# A CONTINUOUS OXIDATION PROCESS FOR FLUX OILS USED IN THE MANUFACTURE OF ASPHALT ROOFING

Thesis for the Degree of C. E.

James Allan Stone

1935

THESIS

Roofing

# A CONTINUOUS OXIDATION PROCESS FOR FLUX OILS USED IN THE MANUFACTURE OF ASPHALT ROOFING

THESIS

BY

JAMES ALLAN STONE

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

C. E.

MICHIGAN STATE COLLEGE

EAST LANSING

MICHIGAN

1935

THESIS

DESCRIPTION OF PRESENT OXIDATION PROCESS

Definition of Petroleum Flux Oil

Petroleum flux oil is a residual oil in the process of refining petroleum into gasolene, solvents, lubricants, fuel oils, etc. It is comparable to the natural asphalts in general properties and can be used for the same purposes. Throughout this design the words flux oil and asphalt are used synonymously. Among its uses are those of road construction and manufacture of roofing. Even at this residual stage flux oil, like the original petroleum, is a mixture of oils, and by distillation the properties of flux oil may be changed from that of a liquid at ordinary temperatures to that of a pitch with a melting point of 300 degrees Fahrenheit or more. However, if air is introduced through the flux oil at the temperature at which distillation takes place, oxidation of the lighter oils occurs. This oxidation takes place more rapidly than distillation, and has now become the method by which the melting point of flux oils is raised. In the uses of flux oil the melting point characteristic is most important.

98894

## Use of Petroleum Flux Oil

Asphalt roofing is composed of two types, built-up roofing and prepared roofing. The first is used on factories, warehouses, and office buildings; while the latter is used mainly on homes. Both types of roofing are essentially alike. One, however, as its name implies, is built-up on the roof deck to be covered, while the other is completely manufactured and only needs to be laid. Both roofings are made up of a felt base which has been saturated with asphalt. This is the body of the roofing. The built-up roofing consists only of this saturated felt, a coating of higher melting point asphalt, and a sprinkled layer of gravel. The latter two items are applied on the job. The prepared roofing is also composed of this saturated felt, a coating of higher melting point flux oil, and a layer of granulated slate pressed into the coating; this process is completed at the factory.

## Saturant of Roofing Felt

The melting point of flux oil used as a saturant is 100 degrees Fahrenheit, except in the case of shingles when it is about 150 degrees Fahrenheit. The reason for a higher melting point saturant for shingles is to provide a more rigid base. The asphalt used as a coating for built-up roofing has two ranges of melting points, the lower for flat roofs and the higher for sloping roofs.

## Coating on Prepared Roofing

Prepared roofings are composed of three types: Smooth surface, slate rolls, and shingles. The smooth surface roofing has only a dusted surface of mica or soapstone on top of the coating. Slate rolls have granulated slate imbedded in the coating. Shingles are similarily made as slate rolls and then are cut into shingle patterns. The coatings vary in melting point from 200 degrees Fahrenheit on smooth surface roofings to 240 degrees Fahrenheit on shingles. The latter require a higher melting point to obtain rigidity.

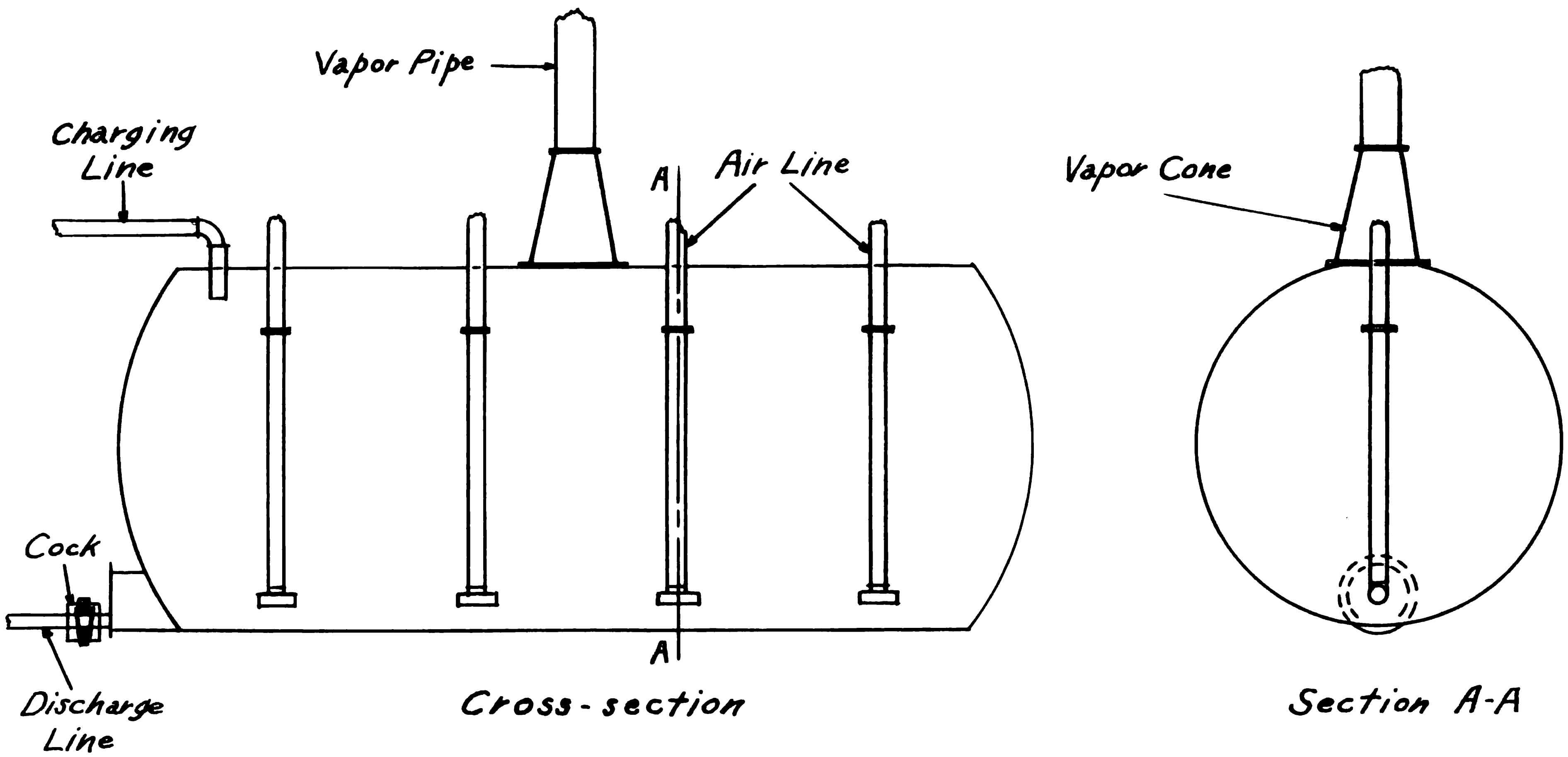
## Definition of Oxidation of Flux Oil

Asphalt of a melting point meeting the requirement for a saturant is usually purchased from the refineries. This melting point is about 100 degrees Fahrenheit. The roofing manufacturer then oxidizes this flux oil to raise the melting point to that required for coatings and shingle saturant. Oxidation in this case consists of heating up the asphalt and passing air through it until the required melting point is attained. This is accomplished by filling or charging a horizontal still with the flux oil. Sometimes two or more kinds of flux oil are used in making a charge, depending upon the properties desired by specification. One source of flux oil may not be able to meet all requirements. Blending with an asphalt from another oil field is necessary to meet the specification of penetration or prevent discoloration of slate granules.

