NATIONAL BUREAU OF STANDARDS REPORT

5904

TABLES OF SPECTROPHOTOMETRIC AND COLORIMETRIC DATA ON SOME MOLDED PHENOLIC PLASTICS

By

Harry J. Keegan

and

John C. Schleter

To

U. S. Department of the Army
Ordnance Corps
Picatinny Arsenal
Dover, New Jersey

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
0201-20-2347

September 1959

NBS REPORT
5904

TABLES OF

SPECTROPHOTOMETRIC AND COLORIMETRIC

DATA ON

SOME MOLDED PHENOLIC PLASTICS

By

Harry J. Keegan
and
John C. Schleter

Photometry and Colorimetry Section
Optics and Metrology Division

To

U. S. Department of the Army
Ordnance Corps
Picatinny Arsenal
Dover, New Jersey

Project No. TB4-721

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Preface

This is a report on the spectrophotometric measurements and colorimetric computations done under NBS Project 0201-20-2347 entitled Color Coding of Plastics, financed by the Samuel Feldman Ammunition Laboratories, Picatinny Arsenal, U. S. Army Ordnance Corps, Dover, New Jersey, under Army Ordnance Contract for Project No. TB4-721.

Harry J. Keegan
Project Leader

Tables of Spectrophotometric and Colorimetric Data on Some Molded Phenolic Plastics

Harry J. Keegan and John C. Schleter

Abstract

Spectral directional reflectance measurements were made of a number of painted cardboards and dyed plastic materials currently in use for the specification of the colors used for camouflage and color coding by the Ordnance Corps, U. S. Department of the Army. From these spectrophotometric data, colorimetric conversions were made for the Standard Observer and Coordinate System for Colorimetry of the International Commission on Illumination (C.I.E.). The C.I.E. colorimetric data were converted into terms of dominant wavelength and excitation purity, and into terms of the Munsell renotation system and thence to color name designations of the ISCC-NBS (Inter-Society Color Council - National Bureau of Standards). These various data obtained with available molded phenolic plastics were obtained for use in the preparation of a specification of these colors for coding purposes.

Contents

I. Introduction

The overall objective of this Army Ordnance project is stated as follows: "To standardize eight plastic colors currently recommended for use by the Ordnance Corps; to supply limit data for these colors; to check the standards manufactured to these data; and to prepare a specification for these colors."

In a letter dated July 23, 1956, from the Samuel Feltman Ammunition Laboratories, Picatinny Arsenal, Ordnance Corps, Dover, New Jersey, the problem was stated as follows: "The Ordnance Corps would like to use colors for coding purposes in ammunition items. However in order to do so, standards for acceptance must be established. Very precise control is not necessary but with some colors, disagreement does occur. This is especially true of the olive drab where materials ranging all the way from brown to green are designated olive drab by some people. In addition to olive drab, colors now being considered are red, yellow, green, brown, and black. For each of these, we would like to have tolerances from the standards as required. For instance, olive drab might require a tolerance as to lightness and darkness as well as greenness and yellowness. On the other hand, black might require only two tolerances one for grayness (or lightness) and one for greenness. What we propose, if a contract is arranged, is that the contractor (NBS) would set up standards and tolerances, arrange acceptance of the proposals with the Ordnance Corps inspectors and the manufacturing industry, and write a specification for colors and their test methods which could be referenced in other plastic specifications. A second phase of the contract might be to establish test procedures and allowable limits for color stability. The above is a brief outline of what is being considered at present; it may have to be altered for technical reasons which you know."

II. Acquisition of Material Samples

1. First Canvas of Manufacturers.

At first, it was expected that all that was necessary to obtain samples of suitable phenolic plastic resins was to canvas the leading manufacturers who normally supply the Ordnance Corps with color plastics. The names of these manufacturers supplied by Picatinny Arsenal were (1) Durez, Plastics Division, North Tonawanda, New York; (2) Koppers Company Inc., Chemical Division, Pittsburgh, Pennsylvania; (3) Rogers Corporation, Rogers, Conn.; (4) Bakelite Company*, New York, N. Y.; (5) Monsanto Chemical Company, Plastics Division, Springfield, Mass.; (6) Fibrite Corporation, Winona, Minn.; and (7) The Bordon Company, Chemical Division, Durite Products Department, Philadelphia, Pa.

Accordingly, individual letters were prepared and mailed to these seven manufacturers. A total of sixteen samples (4" diam., 1/8" thick) consisting of four blacks, six browns, three reds, one green, one yellow, and one olive drab, were received from four of the seven manufacturers as follows:

* Union Carbide Plastics Division, Union Carbide Corporation

Manufacturer	Samples
Bordon	Black; and Brown.
Durez	Black; Brown; and Red.
Fibrite	Black; Brown; Olive Drab; Red; and Yellow.
Monsanto	Black; three different Browns; Green; and Red.

2. Paint Color Reference Samples.

Because of the inadequate number of samples received from the first canvas of the phenolic plastic resin manufacturers, it was decided to have the personnel of the Plastics Research Section of Picatinny Arsenal designate approximately the colors desired by them from existing charts of material color samples in paints that we could procure and send to the manufacturers as a guide on the color range with which we were expecting to obtain samples in phenolic plastic resins.

The colors suggested by Picatinny Arsenal (see letter dated December 18, 1956, signed by L. H. Eriksen, File Ref: ORDBB-TM-2/6177) were selected by them from Federal Specification TT-C-595 "Colors for Ready-Mixed Paints" [1].* These paint color selections were "Red 1110, Yellow 1310, Brown 1710, Black 1770, Olive Drab 1415, Orange 1210, and White 1755."

Following the selection of the above colors by Picatinny Arsenal from Federal Specification TT-C-595, and as this specification has been superseded by other colors in the present Federal Standard No. 595 entitled "Colors" [2], wherever available these selections were converted into those color cards of the currently available specification as follows: "Red 11105, Yellow 13538, Brown 10080, Black 17038, Forest Green 14052, Orange 12246, and White 17875." Of these seven conversions, it was found that six were considered to be acceptable color matches for the requested samples from TT-C-595. The one sample which was considered to be not acceptable as a color match was the Forest Green chip No. 14052.

There is some difference of opinion as to what color constitutes the color "Olive Drab". The color adopted by the representative of Picatinny Arsenal for the use of this project study is the No. 110 Olive Green of USA 3-1 [3] and No. 1410 Olive Green of TT-C-595. As the equivalent to No. 1410 of TT-C-595 was not an acceptable match in F. S. 595, it was necessary to look elsewhere for duplicates of sample 1410.

The available six colors from Federal Standard 595: Red 11105, Yellow 13538, Brown 10080, Black 17038, Orange 12246, and White 17875, were ordered from the Federal Supply Service, General Services Administration. The Olive Green color was ordered commercially from the Color Marketing Division, Magill-Weinsheimer Company, Cleveland, Ohio.

After all of the samples of the reference paint colors were procured they were spectrophotometered and chromaticity coordinates were computed so that we would have a quantitative record of the colors we were trying to

* Numbers in brackets refer to Bibliography on page 9 .

obtain from the manufacturers of phenolic plastic resins.

In the meantime, the project officer administering technical supervision of this project at the Picatinny Arsenal visited the National Bureau of Standards and reviewed some of the results of this project and some of the difficulties that had been encountered. It was at this visit that it was learned that the Picatinny Arsenal required three types of phenolic plastic resins as follows: Class 2, General purpose, with wood-flour filler; Class 5, Medium impact strength, with fabric filler; and Class 6, High impact strength, with cord filler. These classes of material are listed in Specification MIL-P-10420 (Ord) 8 August 1950 [4].

3. Second Canvas of Manufacturers.

A second canvas of manufacturers was needed in order to obtain a sufficient collection of samples of the colors needed by the Ordnance Corps in phenolic resins. It was decided to have a meeting of representatives of the seven leading manufacturers and five additional firms whose names were supplied by Picatinny Arsenal. In the invitation it was stated that the purpose of the meeting was to discuss a proposed color specification for three types of phenol-formaldehyde resins, namely: (1) general purpose, with wood-flour filler; (2) medium impact strength, with fabric filler (coarse); and (3) high impact strength, with cord filler. It was further stated that the colors to be considered were seven (red, orange, yellow, brown, black, white, and olive green). To aid in the identification of the colors to be studied, samples of each of the colors shown in paint on 3 x 5 inch cardboard were enclosed together with their chromaticity coordinates, daylight reflectances, and Munsell renotations as shown in Table I. These paint colors were intended to apply to each of the three types of phenol-formaldehyde resins, and were submitted to give some guide as centers of the tolerable ranges for these colors.

Only one manufacturer's representative attended the meeting at the National Bureau of Standards on June 11, 1957. However, his participation, together with that of one representative from Picatinny Arsenal, one representative from the Office Chief of Ordnance, and three representatives from the National Bureau of Standards, enabled us to progress in this investigation and gave us the material needed to write this report.

Only two manufacturers submitted samples on the second canvas: Rogers Corporation, Rogers, Conn., and the Union Carbide Plastics Company, a Division of the Union Carbide Corporation, Bound Brook, N. J. (formerly the Bakelite Company).

The Rogers Corporation submitted six samples of colors, 4 inches in diameter and 1/8 inch in thickness, designated with reference to specifications MIL-P-10420 [4] and MIL-M-14E [5], as follows:

Color	Material Type	Specification
Red	RX-431	MIL-M-14E, Type CFI-10
Yellow	RX-429	MIL-P-10420, Class 4
Brown	RX-429	MIL-P-10420, Class 4
Olive Drab	RX-431	MIL-M-14E, Type CFI-10
Black	RX-429	MIL-P-10420, Class 4
Orange	RX-428	MIL-M-14E, Class CFI-5

Mr. William J. Goodwin, Development Department, Union Carbide Plastics Company, brought to the meeting on June 11, 1957, twenty-one plastic chips, 2 inches in diameter and 1/8 inch thickness, grouped as follows:

Color	Sets
Black	Two sets (one set with four and one set with five chips)
Red	Two sets (one set with two and one set with three chips)
Yellow	One set with three chips
Brown	One chip only
Olive Drab	One set of three chips

These 27 samples raised the total of plastic color chips submitted for test from 16 to 43. Later, Mr. Goodwin submitted 25 more colored chips, making the final total of 68 phenolic plastic resin chips with which this report is concerned.

At the same meeting, Mr. T. B. Blevins, Office Chief Ordnance, U. S. Department of the Army, submitted two publications showing what colors the Army and the Air Force had been using. One of these was a color card [6], and the other was a manual [7]. The color card contained eight colors: Yellow, Red, Light Brown, Light Blue, Blue Gray, Green, Black, and Olive Drab. The manual contained nineteen pages of colored illustrations in printing inks for the markings of ammunition and bombs. The ammunition body colors were: Olive Drab, Black, Gray, and Blue, with markings in Yellow, White, Green, Red, or Purple. The bomb body colors are: Olive Drab, Gray, and Blue, with markings in Black, Yellow, Purple, or Green, and with from one to three bands for further identification in Yellow, Purple, Green, or Black.

To assist the National Bureau of Standards in this study of the color coding of plastics, Mr. Goodwin submitted two books of graphs of the Bakelite Company Standard Testing Methods, one for the conversion of chromaticity coordinates x, y, and daylight reflectance, Y, into dominant wavelength [8], and the other for the determination of small color differences [9].

III. Spectrophotometric Measurement Method

Measurements of spectral directional reflectance were made on the NBS General Electric recording spectrophotometer [10 and 11] for the condition of excluded specular component of the reflected radiant energy and for the spectral range 400 to 750 millimicrons. Slits of approximately 10 millimicrons of spectral width were used for these measurements. All recordings were made with calibration curves of standard didymium and Vitrolite for making the wavelength and photometric scale corrections [12]; zero curve corrections were also made.

The method used for the exclusion of the specular component was that of placing a black velvet plug in the wall of the integrating sphere, on the sample side only, so that that portion of the component falling on the black plug was absorbed and thus excluded from the measurement. Each sample was spectrophotometered twice; the second measurement was made after the sample had been turned in its own plane through 90° from the first position.

A key to the sample designations of the participating companies and the graph sheet and curve numbers of the General Electric recording spectrophotometer measurements are listed in Table II, together with a numerical sample number (S-1 to S-68) assigned in alphabetical order of manufacturer's color name. Photocopies of the eleven spectrophotometric graph sheets of these measurements are included in Appendix B of this report.

IV. Spectrophotometric Results

The results of these spectrophotometric measurements of the 68 samples of phenolic resin colors are shown on the copies of the eleven graph sheets obtained on the General Electric recording spectrophotometer in Appendix B of this report.

Each of the eleven curve sheets of the spectral directional reflectance of the 68 plastic colors was read and corrected at each ten millimicrons, and these data were extrapolated to include the wavelengths 380, 390, 760, and 770 millimicrons. These corrections were made on an IBM 704 high-speed electronic computer using a program for these computations [13] developed here.

All of these corrected data of spectral directional reflectance for the 40 wavelengths between 380 and 770 millimicrons are listed in Appendix A of this report.

V. CIE Colorimetric Computations

The corrected spectral directional reflectances for the visible spectrum 380 to 770 millimicrons for the 68 plastic samples were reduced by means of the CIE Standard Observer and Coordinate System [14 and 15] for CIE Source C, representative of average daylight.

These colorimetric computations yielded the tristimulus values (X, Y, and Z), and the chromaticity coordinates (x, y, and z) listed in Table III. These computations were made on the IBM 704 high speed electronic computer and were obtained at the same time that the corrections of the photometric and wavelength scale errors were made.

These chromaticity coordinates and daylight reflectances provide the basic data for the colorimetric specification of the Army Ordnance colors.

Table III lists the samples in the alphabetical order of manufacturers color names, as follows: Black, Blue, Brown, Gray, Green, Maroon, Navy, Olive, Olive Drab, Orange, Purple, Red, Tan, and Yellow. This same order is used in the rest of the tables of this report.

VI. Munsell Renotations and ISCC-NBS Color Designations

By the use of the above CIE chromaticity coordinates and daylight reflectances of the 68 plastic resin colors, Munsell renotations were obtained on the IBM 704 high-speed electronic computer, using a computer code for this conversion developed at the NBS during the past two years [16]. These Munsell renotations of the 68 plastic samples are listed in Table IV. From the Munsell renotations, color designations were graphically estimated in terms of the ISCC-NBS method of designating colors [17]. These color designations of the 68 plastic samples are also listed in Table IV.

VII. Dominant Wavelength and Excitation Purity

Dominant wavelength and excitation purity are alternate standard specifications for color. They are more or less suggestive of the appearance of the color of an object; thus when used as a part of the chromaticity specification of the color of that object they are sometimes more easily understood than are the chromaticity coordinates, x and y. The dominant wavelengths and excitation purities of this report were estimated from the chromaticity data by means of graphs showing the conversion of CIE chromaticity data into these terms [8 and 18]. This method is recognized by the American Standards Association [19]. The dominant wavelengths and excitation purity of the 68 plastic samples are shown in Table V.

VIII. Summary

This study of the spectrophotometric and colorimetric properties has provided the basic data for the determination of the tolerances of the colors required for ammunition identification and other colors. A separate report will deal with the problem of color tolerances and color specification of the U. S. Army Ordnance Corps usage of colors for coding.

IX. Bibliography.

[1] Colors; (for) ready-mixed paints. Federal Specification TT-C-595, January 12, 1950, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C. Price $4.50, (Obsolete).

[2] Colors. Federal Standard No. 595, March 1, 1956, General Services Administration, Business Service Center, Region 3, 7th & D Streets, S.W., Washington 25, D.C. Price $2.25 (Individual 3 by 5 inch chips, 5 cents; one each of 358 color chips, $15.00).

[3] Color Card, Supplement to U. S. Army Specification No. 3-1, Revised April 21, 1943 (Obsolete).

[4] Plastic, phenolic, molded parts and molding material (for Ordnance use). MIL-P-10420 (Ord), August 8, 1950.

[5] Molding plastics and molded plastic parts, thermosetting. MIL-M-14E, February 10, 1956.

[6] Lusterless color card. For use with U. S. Army Specification No. 3-67, Paint for ammunition, and U. S. Army Specification No. 3-162, Lacquer for ammunition, Pending revision of U. S. Army Specification No. 3-1, Paint and related materials, General Specifications, Color Card Supplement only.

