SOCIETY OF PETROLEUM ENGINEERS OF AIME
6200 North Central Expressway
Dallas, Texas 75206

PAPER NUMBER SPE 3349

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WEMCO Depurator™ System

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This paper was prepared for the Rocky Mountain Regional Meeting of the Society of Petroleum Engineers of AIME, to be held in Billings, Mont., June 2-4, 1971. Permission to copy is restricted to an abstract of not more than 300 words. Illustrations may not be copied. The abstract should contain conspicuous acknowledgment of where and by whom the paper is presented. Publication elsewhere after publication in the JOURNAL OF PETROLEUM TECHNOLOGY or the SOCIETY OF PETROLEUM ENGINEERS JOURNAL is usually granted upon request to the Editor of the appropriate journal provided agreement to give proper credit is made.

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INTRODUCTION

The meaning of the word depurate is "to purify or cleanse"; therefore, a depurator is one which purifies or cleanses. Depurator is the name given to the four cell flotation system, WEMCO ™ Depurator System, which is manufactured by WEMCO Division of Envirotech Corporation.

The Depurator System is a natural aspirating, shear force flotation cell that has been designed for use in hazardous locations in the petroleum industry. The primary function of the Depurator System is to reduce the oil content in oily waters. In most cases, with chemical aid, the oil content can be reduced to acceptable limits such as 20 ppm oil or less.

ORIGIN

The WEMCO Depurator System originated from the WEMCO Fagergren flotation cell which is used in the benefication of ore in the mining industry. The WEMCO Fagergren is a single cell flotation unit which has been used for years; as a matter of fact, more than 15,000 WEMCO Fagergren flotation cells are presently in use. Other than the principle of self air inducement, the similarity just about ends. The WEMCO Depurator System operates with four cells in series which are completely enclosed, and explosion-proof motors; whereas the WEMCO Fagergren is an open cell which does not require explosion-proof motors. Also, the tank design is different. The Fagergren is designed for solid-liquid separation and the Depurator is designed for liquid-liquid separation.

Questions have arisen regarding how the WEMCO Depurator System came about as far as the petroleum industry is concerned, and what the need is for this equipment. First, the market was developed by federal, state and local agencies that began to enforce and regulate the discharge of water to open ditches, pits, ponds, lakes, rivers and oceans. In most areas the maximum oil content allowed in effluent waters is 20 ppm. To meet this demand, a process was necessary that would be both efficient and economical. Therefore, the market is there for any process meeting these requirements; the WEMCO Depurator System does.

The next question was, how did the use of the WEMCO Depurator System come about for this purpose? It just so happens that during an equipment exposition in 1968, a representative for the Tretolite Division of Petrolite Corporation saw a Fagergren bench model on display. After finding out that the Fagergren was used in benefication of ore, questions and interest developed into a program to determine if the Fagergren could be useful in effluent water clarification. To gather this

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References and illustrations at end of paper.

information, a prototype model was built from knowledge which WEMCO Division had on the Fagergren and test work with a bench model. In 1969 a prototype 150 GPM WEMCO Depurator System was installed in Long Beach, California. After several weeks of testing, a modified 300 GPM Depurator System was sold to Gulf Oil Company in Bakersfield, California. This unit, now operating for two years, is the oldest WEMCO Depurator System in operation.

Since 1969 this system has been sold to oil companies for installation in the oil fields of Los Angeles and Long Beach, California; Wyoming; off-shore Louisiana and for refineries in Montreal, Quebec; Vancouver, British Columbia; Wilmington, California; Fort Worth, Texas; Ashland, Kentucky; New Orleans, Louisiana and Odessa, Texas.

DESIGN

The WEMCO Depurator System is continuing to undergo changes which will improve its efficiency, economics and maintenance. Although there have been some improvements in the design, the principle of operation is the same, which is described as follows:

All the Depurators are four-cell units with each cell having one minute retention time; four minute retention time for the entire machine. The rated capacity of these units is based on the fact that three minute flotation time has been necessary in all production and refinery waters tested; field tests with standard equipment gave this information. A one minute safety factor has been added in establishing the rated capacity of all the commercial machines.