## Present Method of Oxidation

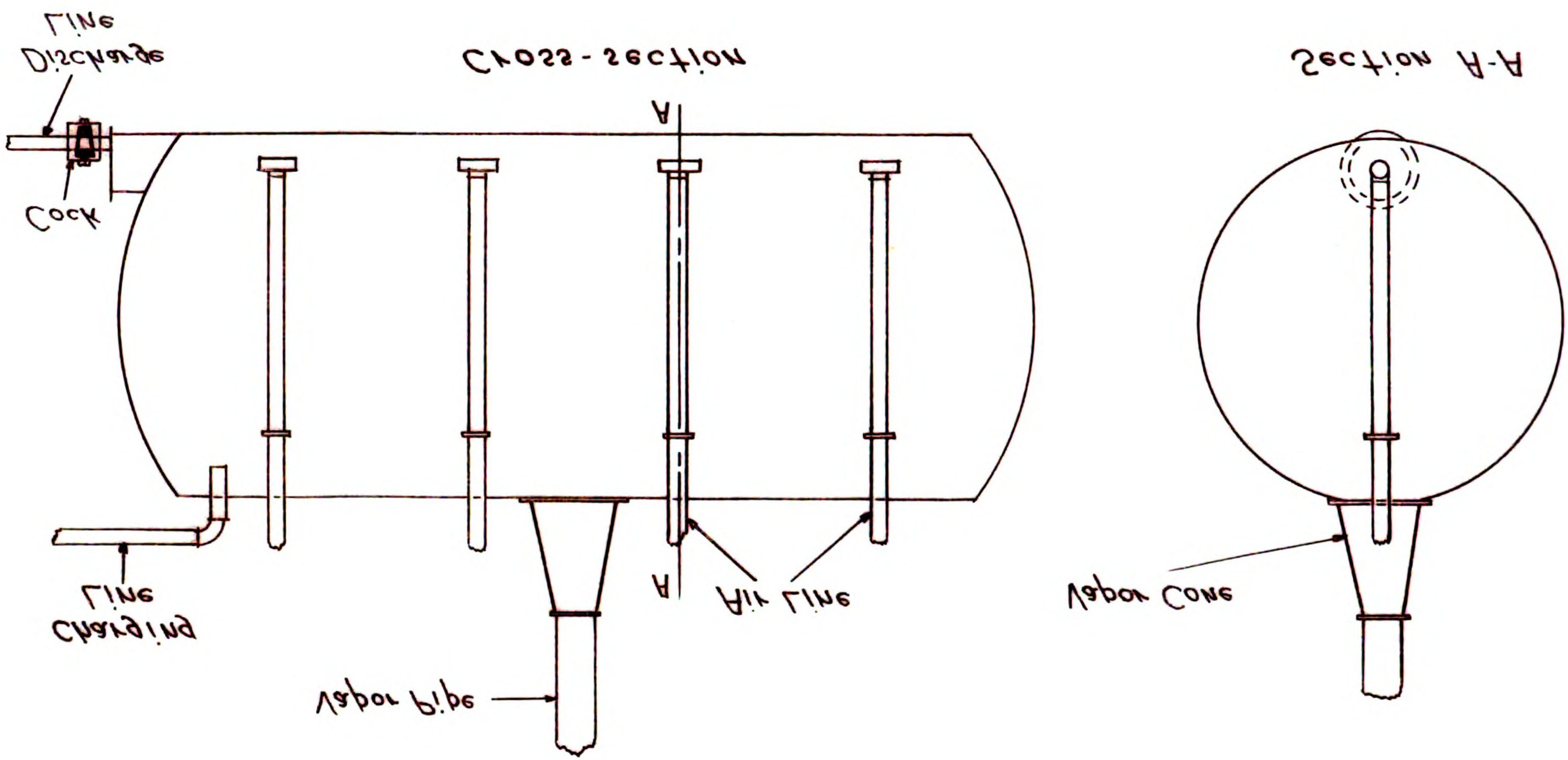
After charging heat is applied to the still bottom heating the asphalt to a temperature of about 450 degrees Fahrenheit. Air is blown through the flux oil from a series of vertical pipes with outlet holes on the bottom, so that air bubbles rise through the liquid. Oxidation between the air and lighter oils occurs giving off heat during the chemical reaction, raising the temperature of the charge. The oxidized vapors are exhausted from the still by means of a fan. The air is produced by low speed air compressors at a pressure of about two pounds per square inch.

Experience in knowing when to stop firing the still bottom is necessary in order to control the rise in temperature due to oxidation. The maximum




PRESENT HORIZONTAL STILL.

# PRESENT HORIZONTAL STILL.



safe temperature to oxidize is about 530 degrees Fahrenheit; above this point there is danger of flash or fire. Usually the rise during oxidation from the initial temperature of 450 degrees Fahrenheit is about 50 degrees to 70 degrees Fahrenheit, making a total temperature of between 500 degrees to 520 degrees Fahrenheit. Samples are taken from time to time until the required melting point is attained, at which time the air is turned off and the completed coating pumped to the supply tanks over the roofing machines. The total time from charging to pumping, of course, varies with the melting point to be attained and the amount of flux oil to be oxidized. The range is from twelve to twenty-four hours.

## Method of Charging

There are two methods of charging. One is to pump the asphalt directly from the storage tank to the still and then start firing the still. The other method is to pump the flux oil through a tube heater and preheat it before placing it in the still. However, even after this preheating, by the time the still is charged it must be reheated to attain the initial oxidizing temperature. Nevertheless the tube heater having better heat contact is more economical in the use of fuel. Also the still-time is reduced because of less firing to attain the initial oxidizing temperature.

## PROPOSED METHOD OF OXIDATION

The asphalt leaving the tube heater has a temperature between 450 degrees and 500 degrees Fahrenheit depending on the temperature of the heater and the rate of pumping. Since this range of heat is sufficient to start oxidation of the flux oil, if air could be introduced through it, oxidation would occur without heating in a still. The stills are of 5,000 and 10,000 gallon capacity. The pumping rate through the heater is from 1,500 gallons to 2,000 gallons per hour. This requires about three hours to charge a small still and about six hours for a large still. It is during this period that the asphalt cools down requiring firing up in order to attain the initial oxidizing temperature.

To oxidize the flux oil while it is sufficiently hot would require that the air be blown through it while it is in motion. After being pumped through the heater and heated to 450 degrees Fahrenheit, if the asphalt flowed through a small tank and air was blown through it oxidation would take place. Thus the flux oil could be drawn from the storage tank, pumped continuously through the tube heater and on through an oxidizing tank, to the supply tanks above the roofing machine.

## Purpose of This Method

This would reduce heating to a minimum, eliminating the firing of the still. Frequently the still charge is finished long before it is needed at the roofing machines. During this interval the finished product cools down so that when the time arrives to pump out the still the charge is too cold and must be reheated. By oxidizing the asphalt as it is needed, continuously, this reheating could also be eliminated.

If the flux oil could be oxidized while it is pumped, at a rate of 1,500 gallons per hour, it would increase the capacity of a single unit by a big margin. The large still has a capacity of 10,000 gallons requiring from 12 hours to 17 hours to oxidize, plus 6 hours to charge, making a total time of 18 to 23 hours. While continuous oxidation at 1,500 gallons per hour would total 36,000 gallons in 24 hours.

The present still is charged a definite amount which may be more or less than is needed in a day's production at the machine. A continuous oxidizing unit would allow control of the amount to be oxidized. This amount varies with the type of roofing being produced.

The present still charge is oxidized to a definite melting point. Continuous oxidizing would permit control of melting point by changing velocity of flow or time of contact with the air so that successive melting points might be produced. One unit could produce different coatings, thereby replacing several stills.

Another benefit to the manufacture of roofing would be the reduction in the amount of inventory of finished products. At present it requires 24 hours notice to prepare the coating for a machine run. A continuous oxidizing process would require only a few hours notice to schedule a machine run. This would allow operating to customers' orders.

