IV. CENTRIFUGING UNITS.

(a) The units consists of thirty-six (36) continuously operating De Laval centrifuges, each handling two (2) cubic meters/hour throughput (Fig. 20).

(b) The mud in the coal stall effluent is separated in the centrifuging units into an oil free from solids, suitable for diluent oil, and a solid residue which is later coked in coke ovens.

(c) The mud is first de-sanded in a conical settling tank, forty (40) cubic meters capacity. The feed enters tangentally and passes down through a fine screen (0.8 millimeter mesh). The sand is removed through the bottom cone.

(d) The de-sanded product is pumped from a recirculating pipe system to the centrifuges. These rotate at three thousand two hundred (3,200) revolutions per minute and have a drum diameter of four hundred thirty (430) millimeters, and a factor:

IV. CENTRIFUGING UNITS. (Cont'd.)

C = 2,500 kilograms. The vertical shaft carries on its upper end the so called plate block, consisting of two hundred twenty-five (225) superposed plates, two hundred eighty (280) millimeters in diameter and 0.5 millimeters apart. The plate block rotates in the drum which has a discharge orifice at the center made of Widia metal (tungsten carbide). Between the plate block and the drum is a latticed basket with Widia edges which scrapes off the residue from the drum sides. Through cyclic operation, a difference in speeds of fifteen (15) revolutions per minute is set up between the basket and the drum.

(e) The feed enters the centrifuge from the top through a throat to a measuring device and then through the hollow shaft. In the narrow space between the plates, the separation of oil and mud takes place. The oil flows upwards through holes in the plates near the shaft. The solids contained in the residue pass through orifices in the drum wall.

(f) The resistance offered by the basket has an important influence on good operation. This normally amounts to 1.5 kilograms but rises occasionally to from 3.0 to 3.5 kilograms. As a safety device, shear pins are installed. After numerous experiments, it was possible to arrange the motor circuit to cut out if the resistance on the basket became too great.

(g) Proper operation of the centrifuges depends on the following factors:

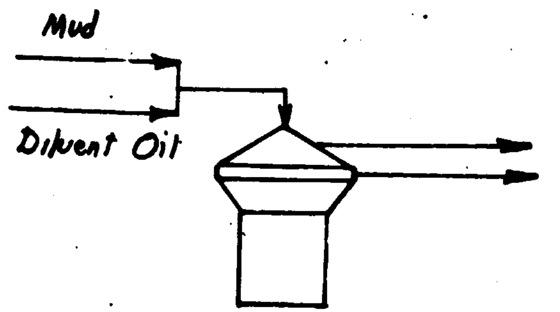
(1) Pressure in recirculating lines;
(2) Solid content;
(3) Temperature of feed 140°C.

Hence the throat and orifice diameters in the centrifuge must be so chosen as to give the highest possible solid content in the residue and the lowest in the centrifuged oil.

