AN EXPERIMENTAL STUDY OF AIR BLOWING OF ROAD OILS AND THEIR CORRELATION TO QUALITY

Thesis for the Degree of B. S.

A. J. Moore

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Asphalt

Civil engineering - Highway engineering

An Experimental Study of Air Blowing of Road Oils and their Correlation to Quality

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THESIS

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Introduction

"Introduction"

In this investigation, tests are to be made on oils refined from crude petroleums which were formed by an exceedingly slow process deep in the earth ages ago. The petroleum thus formed is a very complex and variable mixture of hydrocarbons and in the process of refining, the various burning and lubricating oils are distilled off, leaving a residue which is a black viscous substance. The residue may consist of hydrocarbons of the paraffin series or may contain none of them, in which case, it is called asphaltic, or may be composed of both classes. Therefore petroleums are referred to as asphaltic, semi-asphaltic or paraffins, depending upon the characteristic of the basic compound.

The residue from refining some kinds of petroleums is suitable for road construction without further treatment and is used thusly. However, in other cases the residue is either too hard or too soft and must be brought to the desired consistency by variation in refining process or by addition of asphalts or fluxes from other sources. (1)

Sometimes a petroleum residue is subject to a process known as "Blowing." This process improves them for use in paving work. Briefly, it is a process whereby air is blown into the residue heated from 200°F to 400° F and bringing the oil to a desired consistency. This process lasts from 5 to 20 hours. This results in a waxy asphalt of low ductility but reasonably stable. These asphalts are known as "Blown Oils." (1)

The hydrocarbons we are principally interested in are collectively known as bitumens. A bitumen is a mixture of hydrocarbon compounds either found as such in nature or artifically prepared by the distillation of bitumenous coals. The mixture of hydrocarbons in bitumens are so complex that it is most difficult to separate them into individual compounds; therefore we are limited to a study of certain series or families of hydrocarbons contained in the bitumen; all members of such families have properties of the mixture. It is these predominating properties which determine the classification of the bitumen; that is, paraffins and asphalts. The physical difference between these is that paraffins are greasy and asphalts are sticky.

Physically, bitumen accuring in nature are gases, liquids, solids or mixed, forming a heavy dark yellowish green liquid known as crude petroleum oil from which gaseous hydrocarbons readily escape under ordinary conditions of pressure and temperature.

When crude petroleum oil is distilled the following products result.

Low boiling products

40° - 150° C - gasoline collected by condensation
150° - 300° C - kerosene collected by condensation

High boiling point products

Over 300°C- heavy oils and greases and waxes
depending on the characteristic of
the crude petroleum.

The oxidation of residua obtained from the distillation of petroleum oils with air at elevated temperatures has been practiced in the United States for nearly 40 years (2) and there has been several research tests carried out on oxidation of oils some of which are; Oxidation of white oils (3), oxidation of drying oils (4), Indiana oxidation test for motor oils (5) and also oxygen absorption test on the constituents of asphalts. In this last test the amount of oxygen absorbed by asphaltenes, asphaltic resins, petroleum resins and light oils, which are the constituents of soft Mexican asphalt is determined. It was found that the asphaltenes oxidized the most readily of any of the constituents under the conditions of the experiment (2). In another research problem, the low temperature oxidation of hydrocarbons was studied. Tests were made on spindle oils. The oils were subjected to air by blowing and the weight of water and carbon dioxide given off due to oxidation was noted.(6)

The purpose of this experiment is to attempt to correlate, if possible, the oxidation of various oils with the quality of the oxidized oils as determined by various tests both before and after oxidation, and at the same time the oxidation is performed, to collect H_2O and CO_2 formed as as the result of oxidization and thereby determine the comparative amount that the oil has oxidized. Having the above data one may have an idea as to the oils comparative ability to be oxidized. Then by means of the bromine absorption test on the oxidized oils it can be decided if the two compared show any consistency as to the amount of oxidization. If so, the two may be used to an advantage in the future. It may be however, that due to other chemical actions in the bromine absorption test, they will not indicate the same.

Knowing the qualities and properties of the oils before and after oxidization one will be able to correlate the oxidization of the oils to the qualities. It is certain that the change in quality can be determined but it is another thing to correlate the quality with the oxidization of the oils. Since the oils which are to be oxidized come from different locations are also prepared for distribution by different methods of refining, such as; cracking, blending, cutting back, steam refined, and straight run; and since it is known that the oils are composed largely of bituminous substances having very complex chemical structures it is quite plain that no two oils are alike. As pointed out before, certain chemical substances predominate in some oils, while in others it is absent or present in smaller amounts. This may alter the effect of oxidization upon the various oils.

Thus it would seem that all oils would not be affected the same when air is blown through them. There are various properties which complicate the correlation of oxidization to the quality of the oils and much must be done before there can be a definite correlation. This investigation is but a very minute part in the attempt to do such a thing but it is hoped that the data collected will in some way aid directly or indirectly to enable a very definite correlation of the oxidization of oils and their quality.

As a first step, the oils will be taken as a whole and the effect of oxidization noticed. No attempt will be made to correlate the quality and the amount of oxidization on the oils. Having performed this it may be possible to correlate the oils as to types. Then finally, if possible, the amount of oxidization will be correlated to the quality and grouped according to types; or so to speak attempt to answer such questions as which oils are effected most by oxidization. Do the oils group themselves according to the way they are refined?

