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PARLIN LABORATORY

MEMORANDUM REPORT NO. 50

SUBJECT: A STUDY OF THE CRACKING CHARACTERISTICS OF 233-35097 PRIMER-SURFACER

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SUBJECT: A STUDY OF THE CRACKING CHARACTERISTICS OF 233-35097 PRIMER-SURFACER

INTRODUCTION

During the latter part of 1947 numerous complaints were received at Parlin on Philadelphia (233-35097) primer-surfacer production. These complaints registered the tendency of a thin film of this material to crack or separate from the surface to which it was applied.

Actual evaluation of these complaints or the assignment of responsibility in their investigation was, at the time, impossible. There was no test by which this characteristic could be accurately determined and, consequently, there was no means by which the identification of the contributing factors could be established either for the assignment of responsibility or for corrective recommendation in manufacture.

The purpose of the work covered in this report was, consequently, of a two-phase nature; (1) to develop a test which would accurately measure this cracking condition and (2) with such a test available to evaluate and determine which factors in formulation and/or processing were responsible for the cracking characteristics of this material. In addition, it was felt that the results of this work would make available valuable information which could be advantageously used in correcting existing formulation deficiencies and at the same time be applied profitably in future development work on primer-surfacer materials.

A comparison of the active Parlin formula, on which there had been no cracking complaints, with the Philadelphia formula revealed several significant differences in formulation. There was a marked variation in solvent composition along with differences in the amount and type of carbon black used. The difference in solvent composition was the result of Philadelphia having aligned against a Flint formula instead of a Parlin formula. It should further be explained that the difference in type of carbon black used was due to a shortage of the preferred pigment (W-240 Peerless Black). As a result Philadelphia's manufacture was based on Lamp Black (W-205). The higher carbon black content employed by Philadelphia was a result of their attempt to maintain satisfactory color. It is worthy of note that W-205 had also been used in Parlin production at various times during this same period without apparent difficulty.

A comparison of processing conditions showed that Philadelphia was using larger diameter mills and higher steel ball ratios in the grind portion of the formulas which, when compared to Parlin processing, suggested more severe grinding of the Philadelphia-produced material.

One or possibly a combination of these variables was suspected of being responsible for or contributing to the cracking characteristics under study. On this basis, a program was established to evaluate both the effect of each variable separately and the cumulative effect of pyramiding these variables.

SUMMARY AND CONCLUSIONS

An accurate test to measure the cracking characteristics of primer-surfacers was developed. The test consists of pouring a sample of the primer-surfacer, which has been adjusted by thinning to a given viscosity, on a specially prepared panel and visually noting the cracking characteristics of the film of primer-surfacer on drying. In addition to showing the cracking characteristics of the film, the extent to which the cracking progresses measures quantitatively, to a reasonable degree, the deficiency of the material under test. The test has shown satisfactory reproducibility in extensive use and has been issued as T.M. #103 for Division distribution use.

Results of the evaluation work in a comparison of the Philadelphia and Parlin formulations have led to the following conclusions:

(1) Under all conditions the Philadelphia vehicle is considerably inferior to the Parlin vehicle. In fact, there was not a single experiment involving Philadelphia vehicle that did not produce some degree of cracking.

(2) Lamp Black (W-205) is apparently inferior in cracking characteristics to Peerless Black (W-240) in that it is considerably more susceptible to the influence of over-pigmentation and extended or harsh grinding conditions.

(3) The effects of long or harsh grinding conditions cannot be over emphasized in that any formulation weakness, either as a result of vehicle composition, type or amount of pigmentation becomes more marked under these conditions of grind. The one exception, worthy of note, however, is that W-240 pigment is not nearly so sensitive to the effect of over-grinding as the W-205 pigment.