The operating mechanism of the Depurator is generally illustrated by Figure No. 1. The bearing stand with grease lubricated Timken bearings, grease seals, shaft, V-belt drive for speed reduction with built-in drive take-up, drive guard, disperser and hood, and general assembly have the same design on all units. The base of the mechanism casting is completely sealed to prevent the entrance of gas or vapor into the bearing area. The rotor and disperser are molded neoprene of thickness and strength for severe abrasive duty.

The dimensions of the mechanism, rotor, disperser, and the rotor speed are engineered for each size Depurator. The rotor speed decreases as the size of the machine increases because the rotor diameter increases with the larger machines and its rpm is based upon the tip speed of the rotor. Rotor speed is in the range of 425 rpm for the small machines to 220 rpm for the largest. The V-belt drive provides a simple method of changing rotor speed, if a need arises. It is only necessary to change the diameter of the motor sheave to change rotor speed, both driver and driven sheaves have self-locking type hubs that accommodate various sheave diameters.

OPERATION

The mechanism is designed to induce gas into the water at atmospheric pressure. The adjustable gas intake into the Depurator standpipe is between the gas-tight cover of the tank and the water level. The gas from this area is continuously recirculated through the water at the rate of approximately 15 cubic feet per barrel (each cell) of liquid, at the specified capacities, or approximately 60 cubic feet for the entire machine. This 60 cubic feet per barrel does not represent the amount of gas required from an outside source, it is the total amount recirculated. The amount of make up gas is usually in the range of 0.1 to 0.2 cubic feet per barrel or just enough to maintain a gas blanket of 0.5 to 1.0 ounces pressure between the liquid level and the gas tight cover. When air is used, it is introduced to the Depurator at atmospheric pressure. Therefore, no auxiliary equipment such as blowers, compressors, or pumps are required for mixing the gas with the liquid.

The action of the rotor-disperser assembly is to pump the water through the disperser area, that intimately mixes the gas with the water as both are forced through the openings in the disperser. The hood is stationary; its purpose is to prevent turbulence directly above the disperser.

INSTALLATION

The Depurator should be installed level in length and width, the action of the mechanisms migrate coarse solids to the discharge end of the machine where these may be removed from the bottom of the tank through the drain plug. To date, it has not been necessary to use the drain plug for this purpose, as the sand, iron sulfide and other solid material has been floated with the oil. If it should become necessary to remove coarse solids from the bottom of the tank, a timed valve could be used at the drain plug. A sand trap is provided at this point to stop coarse material from entering the clean water discharge box.

Water pressure is not required on the water delivered to the Depurator, flanged feed connections are provided on both sides of the feed box, either or both may be used. These have a deflector to help reduce the turbulence in the event the water is brought to the machine under considerable pressure. The flow pattern through the machine is from the lower portion of the feed box into the first cell and then under baffles between cells, over the opening above the sand trap into the discharge box. These baffles extend above water level and retain floating oil and solids. The retained floating material in each cell is skimmed off by a skimmer assembly. This skimmer assembly has a cell-to-cell skim adjustment. If Cell No. 1 is heavily loaded with float material, it is possible to regulate its level to skim more material here and to gradually reduce the amount of skimmed material from cell to cell.

It is necessary to submerge the float collecting flume discharge in a pit or to include a water seal to maintain the gas pressure within the tank.

MECHANISM FUNCTION

A closer look at the mechanism assembly is: The tank (A) is designed at an angle which will allow the water to recirculate for continuous purification. As the rotor (B) spins to act as a pump to force the water through the disperser (C), it creates a vacuum in the standpipe (D). This vacuum allows for the air to be transferred from the air blanket (E) above the water layer down the inside of the standpipe to the rotor. The rotor forces the air into the water, and as it travels at a high velocity through the disperser a shearing force (F) is created that causes the air to form minute bubbles. As these bubbles rise to the surface, oil particles are attached to the interface of the air bubbles. When the air breakes the liquid surface, the oil is left on the surface to be skimmed off, and the air is recirculated.

As the water enters the inbox (A) of the Depurator System, deflection plates deflect the water to the bottom for entrance into the first cell (B). The water and air are mixed by the mechanism (which is the rotor and disperser assembly) in this cell to begin a four-stage flotation process. Through pilot plant test work, it has been determined that four cells in series will give the best results if the retention time in each cell is one minute or less; therefore, in four minutes the water is discharged (C). The air is vented through a low pressure, maximum 4 ounces, relief valve (D), the intake of the air is at (E), and the oil is skimmed over into the float flume on each side (F).

