because it seems to be impossible to purify gas containing water vapor by means of bag filters. But as shown later on, even if dry and cooled gases are purified the bag-filters are inferior to the shaft-filters with respect to the space required and to the installation costs.

c)

Electric precipitation, Lurgi process

Questions concerning the electric precipitation were discussed with the Lurgi staff at Frankfort. Lurgi submitted an offer for the purification of 4700 cu. m. gas + water vapor. According to recommendations made by

Table #1
Operation Data

	Gas vol. cold cu. m./m^2/hr.	Actual gas vol. cu. m./m^2/hr.	Actual veloc. of gas cm/sec.	Ht. of layer m	Size of packing	Pressure loss mm water col
Catalytic hydrogen	870	4500	125	3	3-10	400-800
Hydrocarbon conversion by oxygen using a shaft kiln	1100	8450	235	4	20-30	1000
Oil " " air	1520	10,000	280	4	20-30	1000
F-coal desulphurization	360-600	400-700	11-20	1,2	1-2	80-300
Desulphurization	20	20	0,5-0,6	0,40	2-4	30
Dust boxes	45	45	1,25	0,10	1-2	10-20
Sirka shaft filter	800	930	26	4	2-8	200-300

the Lurgi experts it is advisable to operate the electric filter near the dew point of the gas and to condense simultaneously as much water vapor as possible by injecting cold water. Nevertheless the filter must be shut down from time to time and be flushed with water. Lurgi was by no means sure that a good purification effect would be obtainable and proposed to carry out full scale experiments. Due to the investment costs which were supposed to amount to 35,000-40,000 RM we decided to abandon the electric method.

d) Dust chambers, outputs of packed containers

At Oppau gas purification is already carried out by the application of the so called "dust chambers" just before the F-coal-desulphurization. Table #1 contains figures of the output of the dust chambers and for other packed containers. The removal of carbon black and dust is better with smaller particle sizes of packing and with lower gas velocities. Dust chambers are not suitable for the extraction of carbon black because they are too susceptible to choking. The dust content of the ingoing gas should not be higher than 5-10 mg. per cu. m. Supposing such conditions are available, the dust chambers can be operated for 1 year after which time they must be unpacked and refilled.

3. Development and Results of the Oppau Shaft Filter

The main reason for the development of a shaft-filter was to use the purifying effect of the dust chambers whereby the packing could be discharged continously and could be liberated from the carbon black. In order to obtain a reasonable commercial apparatus the output had to be substantially enlarged. The height of the purifying layer had to be increased and a larger particle size of the packing had to be used. The operation data of the Oppau shaft filter are represented by the lowest row of the table. It is to be observed that they are still inferior to the output of catalyst-furnaces, but are almost equal to the f-coal-absorbers.

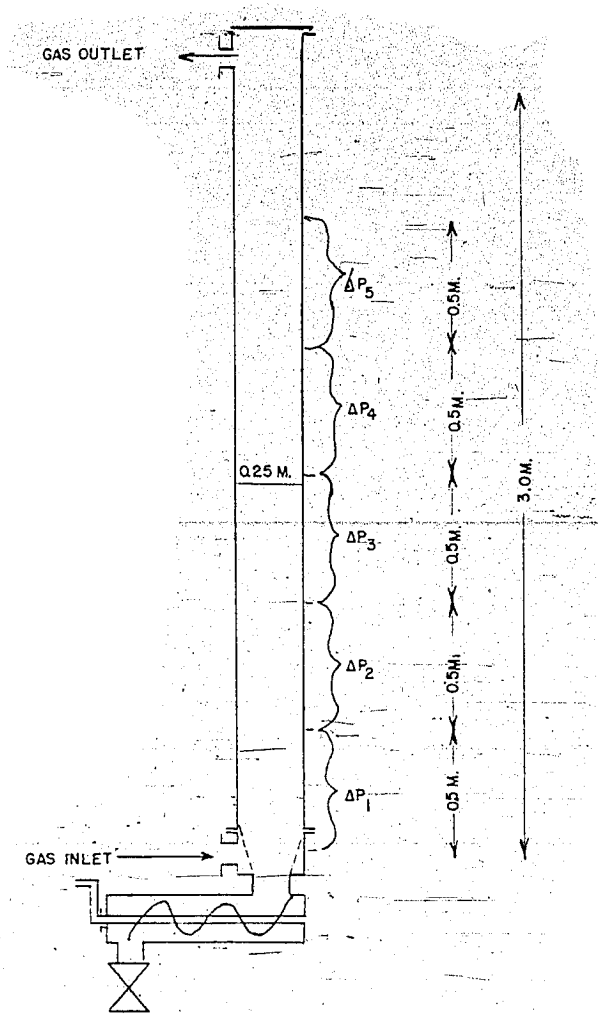
a) Experiments carried out on a scale of 14 cu. m. per hour

The first experiments were carried out with an output of 20 cu. m./h acetylene split-gas. Picture #1 represents the design of the filter. The diameter of the filter was 250 mm., the height 3m. Near the gas intrance, the packing slides through a funnel which is equipped with 5 mm. wide slits into the conveyor screw by means of which it is discharged. Pressure taps were arranged in distances from 50 to 50 cm. (sic) in order to control the pressure loss of the packing. Table #2 represents the results of some tests which were carried out with pumice packings of different size.

Table #2

Size of the pumice packing mm.	Output-cu. m./m^2	Mg. carbon black per m^3 treated gas
12-15	780	36
10-12	780	17
6-8	780	20
3-6	375	4

The best run which was carried out with the 6-8 mm. size of the packing resulted in unsatisfactory purification effect because condensed water influenced the proper performance of the test. The output was reduced for the last test. Picture #2 represents the curve of the pressure loss. An increase of the pressure loss could be observed only



TEST FILTER OP.462 – PICTURE I

CROSS SECTION OF THE SHAFT – 0.049 SQ.M.

GAS OUTPUT – 14 CU. M./HR.

PACKING: PUMICE – 3–6 MM.

E.P.H. – 3/21/47.