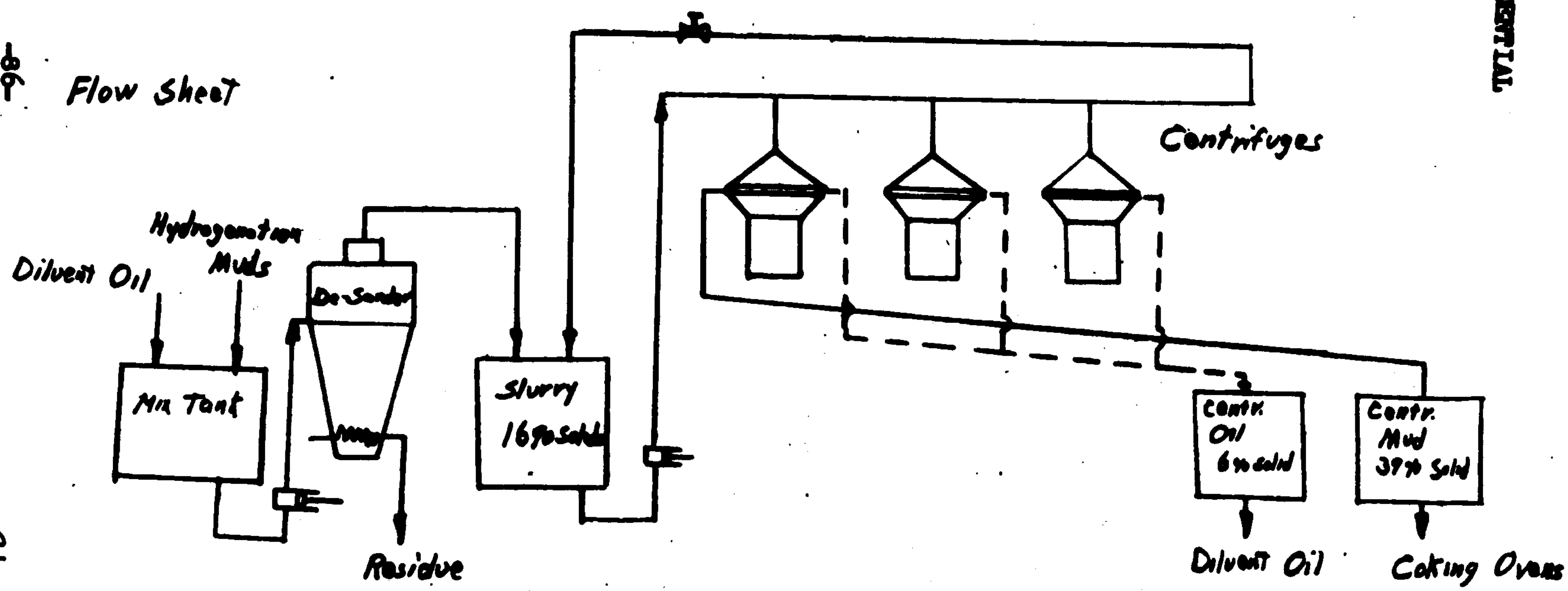
(h) The solids in the mud vary from eighteen (18) to twenty-two (22) percent and can be lowered to sixteen (16) percent by dilution with effluent from the coal stalls. By doing this, the coarse particles can be separated easier in the de-sanding step.

FIG. 20
Centrifuge Units

Principal



Flow Sheet



IV. CENTRIFUGING UNITS. (Cont'd.)

(i) The capacity of the machine can be altered by varying the pressure in the feed pipe system. This pressure is normally maintained at one (1) atmosphere but can be raised to 1.2 atmospheres. A variation in feed rate is accomplished through changing the neck in the feed pipe. These run from 1.8 to 2.2 millimeters. By the above changes, the following operating results can be had:

Load on one centrifuge	3.2 tons/hr	100 %
Product: Centrifuged oil	2.2 tons/hr	69 %
Product: residue	1.0 tons/hr	31 %
Solids in centrifuged oil		6 %
Solids in residue		39 %

By increasing the size of the residue exit orifice and keeping the same entrance throat size, the quantity of solids both in the residue and in the oil is lowered.

(j) Ash, Asphalt and Sand.

The solids in the mud contain from ninety (90) to ninety-two (92) percent coal ash. The ash content in the centrifuged oil is seventy-five (75) percent and in the residue ninty-five (95) percent. The asphalt content of the feed to the centrifuge unit is five (5) percent. The discharge from the de-sander contains twelve (12) percent which removes 0.75 of the total solids in the feed. The discharge is finally pumped back to the residue stream.

(k) Operating Difficulties.

The highest allowable solid content in the residue is forty-two (42) percent. By further concentration the drum and basket become clogged with solids. It is impossible to operate the centrifuges without de-sanding. The biggest operating trouble was in starting up after a coal stall had been idle, as in stopping the nozzles would become clogged with material then in the unit. This was eliminated by thoroughly washing before the machines come to rest. The originally installed pneumatic valves for pressure control were replaced by hand operated ones as the former did not work well. This was due to the colgging up of instrument piping with the product.