Cost Reduction

Most important, a continuous oxidizing unit would save money in its operation. Fuel in heating and reheating would be greatly reduced. It would also reduce still cleaning and operating labor. Firing of a still causes a coke to form on the bottom. This must be removed when the accumulation interferes with the heat transfer from the still bottom to the asphalt. Preheated charging has reduced the amount of coking. It is reasonable to suppose that continuous oxidation would reduce this further by eliminating the still firing.

Usually each machine operated requires a still of coating. Daily production varies from two to four stills normally. By using a single oxidizing unit the time for an operator to supervise the oxidation would be greatly reduced allowing him to handle other functions such as unloading asphalt from incoming cars.

Power would be greatly reduced. Only one air compressor would be needed for the continuous oxidizer and one exhaust fan. At present one of each is used for each still when oxidizing.

## Problem of Design

Oxidation of asphalt continuously by heating it to 500 degrees Fahrenheit and introducing air through it brings several problems to mind. How long is it necessary for the air to be in contact with the flux oil to produce a definite melting point? How long does it take to raise the melting point a definite range in the present stills? Is there a relation between the different melting points required and the time necessary to oxidize to them?

As the temperature for all oxidizing is fairly constant and the volume of air used remains the same, only the time of contact is variable. The temperature ranges between 500 degrees and 530 degrees Fahrenheit, and the volume of air passed through each charge is 600 cubic feet per minute. The different melting points required are: Shingle saturant, 145 to 165 degrees Fahrenheit; smooth surface roofing coating, 195 to 210 degrees Fahrenheit; slate roll roofing coating, 210 to 220 degrees Fahrenheit; and shingle coating, 230 to 240 degrees Fahrenheit. The flux oil, used as regular saturant, from which these are oxidized, has a melting point of 110 to 120 degrees Fahrenheit. The average rise of shingle saturant is 40 degrees Fahrenheit; of smooth surface roofing coating, as determined by the majority of charges which are to 195 to 200 degrees Fahrenheit, is 80 degrees Fahrenheit;

of slate roll roofing is 100 degrees Fahrenheit; and of shingles is 120 degrees Fahrenheit.

Also there is the question: Is there a relation existing between the oxidizing time of the 10,000 gallon still and the 5,000 gallon still? The first is charged to a depth of 6 feet 6 inches, and the latter to 5 feet 1 inch. The large still has a diameter of 9 feet 0 inches, while the diameter of the smaller still is 7 feet 0 inches. The space between the level of the liquid and the top of the still is used to collect the vapors and allow for the splash caused by the air bubbling through the liquid. There is a difference in the quantities oxidized, one is about 7,600 gallons and the other 4,200 gallons.

The volume of air used in oxidizing both sizes of stills is constant, 600 cubic feet per minute. The temperature, of course, is the same for both. The only variables then are the depth of material through which the air passes and quantity of flux oil in each to be oxidized.

The variable of quantity can be equalized by reducing the oxidizing time to that per 1,000 gallons.

This leaves only the variable of depth to consider as a relation between the oxidizing time of the two sizes of stills.

## DESIGN OF CONTINUOUS PROCESS

### Analysis of Present Method

In order to have facts concerning the operation of the present system of oxidizing the asphalt in horizontal stills a record was kept of each still charge. Table #1 shows a sample of the record kept, in this case 195 to 210 degrees Fahrenheit melting point coating, showing date, size of still, total time from charging to O.K. by laboratory, firing time, oxidation time, and reheating time. These records were grouped by melting points: 145 to 165 degrees Fahrenheit group, 195 to 210 degrees Fahrenheit group, 210 to 220 degrees Fahrenheit group, and 230 to 240 degrees Fahrenheit group. As indicated above these groups were divided into those for the large size stills and those for the smaller stills.

These records were kept over a period of a year and one-half before initial comparisons were made. There exists a wide difference in the figures of each still charge. Some of the higher figures are due to charging a cold still or starting oxidation before a high enough temperature had been reached. The low

TABLE #1

195°-210° F. Melting Point Coating.

Time in Hours.

| Date | Total | | Firing | | Oxidation | | Reheat | |
|---|---|---|---|---|---|---|---|---|
| | Small | Large | Small | Large | Small | Large | Small | Large |
| 2/6 | | 11 | | 4 | | 9½ | | 3½ |
| 2/7 | | 25½ | | 6½ | | 16 | | 3 |
| 2/8 | | 11½ | | 2 | | 6½ | | 5 |
| 2/13 | | 21 | | 5 | | 13 | | 1½ |
| 2/14 | | 13½ | | 1½ | | 10 | | 2½ |
| 2/15 | | 12 | | 3 | | 8 | | 1½ |
| 2/22 | | 13 | | 1 | | 9½ | | 1½ |
| 3/7 | 13½ | | 6 | | 8½ | | 2 | |
| 3/12 | 14½ | | 3 | | 10 | | 3 | |
| 3/16 | 18½ | | 3 | | 16 | | 2 | |
| 3/19 | 15½ | | 5½ | | 12 | | 1 | |
| 3/20 | 16 | | 3½ | | 10½ | | 2 | |
| 3/20 | 13 | | 2 | | 9 | | 0 | |
| 3/21 | 12 | | 1½ | | 4 | | 0 | |
| 3/27 | | 19 | | 1½ | | 14 | | 0 |
| 3/28 | | 16½ | | 5 | | 12 | | 5 |
| 4/2 | 16½ | 22½ | 2 | 3 | 12 | 19 | 2½ | 2 |
| 4/3 | 13 | | 2 | | 10 | | 0 | |
| 4/3 | 10½ | | 2 | | 9 | | 1 | |
| 4/4 | 21 | | 2 | | 17 | | 2 | |
| 4/4 | 12 | | 2 | | 9½ | | 1 | |
| 4/6 | 18½ | | 3 | | 12½ | | 3 | |
| 4/6 | 19 | | 1½ | | 16 | | 2½ | |
| 4/7 | 13½ | 17 | 1½ | 3½ | 10 | 8½ | 2½ | 1 |
| 4/7 | | 17 | | 1½ | | 14 | | 1 |
| 4/8 | 13 | | 1 | | 10½ | | 0 | |
| 4/8 | 14 | | 1 | | 10½ | | 1½ | |
| 4/9 | 16½ | 20 | 3 | 2½ | 8½ | 16½ | 1 | 3 |
| Ave. | 15.0 | 17.0 | 2.5 | 2.9 | 10.8 | 12.1 | 1.4 | 2.1 |

figures are mainly due to leaving part of a previous charge in the still and "topping off" for the new charge. Thus a charge in this case would have a higher original melting point than 115 degrees Fahrenheit. The records were analyzed by throwing out the unusual figures, but the net average was close to the average leaving in these figures.

Before analyzing these records it was assumed that only a flow would be necessary in the present horizontal stills to make a continuous oxidizing unit. The charges in the 10,000 gallon stills were known to require longer total time than the 5,000 gallon stills. This seemed reasonable because the larger still contained more asphalt to be oxidized.