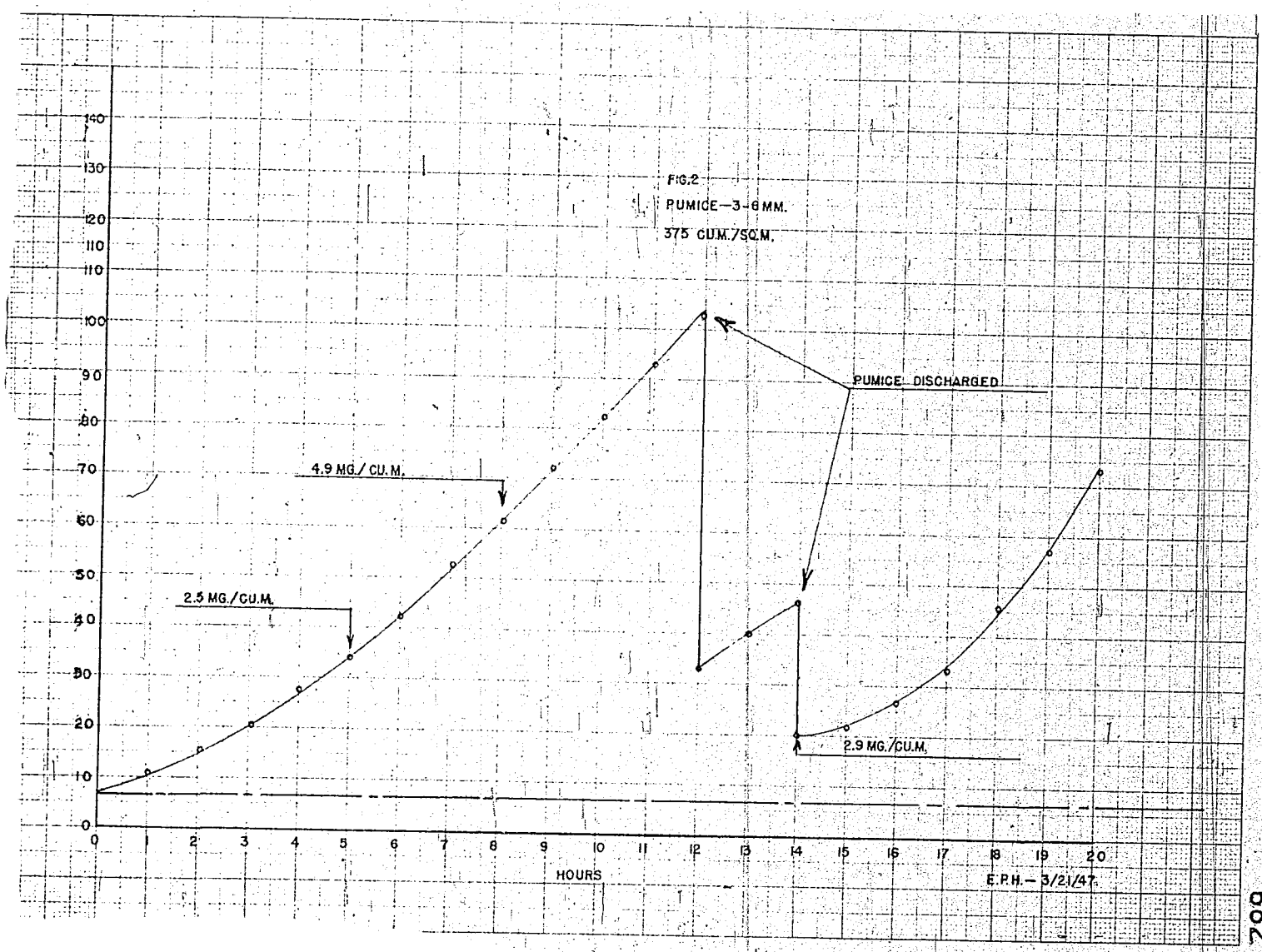


FIG.2
PUMICE—3-6 MM.
375 CU.M./SQ.M.
PUMICE DISCHARGED
4.9 MG./CU.M.
2.5 MG./CU.M.
2.9 MG./CU.M.
HOURS
E.P.H.—3/21/47.

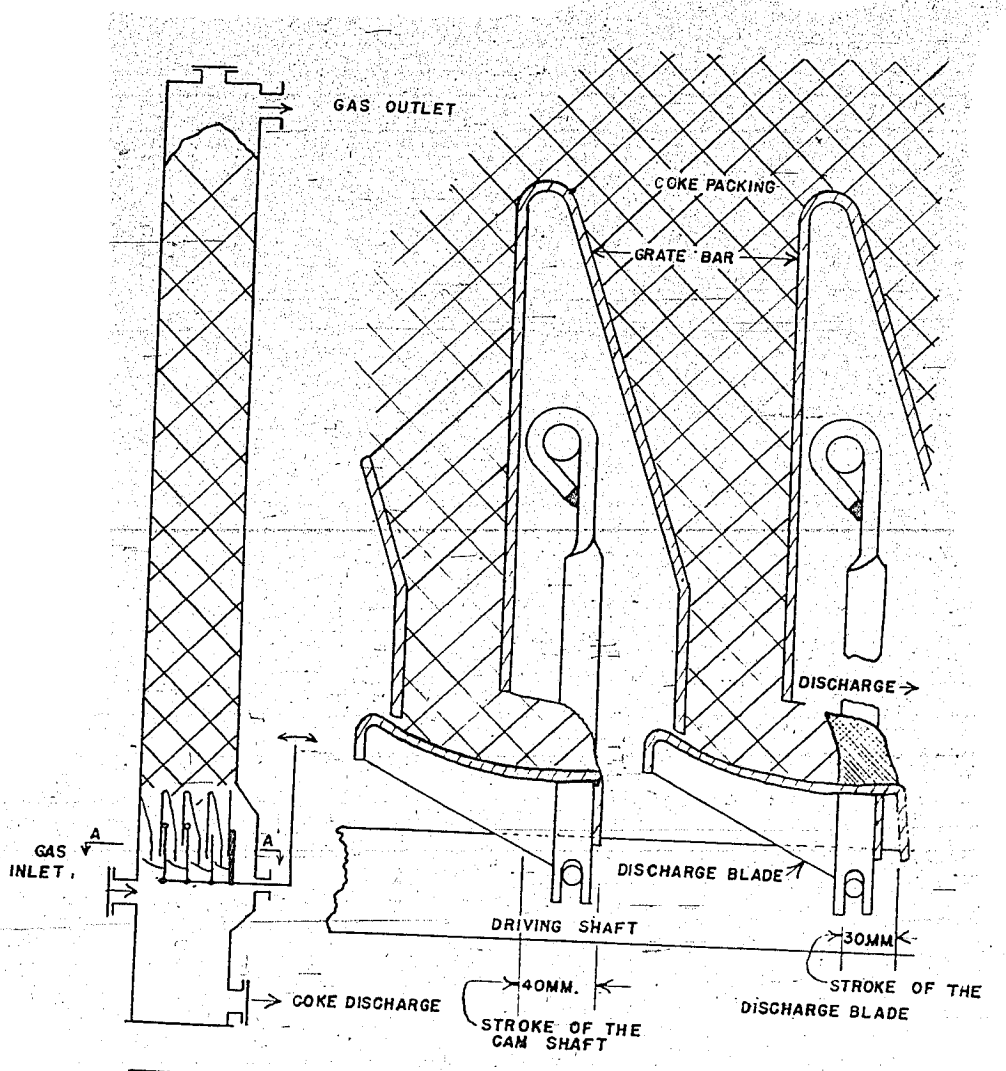
in the lowest part of the shaft (1), while the resistance in the upper part of the layer was almost constant. The shaft was continously operated for 418 hours whereby 5 700 cu. m. gas were treated. A total of 130 liters pumice corresponding to 23 liter per 1,000 cu. m. of gas was discharged. The raw gas contained 180 m. per cu. m. carbon black; occasionally the carbon black content was as high as 400-500 mg. per cu. m. The discharge of the spent pumice was regulated in such a manner that the total pressure loss of the shaft did not exceed 200 mm. water column. The finished gas contained 4 mg. per cu. m. carbon black; the output was 260 cu. m. gas per m^2 per hour corresponding to 375 cu. m. gas + water vapor per m^2 per hour. The dew point of the gas was 70°C.

b) Experiments carried out on a scale of 300 cu. m. per hour

A shaft with a cross section of 0.48 m^2 was designed and constructed. (Picture 3) The filter was equipped with a shaking grate (Picture 3a) which causes the packing to descend uniformly through the shaft and is discharged in a counter current flow to the gas. Synthesis gas containing carbon black which was free from hydrocarbons was used for the experiment. The results of the test are represented by table 3. The following conclusions can be drawn from the experiments:

1. The purifying effect of coke (2-8mm) is better than that of pumice 3-6mm. The used coke was flue coke from the Oppau gas factory. It is important that the coke fraction 2-8mm. contains a high or high proportion of fine material (2-5mm).
2. The less carbon black in the raw gas, the less carbon black in the finished gas. In order to obtain results depending on the carbon black concentration of the raw gas, experiment #6 was carried out with an extremely high carbon black content of the gas. Under those conditions the filter had reached the limits of its efficiency. It is therefore recommended to apply a pre-scrubbing of the gas if such high carbon black contents must be removed. The consumption of the packing per 1000 cu. m. gas increases with decreasing size (compare experiments 3,4, and 5 with 7 and 8). The higher the carbon black content of the raw gas the higher the specific consumption of the packing. (Compare the experiments 6,7, and 8) The resistance of the filter during the course of the experiment was approx. 300 mm. water column against 120 mm. before the test was started. The discharge of the spent packing was regulated in such a manner that a resistance of 300 mm. was obtained.

