THE EFFECT OF HEAT AND PRESSURE UPON THE RESOLUTION OF PETROLEUM EMULSIONS

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Introduction

In the production of crude petroleum from oil bearing formations, the methods of production used are such that they often agitate water present in the formation with the petroleum to form an emulsion. This agitation may be caused by gases bubbling through the oil and water, or by the flow of the two liquids at high velocities through small openings such as pump valves or flow beans. In order that a permanent emulsion be formed under these conditions, an emulsifying agent must be present in the liquids. Some of the substances which will act as an emulsifying agent are microscopic paraffin flakes, particles of asphalt, resinous materials, finely divided clay and napthenic acids and their salts. All these substances are found in petroleum and associated formation water, finely divided clay being the most common. The finely divided particles form emulsions when they are wetted by the two liquids which compose the emulsion. If one of the liquids wets the solid particle more than the other, the liquid-liquid interface will be inclined in the direction of the liquid which possesses the smaller wetting power, thus making it the internal phase.

When the emulsifying agent is a substance such as napthenic acid which has a hydrocarbon group on one end and a water soluble group on the other end, the action is believed by most authorities to be as follows: the molecules of the emulsifying agent orient themselves so that the hydrocarbon tail is in the oil and the polar carboxyl group is in the water. The emulsifying agent thus forms an interface which surrounds the dispersed phase and separates it from the continuous phase. In general, the phase in which the emulsifying agent is more soluble becomes the external or continuous phase.

Economically, these emulsions represent a huge waste of a valuable product since in many cases they are given only a relatively simple destabilizing treatment which removes only free water and loosely bound emulsified water. The fine grained tightly held emulsion which does not respond to treatment collects in tanks and treating equipment where it is periodically removed. In larger installations such as field storage tanks where huge quantities of emulsion have collected the oil is nearly always reclaimed, but in equipment such as lease tanks or gunbarrels where the quantity of oil is considerably smaller and harder to handle it is nearly always burned.

In the past, considerable attention has been given to the reclamation of emulsions in general and as a consequence, numerous methods have been devised. For the most part these methods are the results of cut and try procedure, however, and represent no really scientific approach to the problem.

One of the earlier and more simple methods is known as the 'hot water wash' (6). This method consists of passing the oil-emulsion mixture through a layer of brine, or even fresh water which is maintained at 120 to 180 degrees F. The system usually works at atmospheric pressure. There are countless variations of this method, and for fresh emulsions which are not extremely tight it works satisfactorily.

Another method which has been widely used is the 'haytank' (5).

These tanks are generally tall vertical tanks filled with excelsior, or in some cases, straw. As the emulsion is passed through the tank, a destabilizing action occurs due principally to preferential wetting of the excelsior. The packing is previously wet with oil or water, whichever is the internal phase of the emulsion being treated. Variations of this method have been devised by Tatman (27), Gardner (22), Conway (20), Brady (18), and Pollak (26).

A method of emulsion treating which takes advantage of the thinning action of lighter hydrocarbons present in the emulsion has been devised by Wilke (30). The emulsion is heated to approximately the boiling point of water, at which temperature the water and lighter hydrocarbons are vaporized. These are condensed and returned to the bottom of the tank. As the hydrocarbons rise, they tend to thin and destabilize the emulsion while the water is dumped at the bottom of the tank.

Emulsions have been broken by heating to 230 degrees F. (24) the water being in this case simply boiled off. Suman (12) dehydrated an emulsion containing 25 to 30% water by heating it in a tube still and then spraying it into a separator filled with superheated steam. After this treatment the oil rises through water heated to 90 degrees C. and is separated. Similarly, methods for separating water from oil by distillation have been worked out by Allan (1), Wikner (29), and Graff (23). Neill (9) suggested that multiple effect evaporators be used in the distillation of emulsions to improve efficiency.

Weiss (28) broke emulsions by using a water-insoluble solvent at a high temperature and a definite steam pressure. Bailey (18) broke emulsions by heating them to approximately 100 degrees C., and passing them through cooling tubes after which the water separated.

These methods rely mainly upon the application of heat to achieve demulsification. Several methods combining pressure and heat to break emulsions have also been developed.

The Badische Anilin and Soda Fabrik (17) heated emulsions to approximately 200 degrees C. in closed container, and blew the water off as steam. Moscicki and Kling (26) broke emulsions so completely that only 0.2 to 0.4% water remained. This process consisted of heating the emulsion in a continuous autoclave for 2 hours at 2 to 3 atmospheres pressure. There were three phases present in the autoclave: oil, emulsions and water. A similar method was devised by Pilat and Piotrowski (11) who heated emulsions for about 5 hours at temperatures around 120 to 130 degrees C. and pressures from 3 to 3½ atmospheres. Brown (20) and Burek (3) have also developed methods where emulsions are heated for varying periods of time in closed containers.

There are a few instances where pressure has been chiefly used to break emulsions. Notable among these is the method of Dyer and Heise (22) in which the emulsion is heated and passed through capillary tubes under high pressure. The action is much the same as that of a cream separator. Emulsions may be broken by forcing them through a bed of steel shavings. The water in the emulsion is then allowed to settle.

In recent years, considerable work has been done on the demulsification of oil by the use of heat and chemicals. The accent has been on the use of chemicals. Examples of this work have been discussed by Reed (12), Williams (14) (15), Monson (9), MacDonald (8), Briggs (5), Wilson (16), and Buchan (14).

It is the purpose of this paper to determine the effect of heat and pressures of varying degrees upon the water content of certain emulsions, and to try to correlate the amount of heat and pressure applied with the demulsification achieved in a treater embodying these principles.

Discussion of Results

Table 1

	BS & W % Raw	%BS & W after Autoclave	% BS & W after Calcium Chloride	% BS & W after Treater
Sam. 1.	13	1	6	11
Sam. 2.	42	1.2	17	2.6
Sam. 3.	16	3.4	16	4.5
Sam. 4.	34	0.8	25	5

Table 2

	Salt Content, Raw Emulsion lbs./1000 bbls.	Salt Content after Treater lbs./1000 bbls.
Sam. 1.	2620	3320
Sam. 2.	1630	1680
Sam. 3.	4090	360
Sam. 4.	6320	3160

Sample 1 is a mixture of approximately 90% Oklahoma City crude oil, and about 10% Kansas crude oil. (These percentages may vary). This sample contained about 13% BS & W upon arrival. It is a homogeneous mixture, dark brown in color and free from the odor of sulfide. At room temperatures (70°F.) it flows readily. A photomicrograph (Fig. 19a) shows the water (13% BS&W) present in the emulsion, and seems to indicate that it is a water-in-oil emulsion. This evidence is borne out by the fact that the emulsion is not miscible with water. Repeated leachings with warm Benzene disclose the presence of small

Fig. 19a
Photomicrograph of Sample 1, raw emulsion
120 magnifications

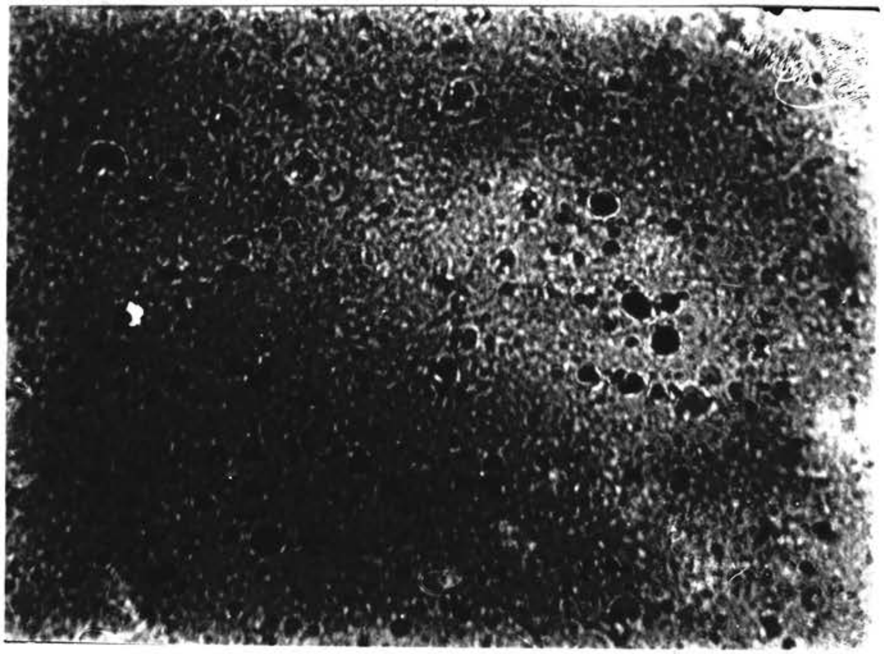


Fig. 19b
Photomicrograph of Sample 1 after 30 minutes at 30 lbs per in^2 pressure in autoclave.
120 magnifications

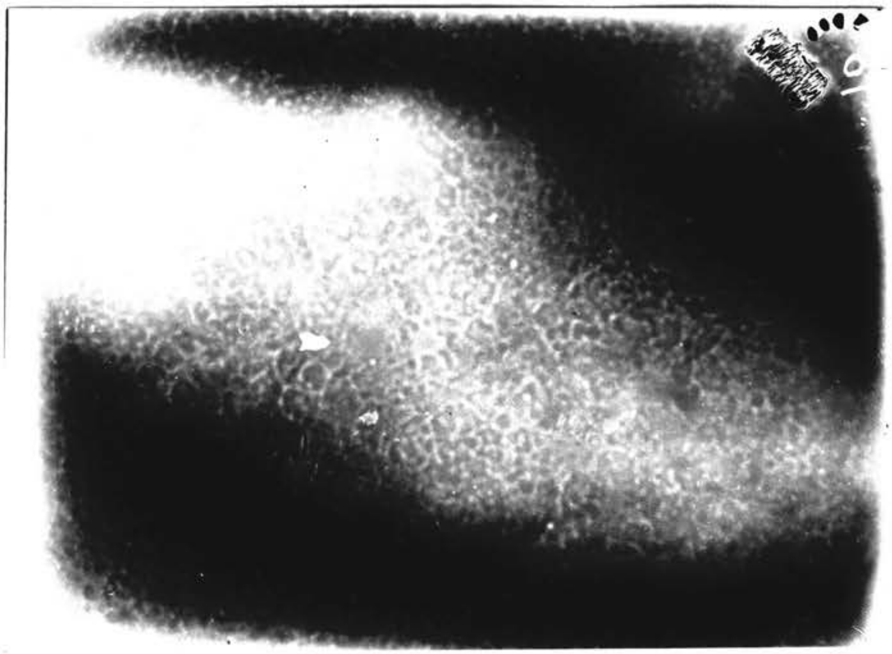


Fig. 19c
Photomicrograph of Sample 1 after reaction
in the treater 30 minutes at 30 lbs per in^2.
120 magnifications

quantities of fine particles which are not oil or water soluble. These particles when viewed under the microscope are too small to be readily seen.

These finely divided particles may help to stabilize the emulsion, since it is known that finely divided particles act as emulsifiers when unequally wet by the two phases. This emulsion contains water as the internal phase, which indicates that the particles are preferentially wet by the oil. There is in addition to the finely divided substance a small amount of some particles which are large enough to be easily seen. They are mainly small crystals of siliceous material.

Fig. 19b is a photomicrograph of the emulsion after 30 minutes at 30 lbs. per sq. in. pressure in the autoclave. Most of the water has disappeared, but there are present dark particles of organic composition, probably wax, since they are deformed by a slight pressure on the cover glass. The BS&W in this oil is about 1%. Fig. 19c is a photomicrograph of the top layer of the emulsion in the receiver tank after it has gone through the treater at a temperature around 280°F. and a pressure around 35-40 lbs. per sq. in. and settled for approximately 70 minutes. The oil contains appreciable amounts of emulsion (11% BS&W) and around 3300 lbs. of salt per 1000 bbls. of oil. (chloride equivalent) as compared with 2600 lbs. of salt per 1000 bbls. of raw emulsion. The emulsion appears smooth, fine-grained, and tightly held.

Fig. 8 shows the quantities of BS&W in the emulsion after various treatments as compared with the raw emulsion. The

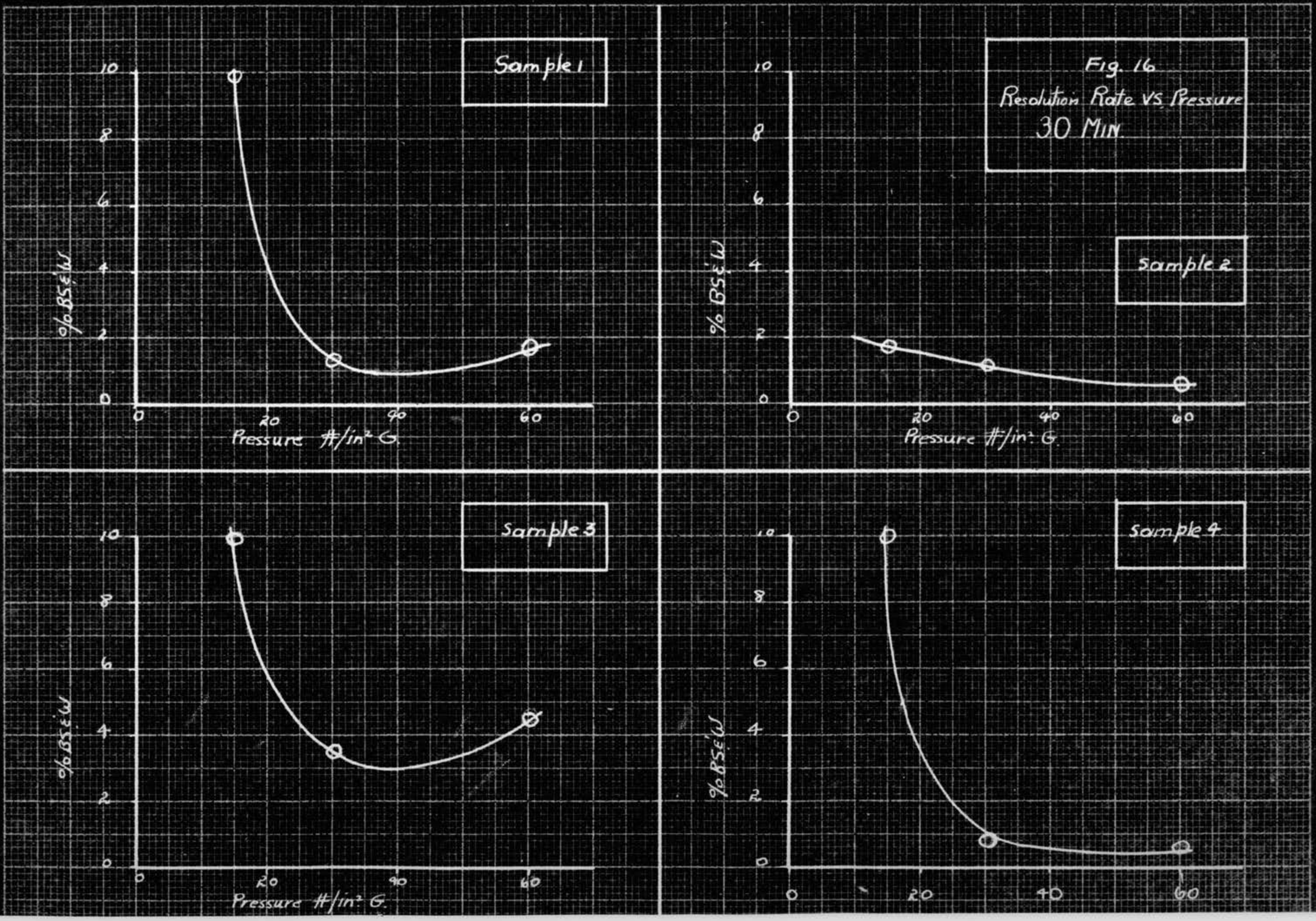


Fig. 16
Resolution Rate VS Pressure
30 MIN.