Relation Between Melting Point Divisions

An examination of Table #2, which is a summary of still charges recorded from August 1, 1932, to March 1, 1935, reveals data about oxidation of the present stills. There are four main groups, in which two are to be analyzed now. These are for the 4,200 gallon still charge and the 7,600 gallon still charge, the normal charges. The total number of charges were divided into the total oxidation hours, which gave the

TABLE #2

| Melt. Point | Number of Still Charges | Total Oxidation Hours | Ave. Oxidation Hours | Ave. Hours per 1,000 g. | Melt. Point Rise | Ave. Time per 1°F. Rise Melt. Point per 1,000 g. |
|---|---|---|---|---|---|---|
| 3700 Gallon Still Charge Depth 4' 6" | | | | | | |
| 195-210 | 16 | 199.0 | 12.43 | 3.36 | 80° | .0420 |
| 210-220 | 4 | 47.5 | 11.88 | 3.21 | 100° | .0321 |
| 230-240 | 16 | 251.0 | 15.69 | 4.24 | 120° | .0353 |
| | | | | Group | Ave. | .0365 |
| 4200 Gallon Still Charge Depth 5' 1" | | | | | | |
| 145-165 | 67 | 327.5 | 4.888 | 1.16 | 40° | .0290 |
| 195-210 | 257 | 2492.0 | 9.700 | 2.31 | 80° | .0289 |
| 210-220 | 52 | 707.5 | 13.606 | 3.24 | 100° | .0324 |
| 230-240 | 89 | 1434.0 | 16.112 | 3.83 | 120° | .0353 |
| | | | | Group | Ave. | .0314 |
| 7000 Gallon Still Charge Depth 6' 0" | | | | | | |
| 195-210 | 20 | 241.0 | 12.05 | 1.72 | 80° | .0214 |
| 210-220 | 22 | 362.0 | 16.85 | 2.41 | 100° | .0241 |
| 230-240 | 22 | 391.0 | 17.79 | 2.54 | 120° | .0212 |
| | | | | Group | Ave. | .0222 |
| 7600 Gallon Still Charge Depth 6' 6" | | | | | | |
| 145-165 | 112 | 621.5 | 5.549 | .73 | 40° | .0183 |
| 195-210 | 176 | 2121.5 | 12.054 | 1.59 | 80° | .0199 |
| 210-220 | 162 | 2411.0 | 14.821 | 1.95 | 100° | .0195 |
| 230-240 | 212 | 3849.5 | 18.160 | 2.39 | 120° | .0199 |
| | | | | Group | Ave. | .0194 |

average oxidation time per charge. These were further reduced to the time per 1,000 gallons. On Chart #1 these figures were plotted for each melting point division and a line drawn for each size charge from the point for 230 to 240 degrees Fahrenheit melting point to the 115 degrees Fahrenheit melting point position. The line for the 7,600 gallon charge approximates the plotted points indicating clearly a relation existing between each melting point position. The line for the 4,200 gallon charge, neglecting the point for 195 to 210 degrees Fahrenheit melting point division, also indicates that such a relation exists. The discrepancy is the plotted point for the 195 to 210 degrees Fahrenheit melting point division, which is low. Looking back to Table #2 it will be noted that the number of charges for this division is several times larger than for any of the others. Therefore, this figure must be authentic.

## Difference in Operation

The difference between this point and the normal line is due to the difference in operation of the 5,000 gallon still for this division. When the other melting point divisions are oxidized the still may not be recharged immediately. This division, however,

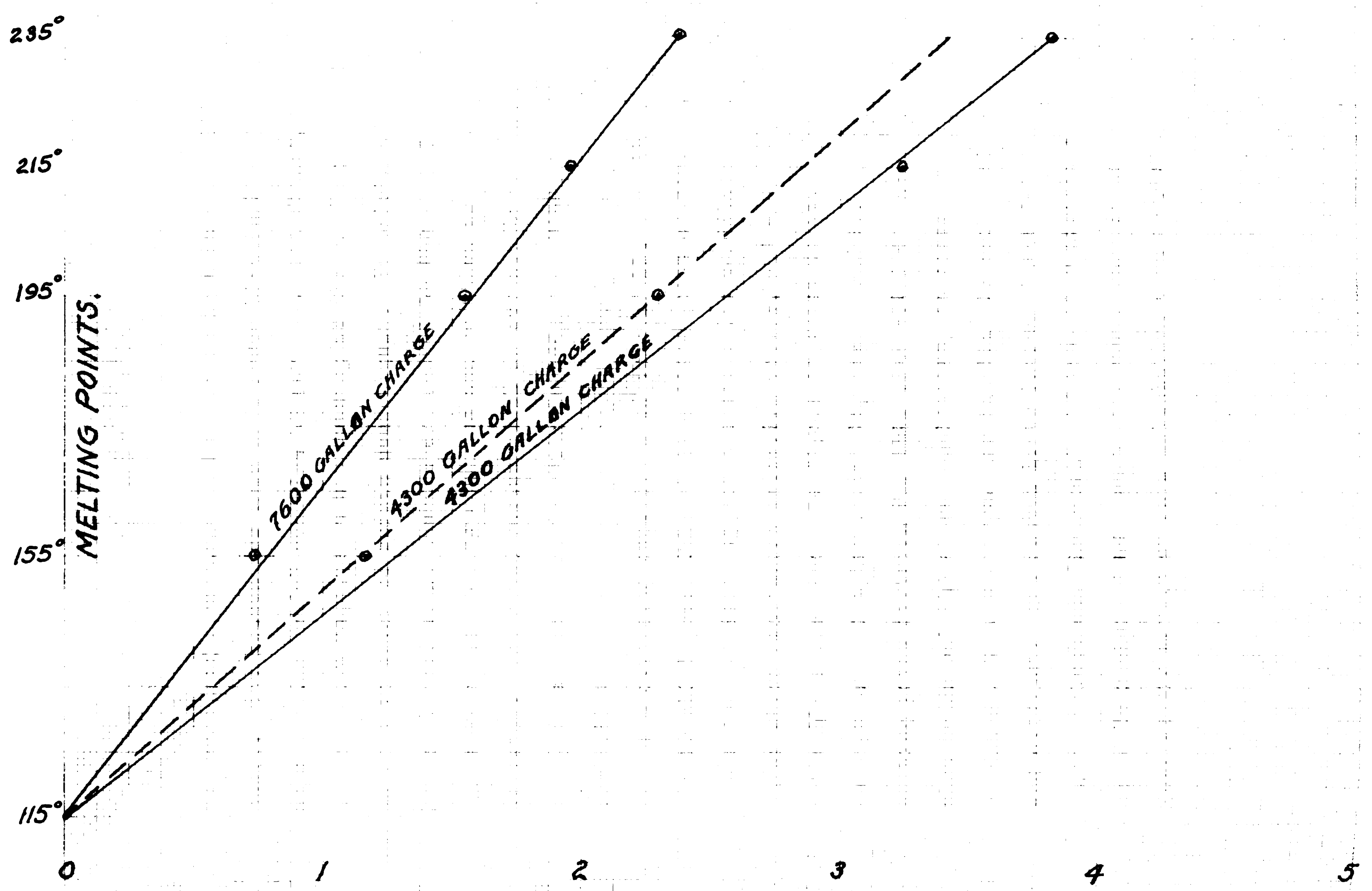

MELTING POINTS.
235°
215°
195°
155°
115°
7600 GALLON CHARGE
4300 GALLON CHARGE
4300 GALLON CHARGE
0
1
2
3
4
5
OXIDATION HOURS per 1000 Gallons.

CHART #1.

is immediately recharged. No heat is lost in the still shell. The reason for this difference lies in its use as a coating, which contains 50 per cent sand filler, which amount requires a hot coating at the roofing machine in order to remain semi-liquid. To maintain hot coatings, small amounts are pumped to the supply tanks over the roofing machines and refilled as depleted. The 5,000 gallon still is repeatedly charged as soon as it is empty to keep pace with production.

The oxidizing conditions of this still, when the 195 to 210 degrees Fahrenheit melting point coatings are being oxidized, approach closely the conditions under which continuous oxidation occurs, and are evidently a more accurate figure on which to base assumptions. The 145 to 165 degrees Fahrenheit melting point division for this size still charge also bears out the above conclusions, as these oxidized saturant charges are immediately recharged and oxidized. The dotted lines through these two points illustrate the result, if the other divisions could be recharged as soon as finished; they indicate further the margin of safe calculation when compared with the line for the 7,600 gallon still charge which is used in the design of the oxidation tank, as will be pointed out later.