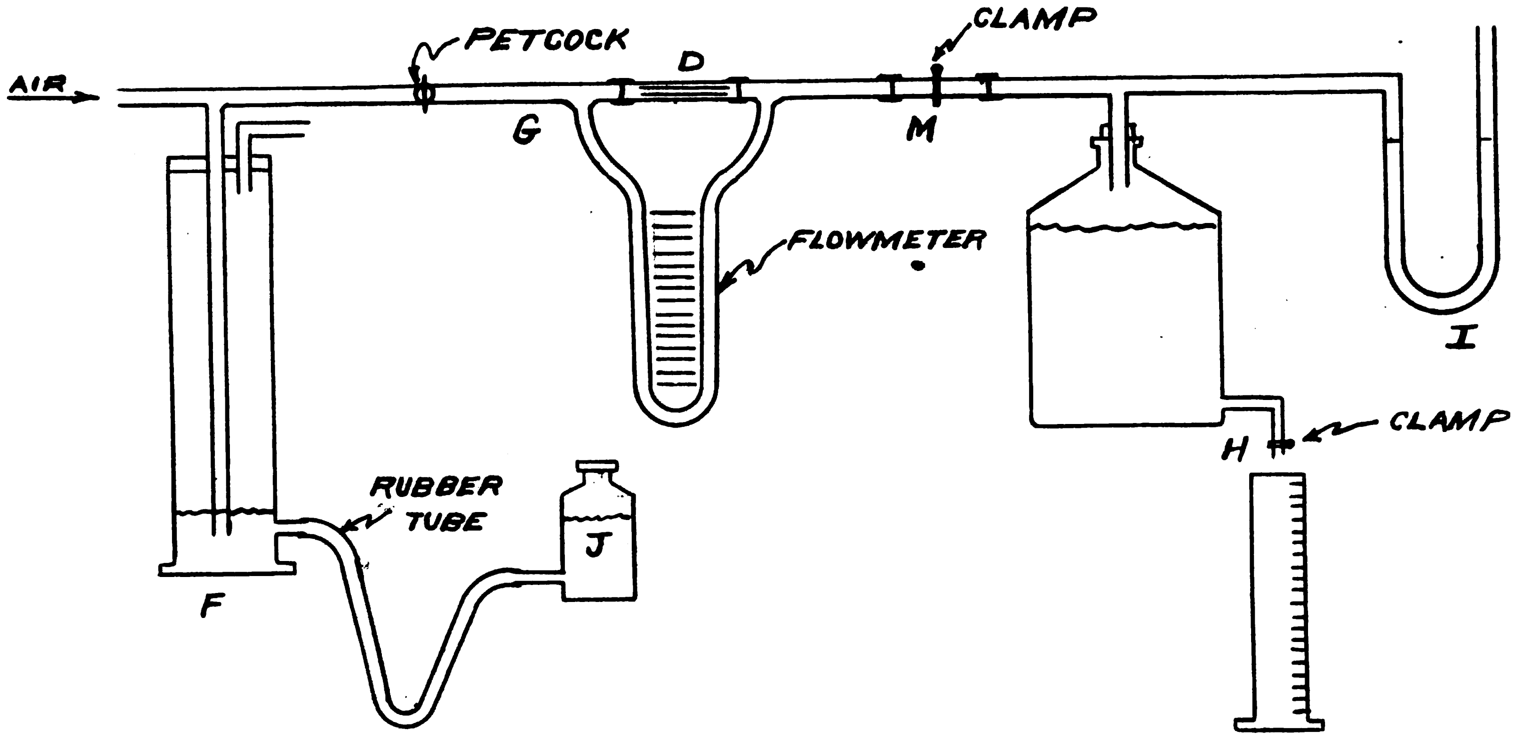
Procedure

Calibration of Flowmeters

In order to pass a definite amount of air through the oil it was necessary to have a flowmeter in the set up. The flowmeter consisted essentially of a capillary tube D having a bore of approximately a millimeter spanning the two ends of a U tube containing water. The pressure drop in the capillary tube was thereby indicated by the difference of level in the liquid of the two arms of the U tubes.

It was of course, necessary to calibrate the flowmeters used since no two are exactly alike. This consisted in determining the relation between pressure drop and volume passing through the flowmeter in unit time. A constant pressure was maintained at G, which was accomplished by adjusting the head of water in F by raising or lowering J depending on the amount of pressure desired. The higher J is raised the higher the pressure. The clamp at M enabled finer adjustment to desired pressure. Having adjusted to a desired pressure, water was then drawn off at H at such a rate that the levels of water on the manometer I, remained constantly level to each other, thereby causing air to pass through the flowmeter at a uniform rate. Thus, the total volume of water drawn off was equal to the total volume of air passing. Therefore, the volume of air in cubic centimeters per minute which passed through the flowmeter at a certain pressure differential as shown by the flowmeter was known. The difference in the level of

FIG. 1



SET UP FOR CALIBRATION OF FLOWMETER

SET UP FOR CALIBRATION OF FLOWMETER

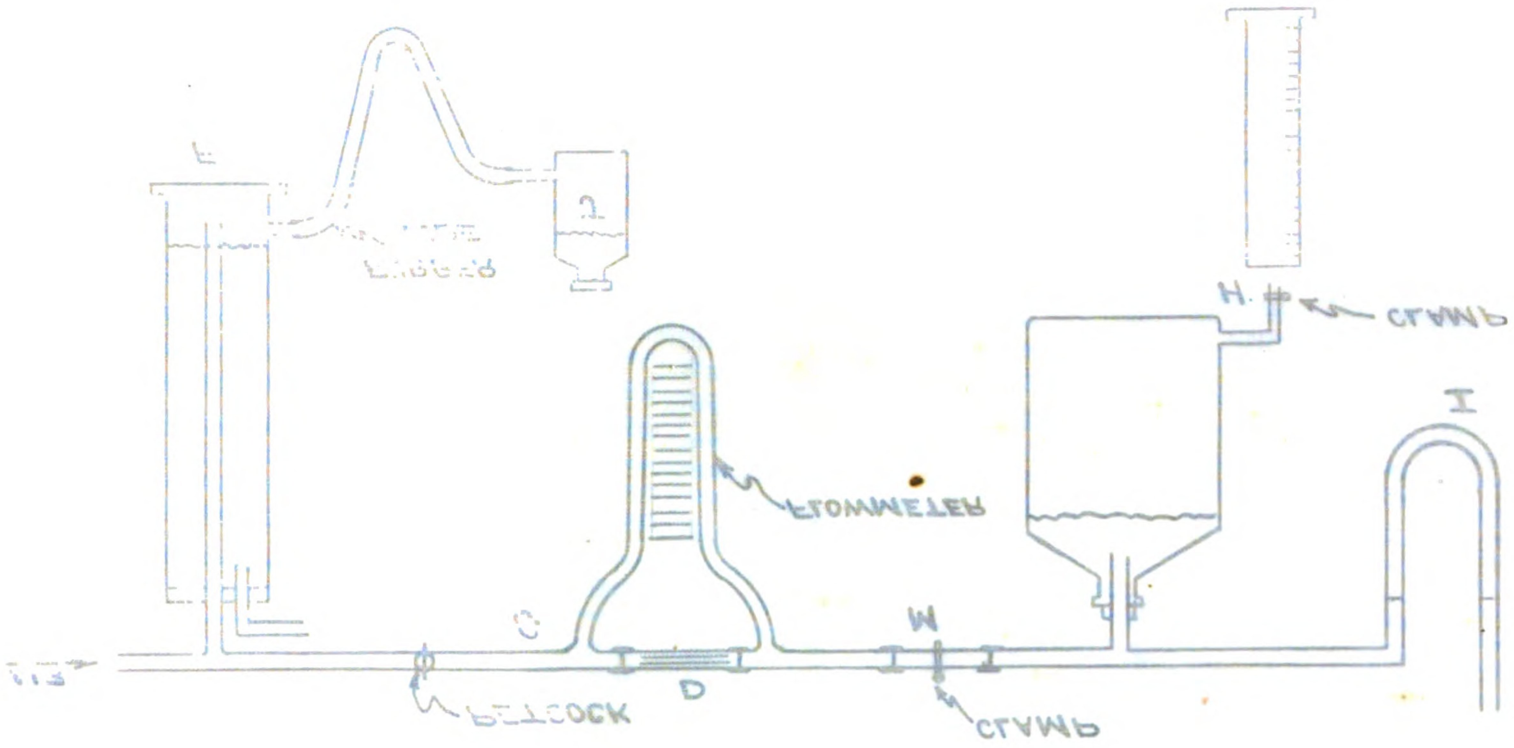
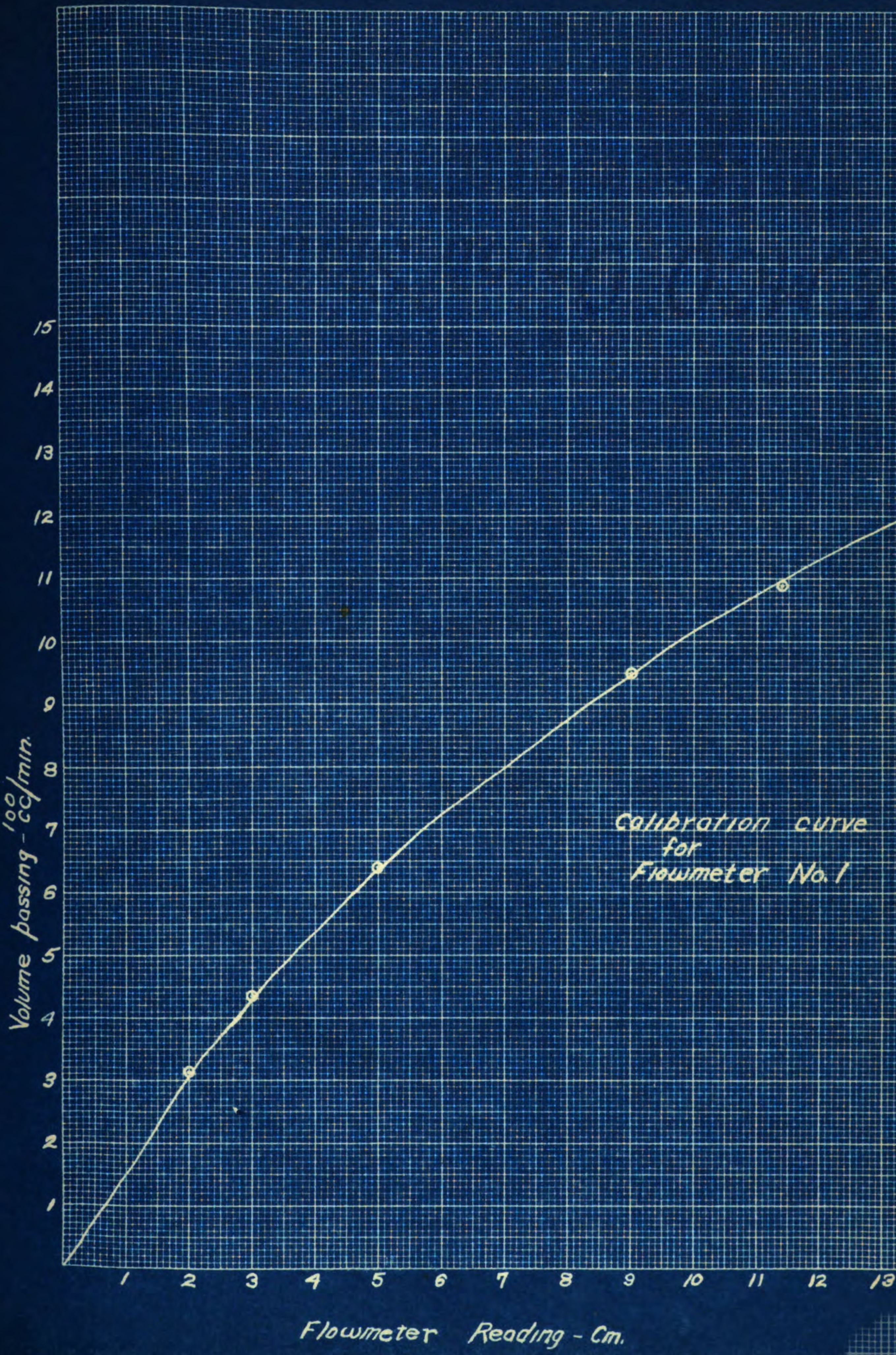