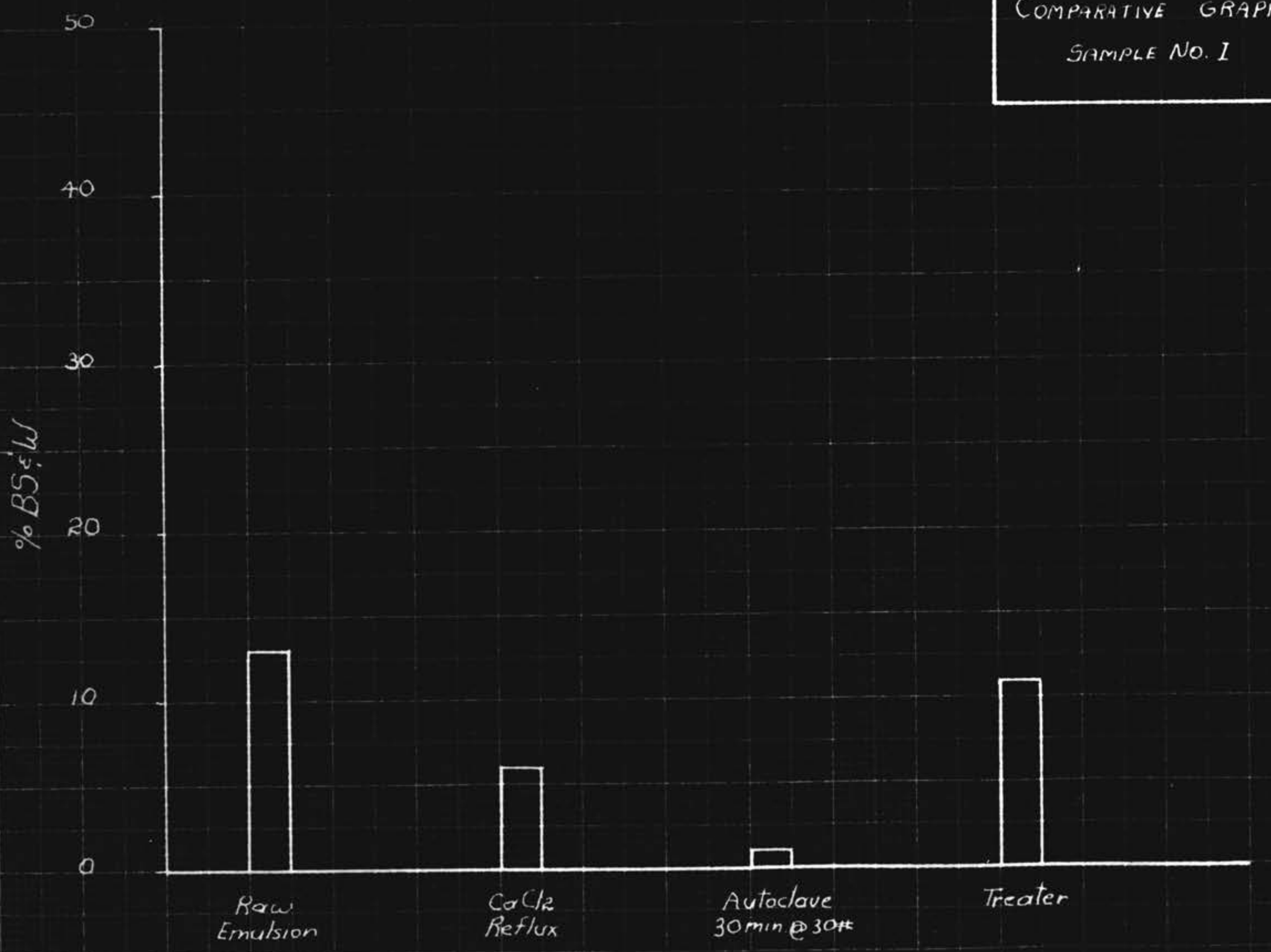


Fig. 8
COMPARATIVE GRAPH
SAMPLE No. I

autoclave reduced the BS&W to 1%, but the treater reduced it only to 11% BS&W. This may be the result of either one of two reactions.(1) The treater may have broken the emulsion only slightly and reduced the BS&W content to 11%, or it may have broken substantially all of the emulsion, then re-emulsified the oil with the calcium chloride solution in the treater. The latter seems feasible since the chloride content changed from 2600 lbs. per 1000 bbls. to 3300 lbs. per 1000 bbls. despite the fact that calcium chloride in general has a destabilizing effect upon emulsions.

Calcium chloride was chosen for the heat transfer medium in the treater for the following reasons:

(1) It has a destabilizing effect upon emulsions. This destabilizing effect is due to the bivalence of the calcium ion, since the effect of a given number of ionic charges increases with an increase in the valence of the ions. In some cases the calcium ion will form an insoluble compound with the emulsifying agent. If the compound formed is oil soluble and present in the correct proportions, complete demulsification may occur.

(2) It serves as a heat transfer medium.

(3) It will remove sulfides present.

(4) It is economical to use.

Oil sample 1 shows decreasing BS&W content at a given pressure as time of treatment increases. (Fig. 5). At 15 lbs. per sq. in. pressure the BS&W content seems to be constant after 120 minutes. At 30 lbs. per sq. in. pressure, the curve

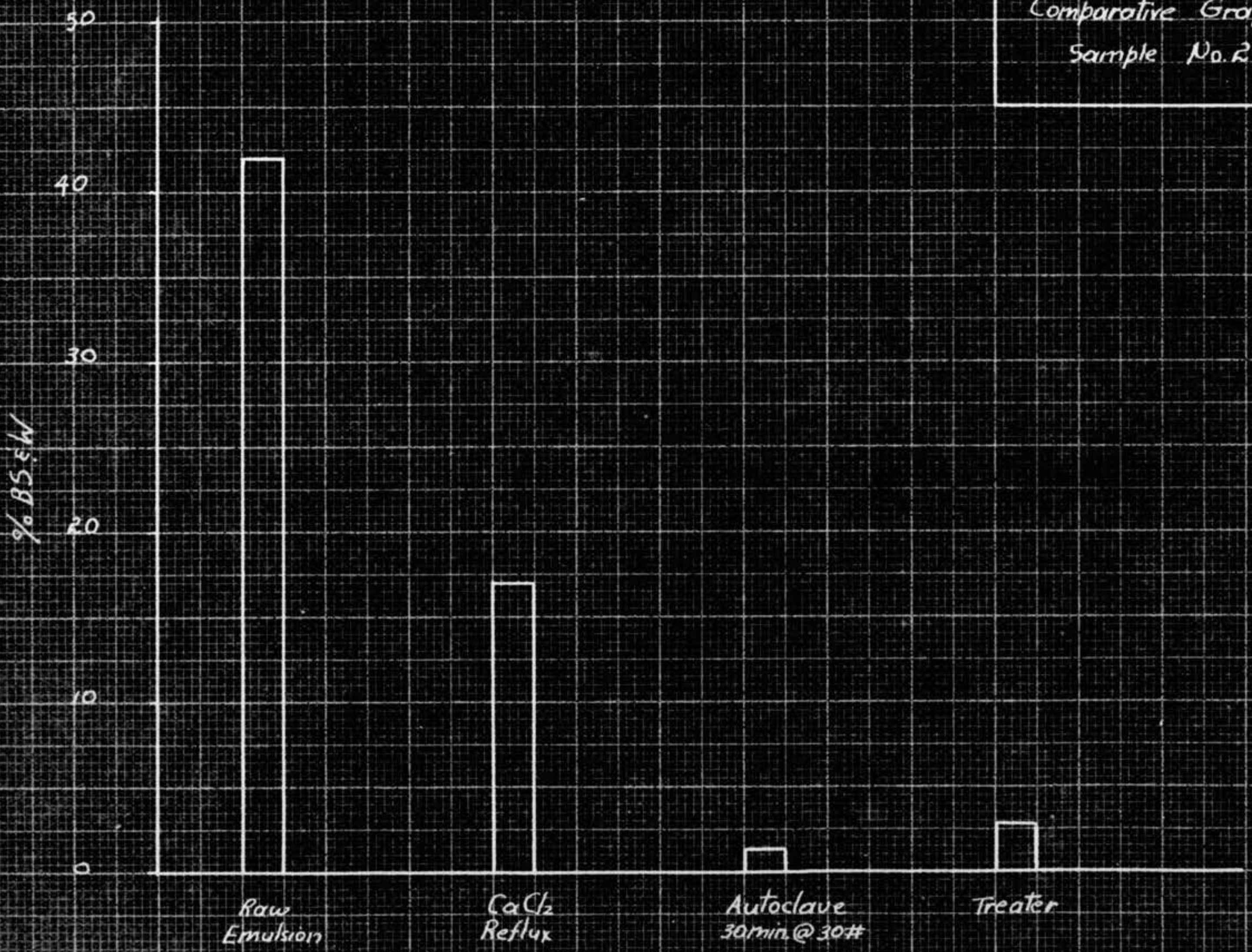


Fig. 9
Comparative Graph
Sample No. 2

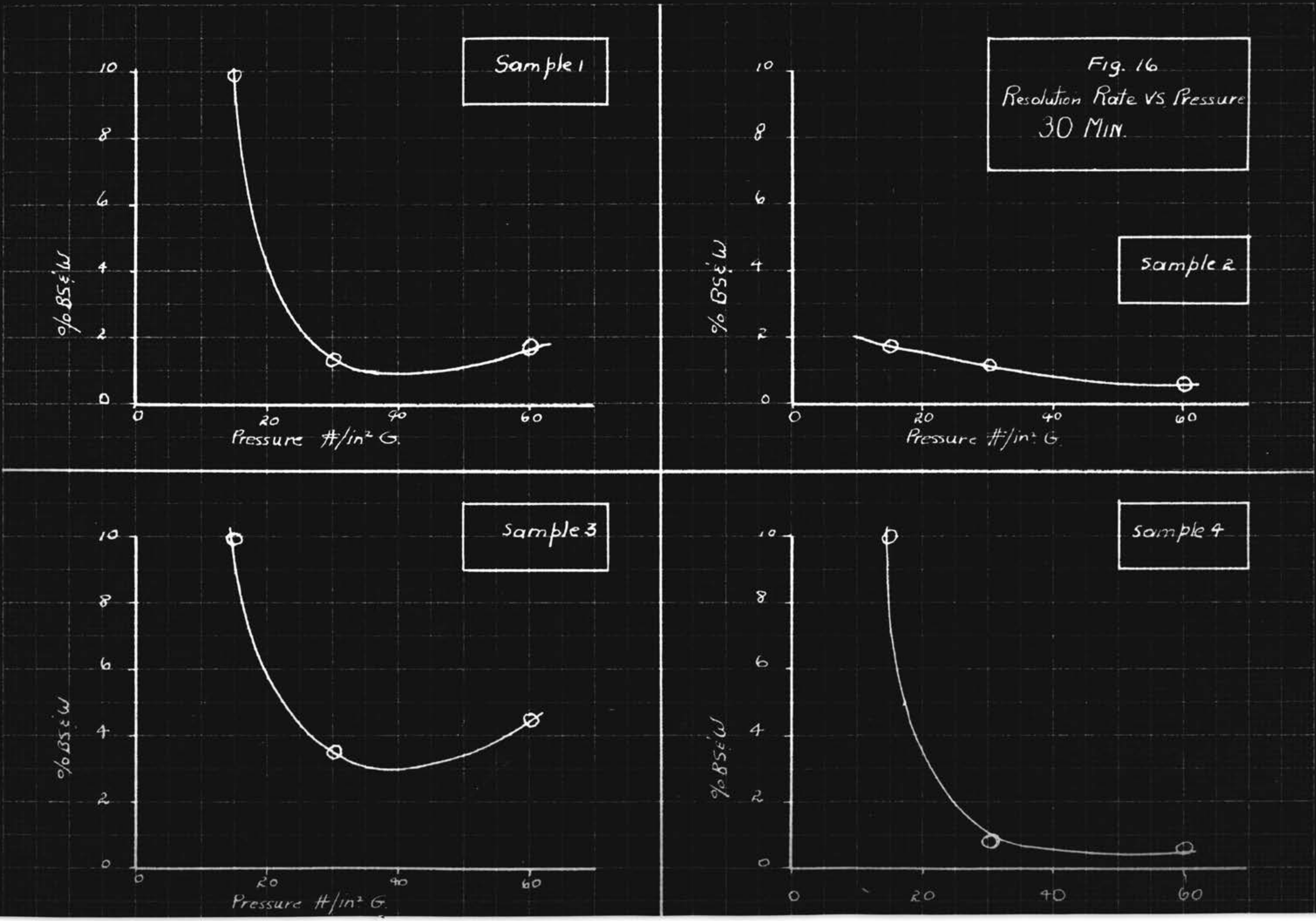


Fig. 16
Resolution Rate VS Pressure
30 MIN.

