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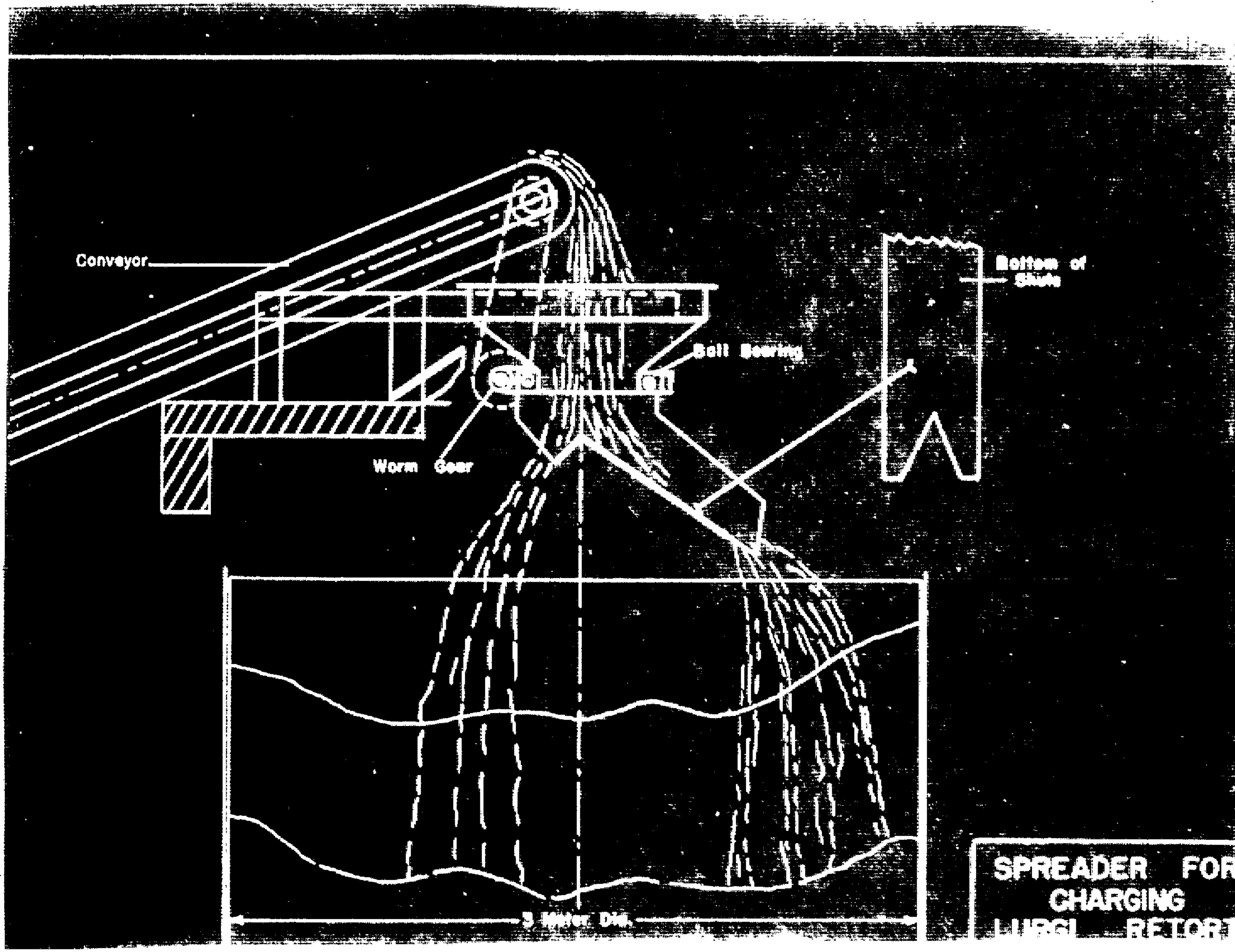
SPREADER FOR CHARGING

OF LURGI-SCHWEITZER RETORT

The Retort (3m - diameter and 7 m - height) is charged and discharged at a filling station. It is carried to this station by a crane. This filling station is connected with the storage bin for shale by a conveyer. This conveyer discharges into a small cone-bin, which is equipped with two rotating chutes of different length. The chutes are retated on a ball bearing by a gear (worm gear or tooth-gearing) from the upper shaft of the conveyer. The spreader is mounted on the frame of the conveyer. The bottom of the chute may be cut out partly for an additional spreading of the shale on the whole surface. In order to equalize the lower resistance along which the gas flows to the wall, the fines are preferably brought to the wall of the retort. The spreader also avoids the locally dense packing which otherwise takes place in a high retort, where the shale drops on the surface.