It was found out by trial that a carbon black content of the finished gas of 5 mg/m^3 was harmless whereby it must be mentioned that all figures are based on dry gas under normal conditions, the actual content is therefore lower. In order to investigate which amounts of carbon black in the finished are permissible, the purified gas was led through a CO-converter (brown oxide catalyst) whereby the resistance and conversion efficiency were determined. The results of a 3 months test run are represented by picture 4. Since the experiments were carried out in connection with other experimental work a uniform operation was impossible. The plant had to be shut down several times or the conditions of the production of synthesis gas were changed. Picture #4 represents the actual operating time of the reactor; shut down periods are not recorded.

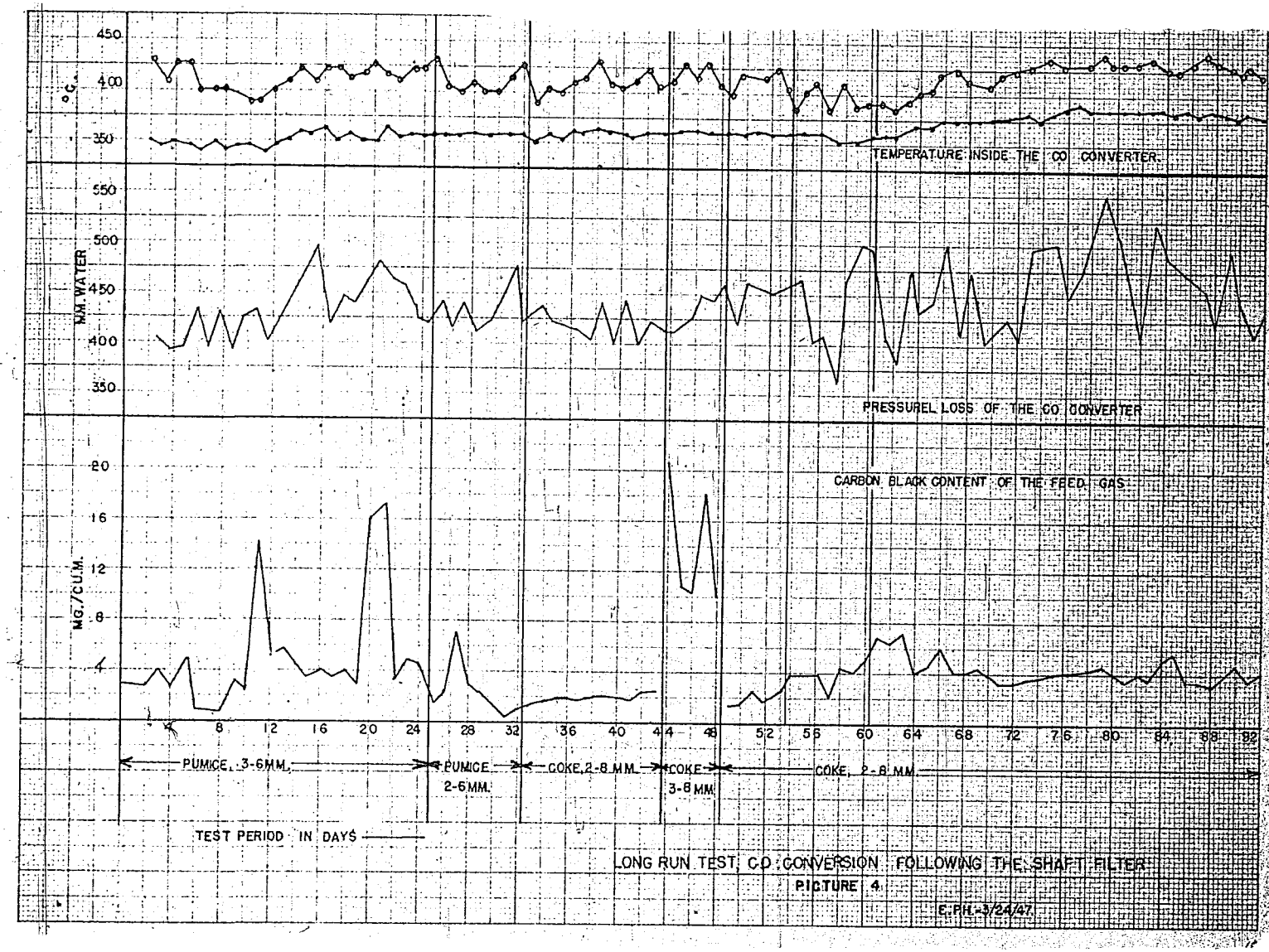


TEST FILTER (Op.462)

GROSS SECTION AREA OF SHAFT = 0.48 SQ.M.

