E. I. DU PONT DE NEMOURS & COMPANY

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PARLIN LABORATORY

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PROJECT NO. J-2023

SUBJECT: EVALUATION OF BCM (RC-800) AS A FINISH INGREDIENT

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I. Introduction

This report covers the work done intermittently from June 8, 1948 to date on the subject project. Previous work had indicated that furniture finishes with very attractive properties can be formulated with RC-800, modified with nitrocellulose and an alkyd resin. Based on the results of previous work three compositions at three levels of RC-800 appeared worthy of further study; viz., ratios of RC-800/nitrocellulose/alkyd resin of 55/35/10, 45/45/10 and 35/55/10.

II. Objectives

Three main objectives have guided the direction of the work as covered in this report. They are:

1. To critically study the three compositions mentioned above, with a view to ultimately offering for field test, a furniture topcoat finish based on the preferred ratio of these ingredients over a suitable undercoat system. This involved a study of not only the physical and chemical properties of the RC-800 containing topcoats but also of each component in the finishing system, from the wood up, through stain, wash coat, filler, sealer, shading lacquer and/or glaze to the topcoat; establishment of methods of application, processing, drying times and baking temperatures, as well as, catalyst/inhibitor ratios to give the maximum shelf life consistent with the lowest possible conversion temperature.

2. To evaluate modifiers for RC-800, other than those mentioned above, with a view to obtaining a more flexible and possibly a more thermoplastic film, at a lower cost. This involved a study of other film formers in place of nitrocellulose and also of plasticizers other than alkyd resin. Considerable attention was given to the possibility of achieving internal plasticization by copolymerizing "in situ" of RC-800 with a mono-functional linear type monomer, such as the monomeric alkyl esters of acrylic and methacrylic acids and other similar materials.

3. To evaluate other thermosetting materials and any commercial finishes as they appeared on the market from time to time, which might be competitive with RC-800.

III. Summary and Conclusions

The results of our evaluation of RC-800/nitrocellulose/alkyd resin compositions may be summarized as follows:

At the 55% RC-800 level, maximum quality (i.e. hardness, heat and solvent resistance, toughness, etc.) is obtained, whereas at the 35% level, the reverse is true. On the other hand, RC-800 is an expensive ingredient and the more there is present, the higher the cost will be of any given composition. Consequently, a formula containing 45% RC-800 on the solids was selected for field testing, as representing a good compromise between cost and quality.

In a small scale field test at the Bassett Superior and Lane Companies, it was demonstrated that the application properties of the 45/45/10 = RC-800/NC/RL-255 formula are satisfactory for conveyorized furniture finishing. As anticipated, the man hours required for processing were from one and one-half to three times greater than that required for furniture "Duco" or "DULUX".

Besides high ingredient and processing costs, RC-800 formulas are accompanied by certain technical difficulties. However, before making additional expenditures to resolve the latter, it seems desirable to determine whether the furniture industry is sufficiently interested in RC-800 finishes to pay the extra money for the superior quality obtainable.

Relative to the other objectives, no plasticizer superior to the alkyd resin currently used was uncovered. Efforts to plasticize RC-800 internally were unsuccessful. Copolymerization with low molecular weight polyesters such as ethylene and propylene glycol maleate/adipates, resulted in incompatibility. The replacement of nitrocellulose with thickening agents (e.g. methyl methacrylate, ethyl cellulose, and polyvinyl butyral, respectively), which are soluble in cheaper solvents than esters and ketones, has not proven feasible to date because of compatibility limitations and the higher conversion temperature (180°F. versus 130°F) required.

Two materials which have appeared on the market, "Phenoplast" and Bakelite's XV-17911, are not likely to offer any serious immediate competition to RC-800 because of application difficulties and other limitations.

IV - Action Taken

Parlin Laboratory Release Letter No. 439 recommends a field testing program aimed specifically at determining whether the furniture industry is sufficiently interested in the improved quality obtainable with the RC-800 finish to accept the increased costs. Such a program has been arranged by Industrial Sales and is in the process of being carried out.

V - Patents

Patent 2,498,091 issued on February 21, 1950, in the name of W.K. Moffett and assigned to duPont, covers the formula it is proposed to field test, as per Parlin Laboratory Release Letter No. 439.

VI. Experimental

The experimental work undertaken to reach the three objectives listed in the introduction of this report, may be divided into the following two main sections for the purpose of this report:

(A) a study of the properties of the topcoat
(b) a study of the individual components of the undercoat system.

A. A Study of the Topcoats

In the study of the properties of the topcoats selected from the results of previous work, the following built-up system was employed:

Stain:	Luxol	- air dried 30 minutes
Wash Coat:	1366	- air dried 30 minutes
Filler:	27-5017	- air dried 4 hours
Sealer:	1366	- air dried 1 hour
Topcoat:	Air dried 1/2 hour, baked 2 hrs. @ 130°F.	

Application of the three initially selected basic topcoats over this undercoat system indicated the following:

(1) All showed varying degrees of pinholing, depending upon the porosity of the piece of wood over which they were applied.

(2) The 35/55/10 and 45/45/10 formulations showed fairly good levelling and freedom from surface defects (other than pinholing). This was particularly true of the 35/55/10 composition.

(3) The 55/35/10 composition showed poor levelling and varying amounts of ridging and cratering.

Preliminary experiments showed the pinholing to be due to the porosity of the wood. A discussion of the experimental work to correct this defect, will be found later on in this report under the topic of undercoat system.

