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Final Report

REAR PROJECTION SCREEN MATERIALS STUDY

F. O. 046564

Project Closed: March 1, 1962

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REAR PROJECTION

SCREEN MATERIALS STUDY

F. O. 046564

By

STAT

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February 12, 1962

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ABSTRACT

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[redacted] has conducted an evaluation of rear projection screen materials suitable for viewing high definition photographic transparencies and prints. The program included the assembly of test apparatus, the use of this equipment in measuring screen sample definition, distribution of illumination, and polarization characteristics. Conclusions are in terms of:

a) Best group viewing screen.

b) Best individual viewing screen.

c) Best stereo group viewing screen.

d) Best individual stereo viewing screen.

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I TECHNICAL DISCUSSION

A. Literature Survey

A literature survey was conducted in which fifty-one published papers were selected as generally applicable to the characteristics and/or evaluation of rear projection screens. The majority of this material pertains to luminance distribution factors as applied principally to theater projection and background screens for television studio work or process photography. Although many of the papers offered information that was of partial interest and value, there was little in the literature which indicated prior concentration on high definition projection. The bibliography is included as Appendix H.

B. Diffusing Screens in Rear Projection

The basic purpose of this program was to evaluate the performance of various screen materials in the rear projection of high definition photographic records. The term "high definition" photography in this use is construed to mean quality in the order of 100 to 200 medium contrast lines per millimeter.

To understand this problem we must first visualize the process of image formation in a turbid or diffusing medium. Basically a projection optical system forms an image at the screen plane and this pattern, because of scattering of light within the medium, is seen multidirectionally at the screen. This scattering process may be caused by any one or a combination of such physical properties as surface roughness, pigmentation, layers of small spheres, or other types of light scattering particles.

The ground surface, as an example, has two optical characteristics - an array of microsurfaces of random tilt with respect to the datum and a random depth or layer thickness. A light bundle striking this surface is therefore scattered by a combined prismatic - lenticular action in that each micro surface deviates the rays intercepted by its area as a function of air index of refraction, angle of incidence on the microsurface and the material index. The random deviations within the material direct the rays in all angles from the points of incidence, to the condition wherein the critical angle is exceeded. Thus the angle of the emergent cone indicates the distance off the optical axis the observer may see the image.

The image spread in a rear projection screen as a result of light scattering and diffusion is similar in concept to the spread which occurs in the image formation process of a photographic emulsion. The photographic situation has been exhaustively discussed as a result of theoretical and experimental studies 1, 2. Therefore, the apparent "granularity" or a screen becomes the major factor controlling the image fidelity presented to the viewer in terms of dimensional alteration of the image and its contrast. To function as a rear projection screen, it must always present an image that is distorted in size and contrast with reference to the original object, otherwise the characteristics causing the screen to serve its function approach zero as image fidelity is maximized.

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It therefore follows that, in the presence of a granular structure, the screen image fidelity is dependent on the size of the incident image structure.

As this micro structure approaches granularity magnitudes, the spreading increases in terms of size and shape distortion and contrast reduction until a "threshold" of apparent detection or recognition is reached, beyond which, with decreasing incident image size, the screen structure is incapable of definition.

Variation of projection magnification is a method whereby the image size may be varied for determination of this threshold region. The change from the "micro" condition to the threshold condition, should be continuous, thereby permitting the operator to seek the "image breakup threshold" without the error inducing distractions of "stepped" magnification changes.[3]

Since the determination of the granular threshold is a visual function, there enters the problem of eliminating experimental errors induced by human acuity limitations. Auxiliary magnification must therefore be provided in amount to insure that visual acuity is not a restricting factor.

The use of such a projection technique would differ from a contact situation, wherein the target is placed in direct contact with the diffusion surface of the sample and read with a microscope viewing through the sample. This difference is evident by the fact that "granularity" is the major factor controlling the image fidelity of a rear projection screen, and as it is decreased the spread effect is decreased and the function of the material as a screen decreases to zero. However, in the case of the "contact situation", as the granularity is decreased, the capability to read higher resolutions increases to the point where at maximum image fidelity, there would be no granularity present on the screen.

It is obvious that the technique of "contact resolution", testing that is, examination of a resolving power target in contact with the screen sample, of materials is of limited, if not misleading value. No basis for assessing the better screens exists other than the loss of information as compared to the target. Also, the position at the image is fixed at the target itself, not in or on the screen. As a result the diffusion process acts as a filter rather than an image transducer.

C. Description of Samples.

A total of 114 specimens were collected for the program as a result of a survey of 17 organizations advertising the production or marketing of rear projection screens.

Particular effort was made to obtain representative types of materials and diffusing surfaces, such as ground glass, matte plastic, beads on glass, chemicals deposited on plastic, single layer, double layer, and homogeneous type and lenticular configuration. These materials were cut and mounted in 2" by 2" photographic slide holders. A coded listing is given in Table I. Throughout the remainder of the body of the report, the number or type of screen only will be used.

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II EXPERIMENTAL INVESTIGATION

A. Test Approach and Method Selection

The following experimental philosophy was adopted:

1. A test utilizing projection techniques most realistically indicates a screen's performance as ultimately used.

2. The performance of the projection test equipment must be that of a high definition system.

3. A variable magnification ratio technique provides the necessary means to establish the screen sample's threshold of definition.

4. Controlled, auxiliary visual magnification is necessary to maintain a constant apparent image scale.

Thus a basic test fixture was outlined requiring the projection of high definition, target - objects with a lens capable of 200 lines per millimeter quality at the short conjugate. Semi-automatic mechanical and optical features were provided to maintain consistent image quality during the operation of the equipment.

Other tests providing significant information were considered to be:

Contact Resolution Test
Luminance Tests
Transmission Tests
Polarization Tests
Profilometer Tests
Photomicrographic Tests
Microdensitometer Tests

The equipment and operations will be discussed in the following sections.

B. Definition Threshold Test Equipment

The variable projection test fixture constructed for the screen sample evaluation is illustrated in Figure 1. The components of the projection system were located on a double rail nine foot lens bench. A carriage which could be moved along the rails by a pulley arrangement held the target-object, the lens, and the autofocusing and manual focusing mechanism. The light source was located to one side but unattached to the fixture because of the need for vibration isolation. The sample holder and viewing microscope were located at one end of the bed.

The target object was a reduced positive transparency of 200 line per millimeter quality, on Minicard emulsion, of a vertical aerial photograph.

The portion of the image selected for this test is shown outlined in the enlarged copy of the target object, reproduced here as Figure 2. The image was projected with a representative 50mm f/2 lens working at f/2.8, which is capable of 202 visual lines per millimeter on axis using a high contrast USAF resolution target.

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The projection magnification range of the instrument was from 40:1 to 1:1 with a coarse autofocus by a cam-activated mechanism and a manual fine focus override. Thus the image focus was monitored on the sample plane throughout the range of magnification.

The image at the sample plane was viewed by the operator with a StereoZoom Microscope with a calibrated, continuously variable range of 14x to 50 x.

The apparatus was used in the following manner to determine the definition threshold of each screen material sample. A specimen was placed in the slide holder with its diffuse side toward the operator. The movable carriage was set at the indexed position of 40:1 and the projected image viewed with the StereoZoom Microscope at 14x. The best focus was selected by remote adjustment with the fine focus knob. The magnification ratio of the projected image was then reduced by carriage movement, resulting in the image becoming progressively smaller in size on the sample plane. The operator varied the magnification of the viewing microscope, maintaining the apparent image size equal to that of the 40:1 condition.

This process was continued until the operator determined the image to be degraded at which point the magnification ratio was recorded as the "definition threshold," for that sample.

The method of arriving at a decision of definition threshold therefore included assessment of the overall quality, edge sharpness, contrast and the recognition of fine detail. The ability to search for the region of apparent image disintegration was found to be a critical factor in the evaluation process. The results are recorded in Table II of Appendix A and the data sheets of Appendix B.

C. Contact Resolution Test

The contact resolution test method was used in this study as a supplemental means of screen performance evaluation. Since this method is simple and easily reproduced with reservations indicated by the more elegant projection method, possibilities of correlation for future sample assessment are provided.

The tests were performed on each screen material using a resolution target with black bars on a clear background and a [redacted] StereoZoom Microscope with a variable magnification range of 7x to 60x. (Figure 3.) The results of this test for each sample are shown graphically, resolution versus magnification, in the data sheets in Appendix B.

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D. Luminance Tests and Equipment

The brightness ratio or fall-off with angle is an important factor in the performance of a rear projection system because of the common requirement of off-axis viewing by multiple observers. In such cases where there is more than one observer, this factor becomes a prime consideration.

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To determine the distribution of photometric brightness of each of the sample screen materials as a function of angle from the normal, a breadboard goniophotometer was assembled. (Figure 4)

The photometer portion of the apparatus was a Photo Research Spectra[4, 5] Brightness Spotmeter, Model SB - 1-1/2°. The brightness meter was mounted to pivot in an arc around a point beneath the screen sample. The illumination of the sample, provided by a 750 watt projection source, was measured at the sample plane as 1600 foot candles with a Weston foot-candle meter. Readings were made of a 0.4 inch diameter portion. The results of the luminance tests for each sample are shown, luminance in percent versus angle of measurement, in the data sheets in Appendix B.

E. Transmission Tests and Equipment

Transmission values of the screen samples are necessary data in the selection and evaluation of screen material because of the interdependence of the projection source illumination, the density of the original record, lens speed, and the screen brightness requirements of a system.

The illumination analyzer, shown in Figure 5, was used to obtain the transmission readings of the screen samples.

Two sets of reading were made for each sample; one with the diffusing or matte surface of the sample toward the analyzer and one with the smooth surface toward the light source. These values are recorded on the individual data sheets in Appendix B.

F. Polarization Tests and Equipment

The purpose of the polarization examination was in anticipation of use with polarizing stereoscopic rear projection viewers. Jenkins and White discuss the basic theories of polarization in reference 7.

Two tests were performed, the first to sort out those samples which wholly depolarized, and the second to measure the amount of depolarization of those samples which indicated partial depolarization. A visual process with a simple polariscope was used in the initial process in which the sample was placed between a polarizer and an analyzer, type HN32, on a light table as shown in Figure 6. The polarizers were crossed and uncrossed and the change in appearance or lack thereof indicated whether or not the material required further test and measurement.

Those samples which had a minimum of depolarizing qualities were further tested with an apparatus which was a combination of the goniophotometer and the polariscope. The technique is basically similar to the above test except that the photometer permits the measurement of the efficiency by the amount of light passing through the system under crossed and uncrossed conditions of the polarizer and analyzer. This efficiency is a ratio of the two values. The results are included in Table II of Appendix A.