STANDARD EQUIPMENT

The tank on a standard WEMCO Depurator System is made of carbon steel and is internally coated, after a commercial sandblast, with coal tar epoxy. The outside of the tank is coated, after a commercial sandblast, with a lead-free zinc base primer and finishing coat of machine enamel. All internal materials that are not coated with coal tar epoxy are made of neoprene.

A pneumatic float level control (G) is also furnished with a standard Depurator System. This level control may be mounted on either side of the discharge box. This level controller has all stainless steel wetted parts and is the torque-arm type. The input gas pressure required for this control is in the range of 20 to 30 psi. If the Depurator System is of sufficient capacity to take the entire flow, the level control may best be used to control a pressure open-spring closed valve, mounted on the clean water discharge from the machine. This would maintain the skim level in the tank regardless of feed fluctuation or complete shut off of feed.

There are seven different Depurator Systems as shown in Table No. 1. All of these machines are skid mounted, self contained, four cell, completely enclosed with inspection doors on each side, Depurator Systems designed to give four minute retention time at the rated capacity.

CHEMICAL INJECTION

To improve the efficiency of this process, chemical aid is injected in the water upstream of the flotation cell. (At this time chemical aids that give the best results are polyamines or polyquaternaries.) These compounds not only tend to break oil-in-water emulsions, but they make the air bubbles more stable. With the air bubbles being more stable, a froth is formed on the water surface. This froth will act as a filter to help remove more oil as the air passes through for recirculation.

As the oil accumulates on the surface, it is swept off by skimmers, one mounted on each side, into a float flume for collection and treatment. Any oil that breaks in one cell is prevented from migrating to the next cell by baffle plates.

Almost as soon as the oil and froth are swept over to the float flume, the froth breaks into water and oil. The total volume of oil and water collected over the float flumes is approximately .5 to 2% of the total flow; depending upon the oil content in the influent. For instance, if the oil content is 200 ppm or less, the overflow would be less than 1% of the total influent; above 200 ppm the overflow would range upward to 2%.

ADVANTAGES

Before the introduction of the WEMCO Depurator System to the petroleum industry, the oil companies used dissolved gas, partial recycle, total pressuration, partial pressuration, etc. as a flotation process. In some cases, the sludge created with this type flotation was a problem in itself. This equipment also requires a large area, since it usually has a flow rate capacity of 2.0 GPM/Ft.^{2} of surface area. Some of this equipment is not enclosed, which prevents the use of natural gas.

The Depurator System does not create a sludge, operates at 7.5 GPM/Ft.^{2} and is completely enclosed so that natural gas may be used. While investigating the use of natural gas with this equipment, it was found that the oxygen content was significantly reduced as Table No. 2 indicates. This testing was done on the Sacramento, California city water supply. Tests for oxygen were made with a Yellowspring Model 54 oxygen meter.

INSTALLATIONS

Table No. 3 gives the flow rates and the oil reduction at several installations.

PLANT DESIGN

Most all these installations are similar in design. The oily water is regulated as much as possible for a steady flow rate to the Depurator System. The removed oil is returned for reclamation and the clean water is discharged for injection or to an acceptable above-ground location.

TABLE 1 - DEPURATOR SIZE

Depurator System No.	GPM	Barrels Per Day	Total Horsepower	Rotor RPM
44	150	5,150	21	425
56	300	10,300	21	375
66	450	15,450	31	320
76	750	25,725	41	285
84	1,125	38,585	61	250
120	2,250	77,175	101	220
120-X	3,000	103,000	101	220