(1) Application

Early experiments to produce a flat RC-800 topcoat had indicated that Santocel "C" had a beneficial effect on the levelling of the RC-800 topcoat. Experiments were undertaken to follow up this lead and to overcome the surface defects occurring with the 55/35/10 formula. It was found that the incorporation of Santocel "C" up to 10% on the solids completely eliminated the ridging and cratering of this composition, and also tended to reduce the pinholing. It was also found that this was true regardless of whether the Santocel "C" was ground 15 hours in a laboratory crock or 144 hours. The only effect of the longer grinding cycle was to increase the gloss (Reference: Notebook Pages 2201-140, 153, 166, 173, 181: 2261-40).

Other pigments and materials examined for this purpose were as follows:

(a) Aluminum Stearage (G-217): This soap also eliminated ridging and cratering but did not appear to have any effect on the degree of pinholing and did not yield as transparent a film as Santocel "C" (Reference: Notebook page 2201-157).

(b) Linde's Coated Silica #30: This pigment also tended to eliminate cratering and ridging but did not seem to have any effect on pinholing. The films also were somewhat gritty. It is believed that this could be overcome by better dispersion (Re: Notebook Page 2201-161).

(c) Blanc Fixe (W-30): No apparent effect on blistering, ridging or cratering was noted at the same pigment level as Santocel "C" but if the amount was increased to three times that of Santocel "C" on a volume basis, it too eliminated these surface defects (Re: Notebook pages 2201-166, 172).

(d) Silex Silica (W-31): Did not eliminate ridging and cratering when used on an equal weight basis with Santocel "C" (Re: Notebook Page 2201-166).

(e) Tamms' Gold Bond Silica: Did not eliminate surface defects when used on an equal weight basis with Santocel "C" (Re: Notebook Page 2201-166).

(f) RBH Dispersions' RV-62: Reduced pinholing and eliminated most surface defects on an equal weight basis with Santocel "C" but did not yield as good clarity (Re: Notebook Page 2201-183).

(g) Iron Hydroxide: Did not eliminate surface defects when used on an equal weight basis as Santocel "C" (Re: Notebook page 2201-188).

(h) Chromium Tetrahydroxide: Did not eliminate surface defects when used on an equal weight basis as Santocel "C" (Re: Notebook Page 2201-194).

From these results, it appeared that Santocel "C" was effective either because of its high bulking value and large surface area with adsorbed air or that it adsorbed something from the film which causes the ridging and cratering.

Experiments were therefore conducted in which Santocel "C", Blanc Fixe, Nuchar, a low absorbent silica GRS-440-52, micronized asbestine, Silex silica and Tamms' silica, were added to the composition in excess, thoroughly mixed and then filtered out. The filtered compositions showed no improvement in ridging, cratering, etc. This indicated that the effect of Santocel "C" is probably that of a bulking value due to its large surface area.

Other materials examined as possible aids in eliminating surface defects which would still permit the formulation of a clear were: (1) calcium octoate and (2) G.E. Silicone 81069. Calcium Octoate inhibited the conversion while the G.E. Silicone 81069 had no beneficial effect on ridging and cratering. (Re: Notebook Pages 2261-92, 2278-4, 2261-84, 2278-62 and 2303-50, 54).

One additional experiment was conducted using an RC-800 syrup (Re: Notebook Page 2248-136) prepared at the writer's request by Mr. Claus Victorius in place of RC-800 monomer. While cratering and ridging of a 65/25/10 composition were not eliminated entirely they were decreased noticeably (Re: Notebook Page 2261-92).

Therefore, for the present, it was decided to confine future work to a clear at the 45/45/10 ratio and a flat containing 10% Santocel "C" on the solids at a 55/40/5 ratio.

(2) Plasticization

Both of these formulations show good resistance to cold checking. However, they were felt to be more brittle than is desirable and attempts were made to improve their flexibility by the use of (1) external plasticizers, and (2) internal plasticization through copolymerization. It was felt that the latter might also increase the thermoplasticity of the film and therefore reduce the labor needed in processing.

Earlier work in which a large number of plasticizers were evaluated had indicated that RL-255, a castor oil modified alkyd resin, was the most satisfactory plasticizer for RC-800/nitrocellulose. Most of our efforts were therefore confined to attempts at internal plasticization.

The following materials were examined:

(a) Butyl Cellosolve Methacrylate Monomer (BCMa)

(1) Castings made in an attempt to copolymerize RC-800 with BCMa showed only a slight flexibilizing action below 25% BCMa - above this percentage, cheesiness, rather than toughening, was apparent. The joint polymerization rate of BCMa/RC-800 decreased as the amount of RC-800 decreased.

(2) In films, only a slight plasticizing action could be noted, being more apparent with ethyl cellulose as the bodying agent than with nitrocellulose. (Re: Notebook Pages 2201-104, 196, 198, 200, 212, 226; 2261-28, 34).

(b) Normal Butyl Methacrylate Monomer (n-BMa):

(1) Castings made in an attempt to copolymerize n-BMa with RC-800 showed only a slight flexibilization, less than with BCMa and again cheesiness rather than toughness developed as the amount of n-BMa monomer was increased. The joint polymerization rate of n-BMa and RC-800 also decreased as the amount of n-BMa increased.

(2) Films showed only a slight plasticization (Re: Notebook Pages 2201-208, 224; 2261-38).

(c) Lauryl Methacrylate Monomer (LMa)

(1) Castings made in an attempt to copolymerize LMa with RC-800 showed only a slight flexibilizing action, less than with BCMa and again cheesiness rather than toughness developed when the LMa ratio was increased. Again the joint polymerization rate of LMa and RC-800 was decreased as the ratio of LMa increased.