Fig. 20a
Photomicrograph of Sample 2, raw emulsion
120 magnifications

is substantially flat after 30 minutes since the BS&W percentages vary only a fraction of a percent. At 60 lbs. per sq. in. pressure, the percentage BS&W drops steeply until at 60 minutes all of the emulsion is broken.

At constant time, the BS&W percentage drops rapidly with increase in pressure. Fig. 16 shows 10% BS&W after 30 minutes at 15 lbs. per sq. in. pressure. The same sample shows about 1.4% BS&W after 30 minutes at 30 lbs. per sq. in. pressure. The slight increase shown at 60 lbs. per sq. in. pressure is evidently experimental error since at 60 minutes and 120 minutes the curves show a decrease in BS&W content to zero.

The top layer of sample 1 in the receiver tank showed essentially no change in composition during settling. The percent BS&W in the third layer was constant at 20% while the fourth layer changed from 75% to 22% over the 60 minutes interval. This great change in BS&W content indicates the shifting of the boundry layer between the water and emulsion from above opening No. 4 to below it.

Sample 2 is composed entirely of western Kansas tank bottoms. It is a heavy black emulsion containing approximately 42% BS&W and is extremely viscous at room temperatures. It has only a slight odor of sulfide. The photomicrograph of the raw emulsion (Fig. 20a) shows the water present as the internal phase of the emulsion. Some of the water is in the form of fine globules, and some is present as large splotches. The splotches are the result of the spreading of relatively large droplets of water when the cover glass was placed upon the

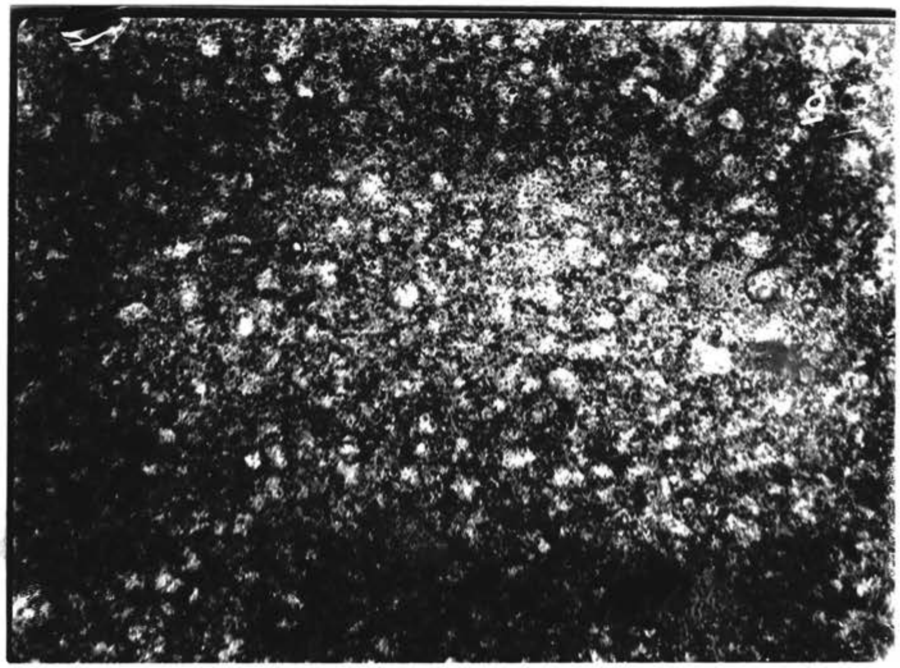


Fig. 20b
Photomicrograph of Sample 2 after 30 minutes
at 30 lbs per in^2. pressure.
120 magnifications

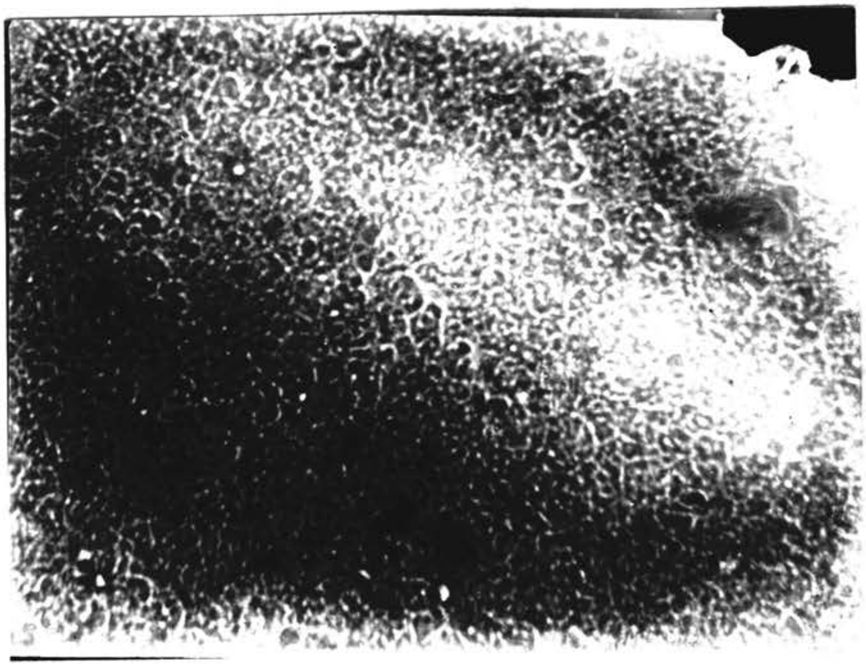


Fig. 20c
Photomicrograph of Sample 2 after reaction in the treater, 30 minutes at 30 lbs per in^2. pressure.
120 magnifications

slide. The sizes of these areas change when the cover glass is moved. Fig. 20b shows the emulsion after treatment in the autoclave. (30 minutes at 30 lbs. per sq. in. pressure.) The water content is 1.2%, and the emulsion appears to contain particles of amorphous material, probably wax and asphalt. Fig. 20c shows the emulsion after treatment in the treater. The appearance of the emulsion is similar to that of Sample 1 in that it is fine-grained and tightly held. The BS&W content is less, being 2.6%.

The pressure and time used in the treatment of Sample 2 in the treater is the same as was used in all samples, namely 30 minutes and 30 lbs. per sq. in. pressure. This pressure and length of treatment was chosen for the treater because it seemed to be the best compromise when the data from the autoclave tests were considered. All of the curves plotted with pressure vs. percent BS&W for a given time show that essentially as much destabilization took place at 30 lbs. per sq. in. pressure as at 60 lbs. per sq. in. pressure. But several cases such as Fig. 16 Samples 1, 3, and 4 show that treatment at 15 lbs. per sq. in. pressure lacked several percent being as efficient as at 30 lbs. per sq. in. pressure. Therefore 30 lbs. per sq. in. pressure was chosen as being the lowest pressure at which appreciable destabilization could be achieved. Fig. 5 shows that at a constant pressure of 15 lbs. per sq. in. the percentage BS&W changed as much as 5½% as time varied from 30 minutes to 60 minutes. At 30 lbs. per sq. in. pressure, however, the percentage change in BS&W content as time varied from 30 minutes to 60 minutes was appreciably less, ranging