[7] Ammunition, general. Department of the Army Technical Manual TM 9-1900, Department of the Air Force Technical Order TO 11A-1-20, June 1, 1956.

[8] Determination of chromaticity coordinates, dominant wavelength, purity, and lightness from CIE tristimulus data. Bakelite Company standard testing method No. WC-5-V/1, May 20, 1955.

[9] Graphical computation of small color differences. Bakelite Company standard testing method No. WC-5-W/1.

[10] A. C. Hardy. A new recording spectrophotometer. J. Optical Soc. Am. 25, 305 (1935); also A. C. Hardy. History of the design of the recording spectrophotometer. J. Opt. Soc. Am. 28, 360 (1938).

[11] J. L. Michaelson. Construction of the General Electric recording spectrophotometer. J. Opt. Soc. Am. 28, 365 (1938).

[12] K. S. Gibson and H. J. Keegan. Calibration and operation of the General Electric recording spectrophotometer of the National Bureau of Standards. J. Opt. Soc. Am. 28, 372 (1938); also H. J. Keegan and K. S. Gibson. On the use of working standards of didymium and Vitrolite glasses for spectrophotometric measurements. J. Opt. Soc. Am. 34, 770 (1944).

[13] H. J. Keegan, W. C. Rheinboldt, J. C. Schleter, J. P. Menard, and Deane B. Judd. Digital reduction of spectrophotometric data to Munsell renotations. J. Opt. Soc. Am. 48, 863 (1958).

[14] Proceedings, Eighth Session, Commission Internationale de l'Eclairage, Cambridge, England, pp. 19 to 29, September 1931.

[15] D. B. Judd. Color in Business, Science and Industry. pp. 98 to 108, 1952 (J. Wiley and Sons Inc. New York, N. Y.)

[16] W. C. Rheinboldt and J. P. Menard. Mechanized conversion of colorimetric data to Munsell renotations. J. Opt. Soc. Am. 48, 864 (1958).

[17] K. L. Kelly and D. B. Judd. The ISCC-NBS method of designating colors and a dictionary of color names. NBS Circular C553, November 1, 1955.

[18] A. C. Hardy. Handbook of colorimetry. Cambridge, Mass. Technology Press (1936).

[19] American standard methods of measuring and specifying color. J. Opt. Soc. Am. 41, 431 (1951). (See also ASA Z58.7.1, .2, .3-1951 obtainable from the American Standards Association, 70 East 45th Street, New York 17, N. Y.)

Table I

CIE Chromaticity Coordinates, Daylight Reflectances, and Munsell Renotations for Standard Source C Representative of Average Daylight of Paint Chips Representative of Army Ordnance Colors.

Name	Daylight Reflectance Y(%)	CIE Chromaticity Coordinates x	y	Munsell Renotations H	V	C
Red	8.1	0.635	0.317	8.1R	3.3/	14.0
Orange	20.7	.589	.380	1.1YR	5.1/	15.3
Yellow	48.6	.506	.460	0.1Y	7.4/	14.6
Brown	5.5	.411	.370	7.2YR	2.7/	3.0
Black	0.3	.289	.297	9.9B	0.2/	0.3
White	83.1	.312	.322	7.9GY	9.2/	0.3
Olive-Green	4.3	.365	.389	8.3Y	2.4/	2.2

Table II

Key to Manufacturers Sample Designations, Assigned Sample Number, GE Graph Sheet and Curve Numbers.

Sample Designation		Assigned Sample Number	GE Graph Sheet Serial No.	Curve Number
ROGERS CORPORATION SAMPLES:				
Black	RX429	S-16	GE II-1883	4,15
Brown	RX429	S-28	-1883	5,14
Olive Drab	RX431	S-47	-1883	6,13
Orange	RX428	S-49	-1883	7,12
Red	RX431	S-61	-1883	8,11
Yellow	RX429	S-68	-1883	9,10
UNION CARBIDE CORPORATION SAMPLES:				
Black 15	2155	S- 1	-1907	4,13
Black 15	BMG2323	S- 2	-1884	4,19
Black 15	2323	S- 3	-1908	4,19
Black 25	2080	S- 4	-1907	5,12
Black 25	BMG5000	S- 5	-1884	5,18
Black 25	5000	S- 6	-1908	5,18
Black 25	5120	S- 7	-1907	6,12
Black 25	5315	S- 8	-1909	4,19
Black 25	5316	S- 9	-1907	7,10
Black 25	5498	S-10	-1909	5,18
Black 35	2051	S-11	-1907	8,9
Blue 25	BMG2010	S-17	-1884	6,17
Brown 15	BMG5000	S-18	-1884	8,15
Brown 65	BMG2010	S-19	-1884	9,14
Brown 115	2010	S-20	-1909	6,17
Brown 195	BMG2010	S-21	-1884	10,13
Gray 25	BMG2010	S-29	-1905	4,19
Gray 35	BMG2010	S-30	-1905	5,18
Gray 65	BMG2010	S-31	-1905	6,17
Gray 105	BMG2010	S-32	-1905	7,16
Green 45	BMG8952	S-33	-1905	8,15
Green 55	BMG2010	S-34	-1905	9,14
Green 65	BMG2010	S-35	-1905	10,13
Green 75	BMG2010	S-36	-1905	11,12
Maroon 25	BMG5721	S-38	-1906	4,19
Maroon 55	BMG5780	S-39	-1906	5,18
Maroon 65	BMG8052	S-40	-1906	6,17
Navy 45	BMG2010	S-41	-1884	7,16
Olive 15	2010 AIM	S-44	-1908	7,16
Olive 15	2010 DARK	S-43	-1908	6,17

Table II (Continued)

Sample Designation		Assigned Sample Number	GE Graph Sheet Serial No.	Curve Number
UNION CARBIDE CORPORATION SAMPLES (cont'd):				
Olive 15	2010 LIGHT	S-45	GE II-1908	8,15
Orange 15	(16094)BMG2010	S-48	-1906	8,15
Purple 15	(17805)BMG2010	S-50	-1906	7,16
Red 45	BMG2010	S-51	-1906	9,14
Red 65	2761 AIM	S-53	-1909	8,15
Red 65	2761 DARK	S-52	-1909	7,16
Red 65	2761 LIGHT	S-54	-1909	9,14
Red 85	2010 AIM	S-56	-1909	11,12
Red 85	2010 DARK	S-55	-1909	10,13
Red 95	BMG2010	S-57	-1906	10,13
Tan 35	BMG2010	S-62	-1884	11,12
Yellow 15	BMG2010	S-63	-1906	11,12
Yellow 15	2010 AIM	S-65	-1908	10,13
Yellow 15	2010 DARK	S-64	-1908	9,14
Yellow 15	2010 LIGHT	S-66	-1908	11,12
Olive Drab	BM-17015 Batch 319A	S-42	-1793	7,8
BORDON				
Black	--	S-12	-1791	4,19
Brown	--	S-22	-1791	5,18
DUREZ				
Black	791	S-13	-1779	4,9
Brown	740	S-23	-1779	5,8
Red	1898	S-58	-1779	6,7
FIBRITE				
Black	FM-1132	S-14	-1792	4,13
Brown	FM-1140	S-24	-1792	5,12
Olive Drab	1330	S-46	-1792	6,11
Red	1153	S-59	-1792	7,10
Yellow	1390	S-67	-1792	8,9
MONSANTO				
Black	1006	S-15	-1791	6,17
Brown	1004	S-26	-1791	7,16
Brown	803A	S-25	-1791	8,15
Brown	10900	S-27	-1791	9,14
Green	(no number)	S-37	-1791	10,13
Red	2739	S-60	-1791	11,12

Table III

CIE Colorimetric Specification of Sixty-Eight Plastic Colors

Sample Number	Sample	Tristimulus Values X	Y	Z	Chromaticity Coordinates x	y	z
BLACK							
S- 1	Bakelite 15-2155	2880	2956	3737	0.3008	0.3088	0.3904
S- 2	Bakelite 15 BMG 2323	1575	1602	2156	.2953	.3004	.4043
S- 3	Bakelite 15-2323	2601	2666	3401	.3001	.3076	.3923
S- 4	Bakelite 25-2080	2666	2726	3489	.3002	.3069	.3929
S- 5	Bakelite 25 BMG 5000	1272	1305	1740	.2946	.3023	.4031
S- 6	Bakelite 25-5000	2408	2465	3175	.2992	.3063	.3945
S- 7	Bakelite 25-5120	2291	2355	2982	.3003	.3087	.3909
S- 8	Bakelite 25-5315	2416	2464	3119	.3020	.3081	.3899
S- 9	Bakelite 25-5316	2639	2690	3468	.3000	.3058	.3942
S-10	Bakelite 25-5498	2611	2674	3456	.2987	.3059	.3954
S-11	Bakelite 35-2051	2568	2628	3401	.2987	.3057	.3956
S-12	Bordon	1829	1881	2396	.2995	.3080	.3925
S-13	Durez 791	1918	1967	2588	.2963	.3039	.3998
S-14	Fiberite FM-1132	3850	3964	4747	.3065	.3156	.3779
S-15	Monsanto 1004	911	936	1247	.2945	.3024	.4031
S-16	Rogers RX-429	1092	1129	1534	.2908	.3006	.4086
BLUE							
S-17	Bakelite 25 BMG 2010	4133	3269	12504	.2076	.1642	.6282
BROWN							
S-18	Bakelite 15 BMG 5000	2768	2478	2462	.3591	.3215	.3194
S-19	Bakelite 65 BMG 2010	3786	3343	2836	.3800	.3355	.2846
S-20	Bakelite 115-2010	8781	7896	5819	.3903	.3510	.2587
S-21	Bakelite 195 BMG 2010	9768	8582	4355	.4302	.3780	.1918
S-22	Bordon	2423	2246	2386	.3434	.3183	.3382
S-23	Durez 740	2804	2558	2671	.3491	.3184	.3325
S-24	Fiberite FM-1140	6202	5851	5155	.3604	.3400	.2996
S-25	Monsanto 803A	14779	14630	7129	.4045	.4004	.1951
S-26	Monsanto 1004	2193	1916	1783	.3723	.3251	.3026
S-27	Monsanto 10900	21139	20271	3959	.4659	.4468	.0873
S-28	Rogers RX-429	5616	4806	2815	.4243	.3631	.2126
GRAY							
S-29	Bakelite 25 BMG 2010	7978	7949	10164	.3058	.3047	.3896
S-30	Bakelite 35 BMG 2010	4887	5276	6418	.2947	.3182	.3871
S-31	Bakelite 65 BMG 2010	5373	5442	6297	.3140	.3180	.3680
S-32	Bakelite 105 BMG 2010	2912	2957	3493	.3110	.3158	.3731

Table III (Continued)

GREEN							
S-33	Bakelite 45 BMG 8952	4488	6102	3459	0.3195	0.4343	0.2462
S-34	Bakelite 55 BMG 2010	3798	4235	4011	.3154	.3516	.3330
S-35	Bakelite 65 BMG 2010	4496	7438	5008	.2654	.4390	.2956
S-36	Bakelite 75 BMG 2010	5725	9772	4841	.2815	.4805	.2380
S-37	Monsanto	2129	2675	1959	.3147	.3956	.2897
MAROON							
S-38	Bakelite 25 BMG 5721	3316	2285	2042	.4338	.2990	.2671
S-39	Bakelite 55 BMG 5780	3254	2695	2522	.3841	.3182	.2977
S-40	Bakelite 65 BMG 8052	7200	4381	2520	.5106	.3107	.1787
NAVY							
S-41	Bakelite 45 BMG 2010	2034	1972	3521	.2702	.2620	.4678
OLIVE							
S-42	Bakelite BM 17015	4768	4870	4176	.3452	.3525	.3023
S-43	Bakelite 15-2010 Dark	5479	5604	5095	.3386	.3464	.3150
S-44	Bakelite 15-2010 Aim	5486	5607	5080	.3392	.3467	.3141
S-45	Bakelite 15-2010 Light	5584	5675	5080	.3417	.3473	.3109
OLIVE DRAB							
S-46	Fiberite 1330	4898	5259	5389	.3150	.3383	.3467
S-47	Rogers RX-431	2604	2743	2296	.3407	.3589	.3004
ORANGE							
S-48	Bakelite 15 BMG 2010 (16094)	26120	17306	4343	.5468	.3623	.0909
S-49	Rogers RX-428	8646	5958	2129	.5167	.3561	.1272
PURPLE							
S-50	Bakelite 15 BMG 2010 (17805)	3112	2607	3313	.3445	.2886	.3668
RED							
S-51	Bakelite 45 BMG 2010	9681	5378	2007	.5673	.3151	.1176
S-52	Bakelite 65-2761 Dark	14013	8224	4011	.5339	.3133	.1528
S-53	Bakelite 65-2761 Aim	13819	8144	3989	.5325	.3138	.1537
S-54	Bakelite 65-2761 Light	13126	7791	3929	.5283	.3136	.1581
S-55	Bakelite 85-2010 Dark	17247	10055	3788	.5547	.3234	.1218
S-56	Bakelite 85-2010 Aim	17822	10375	3789	.5572	.3244	.1184
S-57	Bakelite 95 BMG 2010	15707	8608	2929	.5765	.3160	.1075

Table III (Continued)

RED (continued)							
S-58	Durez 1898	11511	6778	3298	0.5332	0.3140	0.1528
S-59	Fiberite 1153	12566	7968	4901	.4940	.3133	.1927
S-60	Monsanto 2739	13546	8243	2272	.5630	.3426	.0944
S-61	Rogers RX-431	7781	4820	2123	.5285	.3274	.1442
TAN							
S-62	Bakelite 35 BMG 2010	16227	15522	8672	.4014	.3840	.2145
YELLOW							
S-63	Bakelite 15 BMG 2010	36357	35806	7485	.4565	.4496	.0940
S-64	Bakelite 15-2010 Dark	31915	30549	8430	.4502	.4309	.1189
S-65	Bakelite 15-2010 Aim	34047	33009	8579	.4502	.4364	.1134
S-66	Bakelite 15-2010 Light	33579	32634	8020	.4523	.4396	.1080
S-67	Fiberite FM-1390	34765	32356	6966	.4692	.4367	.0940
S-68	Rogers RX-429	16569	15434	2838	.4756	.4430	.0815

Table IV

Munsell Renotations and ISCC-NBS Color Designations of 68 Plastic Colors.

