AN IMPROVED SEPARATOR FOR USE IN THE FIELD DISTILLATION OF PEPPERMINT OIL

by

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CHAPTER 1

PRODUCTION OF PEPPERMINT OIL FROM THE HAY

INTRODUCTION. The production of peppermint oil is a small but important agricultural industry of the Pacific Northwest. Oregon's production in 1950 was 657,000 pounds with a value of $3,515,000 while some 306,000 pounds worth $1,545,000 was produced in the State of Washington during the same period. Michigan and Indiana produced the remainder of the 1,622,000 pounds produced in this country in 1950. Thus Oregon leads in production with 40.5 per cent of the nation's production.[1]

In order to acquaint the reader with the overall picture of the method of extracting the oil from the hay, the material of this chapter is included.

HARVESTING. Peppermint (Mentha piperita) is grown very much like alfalfa hay and is harvested in a similar manner. The peppermint hay is cut with a hay mower and allowed to cure in the field for usually one day. The hay is then picked up from the field and taken to the processing plant by one of two methods. The usual and older

1 Extension Service, Agricultural Economics, Oregon State College.

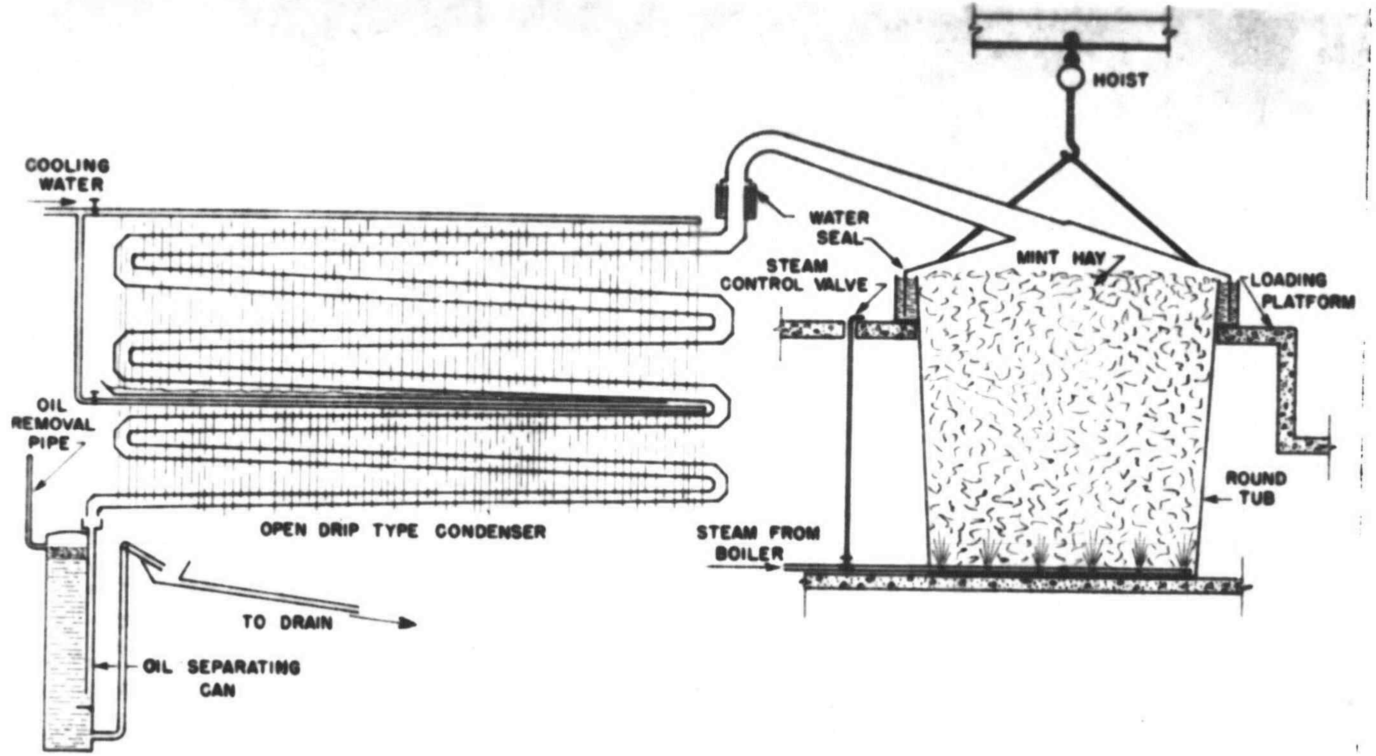

FIG I - FIELD DISTILLATION UNIT WITH STATIONARY TUB AND OPEN DRIP TYPE CONDENSER method is to load the hay on a truck or wagon by hand or with a hay loader and take it to the distilling plant. At the plant the hay is packed into stationary tubs which are about seven feet in diameter, with the sides tapered toward the bottom. Figure 1 shows this type of tub and its relationship to the rest of the plant.

Figure 2 illustrates the portable type of tub. The tub in this case is mounted on a truck and is taken to the field for direct loading. Some operators chop the hay before packing into the portable tubs because it packs better. The loaded tubs are taken to the processing plant where the oil is extracted.

COOKING. The lid is clamped on as shown in Figure 2 or fitted into a water seal as illustrated in Figure 1. Steam is brought in at the bottom and distributed evenly over the bottom by a network of small pipes. The steam escapes from these tubes through drilled holes. As the steam rises up through the hay, it distills the oil out of the leaves and stems and carries it as vapor up through the lid to the condenser.

After cooking, the spent hay is removed from the tubs and spread over the cut fields.

CONDENSING. In the condenser, the mixture of mint vapor and steam is converted to water and peppermint oil

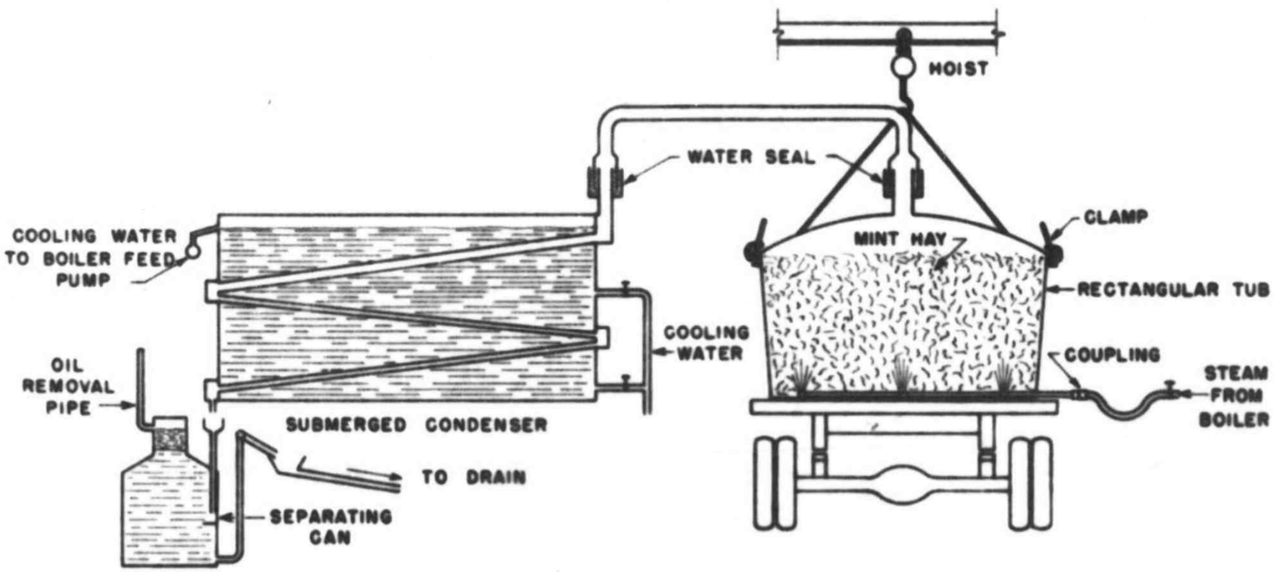

FIG 2 - FIELD DISTILLATION UNIT WITH RECTANGULAR PORTABLE TUB AND SUBMERGED CONDENSER and is called condensate. Figures 1 and 2 illustrate the two main types of condensers. The first is the open drip type where water from an overhead flume drips over the condenser coils. This type is the early model and is still used by many operators. Condensing is accomplished by direct and evaporative cooling.

Figure 2 shows the newer type condenser where the condenser tubes are placed in a tank of water. This type is more efficient and compact because of the better contact between the water and tubes.

SEPARATION. Separation is accomplished by utilizing the difference in specific gravity between the oil and water. Peppermint oil has a specific gravity of about 0.9 so that it will rise to the surface of the water if allowed time enough. In both Figures 1 and 2, the condensate enters the separator on the right side and is carried down a pipe until it strikes a baffle. The baffle is supposed to deflect the condensate out across the separator so that the oil can rise to the top and the water settle to the bottom discharge opening. The water is drawn off periodically from the top of the separator.

The type of separator shown in Figure 1 is gradually being replaced by the type of Figure 2. The older type separator is a galvanized steel cylinder about 15 inches in diameter and 6 to 8 feet long.

The separator of Figure 2 is usually about 30 inches in diameter and 4 feet high. It, too, is constructed of galvanized sheet steel.

RE-DISTILL. Some operators add another piece of equipment to their plants to further process the outflow of the separators. It is called the re-distill and is shaped very much like the separator of Figure 2. A steam coil in the bottom heats and holds the temperature of the water from the separators to about 205 degrees Fahrenheit. At this temperature, part of the remaining oil rises to the surface and is vaporized. This vapor is collected, condensed, and dumped into another separator. The resulting oil is called re-distill oil and has a lower market value; about one-half to two-thirds that of prime oil.

STEAM. Steam to cook the hay and heat the re-distill must be supplied from some source. Many operators use an old donkey boiler or other second-hand boiler for their steam supply. A few of the larger operators have more modern steam generation equipment. Many operators seem to feel it is more economical to use the old equipment because of the short distillation season (a few days to less than a month each year.) Newer, more modern equipment may have a lower operating cost but this saving is felt to be more than consumed by its higher first cost.

ECONOMICS. The present separator used in the field distillation of peppermint oil does not catch all the oil that comes in with the condensate. Information gathered in the field indicates that as high as ten per cent of the oil is lost with the overflow of the separator. This figure is an extreme one and the average would be considerably less but it still represents a considerable loss of income for the farmer. As mentioned above, some operators have added re-distills in an effort to catch this missed oil. This is an added expense in that it costs money for the equipment and steam and the resulting oil is of lower value.

The basic answer to the problem is to improve the separator so that it catches all the oil that comes in with the condensate. An improved separator would probably cost a lot less to operate than the cost of running a re-distill and all the yield would be prime oil resulting in an increased income for the farmer. Even for operators without a re-distill, the increased yield of oil would more than pay for the slightly higher cost of an improved separator.

HISTORY. Very little literature has been published on the general field of peppermint production and even less on the process of extracting the oil from the hay. The first commercial production of peppermint oil in this country occurred at Ashfield, Mass. in 1812. In the early stills, the hay was placed in hot water and the whole boiled. About the only improvements since have been the cooking of the hay dry with steam, the use of submerged condensers, and the change to the shorter, wider separator can. Of course many improvements have been made in harvesting and handling methods, but little attention has been given to the distillation process itself.

CHAPTER 2

SOME PHYSICAL PROPERTIES OF MINT OIL

TIME OF SEPARATION. One very simple but enlightening experiment was to determine the time of separation of the oil from water when the temperature is varied. All that was required was a 500-milliliter erlenmeyer flask containing 300 milliliters of water and 50 milliliters of peppermint oil. A one-hole stopper was fitted in the top with a thermometer extending through the hole into the liquid. The whole flask was vigorously shaken for 30 seconds and then set down and the oil and water allowed to separate. The time of separation was taken as the time from the end of the shaking period to the time when a definite line appeared between the oil and water. The temperature was noted and the whole experiment repeated at a different temperature. The results of this experiment are shown as Figure 3.