Sketch attached hereto.



Conveyor
Bottom of Shute
Ball Bearing
Worm Gear
SPREADER FOR
CHARGING
LURGI RETORT

12

12 B og m.

Dr. Otto Hubmann

TUNNEL KILNS for Carbonization of Oil Shale

For the carbonization of oil shale direct heating of the shale by flush gas has been found very satisfactory for a good recovery of oil and a good quality of the Oils. The simplest and cheapest equipment for a direct heating of solid material is a vertical shaft through which the material is conducted continuously. Such process, however, requires a material, which on no account sticks together or tightens the layer of material up against the flue of gas. Some rich oil shales as those of Estonia are softening under heat and may cake together to a solid rock under the pressure of a higher layer of material. A danger of this kind may exist temporarily even if the medium product of the mine does not stick together, because with a relatively thin seam of changing quality the temporary delivery of rich oil shale cannot easily be avoided.

The danger of sticking together can be reduced by not moving the material during carbonization and by reducing the thickness of the layer. Practically this can be performed in a tunnel kiln by means of flat wagons, on which the shale is placed in layers of 1 to 4 inch thickness, and which are moved through the tunnel. Volumes of hot gases are circulated through the layer of the material by means of numerous fans and gas heaters which are mounted along the tunnel. Even with the applications of this method, caking of the shale cannot be always prevented, but the operations of the plant or its efficiency cannot seriously be influenced. Though the plant and the process are rather complicated, this method has proved satisfactory for Estonian oil shale. Two types of furnaces have been developed:

1. The Esti-Kivioeli tunnel kiln
2. The Sillamaegi tunnel kiln

A. Esti-Kivioeli Tunnel Kiln

This system is working with a horizontal cylindric tunnel made of sheet iron. The tunnel is divided into 12 to 14 carbonization sections which are separated by a slide door from the feeding zone at one side and by another slide door from the quenching and discharging zone at the opposite side of the furnace. Two other doors close the tunnel at both ends. The heaters, one for each wagon are placed in a parallel brick-made channel. They are heated by the flue gases which originate from the combustion of oil shale. A number of fans for the circulation of the heating gas through the shale and the heater are placed parallel the heater channel.

In the latest design of this type developed by the LURGI-Company the heaters are gas fired the heating temperature being regulated by re-circulating gases, enlarged circulating fans are placed under the heaters, and each heater with its circulating fan can be shut off for cleaning without stopping the operation of the tunnel unit.

The wagons are moved periodically. They are connected to the heater at the bottom of the tunnel by two flanges pressed together by the weight of the wagon. The positions of the wagons are adjusted automatically by a corresponding notch of the rails.

The slide gates are operated by a hydraulic gear, which serves also for the moving of the wagons. The supervision and steering device is located at a control room which may be common to several tunnel units.

The heaters consist of vertical tubes made of heat resistant steel, the heating gas passing outside the tubes, the distillation gas inside. The tubes are connected to rectangularly arranged groups. The first 2 or 3 wagons, which have entered the tunnel are operated with lower temperatures for drying only, which has proved very essential for decreased caking and a good output of oils.

B. Sillamaegi Tunnel Kiln

This system which was in operation at the Sillamaegi plant, uses a rectangular tunnel made of sheet iron and placed into a brick channel. This tunnel is of a larger cross section than the Kivioeli tunnel and uses larger wagons operated with a layer of shale only 1 to 2 inch thick. The wagons are closely touching each other with their frontwalls, they are tightened to the bottom of the kiln by the lower end of the sidewalls, moving in grooves. Some differences of construction consist in the heating method and the drive of the wagons by an electric gear. The heaters are mounted above the tunnel. In both plants the shale is crushed and screened to 2 or 3 different sizes which can be treated in the same kiln. The thickness of the layer in the wagon in this case depends on the differenct sizes of the shale or the resistance of the layer against the flow of the gases.

Fines of shale cannot be treated in these tunnel kilns. The fines, which sometimes are plastic or can be made plastic by an addition of some water are formed to irregular balls by passing a rotating drum or by briquetting. They are dried after which the balls are hard enough for the carbonization in the same way as the coarse shale.