FIG. 1


Calibration curve
for
Flowmeter No. 1
Volume passing - 100/cc/min.
Flowmeter Reading - Cm.
1
2
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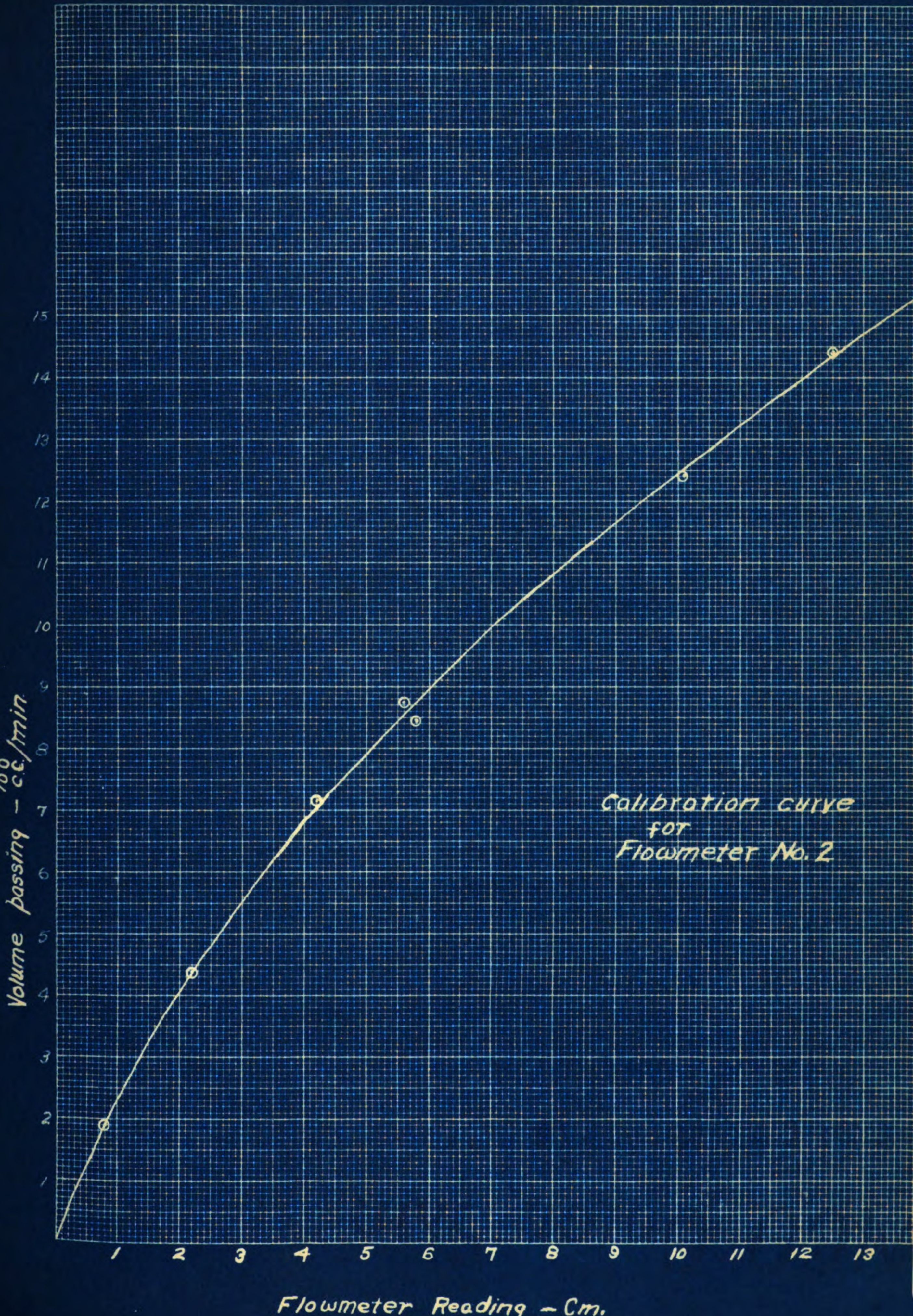
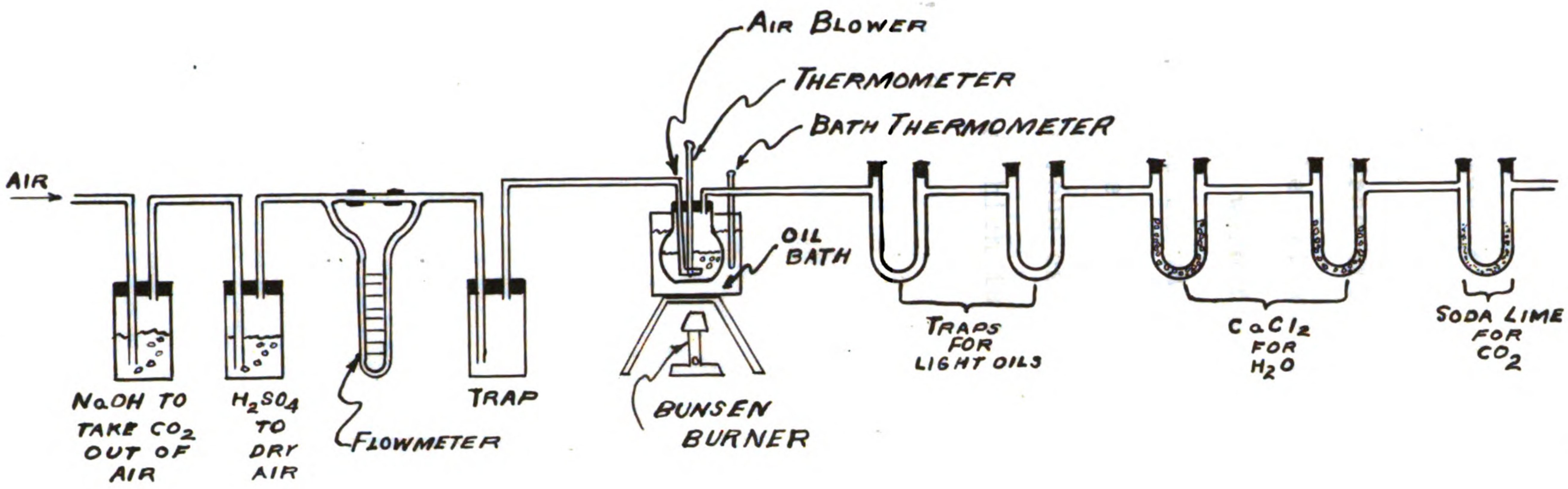