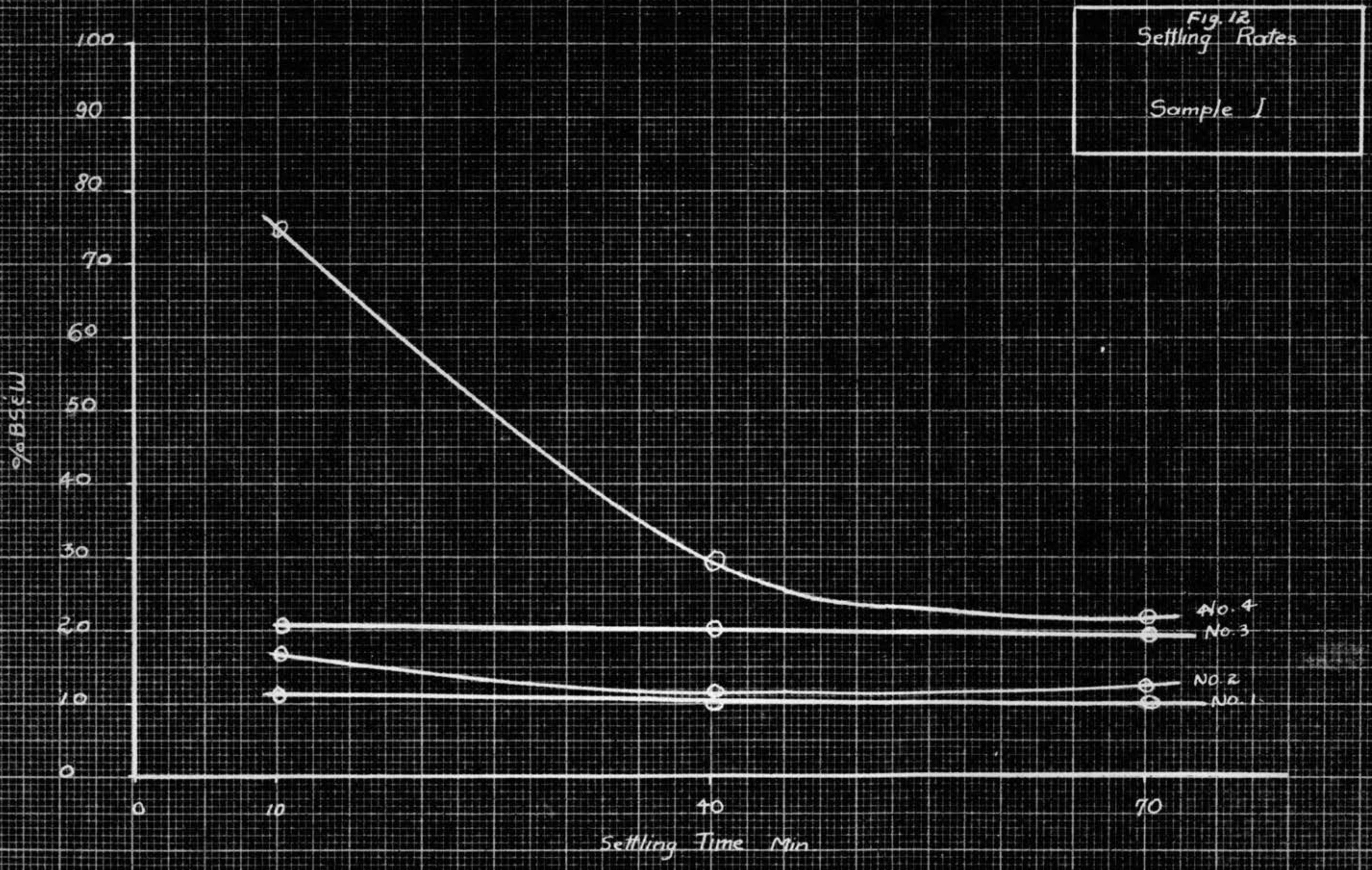


Fig. 12
Settling Rates

Sample I

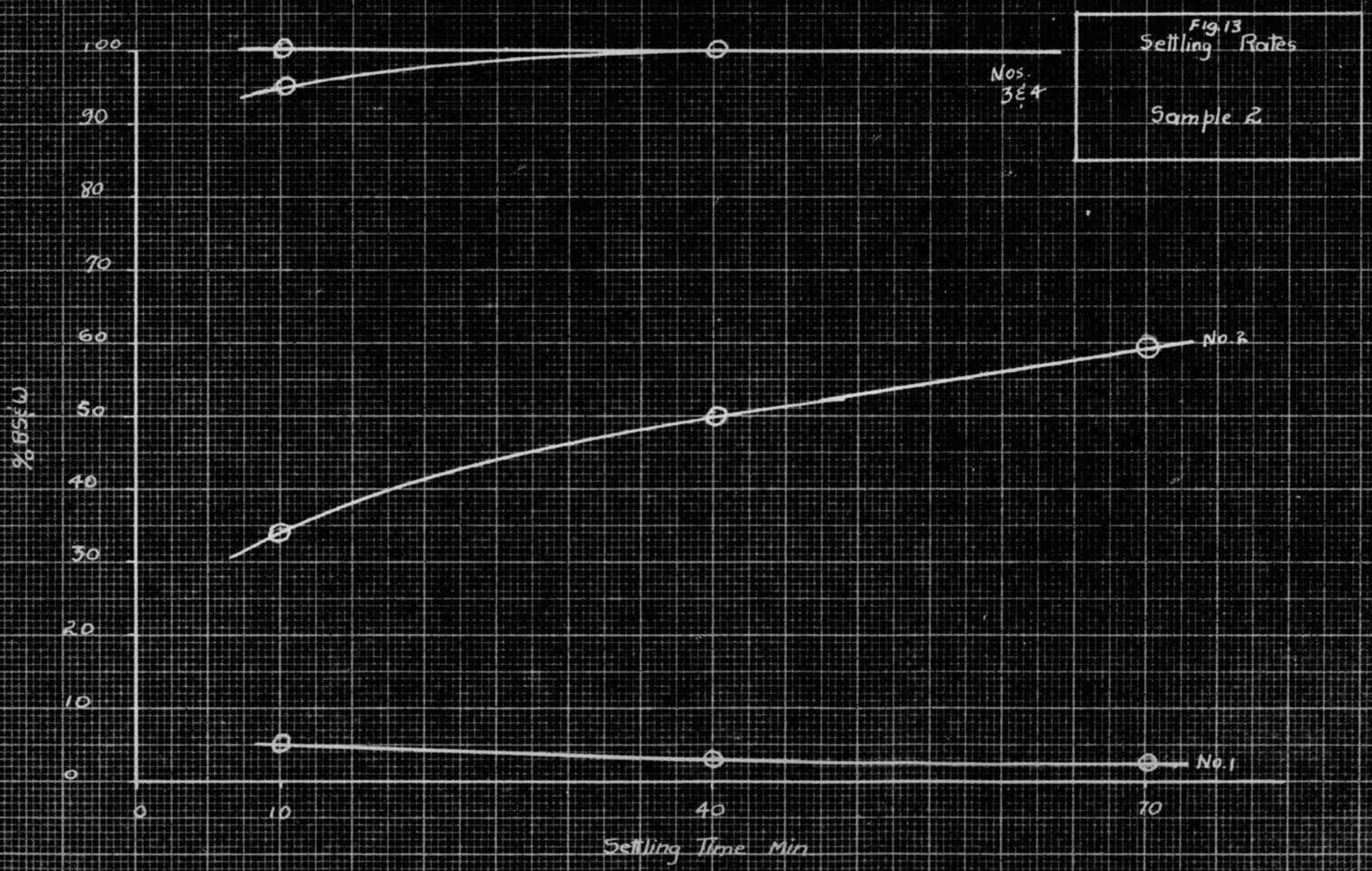


Fig. 13
Settling Rates

Sample 2

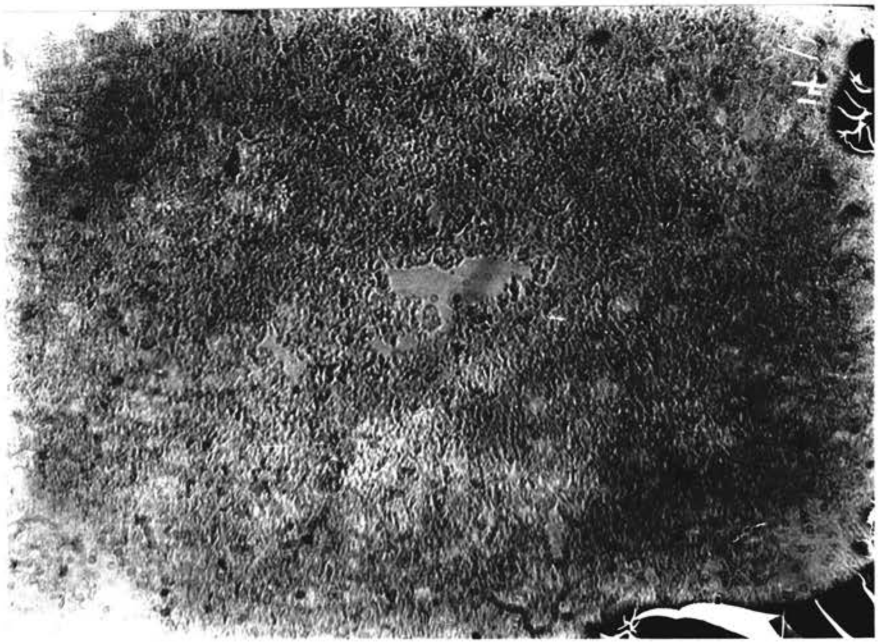


Fig. 21a
Photomicrograph of Sample 3, raw emulsion
120 magnifications

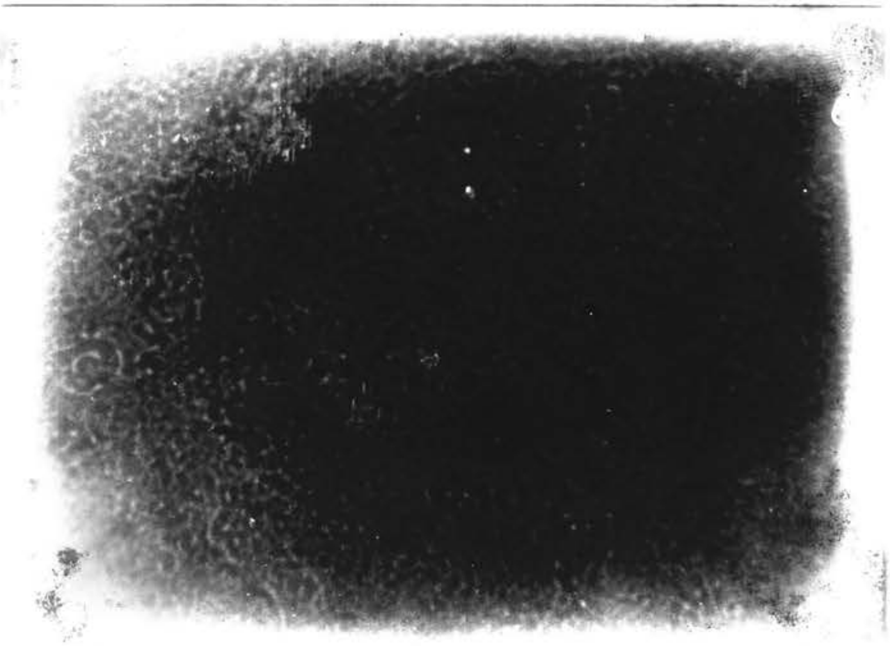


Fig. 21c
Photomicrograph of Sample 3 after reaction in the treater, 30 minutes at 30 lbs per in^2. pressure.
120 magnifications

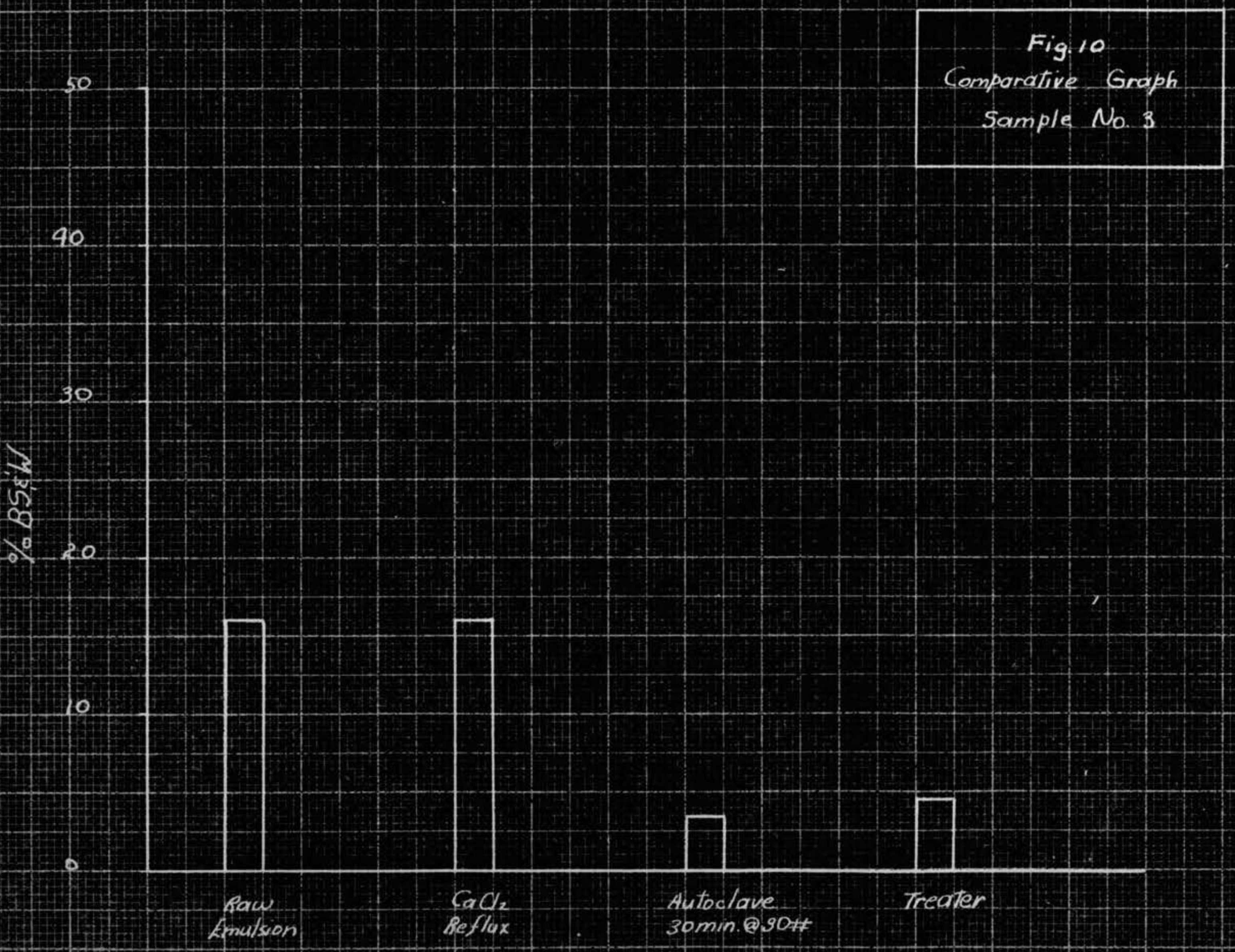


Fig. 10
Comparative Graph
Sample No. 3

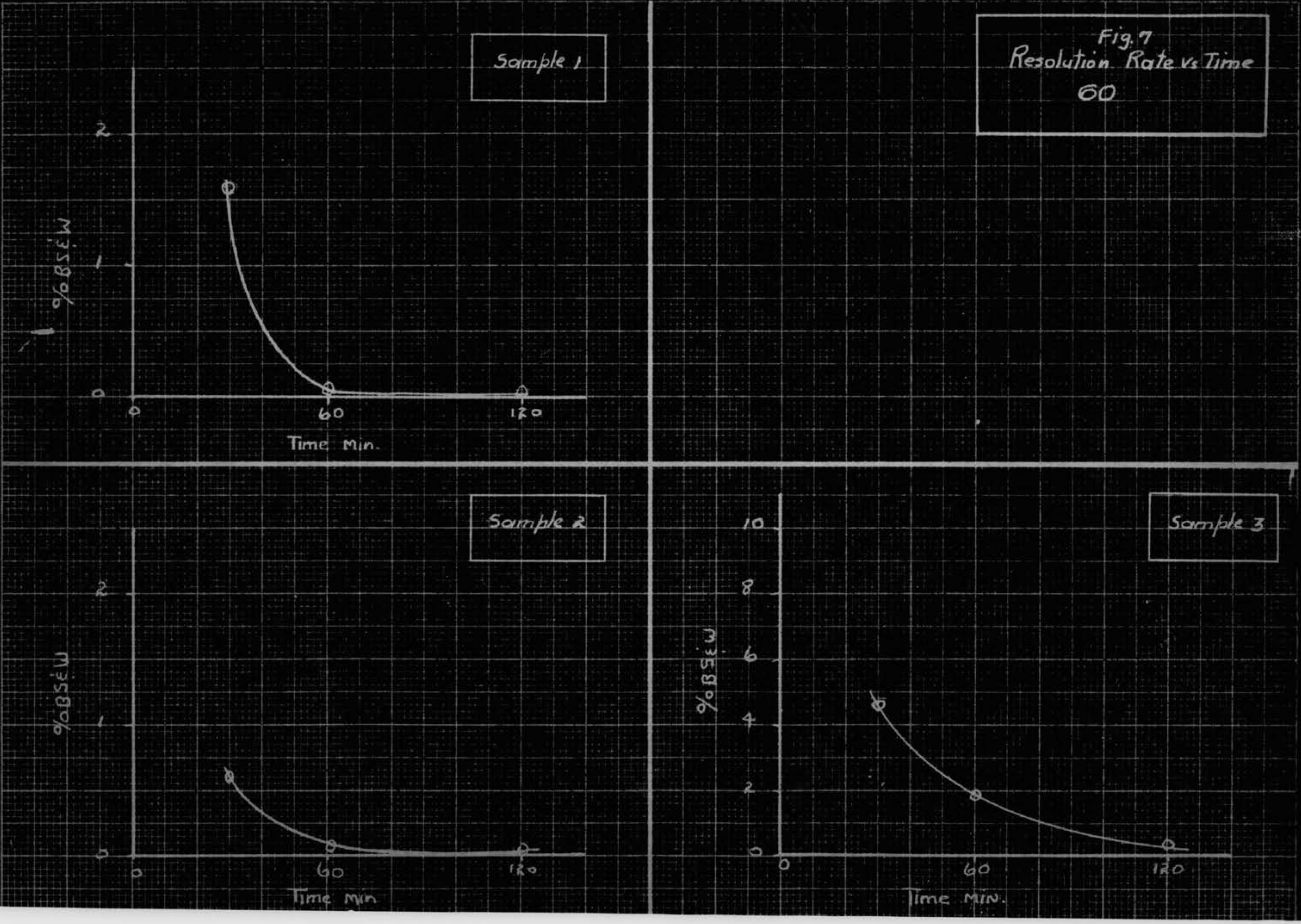


Fig. 7
Resolution Rate vs Time
60

from about 0.9% to a maximum of 2% BS&W. Thirty minutes was, therefore, chosen as the optimum time of treatment.

Fig. 9 shows that while Sample 2 had the greatest amount of water originally, it gave the best results in the treater. This is borne out in Fig. 16 which shows that Sample 2 was reduced to less than 2% in 30 minutes at 15 lbs. per sq. in. pressure, and to 0.4% in 2 hours at 15 lbs. per sq. in. pressure. Fig. 13 shows the settling rate for Sample 2. From 5% after 10 minutes, the percent BS&W at the top of the tank decreased to 2.6%.

Sample 3 is a mixture of about 60-70% Oklahoma City crude, and 30-40% Kansas crude. It is dark brown in color, flows freely at room temperature, and is free from the odor of sulfide. The raw emulsion contains 16% BS&W. Fig. 21a shows Sample 3 to be a fine-grained emulsion containing clear areas. These areas are actually a smooth light brown in color. Fig. 21b shows the emulsion after treatment in the autoclave. There are several light brown areas in the slide which are indicated in Fig. 21b by clear white spots. These areas may be composed of relatively pure wax or asphaltic material. BS&W content of this emulsion was 3.4%.