Sample Number	Sample	Munsell Renotations	ISCC-NBS Color Designations
BLACK			
S- 1	Bakelite 15-2155	9.9hB 1.93/ 0.34	Black
S- 2	Bakelite 15 BMG 2323	3.67PB 1.26/ 0.47	Black
S- 3	Bakelite 15-2323	0.95PB 1.81/ 0.36	Black
S- 4	Bakelite 25-2080	2.25PB 1.84/ 0.37	Black
S- 5	Bakelite 25 BMG 5000	0.97PB 1.07/ 0.41	Black
S- 6	Bakelite 25-5000	1.66PB 1.72/ 0.38	Black
S- 7	Bakelite 25-5120	9.19B 1.67/ 0.32	Black
S- 8	Bakelite 25-5315	3.04PB 1.72/ 0.30	Black
S- 9	Bakelite 25-5316	3.46PB 1.82/ 0.39	Black
S-10	Bakelite 25-5498	1.64PB 1.81/ 0.41	Black
S-11	Bakelite 35-2051	1.91PB 1.79/ 0.41	Black
S-12	Bordon	9.11B 1.42/ 0.32	Black
S-13	Durez 791	1.18PB 1.47/ 0.44	Black
S-14	Fiberite FM-1132	8.42BG 2.30/ 0.16	Black
S-15	Monsanto 1004	0.82PB 0.80/ 0.36	Black
S-16	Rogers RX-429	9.25B 0.94/ 0.47	Black
BLUE			
S-17	Bakelite 25 BMG 2010	7.33PB 2.06/ 7.12	Deep purplish blue
BROWN			
S-18	Bakelite 15 BMG 5000	9.7lR 1.73/ 1.28	Dark grayish reddish brown
S-19	Bakelite 65 BMG 2010	2.47YR 2.08/ 1.89	Dark grayish reddish brown
S-20	Bakelite 115-2010	4.32YR 3.29/ 2.61	Moderate brown
S-21	Bakelite 195 BMG 2010	6.42YR 3.42/ 4.05	Moderate brown
S-22	Bordon	9.19R 1.62/ 0.86	Dark grayish reddish brown
S-23	Durez 740	8.66R 1.76/ 1.07	Dark grayish reddish brown
S-24	Fiberite FM-1140	5.28YR 2.83/ 1.47	Grayish brown
S-25	Monsanto 803A	2.47Y 4.38/ 3.91	Moderate olive brown
S-26	Monsanto 1004	1.11YR 1.45/ 1.39	Dark reddish brown
S-27	Monsanto 10900	2.11Y 5.06/ 7.82	Light olive brown
S-28	Rogers RX-429	4.91YR 2.56/ 3.28	Moderate brown
GRAY			
S-29	Bakelite 25 BMG 2010	2.60P 3.30/ 0.53	Dark purplish gray
S-30	Bakelite 35 BMG 2010	4.41BG 2.69/ 0.86	Dark greenish gray
S-31	Bakelite 65 BMG 2010	4.68YR 2.73/ 0.11	Dark gray
S-32	Bakelite 105 BMG 2010	9.40RP 1.93/ 0.04	Black
GREEN			
S-33	Bakelite 45 BMG 8952	8.35GY 2.89/ 4.30	Dark yellowish green
S-34	Bakelite 55 BMG 2010	7.47GY 2.38/ 1.45	Dark grayish olive green

Table IV (Continued)

GREEN (cont'd)				
S-35	Bakelite 65 BMG 2010	2.37G	3.19/ 6.27	Dark yellowish green
S-36	Bakelite 75 BMG 2010	1.06G	3.64/ 7.40	Deep yellowish green
S-37	Monsanto	8.17GY	1.82/ 2.73	Very dark yellowish green
MAROON				
S-38	Bakelite 25 BMG 5721	5.97R	1.64/ 4.06	Very dark red
S-39	Bakelite 55 BMG 5780	8.08R	1.82/ 2.14	Dark grayish reddish brow
S-40	Bakelite 65 BMG 8052	6.56R	2.43/ 7.37	Dark red
NAVY				
S-41	Bakelite 45 BMG 2010	6.48PB	1.47/ 1.60	Blackish blue
OLIVE				
S-42	Bakelite BM 17015	4.70Y	2.57/ 1.18	Olive gray
S-43	Bakelite 15-2010 Dark	4.91Y	2.77/ 1.00	Olive gray
S-44	Bakelite 15-2010 Aim	4.76Y	2.77/ 1.02	Olive gray
S-45	Bakelite 15-2010 Light	3.90Y	2.79/ 1.07	Brownish gray
OLIVE DRAB				
S-46	Fiberite 1330	6.81GY	2.68/ 0.87	Dark greenish gray
S-47	Rogers RX-431	9.08Y	1.84/ 1.17	Dark grayish olive
ORANGE				
S-48	Bakelite 15 BMG 2010 (16094)	9.86R	4.72/11.56	Strong reddish orange
S-49	Rogers RX-428	1.07YR	2.86/ 6.86	Moderate reddish brown
PURPLE				
S-50	Bakelite 15 BMG 2010 (17805)	7.83RP	1.79/ 1.83	Blackish purple
RED				
S-51	Bakelite 45 BMG 2010	7.27R	2.71/ 9.60	Deep red
S-52	Bakelite 65-2761 Dark	5.50R	3.35/ 9.94	Deep red
S-53	Bakelite 65-2761 Aim	5.54R	3.34/ 9.82	Deep red
S-54	Bakelite 65-2761 Light	5.50R	3.27/ 9.46	Deep red
S-55	Bakelite 85-2010 Dark	6.68R	3.69/11.31	Strong red
S-56	Bakelite 85-2010 Aim	6.79R	3.74/11.53	Strong red
S-57	Bakelite 95 BMG 2010	6.53R	3.43/11.80	Vivid red
S-58	Durez 1898	5.80R	3.05/ 9.05	Deep red
S-59	Fiberite 1153	4.87R	3.30/ 8.15	Dark red
S-60	Monsanto 2739	9.19R	3.36/10.03	Strong reddish brown
S-61	Rogers RX-431	8.32R	2.56/ 7.56	Dark red

Table IV (Continued)

TAN				
S-62	Bakelite 35 BMG 2010	9.97YR	4.49/ 3.71	Moderate yellowish brown
YELLOW				
S-63	Bakelite 15 BMG 2010	2.77Y	6.47/ 9.08	Deep yellow
S-64	Bakelite 15-2010 Dark	1.29Y	6.04/ 7.80	Dark yellow
S-65	Bakelite 15-2010 Aim	1.89Y	6.25/ 8.13	Deep yellow
S-66	Bakelite 15-2010 Light	2.09Y	6.22/ 8.26	Deep yellow
S-67	Fiberite FM-1390	0.43Y	6.19/ 9.24	Dark orange yellow
S-68	Rogers RX-429	1.22Y	4.48/ 7.61	Moderate olive brown

Table V

Dominant Wavelength and Excitation Purity of 68 Plastics.

Sample Number	Sample	Dominant Wavelength λ (mμ)	Excitation Purity p (%)
BLACK			
S- 1	Bakelite 15-2155	480.5	4.4
S- 2	Bakelite 15 BMG 2323	476.0	7.5
S- 3	Bakelite 15-2323	478.8	4.6
S- 4	Bakelite 25-2080	478.0	4.8
S- 5	Bakelite 25 BMG 5000	479.0	7.4
S- 6	Bakelite 25-5000	478.4	5.2
S- 7	Bakelite 25-5120	480.9	4.6
S- 8	Bakelite 25-5315	476.0	4.2
S- 9	Bakelite 25-5316	476.3	5.1
S-10	Bakelite 25-5498	478.8	5.5
S-11	Bakelite 35-2051	478.2	5.5
S-12	Bordon	480.8	5.1
S-13	Durez 791	478.8	6.4
S-14	Fiberite FM-1132	488.8	1.4
S-15	Monsanto 1004	479.1	7.4
S-16	Rogers RX-429	480.1	8.9
BLUE			
S-17	Bakelite 25 BMG 2010	467.9	56.9
BROWN			
S-18	Bakelite 15 BMG 5000	605.0	14.7
S-19	Bakelite 65 BMG 2010	594.9	23.9
S-20	Bakelite 115-2010	489.3	30.7
S-21	Bakelite 195 BMG 2010	486.9	48.8
S-22	Bordon	608.5	9.7
S-23	Durez 740	609.0	11.2
S-24	Fiberite FM-1140	588.0	19.9
S-25	Monsanto 803A	579.2	48.0
S-26	Monsanto 1004	602.4	19.2
S-27	Monsanto 10900	580.0	77.0
S-28	Rogers RX-429	589.8	43.4
GRAY			
S-29	Bakelite 25 BMG 2010	565.5C	3.8
S-30	Bakelite 35 BMG 2010	492.3	5.8
S-31	Bakelite 65 BMG 2010	589.0	1.6
S-32	Bakelite 105 BMG 2010	497.4C	0.4
GREEN			
S-33	Bakelite 45 BMG 8952	554.8	34.2
S-34	Bakelite 55 BMG 2010	558.0	10.9
S-35	Bakelite 65 BMG 2010	526.4	24.4
S-36	Bakelite 75 BMG 2010	540.6	37.8
S-37	Monsanto	554.0	22.7

Table V (Continued)

MAROON			
S-38	Bakelite 25 BMG 5721	492.5C	30.3
S-39	Bakelite 55 BMG 5780	613.0	20.5
S-40	Bakelite 65 BMG 8052	621.0	52.2
NAVY			
S-41	Bakelite 45 BMG 2010	470.8	21.4
OLIVE			
S-42	Bakelite BM 17015	576.8	19.1
S-43	Bakelite 15-2010 Dark	576.6	15.8
S-44	Bakelite 15-2010 Aim	576.8	16.0
S-45	Bakelite 15-2010 Light	577.8	16.8
OLIVE DRAB			
S-46	Fiberite 1330	560.7	7.2
S-47	Rogers RX-431	573.0	19.7
ORANGE			
S-48	Bakelite 15 BMG 2010 (16094)	599.0	75.9
S-49	Rogers RX-428	599.1	65.9
PURPLE			
S-50	Bakelite 15 BMG 2010 (17805)	500.9C	17.8
RED			
S-51	Bakelite 45 BMG 2010	617.1	68.6
S-52	Bakelite 65-2761 Dark	618.4	59.0
S-53	Bakelite 65-2761 Aim	618.2	58.8
S-54	Bakelite 65-2761 Light	618.3	57.7
S-55	Bakelite 85-2010 Dark	612.3	67.3
S-56	Bakelite 85-2010 Aim	611.9	68.5
S-57	Bakelite 95-BMG 2010	616.6	71.4
S-58	Durez 1898	618.0	59.0
S-59	Fiberite 1153	618.9	48.5
S-60	Monsanto 2739	604.9	74.8
S-61	Rogers RX-431	609.9	61.3

Table V (continued)

TAN			
S-62	Bakelite 35 BMG 2010	581.8	42.7
YELLOW			
S-63	Bakelite 15 BMG 2010	478.9	75.1
S-64	Bakelite 15-2010 Dark	580.3	68.2
S-65	Bakelite 15-2010 Aim	579.7	69.8
S-66	Bakelite 15-2010 Light	579.6	71.4
S-67	Fiberite FM-1390	581.5	75.2
S-68	Rogers RX-429	581.3	78.5

Appendix A

Tables of spectral directional reflectance, 380 to 770 millimicrons, of sixty-eight plastic colors submitted by representatives of the manufacturers of phenol-formaldehyde resins for use of the U. S. Army Ordnance Corps. All of the data in this appendix were derived from the spectrophotometric curves of Appendix B. These data were corrected for wavelength and photometric scale errors by means of the zero curve, Vitrolite curve and Didymium curve. The values for wavelengths 380, 390, 760, and 770 were extrapolated.

Spectral Directional Reflectance of Phenolic Resins

Percent Spectral Directional Reflectance of Ten Black Phenol-Formaldehyde Molded Plastics (See Table II for Manufacturer's Designation, and Appendix B, GE Graph Sheet Serial Nos. GE II-1884, 1907, 1908, and 1909).

Wave-length mμ	Sample Numbers									
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
380	3.5	2.1	3.2	3.1	1.6	3.0	2.6	2.8	3.1	3.0
90	3.4	2.1	3.2	3.1	1.6	3.0	2.6	2.8	3.1	3.0
400	3.4	2.0	3.1	3.1	1.5	2.9	2.6	2.8	3.1	3.0
10	3.3	2.0	3.0	3.1	1.5	2.8	2.6	2.7	3.1	3.0
20	3.2	1.9	3.0	3.0	1.5	2.8	2.6	2.7	3.0	3.0
30	3.2	1.9	3.0	3.0	1.5	2.8	2.6	2.7	3.0	3.0
40	3.2	1.9	2.9	3.0	1.5	2.7	2.6	2.7	3.0	3.0
450	3.1	1.8	2.9	3.0	1.5	2.7	2.5	2.7	3.0	3.0
60	3.2	1.8	2.9	3.0	1.4	2.7	2.5	2.7	3.0	2.9
70	3.1	1.8	2.8	3.0	1.4	2.7	2.5	2.6	2.9	2.9
80	3.1	1.7	2.8	2.9	1.4	2.6	2.5	2.6	2.9	2.9
90	3.1	1.7	2.8	2.9	1.4	2.6	2.5	2.5	2.8	2.9
500	3.1	1.7	2.8	2.9	1.4	2.6	2.5	2.5	2.8	2.8
10	3.1	1.7	2.7	2.8	1.4	2.5	2.5	2.5	2.8	2.8
20	3.0	1.6	2.7	2.8	1.3	2.5	2.4	2.5	2.7	2.7
30	3.0	1.6	2.7	2.8	1.3	2.5	2.4	2.5	2.7	2.7
40	3.0	1.6	2.7	2.7	1.3	2.5	2.4	2.5	2.7	2.7
550	3.0	1.6	2.7	2.7	1.3	2.5	2.4	2.5	2.7	2.7
60	2.9	1.6	2.6	2.7	1.3	2.5	2.3	2.4	2.7	2.6
70	2.9	1.5	2.6	2.7	1.3	2.4	2.3	2.4	2.7	2.6
80	2.9	1.5	2.6	2.6	1.2	2.4	2.3	2.4	2.6	2.6
90	2.9	1.5	2.6	2.6	1.2	2.4	2.3	2.4	2.6	2.6
600	2.9	1.5	2.6	2.6	1.2	2.4	2.2	2.4	2.6	2.6
10	2.8	1.5	2.5	2.6	1.2	2.3	2.2	2.4	2.6	2.5
20	2.8	1.5	2.5	2.6	1.2	2.3	2.2	2.4	2.6	2.5
30	2.8	1.5	2.5	2.6	1.2	2.3	2.2	2.4	2.6	2.5
40	2.7	1.5	2.5	2.6	1.2	2.3	2.2	2.4	2.5	2.5
650	2.7	1.5	2.5	2.6	1.2	2.3	2.2	2.3	2.5	2.5
60	2.7	1.4	2.5	2.6	1.2	2.3	2.2	2.3	2.5	2.5
70	2.7	1.4	2.5	2.6	1.2	2.3	2.2	2.3	2.5	2.5
80	2.7	1.4	2.5	2.6	1.2	2.3	2.2	2.3	2.5	2.5
90	2.7	1.4	2.5	2.6	1.3	2.3	2.2	2.3	2.5	2.5
700	2.7	1.4	2.5	2.6	1.3	2.3	2.2	2.3	2.5	2.5
10	2.7	1.4	2.5	2.6	1.4	2.3	2.3	2.3	2.5	2.5
20	2.8	1.5	2.5	2.7	1.4	2.4	2.4	2.4	2.6	2.5
30	2.8	1.6	2.6	2.8	1.5	2.5	2.4	2.4	2.7	2.6
40	2.9	1.7	2.7	2.9	1.7	2.6	2.5	2.6	2.8	2.8
750	3.0	1.9	2.8	3.0	1.9	2.7	2.7	2.7	2.9	2.9
60	3.0	2.1	2.9	3.0	2.1	2.8	2.8	2.9	3.0	3.1
70	3.1	2.5	3.0	3.1	2.5	2.9	3.0	3.1	3.1	3.3

Spectral Directional Reflectance of Phenolic Resins

Percent Spectral Directional Reflectance of Six Black, One Blue and Three Brown Phenol-Formaldehyde Molded Plastics (See Table II and Appendix B, GE Graph Sheet Serial Nos. GE II-1779, 1791, 1792, 1883, 1884, 1907, and 1909.)