(2) Films showed only a slight plasticization (Re: Notebook Pages 2201-203, 222).

(d) 2-Ethyl Hexyl Acrylate (2EHA)

Castings made in an attempt to copolymerize 2-EHA with RC-800 showed only a slight flexibilization, developing cheesiness rather than toughness as the amount of 2-EHA to RC-800 was increased (Re: Notebook Pages 2201-260).

(e) Allyloxy Ethyl Acrylate (7090-164) (AOEA)

(1) In thin films with RC-800 it was too volatile at 130°F.

(2) By itself, when catalyzed with cobalt nitrate hexahydrate and benzoyl peroxide, in a test tube it would not convert in 65 hours at 60°C. (Re: Notebook Page 2201-248).

(f) 1,4 diallyloxy-2-butene (1,4 DAB)

(1) Did not polymerize "en masse" when catalyzed with cobalt nitrate hexahydrate and benzoyl peroxide in 60 hours at 40°C. Incompatible with RC-800 at ratios higher than 50%, 1,4 DAB. At this ratio it did not appear to speed up the joint polymerization with RC-800.

(2) In thin films it volatilizes from the film at 130°F. (Re: Notebook Pages 2201-116, 246, 250).

(g) Diallyl phthalate and Diallyl Glycolate (DAP & DAG)

Did not appear to convert in RC-800 system at 130°F. Acted more like a non-drying oil alkyd (Re: Notebook Pages 2201-148, 214, 215).

(h) 60/40 Allyl Acrylate/Styrene (PRCR-7176)

Incompatible with RC-800. Converted with cobalt catalyst in 2 hours at 130°F. to a non-tacky, soft film (Re: Notebook Pages 2201-238, 248).

(i) 50/50 Allyloxy Ethyl Acrylate/Styrene (PRCP-7168)

Incompatible with RC-800 yielding a hard brittle film of low strength (Re: Notebook Page 2201-191).

(j) PRCP-81522 (a straight glycerol allyl ether phthalate resin)

(1) When used as a plasticizer in the RC-800 system, tended to embrittle the film.

(2) By itself with cobalt catalyst, it converted in 16 hours @ 150°F. to a fairly tough film. (Re: Notebook pages 2201-118, and 2261-68).

(k) PRCP-92135 (a glycerol allyl ether phthalate modified dehydrated castor oil alkyd)

(1) When used as a plasticizer in the RC-800 system it tended to embrittle the film.

(2) By itself with cobalt catalyst it converted in 16 hours @ 150°F. to a somewhat soft but fairly tough film. (Re: Notebook pages 2201-118 and 2261-68)

(l) Propylene Glycol Maleate/Adipate (PMA)

(1) Incompatible with RC-800 when polymerized "en masse" at ratios of 25/75 to 75/25. Addition of monomeric styrene to RC-800/PMA produced a compatible polymer but did not speed up conversion. Castings were exceptionally hard and flexible but tended to embrittle on aging indicating a loss of unreacted styrene monomer.

(2) Thin films of RC-800/PMA/styrene in which nitrocellulose was used as the bodying agent showed excessive cratering and crawling (Re: Notebook Pages 2201-254, 258, 268; 2261-42).

(m) Polyethylene Glycol Maleate/Adipate (PGMA)

Incompatible with RC-800. When catalyzed with cobalt nitrate and benzoyl peroxide, converted to a cheesy film in 2 hours @ 130°F, which crawled and cratered on both glass and wood.

(n) Dioctyl Phthalate (DOP)

This plasticizer was tried as a replacement for RL-255 but when freshly prepared, the highest ratio of DOP that could be used without spewing out was RC-800/PX/DOP = 55/40/5. On aging several months, even this composition showed some spewing (Re: Notebook Page 2201-162).

(3) Processing

As can be seen from the attached properties chart (see page 21) the RC-800 formulations are much more difficult to process than either "Duco" or "DULUX". This was found to be true in the laboratory and was substantiated in a small-scale field test conducted at the Bassett Superior and the Lane Companies. The following studies were made to reduce the work required in processing.

(a) Methods

1. Dry Sanding - No improvement (Re: Notebook Page 2278-52).

2. Camphor in Octyl Alcohol as Lubricant - No improvement (Re: Notebook Page 2278-57).

3. Silicone Oil (G.E. 81069) in Film - No improvement (Re: Notebook Page 2278-62).

(b) Two-Stage Conversion

Experiments had indicated that the labor of processing the RC-800 finishes can be materially reduced, approaching that of "Duco", if the finish is partially converted to an "A" stage, processed, and then the conversion completed to the "B" stage. Conversion to the "A" stage was accomplished by overnight drying at 70°F. or a short force dry such as, one hour at 110°F. However, unless a thermosetting sealer was used, objectionable shrinkage occurred: (Re: Notebook Pages 2261,90; 2278-12, 76, 80, 88 and 90).

(4) Shrinkage

As stated above, when the topcoat bake was split to allow easier processing, objectionable shrinkage occurred when the film was completely converted to the final or "B" stage. The following factors were investigated in an effort to control shrinkage:

(a) RC-800 Syrup in place of Monomer - Some improvement in shrinkage (Re: Notebook Page 2278-4).

(b) Measure of volume change of film at various stages of conversion - Some decrease in volume, 0.7%, occurred between air-drying overnight and 2 hours @ 180°F. This was not a large enough change to explain the degree of shrinkage being encountered. Indications were that most of the shrinkage was due to the undercoat system (Re: Notebook Page 2278-64).