Calibration curve
for
Flowmeter No. 2

water in the flowmeter was plotted as abscissa and the corresponding volume of water passing in cubic centimeters per minute was plotted as an ordinate thus determining a point on the calibration curve. By raising or lowering J, the pressure was altered and thus several points on the calibration curve were determined. Having these points the curve was then drawn.

Air Blowing of Oil Procedure

In order to get an idea as to how much the oil was oxidized when air was passed through it, the set up shown in Fig. 2 was used. The air was first passed through a solution of sodium hydroxide (NA_2CO_3+NaOH) the following chemical reaction resulting to take CO_2 out of the air; $CO_2+NaOH\rightarrow NaHCO_3$ or in other words the carbon dioxide in the air was removed from it by the CO_2 uniting with the soda lime to form sodium bicarbonate. The concentrated sulphuric acid was used to remove any moisture that might be in the air. It was necessary to remove H_2O and CO_2 from the air as these elements would render void the determination of CO_2 and H_2O passed off from the oil due to oxidation of the oil as the air is blown through it. From the sulphuric acid bottle the air passed through the flowmeter and then through the trap whose purpose as can obviously be seen was to prevent any water from the flowmeter from getting into the oil. From the trap the air passes into the blower and is blown through the oil. The oxygen of the air has ample opportunity to oxidize the oil

FIG. 2



APPARATUS FOR OXIDATION DETERMINATION

to the extent that it will be oxidized according to the type of oil and conditions of the experiment. The blower used is a copper tube with a circular hook containing small holes in the bottom from which the air is emitted.

The air was free from CO_2 and H_2O as it entered the oil, but during the oxidation of the oil CO_2 and H_2O as well as light oils were formed and passed off into the series of U. tubes shown in Fig. 2. The first two empty tubes collected the light oils; The next two which were filled with anhydrous calcium chloride collected the H_2O and the last one which is filled with soda lime collected the CO_2 formed.

Oils Used, Their Company and Refining Method

A. Texas Oil Company called "Indiana Surfacing" manufactured from Mid-Continent Crudes by the cracking process. Lockport Illinois Refinery.

B. Standard Oil of Indiana, Whiting, Indiana. Manufactured from Mid-Continent Crudes. Supposed to be a cracked product.

C. Shelly Oil Company, El Dorado Kansas Refinery. Manufactured from mixed Kansas Crude using a vacuum refined asphalt, cut back with gas oil.

D. Leon Oil Company, El Dorado, Arkansas. Manufactured from Urbana Crude. It is a topped crude product.

E. Leon Oil Company, El Dorado, Arkansas. Urbana Crude was used. It is a blend consisting of 30% cracked tar and 70% uncracked crude bottoms.

F. Leon Oil Company, El Dorado, Arkansas. This is a blend consisting of 100 degrees F. melting point topped Smackover Crude and non adjacent gas oil from Smackover Crude.

G. Shell Petroleum Corporation. From their Norco, La. refinery. It is a steam refined Mexican Crude.

H. Shell Oil Petroleum Corporation. From their East Chicago refinery and it is a mixture of cracked residue from Mid-Continental Crudes.

I. Texas Oil Company. From their Cody, Wyoming refinery. It is a steam Distilled Manufactured from Oregon Crude.

J. Standard Oil of California. From their Richmond refinery. This is a blend consisting of 80%, 140 grovely residuum and 20% of 50 Penetration steam refined asphalt both produces from California Crudes.

K. Secony Vacuum Oil Company. From their Augusta Kansas Refinery. It is a product resulting from the vaccuum and steam distillation of mixed base Kansas Crudes.

L. Secony Vac uum Oil Company. From their Casper, Wyoming refinery. This is a blend consisting of residues from the cracking process and the vaccuum steam distillation of Kansas base crudes.