The main point to obtain from the time of separation curve is the fact that the time decreases with increasing temperature. This decrease is almost of exponential order. The results indicate that better separation would be obtained at higher temperatures.

Many operators run as much cold water as they can through their condensers in order to get the condensate

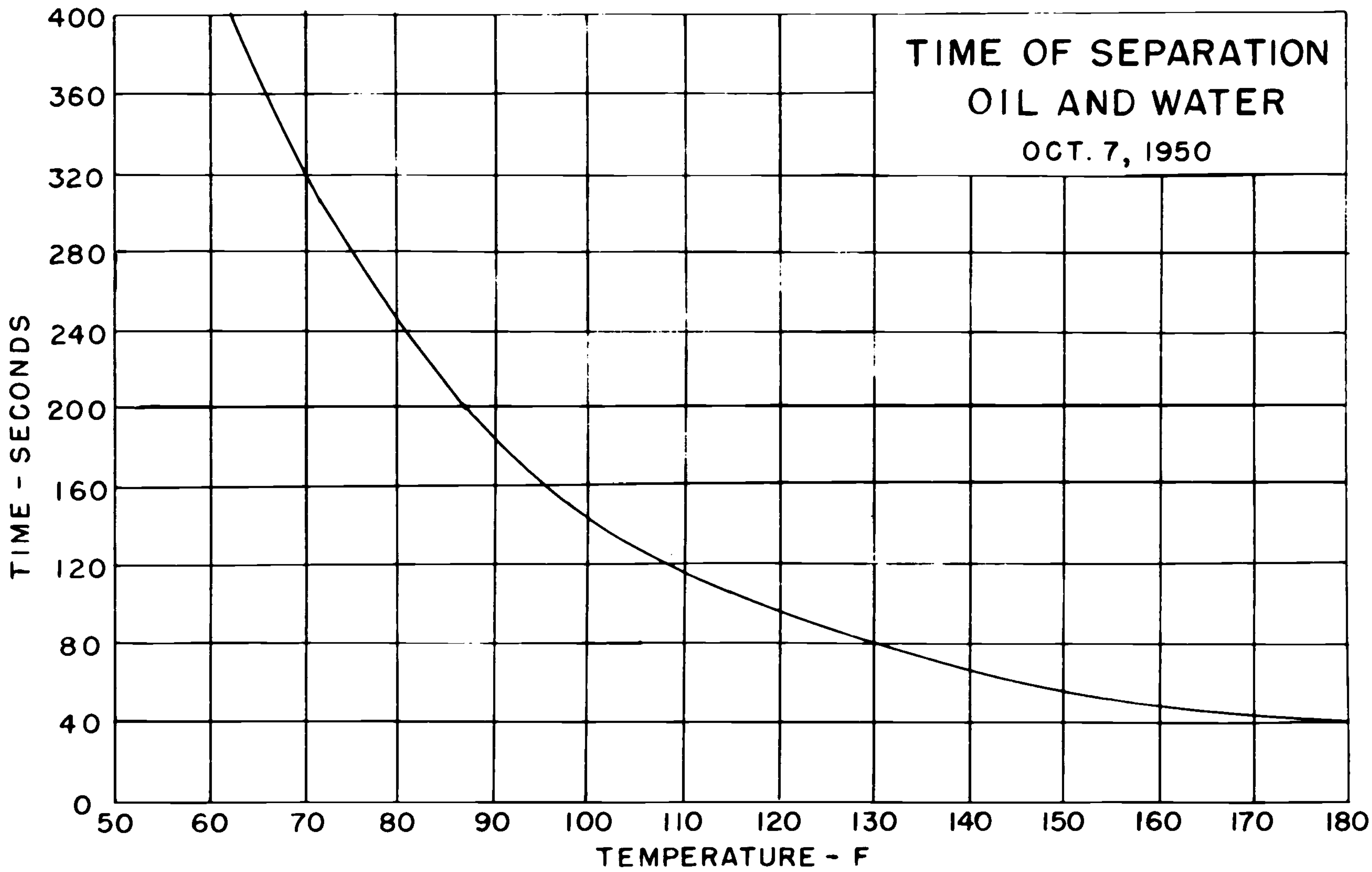

FIG. 3 - TIME OF SEPARATION OF PEPPERMINT OIL IN WATER

as cold as possible in the belief that some of the mint vapors would not be condensed at higher temperatures. This loss would be very small up to a temperature of 100 to 110 degrees Fahrenheit and is completely over-shadowed by the possible loss out the separator drain by incomplete separation at low temperatures. The usual range of condensate temperature is from a low of about 60 degrees Fahrenheit to a high of about 120 to 130 degrees Fahrenheit. Occasionally when the cooling water rate is not sufficient, it will come over at much higher temperatures; even boiling once in a great while, if the operator does not increase the cooling water soon enough.

VISCOSITY. In an attempt to determine the reason for the shape of the time of separation curve, the variations of specific gravity and viscosity with temperature were determined. To determine the viscosity of the oil, A.S.T.M. Procedure, "Test for Kinematic Viscosity", (D 445-46T), Method B, Modified Ostwald Viscosimeter was used. The oil tested was prime oil as supplied by the A.M. Todd Co.

The result of the viscosity test is shown as Figure 4. The curve is very similar in shape to the time of separation curve.

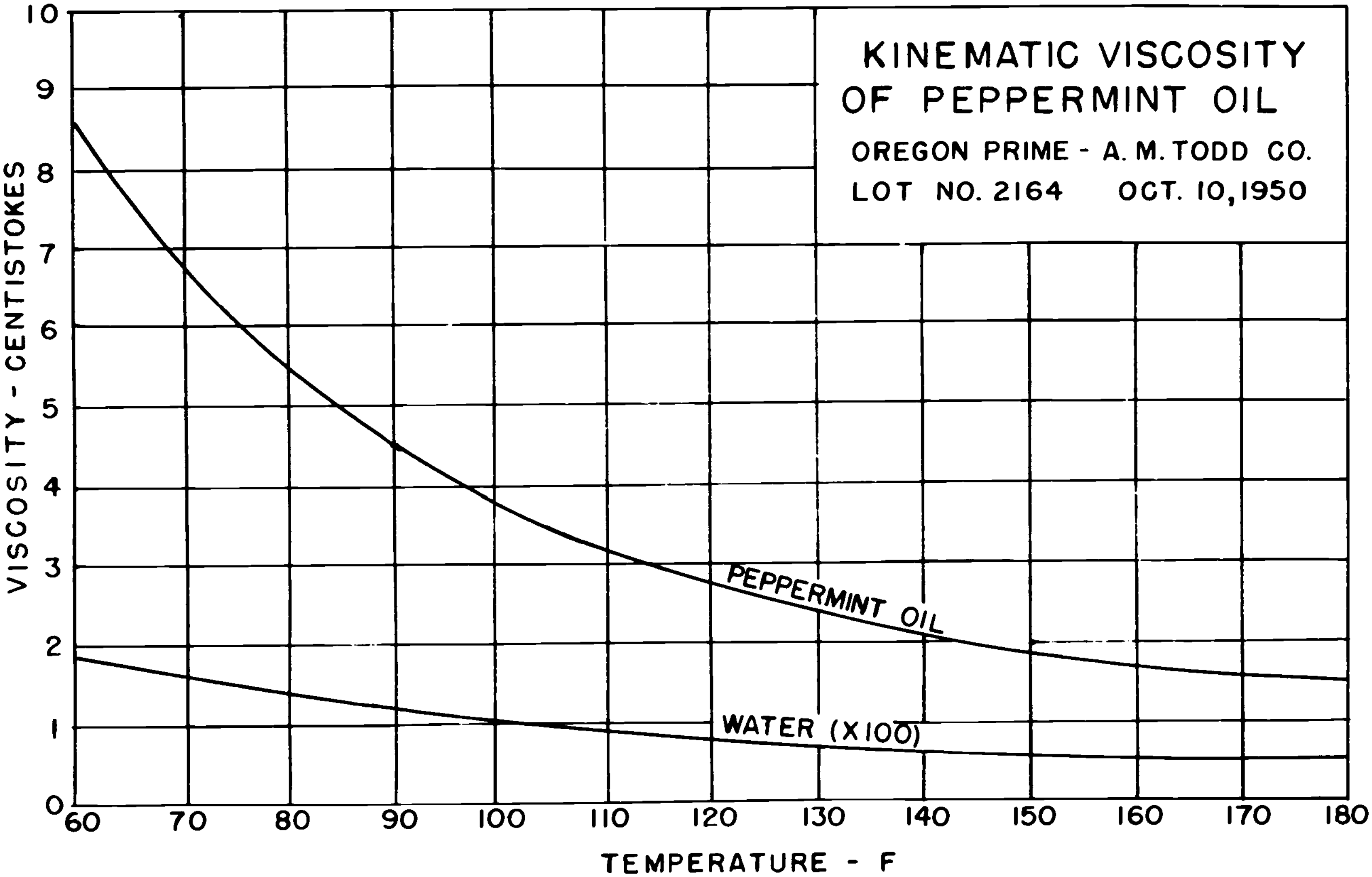

FIG. 4 - VISCOSITY OF PEPPERMINT OIL

Another property not analytically determined was the variation of surface tension with temperature; but for practically all liquids, the surface tension decreases with an increase in temperature.

These two properties offer a good explanation for the shape of the time of separation curve. With the lowering of the viscosity of both the oil and water as the temperature increases, the droplets of oil can move more easily and make their way to the surface more quickly. Also there will be more collisions between the droplets. And with the lowering of the surface tension, the droplets will merge more readily into larger drops which can then escape to the surface more rapidly.

SPECIFIC GRAVITY. Tests of the specific gravity of the oil were run over the normal range of temperatures with a standard hydrometer. The results showed that the specific gravity decreased about 4 per cent in the temperature range from 60 to 150 degrees Fahrenheit. For the same temperature range, the specific gravity of water decreases 2 per cent. These small changes would have very little effect on the time of separation as compared to the effect of the viscosity and surface tension as discussed above.

VAPORIZATION. From the time of separation curve, it

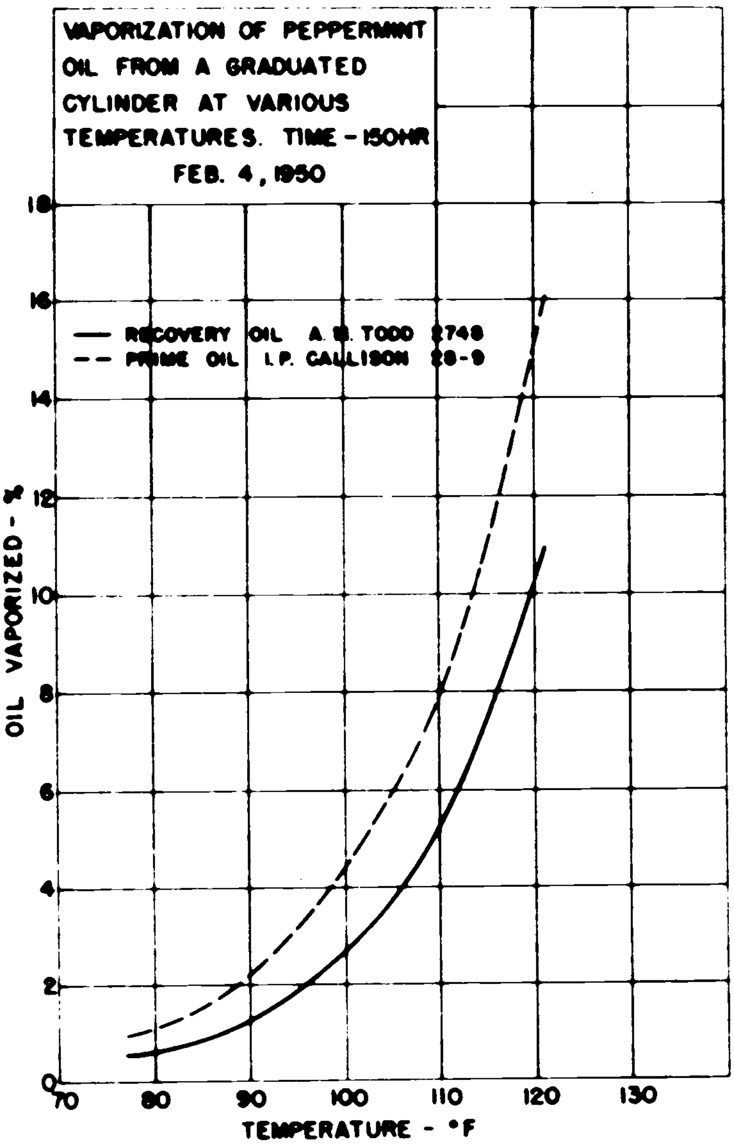

FIG 5 - VAPORIZATION LOSS OF PEPPERMINT OILS AT VARIOUS TEMPERATURES appears that the higher the temperature, the better the separation. This is true but as the temperature is increased to above 110 degrees Fahrenheit, another factor enters the picture; the volatility of the oil. At higher temperatures, the lighter fractions of the oil tend to vaporize.