On Table #2 the average oxidation hours per 1,000 gallons were further reduced to average time per one degree Fahrenheit rise in melting point per 1,000 gallons. As just pointed out the times for the 145 to 165 degrees Fahrenheit and 195 to 210 degrees Fahrenheit melting point divisions are almost identical for the 4,200 gallon charge. The time for the other two divisions of melting points for this size charge is, of course, higher.

The average times per one degree Fahrenheit melting point rise for the 7,600 gallon charges are quite similar. The 145 to 165 degrees Fahrenheit division time is lower and in a way it corresponds in operation to the 195 to 210 degrees Fahrenheit and 145 to 165 degrees Fahrenheit melting point divisions for the 4,200 gallon charge.

## Relation Between Depths of Charges

These final figures eliminate all variables except depth of flux oil through which the oxygen passes. If these times are proportional to the reciprocal of

the depths, this last variable can be eliminated. The group average for the depth of 5 feet 1 inch is .0314 hours per one degree Fahrenheit rise in melting point per 1,000 gallons and the group average for the depth of 6 feet 6 inches is .0194.

$$.0314 : \frac{1}{5.08} = X : \frac{1}{6.5}$$

$$6.5X = .0314 \times 5.08$$

Therefore $X = .0245$ hours, which is much higher than the actual figure of .0194 hours.

## Study of Air Bubbles in a Liquid

A study was made of air bubbles passing through water. A six inch diameter pipe was installed vertically with a glass bulb on the bottom. A one-quarter inch diameter pipe was inserted in the six inch pipe, so that it was only one inch above the bottom of the glass bulb. Air was introduced through the one-quarter inch pipe under enough pressure to barely emerge from the bottom when the six inch pipe was filled to various depths with water. As the bubble left the one-quarter inch pipe it was observed by an assistant who called out. A stop watch was started by the observer and then stopped as the bubble

reached the surface of the water. Table #3 gives the results of this test. The 10 inch depth was used as a base, and the times for the other depths calculated by direct proportion. These figures were close enough to the test figures to assume such a proportion holds true.

This test indicates that another factor must enter into the difference in oxidation time per one degree Fahrenheit rise in melting point per 1,000 gallons for the depths of 5 feet 1 inch and 6 feet 6 inches. It was noted during the test that as the depth of water was increased, the pressure on the air was also increased by opening the valve in order to release an air bubble. Also that the initial bubble size was approximately the same size, but at the surface as the depth increased the size of the emerging air bubble increased.

The Law of Depth

In oxidizing flux oil, then, increasing the depth through which the air bubbles pass not only lengthens the time of contact, but also increases the pressure contact. This indicates not a direct proportion, but a proportion by the squares of the depths.

Now compare the group averages for the depths of

TABLE #3

| Air Bubbles Rising in Water. | | | |
|---|---|---|---|
| Depth | Ave. Time | | Calculated Time |
| 9.5" | 1.20 seconds | | 1.48 seconds |
| 10.0" | 1.56 " | Base | 1.56 " |
| 19.5" | 2.92 " | | 3.04 " |
| 27.0" | 4.02 " | | 4.21 " |
| 29.5" | 4.68 " | | 4.60 " |
| 48.0" | 7.50 " | | 7.49 " |
| 76.0" | 12.50 " | | 11.86 " |
| 94.0" | 15.00 " | | 14.66 " |

5 feet 1 inch and 6 feet 6 inches.

$$.0314 : \left(\frac{1}{5.08}\right)^2 = X : \left(\frac{1}{6.5}\right)^2$$

$$.0314 : \frac{1}{25.81} = X : \frac{1}{42.25}$$

$$42.25X = .0314 \times 25.81$$

Therefore $X = .0192$ hours which is an error of only 1.04 per cent to the actual average of .0194 hours.

Now to be sure that the above formula is not just for these two depths, the still charges for the large and small stills were lowered 6 inches for a period of three months and a record kept. The results are tabulated in Table #2 under the 3,700 gallon and 7,000 gallon charges at depths of 4 feet 6 inches and 6 feet 0 inches respectively. The average time per one degree Fahrenheit rise per 1,000 gallons was computed.

In Table #4 all the charges are compared with the 7,600 gallon charges for oxidation time per one degree Fahrenheit rise per 1,000 gallons, using the above formula. While the figures based on the 7,600 gallon still charges are higher than the actual, nevertheless they indicate closely the relation existing due to the depth of asphalt through which the air bubbles pass.

## TABLE #4

Formula $T_1 : \left(\frac{1}{D_1}\right)^2 = T_2 : \left(\frac{1}{D_2}\right)^2$

$T_1$ = Oxidation hours per 1° F. rise in melting point per 1,000 gal. at $D_1$ depth.

$D_1$ = 5' 1" or 5.08 ft. depth.

$T_2$ = Calculated oxidation hours per 1° F. rise in melting point per 1,000 gal. at $D_2$ depth

$D_2$ = Selected depth; either 4' 6", 6' 0" or 6' 6".

| Still Capacity Gallons | Depth $D_2$ | Melting Point | Oxidation Hours per 1°F. Rise per 1,000 g. | Group Ave. | Calculated Oxidation Hrs. per 1° F. Rise per 1,000 gal. |
|---|---|---|---|---|---|
| 3700 | 4' 6" | 195-210 | .0420) | | .0415 |
| 3700 | 4' 6" | 210-220 | .0321) | | .0407 |
| 3700 | 4' 6" | 230-240 | .0353) | .0365 | .0415 |
| 4200 | $D_1$ | 145-165 | .0290) | | .0300 |
| 4200 | $D_1$ | 195-210 | .0289) | | .0325 |
| 4200 | $D_1$ | 210-220 | .0324) | | .0319 |
| 4200 | $D_1$ | 230-240 | .0320) | .0314 | .0325 |
| 7000 | 6' 0" | 195-210 | .0214) | | .0234 |
| 7000 | 6' 0" | 210-220 | .0241) | | .0229 |
| 7000 | 6' 0" | 230-240 | .0212) | .0222 | .0234 |
| 7600 | 6' 6" | 145-165 | .0183) | | |
| 7600 | 6' 6" | 195-210 | .0199) | | |
| 7600 | 6' 6" | 210-220 | .0195) | | |
| 7600 | 6' 6" | 230-240 | .0199) | .0194 | |

## Increase Efficient Oxidation

To increase the efficiency of an oxidizing unit, the above relation suggests an increase in the depth of flux oil through which the air passes. This change of depth to increase efficiency has physical limits. In shallow depths the air bubble emerging at the surface still has a large portion of oxygen which has not combined with the lighter oils. As the depth is increased this percentage of free oxygen is reduced, approaching zero as a limit. Since the change in depth also causes a change in oxidation time, by the square of the difference in depth, then a depth which is too great would not give the calculated results because the free oxygen available in the emerging bubble would be negligible.

## Design

Without knowing how much free oxygen is still left in the bubble after it has travelled through the charge in the present stills, but believing that it is a high percentage, an arbitrary increase in the depth of asphalt of the proposed oxidation tank is selected. In Table #5 the depth is set at 10 feet 0 inches. Based on the group average oxidation time

## TABLE #5

Formula $$T_1 : \left(\frac{1}{D_1}\right)^2 = T_3 : \left(\frac{1}{D_3}\right)^2$$

$T_1$ = Group average oxidation hours per 1° F. rise in melting point per 1,000 gal. at $D_1$ depth, .0194

$D_1$ = 6' - 6" or 6.5 feet depth.

$T_3$ = Calculated oxidation hours per 1° F. rise in melting point per 1,000 gal. at $D_3$ depth.