PICTURE 3

E.P.H.-3/17/47



LONG RUN TEST, CO CONVERSION FOLLOWING THE SHAFT FILTER

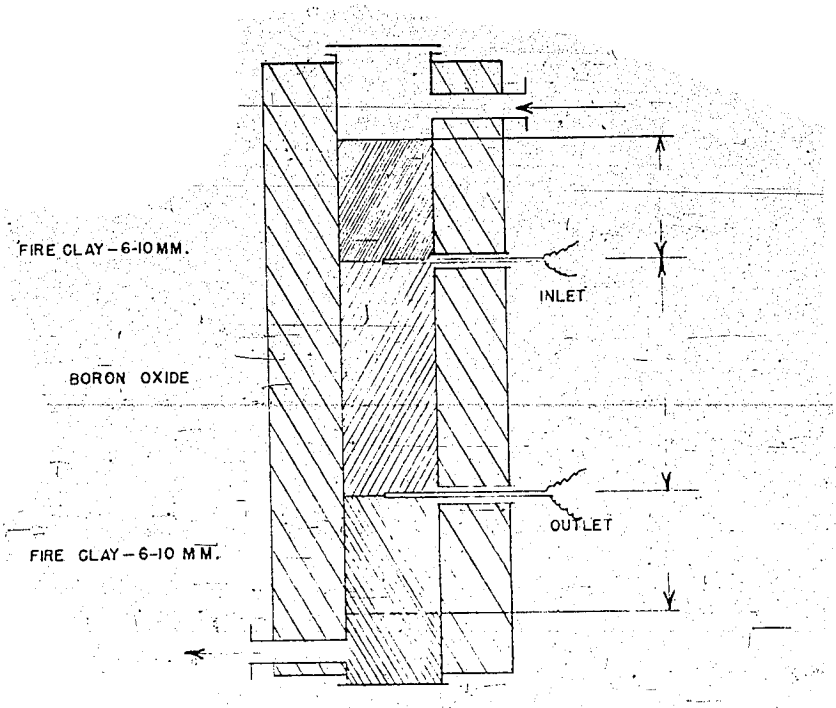
PICTURE 4

E.PH.-3/24/47

TABLE #5

Operation data of the 0.48 m^2 units

Test #	2	4	5	6	7	8
Temperature °C.	70	70	30	70	70	70
Cu. m. gas per h	250	235	240	215	220	215
Cu. m. gas and water vapor per h	350	360	250	300	310	310
Cu. m. gas and water vapor per h per m^2	730	750	520	625	650	650
Carbon black content inlet mg/cu. m.	20-200	30-200	300	1500-3500	500	170-350
Carbon black contents outlet mg/cu.m	3-6	4-12	3-6	5-18	2-5	1,2-2.0
Packing	pumice	pumice	pumice	coke	coke	coke
Size mm.	3-6	3-6	3-6	2-8	2-8	2-8
Total consumption of the packing	800	1470	1550	3495	1070	990
Packing consumption per 1000 cu. m. gas	17	24	21	106	40	32
Test carried out hours	192	240	290	154	120	144



CO – CONVERTER OP. 462.

OUTPUT 340 CU.M. GAS AND WATER VAPOR PER HOUR.

2700 CU.M. GAS AND WATER VAPOR PER SQ.M.

6,300 ACTUAL CU.M. PER SQ.M.

PICTURE 5

E.P.H. – 3/21/47

Table #4

Operating data of the Shaft Filter Oppau 648

Date	Gas $m^3/hr.$	Pressure loss mm. water col.	Coke consumpt. liter coke per 1000 m^3 gas		Carbon black mg/m^3	
			Filter 1	Filter 2	Gas inlet	Gas outlet
July 9, 1941	11,000	320			46	0.5
" 10, 1941	11,000	325			45	0.5
" 11, 1941	10,800	320		5	53	0.6
" 12, 1941	10,900	315	11		88	0.4
" 13, 1941	10,900	320		10	103	0.4
" 14, 1941	10,900	320			132	0.5
" 15, 1941	11,000	320	12	10	110	0.4
" 16, 1941	11,000	315		11	150	0.0
" 17, 1941	10,900	315			150	0.7
" 18, 1941	11,000	315	14	6	153	0.9
" 19, 1941	11,000	310			120	0.8
" 20, 1941	10,800	315	12		100	0.9
" 21, 1941	10,800	310			130	0.8
" 22, 1941	10,800	315		7	120	0.8

Coke with a particle size of 2-8 mm. is more efficient than pumice with a particle size of 3-6 mm. The pumice packing shows sometimes considerable variations in its purifying efficiency which however can be partly traced back to operating failures. The reactor does not show any increase of its resistance during the entire course of the experiments. Even if the resistance increases very slightly with a higher carbon black content of the inlet gas, the normal resistance is regained after a short period of time, indicating that the deposited carbon black is removed by the gas which passes through the reactor. However we did not succeed in determining considerable amounts of carbon black in the gas leaving the reactor. The CO-converter is shown by picture #5. It represents the first layer of a normal furnace. We investigated the rate of conversion in order to find out whether the deposited carbon black leads to any deterioration of the catalyst. The conversion rate is indicated by the increase of the temperature of the gas during its passage through the first bed of the furnace. As the curve shows, the temperature increase remains as high as 40°C. during the entire course of the experiment. The inlet temperature of the gas was slowly increased from 360 to 380°C. Such an increase would be normal for a brown oxide catalyst and is caused by a slight poisoning by sulfur compounds. Furthermore the catalyst was badly abused by the numerous shutdown periods of the plant.

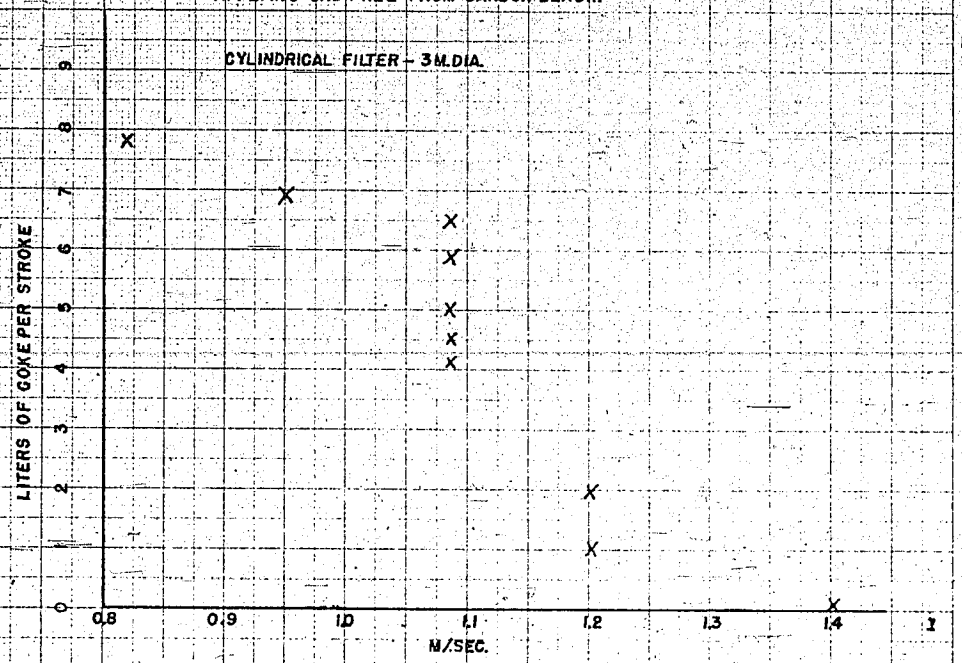
c) Experiments carried out on a scale of 11,000 cu. m. per hour

The first commercial application of the shaft-filter was the purification of hydrocarbon free synthesis gas (hydrocarbon synthesis gas plant Oppau 640) which was obtained by the conversion of hydrocarbon-containing gases with oxygen using a nickel catalyst and applying temperatures of 1000°C. Picture #6 shows the design of the filter used. Two cylindrical filters, each having a diameter of 3 meters were operated with a parallel gas flow. The shaking grate was moved by means of an oil filled pressure cylinder. The number of strokes is controlled by an electrically driven clock. The spent coke was discharged into the cone and from there into the storage bin. Since cone and bin are always filled with water, a rough separation of carbon black and coke takes place already. As soon as the bin is filled up the connecting gate valve between cone and bin was closed and the coke was flushed by means of water through a pipe and fed to a sieve which was situated at the top of the shaft and which separated the coke from the water. The coke slid down into the filter shaft, whereas the water left the apparatus. A further separation of the coke takes place during the flushing period. The carbon black is partly discharged with the flushing water, partly by a second water flow which carries away the carbon black floating in the cone underneath the grate. Details of the washing process and of the movement of the coke will be described in the following paragraph.