Fig. 21c shows the same general structure as Figs. 19c and 20c and seem to be characteristic of oil that goes through the treater. This oil contains 4.5% BS&W. Fig. 10 shows that no change in BS&W content of the oil occurred after refluxing with calcium chloride solution. The tightness of the emulsion is shown in Fig. 7: after 60 minutes at 60 lbs. per sq. in.

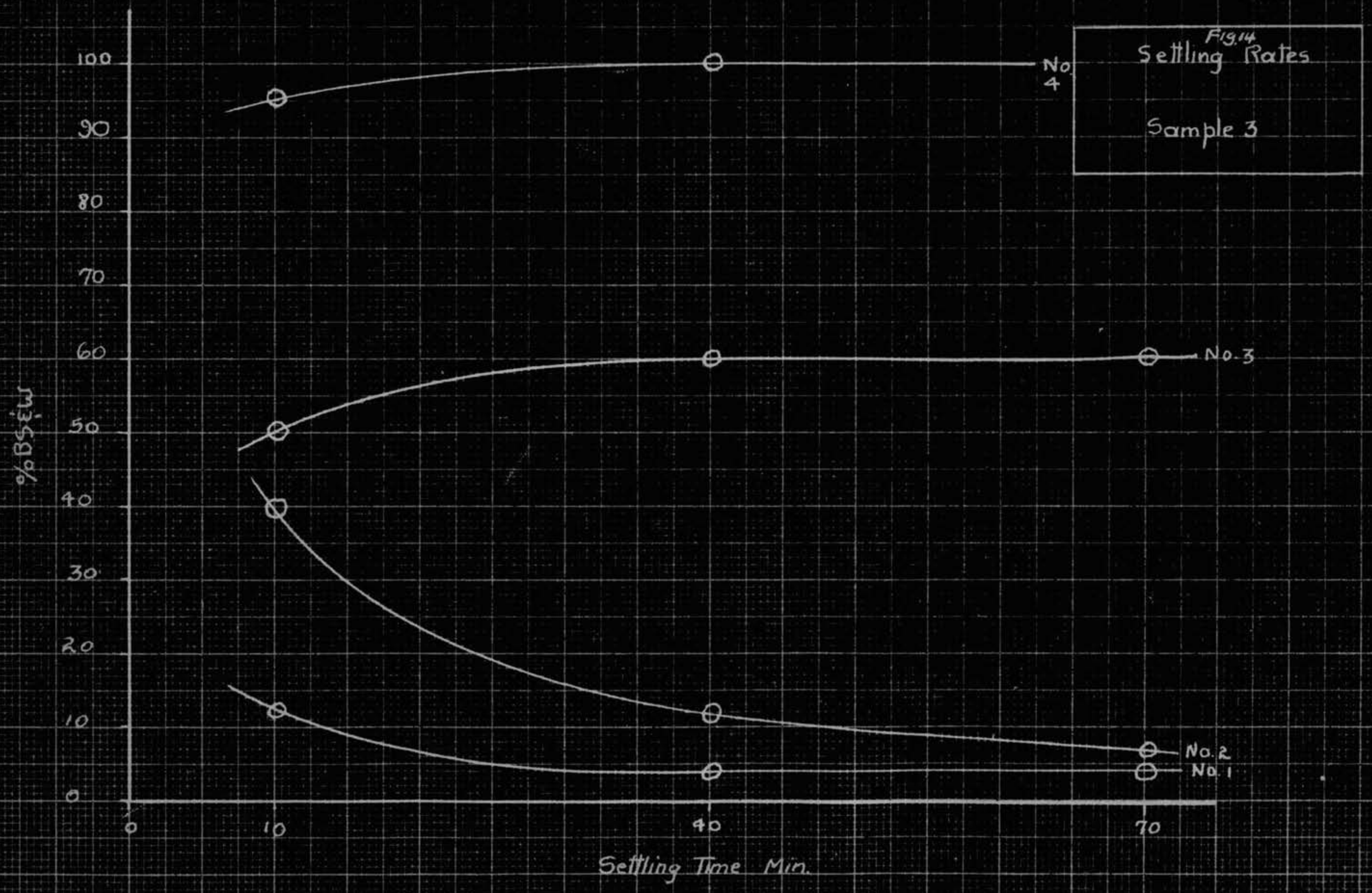


Fig. 14
Settling Rates

Sample 3

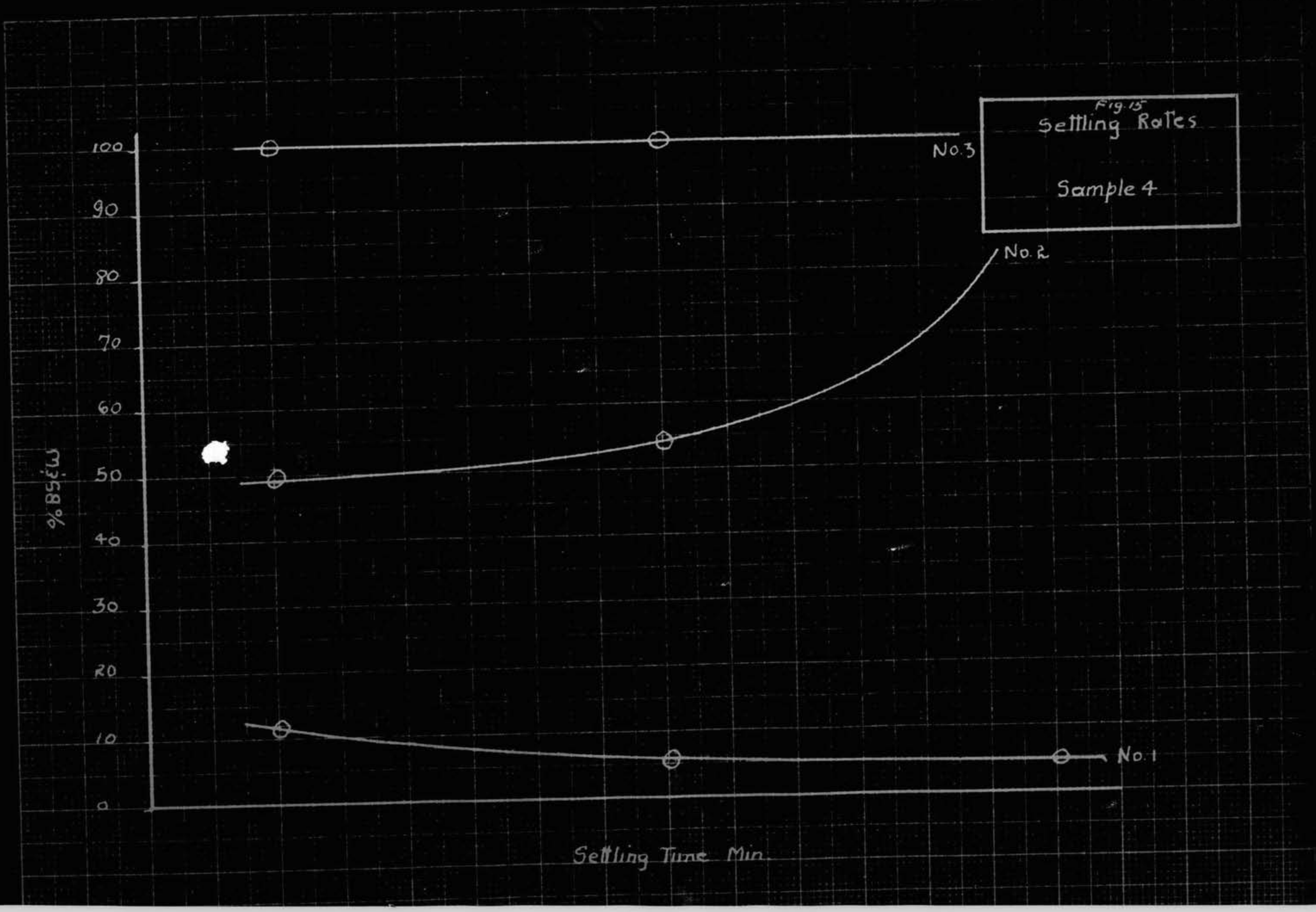


Fig. 15 Settling Rates

Sample 4

pressure, the emulsion still contained 2% BS&W, and after 120 minutes at 60 lbs. per sq. in. pressure it contained 0.4% BS&W. Fig. 14 shows that after 40 minutes essentially no further settling took place.

Sample 4 is a mixture of 35 to 65% Kansas crude, the remainder being Oklahoma City crudes. This emulsion is very similar to Sample 3 in appearance and odor, but in the raw state contains 34% water. Fig. 16 shows that Sample 4 is resolved by heat and pressure since the BS&W content dropped to less than 1% after 30 minutes at 30 lbs. per sq. in. pressure. Fig. 15 shows the settling rate of Sample 4 after going through the treater. A change from 11% BS&W in the top layer at 10 minutes to 6% at 30 minutes and 5% at 70 minutes shows that most of the settling takes place in the first 40 minutes after treatment.

Conclusions

1. When calcium chloride solution is used in the treater, chloride content of the oil may in some cases increase.
2. The small amount of water which is left in the oil after going through the treater is tightly emulsified.
3. At constant pressure, water content decreases with time.
4. For a given amount of time increasing pressure reduces the water content.

Procedure

(1) BS&W Determination.

BS&W determinations were made according to ASTM test D 96-35. The following procedure is quoted from ASTM Standards on Petroleum products, Sept. 1936.

(a) "Exactly 50 ml. of 90% benzol shall be measured into each of two centrifuge tubes and exactly 50 ml. of the oil to be tested shall be added to each. The centrifuge tubes shall be stoppered and shall be shaken vigorously until the contents are thoroughly mixed. The temperature of the bath shall be maintained at 120 degrees F. and the centrifuge tubes shall be immersed there in to the 100 ml. mark for 10 minutes.

(b) The two centrifuge tubes shall then be placed in the centrifuge on opposite sides and shall be whirled at a rate of 1400 rpm or the equivalent for 10 minutes. The combined volume of water and sediment at the bottom of each tube shall be read and recorded, estimating to 0.1 ml. if necessary. The centrifuge tubes shall then be replaced in the centrifuge, again whirled for 10 minutes, and removed for reading the volume of water and sediment as before. This operation shall be repeated until the combined volume of water and sediment in each tube remains constant for three consecutive readings. In general, not more than four whirlings will be required.

The combined total volume of water and sediment shall be read on each tube, estimating to 0.1 ml. if necessary. The sum of the two readings shall be recorded as percentage of water and sediment, centrifuge method".

(2) Autoclave test.

The Autoclave test is as follows:

Two hundred ml. of emulsion are measured into a 35 x 300 mm. test tube. The autoclave is filled with 750 cc. of water, and the tube containing emulsion is placed in it. The tube is stoppered with a cork or rubber stopper, and the top screwed on the autoclave. Bunsen burners (2) are placed under the autoclave, and the prescribed pressure built up as quickly as possible. Burner rates are then adjusted to maintain the prescribed pressure. Pressure readings are made at the beginning, middle, and end of the run. At the end of each run, the burners are removed, and the autoclave allowed to cool in the air. When pressure is zero, the autoclave top is screwed off, and the tube removed. The top 50 ml. of the sample is pipetted off, and analyzed by the standard ASTM method, (ASTM D 96-35).

(3) Viscosities

Viscosities were determined in the following manner:

Emulsion or demulsified oil is heated to 160 degrees F., and poured into the funnel viscosimeter until the oil level is slightly above the top mark. Previously, a 0 to 300 degree F. thermometer is inserted so that the tip of the bulb is level with the lower mark in the viscosimeter. The water bath surrounding the funnel is maintained at 160 degrees F. After the funnel has been filled and the temperature of the oil is exactly 160 degrees F., the stopper in the funnel is quickly removed, and the time for the oil to pass from the top mark to the tip of the thermometer is measured with a stopwatch.

Time should check to 0.2 sec.

(4) Calcium chloride test

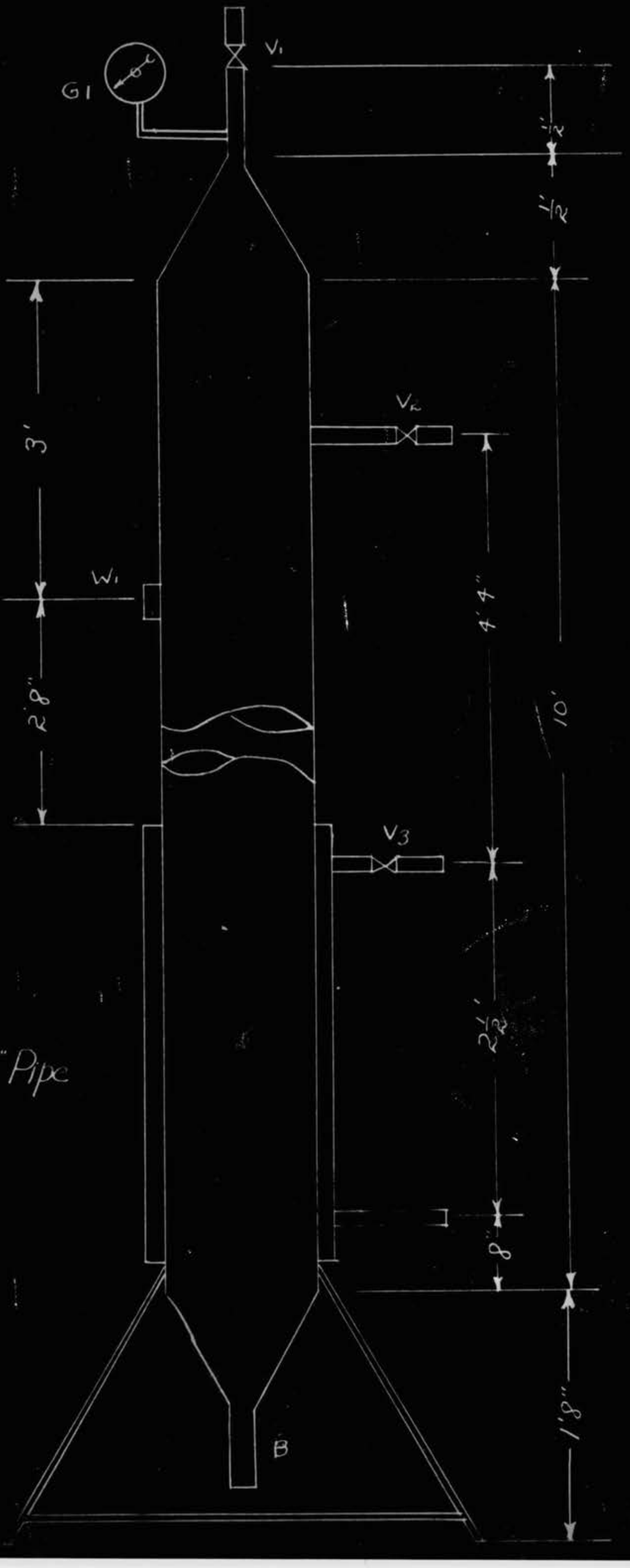
One hundred ml. of 1.0 calcium chloride solution and 100 ml. of emulsion are poured into a 500 ml. Ehrlenmeyer flask and slowly heated. The temperature is taken when the calcium chloride solution first begins to boil. The mixture is then boiled for 15 minutes. As soon as the mixture ceases boiling, the mixture is poured into a 35 x 300 mm. test tube and allowed to stand for 15 minutes at room temperature. At the end of this time, the top 50 ml. are carefully pipetted off and analyzed for BS&W by the standard ASTM method. (ASTM D 96-35).