$D_3$ = 10' - 0" depth.

| Melting Point | Melting Point Rise | Calculated Oxidation hrs. per 1° F. rise per 1,000 gal. | Calculated Oxidation hours per 1,000 gal. |
|---|---|---|---|
| 145°-165° | 40° | | .332 |
| 195°-210° | 80° | .00830 | .664 |
| 210°-220° | 100° | | .830 |
| 230°-240° | 120° | | .996 |

per one degree Fahrenheit rise in melting point per 1,000 gallons for the 7,600 gallon charge, the oxidation time is calculated for all divisions of melting points. Knowing that this group average time is higher than for the actual oxidation time for the 195 to 210 degrees Fahrenheit melting point division for 5,100 gallon charge, a condition which more closely approaches the condition of continuous oxidation, the calculations have a margin of safety.

### Vertical Unit

The above analysis of the facts concerning oxidation time indicates the economical advantage of a vertical oxidation unit. It is also apparent that if this unit is too large the heat imparted to the flux oil by the tube heater will be reduced through cooling. The loss due to radiation is the reason for the present still charge being heated prior to oxidation, in order to reattain the oxidation temperature. On the other hand, if the oxidizing unit is too small, the element of time between the flux oil and the oxygen will be too short.

### Diameter of Unit

The smallest diameter of an oxidizing tank, with a liquid level of 10 feet 0 inches, must be large enough to permit any particle of a constant flow to be in contact with oxygen for at least one hour. This is the shortest span of time in which, by laboratory methods, flux oil is oxidized from 115 degrees Fahrenheit melting point to 235 degrees Fahrenheit melting point. Since the average rate of the pumps feeding the asphalt through the tube heater to a temperature of 500 degrees Fahrenheit is 1,500 gallons per hour, then the smallest capacity should be 1,500 gallons at a 10 feet 0 inches level. The diameter of such a tank would be approximately 5 feet 0 inches.

The asphalt being pumped in a tank of the above dimensions at 1,500 gallons per hour would be in contact with air for one hour. An examination of Table #5 shows that this would be sufficient for oxidation to 195 to 210 degrees Fahrenheit melting point.

1.0 hour $\div \frac{1500}{1000}$ gallons $=$ .667 hours per 1,000 gallons compared with calculated .664 hours per 1,000 gallons. The other melting point divisions would not be taken care of by this procedure.

Mixing Action of Air Bubbles

To suppose that the flux oil, after passing through the oxidizing unit in this manner, would be raised to 195 to 210 degrees Fahrenheit melting point would lead to an error. The air passing through the flux oil provides a mechanical mixing action so that the flux oil emerging is composed of particles which have been in contact with the air the full hour and also of particles which have been in the tank less than one hour. The melting point of the resulting mixture would be one-half or 155 degrees Fahrenheit, the average between the melting point of the asphalt charged and finished.

$$\frac{115^{\circ} \text{ plus } 195^{\circ}}{2} = 155^{\circ}$$

This is because the average time for the entire tankful in contact with the air is one-half hour.

Calculated:

$$.5 \text{ hour} \div \frac{1500g.}{1000g.} = .333 \text{ hours per } 1{,}000$$

gallons.

Table #5 calculated time: .332 hours per 1,000 gallons 145 to 165 degrees Fahrenheit melting point.

As this melting point division is one-third the maximum melting point division, and one-half of the 195 to 210 degrees Fahrenheit melting point division, it becomes necessary to use three oxidizing tanks in series to obtain the maximum required melting point 235 degrees Fahrenheit, and two tanks in series to obtain the 195 degrees Fahrenheit melting point.

For every instant of operation beyond the first hour the flux oil emerging from the oxidation tank is also composed of particles which have been in the tank more than one hour. If operation of the unit continued for a long period it is reasonable to suppose an equilibrium would be reached when the average time for the entire tankful in contact with the air is a full hour. However, in starting up the oxidation unit and continuing for only a few hours it is safe to design the unit with the above calculation. For long periods of operation the speed of the pump can be controlled to produce the required melting point.

Using tanks 5 feet 0 inches in diameter and 10 feet 0 inches in liquid level makes a total capacity of 4,500 gallons. If this capacity could be reduced, the heat loss due to radiation would not be so great. However, it is essential that the diameter of these tanks be large enough for a man to enter and clean them.

A diameter of 4 feet 0 inches is the smallest diameter in which a man could work without undue obstructions.

In Table #6 a tank 4 feet 1 inch in diameter is used, and comparison between actual oxidation hours per 1,000 gallons and the calculated is tabulated. The total capacity of three tanks in series is about 3,000 gallons. This table, further, shows the calculations for the 210 to 220 degrees Fahrenheit melting division, using two regular tanks in series, and the third with a liquid level at 7 feet 0 inches to obtain the desired result.

Operation of Unit

Now to obtain coating and oxidized saturants the asphalt is pumped through the tube heater, raising the temperature to 500 degrees Fahrenheit, then through as many oxidizing tanks as are necessary to reach the required melting point, and from there it is pumped to the roofing supply tanks.

The pumps will operate at a constant rate of 1,500 gallons per hour and the tube heater will be fired at a uniform temperature to impart to the flux oil a temperature of 500 degrees Fahrenheit. Then if shingle

## TABLE #6

Pump Speed - 1500 Gallons Per Hour, Air - 600 cu.ft./min.
Capacity of Tank - 10,070 Gallons Diameter - 4' 1"
Depth of Flux Oil - 10' 0"
Time of Contact with Air - .67 hours/1000 gal.
Effective Time Contact with Air - .333 hours/1000 gal.

| Actual Oxidation Hours per 1000 gal. | Calculated Oxidation Hours per 1000 gal. | Tanks in Series | Melting Point Rise | Resulting Melting Point |
|---|---|---|---|---|
| .333 | .332 | 1 | 40° | 145°-165° |
| .670 | .664 | 2 | 80° | 185°-210° |
| 1.000 | .996 | 3 | 120° | 230°-240° |

For melting point 210°-220° use two tanks in series at flux oil depth of 10' 0" and third tank at flux depth of 7' 0".

$$T_1 : \left(\frac{1}{D_1}\right)^2 = T_4 : \left(\frac{1}{D_4}\right)^2$$

$T_1$ = .0194

$D_1$ = 6' 6" or 6.5'

$T_4$ = Oxidation hours per 1°F. rise in melting point per 1000 gallons at $D_4$ depth.

$D_4$ = 7' 1" or 7.08'

$$.0194 : \left(\frac{1}{6.5}\right)^2 = T_4 : \left(\frac{1}{7.08}\right)^2$$

$$.0194 : \frac{1}{42.25} = T_4 : \frac{1}{50.13}$$

$$50.13\ T_4 = .82965$$

$$T_4 = .01655$$

Rise in melting point = 20°F.

.01655 x 20 = .331 hrs./1000 gal. oxidation.

(Cont.)

TABLE #6 (Cont.)