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G. Miscellaneous and Selected Tests

G-1 Profilometer Tests

In order to define the surface characteristics of samples which have ground surfaces as diffusing media, profilometer tests for surface roughness, per ASA Spec. 46. 1-1955, were run on ground glass samples, #74-80. The instrument built by Micro-metrical Co., is an electro-mechanical device which amplifies and records the departure of a stylus from a mean datum plane as defined through the plane of surface roughness over a specified length. In this case, the length or stroke of the stylus was 0.030 inches.

The results are given in integrated root mean square values of micro-inches, and are indicated on the data sheets of the Appendices.

G-2 Photomicrography

In order to illustrate the effect of projected light passing through a diffuse rear projection screen, photomicrographs were taken of ten screen samples. These were selected from the group as being representative of the general types being investigated. All samples were photographed with their diffusing surface in contact with an opaque plate containing a pinhole measuring 121 microns in diameter and located between the light source and the sample. The photos were of 200x enlargement using a Photomicrographic Camera Model L, with Panatomic X film, developed in D-76 for 9 minutes at 68° F. For comparative purposes, a separate photograph was made of the pinhole without a screen sample in place.

Exposure times were; 1/10 second for the pinhole; 1/5 second for samples #7, 27, 56, 65, and 81; and 1/2 second for samples #13 14, 47, 61, and 68. Contact prints are included in Appendix C.

G-3 Microdensitometer Scanning of Screen Samples

The photomicrographs taken in a previous phase of this study at best provide only qualitative confirmation of the spreading effect caused by diffusion. The microdensitometer approach was used to obtain a numerical measure of the spread effect of the diffusing surface by comparing the recorded trace of the spread with that of the trace of the aerial image of the projected spot of light from the pinhole.

The microdensitometer, in breadboard form, consists essentially of an illumination system, a projection or transmitting microscope, a scanning microscope and a photomultiplier with its associated electronic equipment including a strip chart recorder. Fig. 7 is a schematic diagram of the instrument.

The samples scanned included those photographed previously plus others such as an opal plastic and a finely ground glass.

A 30 micron diameter pinhole image of the transmitting microscope was focused visually on the diffusing surface of a screen sample.

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The aerial image of the pinhole is then focused with the pickup microscope and the focusing eyepiece scanned and recorded.

The samples that had been photographed were scanned and a basis for measuring their spreads was established since the trace of each sample could be overlaid with the trace of the aerial image. In each case the qualitative results of the photomicrographs were confirmed quantitatively by this scanning method.

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III EXPERIMENTAL RESULTS AND DISCUSSION

A. General Tabulation and Recording

The test series results are catalogued in terms of each of the 114 samples in Appendix B. In addition, the data are shown in tabular form in TABLE II, which lists each sample by number in the order or rating of performance for each test.

B. Specific Tests Results

Definition Thresholds Because of the nature of the testing equipment, the data results are given in the form of magnification ratios. Of the 114 samples tested, 78 were within the range of the instrument with readings from 40:1 to 11:1. The remainder were of such quality that they were beyond the 40:1 limitation. In the data sheets this "definition threshold" value has been termed "image breakup magnification."

Contact Resolution Contact resolution performance is given in lines per millimeter and range from 142 to less than 3. The individual graphs each show the resolution values plotted against microscope magnification. The tabular form records the peak values in decreasing order according to their performance.

Luminance Tests A total of the readings of the luminance or photometric brightness for each screen is plotted graphically with the relative luminance expressed in percent versus the angle of observation. The 100% value is the axial reading as shown. Thus each plot shows graphically the relative distribution of illumination throughtout the 0° to 45° area of interest.

From this relative distribution another evaluation criteria is derived, which is called the 50% Fall-off Angle. This is the angular position off-axis where the luminance intensity drops to 50% of the on axis value. These are arranged in order in Table II.

The "Axial Gain", or luminance divided by the illumination (foot Lamberts divided by foot candles, on axis)[8] is calculated and recorded for each screen as a "power" rating of the screen's performance and direction ability.

Hill also developed a single number figure of merit to indicate luminance characteristics called the "Shape Factor."[9] It is based on an empirical formula derived by treating the screen as a type of diffuser which redistributes the light as a calculated power of the cosine of the angle of observation. The theoretical values were computed and plotted in dashed line against the actual brightness values for comparison purposes. Departure from the two curves can be attributed for the most part to absorption and other losses within the screen. Further discussion of the formula, its derivation and an example of a calculation is included in Appendix G.

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Transmission Tests Two measurements in percent are given in the data sheets for each sample, i.e., matte side facing the light source, or reversed. Table II records the values with the smooth side toward the source in order of decreasing transmission.

Polarization Tests The first phase examination resulted in the selection of 19 samples out of the 114 worthy of further testing. Eight of the 19 were ground glass materials. The performance of each sample is rated in order in Table II and individually on their respective data sheets.

Profilometer Tests The test results expressed in micro-inches (rms) for #74 through #80 are given in the individual data sheets.

Photomicrography and Microdensitometer Scanning Results. These results are pictorially illustrated in the Appendices. The measured value of the spread effect of the microdensitometer tracings at the 50% level (halfway between peak and base) is ratioed with the "no sample" aerial condition and the results tabulated in Appendix C.

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IV SUMMARY

In the process of determining which screen materials are most suitable for various categories of rear projection under conditions of high definition, 114 specimens were collected, various testing techniques and equipment were developed, and performance ratings were established. Five basic and three selective tests were performed on these materials. A special test was devised which represented a realistic, high quality projection system using a transparency of an aerial photograph as a target object. The selection of this target object in lieu of test objects such as bar resolution charts, point sources, squares, discs, was to provide the necessary realism representing the conditions of photographic interpretation. The "definition threshold" of each of the sample materials was established as one of the parameters of rating. Contact resolution tests provided a rapid and simplified means of performance rating although these results were not directly correlative with the projection date.

It was generally observed, as a result of definition and luminance distribution tests that, as the granularity of a screen material increases, the brightness distribution becomes more uniform, the image spread factor increases, the definition threshold rises numerically (quality decreases), and the transmission value decreases. The results of each of the tests defining a screen's performance must therefore be carefully weighed according to the use of the material.

The data from this investigation are sufficient to permit the selection of the most suitable material from among the samples tested for particular rear projection applications. Some of the requirements might be; availability of illumination, number of observers, image quality desired, screen size, ambient lighting conditions, brightness uniformity, stereo or non-stereo application, sensitivity to damage, and cost. None of the screens tested in this project is capable of handling all the requirements that might arise in rear projection systems specifications. The selection of a "most suitable" screen for a given application is governed by the importance of each requirement at a sacrifice to the least important factors.

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V CONCLUSIONS

The following screens are suggested in the order of their listing for each of the general categories.

A. Most suitable group viewing screen (3 to 5 persons)
Samples, #106, 113, 41, 104, 59

B. Most suitable group viewing screen (6 or more persons)
Samples, #59, 47, 66, 83, 8

C. Most suitable individual viewing screen (without auxiliary viewing aid)
Samples, #97, 114, 42, 105

D. Most suitable individual viewing screen (with auxiliary viewing aid)
Samples, #35, 104, 63, 97, 16

E. Most suitable stereo group viewing screen
Samples, #64, 63, 7

F. Most suitable stereo individual viewing screen.
Samples, #84, 56

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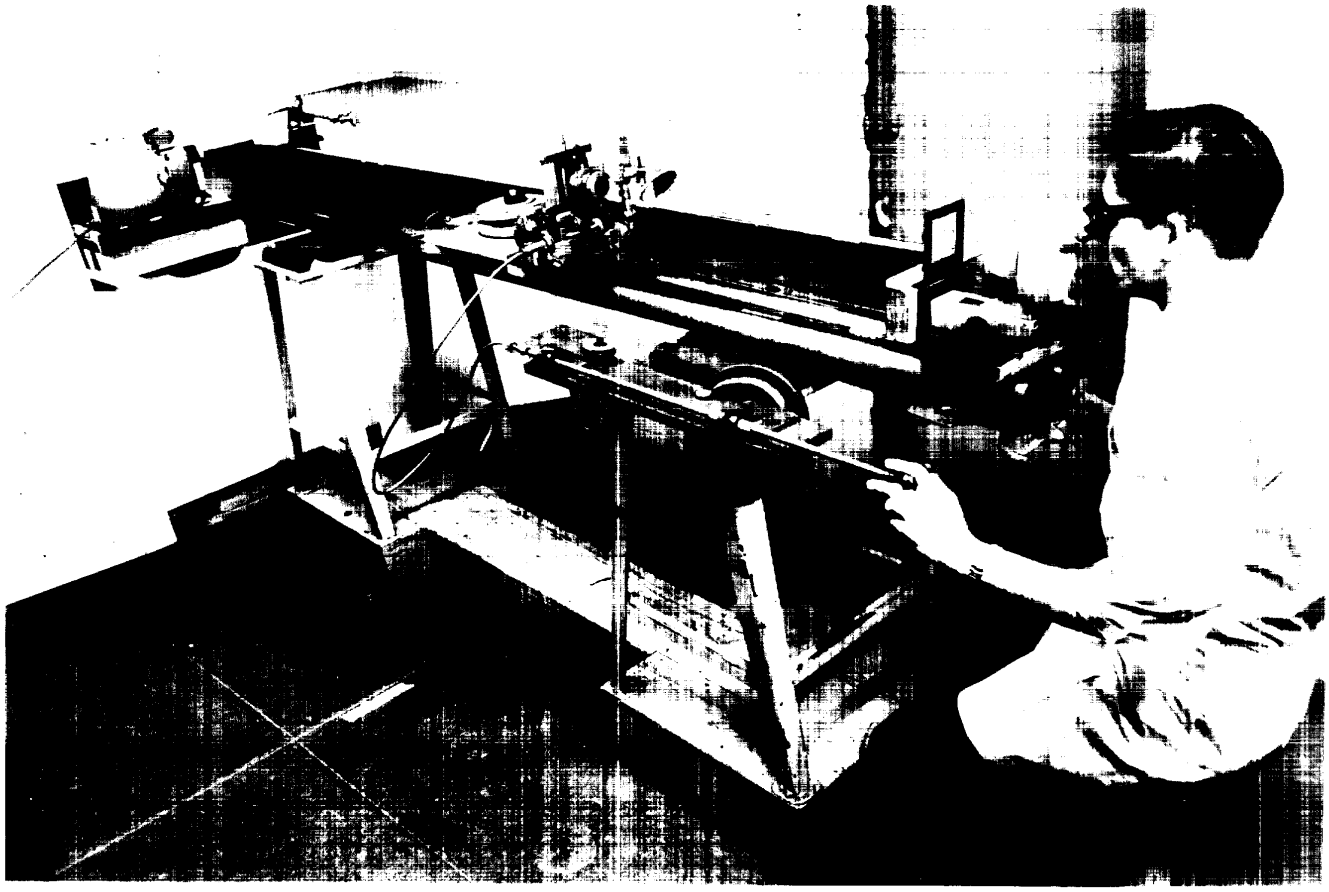