IV. CENTRIFUGING UNITS. (Cont'd.)

IMPORTANT OPERATING RESULTS

Stream efficiency	53.0	%
Avg. No. of units	19.1	%
Avg. capacity	2.86	tons/hr
Operating hours	116,906	hrs/month

FEED COMPOSITION

Mud	88.51	%
Diluent oil	11.49	%

SOLIDS IN:

Mud	18.5	%
Feed	16.4	%
Centrifuged oil	6.8	%
Residue	38.8	%

HOURLY QUANTITIES

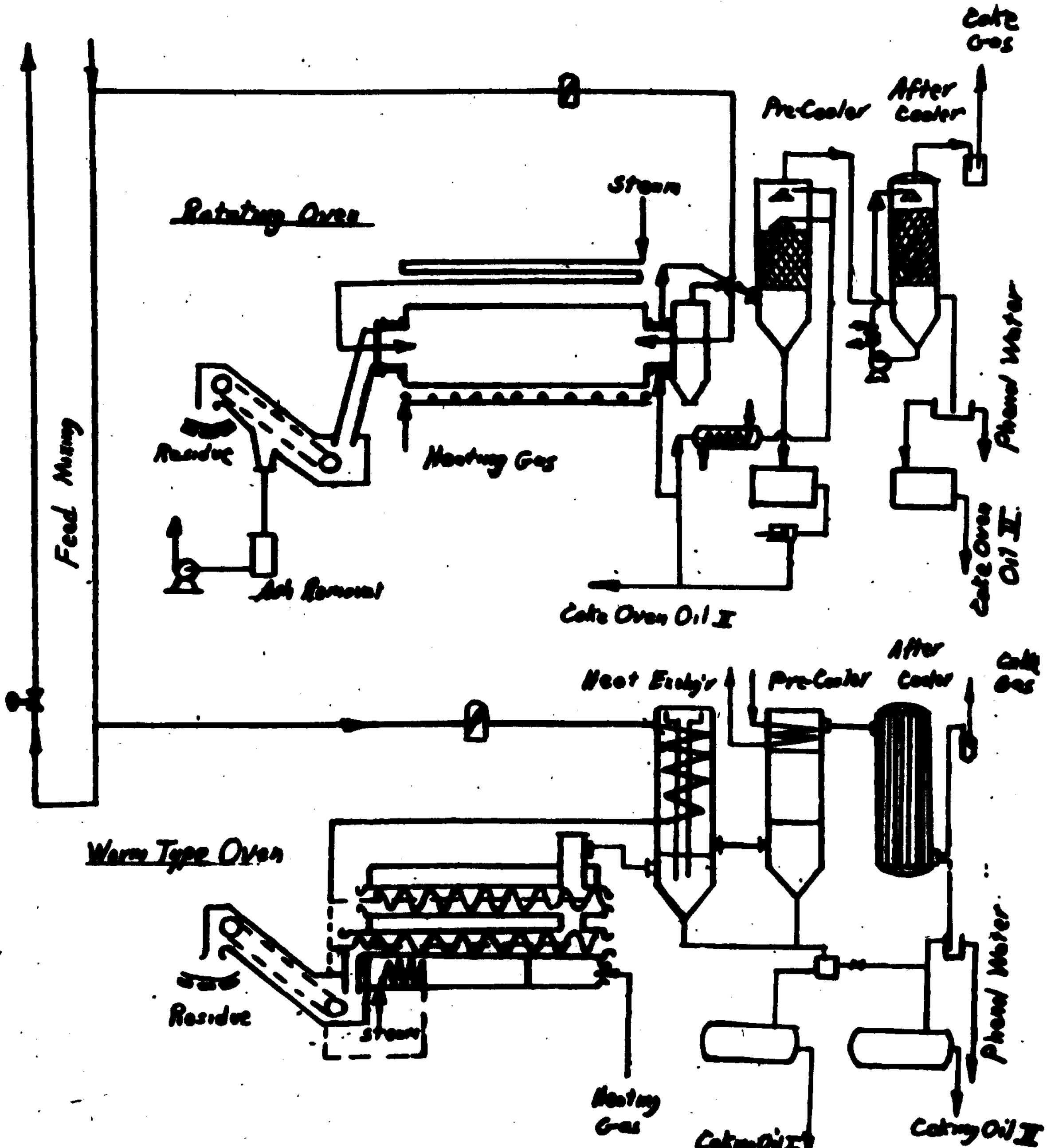
Mud to centrifuges	48.3	tons/hr
Diluent oil	6.3	tons/hr
Total feed	54.6	tons/hr
Centrifuged oil	39.7	tons/hr
Residue	15.4	tons/hr