EXPERIMENTAL

I. Development of Test to Measure Primer-Surfacer Cracking Characteristics

Until the time of this work the only known method of determining the cracking characteristics of primer-surfacer materials consisted of a test wherein a bare spot was sanded

on a "Duco" panel which had previously been exposed (outside) for six months, feathering the edges of the sanded spot and spot-spraying with a sample of the primer-surfacer material under test. In most cases inferior material would crack at the feather-edge upon drying. The test, however, was not dependable in that even with the best known technique results were not always reproducible. Factors such as wet or dry spray, the proximity of the spray gun to the panel while spraying, the thickness of the spray coat, and rate of dry all influenced the results of this test. These inconsistencies in conjunction with the fact that a six month old "Duco" panel was a prime requisite made the test undesirable and impractical for control or evaluation use.

With these factors in mind the course of attack in developing an improved test for this characteristic consisted of determining what film of material on a panel would act in the same manner as the six month old "Duco" panel in promoting cracking and which could be prepared with little or no aging period. Secondly, it was necessary to devise a means of placing a film of the material under test at a reproducible thickness and consistency on such a panel and eliminate all the variable conditions evident in the spot spray method.

The characteristics of an aged "Duco" film which cause it to promote cracking were difficult to define; hence the development of a suitable replacement which could be prepared without long aging posed a considerable problem. Extensive trials and testing finally segregated 233-9607 White Pyra-Prep material as the most satisfactory film in this respect. In addition, the overall time required to prepare and age a panel of this material for use in this test was only one-half hour.

The method of applying a thin film of the primer-surfacer under test to the panel under reproducible conditions of film thickness, "wetness", etc. resolved into simply pouring the material at a controlled viscosity. The results by this technique were reproducible and to a reasonable degree measure the aggregate deficiencies of the sample under test by the extent to which cracking progresses as the film dries.

The actual test method developed and issued as a result of this work is contained as Table VI in the latter part of this report.

II. Evaluation of Primer-Surfacer Formulations in Respect to Cracking

A. General

Exhibit No. 1 illustrates the general inferiority of the complained-of primer-surfacer materials. The exhibited panels represent samples of these materials taken at random

from the Philadelphia production and compared to Parlin standard production in respect to cracking characteristics.

By serial interpretation, the first four panels of Philadelphia material in this exhibit represent November 1946 production, while serial P-49446 was produced in January 1947. If this one panel is representative of the quality of production at this later date, some apparent improvement is indicated over the previously made material which, if true, would probably indicate some change in processing in the intervening period. We are, however, at this time unable to either confirm such a statement as to the relative quality as represented by this one sample or to assign a definite meaning to any such comparison.

As a basis on which to start the evaluation work, the Parlin formula in use at the time and on which there had been no cracking complaints was compared to the Philadelphia formula used in the manufacture of the complained-of materials. (Table II and Table III.)

It was noted that in addition to variations in vehicle composition and type and amounts of pigment used, there were also variations in grinding conditions (Table V). Although no efforts were made to simulate the Philadelphia conditions of higher steel ball ratios in the grind, both long and short grinding cycle runs were made in the evaluation of all the variable conditions under study.

In an effort to study the effects of these known variables in the respective Parlin and Philadelphia formulations, the following laboratory program was outlined:

The variables under evaluation were:

(1) Parlin versus Philadelphia vehicle.
(2) Peerless Black (W-240) versus Lamp Black (W-205).
(3) Over-pigmentation with Carbon Black (Parlin 3.5% versus Philadelphia 5.0%) (see Table IV).
(4) Extended grinding cycles.

These variables were evaluated by modifying the formulas and grinding conditions as noted below:

1. Parlin Vehicle Experimental Formulations

10 and 96 Hour Grinds
(a) Regular amount W-240 pigment.
(b) Extra amount W-240 pigment.
(c) Regular amount W-205 pigment.
(d) Extra amount W-205 pigment.

2. Philadelphia Vehicle Experimental Formulations

10 and 96 Hour Grinds
(a) Extra amount W-240 pigment.
(b) Regular amount W-205 pigment.
(c) Extra amount W-205 pigment.