Wave-length mμ	Sample Numbers									
	S-11	S-12	S-13	S-14	S-15	S-16	S-17	S-18	S-19	S-20
380	3.0	2.1	2.3	4.0	1.1	1.4	4.9	2.1	2.4	3.8
90	3.0	2.1	2.3	4.0	1.1	1.4	5.1	2.1	2.4	3.9
400	3.0	2.1	2.3	4.0	1.1	1.4	5.4	2.1	2.3	4.0
10	3.0	2.1	2.3	4.0	1.1	1.4	6.2	2.1	2.3	4.1
20	2.9	2.1	2.2	4.0	1.1	1.3	7.3	2.1	2.3	4.2
30	3.0	2.1	2.2	4.0	1.1	1.3	8.8	2.1	2.4	4.4
40	2.9	2.1	2.2	4.0	1.1	1.3	10.7	2.1	2.4	4.6
450	2.9	2.0	2.2	4.0	1.1	1.3	12.3	2.1	2.4	4.9
60	2.9	2.0	2.2	4.0	1.1	1.3	13.0	2.1	2.4	5.0
70	2.9	2.0	2.2	4.0	1.0	1.3	12.0	2.1	2.4	5.2
80	2.8	2.0	2.1	4.1	1.0	1.3	10.1	2.1	2.4	5.4
90	2.8	2.0	2.1	4.1	1.0	1.3	8.2	2.1	2.4	5.5
500	2.8	2.0	2.1	4.0	1.0	1.2	6.2	2.0	2.4	5.6
10	2.7	2.0	2.1	4.0	1.0	1.2	4.4	2.0	2.5	6.0
20	2.7	1.9	2.1	4.0	1.0	1.2	3.5	2.0	2.5	6.3
30	2.7	1.9	2.0	4.0	1.0	1.2	3.1	2.0	2.5	6.5
40	2.6	1.9	2.0	4.0	0.9	1.1	2.6	2.0	2.6	6.6
550	2.6	1.9	2.0	4.0	0.9	1.1	2.2	2.1	2.8	6.5
60	2.6	1.9	1.9	4.0	0.9	1.1	2.1	2.2	3.0	6.8
70	2.6	1.8	1.9	4.0	0.9	1.1	2.2	2.4	3.4	7.5
80	2.6	1.8	1.9	3.9	0.9	1.0	2.3	2.7	3.9	8.8
90	2.5	1.8	1.9	3.9	0.9	1.0	2.5	3.0	4.2	10.1
600	2.5	1.8	1.9	3.9	0.9	1.0	2.6	3.2	4.6	11.2
10	2.5	1.8	1.9	3.9	0.9	1.0	2.5	3.4	4.9	12.0
20	2.5	1.8	1.9	3.9	0.9	1.0	2.5	3.5	5.0	12.3
30	2.5	1.7	1.8	3.9	0.8	1.0	2.5	3.7	5.2	12.4
40	2.5	1.7	1.8	3.8	0.8	1.0	2.5	3.8	5.3	12.3
650	2.5	1.7	1.8	3.7	0.8	1.0	2.7	3.9	5.4	12.2
60	2.5	1.7	1.8	3.7	0.8	1.0	3.0	4.0	5.5	12.6
70	2.5	1.7	1.8	3.7	0.8	1.0	3.9	4.1	5.6	13.3
80	2.5	1.7	1.8	3.7	0.8	1.1	5.5	4.3	5.7	14.1
90	2.5	1.7	1.8	3.7	0.9	1.1	8.3	4.5	5.8	14.9
700	2.5	1.8	1.9	3.7	0.9	1.1	12.4	4.6	5.9	15.4
10	2.5	1.8	2.0	3.7	1.0	1.2	18.0	4.9	6.0	15.9
20	2.5	1.9	2.1	3.7	1.1	1.3	24.5	5.1	6.1	16.3
30	2.6	2.0	2.2	3.7	1.2	1.5	31.1	5.4	6.3	16.6
40	2.7	2.1	2.3	3.8	1.5	1.7	37.8	5.7	6.5	16.9
750	2.8	2.4	2.5	3.9	1.6	1.9	43.9	6.0	6.7	17.3
60	2.9	2.6	2.7	4.0	1.7	2.1	49.4	6.4	6.8	17.7
70	3.0	2.8	2.9	4.1	1.8	2.3	54.4	6.8	7.0	18.1

Spectral Directional Reflectance of Phenolic Resins

Percent Spectral Directional Reflectance of Eight Brown and Two Gray Phenol-Formaldehyde Molded Plastics (See Table II and Appendix B, GE Graph Sheet Serial Nos. GE II-1779, 1791, 1792, 1883, 1884, and 1905.)

Wavelength mμ	Sample Numbers									
	S-21	S-22	S-23	S-24	S-25	S-26	S-27	S-28	S-29	S-30
380	2.7	1.9	2.3	4.0	2.7	1.5	1.9	2.0	4.5	3.8
90	2.8	1.9	2.3	4.0	3.1	1.5	1.9	2.0	5.0	4.0
400	2.9	2.0	2.3	4.1	3.4	1.5	1.9	2.1	5.4	4.2
10	3.0	2.0	2.3	4.1	3.8	1.5	1.8	2.0	5.9	4.4
20	3.1	2.0	2.3	4.2	4.2	1.4	1.8	2.0	6.7	4.7
30	3.2	2.0	2.3	4.2	4.7	1.5	1.9	2.0	7.5	4.9
40	3.3	2.0	2.3	4.3	5.0	1.5	2.0	2.1	8.4	5.2
450	3.5	2.1	2.3	4.3	5.5	1.5	2.2	2.2	8.9	5.4
60	3.7	2.0	2.3	4.4	6.2	1.5	2.7	2.4	9.2	5.6
70	3.9	2.0	2.2	4.4	6.8	1.6	3.7	2.6	9.4	5.8
80	4.2	2.0	2.2	4.5	7.5	1.6	5.4	2.8	9.3	6.0
90	4.8	2.0	2.2	4.6	8.4	1.6	7.6	2.9	9.1	6.1
500	5.4	2.0	2.2	4.7	9.3	1.5	9.9	3.0	8.9	6.2
10	5.8	2.0	2.2	4.9	10.5	1.5	12.1	3.0	8.6	6.1
20	6.1	2.0	2.2	5.0	11.6	1.5	14.2	3.1	8.2	6.0
30	6.3	2.0	2.2	5.1	12.8	1.5	16.1	3.2	8.0	5.8
40	6.7	2.0	2.2	5.3	13.7	1.5	17.8	3.5	7.9	5.6
550	7.1	2.0	2.2	5.4	14.6	1.6	19.4	4.0	7.5	5.3
60	7.7	2.1	2.3	5.6	15.3	1.6	20.9	4.4	6.9	5.0
70	8.6	2.2	2.5	5.9	15.9	1.8	22.7	4.9	6.7	4.8
80	9.7	2.4	2.7	6.3	16.4	2.0	24.4	5.5	7.5	4.8
90	11.1	2.5	3.0	6.7	17.2	2.4	26.2	6.2	8.3	4.8
600	12.5	2.6	3.2	7.1	18.1	2.6	27.8	7.0	8.5	4.8
10	13.7	2.8	3.4	7.5	18.6	2.8	29.2	7.7	8.5	4.7
20	14.6	3.0	3.5	7.8	19.1	3.0	30.4	8.3	8.4	4.6
30	15.3	3.0	3.6	8.0	19.7	3.1	31.4	8.8	8.5	4.6
40	15.9	3.1	3.6	8.3	20.3	3.2	32.3	9.3	8.5	4.6
650	16.4	3.2	3.7	8.4	20.9	3.3	33.2	9.7	8.9	4.9
60	16.9	3.4	3.7	8.7	21.5	3.4	33.9	10.1	9.5	5.3
70	17.3	3.5	3.8	8.9	22.0	3.5	34.6	10.6	10.0	5.8
80	17.7	3.5	3.9	9.0	22.5	3.5	35.1	11.0	10.5	6.1
90	18.2	3.7	4.0	9.2	23.3	3.7	35.8	11.5	10.9	6.5
700	18.7	3.9	4.1	9.3	24.0	3.9	36.6	12.1	11.1	6.8
10	19.1	4.0	4.2	9.5	24.8	4.0	37.2	12.8	11.4	6.9
20	19.6	4.2	4.3	9.7	25.6	4.2	37.7	13.5	11.5	7.1
30	20.1	4.6	4.5	9.8	26.1	4.4	38.2	14.0	11.7	7.2
40	20.7	4.9	4.7	9.9	26.7	4.6	38.7	14.7	11.9	7.4
750	21.2	5.2	4.9	10.0	27.2	4.9	39.2	15.3	12.1	7.6
60	21.7	5.4	5.0	10.1	27.9	5.2	39.7	16.0	12.3	7.8
70	22.0	5.7	5.2	10.2	28.5	5.6	40.2	16.6	12.5	8.0

Spectral Directional Reflectance of Phenolic Resins

Percent Spectral Directional Reflectance of Two Gray, Five Green, and Three Maroon Phenol-Formaldehyde Molded Plastics (See Table II and Appendix B, GE Graph Sheet Serial Nos. 1791, 1905, and 1906.)

Wavelength mμ	Sample Numbers									
	S-31	S-32	S-33	S-34	S-35	S-36	S-37	S-38	S-39	S-40
380	3.8	2.4	2.6	2.8	3.1	3.2	1.3	2.0	2.3	2.3
90	4.0	2.5	2.6	2.8	3.2	3.2	1.3	2.0	2.3	2.3
400	4.2	2.5	2.5	2.9	3.2	3.2	1.4	1.9	2.2	2.2
10	4.4	2.6	2.5	2.9	3.2	3.2	1.3	1.9	2.2	2.2
20	4.7	2.7	2.5	3.1	3.2	3.2	1.3	1.8	2.2	2.2
30	4.9	2.8	2.5	3.1	3.4	3.3	1.3	1.8	2.2	2.2
40	5.2	2.9	2.5	3.2	3.5	3.4	1.3	1.8	2.2	2.2
450	5.4	3.0	2.6	3.3	3.7	3.4	1.4	1.8	2.2	2.2
60	5.5	3.0	2.7	3.5	3.9	3.6	1.6	1.7	2.1	2.1
70	5.6	3.1	3.0	3.6	4.1	3.8	1.9	1.7	2.1	2.1
80	5.6	3.1	3.5	3.7	4.6	4.2	2.2	1.6	2.1	2.1
90	5.7	3.1	4.2	4.0	6.3	6.0	2.5	1.6	2.0	2.0
500	5.7	3.1	5.0	4.3	9.9	9.9	2.9	1.6	2.0	2.0
10	5.6	3.0	6.0	4.5	13.3	14.9	3.0	1.5	2.0	1.9
20	5.5	3.0	7.0	4.5	13.9	17.0	3.1	1.5	2.0	1.9
30	5.5	3.0	7.8	4.5	12.6	16.5	3.2	1.5	2.0	1.9
40	5.4	2.9	8.2	4.5	10.7	14.8	3.1	1.5	2.0	1.9
550	5.3	2.9	8.2	4.5	8.6	12.8	3.0	1.5	2.0	2.0
60	5.0	2.8	7.5	4.4	6.9	10.7	2.9	1.5	2.1	2.0
70	5.0	2.7	6.7	4.3	5.5	8.5	2.8	1.6	2.4	2.1
80	5.3	2.9	5.7	4.2	4.5	6.6	2.6	1.7	2.8	2.6
90	5.6	3.0	4.8	4.1	4.0	5.2	2.4	1.8	3.4	4.1
600	5.7	3.0	4.2	4.0	3.5	4.5	2.2	2.3	4.0	7.7
10	5.8	3.0	3.8	4.0	3.4	4.0	2.1	3.0	4.4	12.0
20	5.7	3.0	3.5	3.8	3.1	3.5	2.0	3.9	4.7	15.9
30	5.7	3.0	3.0	3.5	3.0	3.1	1.7	5.7	5.0	18.6
40	5.7	3.0	2.8	3.3	2.8	2.8	1.5	9.0	5.1	20.4
650	5.8	3.1	2.6	3.1	2.7	2.7	1.4	13.3	5.3	21.9
60	5.9	3.1	2.6	3.2	2.8	2.8	1.4	18.5	5.4	23.1
70	6.0	3.3	2.9	3.4	3.1	3.1	1.5	23.5	5.6	24.3
80	6.0	3.4	3.7	3.8	3.8	4.1	1.8	27.7	5.8	25.3
90	6.1	3.4	5.6	4.2	5.5	6.3	2.4	31.1	5.9	26.3
700	6.1	3.5	9.1	4.7	9.2	10.8	3.1	34.0	6.0	27.1
10	6.2	3.6	14.5	5.0	15.1	17.4	3.8	36.4	6.2	27.9
20	6.3	3.7	20.8	5.1	22.6	25.4	4.3	38.6	6.4	28.8
30	6.4	3.8	26.6	5.3	30.4	32.5	4.6	40.5	6.6	29.4
40	6.5	4.0	31.1	5.5	38.0	38.1	4.9	42.2	6.8	30.2
750	6.8	4.1	34.6	5.7	44.3	42.4	5.2	43.7	7.0	30.9
60	7.0	4.4	37.0	5.9	49.5	45.3	5.5	45.0	7.2	31.5
70	7.2	4.6	38.3	6.1	53.5	46.9	5.8	46.1	7.4	32.2

Spectral Directional Reflectance of Phenolic Resins

Percent Spectral Directional Reflectance of One Navy, Four Olive, Two Olive Drab, Two Orange, and One Purple Phenol-Formaldehyde Molded Plastics (See Table II and Appendix B, GE Graph Sheet Serial Nos. 1792, 1793, 1883, 1884, 1906 and 1908).

Wave Length mμ	Sample Numbers									
	S-41	S-42	S-43	S-44	S-45	S-46	S-47	S-48	S-49	S-50
380	2.4	3.0	4.0	3.8	3.8	4.4	1.7	3.5	1.8	3.0
90	2.5	3.1	4.0	3.8	3.8	4.4	1.7	3.5	1.8	3.0
400	2.5	3.1	3.9	3.8	3.8	4.4	1.7	3.5	1.8	2.9
10	2.6	3.1	3.9	3.8	3.8	4.4	1.7	3.5	1.8	3.0
20	2.7	3.2	4.0	3.9	3.9	4.4	1.7	3.4	1.7	3.0
30	2.9	3.3	4.0	4.0	4.0	4.4	1.7	3.4	1.7	3.0
40	3.0	3.4	4.1	4.1	4.1	4.4	1.7	3.5	1.8	3.0
450	3.1	3.4	4.2	4.2	4.2	4.4	1.8	3.5	1.8	3.0
60	3.1	3.5	4.3	4.3	4.3	4.5	1.9	3.6	1.8	2.8
70	3.1	3.7	4.5	4.6	4.5	4.7	2.2	3.6	1.8	2.6
80	3.0	3.8	4.6	4.6	4.6	4.7	2.3	3.8	1.8	2.5
90	2.8	4.1	4.8	4.8	4.8	4.9	2.4	4.3	1.7	2.4
500	2.5	4.3	5.0	5.0	5.0	5.0	2.5	5.2	1.7	2.2
10	2.4	4.4	5.1	5.1	5.1	5.3	2.6	5.8	1.7	2.2
20	2.2	4.5	5.2	5.2	5.2	5.6	2.6	5.9	1.7	2.2
30	2.0	4.6	5.3	5.3	5.3	5.7	2.7	5.9	1.8	2.2
40	1.9	4.7	5.4	5.4	5.4	5.7	2.7	6.1	2.1	2.2
550	1.7	4.8	5.6	5.6	5.6	5.6	2.8	7.0	2.9	2.2
60	1.6	5.0	5.7	5.7	5.8	5.3	2.8	9.5	4.5	2.3
70	1.7	5.1	5.9	5.9	6.0	5.1	2.8	14.3	6.4	2.5
80	1.8	5.2	6.0	6.0	6.1	5.0	2.7	21.2	8.1	2.5
90	1.8	5.4	6.1	6.1	6.4	4.9	2.8	29.0	9.8	2.6
600	1.9	5.5	6.2	6.2	6.5	5.0	2.8	37.4	11.5	2.5
10	1.9	5.6	6.2	6.3	6.5	5.0	2.8	44.9	13.3	2.5
20	1.9	5.5	6.0	6.2	6.1	5.0	2.9	50.9	15.0	2.7
30	1.8	5.2	5.6	5.9	5.7	5.0	2.9	55.0	16.4	3.1
40	1.8	4.8	5.4	5.5	5.4	5.1	3.0	57.8	17.8	4.2
650	1.9	4.6	5.5	5.3	5.5	5.1	3.1	59.9	19.1	6.5
60	2.0	4.8	6.0	5.4	6.0	5.2	3.2	61.1	20.5	10.7
70	2.1	5.3	6.7	5.9	7.0	5.3	3.3	61.6	21.8	16.8
80	2.2	5.9	7.4	6.6	7.9	5.4	3.4	62.7	23.2	23.8
90	2.3	6.6	7.8	7.4	8.6	5.6	3.6	63.3	24.6	30.9
700	2.5	7.1	8.0	8.0	9.0	5.8	3.7	63.1	26.0	36.7
10	2.6	7.5	8.2	8.3	9.3	6.0	3.9	63.2	27.4	41.0
20	2.8	7.7	8.4	8.5	9.5	6.1	4.1	63.2	28.8	44.3
30	3.0	7.9	8.5	8.7	9.6	6.3	4.5	63.5	30.0	46.8
40	3.1	8.0	8.6	9.0	9.8	6.5	4.8	66.1	31.3	49.6
750	3.3	8.3	8.9	9.1	10.0	6.8	5.1	69.0	32.4	51.9
60	3.5	8.6	9.1	9.2	10.2	6.9	5.4	72.1	33.7	53.9
70	3.7	8.9	9.3	9.3	10.4	7.1	5.7	75.4	34.7	55.5

Spectral Directional Reflectance of Phenolic Resins

Percent Spectral Directional Reflectance of Ten Red Phenol-Formaldehyde Molded Plastics (See Table II and Appendix B, GE Graph Sheet Serial Nos. 1779, 1791, 1792, 1906, 1909).