V. COKING UNITS.

(a) The muds from the centrifuging units are coked in an atmosphere of steam which allows for the recovery of seventy-five (75) percent of their oil content, which is split into two (2) fractions (Fig. 21). The coke oven gas wither goes to the flare or is used as heating gas. The residue consisting of sixty-five (65) percent ash-containing solids and thirty-five (35) percent oil is discarded. The unit consists of:

(1) Six rotating furnaces;
(2) Six worm type furnaces.

FIG. 21
Coking Ovens



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V. COKING UNITS. (Cont'd.)

(b) Rotating Furnace.

(1) The rotating oven consists of a horizontal, slightly inclined, drum eleven (11) meters long and 2.2 meters diameter. The inner lining of the drum has a worm welded to it of "guronite" (chrome content twenty-five (25) percent). The drum normally rotates nine (9) revolutions per minute but can be raised to eighteen (18) revolutions per minute. It is heated by twelve (12) gas burners. A second row of burners over the drum, preheats the feed and produces superheated steam. The coking section of the drum, which is approximately three-fourths (3/4) of its length, has nine (9) tons of mill balls, of 1.8 kilograms weight each, while the rear section of the drum has twenty-four (24) mill balls, of ten (10) kilograms each.

(2) The feed after leaving the preheater, passes through a feed orifice and is continuously fed to the forward part of the oven. The mill balls prevent the formation of coke on the hot sides of the drum and assist in heat transfer from the sides to the material. The product passes through the drum to the rear of the furnace, or exit chamber, where it is conveyed to a water washer by a worm. A scraper then feeds it to a loader which fills it into railway cars. Steam is injected through the whole length of travel. The released oil vapors leave the drum and enter a dust catcher. They are then condensed and separated in a system of towers and coolers.

(c) Worm Furnaces.

(1) The worm ovens consist of two stationary drums, one above the other, sixteen (16) meters long and one (1) meter in diameter. They are joined together at the front end by a connecting section. In both frums is a worm, each run by a motor, turning it one (1) revolution per minute. The upper worm is hollow and serves to feed material into the furnace. The material moves to the rear of the upper furnace and falls through the connecting section into the lower drum where it again is moved forward to the exit. From here it falls into a water bath and then is lifted by conveyor into railway cars.

V. COKING UNITS. (c)(Cont'd).

(2) The furnace is heated by a burner in the front section, under the lower drum. The heat is controlled by a heating gas regulating valve. The steam superheater tubes are in the rear sections of both the upper and lower furnaces The oil vapors leave through a vertical pipe at the forward end of the upper drum. It gives up its heat to the incoming feed through a heat exchanger and is then condensed in two (2) stages by a precooler and an after-cooler, both water cooled. The former is a packed dephlegmator and the latter a tubular condenser. The condensate from the precooler and dust catcher is mixed to make coke oil I. Coke oil II comes from the after-cooler, and passes through a water separator. The gas is used either for heating or discarded.

(d) Operation.

(1) The operation of the coking units depends on the following factors:

((a)) Feed rate;
((b)) Furnace temperature;
((c)) Amount and temperature of injection steam;
((d)) Top temperatures of the coolers;
((e)) Furnace pressure.