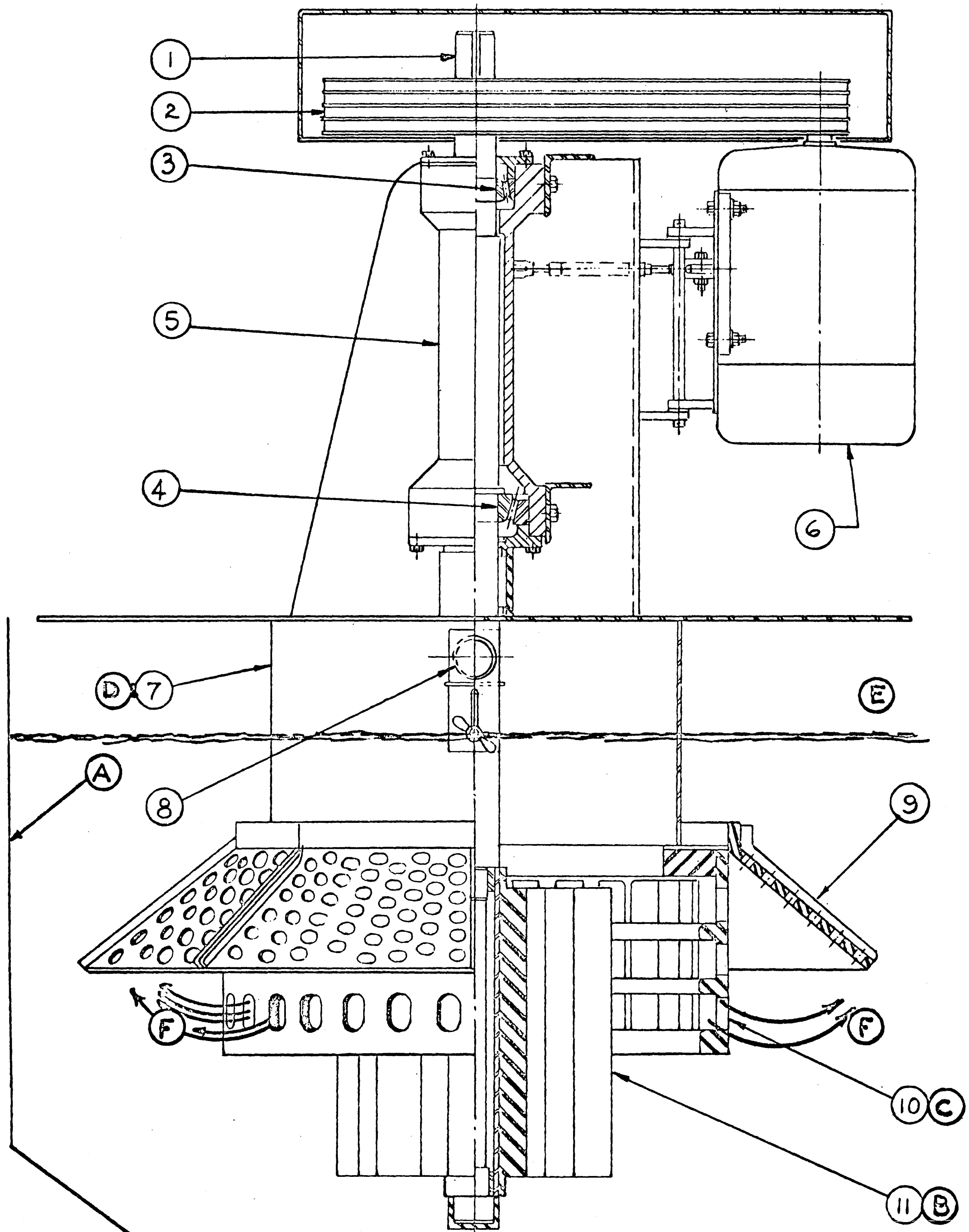
TABLE 2 - DEPURATOR USED TO REDUCE OXYGEN

Oxygen Removal (10/26/70)

Time	O_2, ppm (in)	O_2, ppm (out)
1:30 PM	9.4	2.5
2:30	9.4	1.8
3:00	9.4	1.0
3:45	9.4	1.0
4:30	9.4	1.0
5:00	9.4	1.0

TABLE 3 - PLANT INSTALLATIONS

Size Depurator	Location	Flow Rate Bbls./Day	Oil (in) ppm	Oil (out) ppm	Chemical ppm
76	East Black Bay, La.	10,500	60-160	2- 9	3
76	Ventura, California	9,000	60-350	2- 3	12
66	Los Angeles, California	6,000	81-175	6-10	5
66	Off-shore, Louisiana	13,000	75-100	10-15	0
76	Midwest, Wyoming	25,000	100-400	2-15	10
56	Bakersfield, California	10,600	95-115	2- 4	5
120	Montreal, Quebec	70,000	70- 90	5-10	15



ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Shaft - Rotor	7	Standpipe
2	Belt Drive	8	Gas Intake Control
3	Bearing - Upper	9	Hood
4	Bearing - Lower	10	Disperser
5	Bearing Housing	11	Star Rotor
6	Motor		

Fig. 1 - Mechanism assembly.

