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UNIVERSITY OF LOUISVILLE

The Effect of Carbon Pigments
"on Drying of Linseed Oil

A Dissertation
Submitted to the Faculty
of the Graduate School
In Partial Fulfillment of the
Requirements for the Degree of
Master of Chemical Engineering

Department of Chemical Engineering

By

Hilton
H. A. Bennett Jr.

1938

**The Effect of Carbon Pigments
On Drying of Linseed Oil**

Director: Dr. R. C. Ernst.

Approved by Reading Committee:

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CHAPTER I

INTRODUCTION

When certain pigments are dispersed in drying oils, in the presence of driers, the resulting mixture has drying characteristics different from those of the unpigmented oils. Paints containing these pigments may have approximately normal drying time when freshly made, but after aging will have an unduly long drying time. Since the variation of drying time is most pronounced in paints containing carbon pigments - carbon black, lampblack, graphite and boneblack -, these have been selected for this study.

Little information is available concerning the effect of carbon pigments upon drying of linseed oil. Rhodes and Goldsmith (1) determined the volumetric rate of absorption of oxygen by films of carbon black paint. Their results gave no information on the effect of aging of the paint.

The adsorption of driers by black pigments in naphtha was studied by the Binney and Smith Company (2). Their study listed various carbon blacks in order of drier adsorption from naphtha solution, while practical tests showed that drying difficulties followed in the same order. This study did not include drying oils, however.

To accurately determine the effect of carbon pigments upon the drying of linseed oil, the drying characteristics of actual paint films must be obtained. The drying characteristics will be determined for various combinations of pigments and driers, at comparable conditions of light, temperature, humidity, and film thickness.

CHAPTER II

THEORETICAL

The change resulting when a vegetable oil, such as linseed oil, is spread in a thin film and exposed to air is actually an oxidation and polymerization of the oil, although the change is commonly termed drying.

The following description of the drying of linseed oil is due to Long and associates (3) and Rheineck (4). The chief drying constituent of linseed oil is linolenic acid, which has the following structure:

The drying process is primarily a reaction at the points of unsaturation, that is, at the location of double valence bonds on the structural formula indicated. In the first step of the process, oxygen is absorbed as a peroxide:

This peroxide formation is unstable and exists only up to the point where the oil film is tacky. Once the film is dry to touch, polymerization, and a rearrangement of the peroxide compound occur:

During the latter part of the drying period volatile products are given off by the oil film. This loss of volatile products is explained by reaction of the oxidized linolenic acid with moisture, present either in the oil or in the air:

As linseed oil dries slowly by itself, when flowed out in a thin film, materials known as driers are added to speed up the drying process. These materials act catalytically and are added in small quantities to the oil. Cobalt, lead, and manganese compounds are the common driers; their activity as catalysts of the reaction of the drying of oils depends upon their ability to form two or more compounds with oxygen, which differ from each other in the amount of oxygen with which the same weight of metal is combined. To make active catalyzers, or driers, these compounds with oxygen must be unstable, that is, that they will pass readily from one stage of oxidation to another. These catalyzers form the compounds of largest oxygen content when they are at the surface of the oil film in contact with the oxygen of the air. Later, due to the continuous movement of the particles, the high oxygen bodies come in contact with the unoxidized oil and give up their oxygen, thus quickening the reaction. The drier metals are usually added as linoleates, naphthenates, or similar organic compounds, so that the drier may be readily dispersed in the oil.

The drying of an oil can be represented graphically by a curve showing increase in weight of oil plotted against time. A typical curve shows a slow rate of increase in weight of oil just after the drying begins; this period in the drying is called the induction period. Immediately following the induction period, the curve goes sharply upward at a constant slope, indicating a period of constant rate of increase in weight. The constant rate period continues until a certain stage in drying is reached. The rate of increase in weight then falls off, but the weight increases slowly until a maximum is reached.

Loss of volatile products causes the curve to drop after the maximum is reached.

Graphical representation gives a convenient method of comparing the drying of different mixtures of oil, drier, and pigment.

CHAPTER III

MATERIALS, APPARATUS, AND PROCEDURE

The samples investigated were mixtures of linseed oil with either carbon black, lampblack, graphite, or boneblack, with either lead or cobalt Nuodex used as the drier. The pigment and oil were weighed and the Nuodex drier, which is a solution of a metal naphthenate in naphtha, added with a graduated pipet. Samples of approximately one-half pint were prepared in each case, and ground in a small pebble mill.

The films were prepared by first painting a thick coating of the sample on a flat glass plate, nine by twelve centimeters in size. As indicated in Figure 1, a film of constant thickness was obtained by drawing across the flat glass plate a doctor blade held firmly against the two thickness gage strips. The films were weighed at varying intervals on an analytical balance, and the increase in weight noted.

The films were exposed to the light from a 100 watt General Electric daylight type lamp, which was 31 inches above the plane of the desk top. The temperature was held at 80 degrees Fahrenheit for all tests. The average relative humidity during the tests made on the freshly made samples and on the samples after 4 weeks aging was 30 percent; during the tests made on the samples after 8 weeks aging, the relative humidity was 45 percent.

Figure 1.
Apparatus for Making
Paint Films.

CHAPTER IV

DATA AND RESULTS

To express the increase in weight of the films on a comparable basis, the weight of oil in the film was used as the basis.

The weight of oil in the sample was obtained by multiplying the weight of sample by the percent oil in the sample. The percent oil was known from the preparation of the sample; for example, 98 grams of oil, 1 gram of pigment, and 1 gram of drier gave a mixture of 98 percent oil content. Weight of oil divided by increase in weight gave percent increase in weight of oil, from which the drying curves were plotted.

Table 1 shows the composition of the various mixtures of linseed oil - drier - pigment mixtures studied in this investigation.

Table 1

List of linseed oil - drier - pigment mixtures studied.

Experimental Sample Number	Composition*				Results Reported In Table No.	Results Shown In Figure No.
12	Lead	1	; Carbon Black,	3.5	2	2
13	"	1.5	; " "	3.5	3	3
14	"	2	; " "	3.5	4	4
15	"	1	; " "	7	5	5
16	"	1.5	; " "	7	6	6
17	"	2	; " "	7	7	7
18	"	1	; Bone Black,	10	8	8
19	"	1	; " "	20	9	9
20	"	2	; " "	10	10	10
21	"	2	; " "	20	11	11
22	"	1	; Lamp Black,	7	12	12
23	"	1	; " "	14	13	13
24	"	2	; " "	7	14	14
25	"	2	; " "	14	15	15
27	"	1	; Graphite	14	16	16
29	"	2	; " "	14	17	17
35	"	1	; " "	28	18	18
36	"	2	; " "	28	19	19
30	Cobalt	0.025;	Carbon Black	3.5	20	20
31	"	0.025;	" "	7	21	21
32	"	0.040;	" "	3.5	22	22
33	"	0.040;	" "	7	23	23
8	Lead	1	; (No Pigment)		24	2, 5, 8, 9, 12,13,16,18.
9	"	1.5	; (" ")		24	3, 6.
10	"	2	; (" ")		24	4, 7,10,11, 14,15,17,19.
34	Cobalt	0.025;	(" ")		25	20, 21.
11	"	0.040;	(" ")		25	22, 23.

* The composition of all mixtures is expressed as parts of drier, as metal, and parts of pigment per 100 parts of linseed oil.

