

June 15, 1943.

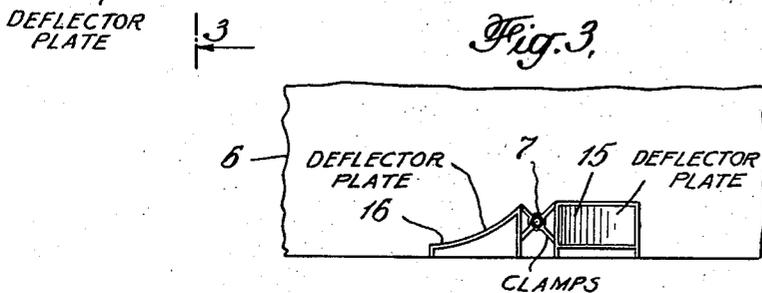
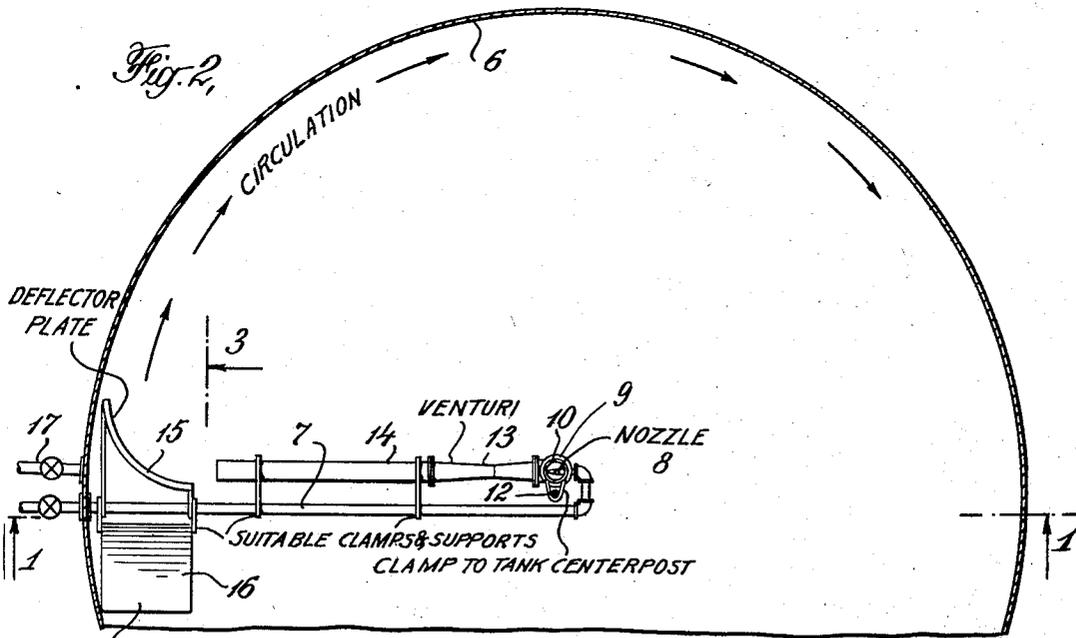
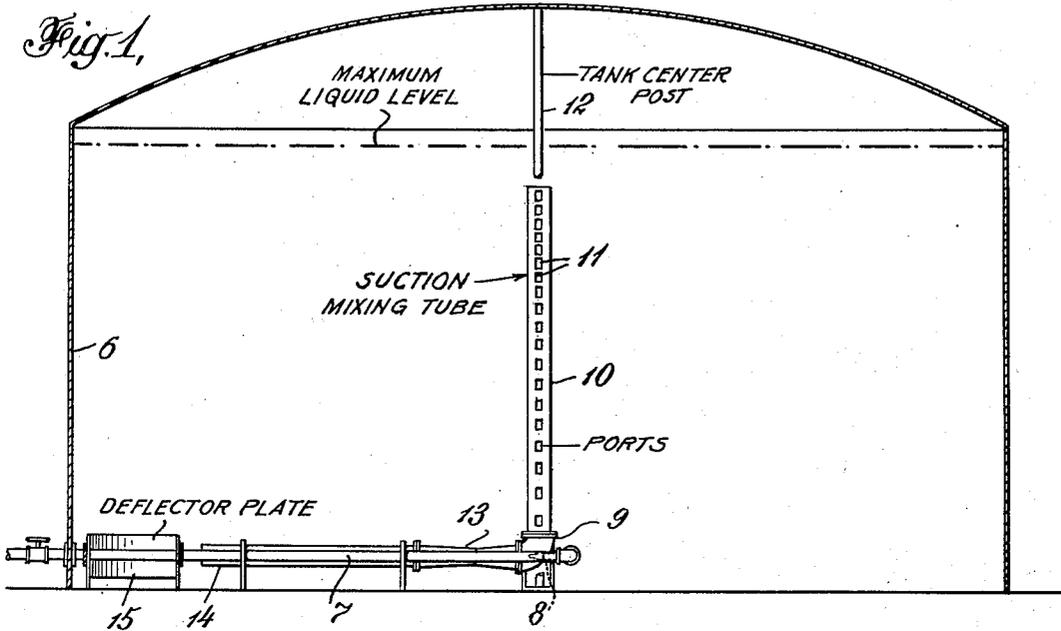
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2,322,087