Before operating the filters some experiments were carried out in order to determine the gas volume which could be blown through the shaft without hindering the discharge of the coke. Picture #7 represents the result of the experiments. A normal discharge of the coke can be maintained up to an output of 850-1000 cu. m. gas per m^2 cross section. As soon as 1,150 cu. m. per m^2 are blown in, the gas will block up the coke in the slots just above the discharging blades preventing a proper gliding of the coke into the bin. The discharged coke quantities decrease at those and higher gas volumes and are irregular from test to test. Picture #7 represents in a second scale

VOLUME OF THE DISCHARGED COKE DEPENDING ON THE GAS OUTPUT APPLYING GAS FREE FROM CARBON BLACK.

CYLINDRICAL FILTER – 3M.DIA.



I GAS VELOCITY IN THE GRATE SLOTS.

II GAS OUTPUT CALCULATED ON THE EMPTY FILTER SHAFT

PICTURE 7

E.P.H.-3/17/47.

the gas velocities which can be found in the slots between the grate bars above the discharge blades. With these preliminary experiments completed the filters were put into operation employing an output of 800 cu. m. gas per m^2 cross section of the shaft based on a temperature of 25°C. Table 4 contains some data of the test run.

Comparing the results with those of the smaller filters it can be easily observed that the efficiency of the filter has increased from enlargement to enlargement. Employing the smallest type, the content of carbon black which remained in the purified gas was 4 mg./m^3 applying an output of 375 m^3/m^2, whereas it was possible to come down to 1 mg. /m^3 carbon black employing the large filters and an output which was twice as high as before.

Picture 8 represents the pressure loss, depending on the height of the filtering bed. Curve #1 shows the pressure loss of the filter at the start of the experiment. The velocity of the coke discharge was regulated in such a manner that the resistance during the operation was as 2½ times as high as at the start of the experiment. It can be observed from the curves that the resistance is mostly due to the lower parts of the bed which are enriched with carbon black, whereas almost no pressure increase can be observed in the higher parts of the bed where the gas is nearly purified from the carbon black. The curves show very easily whether the filter was properly operated and whether the carbon black extraction is satisfactory. With a resistance too high in the middle and upper sections of the filter, the discharge of the packing must be increased. It is very important to determine very carefully the resistance of the filter at the beginning of the operation and to reduce all changes of the resistance to a uniform scale which are due to volume, pressure and temperature. It was observed that with high carbon black contents of the inlet gas which cause a higher coke discharge, the increase of the resistance of the lower section will be higher; whereas with a smaller carbon black content the middle sections of the filter are a little more responsible for the purifying effect.

i) Refreshment and movement of the packing

From the beginning it was intended to refresh and move the packing without coming in contact with the air. Originally a bucket elevator was provided for the movement of the packing, but since the quantity of the packing material to be moved per hour was very small it seemed more simple to lift the material by means of water. The settling speed of pumice and coke in water was determined to be 3 cm. per sec., however speeds of 11 cm. per sec. were also found. If a water flow is applied to lift the material, its velocity must be higher than the determined values of the settling speed of the material to be lifted. On the other hand precautions must be taken that the concentration of the material to be lifted is not too high in order to prevent choking or blocking of the feed pipe. The velocity of the water in the feed pipe is preferably 58-80 cm. per sec. according to our experiments. In order to be able to control the concentration of the packing material in the lifting liquid, one part of the flushing water was injected at the top of the bin (overshot water) and the rest at the outlet of the bin (undershot water) in order to dilute the mixture (Comp. figure 6). The proportion of both water volumes depends on the draining conditions of the water from the bin. In most cases, 2 parts were injected at the top and one part at the outlet of the bin. Employing such conditions 1 cu. m. of water will hoist 0.3-0.4 cu. m. of packing material. Some operating data are represented by table #5.

PRESSURE LOSS IN THE SHAFT FILTER
I. PRESSURE LOSS IN THE FILTER FREE FROM CARBON BLACK
II. COMMERCIAL TEST RUN.
III. TEST RUN NO. 7. TABLE 3.
IV. TEST RUN NO. 8. TABLE 3.
PICTURE 8
E.BH-3/10/47
MM OF WATER
100
200
300
0
1
2
3
4
THICKNESS OF THE BED IN M.
II
III
IV

TABLE #5

Cross section of the filter:	7 m^2
Output	5,500 cu. m. gas per hour
Output based on the cross section	790 $m^3/m^2/hr.$
Coke consumption	15 liter per 1000 cu. m. gas
Coke output	82 liter per hr.
Volume of the bin	4 cu. m.
Time necessary to fill the bin	$\frac{4000}{82}$ = 48 hr.
Diameter of the feed pipe	80 mm.
Water consumption	15 $m^3/hr.$
Quantity of the hoisted coke 15 x 0.35	= 5.25$m^3/hr.$
Time required to empty the bin	46 minutes

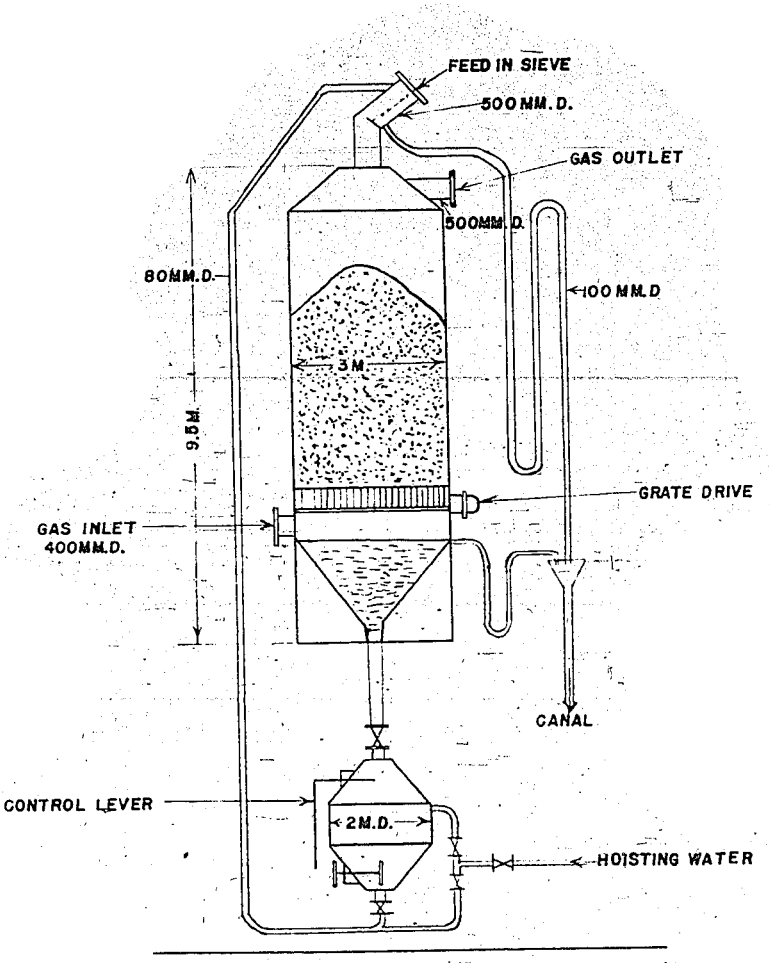
In order to separate the carbon black from the packing material a simple whirling of the packing material in the water is adequate. Some carbon black however will stick to the surface of the packing material but those quantities are harmless because they will stick to the moist packing and will not be transferred into the gas when it is fed to the filter shaft. Numerous experiments were made with the 0.049 and 0.49 m^2 filters to separate the carbon black from the packing without discharging and moving it with the aim to avoid the shaking arrangement and to operate two vessels, one of which extracts the carbon black whereas the second is flushed by water. All such experiments failed. Even if the carbon black concentration of the packing is very high a completely clear water will be drained off unless the packing is whirled or moved.