Figure 1
Definition Threshold Test Equipment

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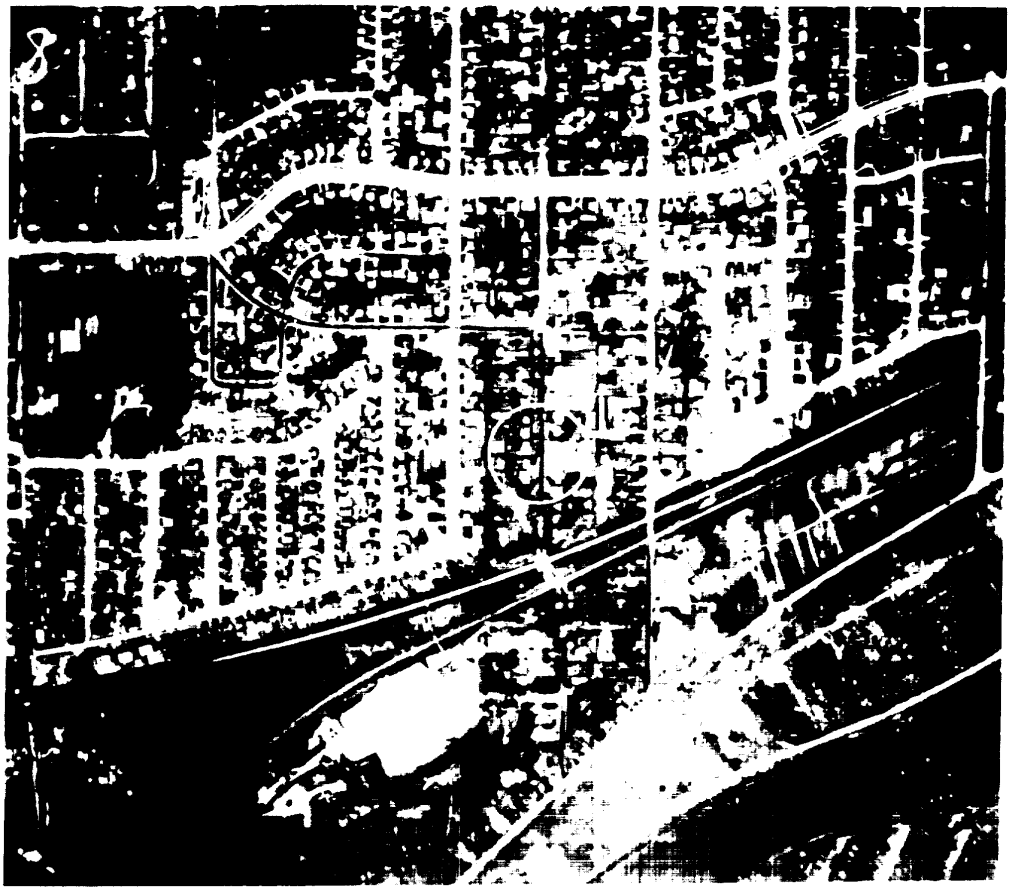

Figure 2
Enlargement of Target - Objective area
(portion used in Definition Threshold test shown outlined)

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Figure 3

Contact Resolution Test of Rear Projection Screen Materials

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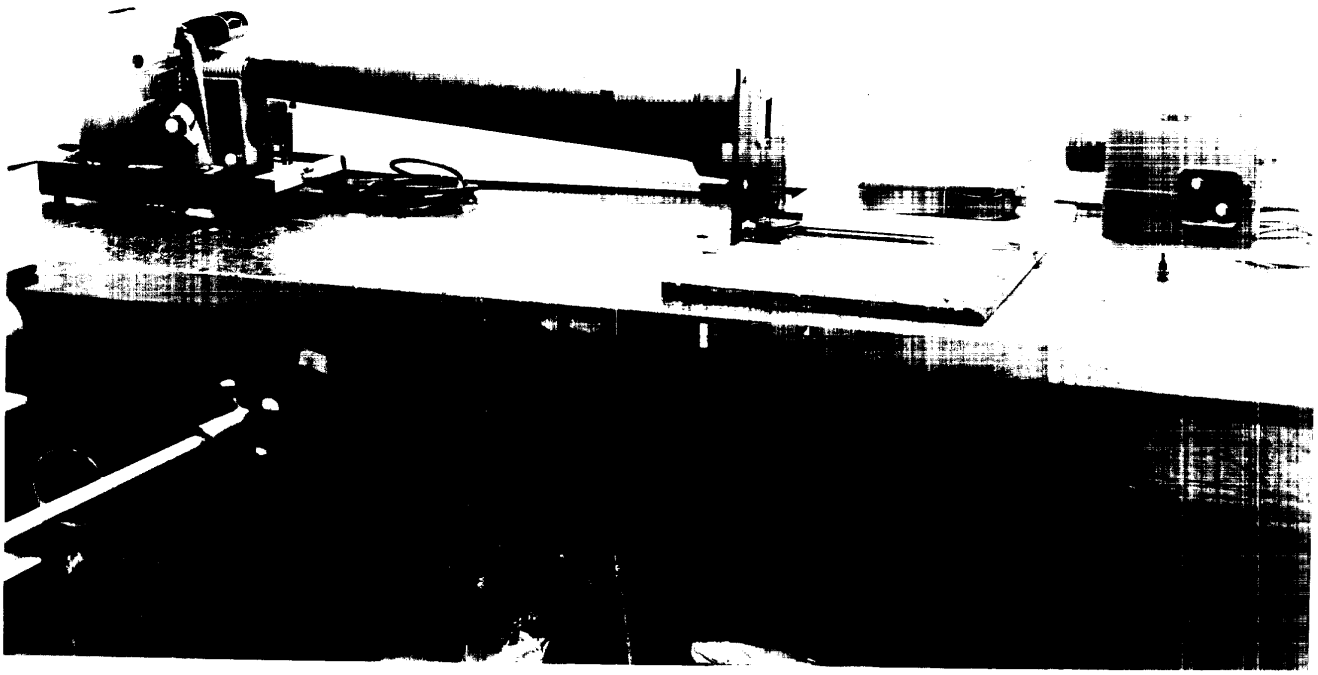

Figure 4
Goniophotometer

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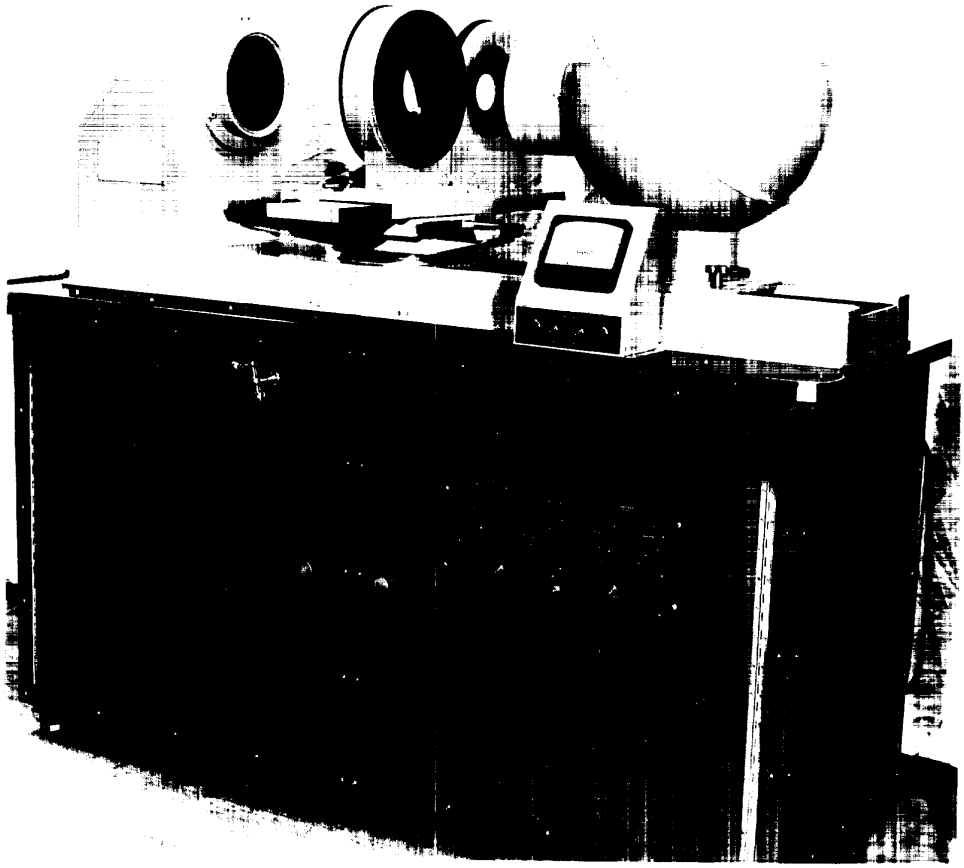

Figure 5
Illumination Analyzer, Model 3

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Figure 6
Polarization Test Equipment

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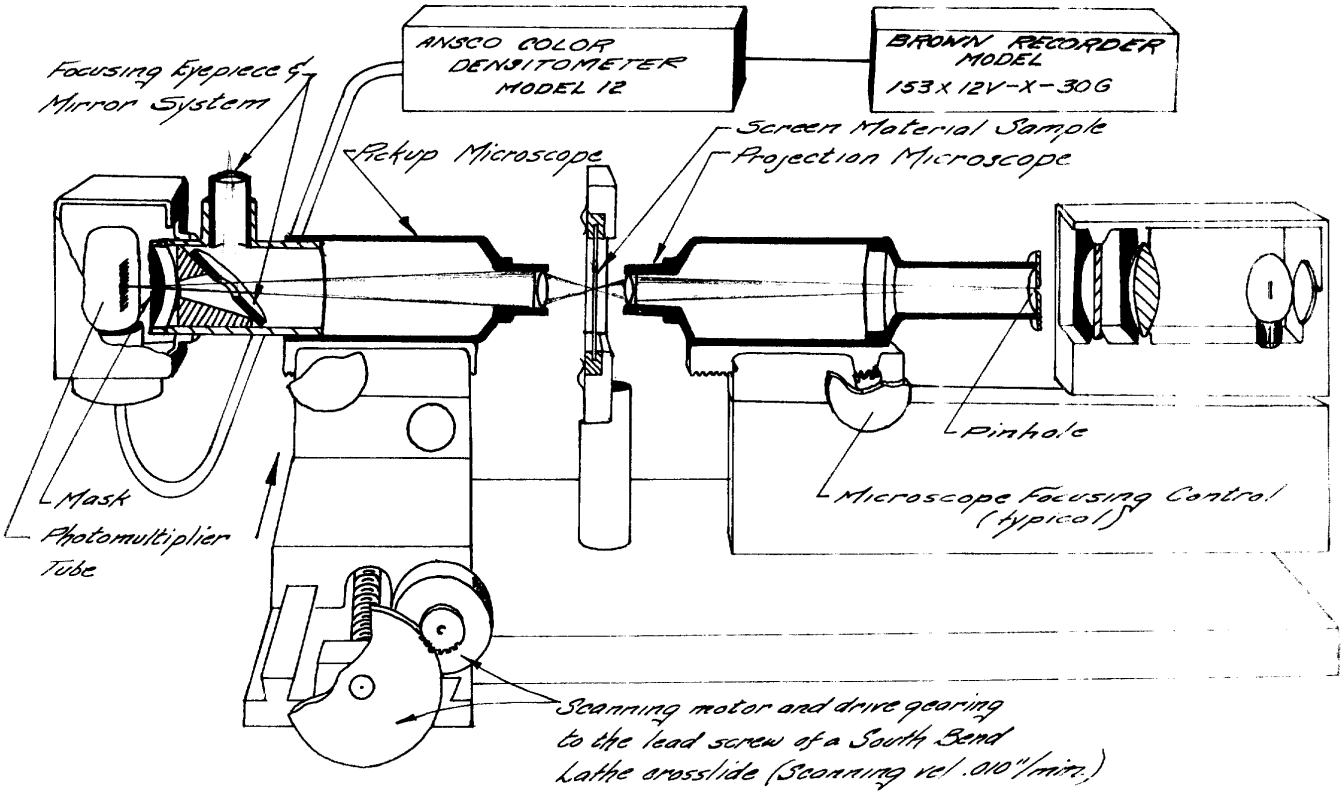