(c) Effect of Filler

1. Length of Filler Dry - No effect on shrinkage. (Re: Notebook Page 2278-65).

2. Flash Dry vs. 27-5000 line Filler - No effect - (Re: Notebook Page 2278-70)

3. Double Filling - No effect (Re: Notebook Page 2278-70).

4. U.F. Modified 27-5000 line Filler - No effect (Re: Notebook page 2278-72, 74).

(d) Effect of Sealer

1. 1366 vs. nylon sealer - Nylon sealer was poorer. (Re: Notebook page 2278-82).

2. RC-800/PVB Sealer - required a high baking temperature or overnight at 120°F. but essentially eliminated shrinkage (Re: Notebook Page 2278-84).

3. RC-800/VMCH Sealer - Required a high baking temperature or overnight at 120°F. but minimized shrinkage. Re: Notebook Page 2278-96).

4. Increasing dry of 1366 and/or nylon sealer - No improvement (Re: Notebook Page No. 2278-98).

5. RC-800/VYCC Sealer - Required a high baking temperature or overnight at 120°F. but practically eliminated shrinkage (Re: Notebook Page 2278-102).

6. Nylon Sealer plus catalyst to crosslink - No improvement when nylon plus citric or maleic acid as catalysts to crosslink nylon, were used (Re: Notebook page 2278-104).

7. Topcoat as Sealer - Eliminated shrinkage essentially one hundred percent (Re: Notebook page 2278-106).

The above results indicated that in order to reduce shrinkage, which occurs when RC-800 finishes are processed to an "A" stage and subsequently converted to a "B" stage, it is necessary to use a thermosetting sealer or one unaffected by the solvents of the topcoat. The extra cost of baking the thermosetting sealer, however, tends to neutralize any savings gained in reducing the labor needed for processing by splitting the bake.

(5) Adhesion

On occasions poor adhesion of the RC-800 topcoat to the 1366 Sealer was encountered. It was investigated as follows:

(a) Effect of Dry of 1366 - None (Re: Notebook page 2278-165)

(b) Effect of Film Thickness of 1366 - Adhesion increased slightly with increased build (Re: Notebook Page 2278-166).

(c) Effect of Moisture Condensed on Sealer (1366) Surface - None (Re: Notebook Page 2278-168)

(d) Effect of Poor Drying Conditions During Entire Finishing Schedule - Promotes poor adhesion (Re: Notebook Page 2278-176).

(e) Effect of Heavy Coats of Stain - Promotes poor adhesion, particularly if not thoroughly dried (Re: Notebook Page 2278-178).

(6) Stability

Initial tests indicated that the shelf life of the 45/45/10 formula without catalyst, at room temperature, in partially full glass containers is approximately one month and in partially full tin containers it is approximately 3 weeks. (Re: Notebook Page 2261-88). The 55/40/5 formula containing 10% Santocel C on the solids, compared to the 45/45/10 composition in partially full phenolic-lined containers, had a shelf life at room temperature, of 12+ months versus six weeks.

A further study of containers (Re: Notebook Page 2261-94) with storage at 105-110°F. indicated the following for the 45/45/10 composition.

Glass	7 days	Re: Notebook Page 2278-8
Iron	40 hours	
Tin	4 days	

Glass	7 days	Re: Notebook Page 2278-39
Aluminum	7 days	
Stainless Steel	4 days	
Galvanized Iron	4 days	
Tin	4 days	

This indicated that the best commercial container is either tin for small quantities or phenolic-lined, for larger quantities.

A study was then made of other methods of splitting the formula and of inhibitors (stability at 105-110°F).

(a) <u>Split Packaging</u> (Re: Notebook Page 2303-134)

System I - Clear topcoat minus catalysts at 41.4% T.S. 1 week
Catalyst solution (cobalt nitrate + benzoin)- No apparent deterioration.

System II - RC-800 - 1 week
Clear topcoat minus RC-800 but with catalysts present.
No apparent deterioration.
Catalyst solution - No apparent deterioration.

System III - RC-800 - 1 week
Clear topcoat minus RC-800 but with catalysts present.
No apparent deterioration.

System IV - RC-800/PX at 57.2% T.S. - 1 week
RL-255 + catalyst solution - No apparent deterioration.

System V - RC-800/RL-255 at 59.1% T.S. - 3 weeks
PX + catalyst solution. No apparent deterioration.

System VI - System I with 10% nitrobenzene on RC-800 - 8 weeks.

This indicates that nitrocellulose does not improve the stability of RC-800 but that RL-255 does, and that nitrobenzene is a stabilizer for RC-800.

(b) Effect of Various Stabilizers

(1) 10% nitrobenzene on the RC-800 in 45/45/10 formula increased the shelf life at 105°F., in tin, from one to five weeks (Re: Notebook page 2303-56).

(2) 50% nitroethane on the RC-800 in 45/45/10 formula increased the shelf life at 105°F., in tin, from one to two weeks. (Re: Notebook page 2303-62).

(3) Toluene in an amount equal to that in the final formula, added to RC-800 increased the shelf life of RC-800 from 10 days to 12 weeks plus, in tin at 105°F. (Re: Notebook Page 2303-64).

(4) 20% nitrobenzene or nitroethane on the RC-800 in a 45/10 combination of RC-800 and RL-255 at 45% T.S. in toluene increased the shelf life from three weeks to twelve weeks plus in tin at 105°F. (Re: Notebook page 2303-70).