Table 2

Drying data for linseed oil containing 1 gram lead and 3.5 grams carbon black per 100 grams oil. (Percent oil, 93.0)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2157 g.			Wt. sample, 0.2323 g.		Wt. sample, 0.2445 g.	
Wt. oil, 0.2002 g.			Wt. oil, 0.2160 g.		Wt. oil, 0.2275 g.	
Time, Hours	Increase in weight, grams	% increase in weight of oil	Increase in weight, grams	% increase in weight of oil	Increase in weight, grams	% increase in weight of oil
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0005	0.3	0.0000	0.0	0.0000	0.0
2.5	0.0010	0.5	0.0002	0.1	0.0000	0.0
3	0.0026	1.3	0.0004	0.2	0.0002	0.1
3.5	0.0040	2.0	0.0004	0.2	0.0002	0.1
4	0.0057	2.8	0.0004	0.2	0.0005	0.2
4.5	0.0073	3.6	0.0004	0.2	0.0005	0.2
5	0.0099	5.0	0.0004	0.2	0.0005	0.2
5.5	0.0118	5.8	0.0004	0.2	0.0006	0.3
6	0.0146	7.3	0.0007	0.3	0.0007	0.3
7	0.0170	8.5	0.0025	1.2	0.0010	0.4
8	0.0198	9.9	0.0054	2.5	0.0029	1.3
9	0.0216	10.8	0.0086	4.0	0.0059	2.6
10	0.0227	11.3	0.0125	5.8	0.0081	3.6
11.5	0.0236	11.8	0.0172	8.0	0.0148	6.5
13	0.0241	12.0	0.0207	9.6	0.0189	8.3
15	0.0247	12.3	0.0227	10.5	0.0236	10.4
17	0.0249	12.4	0.0244	11.3	0.0262	11.5
20	0.0250	12.5	0.0258	12.4	0.0281	12.4
24	0.0254	12.7	0.0280	13.0	0.0293	12.9
29	0.0258	12.9	-	-	-	-
32	-	-	-	-	0.0308	13.6
35	-	-	0.0282	13.1	-	-
48	-	-	-	-	0.0308	13.6
50	-	-	0.0274	12.7	-	-

FIG 2 DRYING RATE OF LINSEED OIL
CONTAINING 1.0 GRAM OF LEAD PER 100 GRAMS OIL

Table 3

Drying data for linseed oil containing 1.5 grams lead and 3.5 grams carbon black per 100 grams oil. (Percent oil, 91.4)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2268 g.			Wt. sample, 0.2067 g.		Wt. sample, 0.2496 g.	
Wt. oil, 0.2070 g.			Wt. oil, 0.1890 g.		Wt. oil, 0.2280 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0006	0.3	0.0000	0.0	0.0000	0.0
2.5	0.0019	0.9	0.0002	0.1	0.0000	0.0
3	0.0045	2.2	0.0002	0.1	0.0000	0.0
3.5	0.0064	3.1	0.0004	0.2	0.0003	0.1
4	0.0082	4.0	0.0009	0.5	0.0003	0.1
4.5	0.0108	5.2	0.0020	1.1	0.0007	0.3
5	0.0135	6.5	0.0035	1.8	0.0010	0.4
5.5	0.0157	7.6	0.0057	3.0	0.0020	0.9
6	0.0180	8.7	0.0079	4.2	0.0033	1.4
7	0.0197	9.5	0.0138	7.3	0.0080	3.5
8	0.0216	10.4	0.0170	9.0	0.0137	6.0
9	0.0229	11.1	0.0191	10.1	0.0182	8.0
10	0.0231	11.2	0.0203	10.7	0.0204	9.0
11.5	0.0231	11.2	0.0217	11.5	0.0237	10.4
13	0.0233	11.3	0.0222	11.7	0.0257	11.3
15	0.0234	11.3	0.0234	12.3	0.0277	12.2
17	0.0234	11.3	0.0236	12.5	0.0287	12.6
20	0.0234	11.3	0.0238	12.6	0.0289	12.7
24	0.0234	11.3	0.0239	12.7	0.0293	12.8
29	0.0236	11.4	-	-	-	-
32	-	-	-	-	0.0297	13.0
35	-	-	0.0230	12.2	-	-
48	-	-	-	-	0.0293	12.8
50	-	-	0.0226	12.0	-	-

FIG 3 DRYING RATE OF LINSEED OIL
CONTAINING 1.5 GRAMS OF LEAD PER 100 GRAMS OIL

Table 4

Drying data for linseed oil containing 2 grams lead and 3.5 grams carbon black per 100 grams oil. (Percent oil, 89.4)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2461 g.			Wt. sample, 0.1783 g.		Wt. sample, 0.2346 g.	
Wt. oil, 0.2200 g.			Wt. oil, 0.1593 g.		Wt. oil, 0.2095 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0000	0.0
2.5	0.0019	0.9	0.0003	0.2	0.0000	0.0
3	0.0061	2.7	0.0006	0.4	0.0002	0.1
3.5	0.0091	4.1	0.0021	1.3	0.0006	0.3
4	0.0125	5.7	0.0038	2.4	0.0009	0.4
4.5	0.0156	7.1	0.0060	3.8	0.0015	0.7
5	0.0185	8.4	0.0099	6.2	0.0031	1.5
5.5	0.0205	9.3	0.0118	7.4	0.0055	2.6
6	0.0222	10.1	0.0134	8.4	0.0086	4.1
7	0.0245	11.2	0.0170	10.7	0.0144	6.9
8	0.0256	11.6	0.0184	11.5	0.0183	8.7
9	0.0264	12.0	0.0193	12.1	0.0215	10.3
10	0.0266	12.1	0.0194	12.2	0.0224	10.7
11.5	0.0268	12.2	0.0199	12.5	0.0238	11.4
13	0.0271	12.3	0.0201	12.6	0.0254	12.1
15	0.0272	12.4	0.0204	12.8	0.0260	12.4
17	0.0272	12.4	0.0204	12.8	0.0263	12.6
20	0.0268	12.2	0.0204	12.8	0.0267	12.8
24	0.0268	12.2	0.0204	12.8	0.0265	12.7
32	-	-	-	-	0.0261	12.5
35	-	-	0.0190	11.9	-	-
48	-	-	-	-	0.0254	12.1
50	-	-	0.0183	11.5	-	-

FIG. 4 DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS OF LEAD PER 100 GRAMS OIL

Table 5

Drying data for linseed oil containing 1 gram lead and 7 grams
carbon black per 100 grams oil. (Percent oil, 89.9)

Time, hours	<u>Freshly made sample</u>		<u>4 weeks aging</u>		<u>8 weeks aging</u>	
	Wt. sample, 0.2765 g. Wt. oil, 0.2484 g.	% increase in weight, grams. of oil.	Wt. sample, 0.2816 g. Wt. oil, 0.2528 g.	% increase in weight, grams. of oil.	Wt. sample, 0.2483 g. Wt. oil, 0.2234 g.	% increase in weight, grams. of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0000	0.0
2.5	0.0008	0.2	0.0005	0.2	0.0000	0.0
3	0.0029	1.2	0.0005	0.2	0.0000	0.0
3.5	0.0056	2.3	0.0005	0.2	0.0003	0.1
4	0.0085	3.4	0.0005	0.2	0.0003	0.1
4.5	0.0114	4.6	0.0005	0.2	0.0003	0.1
5	0.0148	6.0	0.0007	0.3	0.0003	0.1
5.5	0.0169	6.8	0.0007	0.3	0.0003	0.1
6	0.0191	7.7	0.0007	0.3	0.0003	0.1
7	0.0223	9.0	0.0007	0.3	0.0003	0.1
8	0.0234	9.4	0.0010	0.4	0.0003	0.1
9	0.0238	9.6	0.0010	0.4	0.0008	0.4
10	0.0248	10.0	0.0010	0.4	0.0011	0.5
11.5	0.0251	10.1	0.0025	1.0	0.0014	0.6
13	0.0255	10.3	0.0036	1.5	0.0034	1.5
15	0.0256	10.3	0.0115	4.5	0.0095	4.3
17	0.0256	10.3	0.0171	6.8	0.0158	7.1
20	0.0256	10.3	0.0226	9.0	0.0223	10.0
24	0.0258	10.4	0.0288	11.4	0.0259	11.6
29	0.0262	10.5	-	-	-	-
32	-	-	0.0311	12.3	0.0280	12.5
35	-	-	-	-	-	-
48	-	-	-	-	0.0290	13.0
50	-	-	0.0305	12.1	-	-