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Figure 7

Microdensitometer

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Table II

Definition Threshold		Peak Contact Resolution		Transmission		Axial Gain		Angle(°) 50% Relative Luminance		Polarization	
Mag.	Sample#	1/mm	Sample#	T%	Sample#	ft.c. Gain	Sample#	/°	Sample#	%	Sample #
						312.0	46			99.95	78
11:1	35	142	87	90	78	68.75	92		71 20	99.93	84
15	104	142	88	86	27	62.5	54		72 21	99.92	56
15.5	41	141	71	82.5	19	55.625	84		87 22	99.87	92
	61	141	72	82	34	52.5	56		88 23	99.86	79
	62	127	16	82	56	51.3	26		24	99.852	81
	105	127	94	81.5	46	50.0	27		25	99.850	77
16.5	64	113	35	81	15	48.75	34		28	99.80	74
	106	113	46	81	69	43.8	19		29	99.79	63
17	42	113	67	80	17	43.75	89		32	99.76	7
	63	101	69	80	63	40.6	18			99.68	64
17.5	1	100	17	79.5	68	38.2	38		36	99.60	61
	97x	100	38	79	84	36.9	35		37	99.47	93
18	5	90	18	79	89	36.25	16		40	99.36	76
	16	90	15	79	92	35.0	67		47	99.33	62
	114	90	19	78	18	33.33	69		48		
18.5	4	90	56	78	64	32.25	15		49		
19.5	6	80	34	77.5	38	31.25	97x		50		
	39	80	92	77.5	67	30.00	79		51		
	98	71	54	77.5	73	28.75	102		52		
	113	71	89	77	79	28.1125	77		55		
21	43	64	39	76.5	70	27.5	103		59		
21.5	74	63	85	76	16	25.6	17		60		
	76	57	77	76	26	25.0	85		86		
	89	57	84	75.5	77	24.375	65		91		
	92	57	100	75	43	22.5	93		94		
22	46	57	102	74.5	7	19.375	90		95		
	75	51	12	74.5	54	16.25	109		99		
	100	51	14	74	57	14.375	57				
22.5	103	50	53	74	103	13.75	68	45°	66		
	111	50	103	73.5	65	13.75	100	33.5°	83		
23	109	45	97	73	45	12.5	43	30°	31		
23.5	96	40	109	72.5	93	12.5	53	26°	8		
	112	36	30	72	74	12.5	70	23°	82		
24	82	36	114	70	85	11.25	7	23°	5		
24	110	32	104	70	102	10.625	63	22°	11		
24.5	10	32	10	68.5	90	10.625	74	22°	62		
24.5	18	32	11	67.5	101	10.0	114	22°	1		
24.5	19	32	13	67.5	100	9.38	12	21.5°	76		
24.5	101	32	36	66.5	109	9.375	64	21°	41		
25	102	32	58	65	12	9.055	45	20°	73		
25	108	32	75	65	114	8.75	2	20°	80		
25.5	11	32	78	64	53	8.75	14	20°	108		
	34	32	101	63	76	7.825	104	20°	4		
	85	28	37	61	13	7.5	81	20°	10		
	107	28	64	60	58	6.88	3	19.5	98		

DEFINITION THRESHOLD MAGNIFICATION

PEAK CONTACT RESOLUTION

TRANSMISSION (%) (smooth side toward light source)

AXIAL GAIN

ANGLE (°)(50% Rel. Luminance) (angle is greater than 45°

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Table II (continued)

Definition Threshold		Peak Contact Resolution		Transmission		Axial Gain		Angle(°) 50% Relative Luminance	
Mag.	Sample #	1/mm	Sample#	T%	Sample#	ft.c. Gain	Sample#	/°	Sample#
						6.875	44		
25.5	13	28	81	60	14	6.18	13	19°	113
26.5	53	28	105	58.5	75	6.125	73	19°	96
27	12	28	106	58	80	6.125	101	19°	106
27.5	58	28	108	57.5	111	5.937	75	19°	111
	83	26	79	57	107	5.0	105	18°	12
28	15	25	74	56	42	5.0	107	18°	105
	59	25	47	56	6	5.0	9	18°	107
29	14	25	52	55.5	105	4.6875	96	17°	6
29.5	17	25	63	55	9	4.685	58	17°	42
29.5	44	25	76	55	2	4.685	76	17°	110
30	81	22	61	54	91	4.68	6	16°	112
31	8	20	27	54	10	4.375	42	16°	13
31.5	9	20	51	54	35	4.375	80	15°	61
31.5	27	20	62	53.5	30	4.3125	111	15°	75
32	67	20	65	53	98	4.25	112	13°	45
32.5	7	20	66	53	104	4.0625	113	13°	64
33.5	80	18	7	52.5	87	4.0	30	13°	114
34	54	18	31	52.5	112	3.875	106	12.5°	74
35	3	18	43	52	82	3.8125	10	12.5°	101
35	26	18	48	52	99	3.31	11	12°	9
37	66	18	50	51.5	5	3.25	98	12°	14
37.5	30	16	9	51	60	3.185	110	12°	63
37.5	38	16	26	51	11	2.875	1	12°	70
37.5	56	16	49	51	4	2.875	62	12°	104
38.5	52	16	68	50.5	41	2.8125	82	11°	2
39	47	16	107	50.5	106	2.81	4	11°	68
39	77	14	29	49	96	2.81	39	10°	81
39.5	69	14	70	48	1	2.5	61	10°	90
40	2	13	3	48	62	2.22	8	10°	97x
	20	13	5	48	88	2.1875	5	10°	109
	21	13	41	45	31	2.125	41	10°	7
	22	13	44	44.5	8	1.5625	83	10°	18
	23	11	1	43	113	1.5	31	9°	43
	24	11	42	42.5	29	1.375	***99V	9°	44
	25	11	59	41	83	1.3125	91	9°	57
	28	11	80	40.5	59	1.25	***99H	9°	93
	29	10	6	40	28	1.0	29	8°	3
	31	10	8	39.5	86	0.9375	86	8°	39
	32	10	82	39	33	0.875	59	8°	100
	33	10	96	38.5	95	0.875	95	7.5°	19
	36	10	98	38	47	0.7825	28	7.5°	69
	37	10	113	38	110	0.75	66	7.5°	77
	40	9	4	38	71	0.688	33	7°	30
	45	9	110	37.5	52	0.656	52	7°	65
	48	9	111	35.5	72	0.625	47	7°	67
	49	9	112	35	44	0.618	55	7°	79

DEFINITION THRESHOLD MAGNIFICATION

PEAK CONTACT RESOLUTION

TRANSMISSION (%) (smooth side toward light source)

AXIAL GAIN

ANGLE (°)(50% Rel. Luminance)

out at 40X ****

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II (continued)

Definition Threshold Mag.	Sample#	Peak Contact Resolution 1/mm	Sample#	Transmission T%	Sample#	Axial Gain ft.c. Gain	Sample#	Angle(°) 50% Relative Luminance /°	Sample#
OUT AT 40X ****	50	8	2	33.5	55	0.562	32	6.5°	17
DEFINITION THRESHOLD MAGNIFICATION	51	7	45	32	3	0.55	20	6°	15
	55	6	83	31.5	20	0.50	25	6°	58
	57	5	86	30.5	81	0.362	37	6°	85
	65	5	95	30	32	0.25	51	6°	92
	68	5	33	27	25	0.25	24	5°	16
	70	4	57	25	61	0.25	48	5°	27
	73	4	93	22	66	0.2375	49	5°	53
	78	4	28	15	37	0.23125	108	5°	56
	79	3	55	14	48	0.222	50	5°	84
	84	3	90	14	94	0.1625	22	5°	89
	87	3	25	13.5	51	0.106	36	5°	103
	88	less than 31/mm	20	13	39	0.03	40	4.5°	102
	90		21	12.5	49	0.01875	21		26
	91		22	11.5	50	0.0106	23	4.0°	34
	93		23	11	24		60		54
	94		24	8	22		71	3.5°	38
	95		32	5	40	omitted	72	3°	35
	99		40	4	36	not	78	2.5°	78
	60		60	4	108	applicable	87	2°	46
	86		73	3	23		88		
			91	1	21		94		
			99	omitted	97				
*		**		**		**		**	

PEAK CONTACT RESOLUTION

TRANSMISSION(%) (smooth side toward light source)

AXIAL GAIN

ANGLE (°) (50% Rel. Luminance)

* #71 & #72 Polaroid Materials not applicable, hence not included.

** 114 Samples recorded.

*** H&V indicate horizontal and vertical orientation of sample for measurement of values.

**** Out at 40:1 indicates that the definition threshold magnification is beyond the range of the test instrument.

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APPENDIX B

DATA SHEETS

The following data sheets are provided as reference data for each of the individual rear projection screen materials tested and evaluated.