(5) 30% Terpene B on the RC-800 in RC-800/RL-255 = 45/10 reduced to 45% T.S. with toluene, increased the shelf life from three weeks to six weeks plus in tin at 105°F. (Re: Notebook page 2303-114).

(6) From 60-170 ppm. anhydrous NH_3 on the RC-800 increased the shelf life of RC-800, in tin, at 105°F. from one week to four weeks plus (Re: Notebook page 2303-128).

(c) Relative Stability of Various Lots of RC-800

Lot 22 (received 5/9/49) - 10 months at R.T. in phenolic-lined containers

Lot 46 (received 10/5/49)- 1 month in R.T. in phenolic-lined containers.

All stability tests except those on the split package tests listed under (a) above, were run on lot 22. The split packaged systems listed under (a) above employed lot 46.

From these results it appears that one of the best ways to increase the shelf life of the RC-800 monomer is to reduce it with all of the toluene in the formula and/or add Terpene B. The best split system for shipping to the customer is that of packaging the RC-800/RL-255 at 45% T.S. in a toluene/Terpene B mixture in one container (partially full and phenolic lined) with the nitrocellulose, nitrocellulose solvents and the catalysts in the second package. Tin-lined containers can be used for batches of a gallon or less.

(7) Reduction in Cost

As a means of reducing the cost an investigation of thickening agents other than nitrocellulose and ones soluble in hydrocarbons, was undertaken. Three film formers meeting the requirements of solubility in low cost solvents were examined: viz., methyl methacrylate, ethyl cellulose and polyvinyl butyral.

(a) Methyl Methacrylate

Satisfactory conversion cannot be obtained in 2 hrs. at 130°F. with cobalt nitrate and benzoin as catalysts. Temperatures of 180-190°F. are required. No low cost third modifier, compatible with MMa and/or RC-800 was uncovered. Hence an appreciable decrease in cost at the 45% level of RC-800 was not possible. (Re: Notebook Pages 2303-26, 66, 94, 102, 108, 110, 116, 122, 124).

(b) Ethyl Cellulose

Satisfactory conversion is not obtained in 2 hours at 130°F. with cobalt nitrate and benzoin as catalysts. Temperatures of 180-190°F. or a longer bake at 120°F. than 2 hours, are required. No low cost third modifier compatible with ethyl cellulose and/or BCM was uncovered, preventing an appreciable decrease in cost at the 45%, level of RC-800. Also poor adhesion on aging, to 1366 Sealer, was obtained. (Re: Notebook Pages 2303-72, 74, 80, 86, 92, 112, 118, 120 - 2261-24).

(c) Polyvinyl Butyral

Satisfactory conversion is not obtained in 2 hours at 130°F. with cobalt nitrate and benzoin as catalysts. Temperatures of 180-190°F. are required (Re: Notebook page 2303-68).

An appreciable reduction in cost per gallon (approximately 20 cents) is indicated in the RC-800/PX/RL-255 = 45/45/10 formula, by changing the catalysts from cobalt nitrate and benzoin to cobalt naphthenate. An equivalent degree of conversion was obtained at an equal metallic cobalt content (Re: Notebook pages 2303-58, 84).

(8) Catalysts

A high spot investigation of the catalyst requirements for the RC-800/PX/RL-255 (45/45/10) formula indicated:

(a) A minimum metallic cobalt content on the RC-800 of 0.2% (Re: Notebook page 2261-33)

(b) Benzoyl Peroxide without cobalt nitrate is ineffective as a catalyst at 130°F. (Re: Notebook Page 2278-18).

(c) In the presence of cobalt nitrate and benzoin the RC-800/PX/RL-255 formula can be converted in one hour under UV (weatherometer) equivalent to 2 hrs. at 130°F. (Re: Notebook Page 2278-36).

(9) Cold Crack Resistance

Cold crack data indicate that the check resistance of the RC-800/PX/RL-255 formulae, either at 45/45/10 or 55/40/5 plus 10% Santocel "C", is very good even when 1/8" nitrocotton is used. However when extra thick films are applied and for the highest quality finish, 1/4" nitrocotton must be used. This reduces the total solids at spraying viscosity for these formulae from 32% to approximately 26-27% (Re: Notebook Page 2303-88).

(10) Blue Haze

From time to time various difficulties in the application and formulation of the RC-800 finishes have arisen and have been overcome by one means or another. One difficulty that has occurred on only a few panels and for which we do not have an explanation but only a theory, is the occurrence of a blue haze. While we have not been able to reproduce this condition we believe it to be an incompatibility which arises as the panel ages. It will occur in the dark, but heat or light accelerates it.

The following experiments were undertaken to determine the cause of the difficulty, with negative results. They are being recorded here for reference purposes only. All systems were exposed either to carbon arc or to ultra violet.

(a) Effect of Catalysts: None, cobalt nitrate plus benzoyl peroxide, cobalt nitrate plus benzoin and straight cobalt nitrate - baked 2 hrs. at 250°F. - No blue haze.

(b) Same as (a) except baked 2 hrs. @ 130°F. Where no catalyst was employed finish was baked 2 hrs. @ 250°F. No blue haze. (Re: Notebook page 2278-155).

(c) Type of Stain: No stain, NFL, Luxol and oil stain - no blue haze (Re: Notebook Page 2278-153).

(d) Effect of (a) Sealer: None, 1366, 1366 + stain, nylon primer (Re: Notebook Page 2278-163).

(b) Stain: Normal and 5 times normal amount. No haze in either case (Re: Notebook page 2278-163).

(e) Effect of light and heavy coats sealer 1366 - No blue haze (Re: Notebook page 2278-166).