FIG 5 DRYING RATE OF LINSEED OIL
CONTAINING 1.0 GRAM LEAD PER 100 GRAMS OIL

% INCREASE IN WEIGHT OF OIL

A- 0% CARBON BLACK
B- 7.0 GRAMS CARBONBLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

Table 6

Drying data for linseed oil containing 1.5 grams lead and 7 grams carbon black per 100 grams oil. (Percent oil, 88.3)

Time, hours	<u>Freshly made sample</u>		<u>4 weeks aging</u>		<u>8 weeks aging</u>	
	Wt. sample, 0.2392 g. Wt. oil, 0.2112 g.		Wt. sample, 0.2431 g. Wt. oil, 0.2146 g.		Wt. sample, 0.1858 g. Wt. oil, 0.1640 g.	
	Increase in weight, grams.	increase in weight of oil.	Increase in weight, grams.	increase in weight of oil.	Increase in weight, grams.	increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0003	0.1	0.0000	0.0	0.0000	0.0
2.5	0.0004	0.2	0.0008	0.4	0.0000	0.0
3	0.0012	0.6	0.0021	1.0	0.0000	0.0
3.5	0.0020	0.9	0.0043	2.0	0.0002	0.1
4	0.0031	1.5	0.0060	2.8	0.0002	0.1
4.5	0.0046	2.2	0.0083	3.9	0.0003	0.2
5	0.0073	3.5	0.0116	5.4	0.0003	0.2
5.5	0.0096	4.6	0.0132	6.1	0.0007	0.4
6	0.0127	6.1	0.0148	6.9	0.0011	0.7
7	0.0159	7.6	0.0184	8.6	0.0025	1.5
8	0.0194	9.2	0.0205	9.5	0.0049	3.0
9	0.0208	9.9	0.0210	9.8	0.0083	5.1
10	0.0232	10.5	0.0220	10.2	0.0099	6.0
11.5	0.0234	11.1	0.0228	10.6	0.0129	7.9
13	0.0241	11.5	0.0230	10.7	0.0154	9.4
15	0.0249	11.8	0.0238	11.1	0.0173	10.5
17	0.0249	11.8	0.0240	11.2	0.0179	10.9
20	0.0249	11.8	0.0244	11.4	0.0189	11.5
24	0.0255	12.1	0.0246	11.5	0.0189	11.5
29	0.0259	12.3	-	-	-	-
32	-	-	-	-	0.0193	11.8
35	-	-	0.0236	11.0	-	-
48	-	-	-	-	0.0191	11.6
50	-	-	0.0234	10.9	-	-

FIG. 6 DRYING RATE OF LINSEED OIL
CONTAINING 1.5 GRAMS LEAD PER 100 GRAMS OIL

Table 7

Drying data for linseed oil containing 2 grams lead and 7 grams
carbon black per 100 grams oil. (Percent oil, 86.8)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2000 g.			Wt. sample, 0.2008 g.		Wt. sample, 0.1933 g.	
Wt. oil, 0.1738 g.			Wt. oil, 0.1740 g.		Wt. oil, 0.1678 g.	
Time, Hours	Increase in weight grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0009	0.5	0.0000	0.0	0.0000	0.0
2.5	0.0023	1.3	0.0002	0.1	0.0000	0.0
3	0.0050	2.9	0.0014	0.8	0.0000	0.0
3.5	0.0071	4.1	0.0030	1.7	0.0002	0.1
4	0.0093	5.4	0.0051	2.9	0.0002	0.1
4.5	0.0112	6.5	0.0077	4.4	0.0002	0.1
5	0.0134	7.7	0.0105	6.0	0.0004	0.2
5.5	0.0148	8.5	0.0120	6.9	0.0006	0.4
6	0.0164	9.5	0.0137	7.9	0.0012	0.7
7	0.0179	10.3	0.0166	9.5	0.0030	1.8
8	0.0193	11.1	0.0178	10.2	0.0064	3.8
9	0.0198	11.4	0.0185	10.6	0.0103	6.1
10	0.0201	11.6	0.0192	11.0	0.0123	7.3
11.5	0.0204	11.8	0.0194	11.1	0.0150	9.0
13	0.0208	12.0	0.0196	11.3	0.0171	10.2
15	0.0208	12.0	0.0201	11.5	0.0187	11.1
17	0.0207	11.9	0.0201	11.5	0.0192	11.5
20	0.0205	11.8	0.0202	11.6	0.0194	11.6
24	0.0205	11.8	0.0204	11.7	0.0197	11.7
32	-	-	-	-	0.0200	11.9
35	-	-	0.0194	11.1	-	-
48	-	-	-	-	0.0197	11.7
50	-	-	0.0188	10.8	-	-

FIG. 7 DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS LEAD PER 100 GRAMS OIL

% INCREASE IN WEIGHT OF OIL

The drying curves for linseed oil containing lead drier and carbon black, Figures 2, 3, 4, 5, 6 and 7, show that a freshly made carbon black paint has approximately the same drying time as unpigmented oil having the same drier concentration. The length of the induction period and the time for reaching a maximum per cent increase in weight of oil was approximately the same in each case for freshly made carbon black paint and unpigmented oil of equal drier concentration, although the maximum per cent increase in weight of oil of the unpigmented sample was about one per cent greater than the corresponding increase for the freshly made carbon black sample. The effect of aging was to increase the time of the induction period in each case. The slope of all the curves in the constant drying rate period, which immediately follows the induction period, was approximately the same, showing there was no change of drying rate during this period. However, a decreasing constant rate period was noted with increase in age of the sample.

These curves all show that the drying time of a linseed oil - lead dryer - carbon black mixture changes considerably with increase in age of the mixture; and that the increase in drying time is larger for mixtures of higher carbon black concentration.

Table 8

Drying data for linseed oil containing 1 gram lead and 10 grams
boneblack per 100 grams oil. (Percent oil, 87.6)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2900 g.			Wt. sample, 0.2727 g.		Wt. sample, 0.2502 g.	
Wt. oil, 0.2540 g.			Wt. oil, 0.2390 g.		Wt. oil, 0.2194 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0002	0.1	0.0000	0.0	0.0000	0.0
3	0.0004	0.2	0.0000	0.0	0.0000	0.0
4	0.0004	0.2	0.0000	0.0	0.0002	0.1
5	0.0004	0.2	0.0000	0.0	0.0005	0.2
6	0.0004	0.2	0.0000	0.0	0.0006	0.3
7	0.0004	0.2	0.0000	0.0	0.0006	0.3
8	0.0004	0.2	0.0000	0.0	0.0006	0.3
9	0.0004	0.2	0.0000	0.0	0.0006	0.3
10	0.0009	0.4	0.0000	0.0	0.0006	0.3
11.5	0.0022	0.9	0.0000	0.0	0.0006	0.3
13	0.0036	1.4	0.0000	0.0	0.0006	0.3
15	0.0068	2.7	0.0005	0.2	0.0006	0.3
17	0.0104	4.1	0.0011	0.5	0.0011	0.5
20	0.0160	6.3	0.0056	2.3	0.0036	1.7
24	0.0232	9.1	0.0112	4.7	0.0071	3.3
28	0.0299	11.8	0.0200	8.4	-	-
30	-	-	-	-	0.0154	7.1
37	-	-	-	-	0.0243	11.2
48	-	-	0.0325	13.6	0.0290	13.4
50	0.0343	13.9	-	-	-	-

FIG. 8 DRYING RATE OF LINSEED OIL
CONTAINING 10 GRAM LEAD PER 100 GRAMS OIL

A- 0% BONE BLACK
B- 10 GRAMS BONE BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " AGED 4 WEEKS
D- " " " " " " " " AGED 8 WEEKS