(2) The two types of furnaces require different operation due to their design. The coked product from the rotating furnace easily goes to dust. In order to prevent stopping up the equipment, only small quantities of scrubber steam can be used, one hundred (100) kilograms/ton of feed as opposed to five hundred (500) kilograms/ton in the worm oven. To obtain the same coking effect the temperature in the former must be kept higher, namely at five hundred ninety (590) degrees centigrade at the exit while the worm oven is only kept at five hundred sixty (560) degrees centigrade. Higher temperatures tend to coke up the worms. The products are approximately the same, except that the rotating oven residue has more coke due to the higher temperature.

(3) The top temperatures of the pre- and after-coolers require careful attention if a good separation of water in

V. COKING UNITS. (d)(Cont'd.)

coke oil II is to be had. The former runs around two hundred twenty (220) to two hundred forty (240) degrees centigrade and the latter one hundred ten (110) to one hundred thirty (130) degrees centigrade. The pressure in the furnace differs in both types, eighty (80) to one hundred twenty (120) millimeters for H_2O for the rotating oven and forty (40) to sixty (60) for the worm type oven.

(e) Operating difficulties.

(1) The rotating furnace started up without difficulty. Frequent stopping of operation due to air raids would often cause the tubes in the preheator to coke up, requiring the by-passing of the same. The resulting objections were eliminated by reducing the throughput fifteen (15) percent and raising the furnace temperature from five hundred seventy-five (575) to five hundred ninety (590) degrees centigrade. Further, a new type of preheater was considered which would work with the central burner and avoid the errors in the former type. The stopping up of steam superheater tubes, made of Sichromal, was frequent because the flow through three (3) parallel streams is difficult to regulate. By building a single stream superheater, much better operation resulted. The coking residue tends to become slimy due to pulverization by the mill balls and small remaining oil content. For this reason, conveyance by a rubber belt was impossible, and a slurry had to be used. The residue is passed over a grate by the water stream. The grate removes the coarse particles which can then be moved in the normal way. The remainder falls through the grate in fine particles and is sluiced with much water in a tank. It then is pumped through pipes to the ash dump where it is handled by cranes.

(2) The worm type furnaces started up without difficulty. Difficulties were met in the even distribution of heat over the drums. The heating up of a furnace required forty-eight (48) hours as opposed to the six (6) hours of the rotating type. By constructing baffles and by diminishing the size of the combustion chamber a small improvement was obtained. It was finally necessary to build circulating gas blowers as with the rotating ovens. The operating period

V. COKING UNITS. (e)(Cont'd.)

of a furnace is fixed by the coking up time of the worms. This was seventeen (17) to twenty (20) days for the lower and one hundred (100) to one hundred twenty (120) days for the upper worms. An improvement was obtained by not shutting down during alerts and by constructing circulating gas blowers. The heat exchangers were also stopped up due to air raid alarms. For this reason a furnace without preheat was used. In this way the heavy oil condensed in the uncooled exchanger. By circulating coke oven oil I in the exchanger, the process was able to operate and resulted only in a slight loss of capacity and a ten (10) percent loss of possible heat recovered.

OPERATING RESULTS

	Rotating Furnace	Worm Furnace
Dist. of load	70.0 %	30.0 %
Capacity - ton/hr/furnace	3.2	2.0
Capacity oil - ton/hr/furnace	2.0	1.25
Coke oven oil I - ton/hr/furnace	1.4 - 70 %	0.75 - 60 %
Coke oven oil II - ton/hr/furnace	0.1 - 5 %	0.20 - 16 %
Oil recovery	75.0 %	76.0 %
Furnace temperature	590.0 °C	560.0 °C
Heat required/charge	350,000.0 kg cal /ton	350,000.0 kg cal/ton
Steam required/charge	100.0 kg/ton	500.0 kg/ton
Solid content of coke oven feed	39.0 %	39.0 %
Asphalt content of oil in oven feed	13 - 15%	13 - 15%
Analysis of Residue:		
Gasoline soluble	2.0 %	20.0 %
Coke	33.0 %	16.0 %
Ash	65.0 %	64.0 %
Heating valve	3,300.0 kg cal	3,450.0 kg cal