Wave Length mμ	Sample Numbers									
	S-51	S-52	S-53	S-54	S-55	S-56	S-57	S-58	S-59	S-60
380	2.0	3.5	3.5	3.4	3.6	3.6	2.7	3.1	4.4	1.5
90	2.0	3.5	3.5	3.4	3.6	3.5	2.7	3.1	4.4	1.5
400	1.9	3.5	3.5	3.4	3.5	3.5	2.7	3.0	4.4	1.5
10	1.9	3.5	3.5	3.4	3.4	3.4	2.7	3.0	4.4	1.5
20	1.8	3.4	3.4	3.4	3.3	3.3	2.7	3.0	4.4	1.5
30	1.8	3.4	3.4	3.4	3.3	3.3	2.7	2.9	4.3	1.5
40	1.8	3.4	3.4	3.4	3.3	3.3	2.7	2.9	4.2	1.6
450	1.7	3.4	3.4	3.3	3.2	3.2	2.7	2.9	4.2	1.8
60	1.7	3.4	3.4	3.4	3.2	3.2	2.5	2.8	4.1	2.0
70	1.6	3.4	3.3	3.3	3.1	3.1	2.2	2.7	4.0	2.3
80	1.6	3.3	3.2	3.2	3.0	3.0	2.1	2.6	4.0	2.5
90	1.5	3.2	3.2	3.2	3.0	3.0	2.0	2.5	4.0	2.5
500	1.5	3.2	3.1	3.1	3.0	3.0	1.9	2.5	3.9	2.5
10	1.5	3.1	3.0	3.0	3.0	3.0	1.9	2.5	3.9	2.4
20	1.5	3.0	3.0	3.0	2.9	2.9	1.9	2.5	3.9	2.4
30	1.5	3.0	3.0	2.9	2.9	2.9	1.9	2.5	3.9	2.4
40	1.5	3.0	3.0	2.9	3.0	3.0	1.9	2.5	4.0	2.5
550	1.5	3.1	3.0	3.0	3.1	3.1	2.0	2.6	4.1	2.7
60	1.6	3.2	3.2	3.1	3.5	3.6	2.2	2.8	4.4	3.2
70	2.1	3.9	3.9	3.9	4.9	5.0	3.1	3.3	4.9	4.5
80	3.2	5.6	5.8	5.5	8.1	8.6	5.8	4.7	5.8	7.6
90	6.2	9.2	9.5	9.0	14.0	15.0	12.0	7.5	7.6	13.0
600	11.1	15.2	15.3	14.1	22.1	23.0	20.6	12.1	11.4	19.4
10	16.8	22.3	22.5	20.8	30.4	31.4	29.1	18.8	17.3	25.3
20	21.9	30.1	29.4	27.8	37.9	38.8	36.1	25.5	24.9	29.2
30	26.0	36.8	35.3	33.8	43.3	44.3	41.2	30.5	32.2	31.8
40	29.2	41.7	39.9	38.4	47.0	48.1	44.5	33.8	37.3	33.2
650	31.8	45.3	43.7	42.0	49.5	51.0	46.9	36.2	41.3	34.4
60	33.9	48.1	46.9	44.9	51.3	53.2	48.3	38.0	44.6	35.4
70	35.7	49.9	49.7	46.9	51.9	55.0	49.2	39.1	47.3	36.3
80	37.1	52.3	52.3	49.4	53.3	56.7	50.4	40.5	49.9	37.1
90	38.2	53.7	54.5	51.1	53.9	58.1	50.9	41.6	52.2	37.8
700	39.0	54.3	56.4	52.0	53.8	59.0	51.0	42.2	54.4	38.6
10	39.6	55.0	58.0	53.0	54.1	60.1	51.3	42.9	56.3	39.3
20	40.1	55.3	59.3	53.5	54.1	60.8	51.3	43.3	58.0	39.9
30	40.6	55.9	60.5	54.3	54.5	61.8	51.8	44.0	59.4	40.5
40	41.6	59.1	62.5	57.4	57.4	63.5	53.9	46.3	60.5	41.0
750	42.6	62.7	64.2	60.9	60.6	65.0	56.1	48.5	61.4	41.5
60	43.5	66.9	65.8	64.8	64.2	66.3	58.0	50.7	62.3	42.0
70	44.5	71.3	67.1	69.1	68.1	67.4	59.9	53.0	63.1	42.5

Spectral Directional Reflectance of Phenolic Resins

Percent Spectral Directional Reflectance of One Red, One Tan, and Six Yellow Phenol-Formaldehyde Molded Plastics (See Table II and Appendix B, GE Graph Sheet Serial Nos. 1792, 1883, 1884, 1906 and 1908).

Wave Length mμ	Sample Numbers							
	S-61	S-62	S-63	S-64	S-65	S-66	S-67	S-68
380	1.8	4.2	4.9	5.3	5.5	5.5	5.3	1.7
90	1.8	4.5	4.8	5.3	5.5	5.5	5.2	1.7
400	1.8	4.7	4.7	5.5	5.6	5.5	5.1	1.7
10	1.8	5.1	4.7	5.6	5.6	5.5	5.0	1.6
20	1.7	5.5	4.7	5.7	5.7	5.5	5.0	1.6
30	1.7	5.9	4.8	5.9	5.8	5.5	5.1	1.6
40	1.8	6.4	4.9	6.0	6.0	5.6	5.2	1.6
450	1.8	6.8	5.1	6.2	6.2	5.7	5.3	1.7
60	1.8	7.5	5.5	6.5	6.5	6.0	5.3	1.9
70	1.8	7.9	5.9	6.8	6.9	6.3	5.5	2.5
80	1.8	8.8	6.9	7.4	7.8	7.0	6.0	3.5
90	1.7	10.2	9.4	9.4	10.2	9.2	7.2	4.7
500	1.7	11.6	14.9	14.4	15.2	14.4	10.7	6.2
10	1.6	12.5	22.9	21.9	22.1	22.1	15.7	8.1
20	1.6	12.8	30.5	27.8	28.8	29.2	18.9	10.2
30	1.6	13.1	35.0	30.2	32.1	32.4	22.3	12.2
40	1.6	13.3	36.5	30.6	33.2	33.2	28.9	13.9
550	1.8	13.9	36.8	30.0	33.1	32.8	34.6	15.2
60	2.1	14.7	36.3	29.1	32.6	32.0	37.1	16.2
70	3.0	15.9	36.0	28.4	32.1	31.3	37.8	16.8
80	4.7	17.4	37.1	29.0	33.0	32.0	38.5	17.7
90	7.2	19.0	40.5	32.2	36.4	35.3	40.5	19.1
600	10.2	20.5	45.6	38.0	40.9	41.1	44.0	21.0
10	13.2	21.5	50.4	44.5	47.3	47.3	47.6	23.1
20	15.8	22.1	54.2	50.4	52.1	52.5	50.5	24.9
30	17.7	22.6	57.0	54.6	55.4	55.6	52.5	26.4
40	19.2	23.0	59.0	57.6	57.7	57.0	54.2	27.6
650	20.4	23.2	60.6	59.6	59.7	57.6	55.6	28.8
60	21.6	23.5	61.7	60.6	60.8	58.2	56.7	29.8
70	22.7	23.6	62.4	60.2	61.8	58.8	57.5	31.0
80	23.7	23.8	63.4	61.6	63.1	61.2	57.9	32.1
90	24.8	24.0	64.1	61.6	63.9	62.0	58.4	33.3
700	26.0	24.2	64.5	60.6	64.3	61.3	59.4	34.6
10	27.2	24.5	65.0	60.3	64.8	61.2	60.3	36.0
20	28.6	24.6	65.2	59.6	65.2	60.4	61.2	37.6
30	30.2	24.9	65.7	59.8	65.8	60.9	61.6	39.2
40	31.9	25.2	67.4	63.7	67.4	65.2	61.7	41.1
750	33.6	25.5	68.9	68.4	68.8	70.5	61.7	42.9
60	35.5	25.7	70.2	73.7	70.1	76.6	61.7	44.6
70	37.2	26.0	71.5	79.5	71.1	83.6	61.7	46.4

Appendix B

Photocopies of the eleven original graph sheets obtained on the General Electric recording spectrophotometer for the sixty-eight phenol-formaldehyde resin colors supplied by representatives of the manufacturers for use of the U. S. Army Ordnance Corps. An index to the spectrophotometric curves of this set are listed in the following table, together with the date of measurement.

Index to Appendix B

Sample Number	Sample	GE Graph Sheet Serial No.	Curve No.	Date Measured
BLACK				
S- 1	Bakelite 15-2155	GE II - 1907	4, 13	12-19-57
S- 2	Bakelite 15 BMG 2323	1884	4, 19	9-25-57
S- 3	Bakelite 15-2323	1908	4, 19	12-20-57
S- 4	Bakelite 25-2080	1907	5, 12	12-19-57
S- 5	Bakelite 25 BMG 5000	1884	5, 18	9-25-57
S- 6	Bakelite 25-5000	1908	5, 18	12-20-57
S- 7	Bakelite 25-5120	1907	6, 12	12-19-57
S- 8	Bakelite 25-5315	1909	4, 19	12-20-57
S- 9	Bakelite 25-5316	1907	7, 10	12-19-57
S-10	Bakelite 25-5498	1909	5, 18	12-20-57
S-11	Bakelite 35-2051	1907	8, 9	12-19-57
S-12	Bordon	1791	4, 19	2- 8-57
S-13	Durez 791	1779	4, 9	1-24-57
S-14	Fiberite FM-1132	1792	4, 13	2-11-57
S-15	Monsanto 1004	1791	6, 17	2- 8-57
S-16	Rogers RX-429	1883	4, 15	9-25-57
BLUE				
S-17	Bakelite 25 BMG 2010	1884	6, 17	9-25-57
BROWN				
S-18	Bakelite 15 BMG 5000	1884	8, 15	9-25-57
S-19	Bakelite 65 BMG 2010	1884	9, 14	9-25-57
S-20	Bakelite 115-2010	1909	6, 17	12-20-57
S-21	Bakelite 195 BMG 2010	1884	10, 13	9-25-57
S-22	Bordon	1791	5, 18	2- 8-57
S-23	Durez 740	1779	5, 8	1-24-57
S-24	Fiberite FM-1140	1792	5, 12	2-11-57
S-25	Monsanto 803A	1791	8, 15	2- 8-57
S-26	Monsanto 1004	1791	7, 16	2- 8-57
S-27	Monsanto 10900	1791	9, 14	2- 8-57
S-28	Rogers RX-429	1883	5, 14	9-25-57
GRAY				
S-29	Bakelite 25 BMG 2010	1905	4, 19	12-18-57
S-30	Bakelite 35 BMG 2010	1905	5, 18	12-18-57
S-31	Bakelite 65 BMG 2010	1905	6, 17	12-18-57
S-32	Bakelite 105 BMG 2010	1905	7, 16	12-18-57
GREEN				
S-33	Bakelite 45 BMG 8952	1905	8, 15	12-18-57
S-34	Bakelite 55 BMG 2010	1905	9, 14	12-18-57

Index to Appendix B (continued)

GREEN (cont'd)				
S-35	Bakelite 65 BMG 2010	GE II - 1905	10, 13	12-18-57
S-36	Bakelite 75 BMG 2010	1905	11, 12	12-18-57
S-37	Monsanto	1791	10, 13	2- 8-57
MAROON				
S-38	Bakelite 25 BMG 5721	1906	4, 19	12-19-57
S-39	Bakelite 55 BMG 5780	1906	5, 18	12-19-57
S-40	Bakelite 65 BMG 8052	1906	6, 17	12-19-57
NAVY				
S-41	Bakelite 45 BMG 2010	1884	7, 16	9-25-57
OLIVE				
S-42	Bakelite BM 17015	1793*	7, 8	2-14-57
S-43	Bakelite 15-2010 Dark	1908	6, 17	12-20-57
S-44	Bakelite 15-2010 Aim	1908	7, 16	12-20-57
S-45	Bakelite 15-2010 Light	1908	8, 15	12-20-57
OLIVE DRAB				
S-46	Fiberite 1330	1792	6, 11	2-11-57
S-47	Rogers RX-431	1883	6, 13	9-25-57
ORANGE				
S-48	Bakelite 15 BMG 2010 (16094)	1906	8, 15	12-19-57
S-49	Rogers RX-428	1883	7, 12	9-25-57
PURPLE				
S-50	Bakelite 15 BMG 2010 (17805)	1906	7, 16	12-19-57
RED				
S-51	Bakelite 45 BMG 2010	1906	9, 14	12-19-57
S-52	Bakelite 65-2761 Dark	1909	7, 16	12-20-57
S-53	Bakelite 65-2761 Aim	1909	8, 15	12-20-57
S-54	Bakelite 65-2761 Light	1909	9, 14	12-20-57
S-55	Bakelite 85-2010 Dark	1909	10, 13	12-20-57
S-56	Bakelite 85-2010 Aim	1909	11, 12	12-20-57
S-57	Bakelite 95 BMG 2010	1906	10, 13	12-19-57

* Curves 4, 11 of GE II 1793 graph sheet are the spectrophotometric curves of the Olive Green paint color of Table I of this report. Curves 5, 10 and 6, 9 of the same graph sheet do not apply to this report.

Index to Appendix B (continued)

RED (continued)

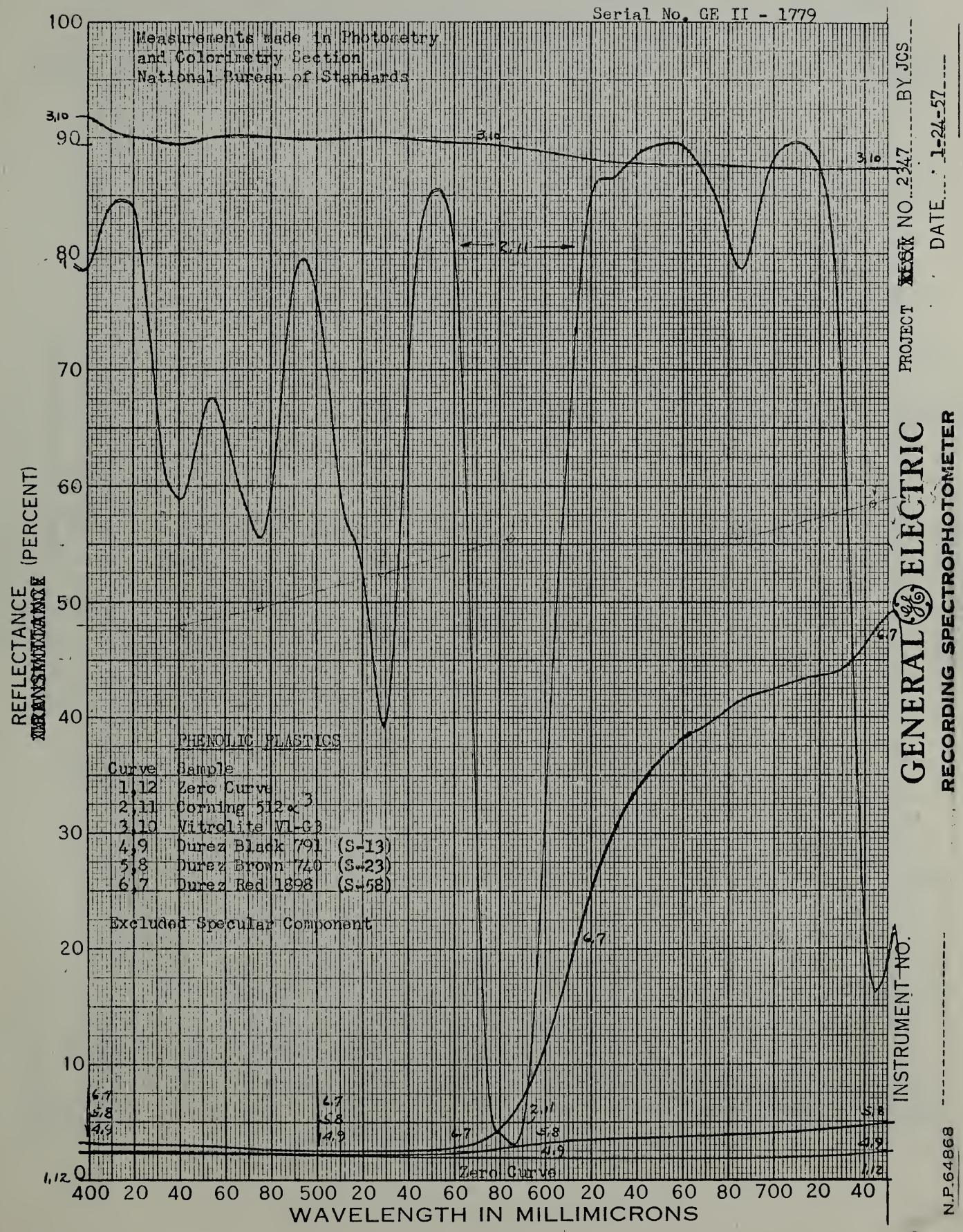
S-58	Durez 1898	GE II - 1779	6, 7	1-24-57
S-59	Fiberite 1153	1792	7, 10	2-11-57
S-60	Monsanto 2739	1791	11, 12	2- 8-57
S-61	Rogers RX-431	1883	8, 11	9-25-57