(5) Procedure for running semi-continuous treater

The treater is filled to W1 (Fig. 1) with 1.0 N. calcium chloride solution. The injection tank is then filled with approximately 5 gallons of emulsion. The pressure in the treater is maintained by admitting steam to the jacket on the treater. When the pressure on the treater has reached the prescribed amount, the air pressure on the injection tank is raised to 15 to 50 lbs. per sq. in. pressure greater than the treater pressure. (Pressure drop is dependent upon the viscosity of the oil.) The valve VI (Fig. 1) is then opened to admit emulsion from the injection tank to enter the treater. Readings of injection pressure, injection temperature, treater temperature, and treater pressure are made every 5 minutes until the run is completed. The valve V2 is tested periodically during the run to determine when the oil level reaches the discharge level. When the oil in the treater reaches the discharge level, it is bled off as nearly as possible at the rate at which it being fed into the treater. As soon as the receiver tank is full, V2 is closed, and the steam shut off from the treater. Oil samples are withdrawn from the receiver tank at the end of 10 minutes, 40 minutes and 70 minutes after the completion of the run. These samples are analyzed by the standard ASTM method. (ASTM D 96-35).

Fig. 1

Emulsion Treater



Mat. Treater: 8" Pipe

Mat. Steam Jacket: 10" Pipe

Fig. 1a

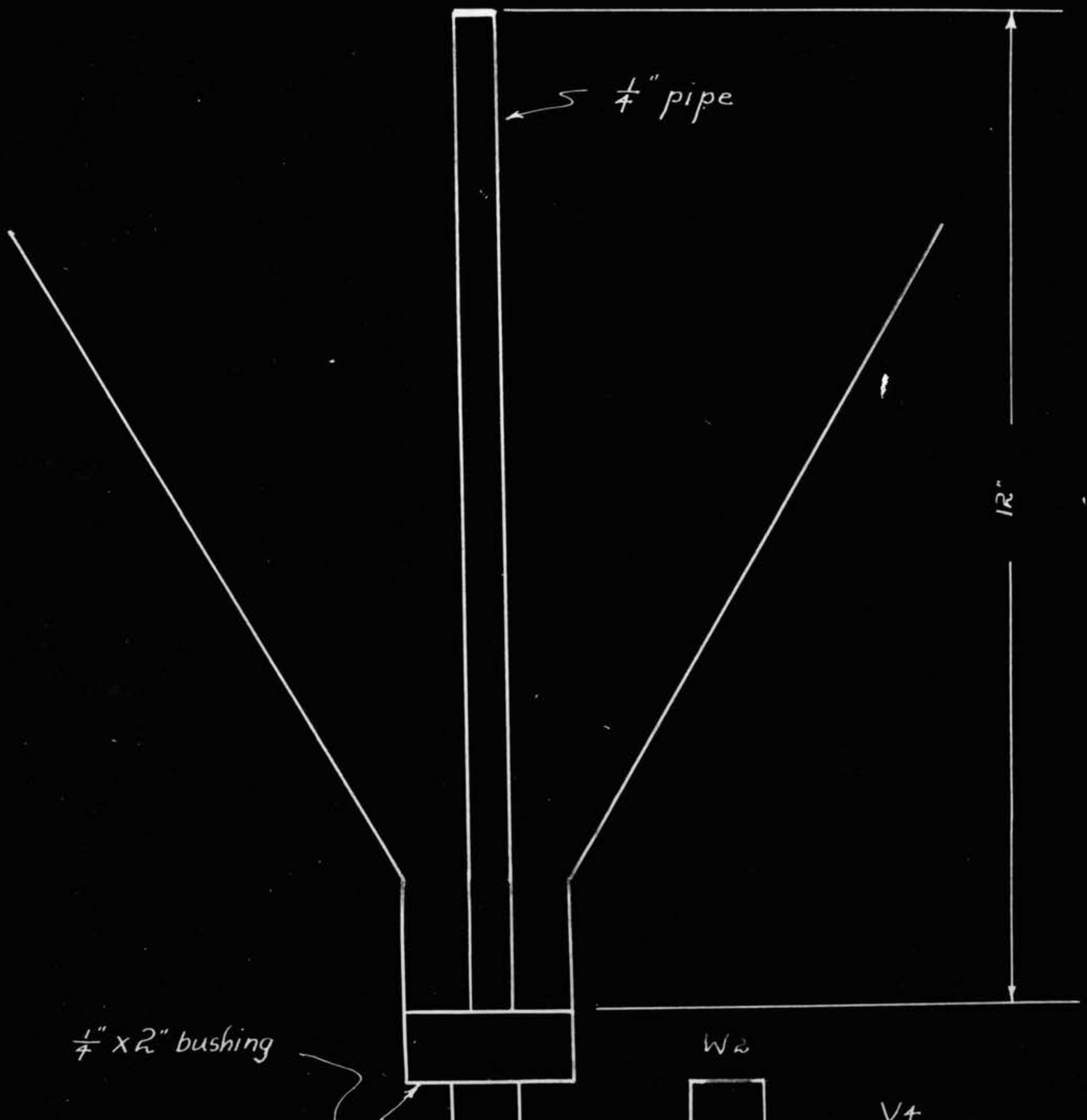
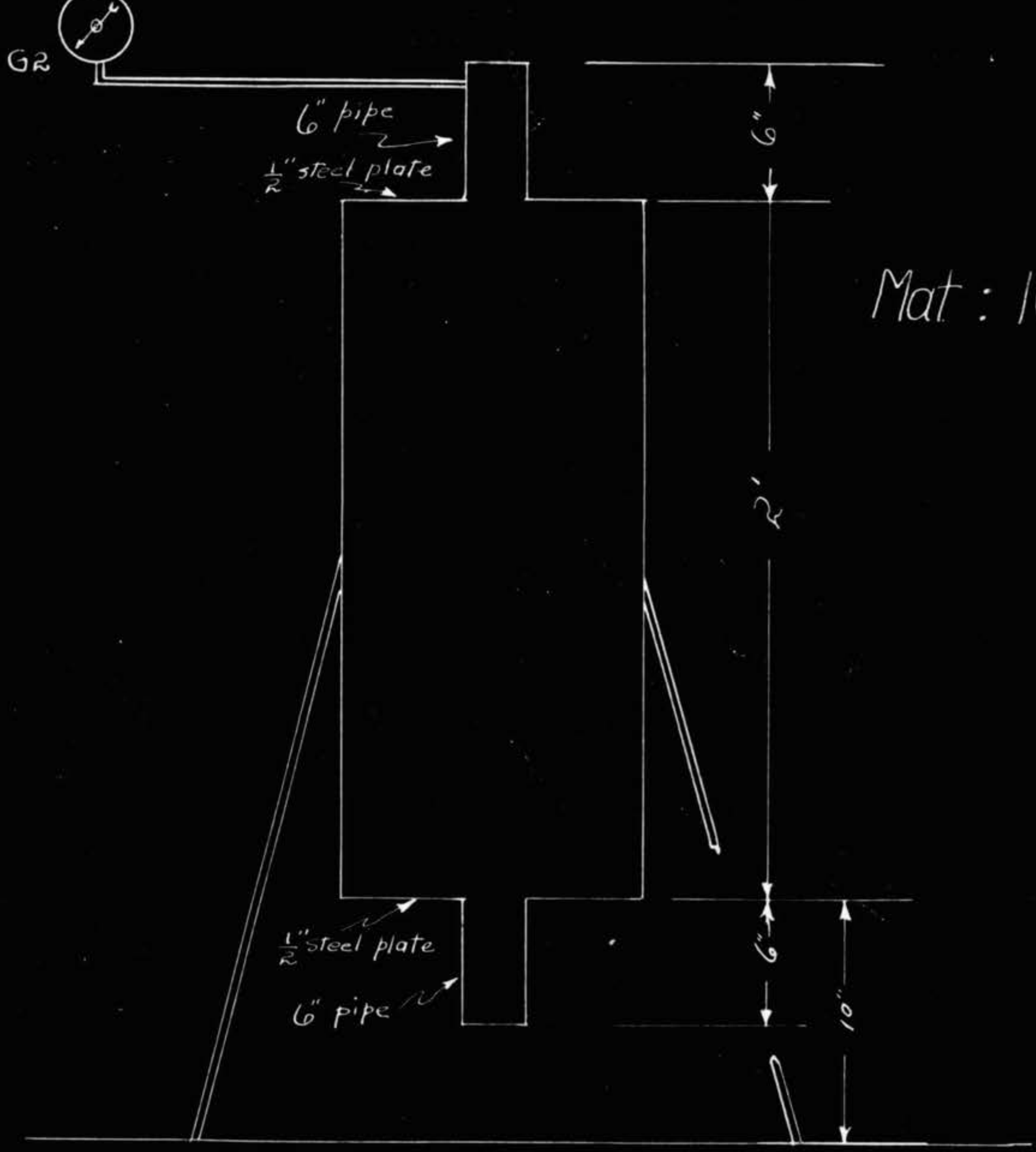


Fig 2

Injection Tank



Mat : 10" Pipe

Description of Apparatus

1. Emulsion Treater.

The emulsion treater is depicted in Fig. 1. The inner section is made up of ten feet of 8 inch pipe. The steam jacket is made up of approximately 3 feet of 10 inch pipe welded to the inner section. All inlets to the inner section of the treater are 1 inch by 6 inch steel nipples welded to the inner section except B which is a 2 inch steel coupling. G1 is a 0 to 60 lbs. per sq. in. pressure gauge for measuring treater pressure. Fig. 1a is a detailed drawing showing how the emulsion is brought into the treater. V4 is a 3/4 inch gate valve for controlling the oil inlet. W2 is a thermometer well for measuring inlet oil temperatures. The oil enters the treater from a ¼ inch by 12 inch nipple which extends into the calcium chloride solution. The treater is supported by a 3/4 inch steel rod frame work welded to the bottom of the inner section. (Fig. 1). A is the steam condensate outlet.

2. Injection Tank

The injection tank is made up of 2 feet of 10 inch pipe with ½ inch steel plates welded to each end. The tank holds approximately 8 gallons of oil. Two 1 inch by 6 inch nipples are welded to the top and bottom of the tank. Gauge G2 measures the injection pressure. The bottom of the tank is connected by a 3/4 inch pipe to the bottom assembly of the treater. The injection tank is supported by 3/4 inch steel legs which are welded to the sides.