Table 9

Drying data for linseed oil containing 1 gram lead and 20 grams
bone black per 100 grams oil. (Percent oil, 80.5)

	<u>Freshly made sample</u>		<u>4 weeks aging</u>		<u>8 weeks aging</u>	
	Wt. sample, 0.3096 g.		Wt. sample, 0.2570 g.		Wt. sample, 0.2717 g.	
	Wt. oil, 0.2490 g.		Wt. oil, 0.2068 g.		Wt. oil, 0.2184 g.	
Time, Hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0000	0.0
3	0.0000	0.0	0.0000	0.0	0.0000	0.0
4	0.0000	0.0	0.0000	0.0	0.0004	0.2
5	0.0000	0.0	0.0012	0.6	0.0005	0.2
6	0.0000	0.0	0.0012	0.6	0.0005	0.2
7	0.0004	0.2	0.0012	0.6	0.0005	0.2
8	0.0004	0.2	0.0012	0.6	0.0005	0.2
9	0.0015	0.6	0.0012	0.6	0.0005	0.2
10	0.0015	0.6	0.0012	0.6	0.0005	0.2
11.5	0.0029	1.2	0.0012	0.6	0.0005	0.2
13	0.0053	2.1	0.0012	0.6	0.0009	0.4
15	0.0071	2.9	0.0028	1.4	0.0050	1.4
17	0.0086	3.5	0.0045	2.1	0.0051	2.3
20	0.0116	4.6	0.0087	4.2	0.0089	4.1
24	0.0153	6.1	0.0136	6.6	0.0124	5.7
28	0.0217	8.7	0.0196	9.5	-	-
32	-	-	-	-	0.0186	8.5
39	-	-	-	-	0.0250	11.4
48	-	-	0.0258	12.5	0.0277	12.7
50	0.0231	9.3	-	-	-	-

FIG. 9 DRYING RATE OF LINSEED OIL
CONTAINING 1.0 GRAM OF LEAD PER 100 GRAMS OIL

- A- 0% BONE BLACK
B- 20 GRAMS BONE BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

Table 10

Drying data for linseed oil containing 2 grams lead and 10 grams
bone black per 100 grams oil. (Percent oil, 84.6)

	<u>Freshly made sample</u>		<u>4 weeks aging</u>		<u>8 weeks aging</u>	
	Wt. sample, 0.2165 g.		Wt. sample, 0.2432 g.		Wt. sample, 0.2547 g.	
	Wt. oil, 0.1826 g.		Wt. oil, 0.2058 g.		Wt. oil, 0.2160 g.	
Time, Hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0000	0.0
3	0.0000	0.0	0.0000	0.0	0.0000	0.0
4	0.0004	0.2	0.0000	0.0	0.0000	0.0
5	0.0026	1.4	0.0000	0.0	0.0000	0.0
6	0.0065	3.6	0.0000	0.0	0.0000	0.0
7	0.0110	6.0	0.0002	0.1	0.0003	0.1
8	0.0149	8.2	0.0002	0.1	0.0005	0.2
9	0.0179	9.8	0.0030	1.5	0.0007	0.3
10	0.0194	10.6	0.0066	3.2	0.0009	0.4
11.5	0.0212	11.6	0.0105	5.1	0.0011	0.5
13	0.0227	12.5	0.0142	6.9	0.0041	1.9
15	0.0231	12.7	0.0183	8.9	0.0094	4.4
17	0.0231	12.7	0.0222	10.8	0.0203	9.4
20	0.0231	12.7	0.0248	11.6	0.0250	11.6
24	0.0231	12.7	0.0263	12.8	0.0265	12.3
28	0.0231	12.7	0.0276	13.4	-	-
32	-	-	-	-	0.0278	12.9
39	-	-	-	-	0.0278	12.9
48	-	-	0.0261	12.7	0.0275	12.7
50	0.0217	11.9	-	-	-	-

FIG. 10 DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS OF LEAD PER 100 GRAMS OIL

A-0% BONE BLACK

B-10 GRAMS BONE BLACK PER 100 GRAMS OIL; FRESHLY MADE

C- " " " " " " " " ; AGED 4 WEEKS

D- " " " " " " " " ; AGED 8 WEEKS

% INCREASE IN WEIGHT OF OIL

12
10
8
6
4
2
0

0

5

10

15

20

25

30

35

40

45

50

TIME IN HOURS

Table 11

Drying date for linseed oil containing 2 grams lead and 20 grams
bone black per 100 grams oil. (Percent oil, 78.0)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2048 g.			Wt. sample, 0.2651 g.		Wt. sample, 0.2391 g.	
Wt. oil, 0.1600 g.			Wt. oil, 0.2066 g.		Wt. oil, 0.1863 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0002	0.1
3	0.0000	0.0	0.0000	0.0	0.0002	0.1
4	0.0000	0.0	0.0000	0.0	0.0002	0.1
5	0.0003	0.2	0.0000	0.0	0.0002	0.1
6	0.0003	0.2	0.0000	0.0	0.0002	0.1
7	0.0003	0.2	0.0003	0.1	0.0002	0.1
8	0.0010	0.6	0.0003	0.1	0.0002	0.1
9	0.0025	1.6	0.0003	0.1	0.0002	0.1
10	0.0034	2.1	0.0003	0.1	0.0002	0.1
11.5	0.0059	3.7	0.0004	0.2	0.0002	0.1
13	0.0081	5.1	0.0006	0.3	0.0007	0.4
15	0.0113	7.1	0.0033	1.6	0.0032	1.7
17	0.0136	8.5	0.0073	3.5	0.0060	3.2
20	0.0160	10.0	0.0144	7.0	0.0107	5.7
24	0.0182	11.4	0.0196	9.5	0.0149	8.0
28	0.0196	12.3	0.0232	11.2	-	-
32	-	-	-	-	0.0192	10.2
39	-	-	-	-	0.0217	11.7
48	-	-	0.0244	11.8	0.0221	11.9
50	0.0209	13.1	-	-	-	-

FIG. II DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS OF LEAD PER 100 GRAMS OIL

A- 0 % BONE BLACK
B- 20 GRAMS BONE BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

% INCREASE IN WEIGHT OF OIL

The drying curves for linseed oil containing lead drier and bone black, Figures 8, 9, 10, and 11, show, unlike the curves for carbon black mixtures, an induction period for the freshly made bone black samples about two to ten times as long as the induction period for unpigmented oil. Also unlike the carbon black curves, the bone black curves have a slope different from the slope of unpigmented oil curves, showing that bone black affects the rate of drying during the constant rate period. The effect of aging is to increase greatly the induction period and hence the time of final drying. Increase of drying time was greater for mixtures of higher bone black concentration; this corresponded to the behavior of carbon black samples. The loss of drying power with increase in age was much greater for bone black mixtures was much greater than for corresponding carbon black mixtures.