EDUCTOR TANK MIXER

Filed Dec. 10, 1942

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

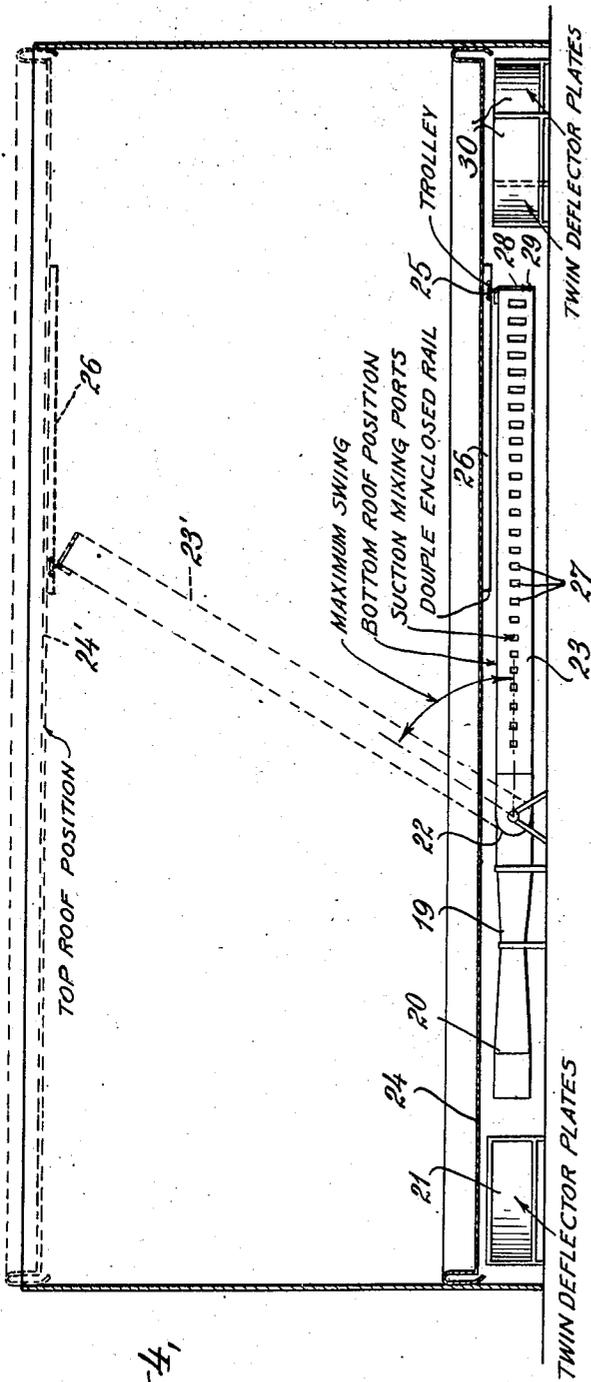


Fig. 4,

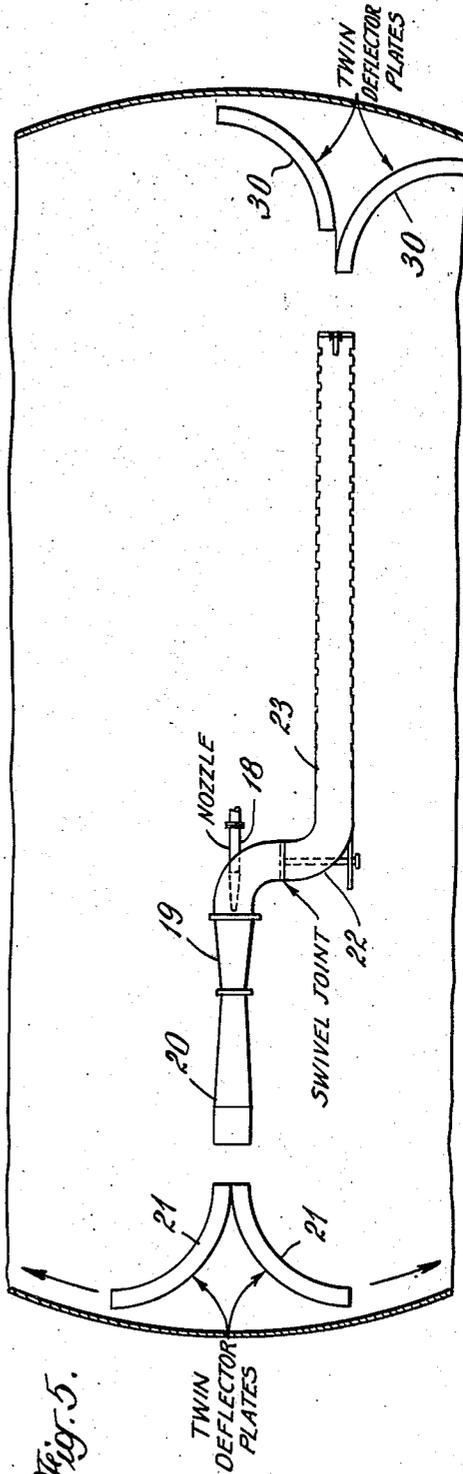


Fig. 5.

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UNITED STATES PATENT OFFICE

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EDUCTOR TANK MIXER

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8 Claims. (Cl. 259—18)

In the mixing of large quantities of crude petroleum oils or petroleum products where oils of different gravity are put in tanks it is observed that there is a marked tendency for the oils to separate by stratification into layers of different gravity. Even in a product of extremely high fluidity, such as gasoline, specific gravity differences amounting to one degree of A. P. I. gravity and sometimes more have been noted in a tank 30 feet in height when filled and allowed to stand for a week or so. These differences are particularly acute and of importance with heavier, more viscous oils. For example, it is customary in many refineries to blend several different crude oils, of different properties, together to assure a uniform charging stock for continuous distilling operations. In some such cases, these blends give great difficulty in arriving at uniformity. Also, in preparing products for market, much blending is done, such as cutting back a heavy fuel oil stock with a lighter gas oil. Many of these blending operations, particularly in the case of preparing crude oil blends for distillation, take place in quite large tanks. The standard "55," that is a tank holding 55,000 barrels of 42 gallons each, which is almost uniformly used throughout the industry for crude and major product storage, is a tank of about 117 feet diameter and 30 feet of height. It can readily be appreciated that assuring adequate mixing in vessels of proportions such as these is no mean problem. Even in much smaller tanks, such as those of 5, 10 or 20 thousand barrels capacity, the problem is major.

There are several methods of mixing now in use. The commonest; that of "turnover" pumping, consists of pumping from and to the tank, using suction and discharge as far separated as the fitting of the tank will allow, is also probably the most ineffective, particularly on heavy oils. Dependent somewhat upon the size of piping and pump available as regular equipment, circulation pumping time is many hours—15 to 24—and frequently a couple of days circulation is necessary.