Furthermore it was tried to abandon the bin underneath the shaft filter and to draw off a mixture of water and packing material from the cone by means of a canal pump (diaphragm pump-?) which also takes care of the lifting of the packing material. The experiments failed due to the abrasion to which the packing was subjected during its passage through the pump.

) Experiments with the aim to separate the carbon black from the water

In all cases of a water shortage, it will be necessary to liberate the waste water from the carbon black in order to be able to recirculate the refreshed water. It is advisable to operate the filters in such a manner that a minimum of waste water of a high carbon black concentration must be treated. It may be desirable also to recirculate the carbon black containing water over a cooling tower and to draw off from the cycle a side-steam which is filtered. It is then possible to increase slightly the carbon black concentration of the cycle and to draw off the side-steam at a point of higher concentration in order to obtain a mixture which can be filtered. Even if that method is employed, the carbon-black concentration will be so low that it is impossible to apply a rotary drum filter. Numerous tests employing filter presses were carried out in order to determine their output. Table 6 contains the data of the tests and picture 9 represents the press of the filtering process.

Carbon black originating from acetylene-split gas is easier to filter than that from synthesis gas because the former is not so greasy to work. However it is impossible to recognize a difference with the naked eye.



SHAFT FILTER

DIA. 3M.
AREA 7 SQ.M.

PICTURE 6

E.P.H.3/17/47

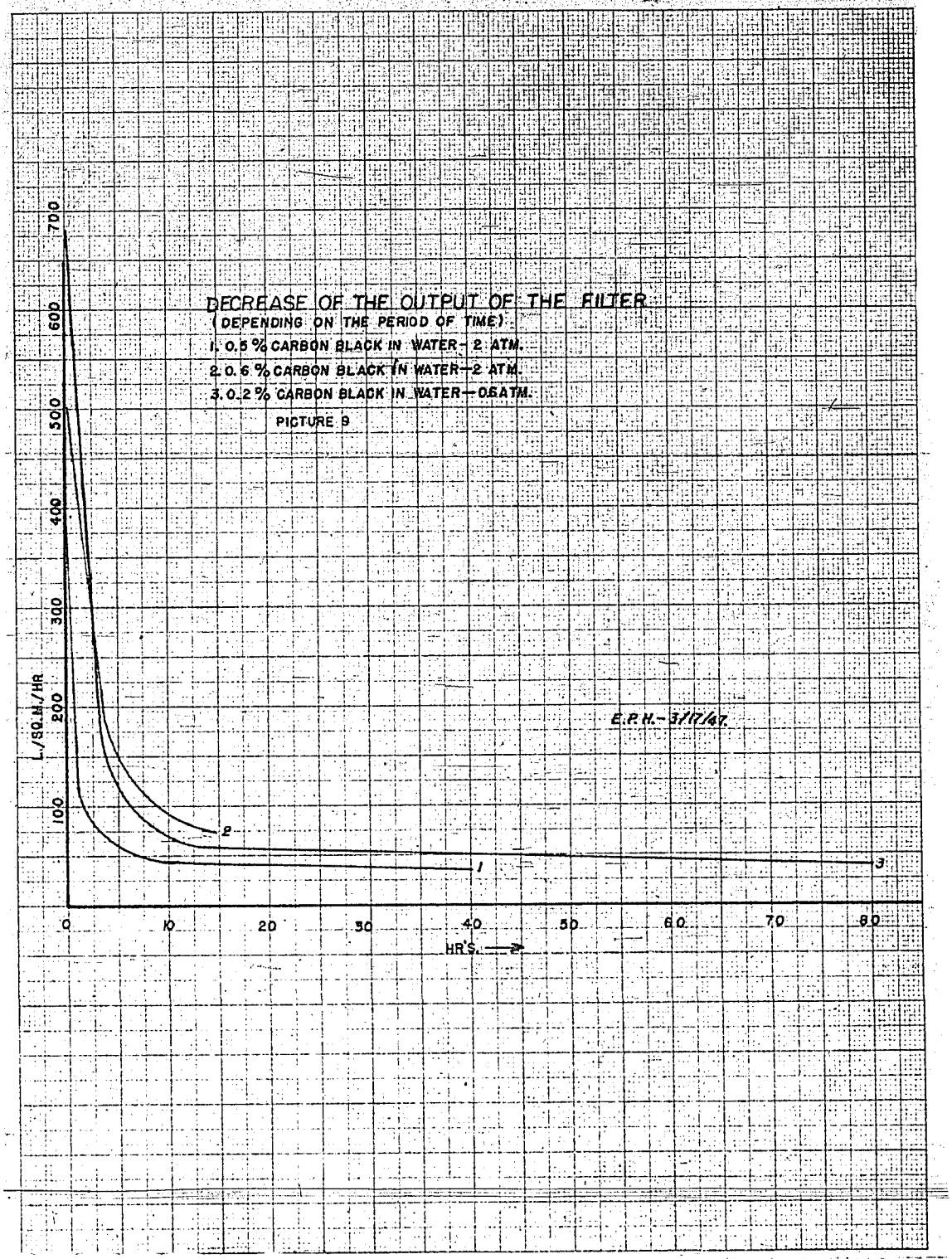
Table #6

Purification of carbon-black containing water by means of filter-presses

Test	Concentr. of carbon black %	Origin of the carbon black	Area of filter	Vol. of frame lit.	Filtering time	Avg. output of filter $l/m^2/hr.$	carbon black $kg./m^2$	Pressure atm.
1	0.5	S	0.220	2.28	43 hrs.	38	8.8	2
2	0.6	S	0.114	1.14	12.5 hrs.	68	9.5	2
4	2.8	A	0.152	1.52	12 min.	980	5.6	2
5	0.1	S	0.030	0.38	86 hrs.	89	frame not completely filled	2
6	0.5	S	0.038	0.76	33 hrs.	105	"	2
7	0.5	S	0.038	0.76	94 hrs.	77	"	0.6
8	0.2	S	0.038	0.38	83 hrs.	463	7.0	0.6

S Carbon-black extracted from synthesis gas.

A Carbon-black extracted from acetylene.


DECREASE OF THE OUTPUT OF THE FILTER
(DEPENDING ON THE PERIOD OF TIME)
1. 0.5 % CARBON BLACK IN WATER - 2 ATM.
2. 0.6 % CARBON BLACK IN WATER — 2 ATM.
3. 0.2 % CARBON BLACK IN WATER — 0.6 ATM.
PICTURE 9
E.P.H. - 3/17/47.
L/SQ.M./HR
700
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
HR'S.
1
2
3

2. The output of the filter decreases very rapidly from an initially high value to the small one of 50 liter/m^2/hr. The latter is maintained constant over a long period of time.

3. The increase of the applied pressure does not result in a remarkable increa se of the output of the filter. Apparently the deposited carbon black layer is more highly compressed by the higher pressure, thus enlarging the resistance of the filter against the flow of the liquid.

The described experiments should be used only as hints in designing a filter press.