V. COKING UNITS. (Cont'd.)

TOTAL COKE UNIT

Feed	16.0 tons/hr
Coke oven oil I	5.69 tons/hr
Coke oven oil II	1.34
Coke oven gas	0.42
Oil less from injected oil	27.29 %

ROTATING OVEN

Stream efficiency	57.59 %
Total hours in operation	30,269.0
Avg. No. of operating furnaces	3.46
Avg. furnace load	3.26 tons/hr

Charge

Solids	39.54 %
Asphalt content in oil	24.2

Residue

Gasoline soluble	2.4 %
Ash	64.2 %
Heating valve	3,498.0 K cal/kg

Hourly Quantities

Feed	11.28 tons/hr
Coke oven oil I	4.03 tons/hr
Coke oven oil II	0.84 tons/hr
Gas	0.35 tons/hr
Outside oil injected and lost	28.5 %

WORM OVEN

Stream efficiency	34.2 %
Operating hours	17,973.0
Avg. No. of operating furnaces	2.05 %
Avg. furnace load	2.30 tons/hr

V. COKING UNITS. (Cont'd.)

	Monthly Quantity
Oil lost by injecting outside oil	24.4 %
	Charge
Solids	34.49 %
Asphalt in oil	24.2 %
	Residue
Gasoline soluble	18.9 %
Ash	80.31 %
Heating	3,449.0 K cal/kg
	Hourly Quantities
Feed	4.72 tons/hr
Coke oven oil I	1.66 tons/hr
Coke oven oil II	0.50 tons/hr
Coke oven gas	0.07 tons/hr

(f) Production of Briquette Binder.

The large demand for briquette binder material for French hard coal led to experiments using the coke oven residue. In these, only a part of the light oil was removed at low temperature operation. As Fig. 22 indicates, the product from the oven enters a conical tank and is then circulated around by a pump through a cooler, or pumped directly to a tank car. The experiment was conducted under the following conditions.

	Feed	Product
Solid content	16.8 %	32.1 %
Ash content in solids	85.3 %	79.6 %
Asphalt in oil	26.3 %	41.0 %
Sp. gravity at 80°C	1.2 kg/liter	1.42 kg/liter
Penetration point (Krämer Sarnow)		74.5 °C