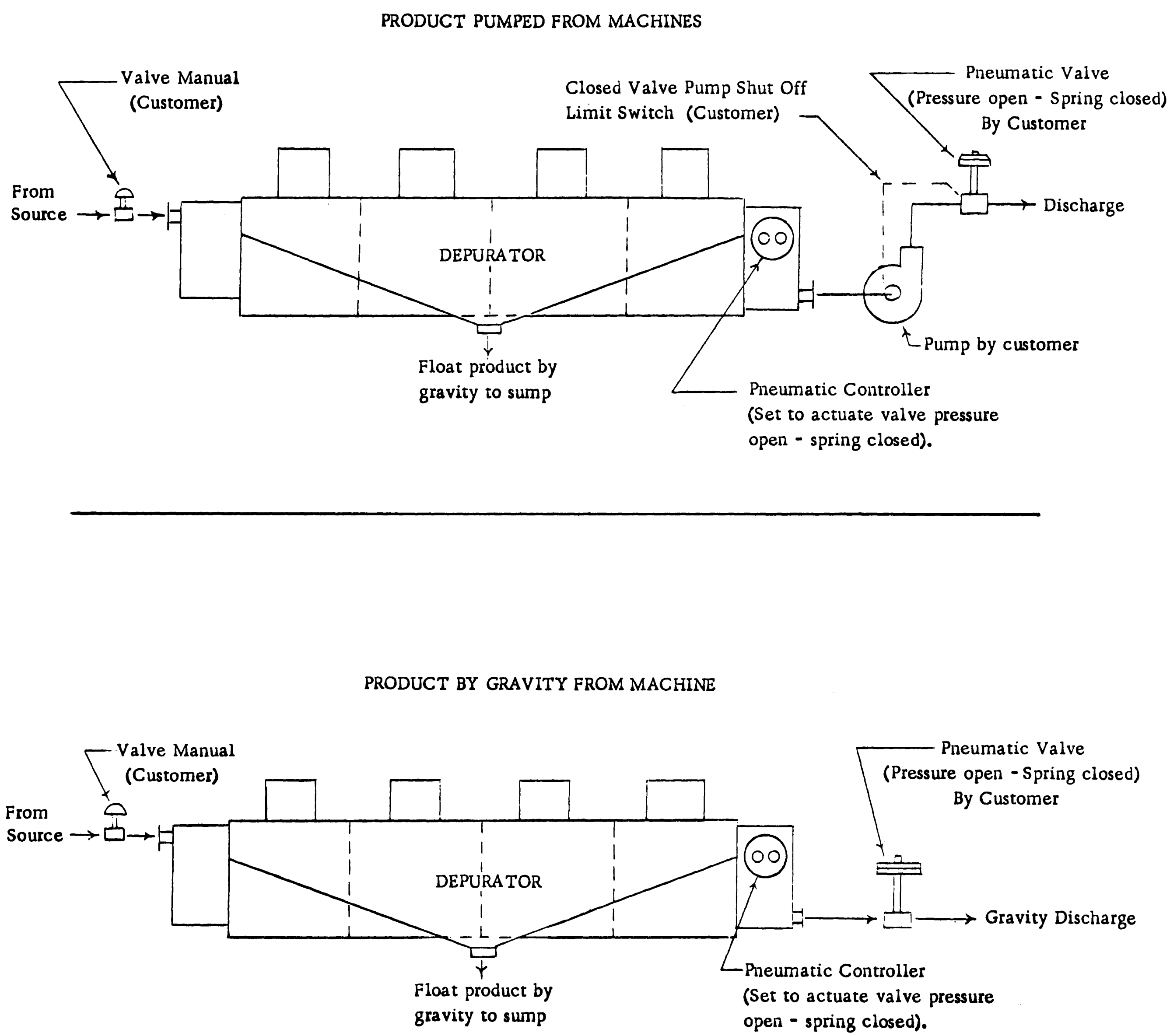


Fig. 2 - Flow control diagram.