Impeller or propeller type mixers driven by a shaft extending through the side of the tank are frequently used, but are highly consumptive of power, and can be operated with assurance only in quite small tanks or if rapid and complete mixing in large tanks is to be assured, three or more large propellers and motors must be installed per tank at an excessive installation cost.

Some eductor type tank mixers have been proposed and used, wherein an incoming stream of oil, either oil coming to be stored or a circulation

stream withdrawn from the tank itself is used, in an injector nozzle, to entrain oil from within the tank. No one of these of which I am aware has been capable of providing adequate high capacities of entrained oil, nor have any been so designed as to entrain oil in any other layer than those near the bottom of the tank except to the small degree obtained by turbulence of an inclined discharge. While such mixers are more efficient than plain "turnover" pumping, the present design still requires long pumping times and large power expenditures.

The objects of this invention are the provision of an eductor type tank mixer capable of effective mixing with small power expenditure, capable of effectively mixing two or more grades of oil in a tank during the filling operation by merely pumping them into the tank one after the other at the normal filling rate and with the existing filling pump, capable of complete mixing within a wide range of level of oil in tank, capable of complete mixing in a shorter length of time than by existing means, and capable of ready and cheap installation.

These objects are accomplished by the application of the principle of entraining a relatively great volume of tank fluid in the eductor, drawing that fluid simultaneously from all levels of fluid within the tank, regularly increasing the proportion drawn from each higher level within the tank and by baffling the eductor discharge in such a way that one or more circulation zones are created causing further mixing by turbulence in the tank and so arranged that the educted fluid is drawn from the relatively idle part of the circulation zone or zones.