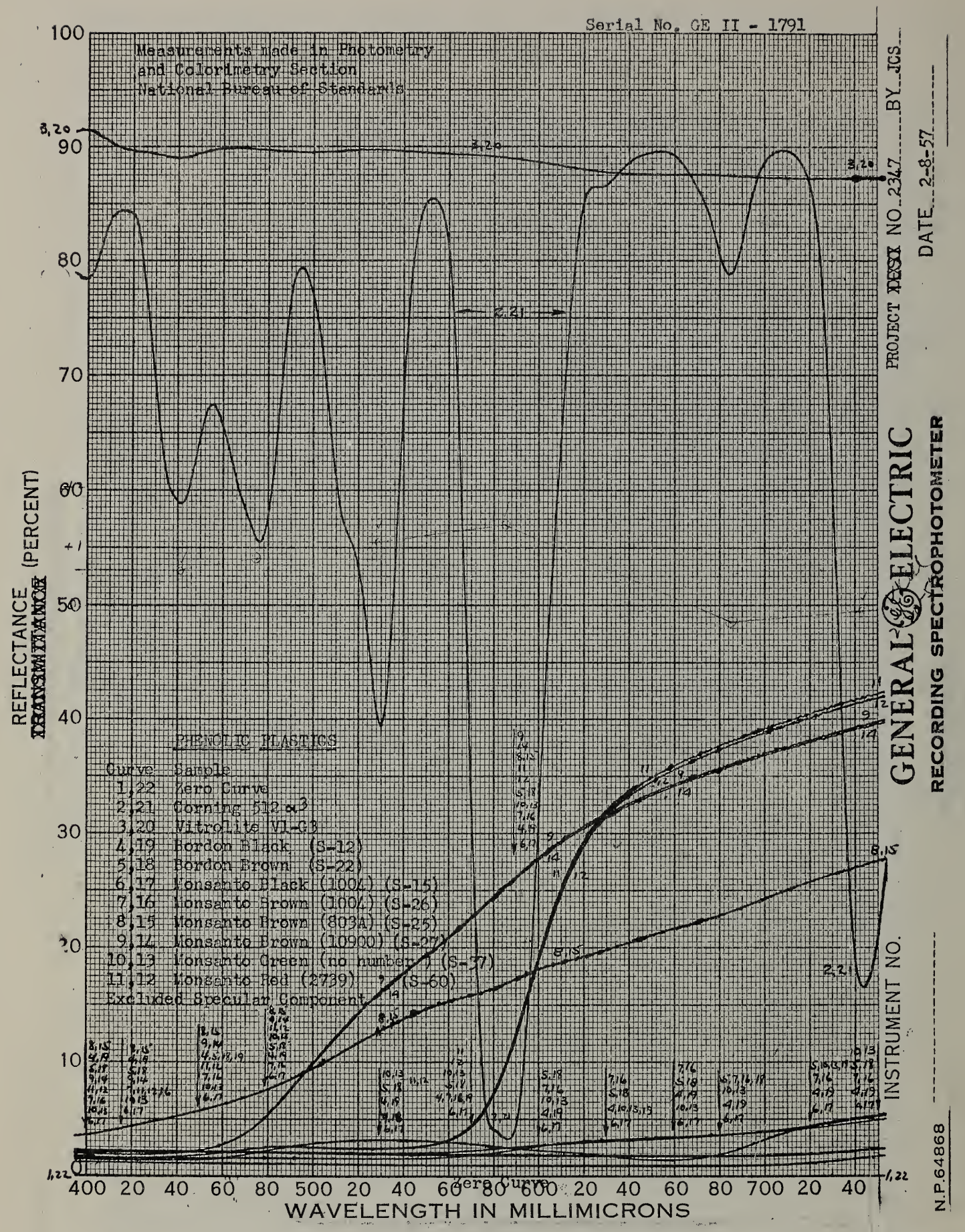
TAN

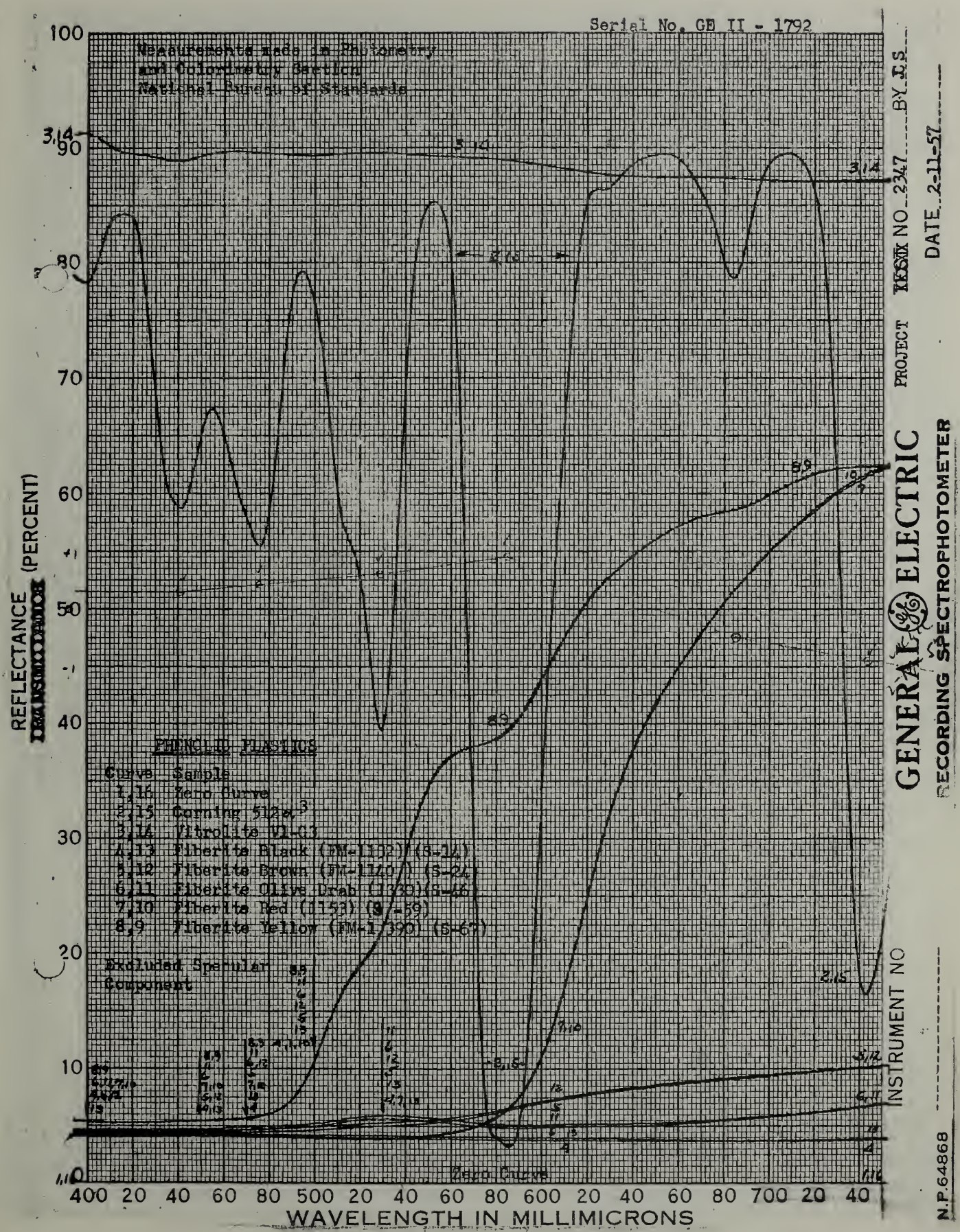
S-62	Bakelite 35 BMG 2010	1884	11, 12	9-25-57

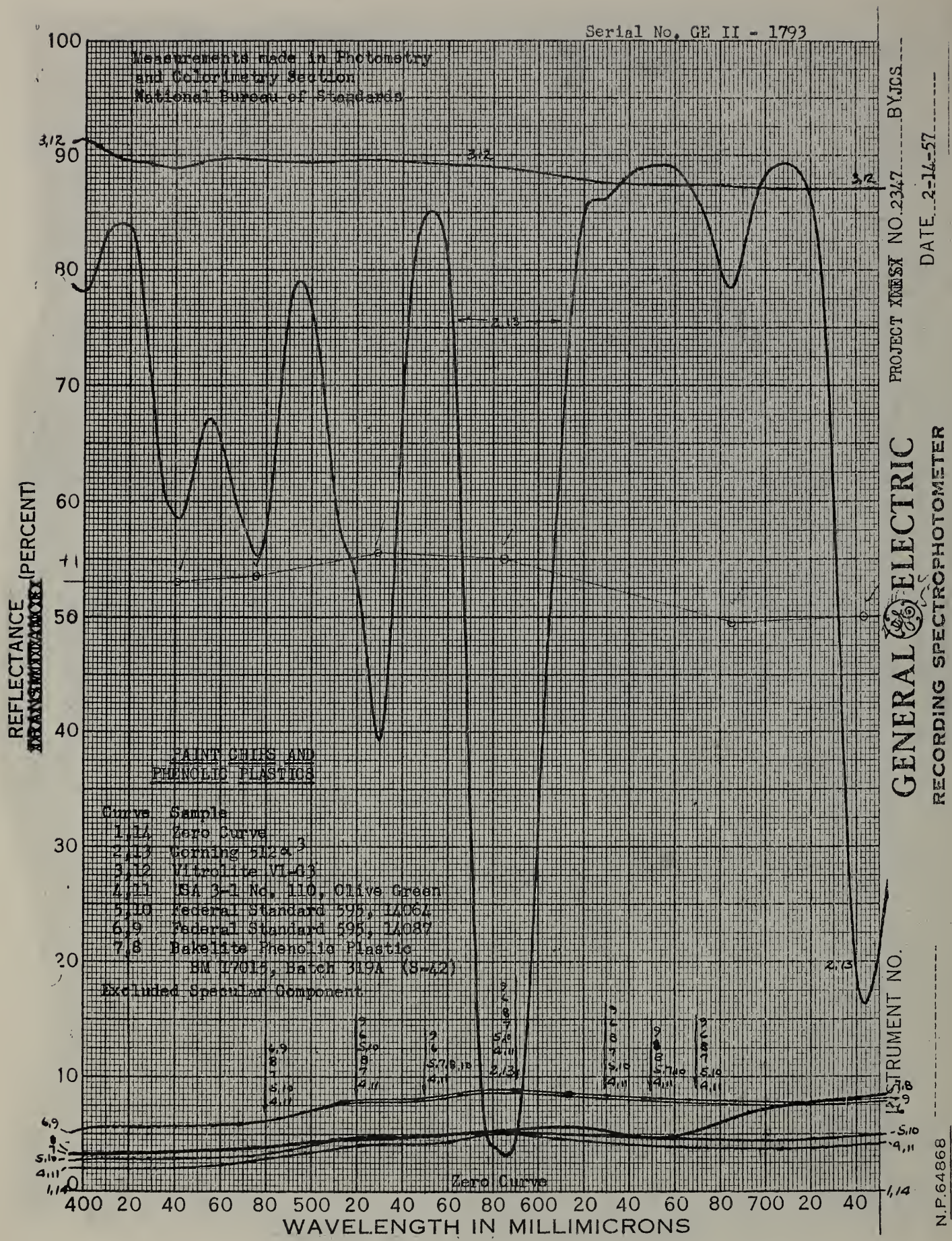
YELLOW

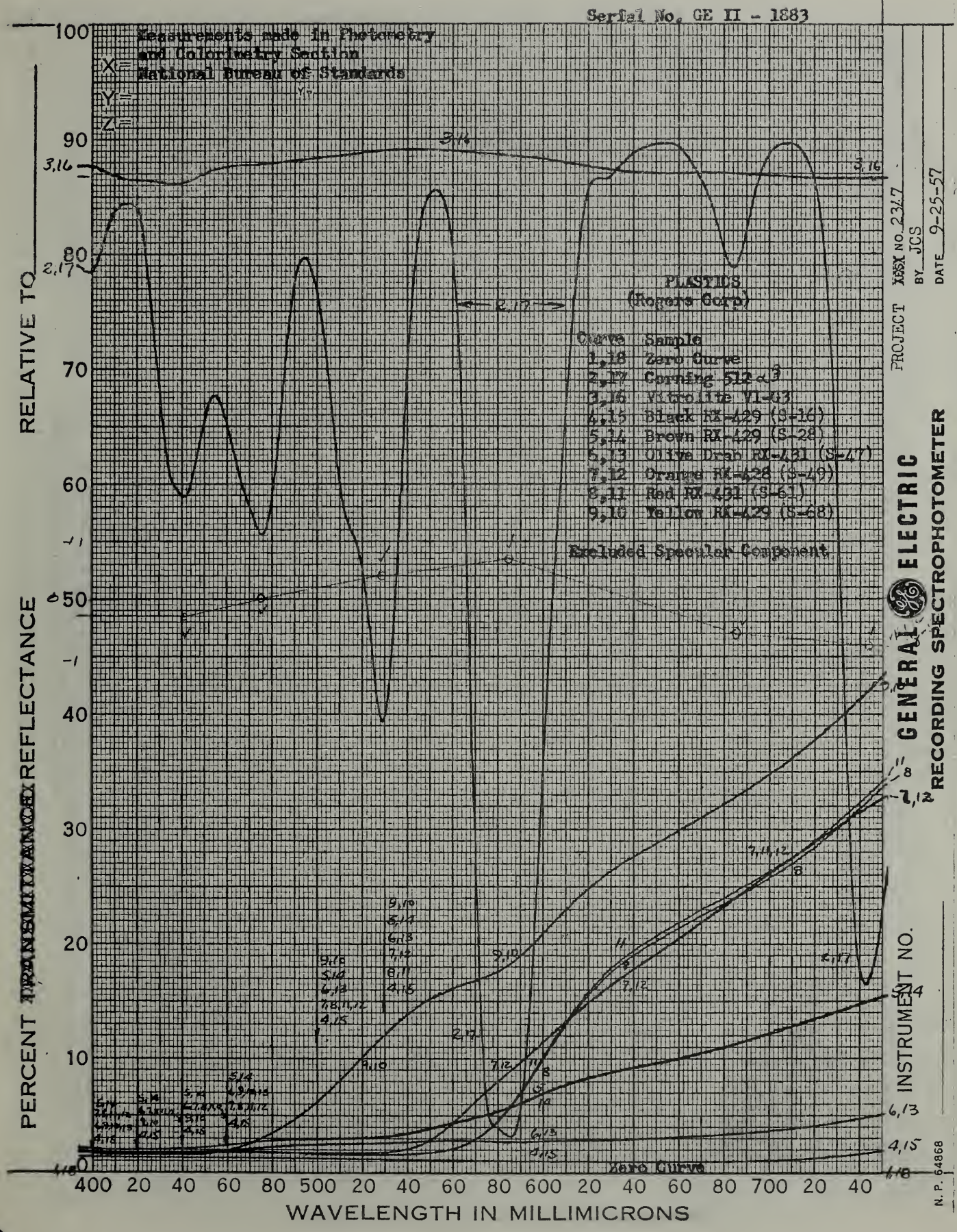
S-63	Bakelite 15 BMG 2010	1906	11, 12	12-19-57
S-64	Bakelite 15-2010 Dark	1908	9, 14	12-20-57
S-65	Bakelite 15-2010 Aim	1908	10, 13	12-20-57
S-66	Bakelite 15-2010 Light	1908	11, 12	12-20-57
S-67	Fiberite FM-1390	1792	8, 9	2-11-57
S-68	Rogers RX-429	1883	9, 10	9-25-57