M. Secony Vaccuum Oil Company. From their Casper Wyoming Refinery. This is a straight run product of Wyoming Crudes.

O. Gulf Refinery Company. From their Cincinnati, Ohio Refinery. It is a cracked product of mixed Mid-Continent Crudes.

General Table

	Viscosity in stokes				Specific Gravity		% H_2O in original oil	% H_2O Collected During air Blowing
	Original		After Air Blown		Original	Before air Blowing		
	25°C	60°C	25°C	60°C				
A	1205	10.0	36,000	6,884	1,060	1,088	.0	1.51
B	257	10.3	7,400	5,945	.990	1.003	.3	1.55
C	250	9.1	8,300	8,335	.978	.988	.4	1.48
D	263	9.5	760	1,475	.979	.981	.05	.763
E	418	11.8	5,200	4,535	1.000	1.005	.0	.726
F	403	14.0	7,600	8,183	.979	.992	.0	.625
G	281	11.8	21,000	22,104	.986	1.009	.05	1.09
H	639	9.8	16,000	18,798	1.053	1.070	.02	2.17
I	354	11.2	3,600	5,080	.992	1.001	.05	1.79
J	634	11.6	2,380	1,943	.972	.984	.0	.928
K	258	9.5	11,740	6,159	1.003	1.007	.2	.594
L	464	9.5	28,000	12,556	1.027	1.038	.0	1.79
M	511	13.9	5,340	5,475	.999	1.003	.5	.787
N	671	13.9	32,000	17,923	1.020	1.032	.0	.625
O	788	9.0	9,000	5,568	1.031	1.046	.4	.769
P	551	11.5	1,900	2,127	.976	.983	.0	.769
Q		9.00		5,158	1.031	1.042		.830

General Table

	% CO_2 Collected During air Blowing	Bromine Absorption Tests		Asphalteness		Heterogenity		Distallation of original oil up to 360° % Oils
		Original Oil %	After Air Blown	Original %	After Air Blown %	Original	After	
A	.346	34.18	15.98	26.00	31.30	Pos.	Pos.	1.8
B	.878	18.29	14.32	8.95	14.16	St. Pos.	St. Pos.	7.5
C	.863	17.51	12.76	12.66	17.78	Neg.	Neg.	5.5
D	.714	9.38	7.73	6.46	10.26	Neg.	Neg.	1.0
E	1.27	16.05	9.15	8.80	13.53	St. Pos.	Pos.	1.5
F	.299	9.39	9.20	8.61	13.50	Neg.	Neg.	3.
G	.932	15.54	14.74	10.41	25.96	Neg.	Neg.	1.3
H	1.52	13.64	21.31	19.05	26.48	Pos.	Pos.	3.5
I	.436	18.29	19.71	13.14	19.52	Neg.	Sl. Pos.	2.5
J	.583	9.47	13.39	10.00	14.16	Neg.	Neg.	2.5
K	.515	12.00	9.31	11.78	17.88	Neg.	Neg.	3.
L	2.47	16.84	11.03	14.66	21.70	Pos.	Pos.	1.
M	1.87	13.95	11.02	14.07	18.60	Neg.	Sl. Pos.	2.
N	.299	12.57	12.24	13.04	22.88	Pos.	Pos.	4.
O	.884	12.17	11.15	13.29	19.16	Pos.	Pos.	.5
P	.474	11.28	9.21			Neg.	Neg.	.5
Q	1.048							

Table for Type I Oils
Steam and Vacuum Refined Oils

	Oil D		Oil G		Oil I	
	Before	After	Before	After	Before	After
Viscosity @ 25°C in Stokes	563	760	221	21,000	314	5000
Specific Gravity	.979	.991	.936	1.009	.992	1.001
% Bromine Absorption	16.05	9.15	17.94	14.74	18.89	17.71
% Asphaltenes	6.46	10.96	20.41	25.96	13.14	19.52
% Distillates to 360°C	1.0		13.0		2.5	
Heterogenity	Neg	Neg	Neg	Neg	Neg	Sl. Pos
% H_2O in original oil	.05		.05		.05	
% H_2O Collected while air blowing	.763		1.09		1.79	
% CO_2 Collected while air blowing	.714		.932		.436	

Table [illegible] Type I Oils
Steam and Vacuum Refined Oils

	Oil K		Oil M		Oil P	
	Before	After	Before	After	Before	After
Viscosity @ 25°C in Stokes	[illegible]	1740	511	[illegible]	551	1900
Specific Gravity	1.003	1.007	.993	1.003	.976	.983
% Bromine Absorption	18.00	9.51	17.25	11.02	31.88	9.81
% Asphaltenes	11.73	17.88	14.07	18.30		
% Distillates to 360°C	5.0		2.0		.5	
Heterogeneity	Neg.	Neg.	Neg.	Sl..Pos.	Neg.	Neg.
% H_2O in original oil	.2		.05		.0	
% H_2O Collected while air blowing	.594		.758		.739	
% CO_2 Collected while air blowing	.515		1.87		.474	

Table For Type 2 Oils
Blend Steam Refined Oils

	Oil L		Oil B		Oil E	
	Before	After	Before	After	Before	After
Viscosity @ 25 C in stokes	464	28,000	257	7,400	413	5200
Specific Gravity	1.027	1.038	.990	1.003	1.000	1.005
% Bromine Absorption	16.84	11.03	13.29	14.32	16.00	9.15
% Asphaltenes	14.66	21.70	8.95	14.16	8.80	13.58
% Distillates up to 360 C	1		7.5		1.5	
Heterogenity	Pos.	Pos.	Sl.Pos.	Sl.Pos.	Sl.Pos.	Pos.
% H_2O in original oil	.0		.3		.0	
% H_2O collected while air blowing	1.79		1.56		.726	
% CO_2 collected while air blowing	2.47		.878		1.27	

	Table For Type 3 Blend Steam Refined Residues		Table For Type 4 Oil Blended Crushed Residues			
	J		N		H	
	Before	After	Before	After	Before	After
Viscosity @ 25 C in stokes	634	2380	671	32000	639	5600
Specific Gravity	.972	.984	1.020	1.032	1.053	1.07
% Bromine Absorption	9.47	13.39	12.57	12.24	13.64	21.31
% Asphaltenes	10.00	14.16	13.04	22.88	19.05	26.48
% Distillates up to 360° C	2.5		.5		3.5	
Heterogenity	Neg.	Neg.	Pos.	Pos.	Pos.	Pos.
% H_2O in original oil			.0		.02	
% H_2O collected while air blowing	.928		.625		2.17	
% CO_2 collected while air blowing	.583		.299		1.52	

	Table for Type 5 Oils Straight Cracked Oils				Table for Type 6 Oils Steamed Refined Cut Back with Gas Oil.			
	A		O		F		G	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Viscosity @25 C in stokes	1205	36000	788	9000	403	7600	250	8300
Specific Gravity	1.080	1.088	1.031	1.046	.979	.992	.978	.988
% Bromine Absorption	39.18	15.98	12.17	11.15	9.39	9.20	17.51	12.76
% Asphaltenes	26.00	31.30	13.29	19.16	8.61	13.50	12.66	17.78
% Distillates up to 360	1.8		.5		3		5.5	
Deterogenity	Pos.	Pos.	Pos.	Pos.	Neg.	Neg.	Neg.	Neg.
% H O in original	0.0		.02		0.0		.4	
% H O collected while air blowing	1.51		.769		.625		1.48	
% C O collected while air blowing	.346		.474		.299		.863	