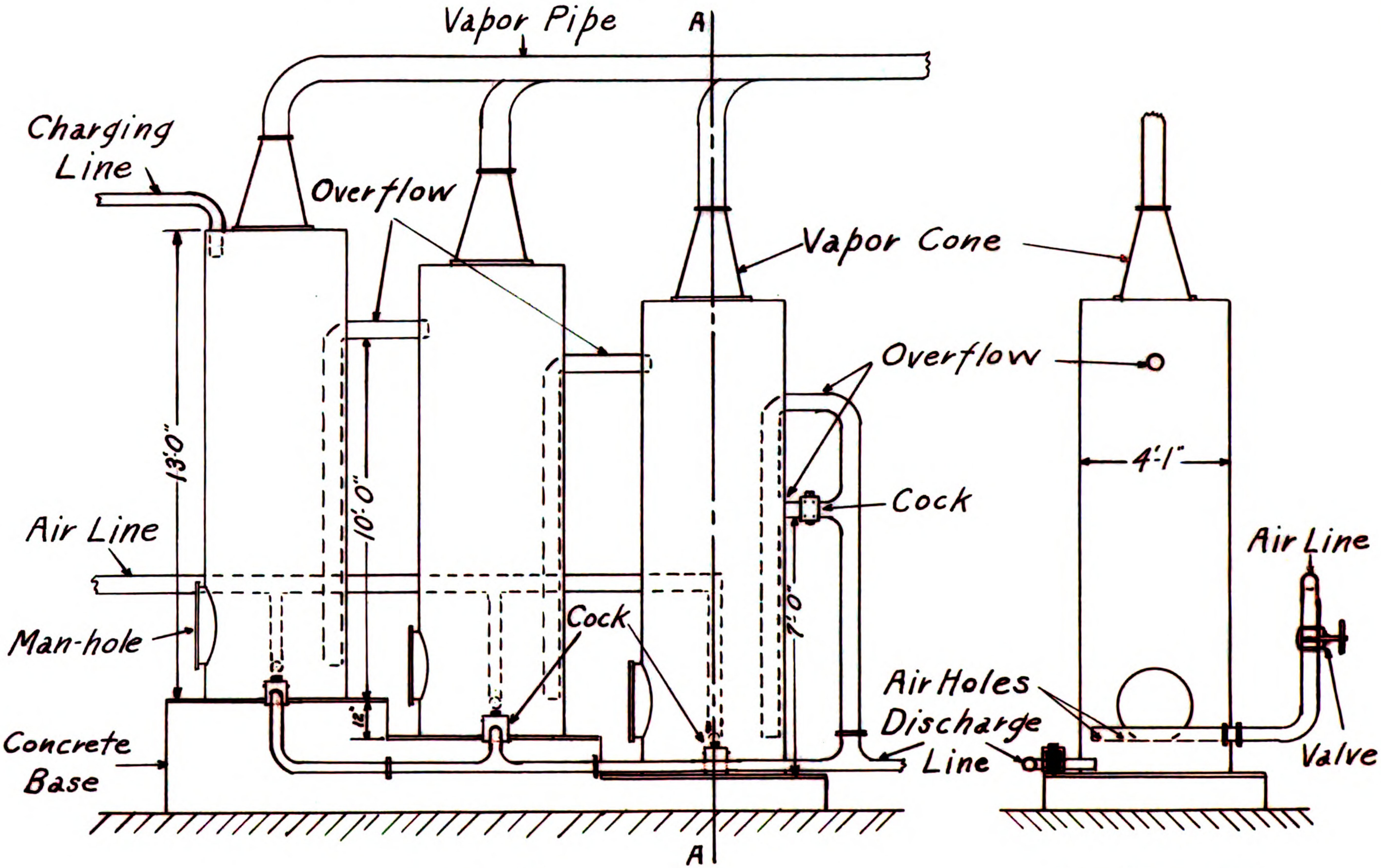
Capacity at 7' 1" level = 700 gallons<br>
700 ÷ 1500 G.P.H. = .46 hours<br>
.46 ÷ 2 = .23 hours effective oxidation of 700 gal.<br>
700 : .23 = 100 : X<br>
700X = 230<br>
X = .329 hours/1000 oxidation, comparing closely<br>
with calculated .331 hours/1000.

saturant (145 to 165 degrees Fahrenheit melting point) is desired the asphalt will be pumped into #1 oxidizing tank. It overflows to #2 oxidizing tank and the bottom valve is opened to the suction line to another pump which in turn pumps it to the roofing saturators. When 195 to 210 degrees Fahrenheit melting point coating is required, the asphalt will be oxidized in #1 and #2 oxidizing tanks, overflowing into #3, thence by the second pump to the roofing supply tanks. When 210 to 220 degrees Fahrenheit melting point coating is required, the asphalt will be oxidized in #1, #2 and #3 oxidizing tanks using, however, the 7 foot 1 inch overflow in #3 oxidizer. When 230 to 240 degrees Fahrenheit melting point coating is needed the flux oil will be oxidized in all three tanks at the levels of 10 feet 0 inches.

## Control of Oxidation

Since 600 cubic feet of air per minute are blown through the 4,200 gallon and 7,600 gallon charges of the present stills, it is reasonable to presume that a large portion emerging from the flux oil is still free air. The total capacity of the three oxidizing tanks is 3,000 gallons which is less than the present

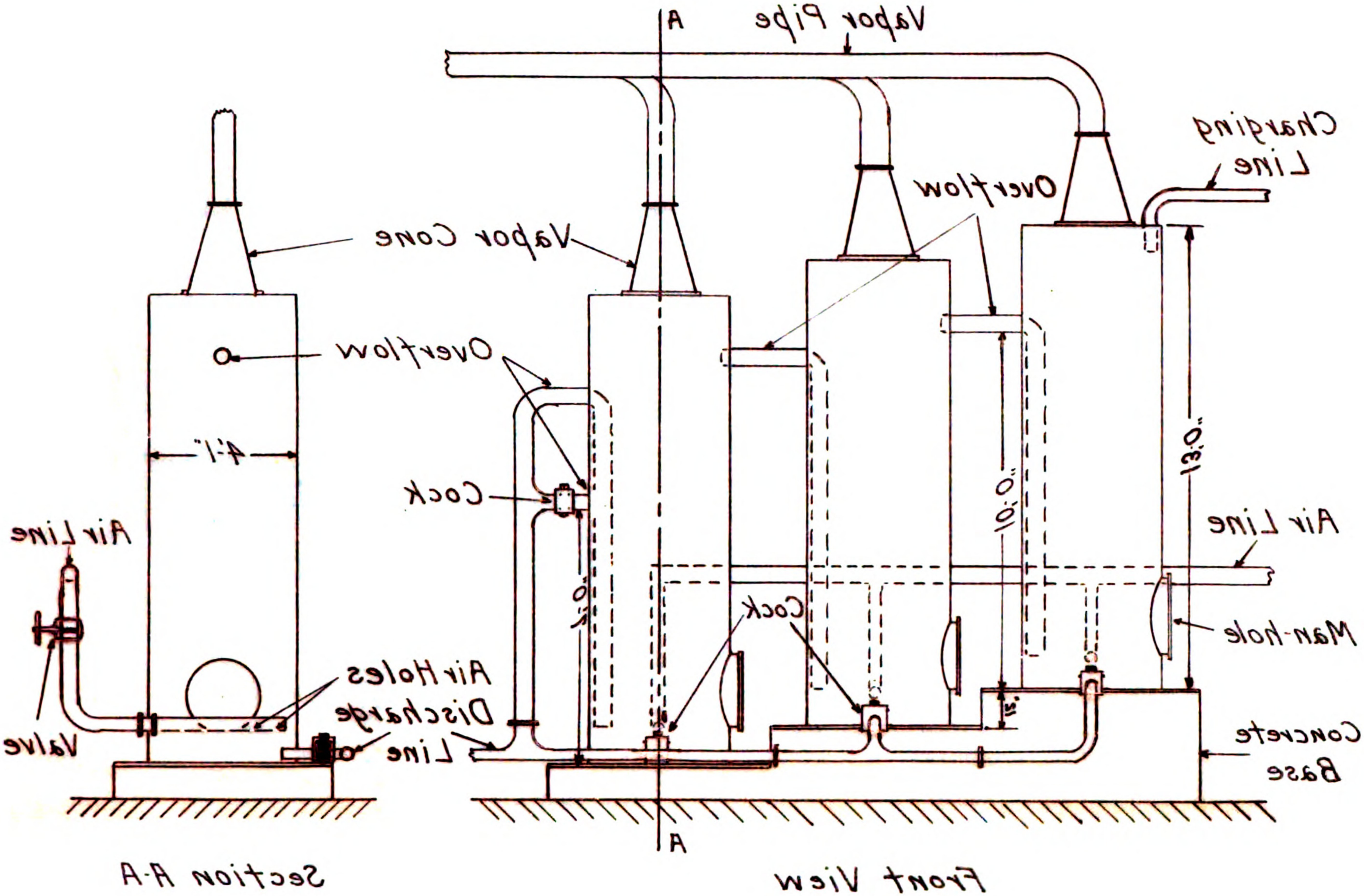
# CONTINUOUS OXIDIZING TANKS.