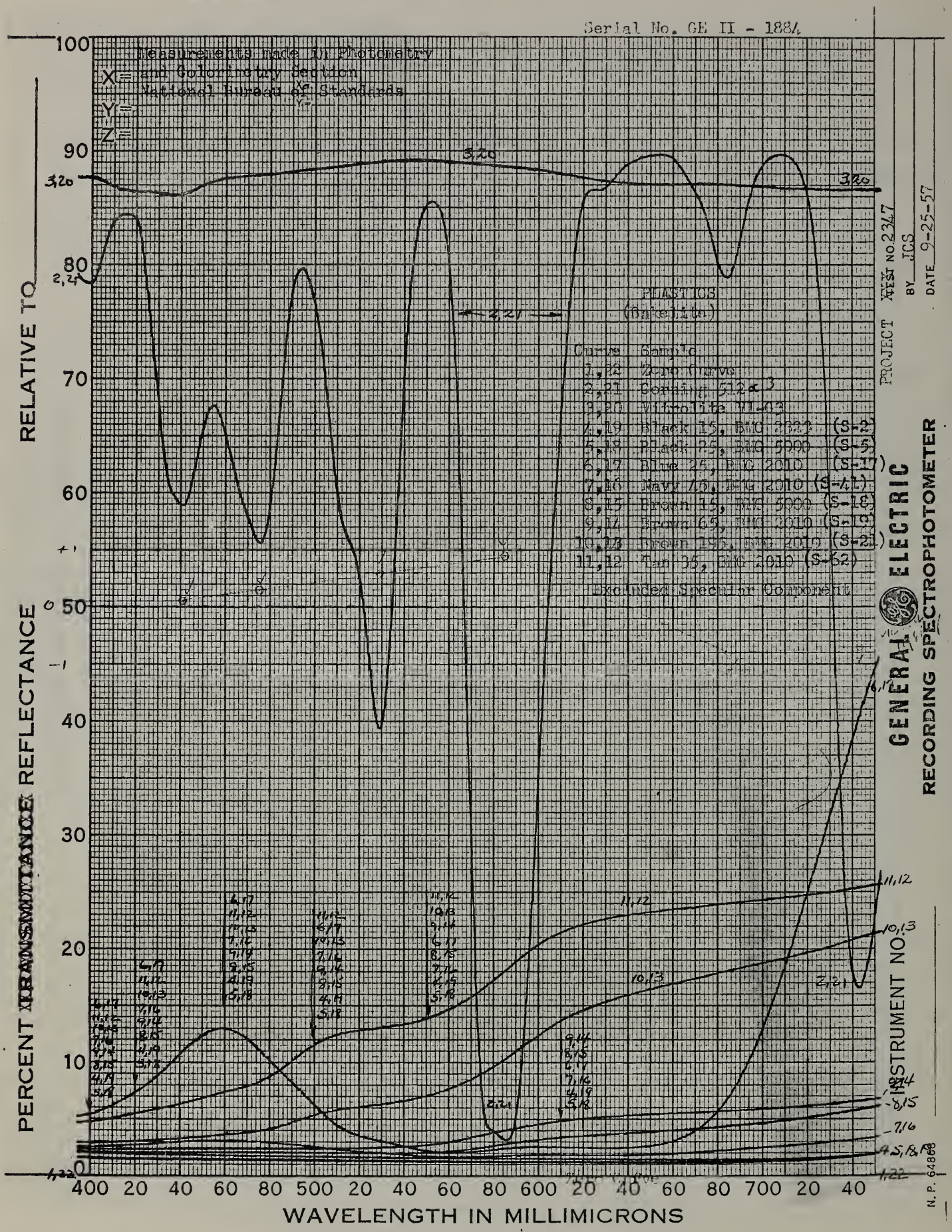

Serial No. GE II - 1779
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
PROJECT NO. 2347 BY JCS
DATE 1-24-57
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
N.P.64868
REFLECTANCE (PERCENT)
WAVELENGTH IN MILLIMICRONS
PHENOLIC PLASTICS
Curve Sample
1,12 Zero Curve
2,11 Corning 512 ~ 3
3,10 Vitrolite V1-G3
4,9 Durez Black 791 (S-13)
5,8 Durez Brown 740 (S-23)
6,7 Durez Red 1898 (S-58)
Excluded Specular Component
Zero Curve

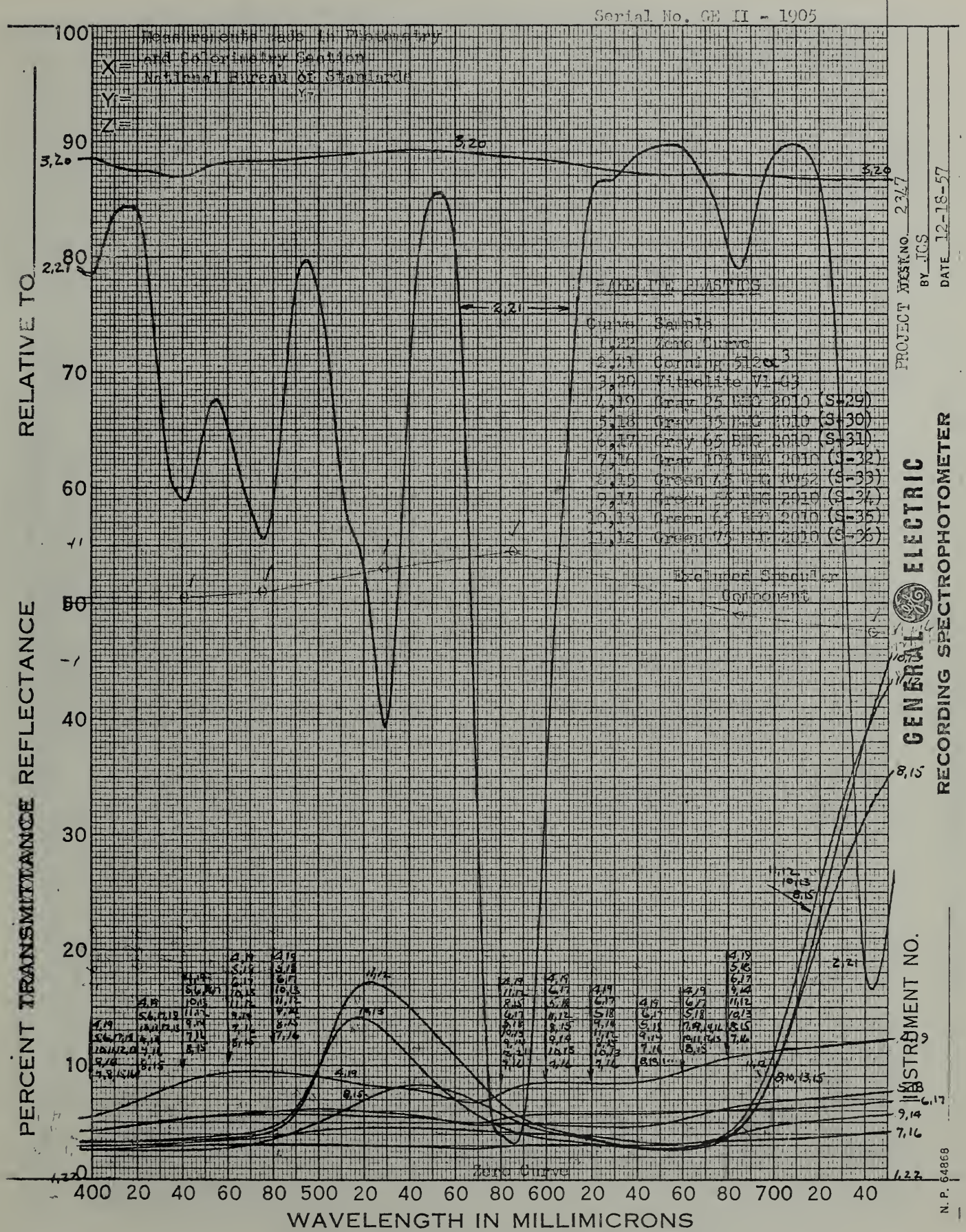

Serial No. GE II - 1791
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
PROJECT NO. 2347 BY JCS
DATE 2-8-57
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
N.P.64868
REFLECTANCE (PERCENT)
TRANSMITTANCE
WAVELENGTH IN MILLIMICRONS
PHENOLIC PLASTICS
Curve Sample
1,22 Zero Curve
2,21 Corning 512 α3
3,20 Vitrolite VI-G3
4,19 Bordon Black (S-12)
5,18 Bordon Brown (S-22)
6,17 Monsanto Black (100L) (S-15)
7,16 Monsanto Brown (100L) (S-26)
8,15 Monsanto Brown (803A) (S-25)
9,14 Monsanto Brown (10900) (S-27)
10,13 Monsanto Cream (no number) (S-37)
11,12 Monsanto Red (2739) (S-60)
Excluded Specular Component
Zero Curve

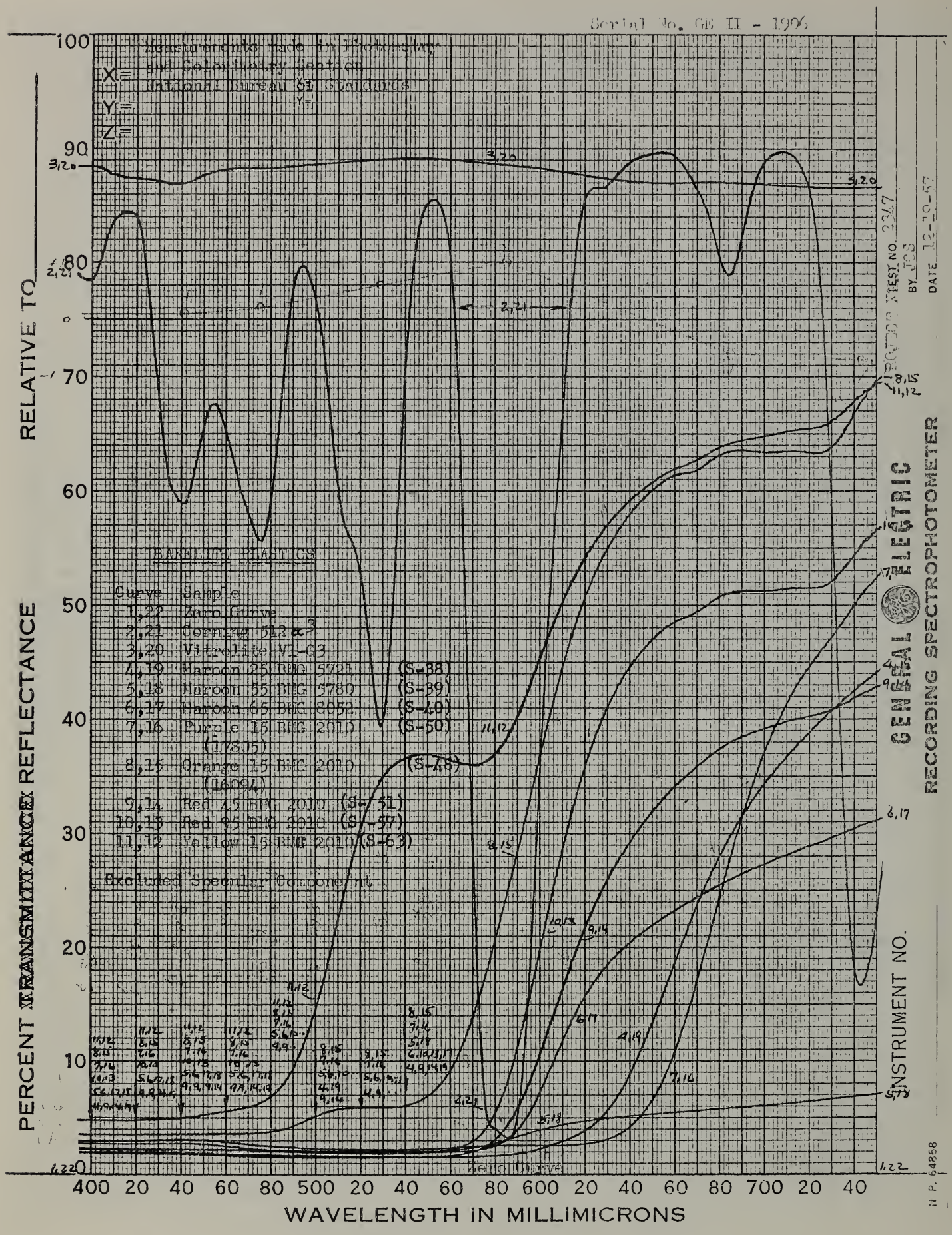

Serial No. GE II - 1792
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
REFLECTANCE (PERCENT)
100
90
80
70
60
50
40
30
20
10
0
400 20 40 60 80 500 20 40 60 80 600 20 40 60 80 700 20 40
WAVELENGTH IN MILLIMICRONS
PRINCIPAL PLASTICS
Curve Sample
1,16 Zero Curve
2,15 Corning 512a.3
3,14 Vibrolite V1-G3
4,13 Fiberite Black (FM-1132) (S-24)
5,12 Fiberite Brown (FM-1120) (S-24)
6,11 Fiberite Olive Drab (1130) (S-46)
7,10 Fiberite Red (1153) (S-59)
8,9 Fiberite Yellow (FM-1139) (S-67)
Excluded Specular Component
Zero Curve
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
PROJECT
TEST NO 2347 BY E.S.
DATE 2-11-57
INSTRUMENT NO
N.P.64868

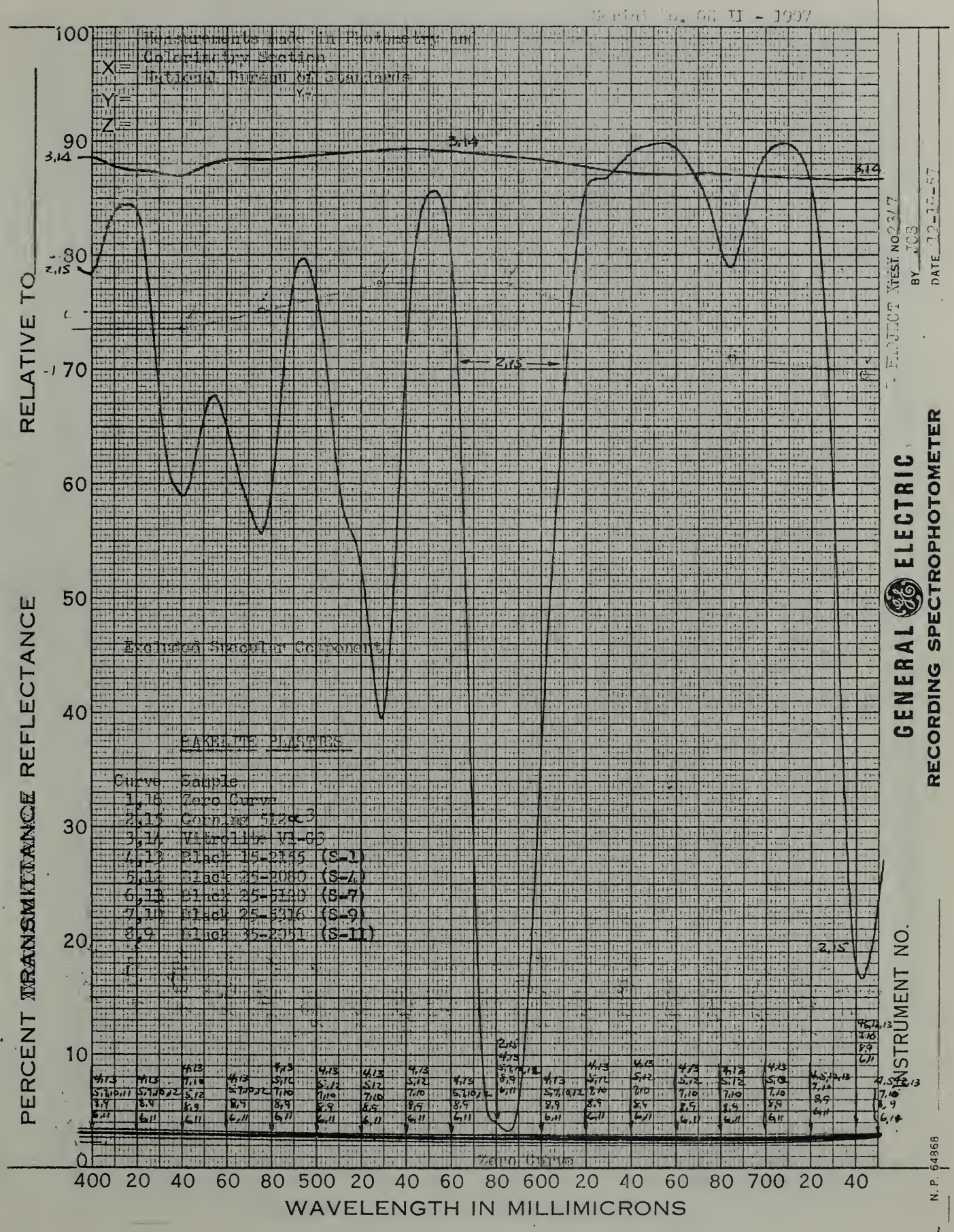

Serial No. GE II - 1793
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
PROJECT XXXXX NO. 2347 BY JCS
DATE 2-14-57
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
N.P.64868
REFLECTANCE TRANSMITTANCE (PERCENT)
PAINT CHIPS AND PHENOLIC PLASTICS
Curve Sample
1,14 Zero Curve
2,13 Corning 512 x 3
3,12 Vitrolite VI-G3
4,11 ISA 3-1 No. 110, Olive Green
5,10 Federal Standard 595, 14064
6,9 Federal Standard 595, 14087
7,8 Bakelite Phenolic Plastic BM 17015, Batch 319A (8-4.2)
Excluded Specular Component
Zero Curve
WAVELENGTH IN MILLIMICRONS