(f) Effect of 1366 vs. RC-800/ethyl cellulose wash coat in a system employing a thermosetting sealer - No blue haze (Re: Notebook page 2278-167).

(g) Effect of moisture on sealer: 1366, 1366 + water, no sealer, and water on filler surface before 1366 was applied - No blue haze (Re: Notebook page 2278-168).

(h) Effect of drying under adverse conditions (72°F. & 84% R.H.) - No blue haze (Re: Notebook page 2278-176)

(i) Effect of amount of stain and dry of stain: No stain, normal VS-4489, 5 times normal VS-4489, air dried 1/2 hour; and 5 times normal VS-4489 force dried 2 hrs. at 130°F.; each under 1366 and J-1300-X-10362, (1366 made with PVB of our own manufacture) - No blue haze (Re: Notebook Page No. 2278-178).

(j) Effect of Adding Film Formers to the Stain: Polyvinyl butyral and ethyl cellulose - No blue haze (Re: Notebook page 2278-180).

(k) Effect of Slow Solvents in 1366: Butyl lactate, ethyl lactate, Cellosolve and Cellosolve acetate - No blue haze (Re: Notebook page 2278-183).

(l) Comparison of Oil Type, NFL and Luxol Stains - Applied in normal and in extra heavy coats - No blue haze (Re: Notebook Page 2278-183).

(m) Influence of Each Element in System with normal and 5 times normal amount of stain - No blue haze (Re: Notebook page 2278-184).

(n) Wash Coat: 5% T.S. RC-800/E.C. up to 25% RC-800/E.C. and 15% T.S. RC-800/N.C. - No blue haze (Re: Notebook page 2278-190).

(o) Effect of Blending RC-800/EC with RC-800/PX/RL-255: No blue haze (Re: Notebook page 2278-192).

(p) Effect of Using a High Alcohol 1366 - No blue haze (Re: Notebook page 2278-195)

(q) Effect of Dry of Wash Coat - No blue haze (Re: Notebook page 2303-3).

(r) Effect of high alcohol 1366 vs. 1366 + 5% Cellosolve - No blue haze (Re: Notebook page 2303-5)

(s) Effect of 1366 vs. 1366 + 5% ethyl butyral - Over normal and heavy stain - No blue haze (Re: Notebook page 2303-7).

(t) Effect of speeding up the dry of the system - No blue haze (Re: Notebook page 2303-10)

(u) Effect of normal and extra heavy wet coats of topcoat - No blue haze. Re: Notebook page 2303-16)

(v) Effect of 1366 in Topcoat - No blue haze (Re: Notebook page 2303-18)

(w) Effect of stain in topcoat (NFL and Luxol) No blue haze. (Re: Notebook page 2303-20)

(x) Effect of temperature of conversion of topcoat - No blue haze (Re: Notebook page 2303-22).

(y) Effect of age of topcoats before application - No blue haze. (Re: Notebook pages 2303-24, 28)

(z) Effect of excess phosphoric acid in filler - No blue haze (Re: Notebook page 2303-30).

(aa) Effect of inhibitor in filler - No blue haze - (Re: Notebook page 2303-32-34).

(bb) Benzaldehyde as a Contaminant - No blue haze (Re: Notebook page 2303-52)

(cc) Effect of Urea as a Contaminant - No blue haze (Re: Notebook page 2303-60).

B. Study of the Components of the Undercoat System

The recommended undercoat system for the preferred topcoats consists of the following:

(a) Stain	(d) Sealer
(b) Wash coat	(e) Glazing Stain } where needed
(c) Filler	(f) Glazing Lacquer } where needed

Any system may vary from consisting of just sealer to containing all of the above components. Considering them individually and in the order listed above, each was investigated as follows:

(1) Stain

(a) Over close grain woods such as birch and maple, oil type stain has been found to be satisfactory if dried overnight or its equivalent (Re: Notebook page 2278-62)

(b) Over porous woods such as walnut or mahogany, either a "Luxol" dye stain or an NFL may be used. However, over mahogany with a 27-5000 line filler, gray pores and poor adhesion may develop, if the stain is applied in heavy coats and is not thoroughly dried (Re: Notebook pages 2261-78, 2278-184 and 2303-40).

(2) Wash Coat

Early in the work on this project considerable pinholing was encountered. We were able to show that this was due in the main to the porosity of the wood. To a less extent, how well the wood was filled and how thoroughly the filler was dried were also shown to have some effect. (Re: Notebook Page 2201-142).

A study of various means for sealing the wood was therefore undertaken and the following materials examined as possible wash coats:

(a) RK-5760 Furniture "DULUX" at 12% T.S.

When baked 2-1/2 hours at 130°F. was definitely superior to 1366 from the standpoint of reducing pinholing, but it impaired adhesion (Re: Notebook Page 2201-108).

(b) 13016 Penetrating Primer at 12% T.S.

Poorer than 1366 for pinholing (Re: Notebook page 2201-108).

(c) RC-800/PX/RL-255 (55/35/10) at 12% T.S.

Some improvement in pinholing but not as good as RK-5760. Adhesion was poorer than with 1366.

(d) Shellac

No improvement in minimizing pinholing. (Re: Notebook page 2201-108).

(e) Vinylite VMCH at 8% T.S.

No reduction in pinholing. Impaired adhesion (Re: Notebook Page 2201-139).

(f) RC-800 at 12% T.S.

No decrease in pinholing. Impaired adhesion. (Re: Notebook page 2201-139).