B. Formulations

1. Philadelphia Formula

This formula (Table II) is apparently a derivative of the Flint formula dated August 1946 and secured by Philadelphia from Flint on or about September 1946 for use in the production of 233-35097 Primer-Surfacer.

This formula varies in several respects from the Parlin formula in that it employs a solvent composition composed of high amounts of HB-6, H-35, and H-47 and is, therefore, somewhat richer than the solvent composition of the Parlin formula in which the main ingredients are HA-65, H-51, and H-29. In addition, the Philadelphia formula as derived from a representative batch slip contains a relatively higher amount and a different type of carbon black than the Parlin formula.

In the course of this work the Philadelphia formula has been shown to be weak in the following characteristics in respect to cracking.

(a) Weak in vehicle composition (Exhibit 2 through 5).
(b) Uses an inferior pigment W-205 (Exhibit 4).
(c) Over-pigmented. (Exhibits 2-3 and 5).
(d) Apparently overground (Exhibit 3 and 5).

2. Parlin Formulation

The Parlin formula (Table III) used in this study was the one in active use at Parlin at the time this study was begun.

No fundamental weaknesses were observed in this formula. However, it was shown in this work that this formulation would not permit over-pigmentation with the inferior W-205 pigment without cracking on extended grinding (Exhibit 3).

3. Vehicle Evaluation

The superiority of the Parlin vehicle over the Philadelphia vehicle under all conditions of variation in formulation is confirmed throughout (Exhibits 2-3-4 and 5). This difference, however, is most prominent in Exhibits 2 and 3 where series of Parlin versus Philadelphia vehicles show the aggregate effects of variations in type and amount of pigment in each vehicle on both short and long grinding cycles.

It is interesting to note that in only one instance has the Parlin vehicle failed to produce satisfactory quality material. The conditions responsible for this failure were a combination of overgrinding, over-pigmentation, and the use if the inferior pigment (W-205). The Philadelphia vehicle on the other hand failed to produce entirely satisfactory material under any conditions of type or amount of pigmentation or grinding. (It should be noted that W-240 in the regular amount was not tested in this vehicle. It is possible that this combination would have been satisfactory in cracking.) A summary of the individual and aggregate effects of the variables involved has been tabulated as Table I for reference in this comparison.

4. Comparison of Pigments

In Exhibit 2 it is apparent that there is no appreciable difference between W-205 and W-240 pigments in short grinds. However, Exhibit 3 clearly illustrates the inferiority of W-205 to W-240 pigment when the grind is extended.

5. The Effect of Varying the Amount of W-205 Pigment at Various Grinding Cycles

In making a comparison of the effects of grinding on regular and extra amounts of W-205 pigment, Exhibit 4 clearly illustrates that in cases of the higher pigmentation the effects resulting from long or harsh grinding conditions are decidedly more marked than in those cases where lesser or regular amounts of pigment are used.

6. The Effect of Grinding Cycle on Over-Pigmented Formulations

A comparison of the over-pigmented formulations involving the two types of carbon black under varied grind conditions, (Exhibit 5) again points out the inferiority of W-205 to W-240 pigment. This inferiority is not apparent in the short grinds but is very pronounced in the long grinds. It is thereby evident that W-240 is not nearly so sensitive to overgrinding as W-205.

7. Pyramid of Variable Factors Influencing Cracking

Exhibit 6 is self-explanatory in that the individual variables known to produce cracking have been pyramided to show the cumulative effect of the differences between the Parlin and Philadelphia formulations. It is implied in this progression that Philadelphia material has received longer and harsher grinding than the Parlin material. Reference to Table V, wherein a description of grinding conditions, as obtained from the respective Plants mentioned is noted, will confirm this contention. Size of mills, steel ball ratio, etc. are both greater at Philadelphia than at Parlin and it is reasonable, therefore, to assume that grinding conditions at Philadelphia are more harsh than at Parlin.