Table 12

Drying date for linseed oil containing 1 gram lead and 7 grams
lamp black per 100 grams oil. (Percent oil, 90.8)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2595 g.			Wt. sample, 0.2350 g.		Wt. sample, 0.2203 g.	
Wt. oil, 0.2355 g.			Wt. oil, 0.2134 g.		Wt. oil, 0.2000 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0002	0.1	0.0000	0.0	0.0000	0.0
2	0.0003	0.1	0.0000	0.0	0.0003	0.2
2.5	0.0006	0.3	0.0000	0.0	0.0005	0.3
3	0.0009	0.4	0.0003	0.1	0.0005	0.3
3.5	0.0018	0.8	0.0005	0.2	0.0010	0.5
4	0.0032	1.4	0.0012	0.6	0.0012	0.6
4.5	0.0049	2.1	0.0020	0.9	0.0015	0.8
5	0.0074	3.1	0.0032	1.5	0.0016	0.8
5.5	0.0102	4.3	-	-	0.0028	1.4
6	0.0121	5.1	0.0087	4.1	0.0049	2.5
7	0.0169	7.2	0.0114	5.3	0.0080	4.0
8	0.0211	9.0	0.0156	7.3	0.0111	5.5
9	0.0231	9.8	0.0198	9.3	0.0148	7.4
10	0.0249	10.6	0.0222	10.4	0.0182	9.1
11.5	0.0267	11.4	0.0241	11.3	0.0219	11.0
13	0.0278	11.8	0.0253	11.9	0.0239	12.0
15	0.0286	12.1	0.0260	12.2	0.0246	12.3
17	0.0286	12.1	0.0269	12.6	0.0258	12.9
20	0.0296	12.6	0.0277	13.0	0.0264	13.2
24	-	-	0.0279	13.1	0.0268	13.4
28	-	-	0.0283	13.3	-	-
32	0.0299	12.7	-	-	0.0271	13.6
39	-	-	-	-	0.0268	13.4
48	-	-	0.0283	13.3	0.0271	13.6

FIG 12 DRYING RATE OF LINSEED OIL
CONTAINING 1.0 GRAM OF LEAD PER 100 GRAMS OIL

- A- 0% LAMP BLACK
B- 7 GRAMS LAMP BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

Table 13

Drying date for linseed oil containing 1 gram lead and 14 grams

lamp black per 100 grams oil. (Percent oil, 84.5)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.3015 g.			Wt. sample, 0.2298 g.		Wt. sample, 0.2201 g.	
Wt. oil, 0.2547 g.			Wt. oil, 0.1940 g.		Wt. oil, 0.1860 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0002	0.1	0.0000	0.0	0.0013	0.7
2.5	0.0004	0.2	0.0009	0.5	0.0017	0.9
3	0.0009	0.4	0.0010	0.5	0.0027	1.5
3.5	0.0020	0.8	0.0019	1.0	0.0038	2.0
4	0.0036	1.4	0.0034	1.8	0.0053	2.8
4.5	0.0057	2.2	0.0054	2.8	0.0068	3.7
5	0.0087	3.4	0.0075	3.9	0.0078	4.2
5.5	0.0112	4.4	-	-	0.0093	5.0
6	0.0128	5.0	0.0114	5.9	0.0116	6.2
7	0.0169	6.6	0.0133	6.9	0.0135	7.3
8	0.0206	8.1	0.0162	8.4	0.0155	8.3
9	0.0233	9.2	0.0186	9.6	0.0171	9.2
10	0.0247	9.7	0.0200	10.3	0.0188	10.1
11.5	0.0268	10.5	0.0212	10.9	0.0204	11.0
13	0.0279	11.0	0.0221	11.4	0.0215	11.5
15	0.0287	11.3	0.0227	11.7	0.0221	11.9
17	0.0289	11.3	0.0230	11.9	0.0226	12.2
20	0.0291	11.4	0.0240	12.4	0.0230	12.4
24	0.0297	11.6	0.0240	12.4	0.0233	12.5
28	-	-	0.0242	12.5	-	-
32	0.0305	12.0	-	-	0.0235	12.6
39	-	-	-	-	0.0234	12.6
48	-	-	0.0240	12.4	0.0230	12.4

FIG 13 DRYING RATE OF LINSEED OIL
CONTAINING 10 GRAM OF LEAD PER 100 GRAMS OIL

A-0% LAMP BLACK
B-14 GRAMS LAMP BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

Table 14

Drying date for linseed oil containing 2 grams lead and 7 grams
lamp black per 100 grams oil. (Percent oil, 86.8)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2779 g.			Wt. sample, 0.0862 g.		Wt. sample, 0.2537 g.	
Wt. oil, 0.2415 g.			Wt. oil, 0.1618 g.		Wt. oil, 0.2200 g.	
Time, hours,	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0000	0.0
2.5	0.0002	0.1	0.0000	0.0	0.0002	0.1
3	0.0017	0.7	0.0005	0.3	0.0006	0.3
3.5	0.0051	2.1	0.0015	0.9	0.0015	0.7
4	0.0093	3.8	0.0042	2.6	0.0040	1.8
4.5	0.0130	5.4	0.0079	4.9	0.0066	3.0
5	0.0163	6.8	0.0118	7.3	0.0105	4.8
5.5	0.0189	7.8	-	-	0.0132	6.0
6	0.0202	8.4	0.0159	9.8	0.0171	7.8
7	0.0234	9.7	0.0174	10.9	0.0207	9.4
8	0.0251	10.4	0.0185	11.4	0.0216	9.8
9	0.0262	10.9	0.0195	12.1	0.0239	10.9
10	0.0270	11.2	0.0199	12.3	0.0249	11.3
11.5	0.0275	11.4	0.0201	12.4	0.0256	11.6
13	0.0278	11.5	0.0203	12.5	0.0262	11.9
15	0.0282	11.7	0.0200	12.4	0.0264	12.0
17	0.0283	11.7	0.0196	12.1	0.0265	12.1
20	0.0274	11.3	0.0198	12.2	0.0266	12.1
24	0.0274	11.3	0.0196	12.1	0.0266	12.1
28	-	-	0.0199	12.3	-	-
32	0.0277	11.5	-	-	0.0266	12.1
39	-	-	-	-	0.0264	12.0
48	-	-	0.0197	12.2	0.0255	11.6

FIG. 14 DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS OF LEAD PER 100 GRAMS OIL

A- 0% LAMP BLACK
B- 7 GRAMS LAMP BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

Table 15

Drying data for linseed oil containing 2 grams lead and 14 grams
lamp black per 100 grams oil. (Percent oil, 81.7)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.3288 g.			Wt. sample, 0.2680 g.		Wt. sample, 0.2084 g.	
Wt. oil, 0.2682 g.			Wt. oil, 0.2186 g.		Wt. oil, 0.1702 g.	
Time, hours,	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0003	0.2
2.5	0.0004	0.2	0.0000	0.0	0.0003	0.2
3	0.0016	0.6	0.0002	0.1	0.0003	0.2
3.5	0.0046	1.7	0.0004	0.2	0.0007	0.4
4	0.0109	4.1	0.0017	0.8	0.0021	1.2
4.5	0.0119	4.4	0.0058	2.7	0.0045	2.6
5	0.0151	5.6	0.0097	4.4	0.0058	3.4
5.5	0.0180	6.7	-	-	0.0080	4.7
6	0.0195	7.3	0.0160	7.3	0.0115	6.8
7	0.0232	8.7	0.0185	8.5	0.0148	8.7
8	0.0255	9.5	0.0210	9.6	0.0167	9.8
9	0.0270	10.1	0.0231	10.6	0.0184	10.8
10	0.0280	10.4	0.0243	11.1	0.0196	11.5
11.5	0.0288	10.7	0.0247	11.3	0.0202	11.9
13	0.0294	11.0	0.0253	11.6	0.0203	11.9
15	0.0294	11.0	0.0253	11.6	0.0207	12.2
17	0.0292	10.9	0.0255	11.7	0.0209	12.3
20	0.0294	11.0	0.0259	11.8	0.0211	12.4
24	0.0298	11.1	0.0259	11.8	0.0209	12.3
28	-	-	0.0263	12.0	-	-
32	0.0301	11.2	-	-	0.0207	12.2
39	-	-	-	-	0.0210	12.3
48	-	-	0.0256	11.7	0.0201	11.8

FIG. 15 DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS OF LEAD PER 100 GRAMS OIL

A- 0% LAMP BLACK
B- 14 GRAMS LAMP BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

The drying curves for linseed oil containing lead drier and lamp black, Figures 12, 13, 14, and 15, show very small difference in induction period between freshly made lamp black samples and unpigmented oil, and practically no difference in induction period between the freshly made samples and the same samples when aged. The drying of the lamp black samples was very similar to the drying of unpigmented oil. The lamp black samples, unlike the carbon black samples and the bone black samples, showed no appreciable loss in drying power at four weeks and eight weeks time after preparation.