4. Constructed plants and plants under construction

The commercial application of the shaft-filter is intended for use in several plants. Table 7 shows the different plants and their outputs. Only the first of the listed plants has been already put in operation.

a) Shaft-filter Oppau 648

6 cylindrical filters each having a diameter of 3 meters have been built at the Oppau plant. Two of them are operated with hydrocarbon free synthesis gas, whereas the remaining 4 are supposed to purify acetylene split gas. The cylindrical form has been selected because it is simple to manufacture. Details of the filter are represented by paragraph 2d and picture #6.

b) Splitting-plant for "Saargas" Oppau 631

Compare picture 10. By conversion of methane and a following conversion of carbon monoxide it is intended to produce nitrogen-synthesis-gas. Between the two steps the carbon black must be separated from the gas (temperature 73oC., saturated with water vapor) to such an extent that the following CO-conversion process can be operated without any difficulties. Cooling the gas below the dew point will will be prevented in order to be able to use the water vapor of the first step for the second step of the process. With the application of cylindrical filters (diameter 3 m.) 4 filters would have been necessary for each methane--or CO-converter respectively. In order to obtain a simple design rectangular filters were employed which can easily be constructed up to a size of 3 x 9 meters (25 m^2 filtering cross section) with respect to the construction, size and drive of the grate. In order to secure a most uniform discharge and feeding of the coke the entire cross section of the shaft was subdivided into square areas (3 x 3 meters). Each of those are equipped with a cone, pump, and feed-in screen. The coke and gas chambers underneath and above the grate are not separated. The grate is subdivided into 3 areas also, which are operated by a shaft which is situated outside of the grate casing and is connected with a cam shaft. The cam shafts are led into the filter case by means of gastight stuffing boxes. The drive can be performed by means of compressed air, compressed oil or motor. The arrangement is carefully insulated.

c) Linz-plant

The Linz plant is of exactly the same design as the Oppau 631 plant. The plant is designed in such a manner that 2 units are able to treat the total gas volume. Under normal operating conditions 3 units are supposed to be operated due to a lower pressure loss and an improved purification effect caused by a smaller output.

d) Waldenburg plant

Methanol synthesis gas is produced by the oxygen process from coke oven gas at the I.G. Waldenburg plant. The gas is cooled and passes through the filters at normal temperature and saturated with water vapor. Three units are provided, two of them capable to treat the total gas volume. Under normal operating conditions 3 units are supposed to be operated. The Waldenburg filters contain only 2 cells per unit resulting in a cross sectional area of the filters of 17 m^2. In order to secure an equal gas distribution orifices are arranged in the exit pipes of the filter.

Because no settling pool was available the hoisting water together with the flushing water is united with the cooling water of the gas condensers and recirculated over a cooling tower. With the carbon black concentration high enough a side flow is drawn off and led to filter presses..

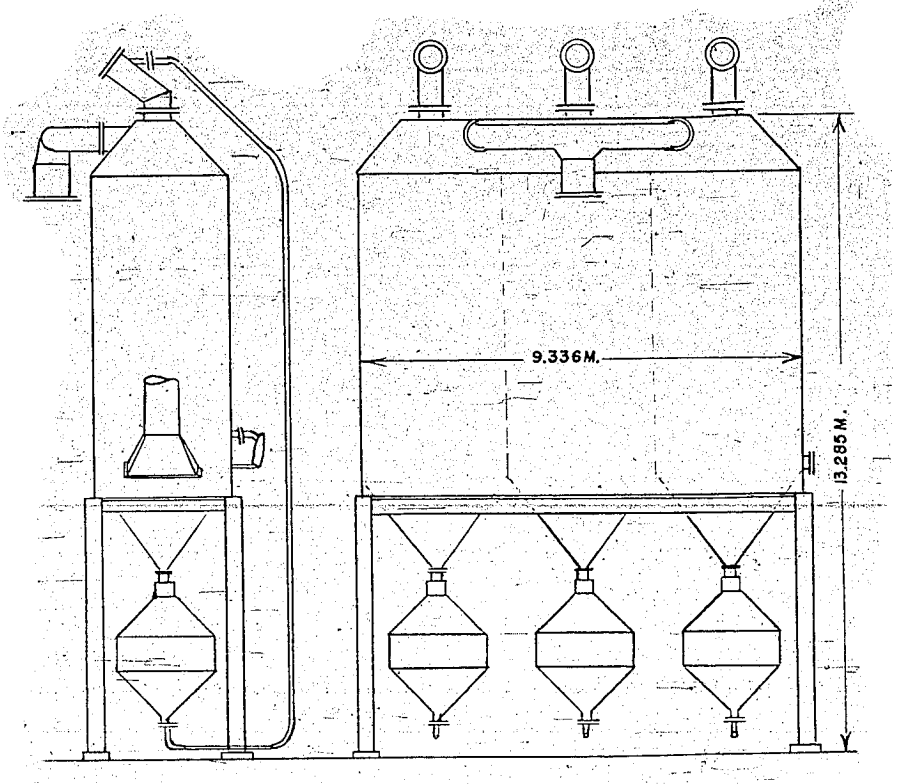
e) Heydebreck plant

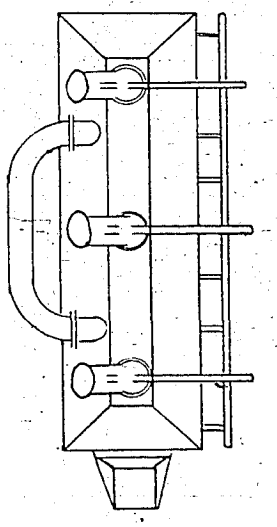
Picture 12. Two kinds of synthesis gas are to be treated. Two shaft filters containing three cells are arranged for each gas. In addition one filter is provided for reserve which can treat each gas. The plant, which consists of 5 filters, can be easily enlarged to 12 filters. The design of the filters is similar to that of the Oppau 631 filters. With respect to the cold eastern climate the basement is made of reinforced concrete which contains all water piping, cones, feed pins, and water seals, thus eliminating the otherwise necessary insulation.

5. Scope of the application of shaft-filters

The shaft filter can be successfully employed in all cases where carbon black or dust containing-gases which simultaneously contain high amounts of water vapors must be treated without cooling the gases. Most of the experiments were carried out near the dew point; it is possible however to treat superheated gases also. Experiments which were performed at temperatures ranging from 400-500°C. were successful.

Bag-filter plants (Both-or Intensiv-design) can be employed if cold gases must be liberated from carbon black and dust. Bag filter plants have the advantage that high purification effect (less than 1 mg. per cu. m.) can be obtained. By the application of bag-filters it is possible to recover a dry and clean carbon black. The shaft-filter however is simpler and safer. Furthermore the investment cost and the required space of a shaft-filter are less than those of a bag-filter. A large, three cells shaft-filter of the Oppau type has a filtering area of 25 m^2 and a capacity of 20,000 cu. m. gas per hour. A normal filter bag has an area of 2.2 m^2. Assuming an output of 17 m^3 gas per m^2 and hour, one filter bag will purify 37.5 cu. m. gas per hour. 650 bags in operation and 100 more which are just in the refreshing period correspond with one shaft-filter. In periods ranging from 6-10 minutes the gas flow must be changed and a filter group must be flushed. The gas to be treated must be dry and no water-vapor condensation should occur, otherwise the bags would be spoiled. The lifetime of the bags is limited if corrosive gases must be purified. The above mentioned considerations led to the decision to employ the shaft filters even for the purification of cold gases, i.e. for the Waldenburg and Heydebreck plant.