In this connection it has been noted through a review of the Philadelphia weekly reports (re: Sept. 9-13, 1946 - May 19-23, 1947, and Dec. 8-14, 1947) that immediately prior to manufacturing 233-35097 material, difficulty was being experienced in maintaining normal grinding temperatures in the ball mills and temperatures as high as 120°F. had been encountered. References to these difficulties are again made in May 1947 and December 1947. Any such conditions would undoubtedly contribute further to over-grinding and be very detrimental to this product as illustrated in the various exhibits.

It will be noted in a review of this exhibit (6) that step by step the intensity of the cracking within the product progresses as the individual variables are introduced and combined until the ultimate change from the most to the least desirable conditions of formulation and processing is obtained.

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TABLE INDEX

TABLE I

SUMMARY OF VARIABLES AFFECTING CRACKING CHARACTERISTICS IN PRIMER-SURFACERS

CRACKING STATUS

Variables		Rating
10 Hour Grind		
Parlin Vehicle		
Regular Amount	W-240	0
Extra Amount	"	0
Regular Amount	W-205	0
Extra Amount	"	0
Phila. Vehicle		
Regular Amount	W-205	1
Extra Amount	"	1+
Extra Amount	W-240	2
96 Hour Grind		
Parlin Vehicle		
Regular Amount	W-240	0
Extra Amount	"	0
Regular Amount	W-205	0
Extra Amount	"	3
Phila. Vehicle		
Regular Amount	W-205	1
Extra Amount	"	4
Extra Amount	W-240	2

Rating	Description
0	No Cracking
1	Slight Cracking
2	Definite Cracking
3	Bad Cracking
4	Very Bad Cracking

TABLE II

PHILADELPHIA FORMULA

This formula was obtained through a breakdown of Philadelphia 233-35097, P-51536, batch slip and includes ingredient adjustments resulting through 233-025 additions for color control:

Ester Gum	(G-608)	4.9%		
Butyl Acetate	(HB-6)	8.1		
Methyl Ethyl Ketone	(H-35)	3.0		
Toluol	(H-47)	6.9		
Methyl Isobutyl Ketone	(H-44)	0.1	Mill Grind	
Isobutyl Acetate	(H-62)	0.3		
Dibutyl Phthalate	(HE-111)	3.0		
Soya Bean Lacquer Oil	(H-194)	1.9		
Butyl Alcohol	(H-12)	1.4		
Titanium Dioxide	(W-28)	4.0		
Blanc Fixe	(W-30)	11.5		
Talc H.D.	(W-132)	16.8		(See Note 1)
B.T. Lamp Black	(W-205)	5.0		
			66.9%	
Ester Gum	(G-608)	2.8	Add to pull	
Methyl Ethyl Ketone	(H-35)	1.6		
Toluol	(H-47)	1.1		
			72.4%	
(See Breakdown Formula)	(B-363)	19.0		
(See Breakdown Formula)	(B-501)	7.7		
(See Breakdown Formula)	(B-544)	.6		
Phosphoric Acid (85%)	(G-697)	.3		
		100.0%		