Figure 5 is the result of a series of tests performed by R.W. Reid, a former student in Mechanical Engineering here at Oregon State College. Samples of peppermint oil in glass graduates were held at a given temperature for a week in a mineral oil bath. At the end of the week's time, the loss of oil was noted and corrected to 150 hours. The experiment was repeated with fresh samples at other temperatures.

In actual operation, the oil would not be exposed to the high temperature for a very long time (a few hours to less than a day); and with a tight fitting lid on the separator can, the loss of oil would be very much lower than that indicated by Figure 5. Combining the effect of the volatility of the oil and the time of separation, it appears that the best operational temperature for best separation is in the range of 100 to 120 degrees Fahrenheit.

CHAPTER 3

TIME-TEMPERATURE-TURBULENCE

TIME. As the condensate flows from the condenser of a field distillation plant, the majority of the oil has already separated into droplets big enough to make their way to the surface of the separator as soon as the condensate is fed into the separator. Practically any separator will catch this easily-separated part of the oil but many separators do not collect a large percentage of the remainder which is in the form of very small droplets in the condensate.

If a sample of condensate is taken in a graduate as it comes from the separator and allowed to stand for two minutes, these small droplets can be seen when the graduate is held up to a source of bright light. The large droplets will have formed a ring of oil at the top while below, the smaller droplets will be moving about in a more or less random but generally upward motion. These small droplets will with the passage of time merge into bigger droplets and move to the surface. An area of clear water will develop at the bottom of the graduate and slowly increase upward until all the visible oil has risen to the surface. The time required for this visible clearing is about half an hour. Also the density of the droplets above the clear area is decreasing all the time. This means to obtain complete a separation as possible, the overflow of the separator should draw from clear water like that which develops in the bottom of the graduate.

TEMPERATURE. There is one very important principle that seems to have been overlooked all these years; that the hot water rises to the top of a tank. A corollary to the above is that the cold water settles to the bottom. These principles are in operation during each run for practically all separators.

The practice of most operators is to leave the cooling water to the condenser running all the time whether or not there is any steam and mint vapors to condense. During part of the cycle while the tub is being unloaded and loaded, and before the steam finally breaks through the hay, there is no flow of steam to the condenser. This means that in the submerged type condenser, the tank is full of cold water when the steam starts to come over. In the type of operation where one condenser and separator serve two tubs, the delay between the end of one run and "break through" on the next is not as long because one tub is unloaded and loaded while the other is cooking, but the effect is still present. "Break through" is the point where condensate first appears from the condenser during the run. It requires time for the steam to heat the hay and until it does this, no condensate will be produced.

The first condensate through the condenser will be cooler than the last through on the previous run so that the incoming condensate is cooler than the water in the can. Figure 6 illustrates the variation of the condensate temperature during a run as well as other quantities of a field distillation plant. This incoming condensate has a higher specific gravity than the water already in the separator and will tend to settle to the bottom of the separator. The oil that does not immediately rise to the surface may be carried along with the cooler water. The illustrations of Chapter 4 very ably bring out this effect.

TURBULENCE. The small droplets of oil are very easily carried about by the slightest currents which would tend to delay complete separation and may result in some of the oil being carried out the overflow. To keep the loss as low as possible, velocities should be kept to a minimum of turbulence. To keep the velocities low, the separator will have to have a large volume and be of the right shape. A long, small diameter separator could have a large volume but its downward velocity would be much higher than one with the same volume but

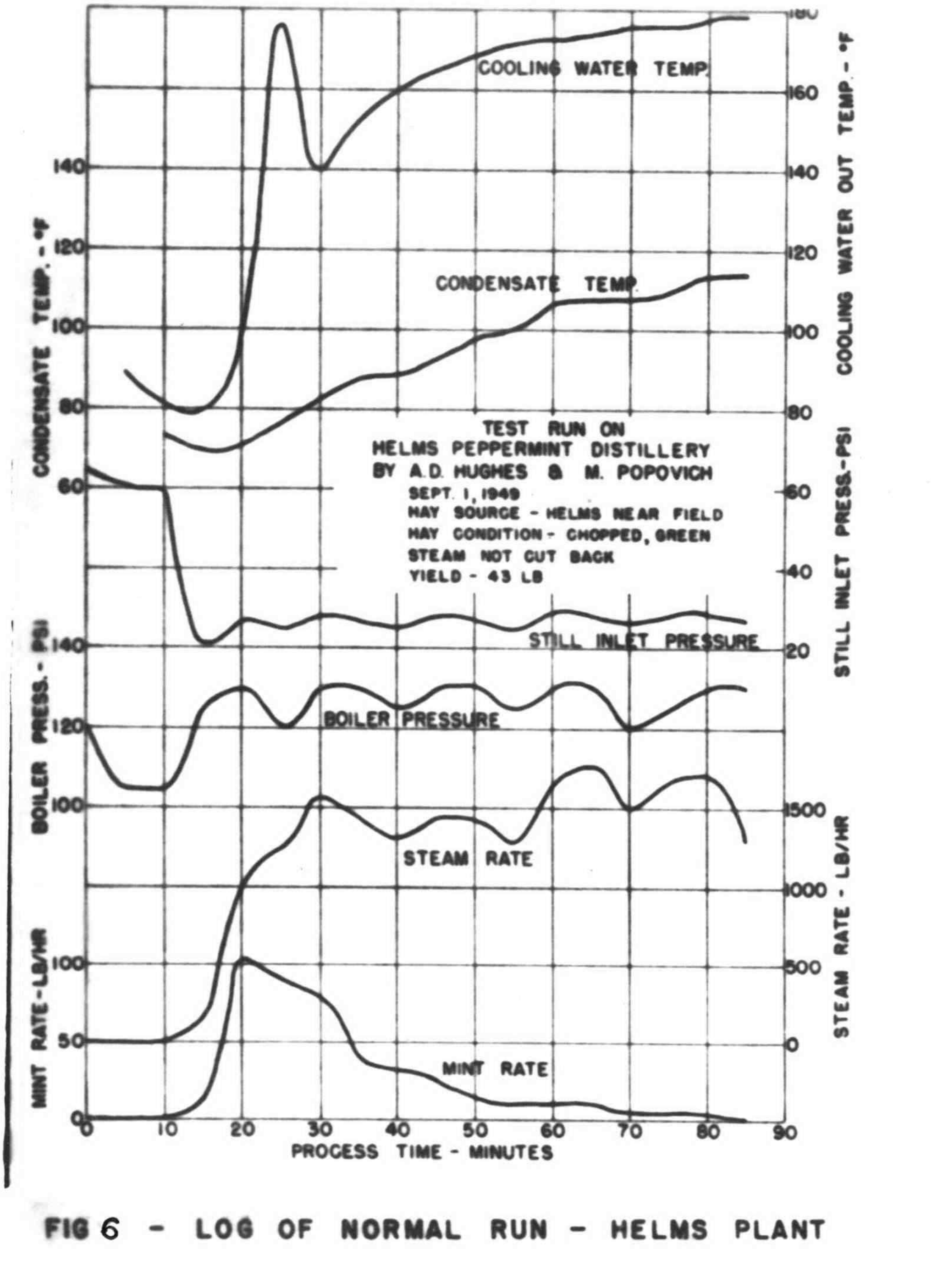

FIG 6 - LOG OF NORMAL RUN - HELMS PLANT

with a shortened height and increased diameter.

The first two pictures of Figure 9 show the effect of turbulence caused by the introduction of the feed. One answer to the problem, the funnel type entrance, is discussed in the latter part of Chapter 4.

As shown by tests in the field and on a pilot plant constructed here on the campus by Professor A.D. Hughes, most of the oil comes over in the first twenty minutes after "break through." During the rest of the run, the oil rate is low. The mint rate curve of Figures 6 and 7 show this variation during the run. In an effort to save steam, the steam to the tub of the pilot plant was cut back about fifteen minutes after "break through." This was after the point of maximum mint rate. The cut had no readily apparent effect on the total yield of oil. At the end of several of these runs, the steam to the tub was returned to its full value to see if any oil had been missed. No increase in the oil rate was obtained except momentarily when the increased flow washed out some of the oil caught in the condenser. Figure 7 is an example of such a run on a field distillation plant.

In general, the separation should be improved by cutting back the steam during the run because the condensate would be in the separator longer, the velocities would be reduced, and turbulence caused by the incoming