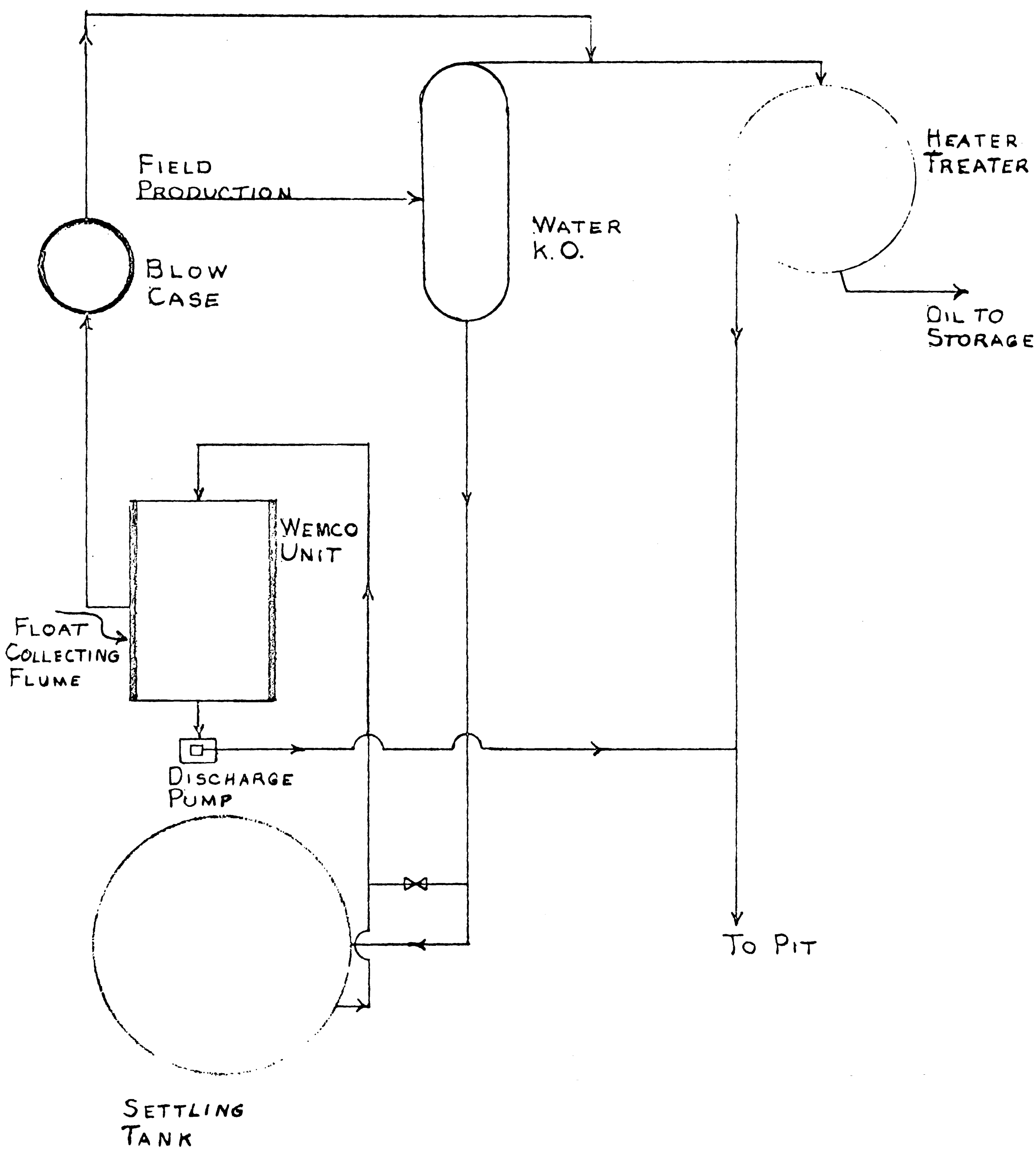


Fig. 3 - Treating and disposal system.