TABLE II-A

PHILADELPHIA FORMULA
INGREDIENT BREAKDOWN

			Parts
Ester Gum	(G-608)	7.7%	7.7
Butyl Acetate	(HB-6)	9.1	1.2
Methyl Ethyl Ketone	(H-35)	8.7	4.6
Toluol	(H-47)	11.0	0.9
Methyl Isobutyl Ketone	(H-44)	2.4	2.1
Isobutyl Acetate	(H-62)	0.3	
Dibutyl Phthalate	(HE-111)	3.0	3.0
Soya Bean Lacquer Oil	(H-194)	1.9	
Butyl Alcohol	(H-12)	1.4	
Methyl Isobutyl Carbinyl Acetate	(HA-55)	0.7	0.9
Isopropyl Alcohol Anhydrous	(H-69)	0.8	1.5
Naphtha 95-140°C.	(H-51)	1.9	8.9
Methyl Isobutyl Carbinol	(H-48)	0.8	1.8
Petroleum Xylol	(H-583)	1.3	1.6
Belle Amyl Acetate	(HA-65)	0.4	9.2
Phosphoric Acid 85%	(G-697)	0.3	0.3
Titanium Dioxide	(W-28)	4.0	5.2
Blanc Fixe	(W-30)	11.5	11.9
Tale H.O.	(W-132)	16.8	12.4
B.T. Lamp Black	(W-205)	5.0 w.240	3.5
PX Nitrocotton	(PX)	7.7	7.6
Alcohol of Dehydration	(H-75-d)	3.3	3.4
		100.0%	

TABLE III

PARLIN FORMULA

Obtained from Parlin Active Formula File

Ester Gum	(G-608)	4.8%		
Petroleum Naphtha (88 or 131°C.)	(H-29)	2.3		
Dibutyl Phthalate	(HE-111)	3.0		
Blown Soya Bean Oil	(H-193)	2.0	Mill Grind	
Belle Amyl Acetate	(HA-65)	9.2		
(See Breakdown Formula)	(3224)	1.5		
Naphtha 95-140°C.	(3214) (H-51)	6.5		
Titanium Dioxide	(W-28)	5.2		
Blanc Fixe	(W-30)	11.9		
Talc H.O.	(W-132)	17.4		
Peerless Black	(W-240)	3.5		(See Note 1)
			67.3%	
Petroleum Naphtha (88 or 131°C.)	(H-29)	3.0	Add to pull	
(See Breakdown Formula)	(B-363)	5.6		
			75.9%	
(See Breakdown Formula)	(B-363)	17.9		
(See Breakdown Formula)	(B-501)	3.0		
Phosphoric Acid 85%	(G-697)	0.3		
Ester Gum	(G-608)	2.9		
		100.0%		

TABLE III-A

PARLIN FORMULA
INGREDIENT BREAKDOWN

Ester Gum	(G-608)	7.7%
Petroleum Naphtha 88 or 131°C.	(H-29)	5.3
Dibutyl Phthalate	(HE-111)	3.0
Blown Soya Bean Oil	(H-193)	2.0
Belle Amyl Acetate	(HA-65)	9.2
Naphtha 95-140°C.	(H-51)	8.9
Methyl Isobutyl Carbinol	(H-48)	1.8
Isopropyl Alcohol Anhydrous	(H-69)	1.5
Methyl Ethyl Ketone	(H-35)	4.6
Methyl Isobutyl Ketone	(H-44)	2.1
Toluol	(H-47)	0.9
Butyl Acetate	(HB-6)	1.2
Methyl Isobutyl Carbinyl Acetate	(HA-55)	0.9
Petroleum Xylol	(H-583)	1.6
Phosphoric Acid 85%	(G-697)	0.3
Titanium Dioxide	(W-28)	5.2
Blanc Fixe	(W-30)	11.9
Talc H.O.	(W-132)	17.4
Peerless Black	(W-240)	3.5
PX Nitrocotton	(PX)	7.6
Alcohol of Dehydration	(H-75-d)	3.4
		100.0%

NOTES ON FORMULATIONS

Note 1: For the sake of standardization in the experimental work the amount of Carbon Black designated in the Parlin formulation was taken as the "Regular Amount" and that amount designated in the Philadelphia formulation was taken as the "Extra Amount" or:

Regular Amount Carbon Black	3.5%
Extra Amount Carbon Black	5.0%

MILL GRIND DATA

233-35097

TABLE V

	Philadelphia		Flint		Parlin
	A	B	A	B	A
Mill Size (I.D.)	Diameter 60"	72"	Diameter 55"	53"	Diameter 53"
	Length 48"	72"	Length 55.5"	58"	Length 36"
R.P.H.	1560		1380		1280
Type Mill	Unlined - Water Cooled		Unlined - Water Cooled		Unlined - Water Cooled
Mill Ratio Steel Balls to Charge	40% of Mill Volume is occupied by steel balls in a total mill load of 80% volume or Wt. 2.5:1 (calculated)		40% of Mill Volume is occupied by steel balls in a total mill load of 80% volume or Wt. 2.5:1 (calculated)		Wt. 2:1 (specified)
Grind Cycles	Rated 23000 Act. 18000		Rated 23000		Rated 23000
Hours Grind	Act. 12 hrs.		14.7 hrs.		Act. 12 hrs.
Temp. °F. Grind	Effluent Water Temp. 75°F.*		Effluent Water Temp. 75°F. Measured Charge Temp. 80-85°F.		Effluent Water Temp. 70-75°F.
Charge Weight	A ca 3790 lbs.	B ca 8160 lbs.	A ca 3660 lbs.	B ca 3660 lbs.	A ca 2200 lbs.
Mill Capacity	A	B	A	B	A
	Cu Ft. 78.5	169	Cu Ft. 76	75.2	Cu Ft. 45.5
	Gals. ca 590	ca 1270	Gals. ca 570	ca 563	Gals. ca 338

*This temperature was apparently higher Sept. 1946 through December 1947 as reference is made in the Philadelphia Weekly Reports (Sept. 9-13, 1946 - May 19-23, 1947 - Dec. 8-14, 1947) of steel ball mills running hot, as high as 120°F. being reported.

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TABLE VI

CRACKING TEST FOR PRIMER-SURFACERS

Purpose

To determine the tendency of a thin film of primer-surfacer to crack or separate from a surface to which it has been applied.

Principle

Measurement of this cracking tendency by the method described herein consists of having set up as standard, a material which has proven to be satisfactory in cracking characteristics and comparing questionable or newly produced materials to it in this respect.

Status

This method has been recently developed in the laboratory for use at Parlin to measure the cracking characteristics of "Dark Gray Primer-Surfacer".

Time Requirement

Man Hours.....30 minutes
Overall Test Time.... 2 hours

Equipment Needed

4 x 6" Steel Panels
233-9607 White Pyra-Prep

Panel Conditioning

A 4 x 6" steel panel is sanded with 280A Tri-M-ite paper wet with H-29 to remove grease and grit and is wiped clean. The panel is then washed with solvent and wiped dry.

A portion of 233-9607 is cut with an equal volume of 36000 Thinner and thoroughly mixed. A single coat of the thinned material is sprayed to a thickness of 0.4 to 0.8 mil on a previously prepared panel and force dried for 15-20 minutes at about 65°C. and allowed to cool to room temperature. Film thickness may be measured by use of the G.E. Thickness Gauge or other suitable instrument. It is important that freshly prepared panels be used in this test.

Each batch of 233-9607 base coat should be pre-tested with primer-surfacer materials of known cracking characteristics as a precautionary measure before use to assure that the 233-9607 is normal in all respects and that both negative and positive cracking characteristics may be duplicated with its use.

The formulation of 233-9607 dated February 13, 1948 on which this cracking test was developed together with manufacturing directions for the same is noted below. This will

serve as a permanent record in case of drift in test characteristics as a result of future formula revisions.

233-9607 WHITE SEALER

First Portion		
HB-6	9.9%	Load with mixer running. Use buggy or barrel with special head and valve for base. Base to be added in stream the thickness of a pencil. Mix 2 hours.
H-47	5.7	
H-35	9.6	
HE-111	5.6	
H-22	1.4	
B-563	33.9	
B-501	4.0	
WX-0028	8.4	
Second Portion		
RC-12007	21.2	Add and mix 2 hours
G-697	0.3	
	100.0%	

Wt./gal.: 8.24 lbs. @ 25°C.
Visc.: 60-80" 10 cup @ 25°C.