Table I

Original and After Blowing Comparison Table

% H_2O Collected	% H_2O in Original Oil	Corrected % H_2O Collected	% CO_2 Collected
H-2.17	C-.4	H-2.15	L-2.47
L-1.79	O-.4	L-1.79	M-1.87
I-1.78	B-.3	I-1.73	H-1.52
B-1.56	K-.2	A-1.51	E-1.27
A-1.51	D-.05	C-1.48	G- .932
C-1.48	G-.05	B-1.26	O- .884
G-1.09	M-.05	G-1.04	B- .878
J- .928	I-.05	J- .0928	C- .863
M- .787	H-.02	M- .787	D- .714
O- .769	A-.00	O- .769	J- .583
P- .769	E-.00	P- .769	K- .515
D- .763	F-.00	D- .758	P- .474
E- .726	J-.00	E- .726	I- .436
F- .625	L-.00	F- .625	A- .346
N- .625	N-.00	N- .625	N- .299
K- .594	P-.00	K- .394	F- .299

Table 2

Original and After Blowing Comparison Table Viscosity

Original Viscosity @ 25°C In stokes	Air Blown Viscosity @ 25°C in stokes	Increase Viscosity @ 25°C in stokes
A-1,205	A-36,000	A-34,800
O- 788	N-32,000	N-31,330
N- 671	L-28,000	L-27,540
H- 639	G-21,000	G-20,720
J- 634	H-16,000	H-15,360
P- 551	O- 9,000	O- 8,212
M- 511	C- 8,300	C- 8,050
L- 464	F- 7,600	F- 7,197
E- 418	B- 7,900	B- 7,143
F- 403	M- 5,340	M- 4,829
I- 354	E- 5,200	E- 4,782
G- 281	I- 3,600	I- 3,346
D- 263	J- 2,380	J- 2,746
K- 258	P- 1,900	K- 1,482
B- 257	K- 1,740	P- 1,450
C- 250	D- 760	D- 497

Table 3

Original and After Blowing Comparison Table

Specific Gravity Original	Specific Gravity After	Increase Specific Gravity	Amount of Distillation % of Original	Increase Viscosity @ 25°C in stokes
A-1.080	A-1.088	H-.017	G-13.00	A-34,800
H-1.053	H-1.070	O-.015	B- 7.5	N-31,330
O-1.031	O-1.046	G-.013	C- 5.5	L-27,540
L-1.027	L-1.038	F-.013	N- 4.0	G-20,720
N-1.02	N-1.032	L-.012	H- 3.5	H-15,360
K-1.003	G-1.009	N-.012	K- 3.0	O- 8,212
E-1.000	K-1.007	C-.010	F- 3.0	C- 8,050
M- .999	E-1.005	I-.009	I- 2.5	F- 7,197
B- .996	M-1.003	J-.009	J- 2.5	B- 7,143
I- .992	B-1.003	A-.008	M- 2.0	M- 4,829
G- .986	I-1.001	B-.007	A- 1.8	E- 4,782
F- .979	F- .992	P-.007	E- 1.5	I- 3,246
D- .979	C- .988	E-.005	L- 1.0	J- 2,746
C- .978	J- .984	M-.004	D- 1.0	K- 1,482
P- .976	P- .983	K-.--4	D- .5	P- 1,450
J- .972	D- .981	D-.002	P- .5	D- 497

Table 4

Original and After Blowing Comparison Table

Asphaltenes

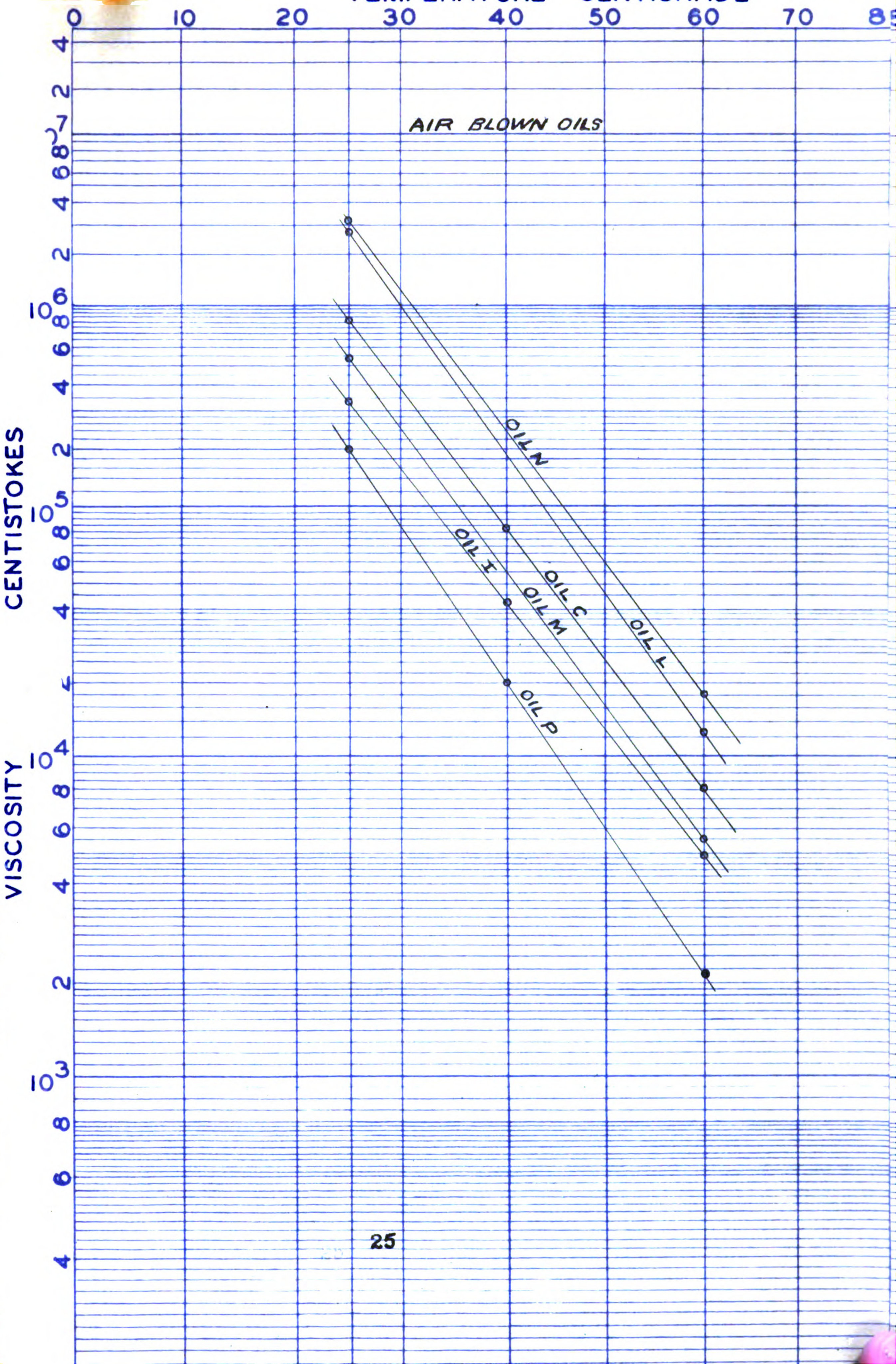
% Asphaltenes Original	% Asphaltenes After	% Asphaltenes Increase Order
H-26.00	A-31,30	A-9.84
G-20.41	H-26.48	H-7.43
H-19.05	G-25.96	L-7.04
L-14.66	N-12.88	I-6.38
M-14.07	L-21.70	K-6.10
O-13.29	I-19.52	O-5.87
I-13.14	O-19.16	G-5.55
N-13.04	M-18.60	A-5.3
C-12.66	K-17.88	B-5.21
K-11.78	C-17.78	C-5.12
J-10.00	B-14.16	F-4.89
B- 8.95	J-14.16	E-4.78
E- 8.80	E-13.58	M-4.53
F- 8.61	F-13.50	J-4.16
D- 6.46	D-10.26	D-3.80