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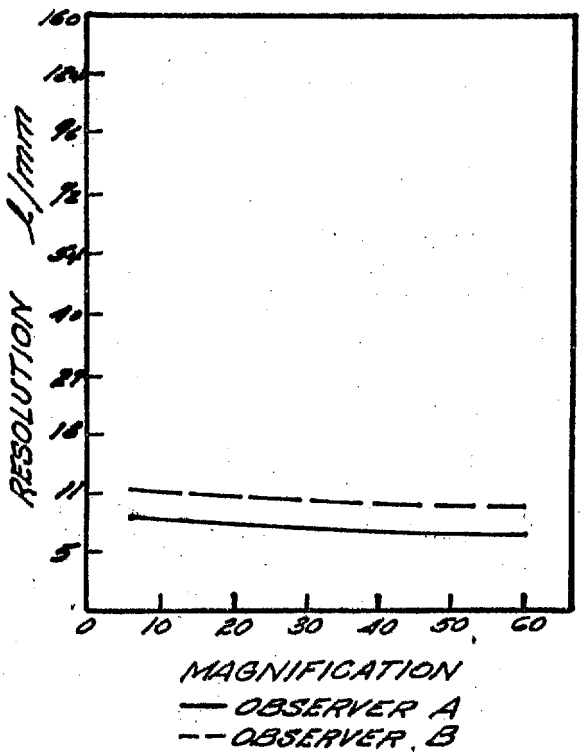
SAMPLE #1

STAT

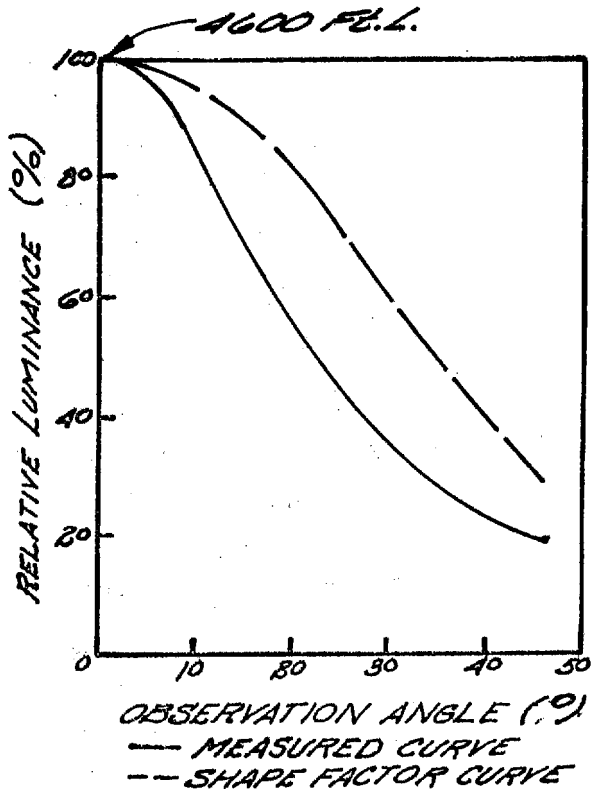
MANUFACTURER	
DESIGNATION	LUXCHROME "50"
PHYSICAL STRUCTURE	FLEXIBLE ETHYL CELLULOSE (GREY)

TRANSMISSION (MATTE)	48 %
TRANSMISSION (SMOOTH)	48 %
AXIAL GAIN	2.875
IMAGE BREAKUP MAGNIFICATION	17.5 X
POLARIZATION QUALITIES	
THICKNESS	.010 INCHES
ANGLE (50% REL. LUM.)	22°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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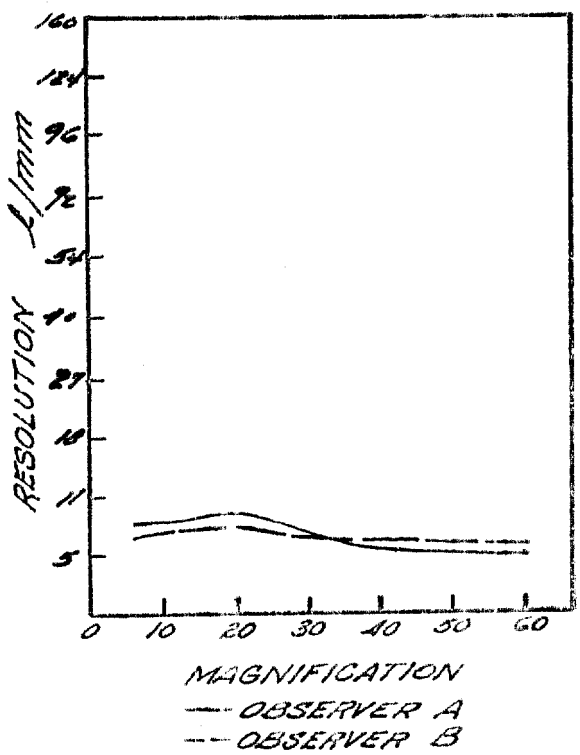
SAMPLE #2

STAT

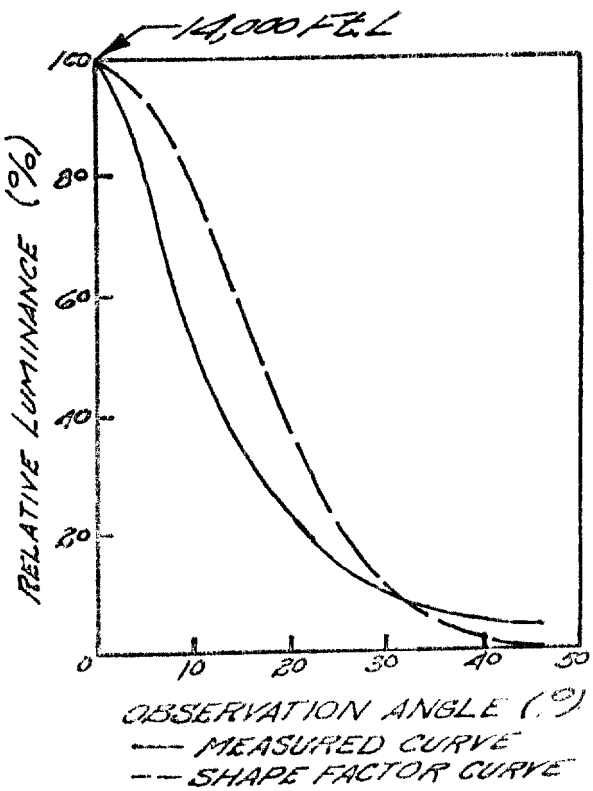
MANUFACTURER
DESIGNATION LUXCHROME "B"
PHYSICAL STRUCTURE FINE GRAIN, FLEXIBLE ETHYL CELLULOSE (GREY)

TRANSMISSION (MATTE) — 55 %
TRANSMISSION (SMOOTH) — 55 %
AXIAL GAIN — 8.75
IMAGE BREAKUP MAGNIFICATION — 40 X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) — 11°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #3

STAT

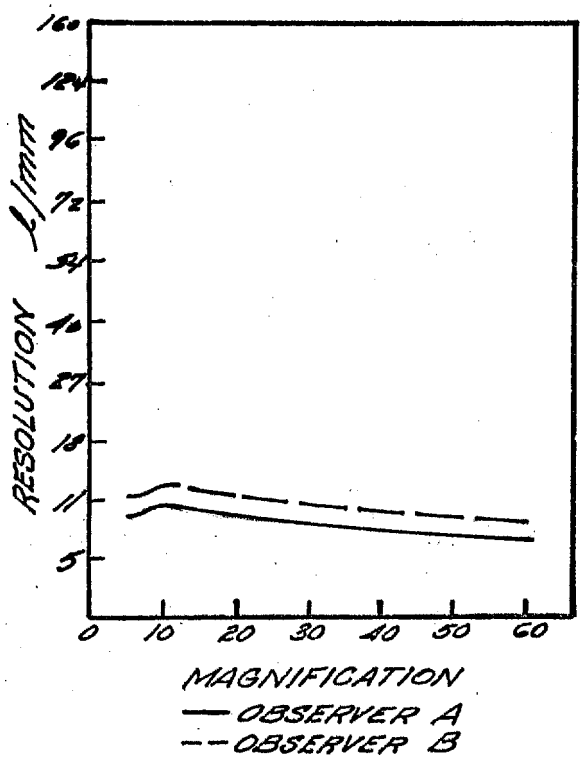
MANUFACTURER

DESIGNATION STEWART BLACK

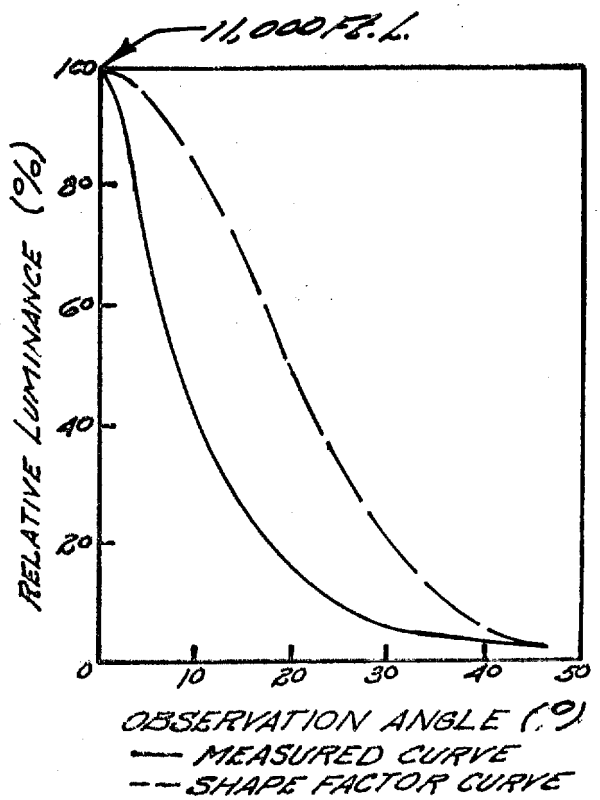
PHYSICAL STRUCTURE FINE GRAIN ETHYL CELLULOSE FLEXIBLE BLACK
80-45 RMS PROFILOMETER (.030" STROKE) READING / ASA PH2.1-1955

TRANSMISSION (MATTE) — 32 %
TRANSMISSION (SMOOTH) — 32 %
AXIAL GAIN — 6.88
IMAGE BREAKUP MAGNIFICATION — 35X
POLARIZATION QUALITIES —
THICKNESS — .009 INCHES
ANGLE (50% REL. LUM.) — 8°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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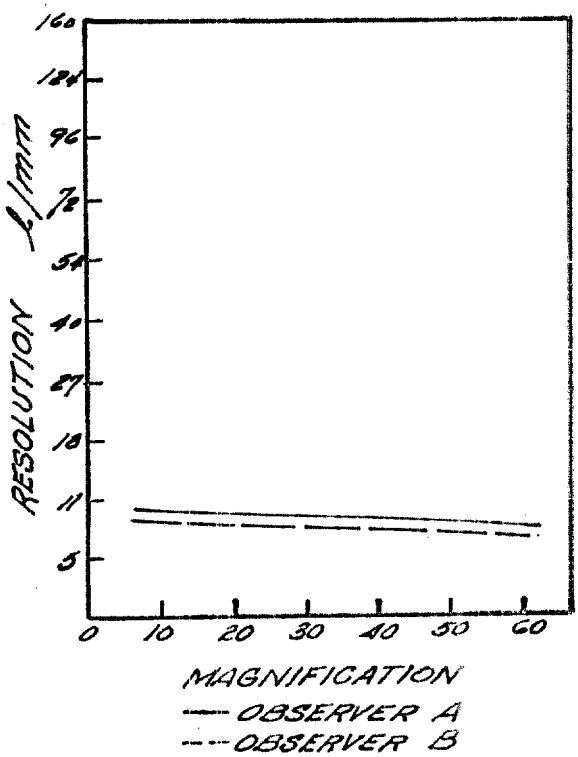
SAMPLE #4