The invention may be understood readily by reference to the drawings attached hereto. In these drawings Figure 1 shows a vertical view of a tank to which the mixer is applied, Figure 2 shows a plan view therein, and Figure 3 shows a baffle detail. Figures 4 and 5 respectively are vertical section and plan as applied to a tank with a floating roof.

In Figures 1 and 2, which should be read together, there is provided within tank 6 an inlet pipe 7 which terminates in a nozzle 8 within an eductor 9 from which there extends a vertical intake pipe 10 having orifices 11. The vertical pipe 10 is conveniently mounted by clamping to the tank center post, 12, as shown. The eductor 9 is fitted with a Venturi throat 13 and a discharge tube 14. This tube is directed toward the tank wall and in front of it, against the tank wall there is placed a curved baffle 15 adapted to

change the course of the discharge stream into a swirling motion within the tank. This curved vertical baffle 15 is associated with a curved lifting baffle 16, as may be clearly seen in Figure 3, which serves to lift the swirling tank liquid and in effect, to slide the mixed discharge stream under it. These baffles may be effectively fixed in position by clamping to the inlet pipe 7 as may be clearly seen in Figure 3. Since in most tanks inlet and outlet pipes are adjacently located, as at the left side of Figure 2, it is usually convenient to provide that the tank outlet pipe 17 is located behind the baffles 15 and 16.

In Figures 4 and 5, which should be read together, there is shown a slightly different arrangement to be used in tanks when the roof floats upon the stored liquid. In these figures the details of inlet piping are not shown, but, as before, the inlet pipe discharges through a nozzle 18 in a venturi 19 and mixer tube 20. Due to the large torsional effect that a single swirling motion would have on a floating roof, it appears best to use a double deflector baffle 21—21 to set up a double swirling motion to counteract the tendency the roof would otherwise have to stick on its vertical guide. The intake pipe in this case communicates with the eductor through a "swing joint" to which intake pipe 23 is affixed so that it may rise with the roof 24 to the positions shown at 23' and 24'. A good method of affixing the pipe 23 to the roof 24 is by an enclosed trolley 25 operating in track 26. Pipe 23 is provided with orifices 27, and its end is closed by plate 28 in which there is an orifice 29. There are also provided, in this tank, baffles 30—30 to complete the double swirl. A double suction mixing tube could be used, each drawing from the center of one of the swirls, but the added efficiency would not usually be sufficient to justify the added complications.

The efficiency of this device depends upon certain design factors. First the nozzle and eductor system are so designed as to secure a very high ratio of entrained fluid to nozzle fluid, greater than 2 to 1 and preferably of the order of 5 to 1, with increasing efficiency as this ratio is increased. Due to the low differential heads, these ratios are obtained with comparative ease, and in some cases ratios of better than 10 to 1 have been attained.

Second, the location and proportioning of areas of the orifices in the intake mixing tube. These orifices are (a) so located that oil is simultaneously withdrawn from all vertical levels in the tank, and (b) are so proportioned that the amount drawn from each level increases upwardly along the intake mixing tube. In most tank mixing problems it is usually convenient to have the rate of increase of amounts drawn from succeeding higher levels arranged in simple arithmetic progression. That is, it is convenient to arrange the areas of orifices in successive intervals of one foot each, taken upwardly, to have some such relationship to each other as 1: 2, 3: 4; etc., or 15: 16, 17: 18; etc.

The sum of the area of the orifices in the intake mixing pipe should be such that when the tank is full, all orifices are submerged, and the jet is entrained the full capacity for which it is designed, the velocity through the orifices is of the order of about two feet per second. In the swinging intake mixing tube for floating roof tanks, the end of the intake pipe should be closed except for an orifice capable of handling, at a velocity of about two feet per second, a flow of

about one-tenth to one-fifteenth the total being circulated.

The arrangement of ports described above provides that the largest portion of fluid educted comes from horizontal layers farthest away from those which compose the jet or the freshly mixed fluids, when mixing by recirculating, and draws back the largest portions of fluid first pumped in for mixing with that last pumped in thru the jet, when mixing during filling.

Third. Arranging the very large discharge from the mixer to flow tangentially to the tank shell creates a strong swirl which keeps the freshly mixed stocks near the shell and the least mixed stocks in each layer near the center. Locating the inlet mixing tube at the center draws to the mixer these least mixed stocks first.