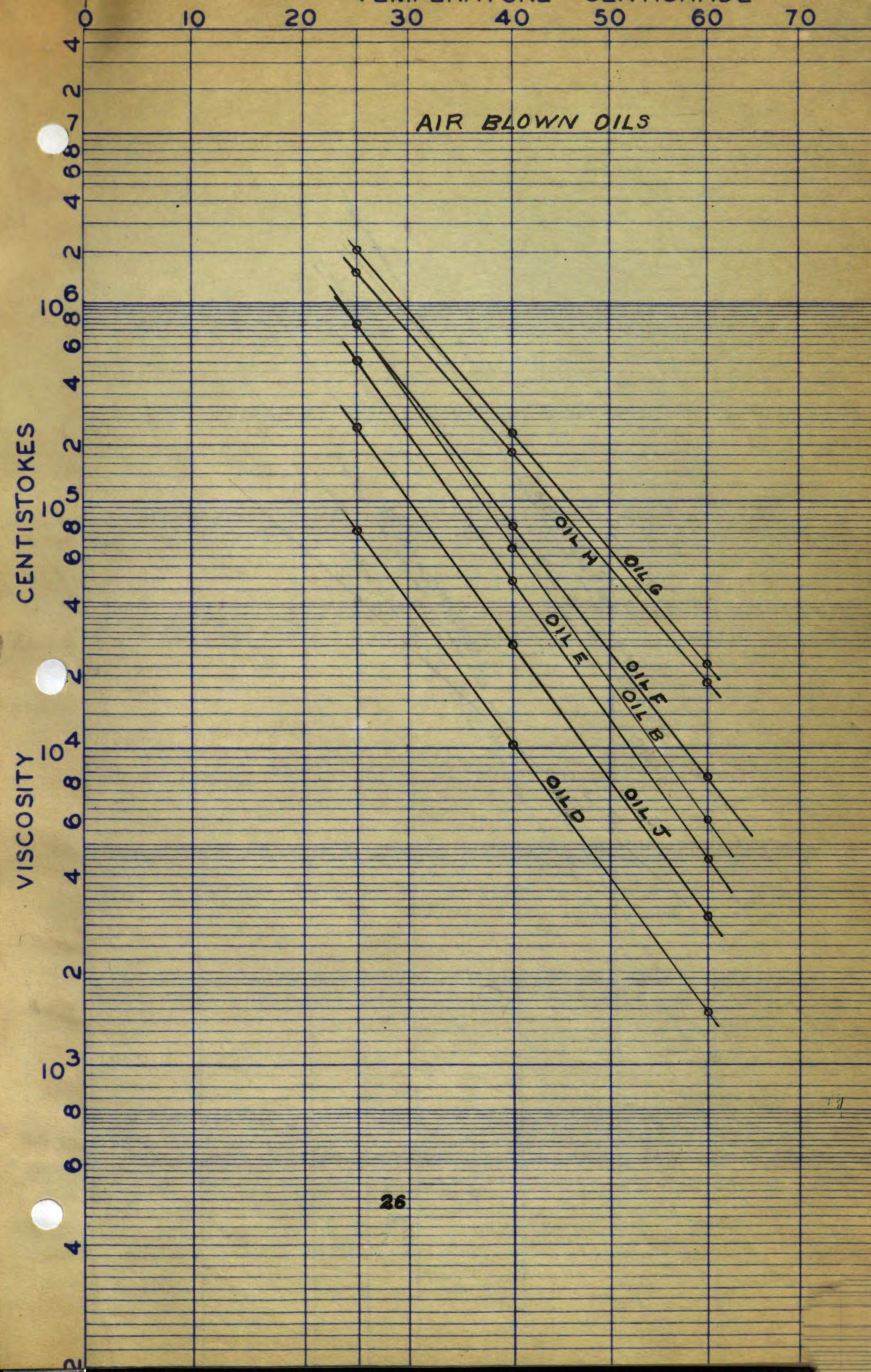
Table 5

Original and After Blowing Comparison Table

Bromine Absorption

% Bromine Absorption Original	% Bromine Absorption After	% Bromine Absorption Least Absorbed Order
A-34.18	H-21.31	F- .19
B-18.29	I-19.71	N- .33
I-18.29	A-15.98	G- .80
C-17.51	G-14.74	O-1.02
L-16.84	B-14.32	D-1.65
E-16.05	J-13.39	P-2.07
G-15.54	C-12.76	K-2.69
M-13.95	N-12.24	M-2.93
H-13.64	O-11.15	J-3.92
N-12.57	L-11.03	B-3.97
O-12.17	M-11.02	C-4.75
K-12.00	K- 9.31	L-5.81
P-11.28	P- 9.21	E-6.90
J- 9.47	F- 9.20	A18.20
F- 9.39	E- 9.15	I-7.67 (-)
D- 9.38	D- 7.73	H-1.42 (-)


0
10
20
30
40
50
60
70
85
AIR BLOWN OILS
VISCOSITY CENTISTOKES
4
2
10^7
8
6
4
2
10^6
8
6
4
2
10^5
8
6
4
2
10^4
8
6
4
2
10^3
8
6
4
OIL N
OIL L
OIL C
OIL M
OIL I
OIL P