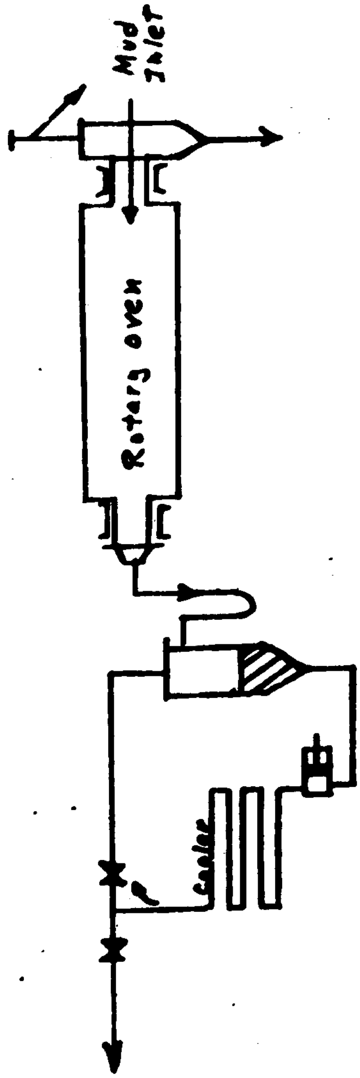
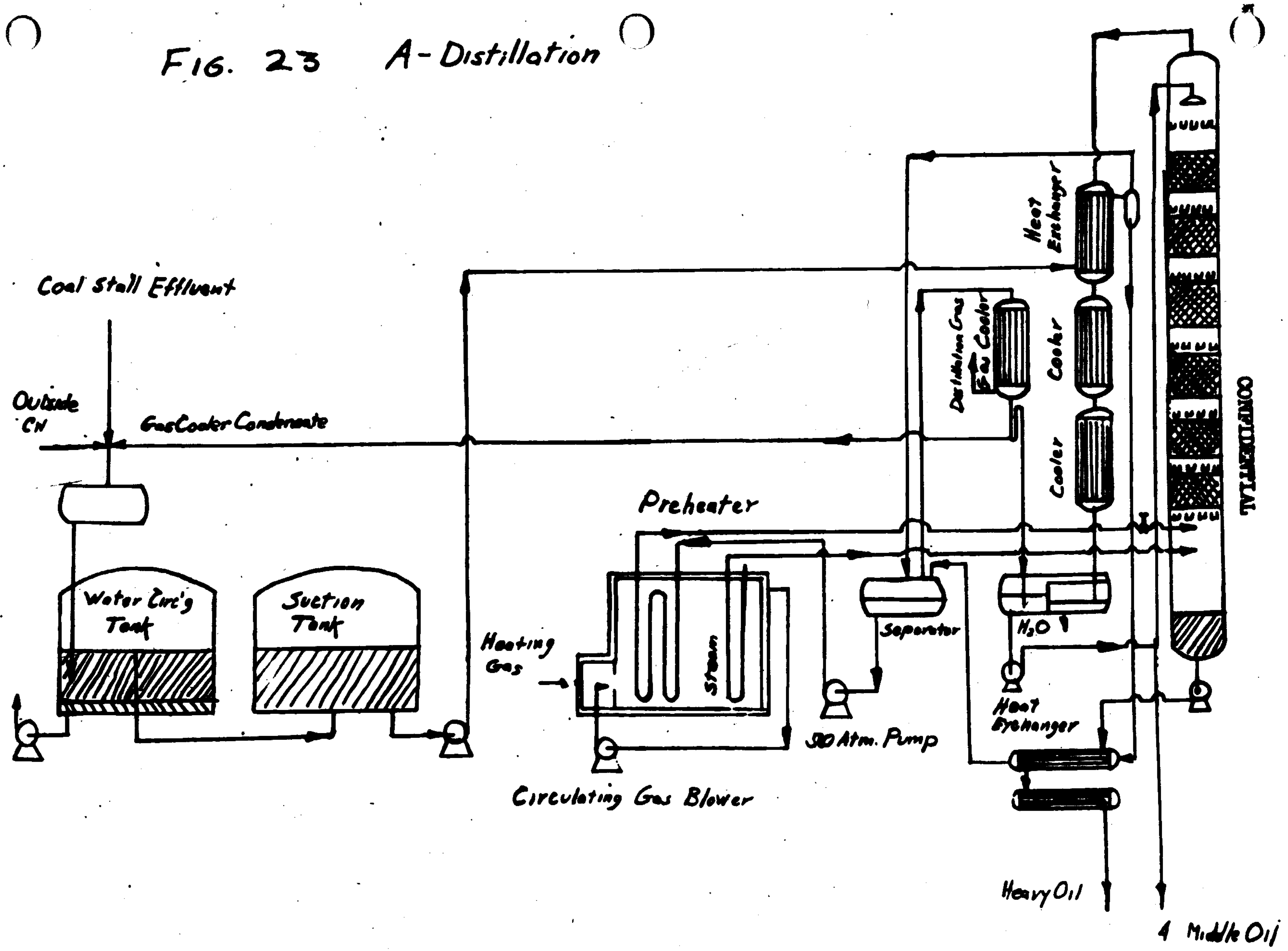


FIG. 22

FIG. 23 A-Distillation



V. COKING UNITS. (Cont'd.)

Capacity	3.6 tons/hr
Oil	3.6 tons/hr
Solid	0.6 tons/hr
Steam added	0.21 tons/hr
Furnace temperature	500.0 °C

YIELDS

Coke oven oil I + II	1.36 tons/hr
Residue	2.13
Oil	1.44
Solid	0.69