The capacity of the Kivioeli kiln has been increased to a daily capacity of 400 to 500 metric tons, whereas the Sillamaegi kiln treats 500 to 550 metric tons per day. The efficiency of the oil extraction utilizing the tunnel kiln, is 92 to 98% compared with the Fischer Assay.

The quality of the oils is very good containing a high percentage of light oil due to a slight cracking of the oil vapors in the heaters.

Operation of the tunnel kilns must be stopped and the kiln cooled down every 3 to 5 weeks for a thoroughly and costly cleaning of heaters and pipes, so that the working days are reduced to 250 - 300 days per year. In the tunnel kiln very little permanent gas is developed from oil shale. The condensation of the oils and recovery of light oils requires a relatively very small installation. The recircled gas which enters the shale is heated to not more than 500 - 520° C. The oil vapors being slightly cracked during their circulation through the heater the tunnel process furnishes oils with a very high content of light oils.

The necessity of frequent cleaning under unfavorable working conditions and the periodical standstill of a big part of the plant makes the tunnel-system unsuitable for smaller plants and for a high labor standard. High cost of repair and labor makes its operation too expensive in most countries, and for any shale with less than 20% of oil content. For Estonian oil shale and the labor conditions of this country it has been proved as most successful for many years. Some figures of the production and operation of the Kivioeli plant are the following:

<u>Oil shale charged</u> (10-80 mm size)

Moisture:	7.5%	**Fischer-Assay 500° C.**	
Analysis based on dry shale:		Oils	22.9%
CO_2	18.8%	H_2O	1.5%
Ash	46.8%	Residue	69.0%
Organic Substance	34.4%	Gas	6.6%

figures are taken from the report of a thorough examination of the 4 kiln plant Kivioeli practiced in August 1938 by LURGI engineers.

The organic substance of Estonian Oil shale is relatively high in oxygen and nitrogen, which determines the special characteristics of Estonian oil products.

A mixture of all the condensates made in proportion to production figues, showed the following analysis:

Oils

I.	Gravity at 15°C.	0.946
	H_2O	1.1%
	dust (Unsoluble)	0.10%
	red resins	8.6%
	asphalts	0.5%
	ash	0.02%
	phenols	16.3%

Elementary analysis:

C	83.2%
H	10.7%
S	0.8%
O	5.1%
N	0.2%

II. Distillation test (Engler)

Boiling point 60°C.

to 100°C	7%	total	7%
100-150°	5%		12%
150-185°	5.5%		17.5%
185-250°	7.8%		25.3%
250-300°	9.2%		34.5%
300-325°	4.6%		39.1%

III. Fractionating-test

a.	benzine - 185° C.	17.8% weight
b.	gas oil 185-325° C.	25.3% "
c.	residue	56.2% "
	lost	0.7% "

IV. Fractions

a. Benzine

gravity 15° C.	0.743
sulfur	0.8%
phenols	0.8%

Distillation (Engler):

boiling point	43° C.	
-75° C.	19.5%	total 19.5%
75-80° C.	4.5%	24.0%
80-100°	19.0%	43.0%
100-150°	39.0%	82.0%
150-185°	10.0%	92.0%
End point 201°		95.0%

b. Gas oil

gravity 15°C.	0.903
sulfur	1.2%
phenols	12.9%

Distillation (Engler):

boiling point	144°C.	
-185° C.	6.0% Vol. total	6.0%
185-200° C.	8.0% " "	14.0%
200-250° C.	31.5% " "	45.5%
250-300° C.	32.5% " "	78.0%
300-350° C.	11.5% " "	89.5%
End point 374° C.		95.0%

c. Residue (fuel oil)

gravity 15° C.	1.051
paraffin wax	0.0%
red resins	12.0%
asphalts	1.4%

Distillation under vacuum (4 mm Hg absolute)

to 200° C. 7.0%	total	7.%W.
200-225°C.12.1%		19.1%W.
225-250°C.12.1%		31.2%W.
250-275°C.11.4%		42.6%W.
275-300°C.11.3%		53.9%W.
300-325°C.11.2%		65.1%W.
325-350°C.11.8%		76.9%W.
Residue (pitch) 19.6%		96.5%W.
losses 3.5%		