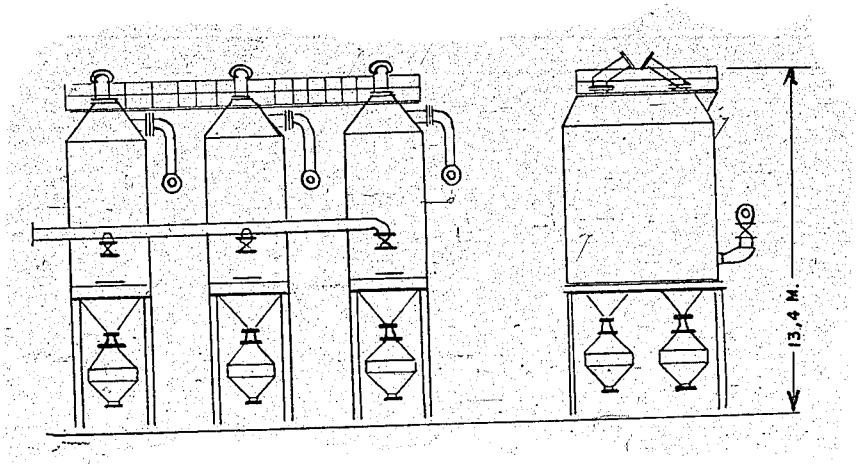


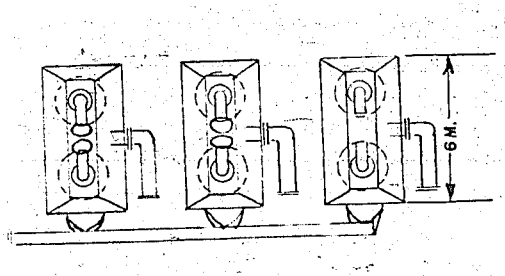
SHAFT FILTER

OP. 631 B LINZ
OP. 631 - 1 FILTER
LINZ — 3 FILTERS.
CROSSECTION AREA OF SHAFT = 25 SQ.M

PICTURE 10

E.P.H. - 3/17/47





SHAFT FILTER PLANT—WALDENBURG

OUTPUT 26,000 CU.M./HR. SYNTHESIS GAS (15° I ATM.)

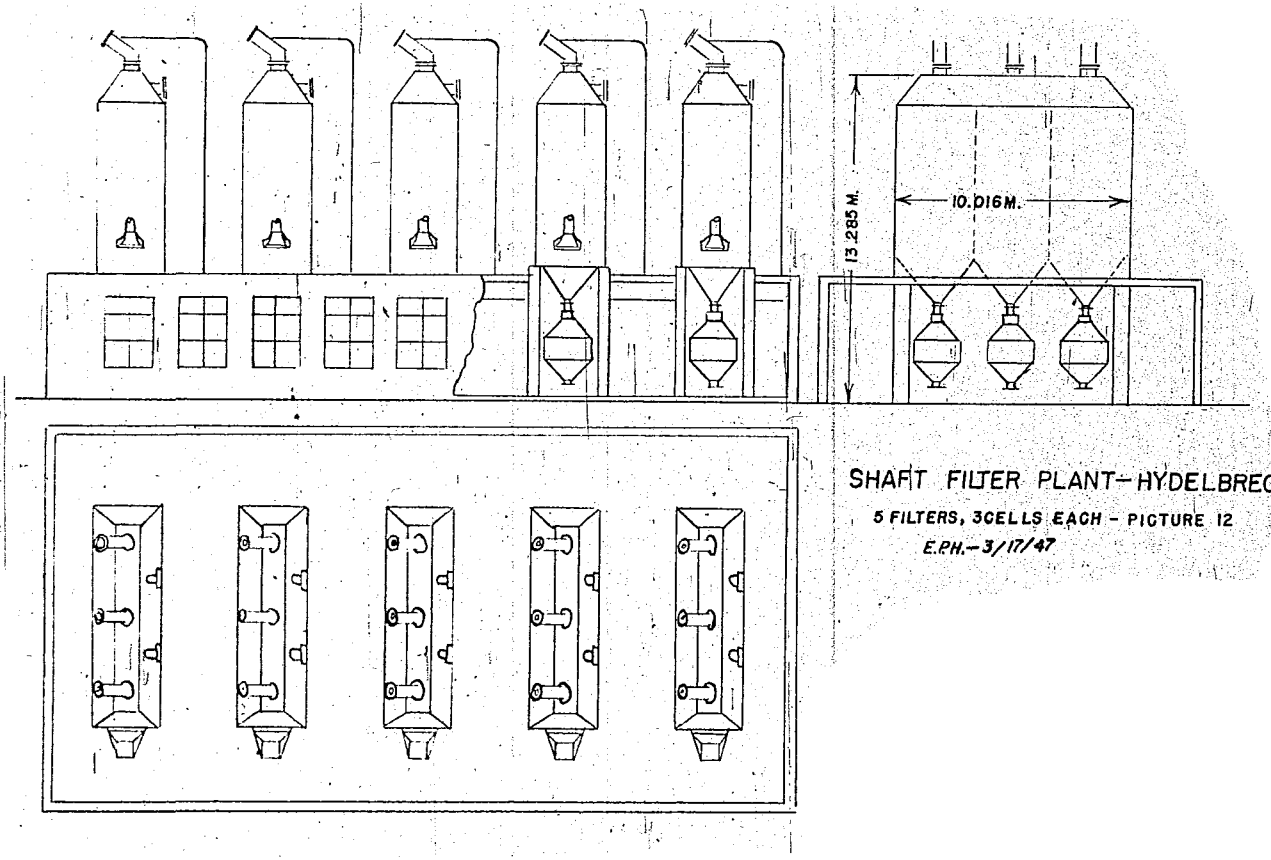
3 FILTERS-2 CELLS EACH

(2 FILTERS OPERATING, 1 FILTER RESERVE)

CROSS SECTION AREA OF DRAFT-17 SQ. M.

PICTURE H

E.P.H.—3/17/47



SHAFT FILTER PLANT- HYDELBRECK

5 FILTERS, 3CELLS EACH - PICTURE 12

E.P.H.-3/17/47

Table #7
Planned and Constructed Shaft-filters

	Hydrocarbon synthesis Gas-plant, Oppau 648		Gas splitting plant Oppau 631	Nitrogen plant Linz	I.G. Waldenburg	I.G. Heydebreck
Type of N-synthesis gas	gas	C_2H_2 split gas	N-synthesis gas	N-synthesis gas	Methanol-synthesis gas	Tanole+ N-synthesis
Actual temp	25	83	73	73	25	25
No. of units	2	4	1	3	3	5
Type filter	Cylinder	Cylinder	3-cells	3-cells	2-cells	3-cells
Cross section area per unit m^2	7	7	25	25	16.6	25
Total cross section area of the filter m^2	14	28	75	75	50	125
Output: m^3 gas + water vapor per hr. (800 m^3/m^2)	11,200	22,400	20,000	60,000	40,000	100,000
Output m^3 gas per hr.	11,200	10,200	14,000	43,200	40,000	100,000
Commercial output gas + water vapor/hr.	11,200	15,000	20,000	37,000	26,200	75,000
m^3 gas + water vapor/m^2/hr.	800	535	800	494	525	600
m^3 gas/hr.	11,200	7,500	14,000	26,600	26,200	75,000