Solids		Ratio
PX	11.6%	10.0
RC-12007(solid)	11.7	10.1
HE-111	5.6	4.8
H-22	1.4	1.2
Pigment	5.0	4.3
G-697	0.3	0.3
Theo.	35.6%	
Anal.	34.2%	

Developed for Refinish Sales as J-233-X-8545 (233-34120); reissued to provide simpler code.

Revised to lower PX content.

Issued by Parlin 2/13/48 Superseding formula dated 12/3/47 JWG:RHM

Detailed Test Procedure

Portions of the standard sample and the batch undergoing test are thinned to pouring consistency with 36000 Thinner using the ratio of 45 parts sample to 55 parts of 36000 Thinner. When the samples have been thinned and thoroughly mixed pours of the standard and test sample are made side by side on a freshly prepared test panel. Pours are allowed to drain and dry at room temperature while the panel remains in a vertical position. Comparison of the test sample is then made visually to the standard. Any batch comparable to or better than standard in cracking characteristics is to be considered satisfactory while any batch exhibiting a greater tendency to crack than the standard sample is considered unsatisfactory.

Miscellaneous Test Data

Parlin batch 233-35097, Serial 386356, has been selected as the standard sample for use in this test. In order to guarantee uniform comparison over a long period of time, 5-1 gallon cans of this material have been obtained and reserved for use as standard.

Using the 233-35097, Serial 386356, as a basis for comparison respective standards should be developed on each type of primer-surfacer material subjected to this test.

Proper preparation of test panels in regards to film thickness and the use of freshly prepared panels is very important.

TABLE VI (continued)

Best results are obtained when the samples under test are around 17-18" viscosity (10 cup) which can normally be obtained by diluting O.K. viscosity material in the ratio to 36000 Thinner described above.

The presence of grit on the test panel will cause the poured surfacer samples to split by flowing around such an obstruction. This should not be confused with "cracking" and if present may easily be identified as such. However, this condition may easily be controlled by eliminating grit from the thinned 233-9607 through filtration before spraying the test panel.

INDEX TO EXHIBITS

Exhibit	Description
No. 1	Philadelphia production versus Parlin standard.
No. 2	Pigment variables with constant 10 hour grinding cycle in: Parlin Vehicle — Series A Philadelphia Vehicle — Series B
No. 3	Pigment variables with constant 96 hour grinding cycle in Parlin Vehicle — Series C Philadelphia Vehicle — Series D
No. 4	The effect of varying the amount of W-205 pigment at various grinding cycles Parlin Vehicle — Series E Philadelphia Vehicle — Series F
No. 5	The effect of grinding cycle on over-pigmented formulations Parlin Vehicle — Series G Philadelphia Vehicle — Series H
No. 6	Pyramid of variable factors influencing cracking

Note: Photostats of the above exhibits are shown as negatives in order to avoid the loss in detail in making positive prints.

The vertical breaks noticeable on some of the exhibited panels should not be confused with cracking. These latitudinal breaks are a result of film imperfections and should not be interpreted as the longitudinal cracking.