Table 16

Drying date for linseed oil containing 1 gram lead and 14 grams
graphite per 100 grams oil. (Percent oil, 84.7)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2531 g.			Wt. sample, 0.2486 g.		Wt. sample, 0.2473 g.	
Wt. oil, 0.2140 g.			Wt. oil, 0.2105 g.		Wt. oil, 0.2094 g.	
Time, hours,	Increase in weight, grams.	% increase in weight of oil.	Increase in weight grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0004	0.2	0.0000	0.0	0.0007	0.3
2.5	0.0007	0.3	0.0002	0.1	0.0007	0.3
3	0.0020	0.9	0.0006	0.3	0.0013	0.6
3.5	0.0041	1.9	0.0020	0.9	0.0023	1.1
4	0.0063	2.9	0.0050	2.4	0.0046	2.2
4.5	0.0094	4.4	0.0080	3.8	0.0065	3.1
5	0.0122	5.7	0.0103	5.1	0.0090	4.3
5.5	0.0146	6.8	-	-	0.0111	5.3
6	0.0166	7.8	0.0170	8.1	0.0150	7.2
7	0.0197	9.2	0.0194	9.2	0.0180	8.6
8	0.0222	10.4	0.0221	10.5	0.0207	9.9
9	0.0240	11.2	0.0248	11.8	0.0233	11.1
10	0.0249	11.6	0.0263	12.5	0.0250	12.0
11.5	0.0263	12.3	0.0272	12.9	0.0266	12.7
13	0.0271	12.7	0.0280	13.3	0.0272	13.0
15	0.0273	12.8	0.0287	13.6	0.0281	13.4
17	0.0278	13.0	0.0290	13.8	0.0288	13.6
20	0.0281	13.1	0.0293	13.9	0.0288	13.8
24	-	-	0.0293	13.9	0.0286	13.7
27	0.0285	13.3	0.0293	13.9	-	-
32	-	-	-	-	0.0286	13.7
35	0.0289	13.3	-	-	-	-
39	-	-	-	-	0.0284	13.6
48	-	-	0.0289	13.7	0.0273	13.1

FIG 16 DRYING RATE OF LINSEED OIL
CONTAINING 1.0 GRAM OF LEAD PER 100 GRAMS OIL

Table 17

Drying data for linseed oil containing 2 grams lead and 14 grams
graphite per 100 grams oil. (Percent oil, 81.9)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2766 g.			Wt. sample, 0.2537 g.		Wt. sample, 0.2937 g.	
Wt. oil, 0.2264 g.			Wt. oil, 0.2074 g.		Wt. oil, 0.2400 g.	
Time,	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0004	0.2	0.0000	0.0
2.5	0.0012	0.5	0.0023	1.1	0.0003	0.1
3	0.0047	2.1	0.0040	1.9	0.0013	0.5
3.5	0.0096	4.2	0.0071	3.4	0.0030	1.3
4	0.0131	5.8	0.0119	5.7	0.0077	3.2
4.5	0.0165	7.3	0.0149	7.2	0.0109	4.5
5	0.0188	8.3	0.0173	8.2	0.0145	6.0
5.5	0.0207	9.1	-	-	0.0169	7.0
6	0.0220	9.7	0.0206	10.0	0.0201	8.4
7	0.0244	10.8	0.0219	10.6	0.0225	9.4
8	0.0254	11.2	0.0231	11.1	0.0243	10.1
9	0.0262	11.5	0.0241	11.6	0.0258	10.7
10	0.0267	11.8	0.0244	11.8	0.0264	11.0
11.5	0.0272	12.0	0.0246	11.9	0.0271	11.3
13	0.0274	12.1	0.0249	12.0	0.0277	11.5
15	0.0274	12.1	0.0249	12.0	0.0279	11.6
17	0.0274	12.1	0.0247	11.9	0.0281	11.7
20	0.0275	12.1	0.0247	11.9	0.0281	11.7
24	-	-	0.0247	11.9	0.0281.	11.7
27	0.0276	12.2	0.0247	11.9	-	-
32	-	-	-	-	0.0278	11.6
35	0.0274	12.1	-	-	-	-
39	-	-	-	-	0.0274	11.4
48	-	-	0.0245	11.8	0.0268	11.2

FIG 17 DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS OF LEAD PER 100 GRAMS OIL

Table 18

Drying data for linseed oil containing 1 gram lead and 28 grams
graphite per 100 grams oil. (Percent oil, 75.7)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2051 g.			Wt. sample, 0.2583 g.		Wt. sample, 0.3389 g.	
Wt. oil, 0.1551 g.			Wt. oil, 0.1956 g.		Wt. oil, 0.2565 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0013	0.8	0.0010	0.5	0.0000	0.0
2.5	0.0026	1.7	0.0039	2.0	0.0014	0.5
3	0.0044	2.8	0.0055	2.8	0.0042	1.6
3.5	0.0059	3.8	0.0080	4.1	0.0062	2.4
4	0.0079	5.1	0.0114	5.8	0.0111	4.3
4.5	0.0095	6.1	0.0145	7.4	0.0136	5.3
5	0.0120	7.7	0.0169	8.6	0.0163	6.3
5.5	0.0133	8.6	-	-	0.0188	7.3
6	0.0149	9.6	0.0203	10.4	0.0217	8.5
7	0.0166	10.7	0.0210	10.7	0.0239	9.3
8	0.0186	12.0	0.0224	11.5	0.0259	10.1
9	0.0200	12.9	0.0234	12.0	0.0276	10.8
10	0.0205	13.5	0.0241	12.3	0.0290	11.3
11.5	0.0209	13.5	0.0242	12.4	0.0297	11.6
13	0.0209	13.5	0.0246	12.6	0.0301	11.7
15	0.0209	13.5	0.0248	12.7	0.0308	12.0
17	0.0209	13.5	0.0250	12.8	0.0312	12.2
20	0.0207	13.3	0.0255	13.0	0.0317	12.4
24	0.0205	13.2	0.0255	13.0	0.0317	12.4
28	0.0201	13.0	0.0249	12.7	-	-
32	-	-	-	-	0.0317	12.4
39	-	-	-	-	0.0309	12.0
48	-	-	0.0248	12.7	0.0301	11.7
50	0.0196	12.6	-	-	-	-

FIG. 18 DRYING RATE OF LINSEED OIL
CONTAINING 1.0 GRAMS OF LEAD PER 100 GRAMS OIL

Table 19

Drying data for linseed oil containing 2 grams lead and 28 grams graphite per 100 grams oil. (Percent oil, 73.3)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.3323 g.			Wt. sample, 0.2250 g.		Wt. sample, 0.3169 g.	
Wt. oil, 0.2440 g.			Wt. oil, 0.1650 g.		Wt. oil, 0.2322 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0009	0.4	0.0007	0.4	0.0000	0.0
2.5	0.0023	0.9	0.0023	1.4	0.0017	0.7
3	0.0057	2.3	0.0042	2.5	0.0038	1.6
3.5	0.0084	3.4	0.0065	3.9	0.0060	2.6
4	0.0123	5.0	0.0100	6.1	0.0118	5.1
4.5	0.0144	5.9	0.0121	7.3	0.0142	6.1
5	0.0183	7.5	0.0136	8.2	0.0168	7.2
5.5	0.0202	8.3	-	-	0.0183	7.9
6	0.0217	8.9	0.0163	9.9	0.0203	8.7
7	0.0241	9.9	0.0168	10.2	0.0221	9.5
8	0.0259	10.6	0.0175	10.6	0.0231	9.8
9	0.0270	11.1	0.0177	10.7	0.0241	10.4
10	0.0277	11.4	0.0177	10.7	0.0250	10.8
11.5	0.0281	11.5	0.0178	10.8	0.0253	10.9
13	0.0283	11.6	0.0178	10.8	0.0258	11.1
15	0.0283	11.6	0.0178	10.8	0.0259	11.2
17	0.0283	11.6	0.0178	10.8	0.0262	11.3
20	0.0283	11.6	0.0178	10.8	0.0266	11.5
24	0.0283	11.6	0.0173	10.5	0.0262	11.3
28	0.0283	11.6	0.0171	10.4	-	-
32	-	-	-	-	0.0264	11.4
39	-	-	-	-	0.0260	11.2
48	-	-	0.0171	10.4	0.0254	10.9
50	0.0281	11.5	-	-	-	-

FIG 19 DRYING RATE OF LINSEED OIL
CONTAINING 2.0 GRAMS LEAD PER 100 GRAMS OIL

The drying curves for linseed oil containing lead drier and graphite, Figures 16, 17, 18, and 19, showed approximately equal induction periods, as was the case with the lamp black samples. The graphite samples were also like the lamp black samples in that the curves were similar throughout the drying period, and that there was no great loss of drying power with increase in age , up to eight weeks.