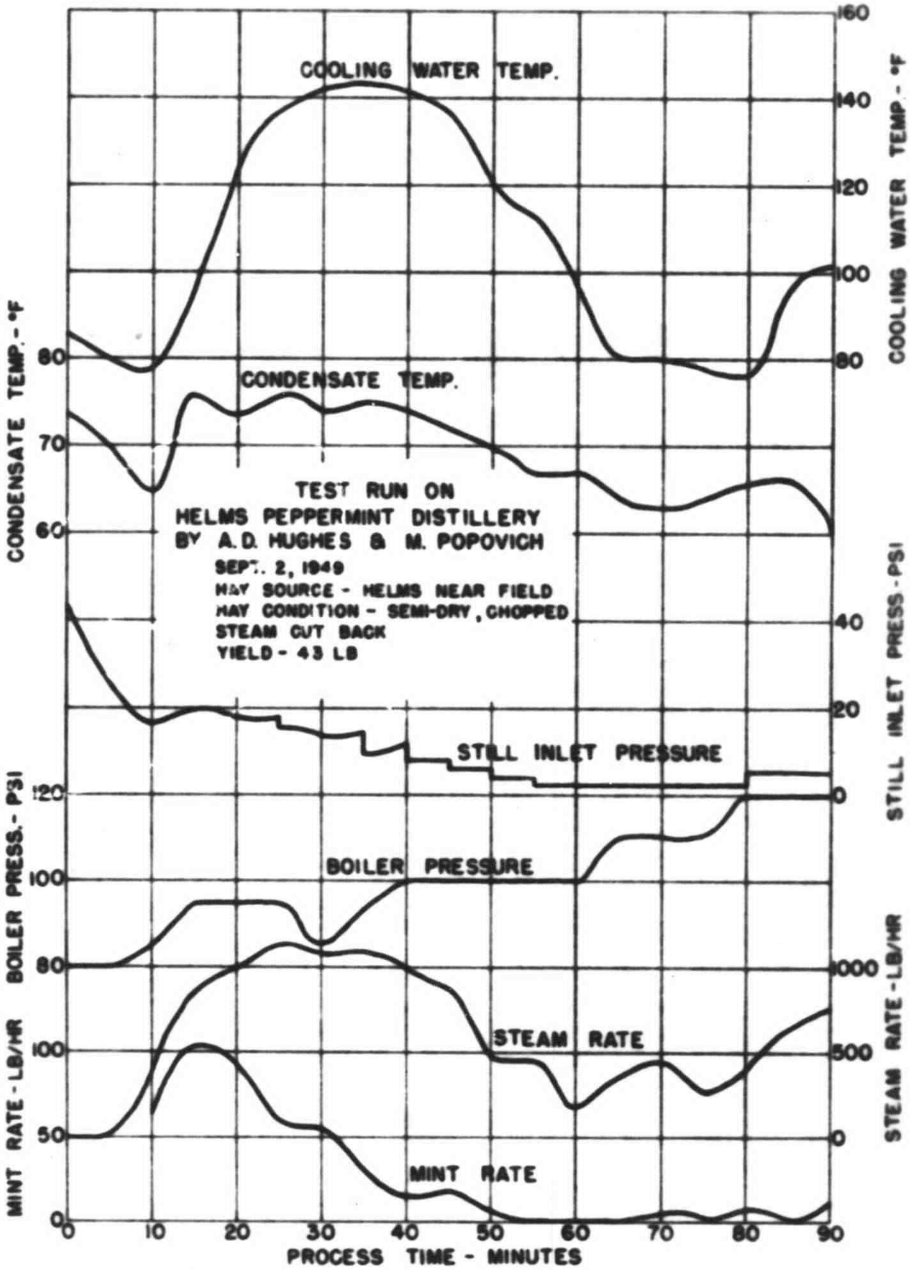

FIG 7 - LOG OF TEST RUN WITH STEAM CUT BACK feed would be reduced.

Figures 6 and 7 are examples of test runs made on field distillation units and tests made on other plants would yield different-shaped curves but in general like these. A few but not many would differ rather radically from these. In both figures, the cooling water rate was approximately constant during the run.

CHAPTER 4

THE GLASS SEPARATOR

THE SEPARATOR. As an aid in designing a better field separator, a section of a separator to a reduced scale was constructed with glass sides. With this model, it is possible to observe and photograph what occurs inside the separator under various conditions. The model is eight inches wide by twelve inches high and is three inches between the pieces of glass.

Peppermint oil is a clear, practically colorless liquid and without some type of dye it would not be visible for photographic purposes in the separator. The dye had to be easily visible and not soluble in the water but soluble in the oil. Sudan III recommended by Mr. D.E. Bullis, chemist in the Agricultural Experiment Station, was the dye that filled the above qualifications, coloring the oil a bright red.

An approximation to the condensate mixture that comes from the condenser was obtained by mixing water and oil together with an electric stirrer. The first stirrer tried had too much power, resulting in an emulsion of air, oil and water. Another stirrer but with much less power produced a mixture apparently close to the field condensate. The mixture was siphoned to the glass separator.

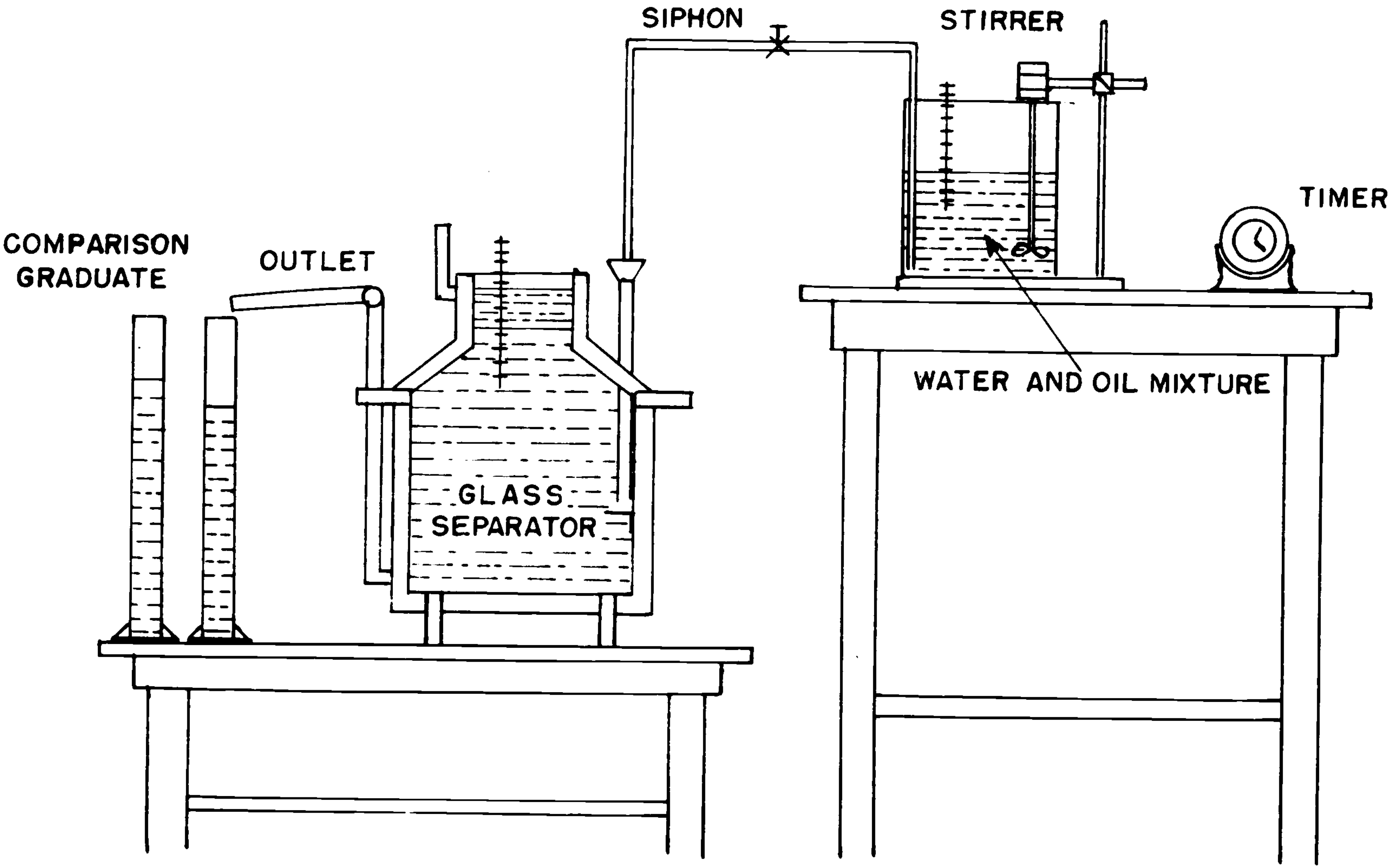

FIG. 8 - TEST SET-UP USING GLASS SEPARATOR

Figure 8 shows the general set-up used for obtaining the pictures that follow in this chapter. The rate of flow through the separator was determined by observing the time required for 100 milliliters of the mixture to run into a graduate both before and after a series of pictures. The flow rate was taken as the average of the two. Also from these 100 milliliter samples, the percentage of oil was obtained by reading the graduate after the oil has separated from the water.

Various types of internal construction were used to see what effect they had on the separation. The various types are discussed below.

FIELD TYPE. Figure 9 a to d shows the glass separator with the internal construction as it is in most field separators. The condensate enters on the right and is carried about half way down the side where it hits a small baffle. This baffle shows as a thin white line in the pictures of Figure 9. A better view of this baffle is obtained in the pictures of Figure 10. In theory, the baffle is supposed to deflect the condensate out across the separator, allowing the oil to rise and the water to settle. The pictures show that the baffle is not too successful in this endeavor.

As discussed in Chapter 3, these pictures of Figure 9 show very clearly the effect of having the

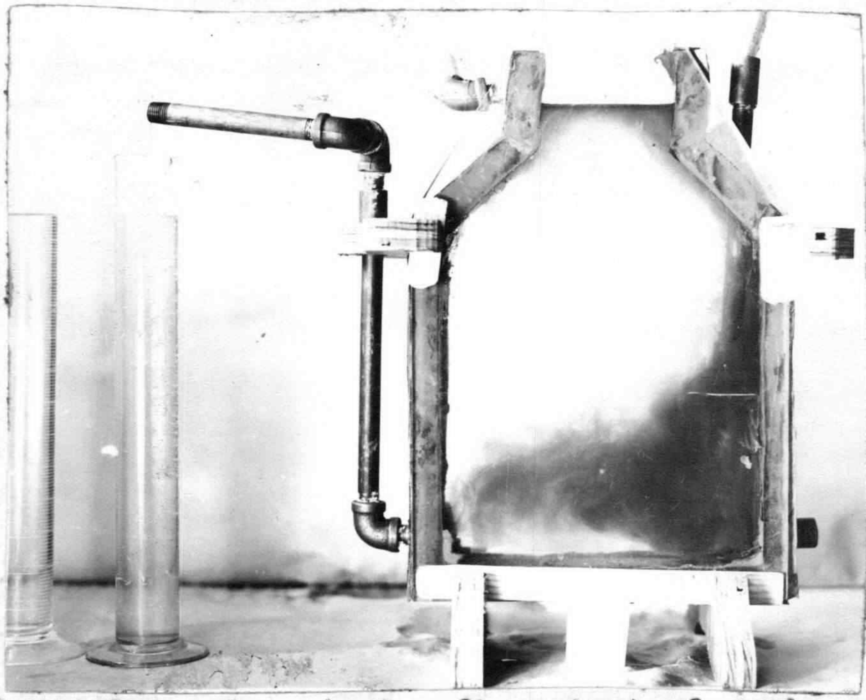

Figure 9 a. One minute after start of condensate.

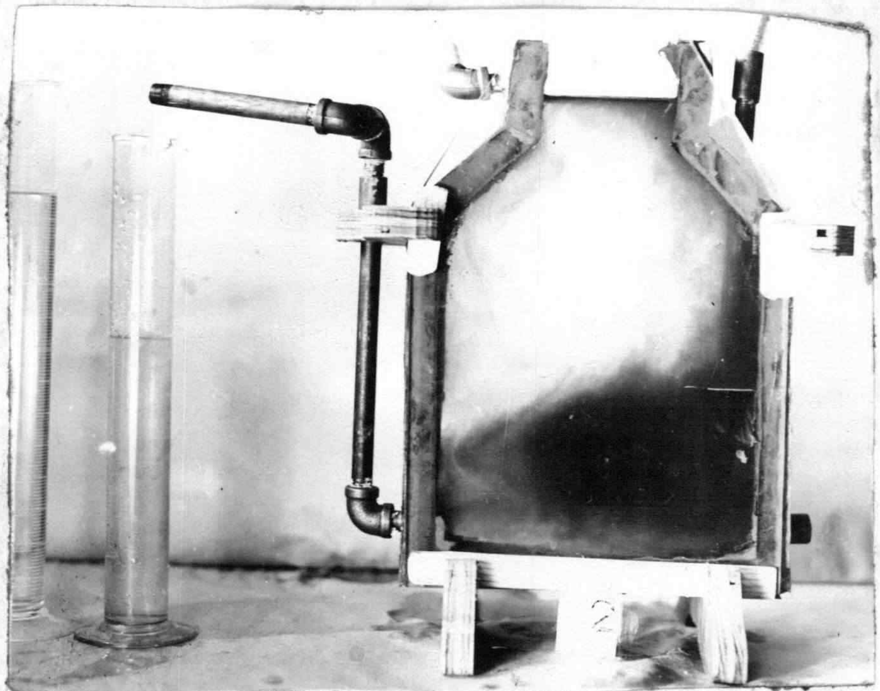

Figure 9 b. Two minutes after start.