Fig. 3

AUTOCLAVE

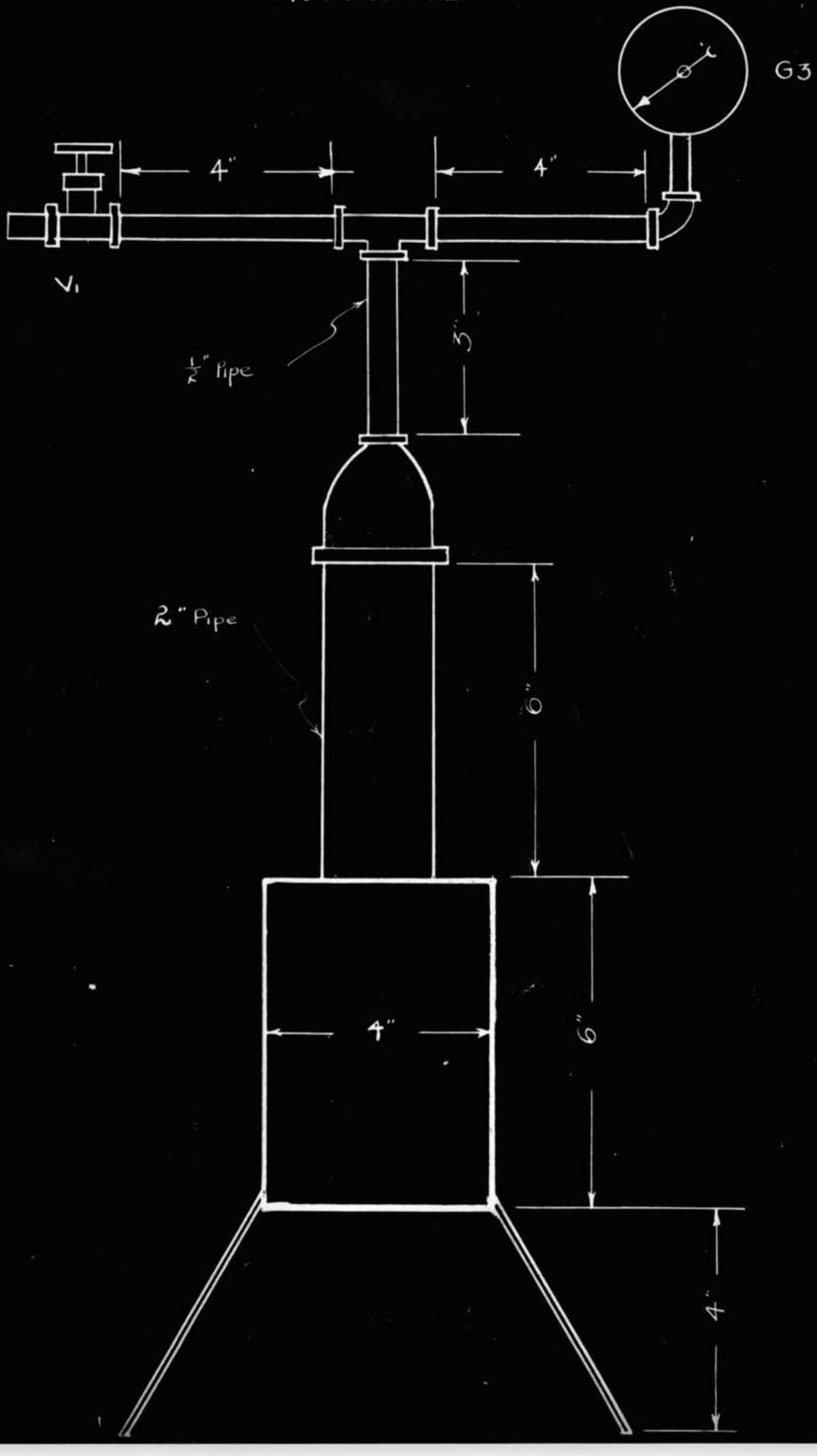
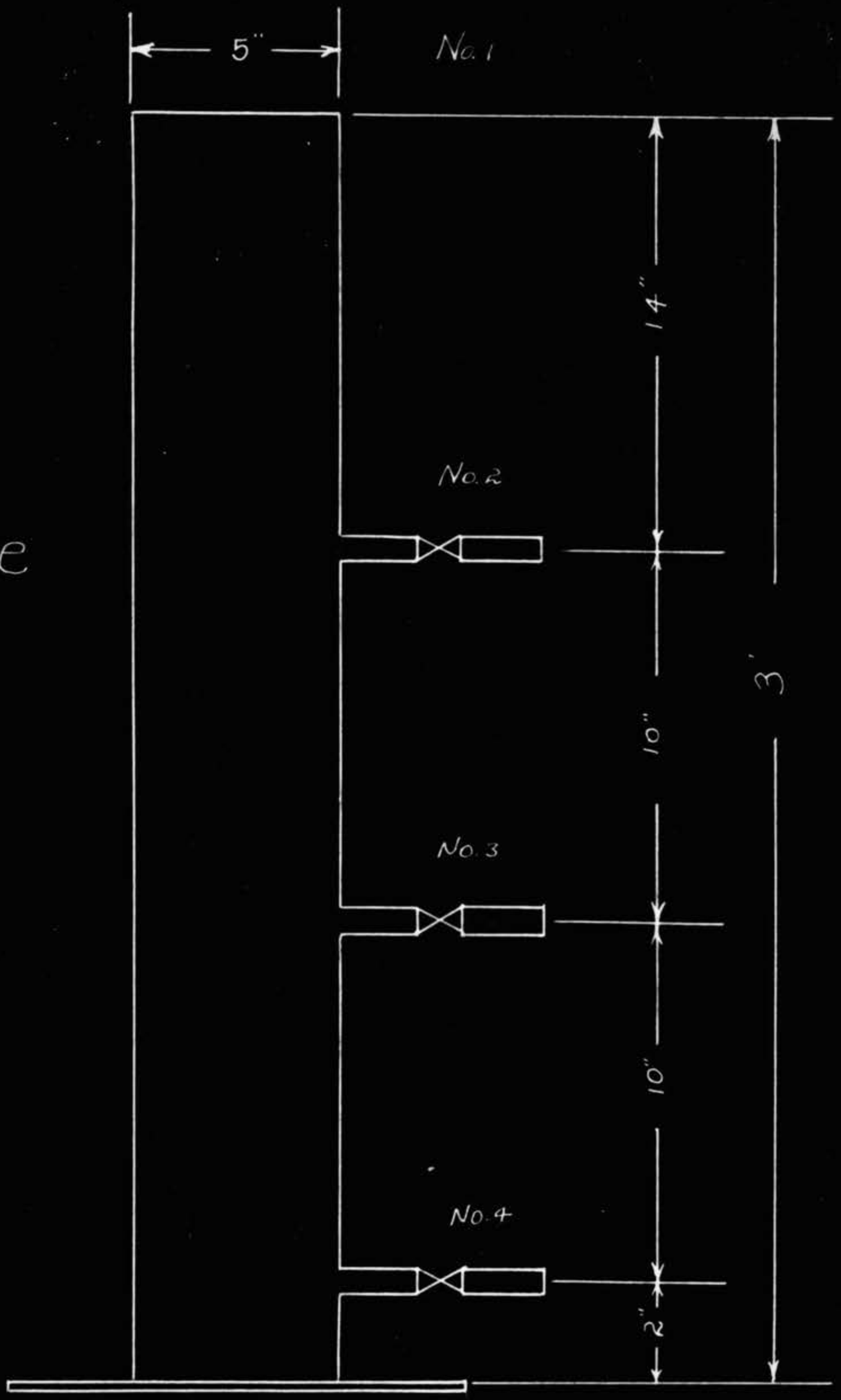


Fig. 4

Receiver Tank



Material: 5" Pipe

3. Receiver Tank.

The receiver tank is made up of 3 feet of 5 inch pipe into which 3 3/4 inch by 6 inch nipples are welded at various heights. (Fig. 4). Opening No. 1 is the open top of the receiver tank, while No. 2, 3, and 4 are 3/4 inch gate valves.

4. Autoclave.

The autoclave is made up of 6 inches of 4 inch pipe closed at the ends by 1/2 inch steel plate. Welded to the top plate is a 2 inch x 6 inch nipple. The pressure relief valve V1 and pressure gauge G3 are connected through ½ inch fittings to a ½ inch by 2 inch reducer which screws off the top of the 2 inch by 6 inch nipple.

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APPENDIX

Sample Calculations

Sample 1. 10 ml. aliquot taken from 50 ml. water.
25 ml. oil
AgNO3=0.0982N. Initial burette reading = 0.60nl.
Final burette reading = 9.00nl.
8.40nl
ml. required for blank = 0.13

Net. AgNO3 solution used = 8.40 0.13=8.27 ml.

From tables 8.27 ml.AgNO3 =678 lbs. chloride per 1000 bbls. oil when N=0.10 and 50 ml. water is taken.

Therefore, lbs chloride per 1000 bbls. oil

$$= \frac{50}{10} x \frac{0.0982}{0.10} x 678 = 3320 \text{ lbs. chloride per 1000 bbls. oil.}$$

Experimental Data

Sample 1.

Autoclave Run No.	Time	Pressure	BS&W	Viscosities
1	30 min	18 lbs/in^2.	10%	4.2 sec.
		16.5 "		
		17 "		
2	30 min	30 "	1%	3.9 sec.
		25 "		
		30 "		
3	30 min	60 "	1.6%	3.8 sec.
		59 "		
		60 "		
4	1 hr.	15 "	4.4%	3.7 sec.
		10 "		
		18 "		
5	1 hr.	30 "	1.5%	4.0 sec.
		29 "		
		31 "		
6	1 hr.	60 "	0%	3.7 sec.
		60 "		
		61 "		
7	2 hr.	15 "	3.4%	4.0 sec.
		15 "		
		18 "		
8	2 hr.	30 "	0.7%	4.0 sec.
		30 "		
		30 "		
9	2 hr.	60 "	0%	
		55 "		
		65 "		

Experimental Data

Sample 2.

Autoclave Run No.	Time	Pressure	BS&W	Viscosities
1	30 min	15 lbs/in.^{2}	1.6%	4.6 sec.
		15 "		
		17 "		
2	30 min	31 "	1.2%	5.2 sec.
		32 "		
		32 "		
3	30 min	60 "	0.6%	4.5 sec.
		60 "		
		60 "		
4	1 hr.	15 "	1.6%	4.4 sec.
		15 "		
		13 "		
5	1 hr.	29 "	0.4%	4.5 sec.
		32 "		
		30 "		
6	1 hr.	60 "	0%	4.2 sec.
		60 "		
		60 "		
7	2 hr.	15 "	0.7%	4.6 sec.
		14 "		
		17 "		
8	2 hr.	30 "	0.5%	
		29 "		
		30 "		
9	2 hr.	60 "	0%	
		60 "		
		60 "		

Experimental Data

Sample 3.

Autoclave Run No.	Time	Pressure	BS&W	Viscosities
1	30	15 lbs/in^2.	10%	3.9 sec.
		15 "		
		15 "		
2	30	30 "	3.4%	4.1 sec.
		30 "		
		31 "		
3	30	58 "	4.7%	
		58 "		
		59 "		
4	1 hr.	15 "	11%	
		15 "		
		14 "		
5	1 hr.	30 "	1.4%	
		30 "		
		32 "		
6	1 hr.	60 "	1.8%	
		60 "		
		60 "		
7	2 hr.	15 "	0.4%	
		14 "		
		14 "		
8	2 hr.	29 "	0.4%	
		29 "		
		30 "		
9	2 hr.	59 "	0.4%	
		59 "		
		61 "		

Experimental Data

Sample 4.

Autoclave Run No.	Time	Pressure	BS&W	Viscosity
1	30 min.	15 lbs/in^2.	10.0%	
		15 "		
		15 "		
2	30 min.	30 "	0.8%	
		30 "		
		25 "		
3	30 min.	60 "	0.6%	
		60 "		
		60 "		

Experimental Data

Treater Run No. 1 (Sample 1)

Time	Temp oil in, Degrees F	Injection Pressure lbs/in^2	Treater Pressure lbs/in^2	Treater Temperature Degrees F.
8:45	108	50	35	278
8:50	95	45	31	269
8:55	90	55	35	278
9:00	90	63	35	281
9:05	88	50	35	283
9:10	88	70	40	285
9:15	170	60	42	286
9:20	182	65	45	278

		BS&W %	Temp. when taken
10 minutes:	No. 1	11	around 180°F.
	No. 2	17	"
	No. 3	20	"
	No. 4	75	"
40 min	No. 1	12	160
	No. 2	12	138
	No. 3	21	144
	No. 4	30	134
70 min	No. 1	11	140
	No. 2	12	137
	No. 3	19	138
	No. 4	22	133

Experimental Data

Treater Run No. 2 (Sample 2)

Time	Temp oil in Degrees F	Injection Pressure lbs/in^2	Treater Pressure lbs/in^2	Treater Temperature Degrees F.
8:35	120	61	32	268
8:40	137	60	31	275
8:45	157	56	37	282
8:50	148	56	38	280
8:55	166	58	36	287
9:00	180	63	38	283
9:05	164	87	29	276
9:10	172	95	27	273
9:15	163	88	24	269

		BS&W %	Temp. when Taken Degrees F
10 min:	No. 1	5	196
	No. 2	34	152
	No. 3	95	158
	No. 4	100	134
40 min:	No. 1	2.8	177
	No. 2	50	167
	No. 3	100 (water)	164
	No. 4	100 (water)	-
70 min:	No. 1	2.6	169
	No. 2	60	158
	No. 3	100 (water)	155
	No. 4	100 (water)	

Experimental Data

Treater Run No. 3 (Sample 3)

Time	Temp oil in Degrees F.	Injection Pressure lbs/in^2	Treater Pressure lbs/in^2	Treater temp. degrees F.
11:00	101	50	34	284
11:05	101	50	35	283
11:10	104	55	34	283
11:15	163	65	37	283
11:20	145	71	36	283
11:25	132	67	39	290
11:30	126	63	36	284
11:35	122	60	38	287

		BS&W %	Temp. when taken, degrees F.
10 min:	No. 1	12	162
	No. 2	40	162
	No. 3	50	132
	No. 4	95	130
40 min:	No. 1	4	142
	No. 2	12	141
	No. 3	60	140
	No. 4	100(water)	122
70 min:	No. 1	4.5	120
	No. 2	5.6	138
	No. 3	60	140
	No. 4	100(water)	141

Experimental Data

Treater Run No. 4 (Sample 4)

Time	Temp oil in Degrees F.	Injection Pressure lbs/in^2	Treater Pressure lbs/in^2	Treater temp. degrees F.
10:50	168	58	32	280
10:55	150	62	35	285
11:00	158	60	33	282
11:05	164	95	31	278
11:10	168	95	32	280
11:15	170	95	30	278
11:25	172	95	36	288

		BS&W %	Temp. when taken degrees F.
10 min:	No. 1	5	182
	No. 2	50	173
	No. 3	100	-
	No. 4	100	-
40 min:	No. 1	5.2	166
	No. 2	54	160
	No. 3	100 water	-
	No. 4	100 "	-
70 min:	No. 1	11	144
	No. 2	10	140
	No. 3	100 water	-
	No. 4	100 "	-