Table 20

Drying data for linseed oil containing 0.025 gram cobalt and 3.5 grams carbon black per 100 grams oil. (Percent oil, 96.4)

Time, hours	<u>Freshly made sample</u>		<u>4 weeks aging</u>		<u>8 weeks aging</u>	
	Wt. sample, 0.2818 g. Wt. oil, 0.2718 g.	% increase in weight, grams. of oil.	Wt. sample, 0.2630 g. Wt. oil, 0.2535 g.	% increase in weight, grams. of oil.	Wt. sample, 0.2175 g. Wt. oil, 0.2085 g.	% increase in weight, grams. of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0007	0.3
2.5	0.0000	0.0	0.0000	0.0	0.0007	0.3
3	0.0003	0.1	0.0000	0.0	0.0007	0.3
3.5	0.0015	0.6	0.0007	0.3	0.0007	0.3
4	0.0026	1.0	0.0022	0.9	0.0009	0.4
4.5	0.0049	1.8	0.0045	1.8	0.0009	0.4
5	0.0074	2.7	0.0075	3.0	0.0009	0.4
5.5	0.0104	3.8	-	-	0.0009	0.4
6	0.0134	4.9	0.0137	5.4	0.0009	0.4
7	0.0196	7.2	0.0167	6.6	0.0009	0.4
8	0.0237	8.7	0.0211	8.3	0.0009	0.4
9	0.0270	9.9	0.0251	9.9	0.0009	0.4
10	0.0296	10.9	0.0266	10.5	0.0009	0.4
11.5	0.0308	11.3	0.0279	11.0	0.0012	0.6
13	0.0312	11.5	0.0288	11.4	0.0028	1.3
15	0.0320	11.8	0.0288	11.4	0.0068	3.3
17	0.0321	11.8	0.0292	11.5	0.0118	5.7
20	0.0319	11.7	0.0294	11.6	0.0208	10.0
24	-	-	0.0294	11.6	0.0262	10.9
27	0.0319	11.7	0.0288	11.4	-	-
32	-	-	-	-	0.0288	13.7
35	0.0317	11.7	-	-	-	-
39	-	-	-	-	0.0279	13.4
48	-	-	0.0287	11.3	0.0268	12.8

FIG. 20 DRYING RATE OF LINSEED OIL
CONTAINING 0.025 GRAM COBALT PER 100 GRAMS OIL

- A-0% CARBON BLACK
B-3.5 GRAMS CARBON BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

Table 21

Drying data for linseed oil containing 0.025 gram cobalt and 7 grams carbon black per 100 grams oil. (Percent oil, 93.2)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2723 g.			Wt. sample, 0.2203 g.		Wt. sample, 0.2321 g.	
Wt. oil, 0.2540 g.			Wt. oil, 0.2056 g.		Wt. oil, 0.2161 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0004	0.2
2.5	0.0000	0.0	0.0000	0.0	0.0004	0.2
3	0.0000	0.0	0.0000	0.0	0.0006	0.2
3.5	0.0000	0.0	0.0002	0.1	0.0006	0.2
4	0.0000	0.0	0.0002	0.1	0.0006	0.2
4.5	0.0000	0.0	0.0002	0.1	0.0006	0.2
5	0.0000	0.0	0.0002	0.1	0.0006	0.2
5.5	0.0000	0.0	-	-	0.0007	0.3
6	0.0002	0.1	0.0002	0.1	0.0007	0.3
7	0.0015	0.5	0.0002	0.1	0.0007	0.3
8	0.0026	1.0	0.0002	0.1	0.0007	0.3
9	0.0062	2.3	0.0002	0.1	0.0007	0.3
10	0.0113	4.2	0.0004	0.2	0.0007	0.3
11.5	0.0183	6.7	0.0010	0.5	0.0007	0.3
13	0.0231	8.5	0.0020	1.0	0.0007	0.3
15	0.0267	9.9	0.0068	3.3	0.0009	0.4
17	0.0298	11.0	0.0128	6.2	0.0016	0.8
20	0.0305	11.2	0.0140	11.7	0.0018	0.8
24	-	-	0.0274	13.3	0.0018	0.8
27	0.0307	11.3	0.0278	13.5	-	-
32	-	-	-	-	0.0023	1.1
35	0.0302	11.1	-	-	-	-
39	-	-	-	-	0.0057	2.6
48	-	-	0.0276	13.4	0.0167	7.2

FIG. 21 DRYING RATE OF LINSEED OIL
CONTAINING 0.025 GRAM COBALT PER 100 GRAMS OIL

A- 0% CARBON BLACK
B- 7 GRAMS CARBON BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

% INCREASE IN WEIGHT OF OIL

Table 22

Drying data for linseed oil containing 0.04 gram cobalt and 3.5 grams carbon black per 100 grams oil. (Percent oil, 96.2)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2406 g.			Wt. sample, 0.2237 g.		Wt. sample, 0.2377 g.	
Wt. oil, 0.2314 g.			Wt. oil, 0.2146 g.		Wt. oil, 0.2282 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0012	0.5	0.0000	0.0	0.0000	0.3
2.5	0.0029	1.3	0.0000	0.0	0.0000	0.3
3	0.0054	2.3	0.0000	0.0	0.0000	0.3
3.5	0.0097	4.2	0.0000	0.0	0.0000	0.3
4	0.0128	5.5	0.0000	0.0	0.0006	0.3
4.5	0.0160	6.9	0.0000	0.0	0.0006	0.3
5	0.0190	8.2	0.0000	0.0	0.0006	0.3
5.5	0.0207	9.0	0.0000	0.0	0.0006	0.3
6	0.0223	9.7	0.0000	0.0	0.0006	0.3
7	0.0232	10.9	0.0000	0.0	0.0006	0.3
8	0.0257	11.1	0.0000	0.0	0.0006	0.3
9	0.0260	11.2	0.0000	0.0	0.0006	0.3
10	0.0263	11.4	0.0005	0.2	0.0012	0.5
11.5	0.0260	11.2	0.0012	0.6	0.0014	0.6
13	0.0260	11.2	0.0022	1.0	0.0018	0.8
15	0.0263	11.4	0.0112	5.2	0.0050	2.2
17	0.0258	11.2	0.0210	9.8	0.0121	5.3
20	0.0258	11.2	0.0263	12.2	0.0156	6.8
24	-	-	0.0267	12.4	0.0196	8.6
27	0.0256	11.1	0.0267	12.4	-	-
32	-	-	-	-	0.0203	8.9
35	0.0251	10.9	-	-	-	-
39	-	-	-	-	0.0190	8.3
48	-	-	0.0264	12.2	0.0180	7.9

FIG. 22 DRYING RATE OF LINSEED OIL
CONTAINING 0.04 GRAM COBALT PER 100 GRAMS OIL

A- 0% CARBON BLACK
B- 3.5 GRAMS CARBON BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