(g) Cellulose Acetate (CA-108)

Slight reduction in pinholing. Adhesion was weakened. (Re: Notebook page 2201-139).

(h) Ureaformaldehyde (RC-721 @ 12% T.S.)

No improvement in eliminating pinholing. Adhesion was weakened. (Re: Notebook page 2201-139).

(i) Phenol Formaldehyde (XV-17911)

Prevented RC-800 topcoats from converting. (Re: Notebook page 2201-139).

(j) 19380 Sealer at 8% T.S.

No improvement in eliminating pinholing. Adhesion weakened. (Re: Notebook page 2201-145).

(k) Animal Glue

No improvement in eliminating pinholing. (Re: Notebook page 2201-192)

(l) Styrenated Alkyds (Styresol 4250 and 4400)

Styresol 4250 showed no reduction in pinholing. Styresol 4400 shows a slight reduction in pinholing. (Re: Notebook page 2161-14).

(m) Butyl Titanate

Some improvement in minimizing pinholing was obtained accompanied by indications of impaired adhesion (Re: Notebook page 2261-56).

(n) RC-800/Ethyl Cellulose

This combination gave a very definite reduction in pinholing, essentially eliminating it and with no sacrifice in scratch resistance. A 50/50 ratio was considered optimum. Medium ethoxy ethyl cellulose was found to be more foolproof from the standpoint of conversion with RC-800 (Re: Notebook pages 2201-245, 252, 262; 2261-48 and 2303-76).

(3) Filler

Because earlier work indicated that under-dried 563-line filler was more apt to cause cratering and ridging than 27-5000 line filler, the latter was selected for use in our preferred undercoat system. A detailed study of the drying conditions necessary for 27-5000 line filler showed 4 hours @ 130°F. to be optimum, if the RC-800/ethyl cellulose wash coat were used (Re: Notebook pages 2201-133, 156).

At this bake, 563-line filler also is fairly satisfactory. It tends to puff somewhat more but is definitely superior in freedom from gray pores in a mahogany system with 1366 as the sealer (Re: Notebook page 2303-40). This is true over an NFL stain, but does not hold over a "Luxol" stain.

(4) Sealers

Earlier work had indicated that 1366 Penetrating Primer was definitely superior to 19380 type sealer in an RC-800 system and that a sealer was necessary to provide maximum adhesion, hold out, and foolproofness against surface defects, such as ridging and crawling. Since 19380 definitely impaired the scratch resistance of the system, 1366 was selected as the sealer in the initial work. A further sealer study was made (1) to improve adhesion and minimize gray pores, and (2) to reduce the shrinkage in the system. Work covering the latter has already been discussed under the heading "Shrinkage" in a previous section of this report (see page 13).

The following study of various sealers was made to improve adhesion.

(a) Nylon 8A1 DV-80

This film former was found to give improved adhesion, more "life" and better pore definition with a minimum of gray pores. Over porous woods such as walnut and mahogany, it yielded the greatest improvement in adhesion when used as a wash coat as well as a sealer. However, it had two defects: (1) high cost, and (2) the built up system exhibited objectionable shrinkage (Re: Notebook pages 2261-44, 74 & 2278-24-98).

(b) Miscellaneous Sealers

Various other sealers were evaluated, such as 10% polyvinyl acetate dissolved in butyl acetate, 4% polyvinyl butyral (G-649) in butyl acetate/alcohol, 10% low molecular weight, solution process, polyvinyl butyral (Re: Notebook page 2249-95), 13016 Penetrating Primer and a penetrating primer based on low molecular weight, solution process polyvinyl butyral. All were either poorer for adhesion or no better for adhesion than 1366 (Re: Notebook page 2278-16).

Based on these results, 1366 was selected as the best sealer except perhaps on maple where the shrinkage of Nylon 8A1-D-80 is not of importance.

(5) Glazing Stains and Shading Lacquers

Two basic types of glazing stains were evaluated for possible use in the RC-800 system; viz: one based upon a drying oil vehicle and coded in the 307 line and the other formulated with castor oil and carrying a 28 line code. The latter was found to be definitely better from the standpoint of adhesion than the former (Re: Notebook Page 2303-42).

The 266 line shading lacquers based on blends of 259 line "Duco" were found to be satisfactory for use in the RC-800 system (Re: Notebook page 2303-44, 46).

(C) Competitive Thermosetting Finishes

Two competitive finishes were evaluated versus the RC-800 system. They were the finishes offered under the trade name "Phenoplast" and Bakelite Corporation's XV-17911. The latter is a phenolformaldehyde type which Bakelite offered to manufacturers of wood finishes.

Our evaluation indicated that "Phenolplast" when properly cured, and over a suitable primer, provided a tough, mar, solvent resistant finish equal to our proposed RC-800 type finish (45/45/10). Although it sprayed or brushed fairly well, it tends to crater and crawl in the same manner as some of the earlier RC-800 type formulas containing high amounts of RC-800. Also its color retention was inferior to our RC-800 finish.

From its general appearance and physical characteristics, "Phenolplast" is apparently very similar to XV-17911, Bakelite's low temperature baking finish for wood. The latter is characterized by the same advantages and disadvantages.

It is not believed that "Phenolplast" as now formulated is a serious immediate competitor in the field in which we contemplate exploiting RC-800 finishes (Re: Notebook pages 2278-23, 25 thru -33).