Figure 9 a to d. Glass separator with internal construction as it is in many field separators. Condensate 16 degrees Fahrenheit cooler than water in separator both at start and finish. Oil seven per cent. Average downward velocity 2.8 feet per hour.

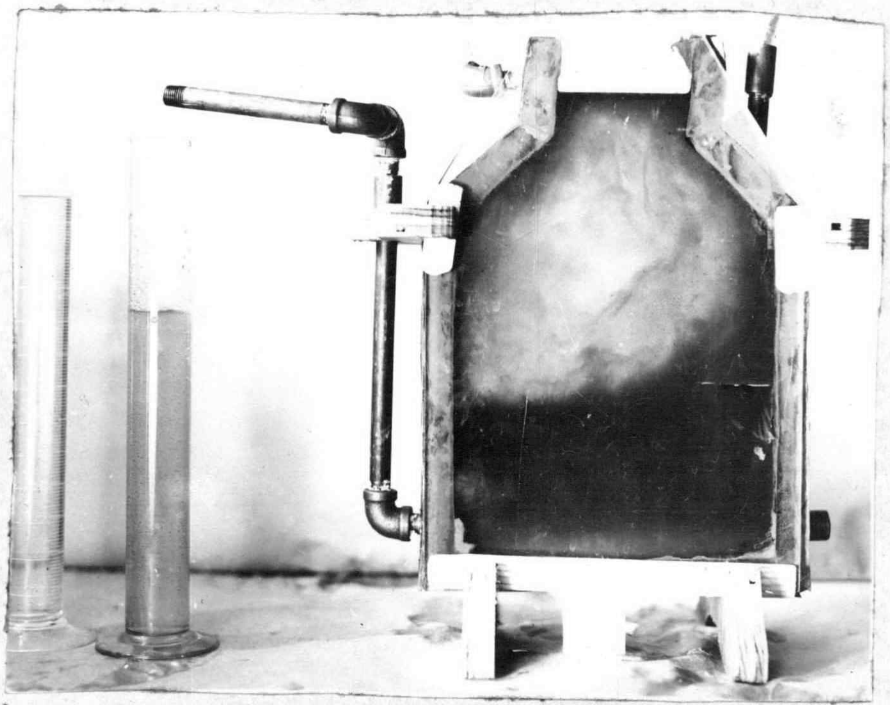

Figure 9 c. Three and one-half minutes after start.

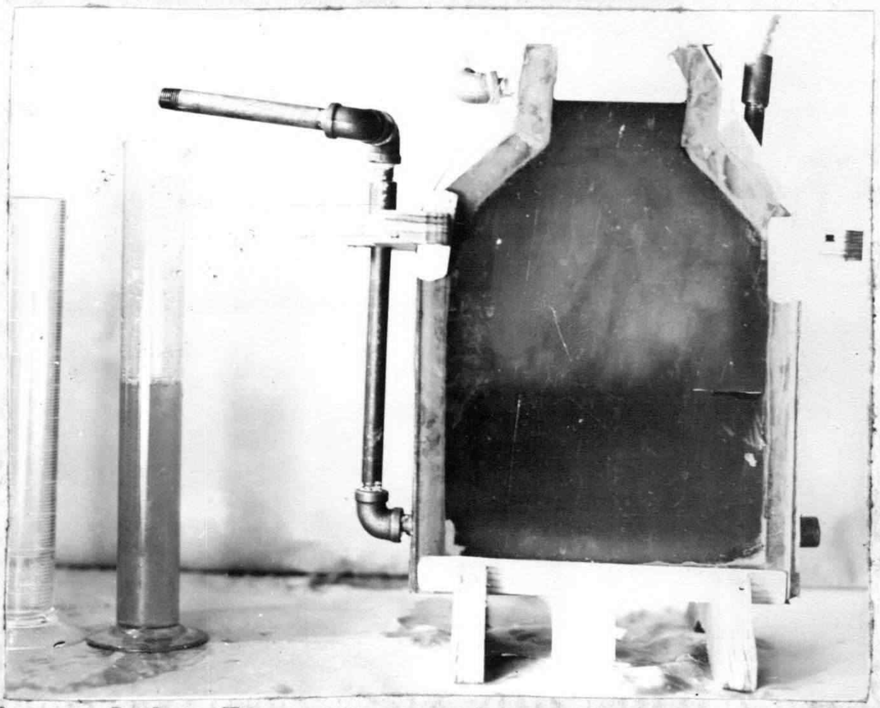

Figure 9 d. Five minutes after start. End of run.

condensate coming in cooler than the water in the separator, and settling toward the bottom. In this case, the temperature difference at the start was 16 degrees Fahrenheit. This effect was noted down to a temperature difference of one degree Fahrenheit on other tests. Comparison of the two graduates on the left in Figure 9 c and d show that oil is being carried out the overflow. The graduate on the extreme left is a reference graduate containing the same water that was in the separator at the start of the run. The one on the right receives the overflow from the separator and its darker color indicates the presence of oil in the effluent. In fact, small drops of oil appeared on the surface of the water in this graduate.

This condition of having the incoming condensate cooler than the liquid in the separator is practically universal in all separators at the start of each run because of the reservoir of cold water in the condenser at the start of the run. This effect would not be so pronounced or for as long a duration for the open drip-type condenser but this type of condenser is in the minority.

A large percentage of the oil collects into droplets in the siphon tube and rises to the surface as soon as the mixture is introduced into the separator. This oil is shown rising along the right side of the separator. The last two pictures show that many of the small droplets of the cloud at the bottom of the separator have collected into drops big enough to move toward the surface. These are shown as the film-like filaments rising across the upper part of the separator.

The separated oil shows as a dark line across the top of the separator, becoming thicker as time passes. This line shows up a little better in the later figures.

Figure 10 a to d shows the opposite effect when the oil and water mixture is warmer than the water in the separator. In this case, all the mixture rises to the surface and the cloud of fine droplets is slowly forced down as more mixture comes in. The cloud is thinner at the bottom, showing that droplets are collecting together and rising toward the surface. The amount of oil left in the light part of the cloud is a very small percentage of the total. If the rate of flow is not too rapid, the cloud holds above the bottom of the separator and no oil is lost because the outlet draws from clear water. Even if the light part of the cloud reached the bottom, very little oil would be lost.

This above effect was noted down to the point where the incoming mixture was the same temperature as that in the separator. The small amount of oil in emulsion in

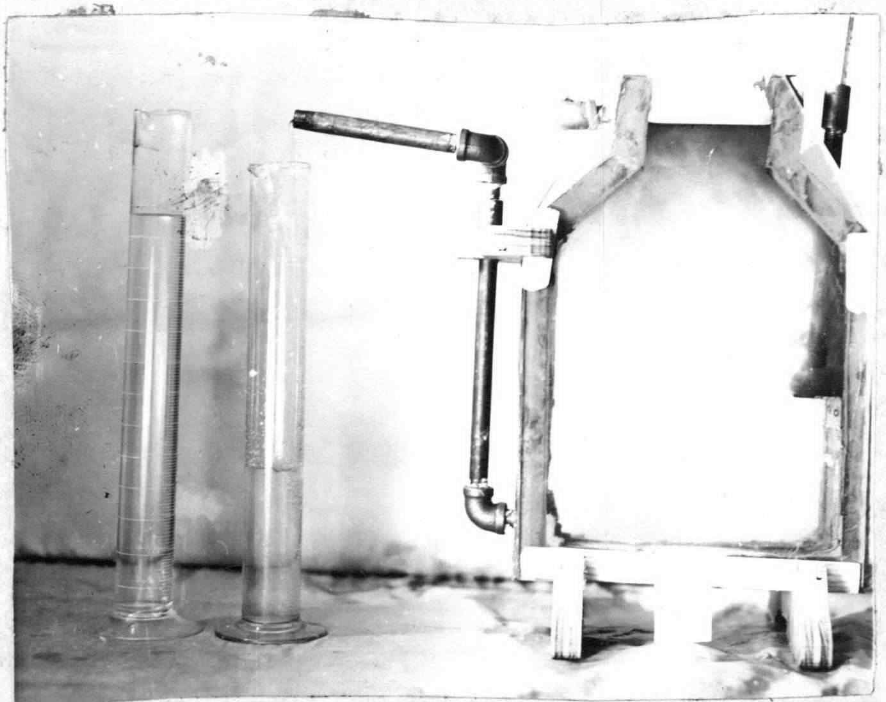

Figure 10 a. One minute after start of condensate.

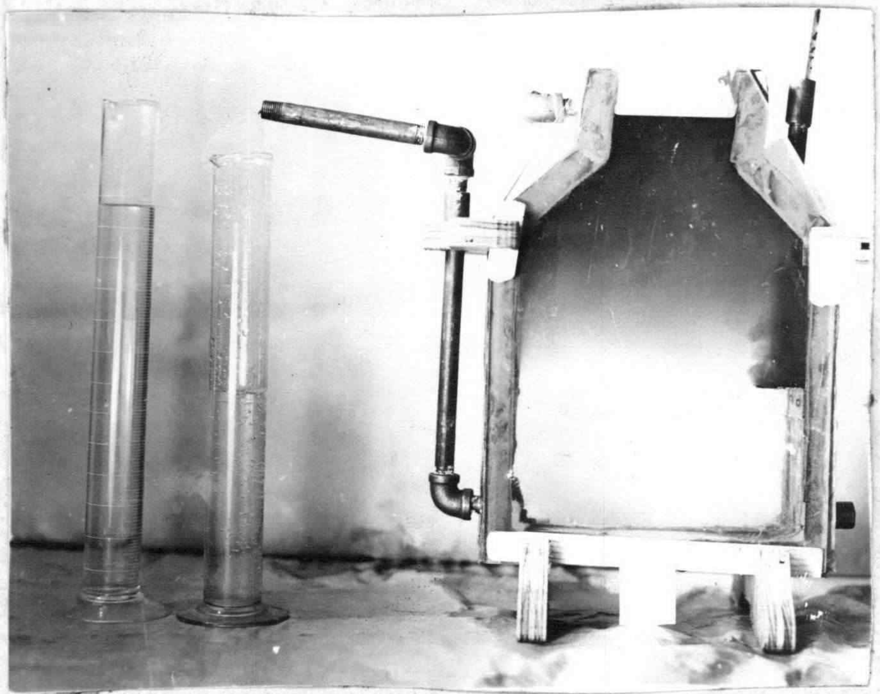

Figure 10 b. Three minutes after start.

Figure 10 a to d. Glass separator as it is in Figure 9 a to d except condensate 10 degrees Fahrenheit warmer at start and 2 degrees Fahrenheit warmer at end of run. Oil six per cent. Average downward velocity 1.5 feet per hour.

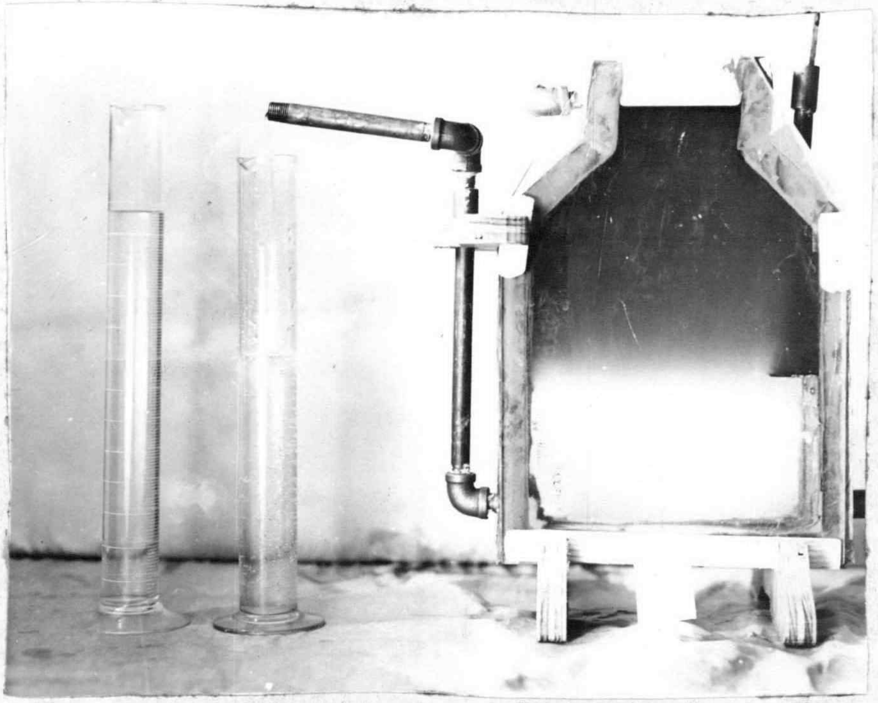

Figure 10 c. Five minutes after start.