Table 23

Drying data for linseed oil containing 0.04 gram cobalt and 7 grams carbon black per 100 grams oil. (Percent oil, 93.0)

<u>Freshly made sample</u>			<u>4 weeks aging</u>		<u>8 weeks aging</u>	
Wt. sample, 0.2043 g.			Wt. sample, 0.2355 g.		Wt. sample, 0.2098 g.	
Wt. oil, 0.1900 g.			Wt. oil, 0.2188 g.		Wt. oil, 0.1950 g.	
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0000	0.0	0.0002	0.1
2.5	0.0000	0.0	0.0000	0.0	0.0003	0.2
3	0.0003	0.2	0.0000	0.0	0.0003	0.2
3.5	0.0016	0.8	0.0000	0.0	0.0003	0.2
4	0.0030	1.6	0.0000	0.0	0.0003	0.2
4.5	0.0056	3.0	0.0000	0.0	0.0003	0.2
5	0.0080	4.2	0.0000	0.0	0.0004	0.2
5.5	0.0105	5.5	0.0000	0.0	0.0008	0.4
6	0.0133	7.0	0.0000	0.0	0.0008	0.4
7	0.0180	9.5	0.0000	0.0	0.0008	0.4
8	0.0200	10.5	0.0000	0.0	0.0008	0.4
9	0.0216	11.4	0.0000	0.0	0.0008	0.4
10	0.0226	11.9	0.0000	0.0	0.0008	0.4
11.5	0.0226	11.9	0.0000	0.0	0.0008	0.4
13	0.0230	12.1	0.0000	0.0	0.0008	0.4
15	0.0230	12.1	0.0000	0.0	0.0012	0.6
17	0.0226	11.9	0.0000	0.0	0.0013	0.7
20	0.0223	11.7	0.0007	0.3	0.0021	1.1
24	-	-	0.0021	1.0	0.0024	1.2
27	0.0223	11.7	0.0119	5.4	-	-
32	-	-	-	-	0.0078	4.0
35	0.0217	11.4	-	-	-	-
39	-	-	-	-	0.0240	12.3
48	-	-	0.0271	12.4	0.0252	12.9

FIG. 23 DRYING RATE OF LINSEED OIL
CONTAINING 0.04 GRAM COBALT PER 100 GRAMS OIL

A- 0% CARBON BLACK
B- 7 GRAMS CARBON BLACK PER 100 GRAMS OIL; FRESHLY MADE
C- " " " " " " " " ; AGED 4 WEEKS
D- " " " " " " " " ; AGED 8 WEEKS

% INCREASE IN WEIGHT OF OIL

The drying curves for linseed oil containing cobalt drier and carbon black were unlike the curves for carbon black samples with lead drier in most respects. The induction period of the freshly made sample of oil and carbon black with cobalt drier was much greater than the induction period of the unpigmented oil except in the case of linseed oil containing 0.025 gram cobalt per 100 grams oil. This exception, however, is contradictory to the general trend of the data. In the case of curves not showing an exceptionally long induction period, the slope of the curves during the constant drying rate period was the same; this corresponds to the behavior of carbon black samples with lead drier.

Table 24

Drying data for linseed oil containing lead drier, with no pigment.

Oil containing 1 gram lead <u>per 100 grams oil.</u>			Oil containing 1.5 grams lead <u>per 100 grams oil.</u>			Oil containing 2.0 grams lead <u>per 100 grams oil.</u>		
Percent oil, 95.7.			Percent oil, 94.3.			Percent oil, 92.5.		
Wt. sample, 0.1161 g.			Wt. sample, 0.1747 g.			Wt. sample, 0.1745 g.		
Wt. oil, 0.1112 g.			Wt. oil, 0.1643 g.			Wt. oil, 0.1612 g.		
Time, hours	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.		
1	0.0000	0.0	0.0000	0.0	0.0000	0.0		
2	0.0004	0.4	0.0005	0.3	0.0005	0.3		
2.5	0.0007	0.6	0.0005	0.3	0.0010	0.6		
3	0.0008	0.7	0.0017	1.0	0.0033	2.0		
3.5	0.0014	1.3	0.0033	2.0	0.0059	3.7		
4	0.0025	2.1	0.0049	3.0	0.0089	5.5		
4.5	0.0033	3.0	0.0069	4.2	0.0113	7.0		
5	0.0043	3.9	0.0090	5.5	0.0134	8.3		
5.5	0.0056	5.0	0.0113	6.9	0.0154	9.5		
6	0.0067	6.0	0.0135	8.2	0.0170	10.5		
7	0.0088	7.9	0.0159	9.7	0.0188	11.7		
8	0.0105	9.4	0.0179	11.0	0.0194	12.0		
9	0.0117	10.5	0.0192	11.7	0.0200	12.4		
10	0.0125	11.2	0.0196	11.9	0.0203	12.6		
11.5	0.0136	12.2	0.0205	12.5	0.0209	13.0		
13	0.0144	13.0	0.0208	12.7	0.0209	13.0		
15	0.0147	13.2	0.0211	12.8	0.0209	13.0		
17	0.0150	13.5	0.0214	13.0	0.0209	13.0		
20.5	0.0153	13.8	0.0214	13.0	0.0204	12.7		
24	0.0147	13.2	0.0211	12.8	0.0203	12.6		

Table 25

Drying data for linseed oil containing cobalt drier, with no pigment.

Time, hours	Oil containing 0.025 grams cobalt per 100 grams oil.		Oil containing 0.040 grams cobalt per 100 grams oil.	
	Percent oil, 99.7. Wt. sample, 0.1126 g. Wt. oil, 0.1121 g.		Percent oil, 99.5. Wt. sample, 0.1836 g. Wt. oil, 0.1826 g.	
	Increase in weight, grams.	% increase in weight of oil.	Increase in weight, grams.	% increase in weight of oil.
1	0.0000	0.0	0.0000	0.0
2	0.0000	0.0	0.0042	2.5
2.5	0.0002	0.2	0.0069	4.1
3	0.0002	0.2	0.0109	6.4
3.5	0.0002	0.2	0.0140	8.3
4	0.0002	0.2	0.0161	9.5
4.5	0.0005	0.4	0.0185	10.9
5	0.0007	0.6	0.0201	11.9
5.5	0.0007	0.6	0.0213	12.6
6	0.0007	0.6	0.0225	13.3
7	0.0007	0.6	0.0232	13.7
8	0.0007	0.6	0.0236	14.0
9	0.0007	0.6	0.0236	14.0
10	0.0007	0.6	0.0236	14.0
11.5	0.0015	1.3	0.0236	14.0
13	0.0041	3.7	0.0234	13.8
15	0.0086	7.7	0.0231	13.6
17	0.0127	11.3	0.0227	13.4
20	0.0142	12.7	0.0219	12.9
24	0.0147	13.1	0.0217	12.8
28	0.0141	12.6	-	-

CHAPTER V

SUMMARY

The drying rates of linseed oil, drier, and carbon pigment mixtures have been determined for freshly made samples, and for samples aged four and eight weeks.

The results show that bone black and carbon black mixtures have the greatest loss in drying power with increase in age of the sample, while graphite and lamp black mixtures show the least loss of drying power. In linseed oil mixtures made with different concentrations of the same pigment and with equal drier concentration, loss of drying power was greater for the mixtures of higher pigment concentration. In linseed oil mixture of different drier concentration, and with equal concentration of the same pigment, the loss of drying power was less for the mixtures of higher drier concentration. These results indicate that the black pigment reduces the efficiency of the drier with increase in age.

No correlation of this investigation with the results of the Binney and Smith work (3) can be made, because only one type of carbon black was studied in this investigation while the Binney and Smith work included only different types of carbon black.

The results of this investigation have the practical application that black linseed oil paints, particularly those made with bone black and with carbon black, should be used as soon as possible after manufacture for good drying results.

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