APPENDIX

(A) TENTATIVE RATING CHART FURNITURE FINISHING SYSTEMS WITH RC-800 TOPCOAT

Properties	Type A "DULUX"	Type H "Duco"	RC-800 Clear
1. Cold Check	6	9	10
2. Durability	-	9	10
3. Humidity	3	10	10
4. Water Resistance	9	8	10
5. Alcohol Resistance	9	5-1/2	10
6. Solvent Resistance	5	0	10
7. Heat Resistance (212°F)	9	4	10
8. Scratch Resistance	8	8	9-1/2
9. Mar Resistance	8	6	9
10. Resistance to Discoloration	9	8-1/2	6
11. Print Resistance	8-1/2	8	10+
12. Clarity	6-1/2	8-1/2	9
13. Sanding	8	7-1/2	4
14. Rubbing	5	8	5
15. High Polish	5	8-1/2	8-1/2
16. Shrinkage	7	8	9
17. Spraying Solids	42%	26%	32%

(B) Compositions of the clear and flat RC-800 topcoats and the ethyl cellulose/RC-800 wash coat are as follows at spraying viscosity:

(a) Clear (45/45/10)

PX-7555 (dry)	14.30%	(1/8 sec. Hercules Nitrocotton)
H-1-d	7.70	(alcohol of drhydration)
H-1	9.00	(ethyl alcohol)
HB-6	18.10	(n-butyl acetate)
HA-136	8.40	(ethyl acetate)
H-12	2.50	(n-butyl alcohol)
RL-255	5.40	(50% castor oil alkyd)
KG-4121	0.45	(cobalt nitrate hexahydrate)
KG-4122	0.45	(benzoin)
KH-4120	14.30	(RC-800 monomer)
H-47	19.40	(toluene)
	100.00%	

Theo: T. S. = 32.7%
Gal. Weight = 8.01#
Visc. 7 cup = 45-55"

(b) Flat (45/45/10)

PX-7555 (dry)	13.0%	(1/8 sec. Hercules Nitrocotton)
H-1-d	7.0	(alcohol of dehydration)
H-1	6.5	(ethyl alcohol)
HB-6	14.7	(n-butyl acetate)
HA-136	7.6	(ethyl acetate)
H-12	3.3	(n-butyl alcohol)
RL-255	4.1	(50% castor oil alkyd)
KG-4121	0.4	(cobalt nitrate hexahydrate)
KG-4122	0.4	(benzoin)
*Mill Base	14.1	(see below)
KH-4120	13.7	(RC-800 monomer)
H-47	15.2	(toluene)
	100.0%	

Theo: T.S. = 32.8%
Gal. Weight = 8.04#
Visc. 7 cup = 45-55"
Sheen = 94 (Gaub)

*Mill Base

H-1	17.0%
H-47	2.5
HB-6	18.3
HA-136	9.5
RL-255	7.4
G-222	11.0 (Santocel C)
H-47	16.5
**Clear Base	13.7
	100.0%

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***Clear Base

PX-7555 (dry)	35.0%
H-1-d	18.8
H-47	15.7
HB-6	17.5
HA-136	9.1
H-12	3.9
	100.0%

(c) Wash Coat (Thermosetting)

KG-4123	5.0%	(7 cps. med. ethoxy Ethocel)
KH-4120	5.0	(RC-800 monomer)
H-1	12.5	(ethyl alcohol)
H-47	43.5	(toluene)
H-12	5.3	(n-butyl alcohol)
H-583	21.5	(xylene)
H-35	7.0	(methyl ethyl ketone)
KG-4121	0.2	(cobalt nitrate hexahydrate)
	100.0%	

(G) RECOMMENDED SYSTEMS FOR USING RC-800 TOPCOATS

Operation	Open Grain Wood (Mahogany & Walnut)	Close Grain Wood (Maple and Birch
1. Stain	NFL for walnut and Luxol for mahogany to minimize gray pores.	307 line (oil type)
Dry	15 to 30 minutes at room temperature.	16 hrs. or longer at room temperatures of 60°F. or higher
2. Wash Coat	1366 for good quality veneer J-RK-X-10336 for poorer quality grades of veneer	None -
Dry	1366 should be flashed 1 hour J-RK-X-10336, if baked simultaneously with the filler, should be flashed one hour. Otherwise bake J-RK-X-10336 for 2 hours or longer at 130-140°F.	-
3. Filler	27-5000 line	None or 27-5000 line
Dry	Filler, or filler plus wash coat, are baked 4 hrs. at 130-140°F.	Filler if used to be baked 4 hrs. at 130-140°F.
4. Sealer	1366	1366
Dry	One hour at room temperature (60°F. or higher)	One hour at room temperature (60°F. or higher)
Sand	Scuff lightly with #360 paper	Scuff lightly with #360 paper.
5. Glaze	Optional. 28 line as represented by the composition of P-28-R-555674.	Optional. 28 line as represented by the composition of P-28-R-55674.
Dry	Flash off solvents which should not require more than 1 hour	Flash off solvents which should not require more than 1 hour.

Operation	Open Grain Wood (Mahogany & Walnut)	Close Grain Wood (Maple & Birch)
6. Shading Lacquer	Optional. 266 line	Optional. 266 line
Dry	1 hour at room temperature (60°F. or higher).	1 hour at room temperature (60°F. or higher)
7. RC-800 Topcoat	For maximum quality apply 2 coats, flashing 30 minutes between coats and 60 minutes prior to baking.	For maximum quality apply 2 coats, flashing 30 minutes between coats and 60 minutes prior to baking.
Bake	2 hours at 130-140°F. and 35% R.H. Cannot be air dried.	2 hrs. @ 130-140°F. and 25% R.H. Cannot be air dried.

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