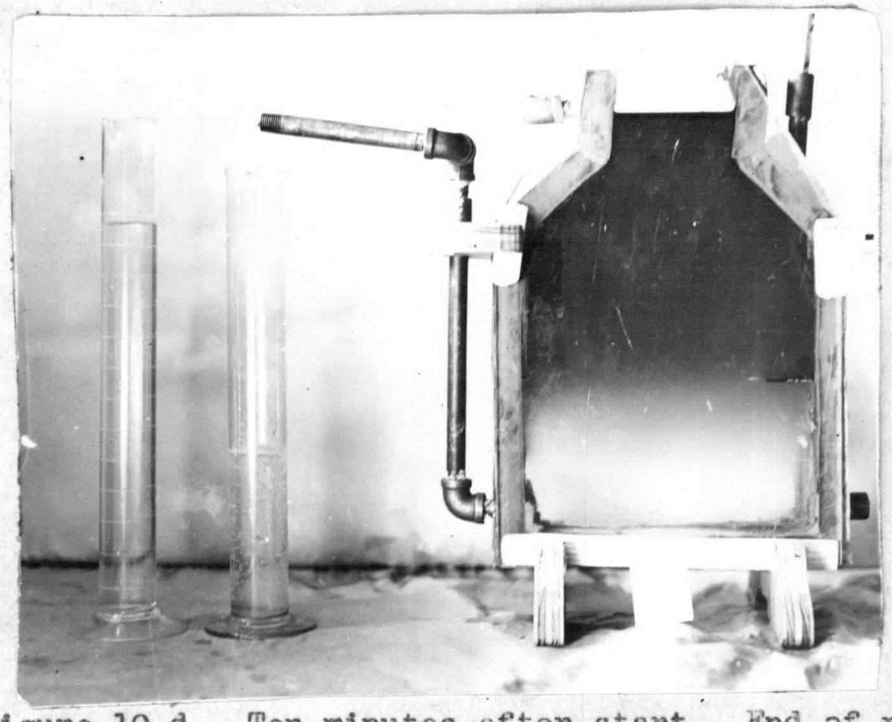

Figure 10 d. Ten minutes after start. End of run.

the water causes the whole mixture to rise at equal temperatures. But the temperature difference between whether the condensate will rise or settle is less than one degree Fahrenheit.

The condition where the incoming condensate is warmer than the water in the separator would rarely occur at the start of a field run, but later in the run, as the condensate warmed, this condition will develop, as indicated by Figure 6. This indicates that the separator must be designed to keep the oil loss to a minimum even though the cooler condensate comes in at the start of the run. As soon as the condensate becomes warm enough to rise, large separator volume will insure good separation.

FUNNEL. Bringing the condensate in through a funnel placed in the bottom of the separator, Figure 11 a to d, helps separation with the cooler feed, but is still not the complete answer. The funnel helps in that the cold feed is warmed somewhat before overflowing the top. The area for overflow is much greater than in a smaller inlet pipe, resulting in a weaker current of cool condensate toward the bottom. But after the passage of time, there is formed in the bottom half of the separator a cloud of peppermint oil droplets in the water.

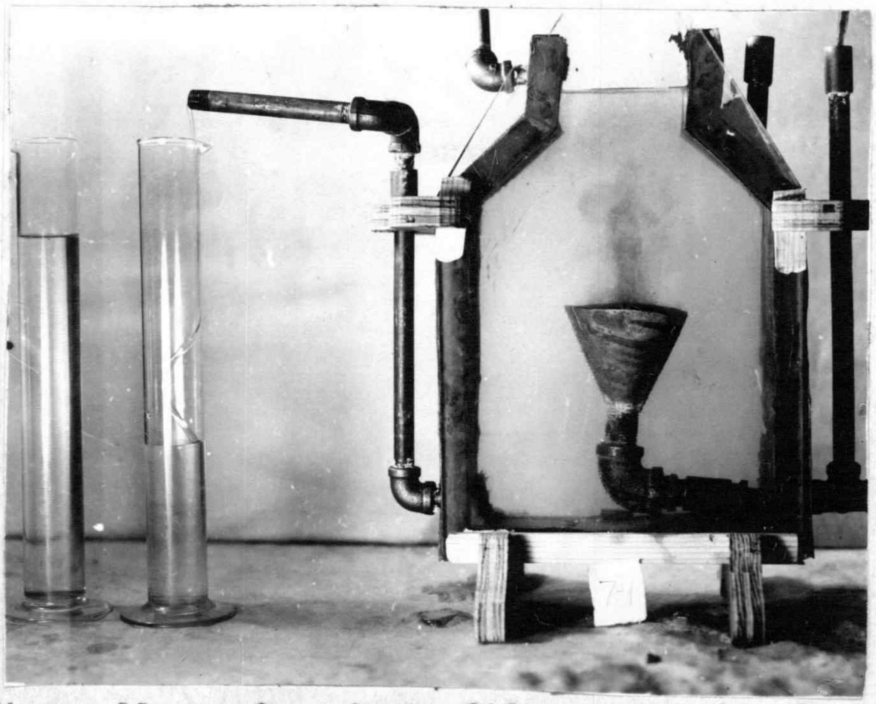

Figure 11 a. One minute fifteen seconds after start.

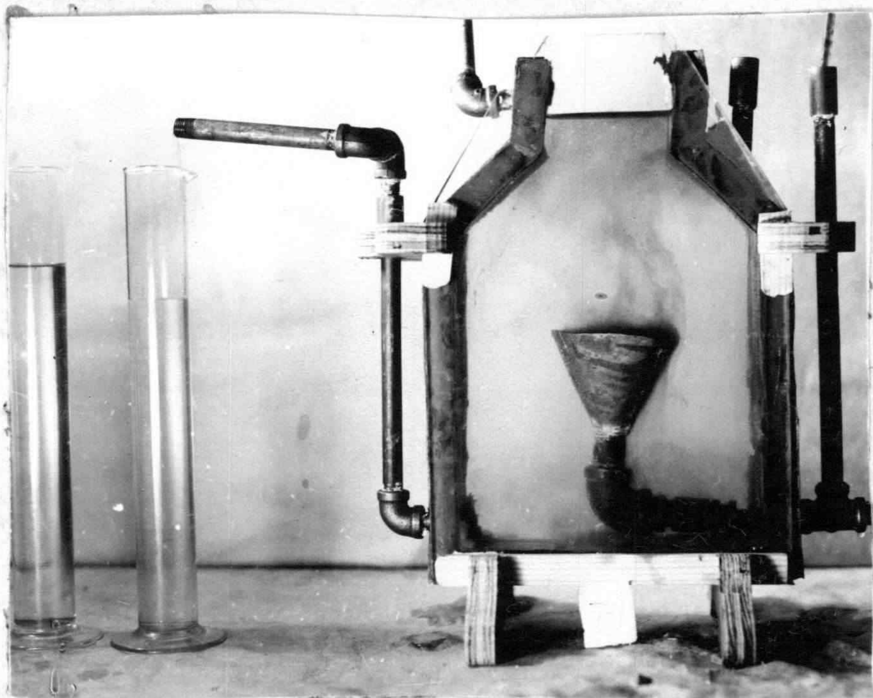

Figure 11 b. Two minutes ten seconds after start.

Figure 11 a to d. Glass separator with funnel type entrance. Condensate 20 degrees Fahrenheit Cooler at start and 16 degrees Fahrenheit cooler at end of run. Oil $4\frac{3}{4}$ per cent. Average downward velocity 1.1 feet per hour.

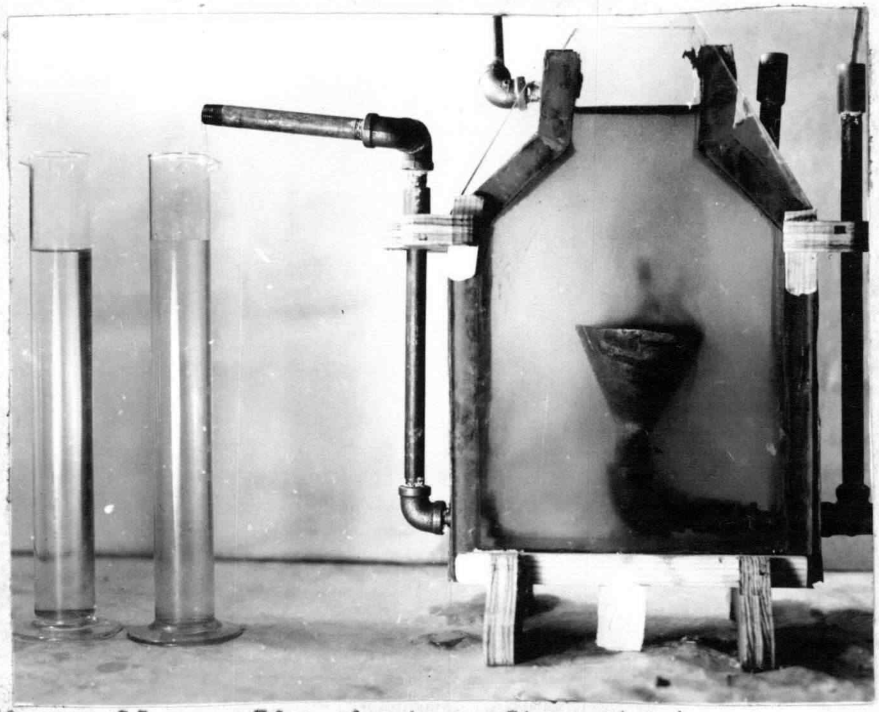

Figure 11 c. Six minutes after start.

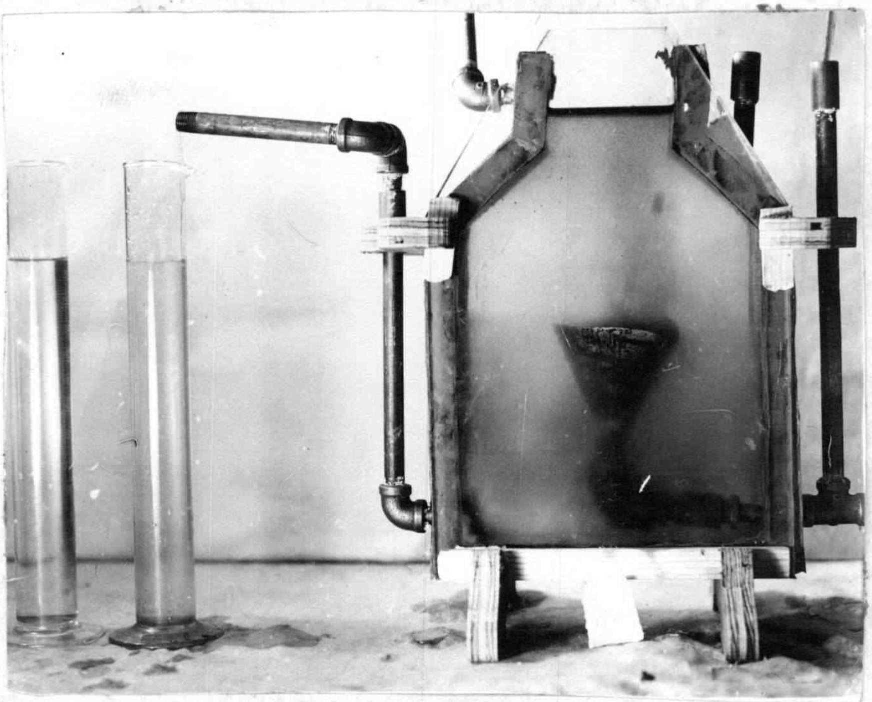

Figure 11 d. Ten minutes fifteen seconds after start. End of run.