Front View

Section A-A

CONTINUOUS OXIDIZING TANKS.



still charges. Six hundred cubic feet of air per minute should be an ample quantity of air to accomplish the calculated results for all three tanks. By the use of valves and pressure guages the amount of air is regulated to provide each tank with approximately 200 cubic feet of air per minute.

The degree of heat and rate of pumping is supervised by an operator. The fly-wheel pump is equipped with recording R.P.M. indicators and speed regulators. The discharge line of the tube heater and each oxidizing tank is equipped with recording thermometers. Each overflow on the oxidizing tanks is equipped with sample valves and samples are taken half hourly for laboratory check on the melting point required. If the melting point is found to be higher than required, the operator speeds the pumping rate. If the melting point is found to be lower than required, the operator slows the pumping rate.

The pump used in discharging the completed coating or saturant operates at a higher rate than the pump feeding the oxidizing tanks to avoid any danger of completely filling the tanks and putting the sides under pressure or overflowing.

The proposed method is simple in construction and operation, and much more efficient than the present stills. It now takes from 12 to 24 hours to charge, oxidize and pump a still, and the charge is only 4,200 to 7,600 gallons. This new method would produce at the rate of 1,500 gallons an hour.

The cost of this oxidizing equipment is about equal to that of a 10,000 gallon still. Yet on a twenty-four hour basis the oxidizing tanks could produce 36,000 gallons, while one 10,000 gallon still would produce only 7,600 gallons. The new method produces almost five times as much.

Specification of Oxidizing Tank

The tanks will be welded one-half inch boiler plate, 4 foot 1 inch inside diameter and 13 feet 0 inches high, and welded bottom will be bolted to anchor bolts in a concrete foundation which is capable of sustaining a total load of 13,000 pounds. The top of each tank will be equipped with a welded cover in the middle of which is a flanged opening 24 inches in diameter. This is the connection for the reducing cone to the 9 inch vapor pipe. Each tank will be equipped with a 24 inch flanged man-hole the bottom of which will be 1 foot 0 inches above the bottom of the tank. This is to be used to clean the tanks of accumulated coke.

Each oxidation tank will be covered, in the field, with a 3 inch thickness asbestos insulation. This will be covered with smooth surface roofing and painted with a tar water-proof paint.

All the pipe fitting will be completed in the field. The pipe for the asphalt will be standard weight, outside jacketed, steel pipe, connected by means of flanges. The pipe for the air lines will be standard flanged steel pipe. The vapor lines will be of welded light steel, one-eighth inch thick, equipped with flanges.

ESTIMATED COST

| | | |
|---|---|---|
| Oxidizing tanks<br>4'1" inside diameter x 13'0" high welded boiler plate, flanged openings | 3 | $1,000.00 |
| Concrete foundation | | 300.00 |
| Insulation, 3" thick | 3 | 450.00 |
| 4" outside jacketed pipe | 40 ft. | 80.00 |
| 4" jacketed cocks | 6 | 90.00 |
| 4" steel pipe | 20 ft. | 10.00 |
| 6" steel pipe | 40 ft. | 30.00 |
| Reducing cones, 2'0" diam. to 0'9" diam. | 3 | 50.00 |
| 9" welded pipe 1/8" thick | 40 ft. | 40.00 |
| 4" rising stem valves | 5 | 100.00 |
| Recording thermometers | 3 | 300.00 |
| Speed regulator & R.P.M. indicator | | 200.00 |
| | | $2,650.00 |
| Labor & overhead | | 1,350.00 |
| | Total | $4,000.00 |

The exhaust fan now used on the stills will be installed for use with the oxidation tanks, and the compressed air will be furnished by the same compressor that now provides air for the stills.

Estimated Annual Savings

The annual saving by the use of this continuous oxidizing process is enumerated as follows:

Fuel Oil. By eliminating the firing of a still, which requires an average of 4 hours x 20 gallons of oil for each charge. In 1934 there were over 500 charges. 4x20x500x$.03 per gallon = $1,200.00

Electric Power. By reducing the number of hours per 1,000 gallons necessary to oxidize asphalt, the use of the air compressor and exhaust fan would be reduced saving electric power. Total annual power consumed with present stills, 5880 oxidation hours x 22.5 K.W. per hour is 132,300 K.W. To produce the same amount of coating and oxidized saturant with the continuous process would require 2,000 hours. 2,000 x 22.5 K.W. = 45,000 K.W. Annual saving in power, 87,300 K.W. @ $.015 is approximately $1,300.00.

Steam. Steam is used to atomize the fuel oil in the burner, the cost averaging $1.00 per still charge. Annual saving, 500 still charges x $1.00 = $500.00

Labor. By being able to oxidize the flux oil into coating a few hours before it is to be used on the roofing machine, a labor saving will be realized. At present the stills are charged 24 hours in advance of their use. At the beginning of the week, Saturday night, the stills are charged for Monday's machine run. If the coating is prepared in the continuous oxidizing tank Sunday night for Monday's run, then there is a saving in being able to start the tube heater 16 hours later. Since there are 3 men on each

8 hour shift, this would mean a saving of 6 men per week. 6 x $5.00 x 50 weeks = $1,500.00

The annual cost for cleaning still bottoms is $600.00. This cost is largely due to the accumulation of coke on the bottom of the still while firing the still charge. The use of the oxidation tanks reduces this localized heating to a minimum, reducing thereby the necessity for cleaning. Experience alone could determine the amount of cleaning required, however, it is estimated at $200.00 annually. The labor saving would be $400.00.

There are other possible labor savings. The stillman at present looks after as many as six stills. With only one unit requiring his attention, and continuous pumping with one set-up he might be able to perform other functions now requiring other men. The present layout with multiple stills and intermittant pumping in or out of these stills requires the work of a pumpman in addition to the still operator. With the installation of the continuous oxidation unit the work of the pumpman could be taken over by the stillman, without any loss in efficient discharge of the stillman's usual duties of supervising the oxidation of asphalt. It is reasonable to suppose that two of the three pumpmen per 24 hour period could be eliminated. This saving in annual cost would amount to roughly $1,500.00, not overlooking a substantial raise in salary for each stillman.

TOTAL ANNUAL SAVING

| | |
|---|---|
| Fuel oil | $1,200.00 |
| Electric power | 1,300.00 |
| Steam | 500.00 |
| Labor | 3,400.00 |
| Total | $6,400.00 |

Thus it is quite evident that the continuous oxidizing process is economically sound, saving $6,400.00 annually, against the initial installation cost of $4,000.00.

It is beneficial in other ways. Because the time of oxidizing a given amount of flux oil is so much more rapid than in the present stills the planning department is enabled to change machine schedules to meet actual orders, instead of anticipating demand, as at present. This would allow building up the stock of standard products, and, also, being able to produce within 24 hours the special orders that the customers demand in style of roofing and colors of slate. Being able to serve each customer's especial demands promptly is sound business. Quality plus service is invaluable to good will and repeat orders.

Therefore, besides its measurable economy, this continuous oxidizing unit would assist in meeting the policy of service by making the roofing machine schedules more flexible.

ROOM USE ONLY