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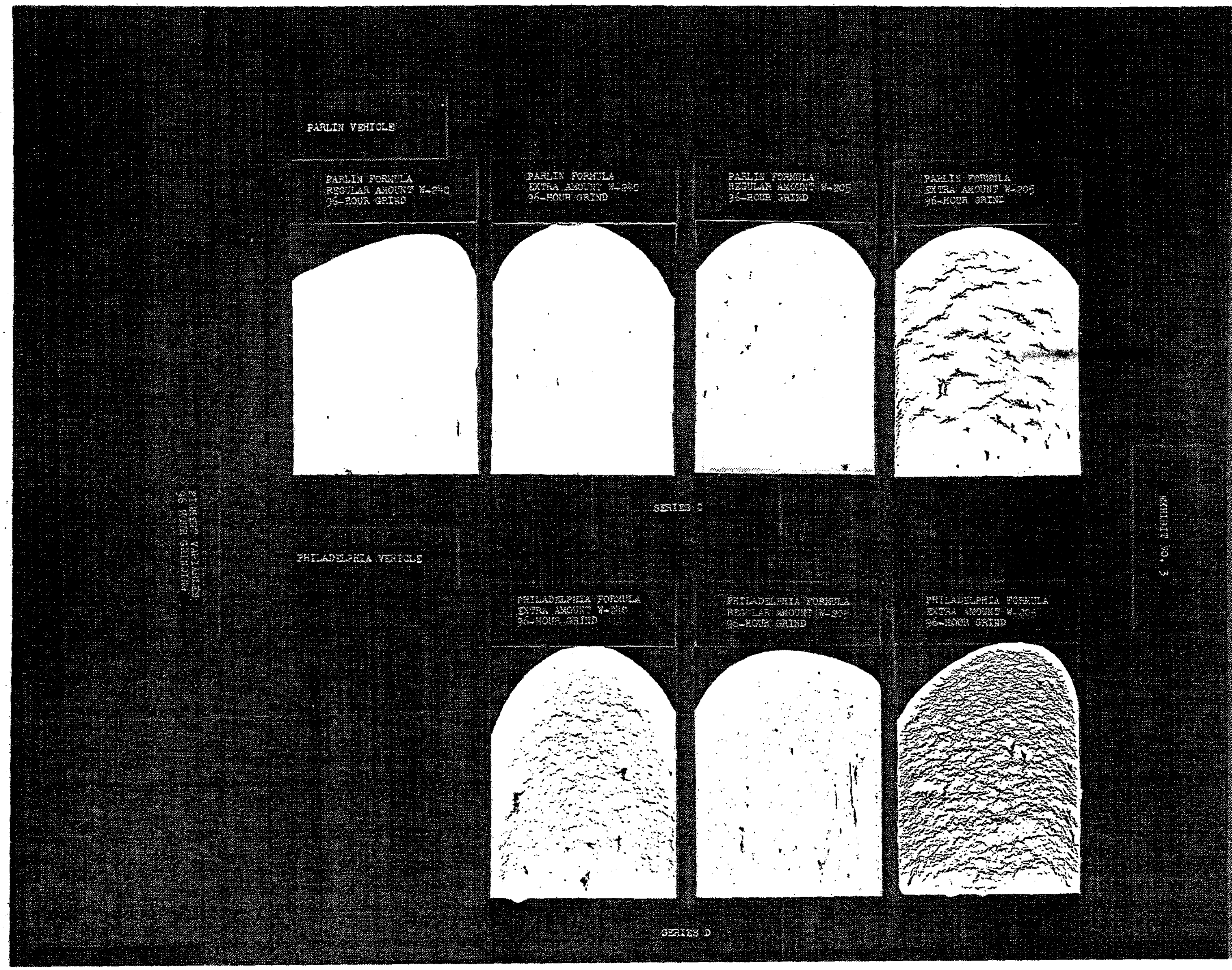
EXHIBIT NO. 3
PARLIN VEHICLE
PARLIN FORMULA
REGULAR AMOUNT W-240
96-HOUR GRIND
PARLIN FORMULA
EXTRA AMOUNT W-240
96-HOUR GRIND
PARLIN FORMULA
REGULAR AMOUNT W-205
96-HOUR GRIND
PARLIN FORMULA
EXTRA AMOUNT W-205
96-HOUR GRIND
SERIES C
PHILADELPHIA VEHICLE
PHILADELPHIA FORMULA
EXTRA AMOUNT W-240
96-HOUR GRIND
PHILADELPHIA FORMULA
REGULAR AMOUNT W-205
96-HOUR GRIND
PHILADELPHIA FORMULA
EXTRA AMOUNT W-205
96-HOUR GRIND
SERIES D
PIGMENT VARIABLES
96 HOUR GRINDING