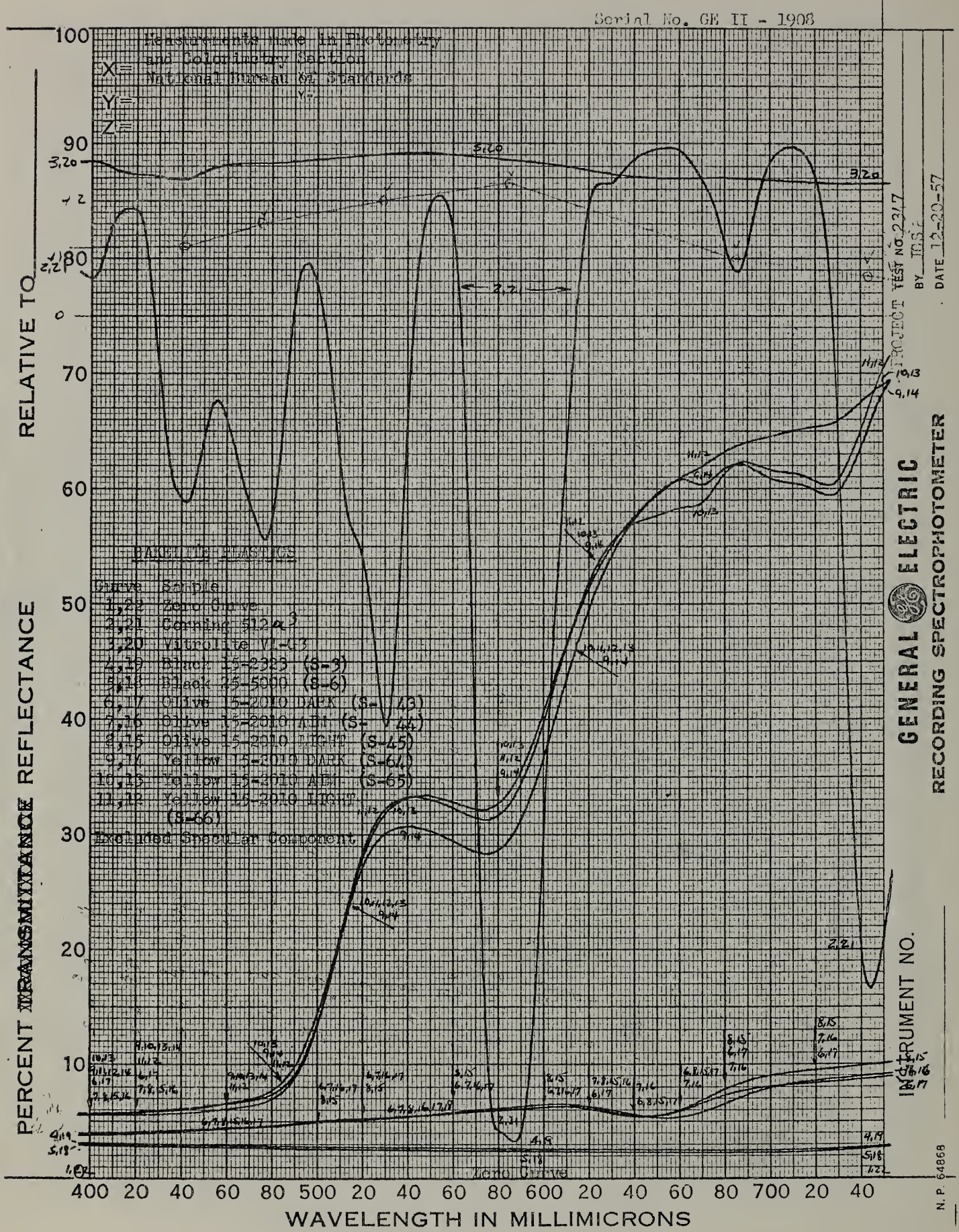

Serial No. GE II - 1883
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
X=
Y=
Z=
PLASTICS (Rogers Corp)
Curve Sample
1,18 Zero Curve
2,17 Corning 512 (3)
3,16 Vitrolite V1-03
4,15 Black RX-429 (S-16)
5,14 Brown RX-429 (S-28)
6,13 Olive Drab RX-431 (S-47)
7,12 Orange RX-428 (S-40)
8,11 Red RX-431 (S-61)
9,10 Yellow RX-429 (S-68)
Excluded Specular Component
PROJECT X65X NO. 2347
BY JCS
DATE 9-25-57
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
N. P. 64868
RELATIVE TO
PERCENT TRANSMITTANCE OR REFLECTANCE
100
90
80
70
60
50
40
30
20
10
0
400 20 40 60 80 500 20 40 60 80 600 20 40 60 80 700 20 40
WAVELENGTH IN MILLIMICRONS
Zero Curve

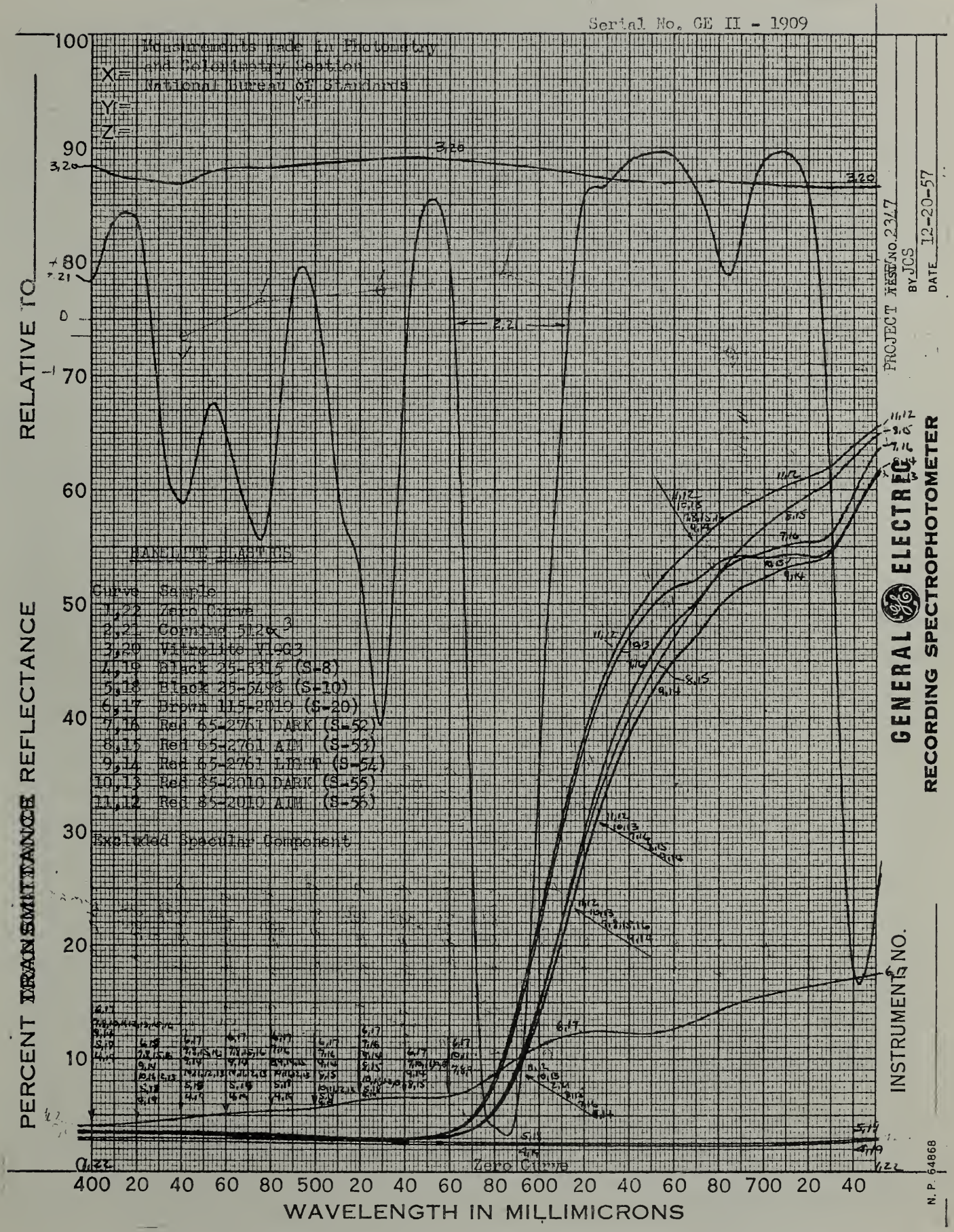

Serial No. GE II - 1884
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
X≡
Y≡
Z≡
PLASTICS (Bakelite)
Curve Sample
1,22 Zero Curve
2,21 Formaldehyde 512 & 3
3,20 Vibrolite VL-403
4,19 Black 15, BIC 2023 (S-2)
5,18 Black 25, BIC 5000 (S-5)
6,17 Blue 25, BIC 2010 (S-17)
7,16 Navy 45, BIC 2010 (S-41)
8,15 Brown 15, BIC 5000 (S-16)
9,14 Brown 65, BIC 2010 (S-13)
10,13 Brown 195, BIC 2010 (S-21)
11,12 Tan 35, BIC 2010 (S-52)
Excluded Specular Component
PROJECT TEST NO. 2347
BY JCS
DATE 9-25-57
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
RELATIVE TO
PERCENT TRANSMITTANCE REFLECTANCE
WAVELENGTH IN MILLIMICRONS
N.P. 64868


Serial No. GE II - 1905
Recommended Scale for Precision and Colorimetry
National Bureau of Standards
X=
Y=
Z=
PERCENT TRANSMITTANCE RELATIVE TO REFLECTANCE
WAVELENGTH IN MILLIMICRONS
3,20
2,21
Zero Curve
VITROLITE PLASTICS
Curve Sample
1,22 Zero Curve
2,21 Corning 512 α 3
3,20 Vitrolite V2-43
4,19 Gray 25 B.C. 2010 (S-29)
5,18 Gray 35 B.C. 2010 (S-30)
6,17 Gray 65 B.C. 2010 (S-31)
7,16 Gray 105 B.C. 2010 (S-32)
8,15 Green 75 B.C. 2010 (S-33)
9,14 Green 55 B.C. 2010 (S-34)
10,13 Green 65 B.C. 2010 (S-35)
11,12 Green 75 B.C. 2010 (S-36)
Enlarged Specular Component
PROJECT MESA NO. 2347
BY JGS
DATE 12-18-57
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
N. P. 64868


Serial No. GE II - 1996
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
X=
Y=
Z=
RELATIVE TO
PERCENT TRANSMITTANCE REFLECTANCE
100
90
80
70
60
50
40
30
20
10
0
3.20
2.21
1.22
Zero Curve
BAKELITE PLASTICS
Curve Sample
1,22 Zero Curve
2,21 Corning 512 α 3
3,20 Vitrolite VL-C3
4,19 Maroon 25 BRG 5721 (S-38)
5,18 Maroon 55 BRG 5780 (S-39)
6,17 Maroon 65 BRG 8052 (S-40)
7,16 Purple 15 BRG 2010 (S-50)
(17805)
8,15 Orange 15 BRG 2010 (S-48)
(16094)
9,14 Red 15 BRG 2010 (S-51)
10,13 Red 95 BRG 2010 (S-57)
11,12 Yellow 15 BRG 2010 (S-63)
Excluded Specular Component
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
PROTOCOL TEST NO. 2347
BY JOS
DATE 12-20-57
400 20 40 60 80 500 20 40 60 80 600 20 40 60 80 700 20 40
WAVELENGTH IN MILLIMICRONS
N P. 6436B


Serial No. 68 II - 1007
Measurements made in Photometry and Colorimetry Section
National Bureau of Standards
X=
Y=
Z=
PERCENT TRANSMITTANCE REFLECTANCE RELATIVE TO
100
90
80
70
60
50
40
30
20
10
0
3.14
2.15
2.13
Excluded Specular Components
BAKELITE PLASTICS
Curve Sample
1,16 Zero Curve
2,15 Corning 512 #3
3,14 Vitrolite V1-80
4,13 Black 15-2755 (S-1)
5,12 Black 25-2080 (S-4)
6,11 Black 25-5240 (S-7)
7,10 Black 25-5276 (S-9)
8,9 Black 35-2951 (S-11)
Zero Curve
400 20 40 60 80 500 20 40 60 80 600 20 40 60 80 700 20 40
WAVELENGTH IN MILLIMICRONS
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
PROJECT TEST NO 2317
BY TCS
DATE 12-12-57
N. P. 64368


Serial No. GE II - 1908
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
X=
Y=
Z=
PERCENT TRANSMITTANCE RELATIVE TO REFLECTANCE
PARTIAL PLASTICS
Curve Sample
1,22 Zero Curve
2,21 Corning 512α3
3,20 Vitrolite VI-43
4,19 Black 15-2329 (S-3)
5,18 Black 15-5000 (S-6)
6,17 Olive 15-2010 DARK (S-43)
7,16 Olive 15-2010 MED (S-44)
8,15 Olive 15-2010 LIGHT (S-45)
9,14 Yellow 15-2010 DARK (S-64)
10,13 Yellow 15-2010 MED (S-65)
11,12 Yellow 15-2010 LIGHT (S-66)
Excluded Specular Component
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
PROJECT TEST NO. 2347
BY TDSE
DATE 12-20-57
INSTRUMENT NO.
Zero Curve
WAVELENGTH IN MILLIMICRONS
N. P. 64868


Serial No. GE II - 1909
Measurements made in Photometry and Colorimetry Section National Bureau of Standards
X=
Y=
Z=
PERCENT TRANSMITTANCE REFLECTANCE RELATIVE TO
100
90
80
70
60
50
40
30
20
10
0
3.20
3.21
2.2
BAKELITE PLASTICS
Curve Sample
1,22 Zero Curve
2,21 Corning 512 (S-3)
3,20 Vitrolite V-903
4,19 Black 25-6315 (S-8)
5,18 Black 25-6498 (S-10)
6,17 Brown 115-2019 (S-20)
7,16 Red 65-2761 DARK (S-52)
8,15 Red 65-2761 AIM (S-53)
9,14 Red 65-2761 LIGHT (S-54)
10,13 Red 85-2010 DARK (S-55)
11,12 Red 85-2010 AIM (S-56)
Excluded Specular Component
Zero Curve
400 20 40 60 80 500 20 40 60 80 600 20 40 60 80 700 20 40
WAVELENGTH IN MILLIMICRONS
PROJECT TEST NO. 2317
BY JCS
DATE 12-20-57
GENERAL ELECTRIC
RECORDING SPECTROPHOTOMETER
INSTRUMENT NO.
N. P. 64868

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, Secretary
NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D.C., and its major laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.


NBS