STAT

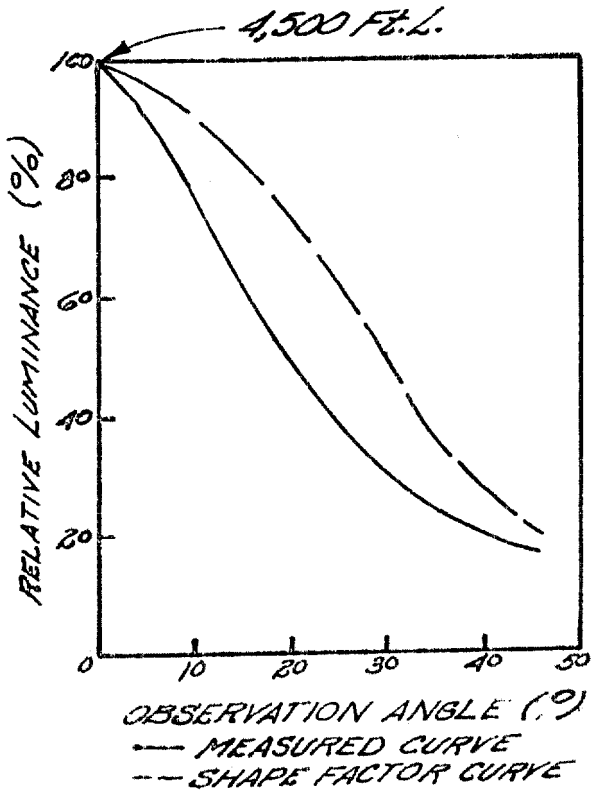
MANUFACTURER
DESIGNATION TV BLUE
PHYSICAL STRUCTURE FINE GRAIN FLEXIBLE ETHYL CELLULOSE (BLUE)

TRANSMISSION (MATTE) — 51 %
TRANSMISSION (SMOOTH) — 51 %
AXIAL GAIN — 2.81
IMAGE BREAKUP MAGNIFICATION — 18.5X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) — 20°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #5

STAT

MANUFACTURER

DESIGNATION S-50-R

PHYSICAL STRUCTURE FINE GRAIN FLEXIBLE ETHYL CELLULOSE (WHITE)

TRANSMISSION (MATTE) — 51.5 %

TRANSMISSION (SMOOTH) — 51.5 %

AXIAL GAIN — 2.1875

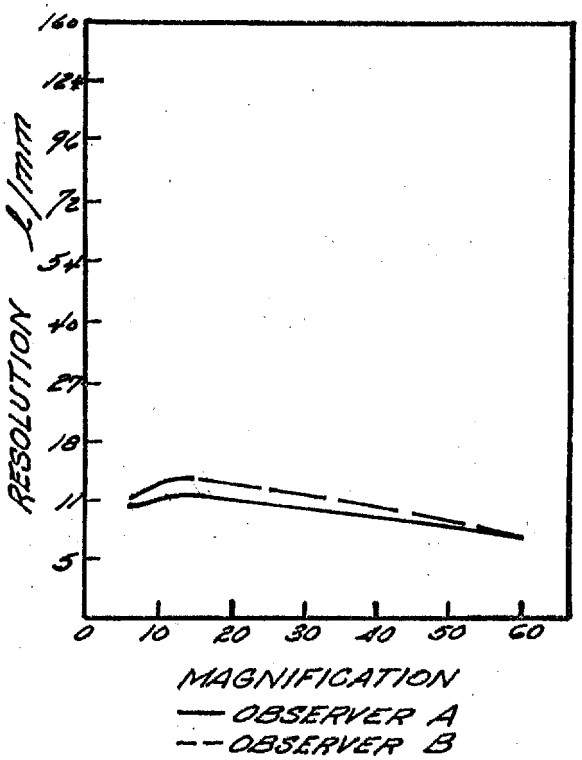
IMAGE BREAKUP MAGNIFICATION — 18.0X

POLARIZATION QUALITIES —

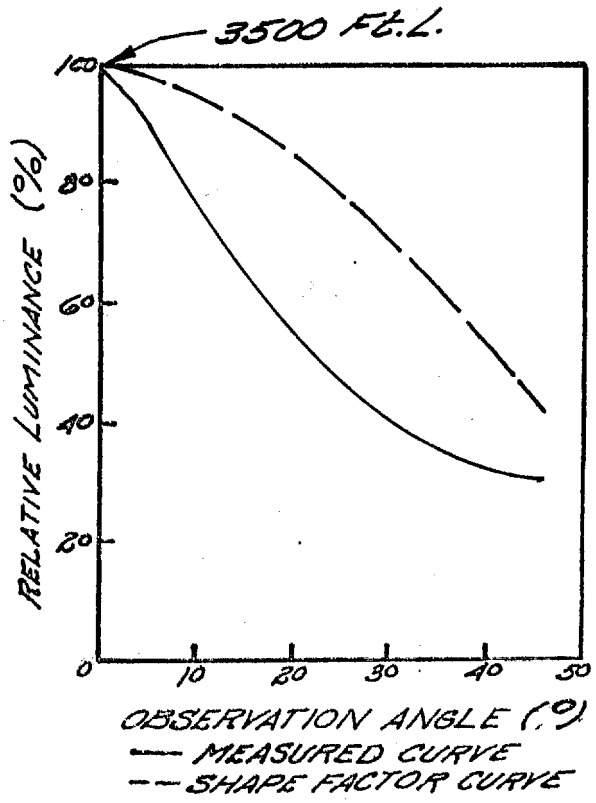
THICKNESS — .011 INCHES

ANGLE (50% REL. LUM.) — 23°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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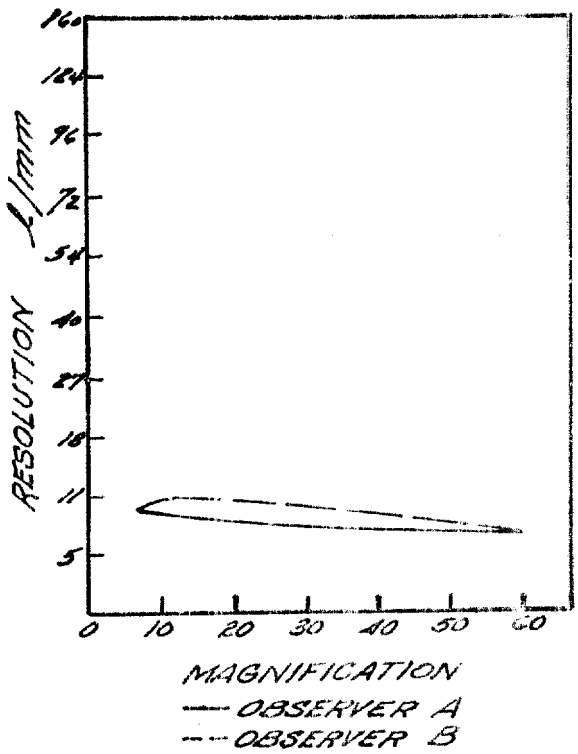
SAMPLE #6

STAT

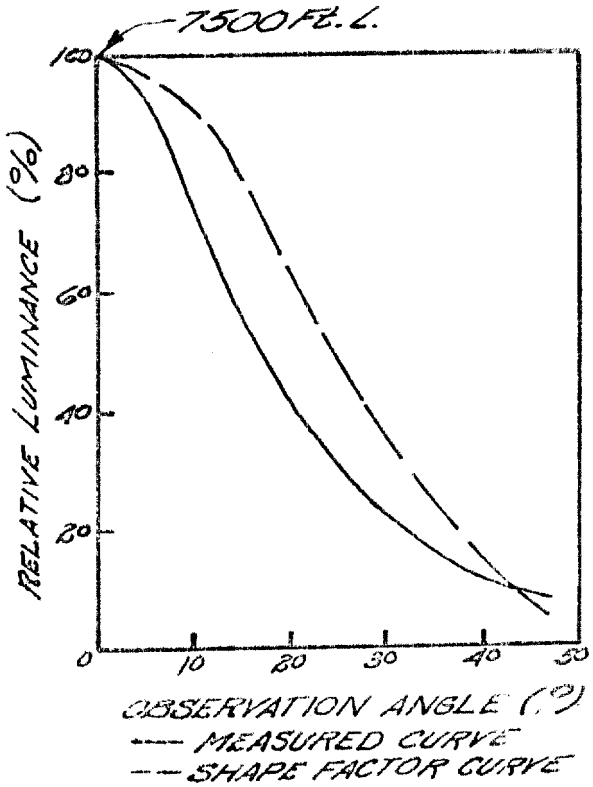
MANUFACTURER
DESIGNATION LUXCH ROME
PHYSICAL STRUCTURE FINE GRAIN FLEXIBLE ETHYL CELLULOSE
COLOR - GREY

TRANSMISSION (MATTE) — 57 %
TRANSMISSION (SMOOTH) — 56 %
AXIAL GAIN — 4.68
IMAGE BREAKUP MAGNIFICATION — 19.5X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) — 17°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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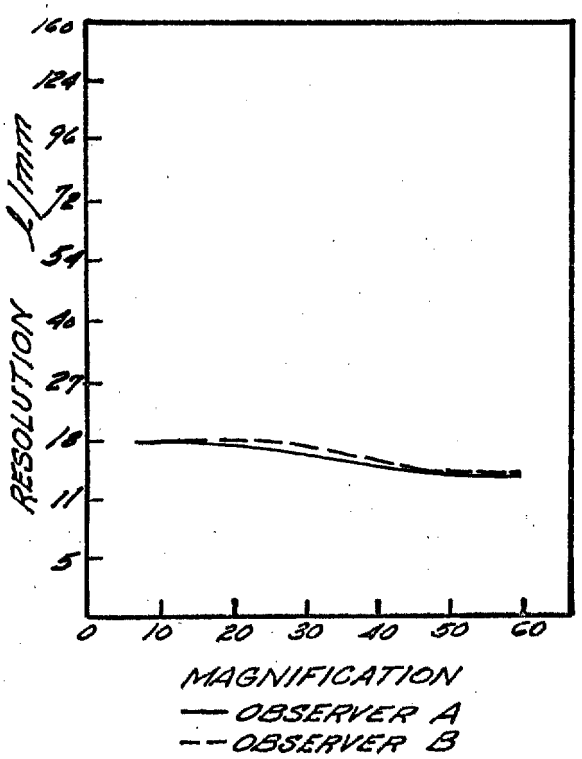
SAMPLE #7