Analysis:

C = 82.8%

H = 9.7%

S = 0.8%

O = 6.4%

N = 0.3%

H.H.V. = 9,335 Cal/kg

L.H.V. = 8,873 Cal/kg

Distillation gas

Analysis: CO_2 = 23.2%

H_2S + RSH = 10.0%

C_nH_m = 14.1%

O_2 = 0.0%

CO = 0.0%

H_2 = 9.2%

C_nH_{2n+2} = 41.0%

N_2 = 2.5%

H.H.V. = 7910 Cal/nm^3

L.H.V. = 7156 Cal/nm^3

Products on dry oil shale:

Oils	22.27%
water	1.50%
gas	3.35%
coke	72.88%

Products of the plant for 1939 were delivered as follows:

gasoline to Estonian market	11,480 t =	16.34%
fuel oil to German Navy	53,384 t =	76.4%
various oils for local market	3,067 t =	4.3%
Loss of refining	2,071 t =	2.96%
	70,002 t	

d. <u>Economy of Tunnel Kiln System</u>

For a plant of modern design as they have been delivered to Estonia in 1943-44 the cost of errections of a 900,000 ton per year plant ready for operation are the following:

		RM
1.	Storage for 5,000 tons of raw shale with conveyers	800,000
2.	Crusher, plant with screening machinery bins and building	1,000,000
3.	Plant for treating fines of shale by agglomeration and drying	900,000

1. Capacity and products.

Oil shale treated per year 900,000 t per year

Residue with 10% moisture 734,000 t per year

Oils: Crude-oil 96% 186,000 t per year

fuel oil 78% of crude oil 145,000 t per year

benzine 22% of crude oil 41,000 t per year

Gas: 22.5 cbm t (7,146 kcal per cbm) used for heating 20,200,000 m^3/year

2. Energy, steam and cooling water

a. Electric energy

60 Kwh per ton of shale 54,000,000 Kwh per year

b. Fresh water

0.50 m^3 per ton of shale 450,000 m^3/year

for power 300,000 "

c. Steam

0.4 per ton of shale 360,000 "

d. Additional heat required for kilns

320,000 cal/ton 288 Bill. Cal/year

for power and stean 180 Bill. Cal/year

3. Labor included for local repair work

480 unlearned laborers

70 learned laborers

20 for powerstation

40 for office, laboratory social rooms

Total 610

6 foreman

3 engineers

1 manager

		Germany RM	USA $
4.	Investment-capital	18,000,000	10,000,000
	working capital	1,500,000	500,000
5.	Production-cost		
	Oil shale, (including dump of residue)		
	900,000 tons x 5.00 RM	4,500,000	
	900,000 tons x 3.00 $		2,700,000
	Water		
	750,000 tons @ 0.05 RM	37,500	
	750,000 tons @ 0.03 $		22,500
	Wages for Labor		
	610 @ 3,000 RM	1,830,000	
	610 @ 2,000 $		1,220,000
	Engineers	70,000	35,000
	Repair and operating material		
	2.5% of 18,000,000 RM	450,000	
	2.5% of 10,000,000 $		250,000
A	Amortization Cost		
	8% of 18,000,000 RM	1,440,000	
	8% of 10,000,000 $		800,000
	Interest		
	3% of 19,500,000 RM	585,000	
	3% of 10,500,000 $		315,000
	Taxes and Administration	550,000	300,000
	TOTAL COST PER YEAR	RM 9,462,500	$ 5,642,500

Production cost per ton of oils:

$$\frac{9,462,500}{186,000} = 51.00 \text{ RM/tons}$$

$$\frac{5,642,500}{186,000} = 30.4 \text{ \$per ton}$$

Cost of gas for heating of kiln and boilers is not included.

Operating cost per ton of oil shale:

$$\frac{9,462,500-4,500,000}{900,000} = 5.51 \text{ RM/ton}$$

$$\frac{5,642,500-2,700,000}{900,000} = 3.27 \text{ \$/ton}$$

Operating cost per ton of oil:

$$\frac{900,000}{186,000} \times 5.57 = 26.7 \text{ RM/ton}$$

$$\frac{900,000}{186,000} \times 3.27 = 15.8 \text{ \$/ton}$$

The operating cost per ton of shale is extremely high owing to high investment and high labor cost.

Payment for heating gas would increase this cost accordingly.