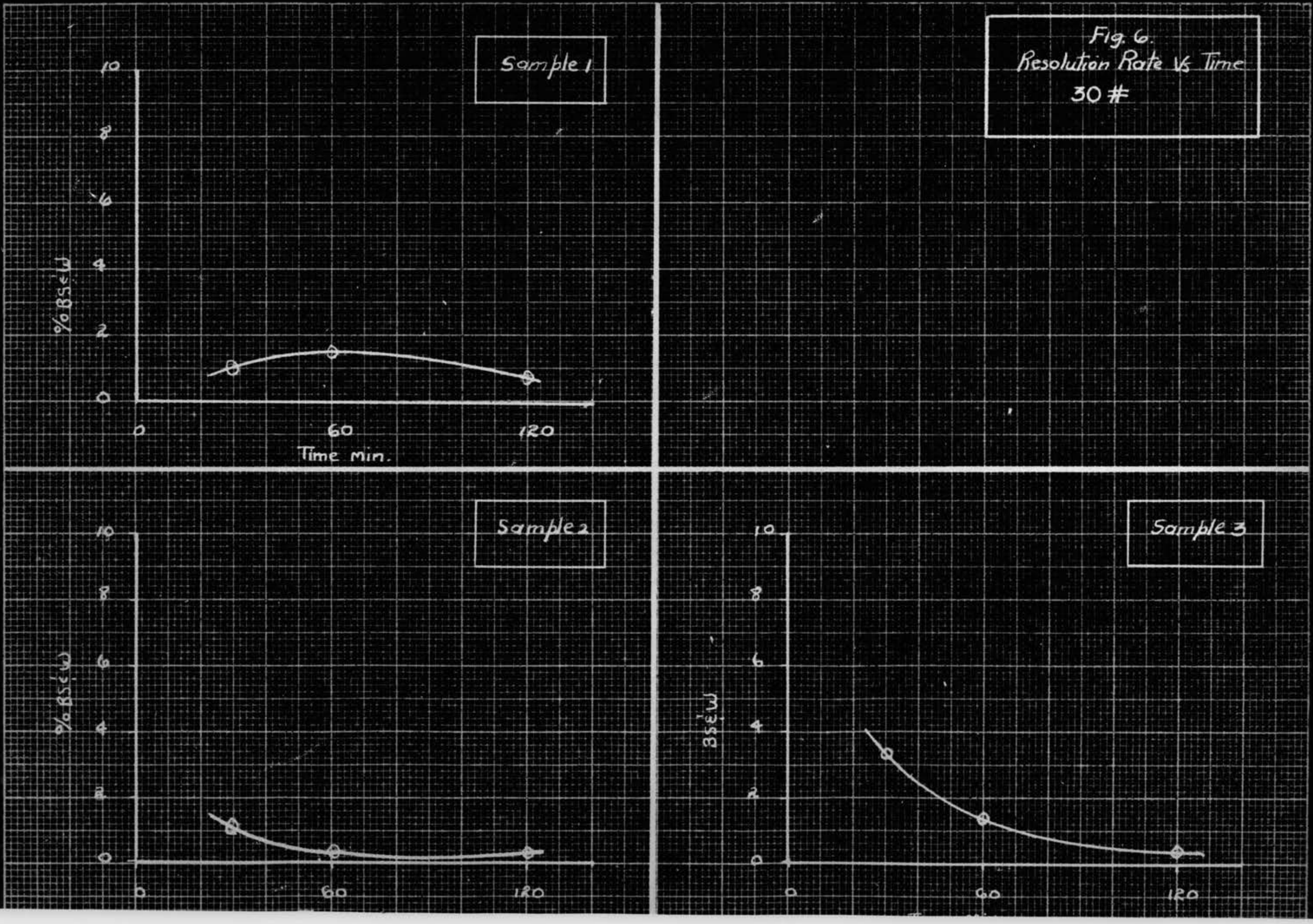

Fig. 6.
Resolution Rate Vs Time
30 #

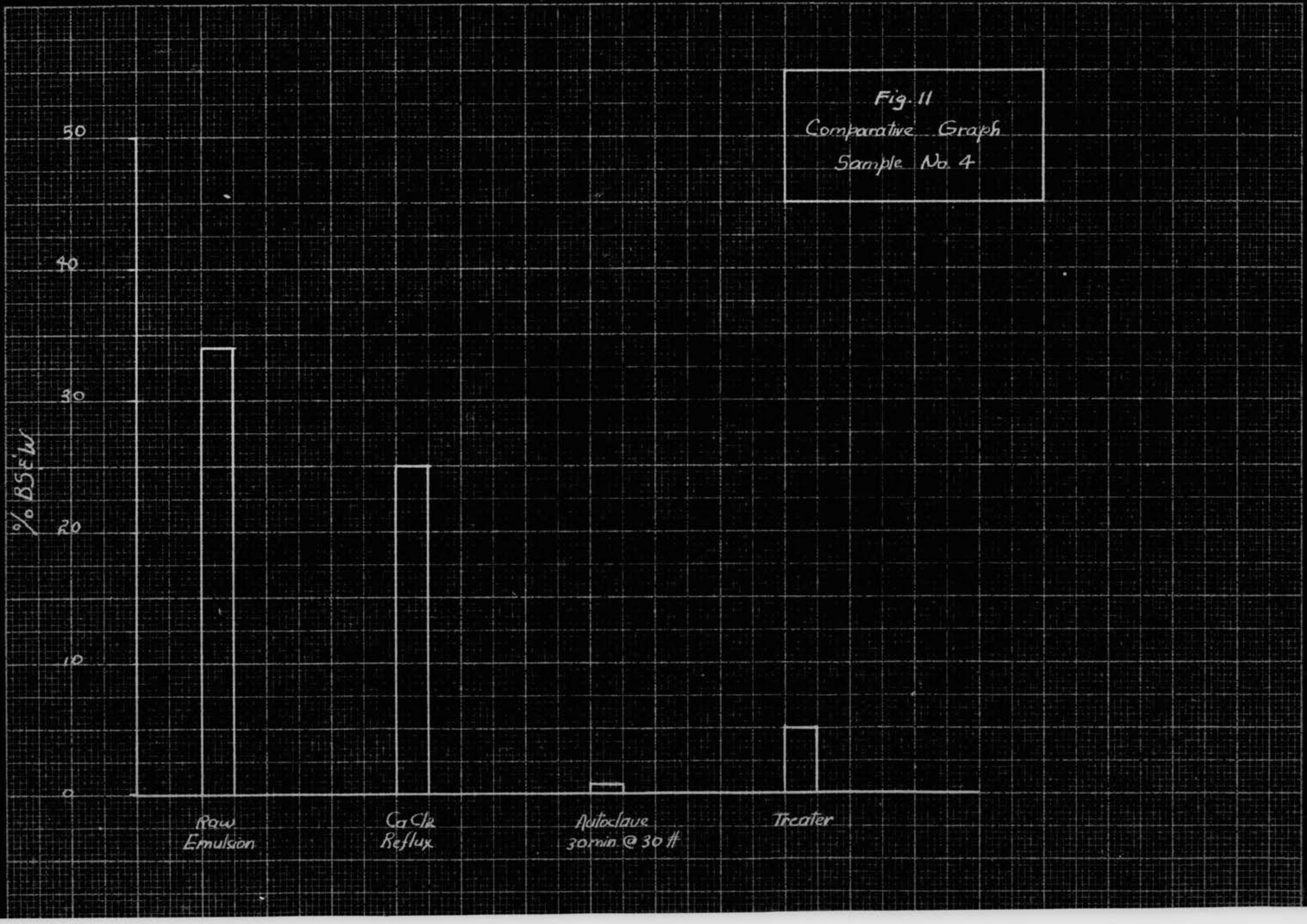

Fig. 11
Comparative Graph
Sample No. 4

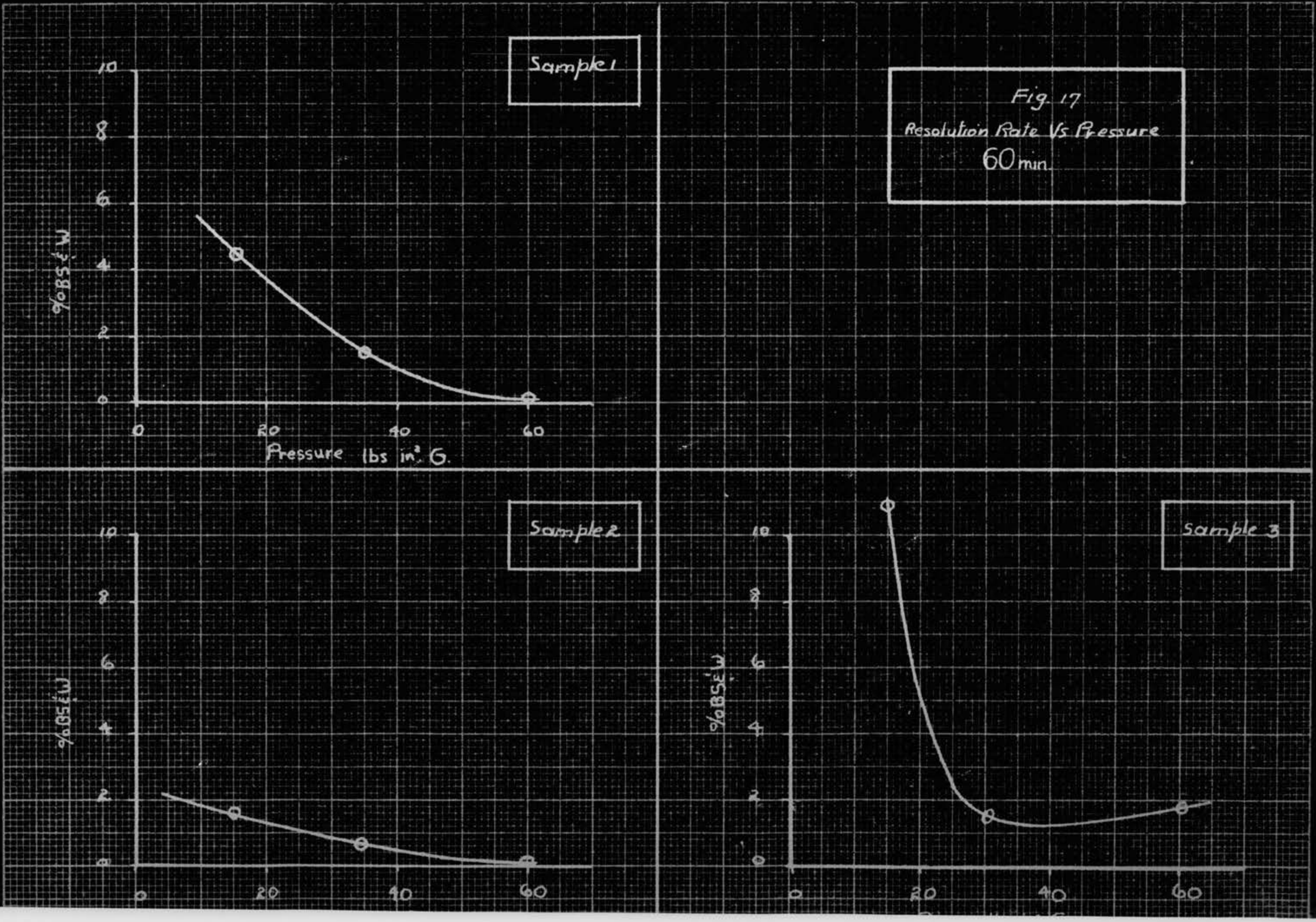

Fig. 17
Resolution Rate Vs Pressure
60 min.

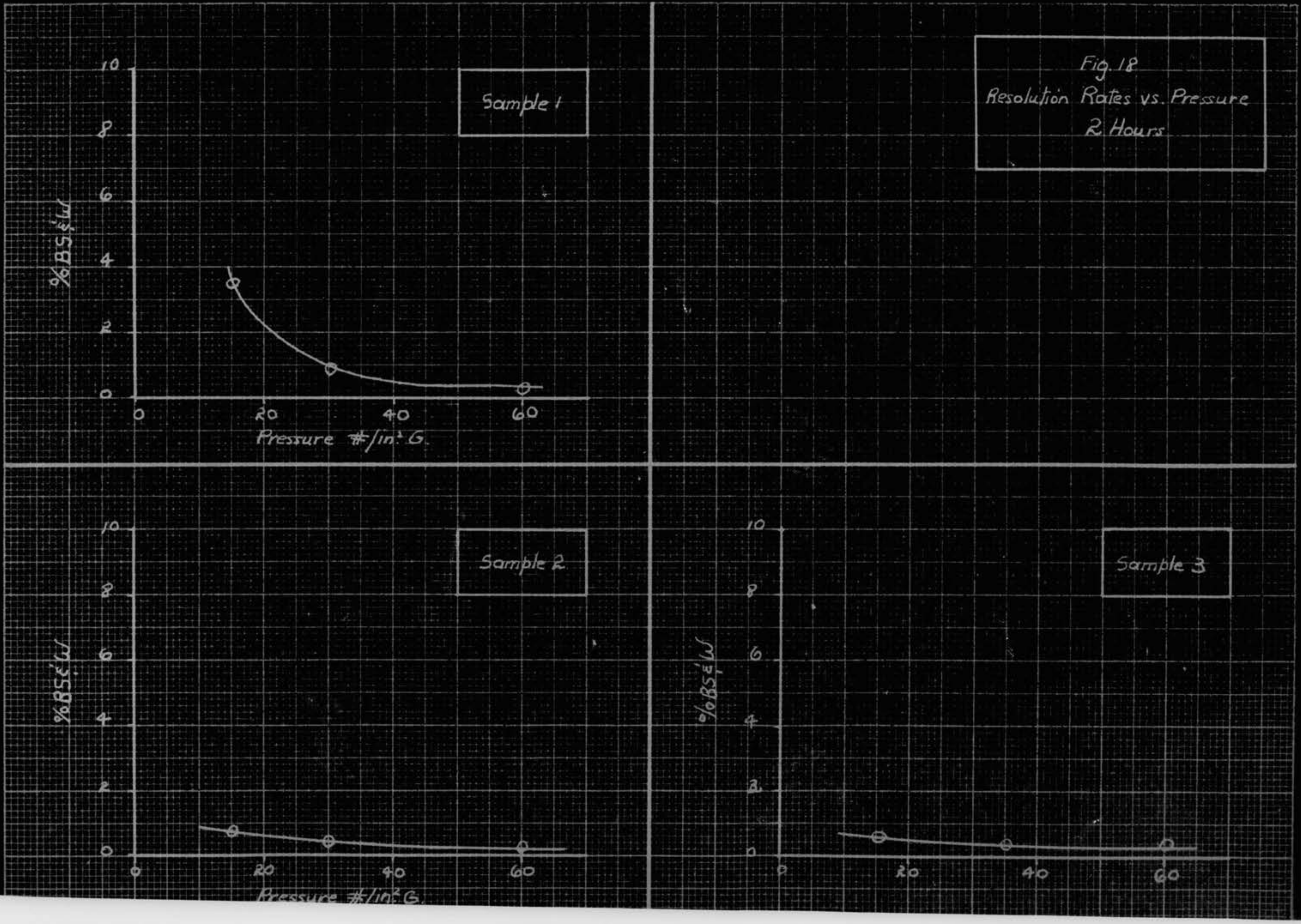

Fig. 18
Resolution Rates vs. Pressure
2 Hours

Typist: Janet Croft