TEMPERATURE CENTIGRADE
0
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AIR BLOWN OILS
VISCOSITY CENTISTOKES
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4
2
10^6
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4
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OIL G
OIL H
OIL F
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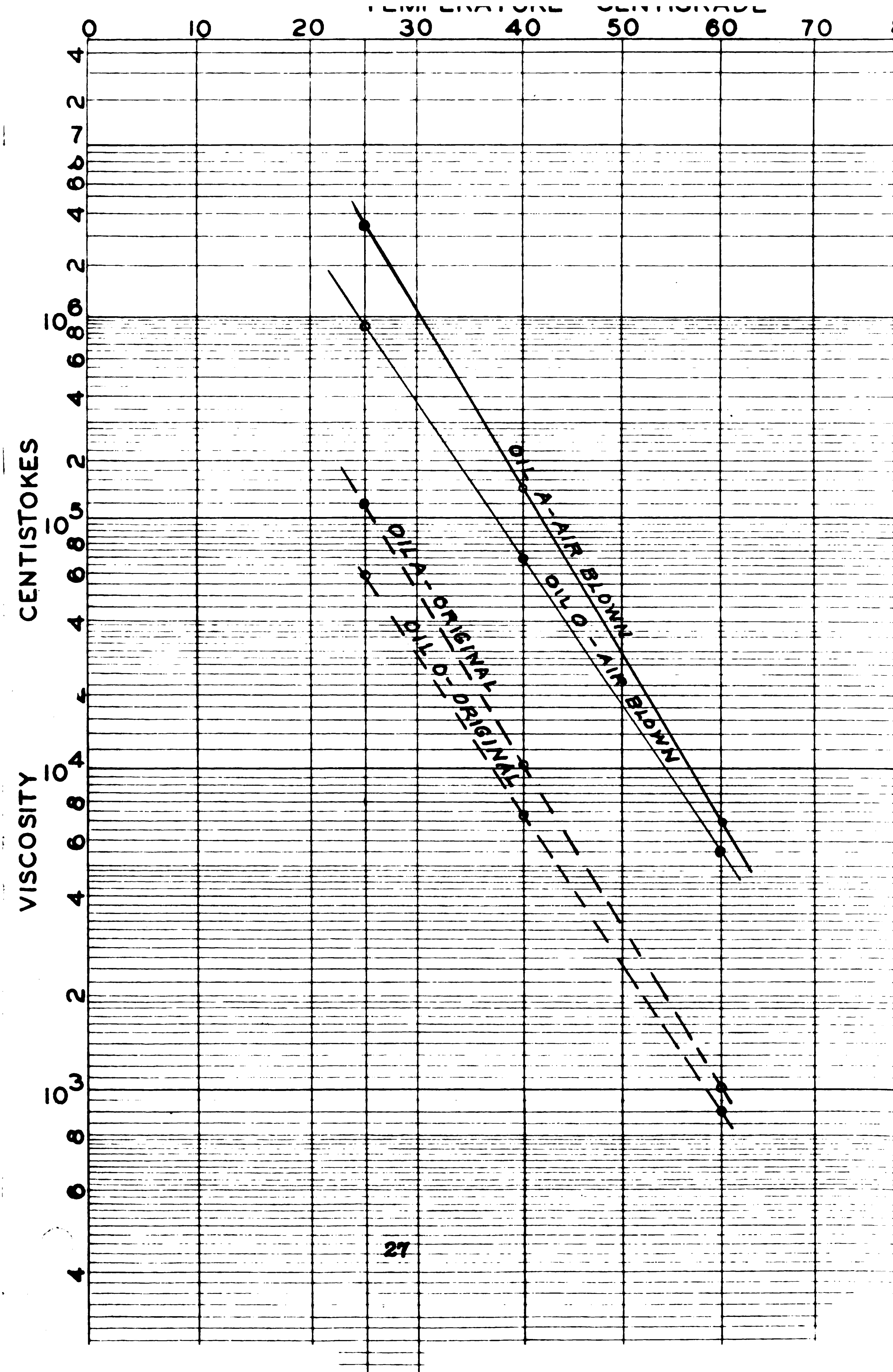
OIL B
OIL J
OIL D


TEMPERATURE CENTIGRADE
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VISCOSITY CENTISTOKES
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10^6
8
6
4
2
10^5
8
6
4
10^4
8
6
4
2
10^3
8
6
4
OIL A-AIR BLOWN
OIL O-AIR BLOWN
OIL A-ORIGINAL
OIL O-ORIGINAL

Conclusions

1. Air Blowing increased the specific gravity of all the oils.

2. The specific gravity does not increase according to amount of distillation which indicates that air blowing does increase the specific gravity.

3. All oils became more viscous and since they do not increase according as the specific gravity increases or to amount of distillation, indications are that air blowing makes the oil more viscous.

4. Generally, oils having high asphaltene percent are the most Viscous oils which indicates that air blowing effects the asphaltenes probably more than any other constituent.

5. Generally oils which showed the least change, showed the least change in viscosity and also the least change in specific gravity.

6. Anamalous results were obtained in the bromine tests on H and I. On observing the percent of H_2O which was high, it is logical to assume that the unsaturated compounds formed were of a type that did not polymerize.as completely as the other oils. All the other oils were found to have a decreased bromine absorption which is indicative of polymerization of unsaturated hydrocarbons.

7. There seems to be a tendency where the percent by weight of asphaltenes are high, for greater formation of H_2O while those having low asphaltenes give off less H_2O. This shows those having less asphaltenes have hydrocarbons of a more saturated nature.

8. The fact that I changed from a heterogenity of negative to slightly positive, indicates that the oil became overheated or possibly some chemical action may have caused it. It is likely I is composed of unsaturated hydrocarbons.

9. Air Blowing tends to make the safetening point higher as indicated by the graphs in connection with viscosity determination at different temperatures.

10. Considering the oils which were steam and vacuum refined, there is indication that they tend to group theirselves according to the comparatively highly oxidized oils as shown by the bromine test. They also group theirselves into low viscosities. So generally the indications are that steam and vacuum refined oils have high oxidation but are not effected so much as the oils having lower oxidation.

11. Considering the oils which are a blend of steamed refined oils, there seems to be no possible way to correlate the oils to amounts oxidized to the quality. This is probably due to the fact that the oils are not composed of like blends.

12. Considering the oils which are a blend of steam refined residue, it is found that the oil had medium oxidation but low increase in viscosity.

13. Considering the oils which are blended cracked residues one notes N has a high increase in viscosity and also a high oxidation rating, indications are that this type of oil is easily oxidized and a high viscosity results.

14. Considering the straight cracked oils, Oil A has a high increase in viscosity but a low oxidation. O has a fair increasing viscosity and a fair oxidation. Indications are they cannot be correlated according to type.

15. Considering steam refined oils cut back with gas oils, indications are that they cannot be correlated to type.

16. As for the method of determining the CO_2 and H_2O it should be stated that the entering effects of volatile material and the effect of polymerization made it very difficult to to make any decisions as to eliminate correlation of the oxidation to the quality of the oil. The bromine test gave a more accurate indication as to the amount of oxidation.

17. Viscosity----Temperature graphs were used to determine temperature at 25° C Koppers Viscometer being used.

18. Noting the Viscosity--Temperature graphs it will be seen that the oils have nearly the same slope, indicating that all oils are affected about the same at different temperatures.

19. The graph showing Oil A, and Oil B before and after air blowing indicates that the oils tend to have the same slope before and after air blowing. This shows that the oils were properly heated and held at the required temperature.

20. Generally air blowing did not change the oils from a negative heterogentry to a positive heterogentry.

SUMMARY

It is found that oils subjected to air blowing at a temperature of 180° C become heavier in gravity, harder, more viscous and higher in softening point. It is also apparent that the asphaltenes play a big part in determining the characteristics and quality of the oils.

As to the correlation of the amount of oxidation to the quality of the oil after being subjected to the air blowing, there seems to be little tendency for the oils to group theirselves according to types. This is probably due to the wide variation in the properties and sources of the original crude petroleum.

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