This cloud is not nearly as dense as the one formed with the original construction, but oil is still being lost through the outlet as shown by the slightly darker color of the water in the graduate catching the overflow.

The funnel gives the incoming condensate a slight upward velocity which starts the oil toward the surface. All the pictures of Figure 11 show a steady stream of droplets rising toward the surface. Many of the smaller of these droplets would have been carried toward the bottom of the separator of Figure 9 where they would have been drawn out the outlet. But because of the slight upward velocity from the funnel they escape to the surface instead of being carried down. This represents an improwement in separation.

The funnel also reduced the turbulence of the incoming condensate by reducing its velocity to practically zero before discharging it into the separator.

BAFFLE. The baffle arrangement is shown in Figure 12. Here again, the condensate is cooler than the water in the separator. This seems to offer the best solution to the problem in that the cool peppermint oil and water mixture is held in the separator for some time before it obtains the opportunity to flow out the outlet. In that time most of the droplets will have reached the surface. In Figure 12-c these droplets can be seen rising toward

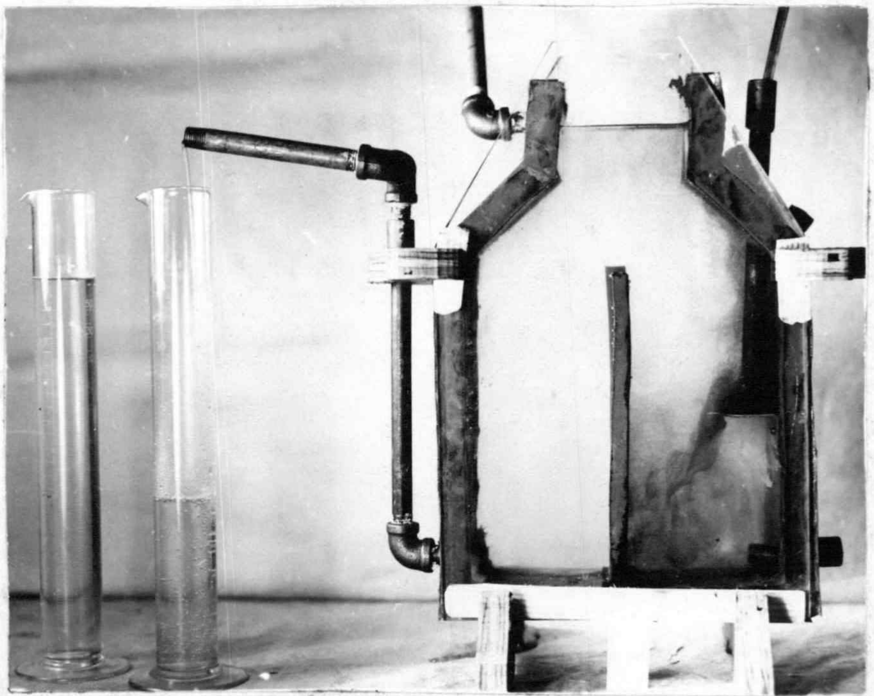

Figure 12 a. One minute after start of condensate.

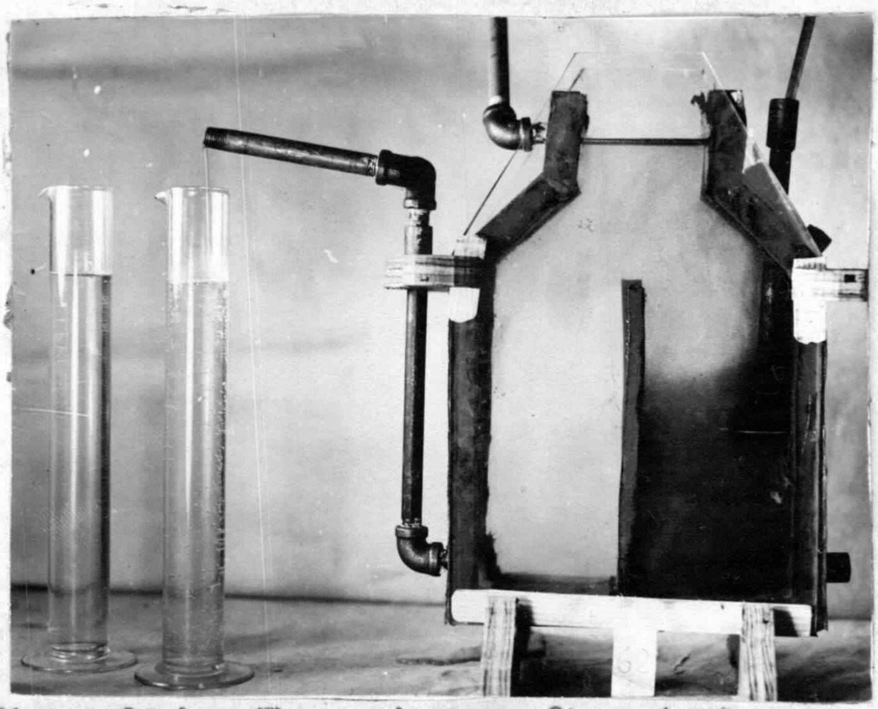

Figure 12 b. Three minutes after start.

Figure 12 a to d. Glass separator of Figure 9 a to d with the addition of a baffle in the center. Condensate 23 degrees cooler at start and 14 degrees cooler at end of run. Oil 4 per cent. Average downward velocity 1.7 feet per hour.

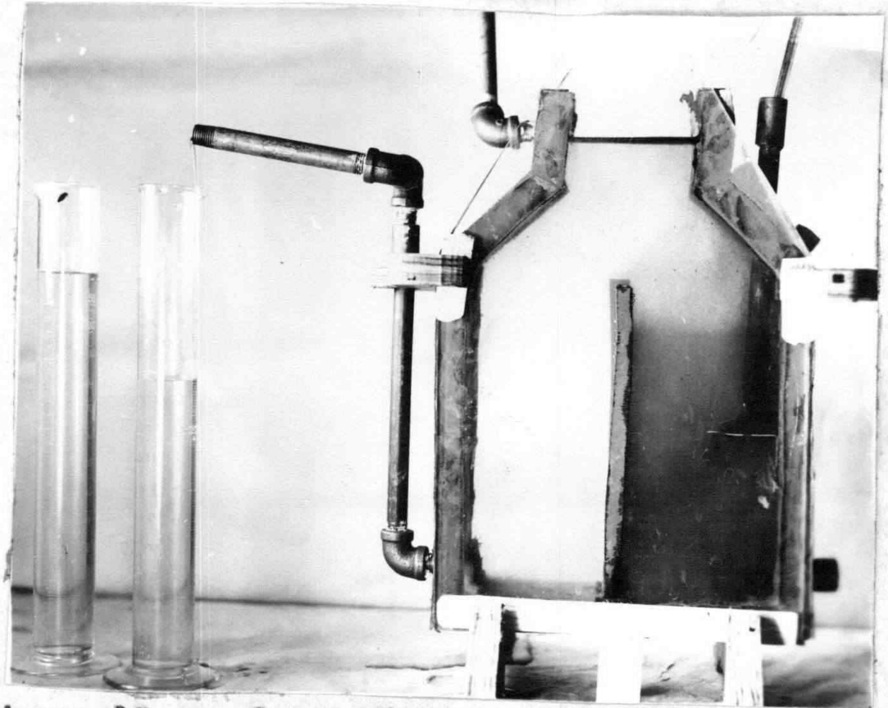

Figure 12 c. Seven minutes after start.

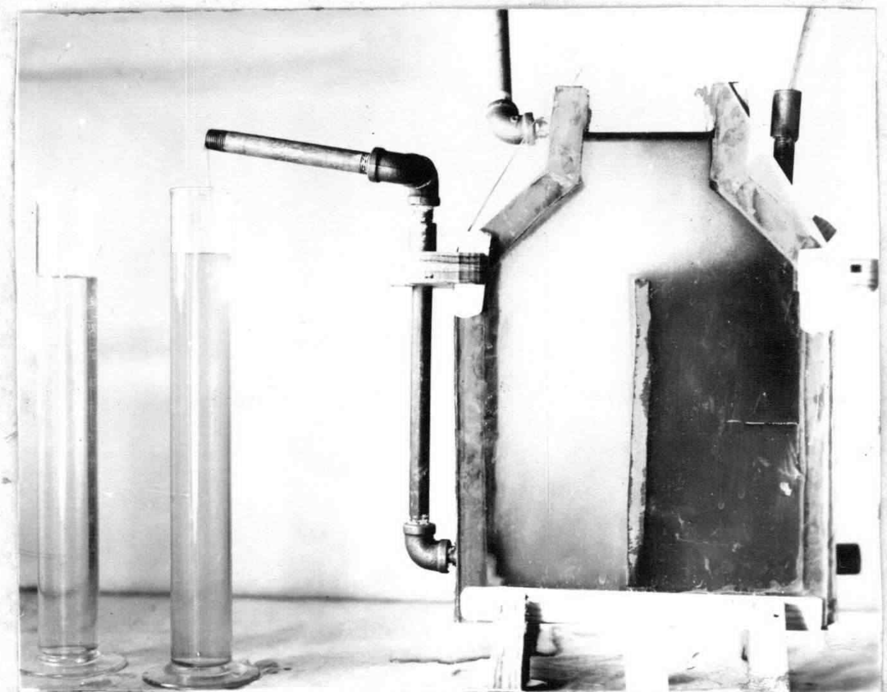

Figure 12 d. Thirteen minutes after start. End of run.

the surface.

Figure 12-c was taken seven minutes after the start of the flow of water and oil mixture. During that time, the area to the right of the baffle has almost filled with a cloud of mint droplets in water. Figure 12-d was taken thirteen minutes after the start. During the interval, the cloud reached the top and overflowed to the left for several minutes but as shown by the thinness of the cloud on the left, most of the oil had already separated. No discernible oil was visible in the graduate catching the overflow.

The baffle has two beneficial effects; more time for separation and time for the condensate to be heated through the baffle by the warmer water on the left. The time for better separation was discussed above. In a regular separator, the baffle would be made of metal and an appreciable amount of heat would be transferred to the condensate. This regenerative effect was noted by Professor Hughes this last summer in an experimental thermal re-separator, designed to replace the "re-distill" unit previously mentioned. This re-separator was similar to a regular separator with the addition of a cylinder in the center. A copper coil was placed inside the cylinder to heat the outflow of several separators introduced at the bottom of the cylinder. The water was heated as it rose in the cylinder but due to the regenerative effect only about half as much heat was supplied to the coil as expected to maintain the desired temperature. This regenerative heating of the condensate will improve separation as shown on the time of separation curve. In the glass separator, the baffle was made of quarter-inch plywood so that very little regenerative effect was obtained.

One slight disadvantage of the baffle is that it increases the velocities in the separator; but this can be remedied by increasing the size of the separator. Increasing the size of the separator has a good effect in that the condensate is in the separator for a greater length of time. This should result in more complete separation.