STAT

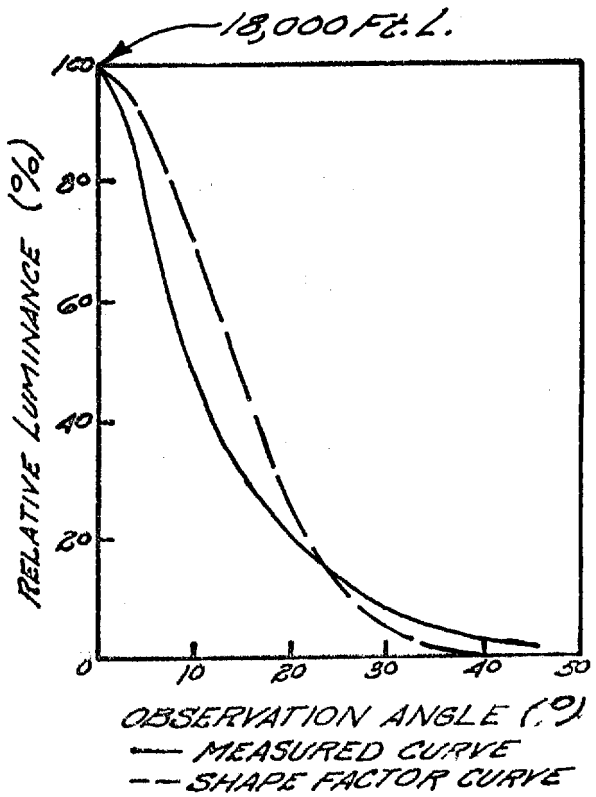
MANUFACTURER
DESIGNATION HI-TRANS
PHYSICAL STRUCTURE FINE GRAIN FLEXIBLE ETHYL CELLULOSE COLOR (NEUTRAL)

TRANSMISSION (MATTE) — 75 %
TRANSMISSION (SMOOTH) — 74.5 %
AXIAL GAIN — 11.25
IMAGE BREAKUP MAGNIFICATION — 32.5X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) — 10°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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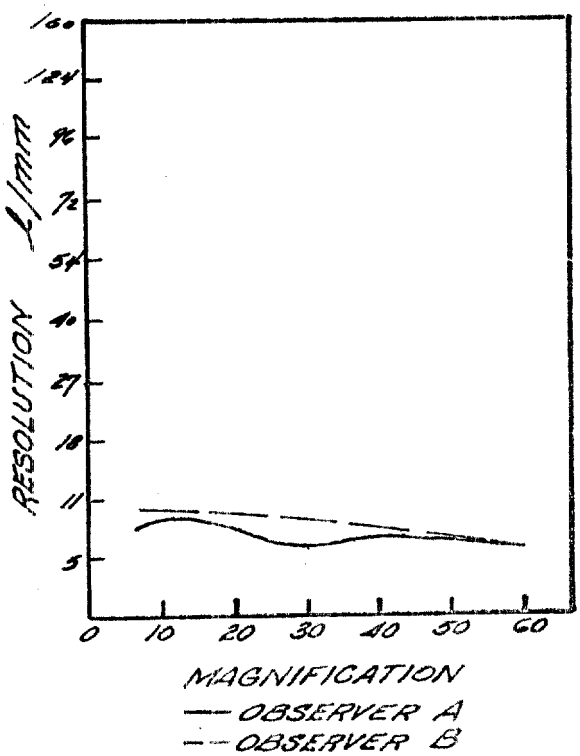
SAMPLE #8

STAT

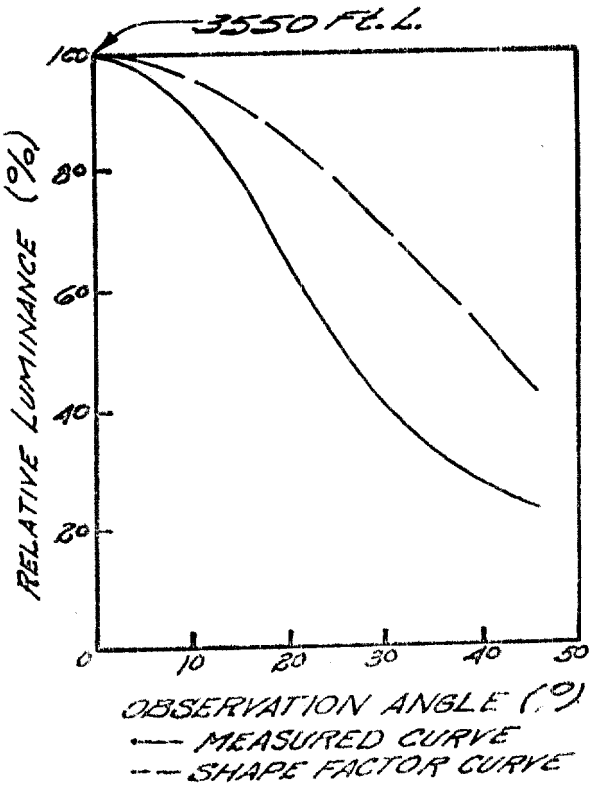
MANUFACTURER	[redacted]
DESIGNATION	LENSCREEN LS 60 VSR
PHYSICAL STRUCTURE	SEMIRIGID VINYL

TRANSMISSION (MATTE)	44.5%
TRANSMISSION (SMOOTH)	44.5%
AXIAL GAIN	2.22
IMAGE BREAKUP MAGNIFICATION	31.0X
POLARIZATION QUALITIES: (Ft.L.) PERPENDICULAR / PARALLEL	59/910
THICKNESS	.0155 INCHES
ANGLE (50% REL. LUM.)	26°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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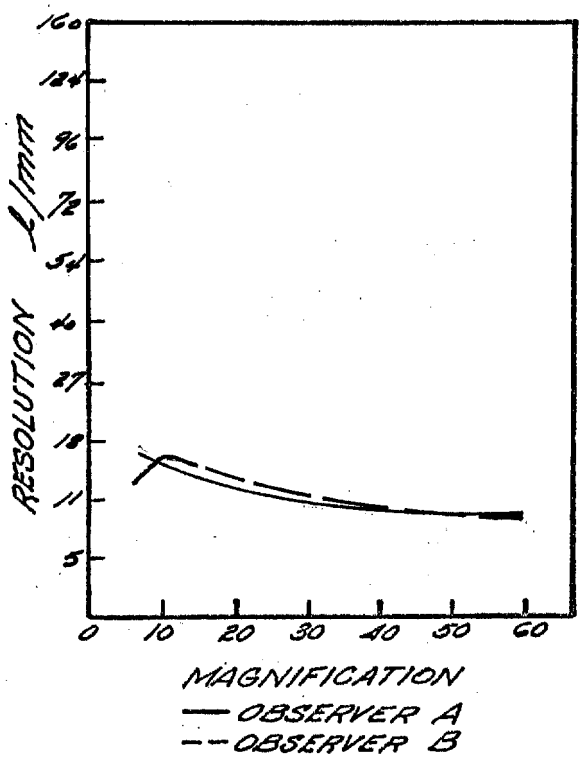
SAMPLE #9

STAT

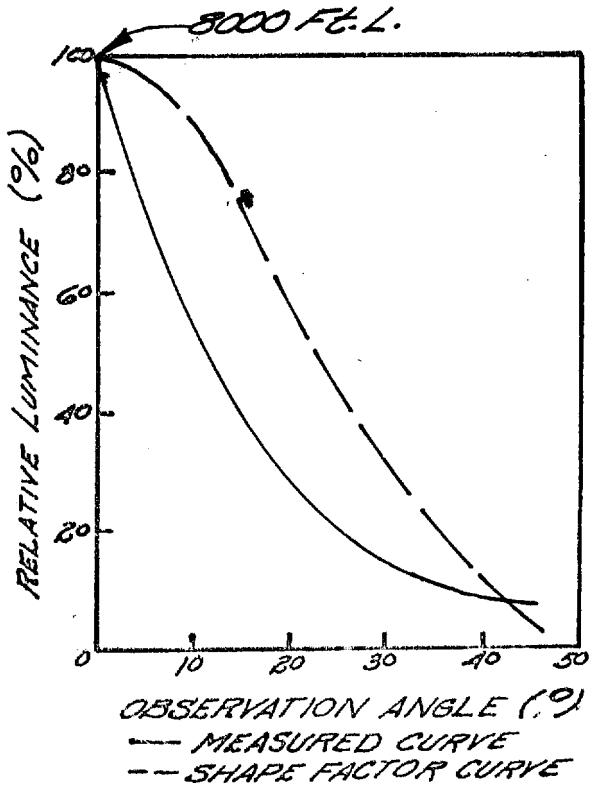
MANUFACTURER	
DESIGNATION	LENSCREEN LS 60F
PHYSICAL STRUCTURE	FLEXIBLE ELASTIC VINYL

TRANSMISSION (MATTE) — 58 %
TRANSMISSION (SMOOTH) — 55 %
AXIAL GAIN — 5.0
IMAGE BREAKUP MAGNIFICATION — 31.5X
POLARIZATION QUALITIES —
THICKNESS — .010 INCHES
ANGLE (50% REL. LUM.) — 12°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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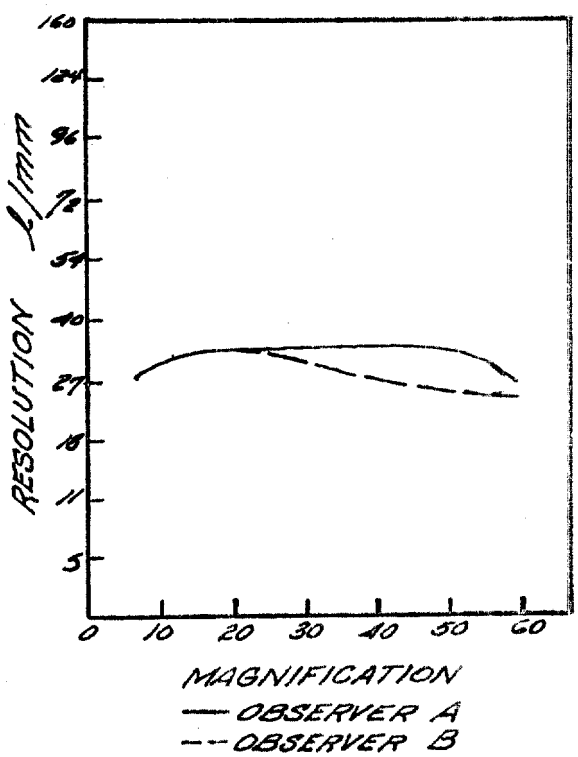
SAMPLE #10