Thus both vertically and horizontally the mixer automatically draws to it the least mixed stocks in the tank.

As an example of the comparative efficiency of this device, the following operation is cited, which was carried out with a very rudimentary form of jet and intake tube, capable of operating only in the lower range of efficiencies indicated. In this operation, no recirculation was performed, the jet fluid being only the incoming crude on its way to storage in the tank. The tank was an 8000 barrel tank, 54 feet in diameter, 25 feet high. The following Coastal Naphthenic Crudes were pumped in one after the other.

Crude	Barrels	Sayb. viscosity @100° F.
Urania.....	3,593	564
Heavy Lockport.....	614	81
Heavy Iowa.....	1,935	83
Mixed Coastal.....	1,825	240

¹ Approximately.

As soon as the filling was complete and without any other mixing, five samples were taken at different levels as follows:

Sample number	Level where sample taken	Sayb. viscosity @100° F.
	<i>Feet from bottom</i>	
1.....	4	249
2.....	8	248
3.....	12	248
4.....	16	249
5.....	20	247

The indicated viscosity of the blend of these crudes in the proportion used, as read from a viscosity blending chart should have been about 245. This deviation from the average of the above is within the range of accuracy obtainable with such a chart.

Repeated tests on such mixtures in this tank confirmed the efficiency of this equipment, so that two other tanks in the same service were equipped with similar jets and suction mixing tubes. About four batches per week were regularly made in these three tanks and previous to the mixer installation, each batch was circulated 15 to 20 hours after filling. In spite of this circulation the batches were very irregular, which caused much trouble in adjusting the still which was running this crude, with frequent slopping of off test stocks, resulting in extra re-running costs.

No recirculation is now necessary, less off test stock is produced, and the same three tanks now

handle about six batches per week and so supply feed to an additional distillation unit which has since been put in service.

Obviously, any device capable of handling a problem of this nature without pumping other than the normal pumping of each new batch of incoming stock into the tank has advantages over the methods of mixing now prevalent.

I claim:

1. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, and a discharge tube leading from the eductor and substantially horizontally mounted so as to cause circulatory motion of the fluid within the tank about the vertical axis of the latter.

2. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, the eductor, intake pipe, and orifices being so proportioned that the volume of entrained fluid is substantially in excess of the volume of nozzle fluid, and a discharge tube leading from the eductor and substantially horizontally mounted so as to cause circulatory motion of the fluid within the tank about the vertical axis of the latter.

3. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, the eductor, intake pipe, and orifices being so proportioned that the ratio of the volume of entrained fluid to the volume of nozzle fluid is in excess of 2:1; and a discharge tube leading from the eductor and substantially horizontally mounted so as to cause circulatory motion of the fluid within the tank about the vertical axis of the latter.

4. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, the eductor, intake pipe, and orifices being so proportioned that the ratio of the volume of entrained fluid to the volume of nozzle fluid is of the order of 5:1; and a discharge tube leading from the eductor and substantially horizontally mounted so as to cause circulatory motion of the fluid

within the tank about the vertical axis of the latter.

5. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, a discharge tube leading substantially horizontally from the eductor, and a baffle mounted in the tank in the path of the stream from the discharge tube to effect circulatory motion of the fluid within the tank about the vertical axis of the latter.

6. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, the eductor, intake pipe, and orifices being so proportioned that the ratio of the volume of entrained fluid to the volume of nozzle fluid is in excess of 2:1, a discharge tube leading substantially horizontally from the eductor, and a baffle mounted in the tank in the path of the stream from the discharge tube to effect circulatory motion of the fluid within the tank about the vertical axis of the latter.

7. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, and a discharge tube leading substantially horizontally from the eductor and so mounted as to cause circulatory motion of the fluid within the tank about the vertical axis thereof, in which the arrangement of the orifices in the intake pipe is such that greater amounts of oil are withdrawn from tank levels most removed from the level to which the discharge tube leads.

8. In a tank and mixer of the kind described a pipe for supplying fluid to the tank, an eductor in which the supply pipe terminates in a nozzle to supply jet fluid therefor, an upwardly extending intake pipe leading into said eductor, orifices so distributed along the length of that intake pipe that fluids may be drawn thereinto from all levels within the tank, and a discharge tube leading substantially horizontally from the eductor and so mounted as to cause circulatory motion of the fluid within the tank about the vertical axis thereof, in which the arrangement of the orifices in the intake pipe is such that greater amounts of oil are withdrawn from tank levels most removed from the level to which the discharge tube leads and in which the intake pipe is located at that portion of the tank in which said circulatory motion is less pronounced.

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