CHAPTER 5

THE IMPROVED SEPARATOR

In the design of an improved separator, there are many points to consider:

1. Temperature of operation and its variation during the run.
2. Velocities in the separator.
3. Shape of the separator.
4. Method of introducing the condensate.
5. Material of construction.
6. Economics.

TEMPERATURE OF OPERATION. If the temperature of the incoming condensate were constant or slightly warmer than the water in the separator, the only thing necessary to improve separation, if it could be improved at all, would be to increase the size of the separator. This condition is rarely realized in the field as brought out in Chapter 3 and Figures 6 and 7 of that chapter. In most runs there is quite a wide variation of temperature during the run. The temperature may increase during the time of the full run or it may vary as it does in Figure 7. This means that at some time during a normal run the incoming condensate is apt to be cooler than the water in the separator, resulting in the condition of Figure 9. It is during this time that oil will more than likely be lost.

for regenerative heating of the cooler condensate. It would be slightly harder to feed the condensate into the bottom of the inner shell but on the whole, the concentric shell seems to be the better of the two.

VELOCITIES. The average downward velocity in a field type separator may be as high as 5 to 6 feet per hour for the short type and much higher in the old long cylinder type. The upward velocity of the smaller droplets appears to be less than the above range. To reduce this velocity, the volume of the separator will have to be increased by increasing the diameter. The velocity could also be decreased by shortening the can and increasing the diameter, holding the volume constant. It would be better to increase the volume because the condensate would be in the can longer which would result in more complete separation. Decreasing the velocity below 2 feet per hour by increasing the volume of the can would result in a very slight if any improvement in separation. An economic balance between the cost of the separator can and the value of the oil saved with a larger can would indicate an average velocity in the range of 2 to 3 feet per hour.

INTRODUCING THE CONDENSATE. The main point to consider in introducing the condensate is to keep the inlet velocity as low as possible and thereby reduce the turbulence. The use of a funnel on the end of the inlet pipe as discussed in Chapter 4 seems to offer the simplest and best method of accomplishing this.

MATERIAL. Practically all the present separator cans are made of galvanized sheet iron. They last a season or two and then must be replaced because of corrosion. Peppermint oil by itself or in the presence of water, and at higher temperatures, is a very corrosive material. The usefulness of most metals, plastics, and rubbers is soon destroyed by its action. The only two common metals that appear to have a high resistance to corrosion by peppermint oil are aluminum and stainless steel. Cans made of these two materials will last many times longer than ones constructed of galvanized iron, paying for their greater cost several times over before need of replacement.

ECONOMICS. To be usable from an economic point of view, the increased cost of the improved separator must be absorbed and exceeded by the saving in cost of operation, or an increase in the yield of oil, or both. In plants with a re-distill, the separator will pay for itself in the reduction of the operating cost, while in plants without a re-distill, the increased yield of oil

The baffle discussed in Chapter 4 seems to offer the best and simplest method of reducing this loss to a low value. The volume behind the baffle should be enough to hold about half the total volume of condensate for the run. Except for an occasional run, this volume should be able to hold all the condensate that is cooler than the rest of the water already in the separator. The baffle should be as low as possible so that the velocities in the upper part of the can will be at a minimum.

There are at least two methods of placing the baffle in the can. One is to build the baffle as a flat partition across part of the separator as was done in the glass separator. This type would be easy to construct, feed with condensate, and empty. It has one serious drawback, however, that might lead to difficulty when filling or emptying the can. One side of the baffle might be full of water while the other side would be empty. With this condition, a stress would be produced in the baffle, and since the cans are usually constructed of light material, the baffle or the sides of the can might buckle.

Another type of baffle suggested would be a concentric shell in the center of the separator. This, too, would be relatively easy to construct and would not have the danger of buckling the sides of the can when filling or emptying. This type would have a much greater area should pay for its greater first cost.

THE IMPROVED SEPARATOR. Figure 13 is a drawing of an improved separator embodying the above points. The basis of design is 1000 pounds of condensate per hour. The volume inside the baffle is 7.4 cubic feet or about 460 pounds of water. The total volume of the can is 30.4 cubic feet or 1900 pounds of water. Then the average time for the condensate in the can with constant flow would be 1.9 hours; but because of shut down between runs, the condensate would probably be in the can about 2.5 hours. The average downward velocity in the area outside the inner shell is 2.7 feet per hour. In the neighborhood of the outlet, the velocity will gradually increase.

The 1000 pounds per hour of condensate basis for design is the average rate after equilibrium has been achieved. As an example, this point would be the 30-minute point of Figure 6 where the average rate is about 1500 pounds per hour after the 30-minute point. The above separator was designed for 1000 pounds per hour while the rate of Figure 6 is 1500 pounds per hour, which means that the dimensions of the can will have to be changed to keep the same relative velocities and volume at the 1500 pounds per hour rate. The following relationships will give the proportional dimensions.

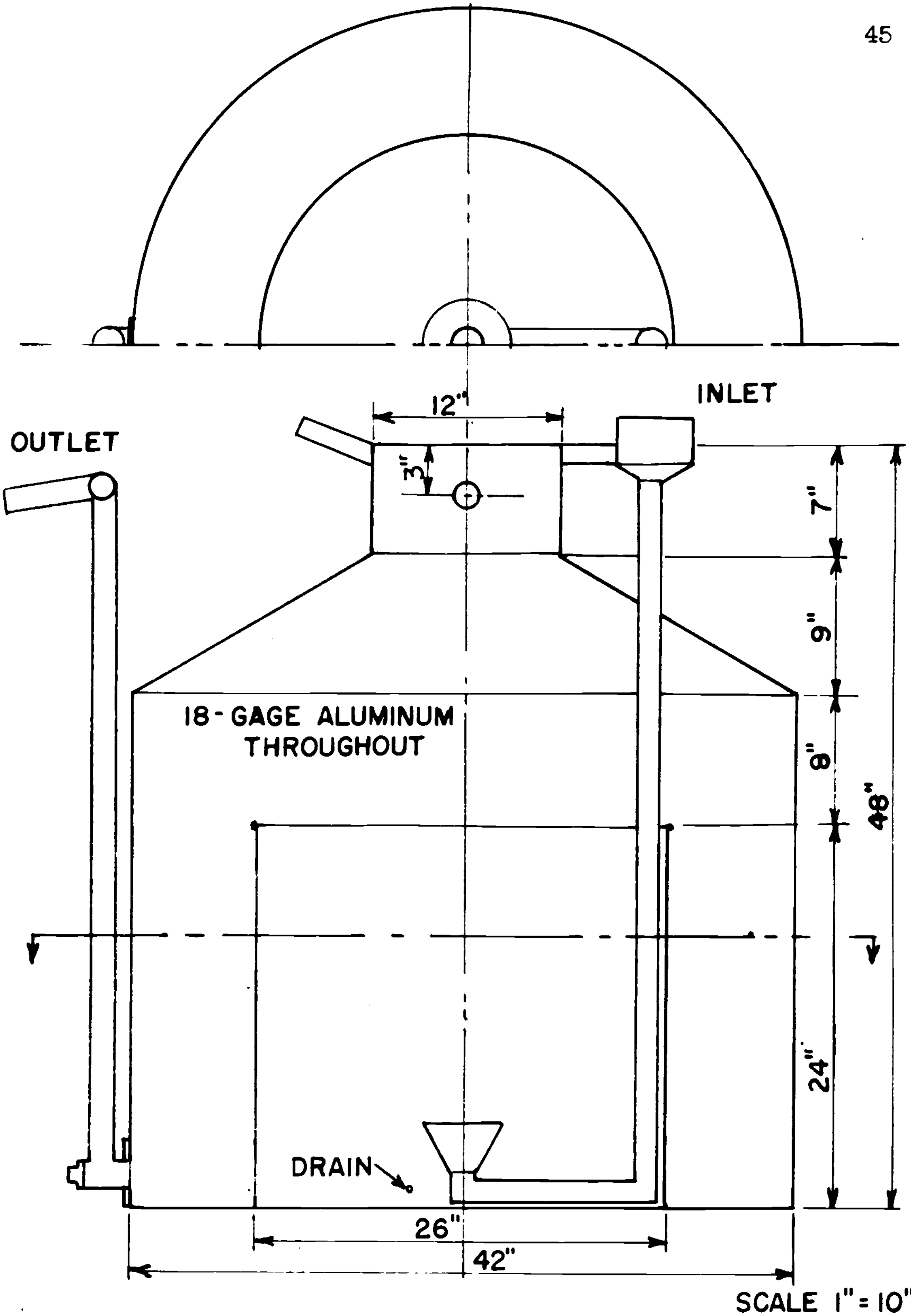

FIG. 13 - THE IMPROVED SEPARATOR

Holding the height of the can constant at four feet:

$$D = D_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{2}}$$

$$d = d_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{2}}$$

Where: D is the overall diameter of the can to be determined

D_o is the diameter of the basic can, 42 inches in this case.

d is the new baffle diameter.

d_o is the basic baffle diameter, 22 inches in this case.

Q is the new flow rate.

Q_o is the initial flow rate, 1000 pounds per hour.

Another method would be to hold the diameter constant and change the height of the can and baffle in direct proportion to the flow rates. This is not recommended because of the changes in the velocities. At greater rates of flow, the downward velocity would be increased and oil might be lost through the outlet. With the lowering of the flow rate, the velocities would be reduced which might help separation, but with low flows, the can would be rather short and not "look right."

The third possibility is to change both the diameter and height of the can in proportion to the flow. The following relationships will yield the relative dimensions:

$$D = D_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{3}} \qquad d = d_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{3}}$$

$$H = H_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{3}} \qquad h = h_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{3}}$$

Where: D, D_o, d, d_o, Q, and Q_o are as listed above,

H is the new height to be determined.

H_o is the initial height, 48 inches

h is the new baffle height

h_o is the initial baffle height, 24 inches

Either the first or last method is the recommended method of changing the dimensions for different flow rates. Of course there is nothing wrong with using a bigger can than indicated, in fact, it might yield a slight improvement in separation, but using a smaller than indicated can might result in a lower separation efficiency.

To illustrate this method of changing the dimensions, the flow rate of Figure 6 was selected and applied to the first of the three methods.

The outside diameter:

$$D = D_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{2}} = 42\left[\frac{1500}{1000}\right]^{\frac{1}{2}} = (42)\ (1.225) = 51.5 \text{ inches}$$

The baffle diameter:

$$d = d_o\left[\frac{Q}{Q_o}\right]^{\frac{1}{2}} = 26\left[\frac{1500}{1000}\right]^{\frac{1}{2}} = (26)\ (1.225) = 32 \text{ inches}$$

IMPROVEMENT OF EXISTING SEPARATORS. The existing separator might be improved until it needs replacement, at which time it would be replaced with an improved type as designed above. One method would be to slip a small cylinder down through the top opening in the separator and feed the condensate into this cylinder. The cylinder should be made water tight at the bottom. Another method that would be effective but rather difficult to install in an existing can, would be to add a partition on the side where the condensate enters, providing the overflow is on the opposite side of the can. The volume behind this partition should not be greater than 20 per cent of the total, otherwise, the downward velocity in the rest of the can will be increased too much. Either of these two methods should improve separation as they are big steps toward the improved separator.

The last possibility is to improve the operational procedure. The first of these is to hold the condensate to as near a constant temperature as possible. This may be done by installing an automatic valve in the cooling water supply line controlled by the condensate temperature. Another way is to cut the steam back 15 to 20 minutes after break through. This will cut down the total flow of condensate so that the condensate will have a longer time in the separator. Also the velocities will be reduced, which with the longer time in the can should improve separation.

FINALE. The overall way to improve the yield of peppermint oil (improve the separation efficiency) is a combination of many of the points discussed above:

1. The temperature in the separator should be about 110 degrees Fahrenheit.
2. The condensate should be fed in at as near a constant temperature as possible.
3. The steam should be cut back.
4. The improved separator used.

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