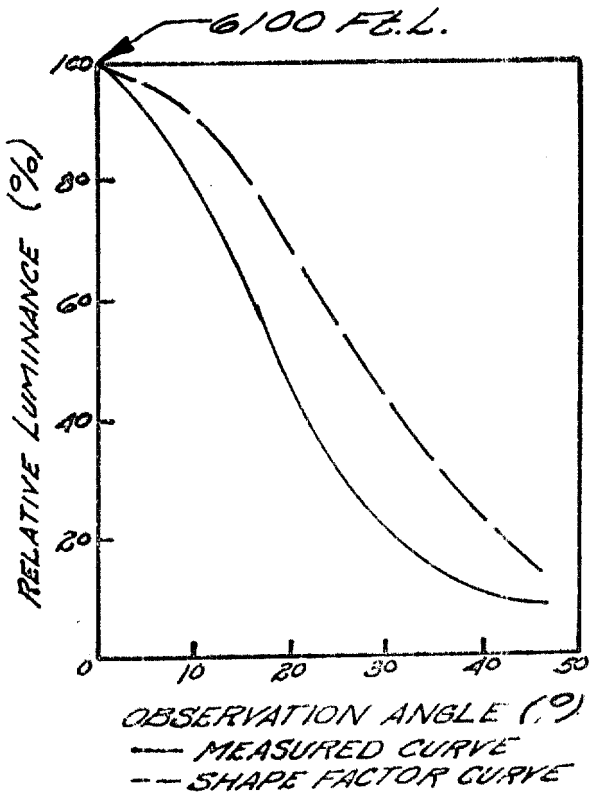
STAT

MANUFACTURER	
DESIGNATION	LENSCREEN LS 60UR
PHYSICAL STRUCTURE	LATEX
TRANSMISSION (MATTE)	57%
TRANSMISSION (SMOOTH)	54%
AXIAL GAIN	3.8125
IMAGE BREAKUP MAGNIFICATION	24.5X
POLARIZATION QUALITIES	
THICKNESS	.030 INCHES
ANGLE (50% REL. LUM.)	20°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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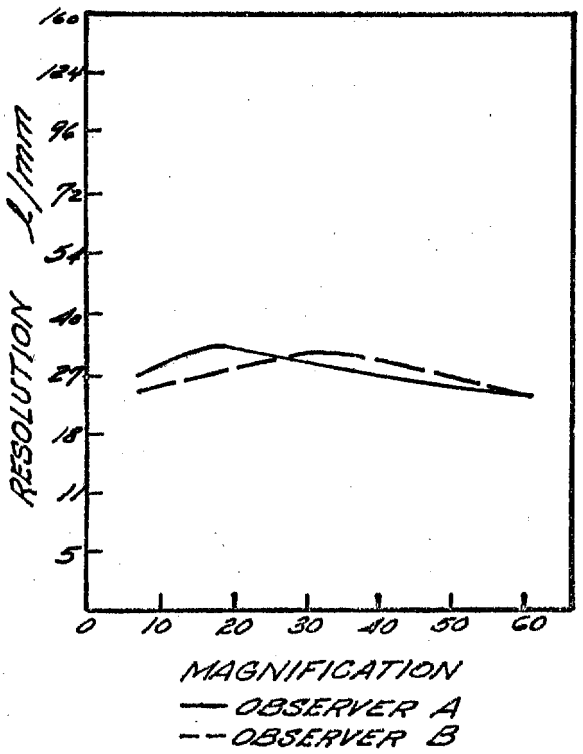
SAMPLE #11

STAT

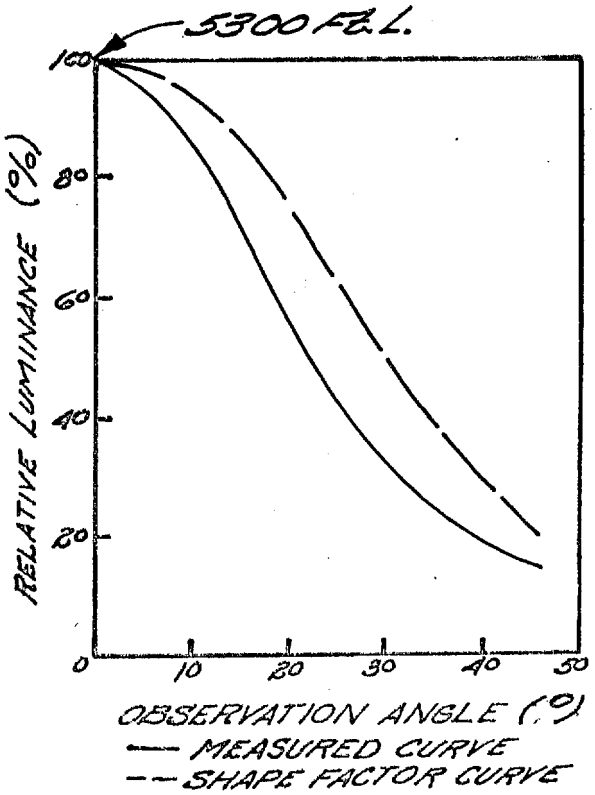
MANUFACTURER	[redacted]
DESIGNATION	LENSCREEN LS 60PL
PHYSICAL STRUCTURE	PLEXIGLASS

TRANSMISSION (MATTE) — 55 %
TRANSMISSION (SMOOTH) — 51 %
AXIAL GAIN — 3.31
IMAGE BREAKUP MAGNIFICATION — 25.5X
POLARIZATION QUALITIES —
THICKNESS — .062 INCHES
ANGLE (50% REL. LUM.) — 22°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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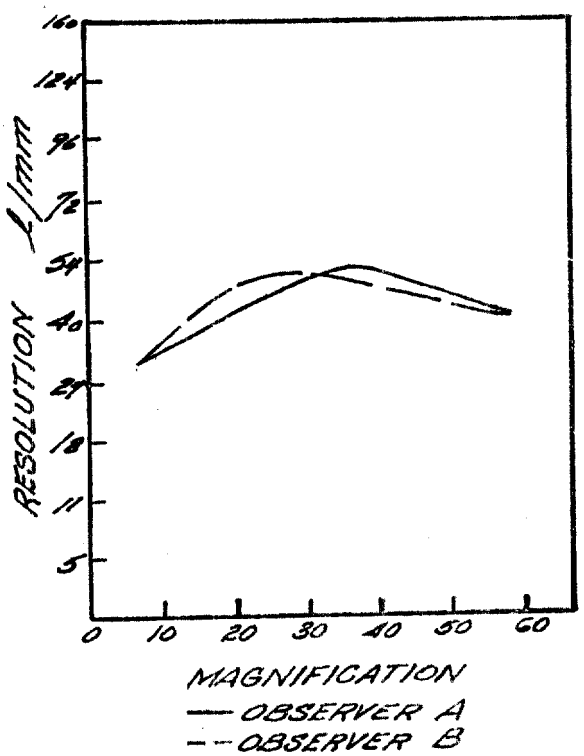
SAMPLE #12

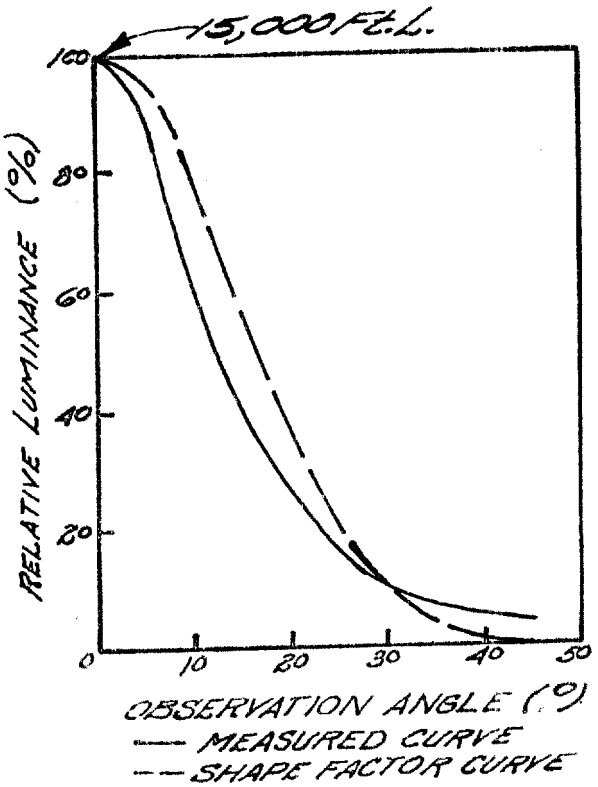
STAT

MANUFACTURER	
DESIGNATION	LENSCREEN LS 75PL
PHYSICAL STRUCTURE	PLEXIGLASS
TRANSMISSION (MATTE)	68 %
TRANSMISSION (SMOOTH)	65 %
AXIAL GAIN	9.38
IMAGE BREAKUP MAGNIFICATION	27.0X
POLARIZATION QUALITIES	
THICKNESS	.064 INCHES
ANGLE (50% REL. LUM.)	18°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #13

STAT

MANUFACTURER

DESIGNATION LENSCREEN LS 606

PHYSICAL STRUCTURE: (20-25 RMS/ASA 46.1-1955, 030 STROKE GLASS PROFILOMETER READING of SURFACE ROUGHNESS)

TRANSMISSION (MATTE) — 63 %

TRANSMISSION (SMOOTH) — 61 %

AXIAL GAIN — 6.18

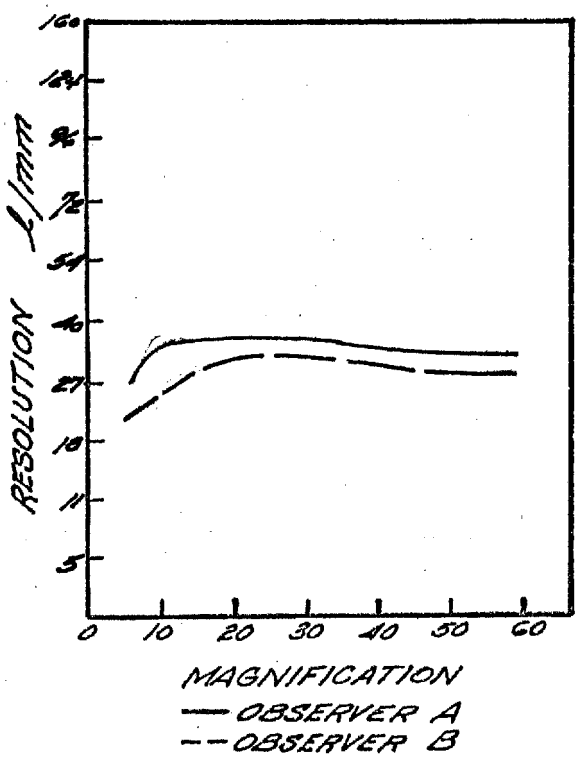
IMAGE BREAKUP MAGNIFICATION — 26.5X

POLARIZATION QUALITIES —

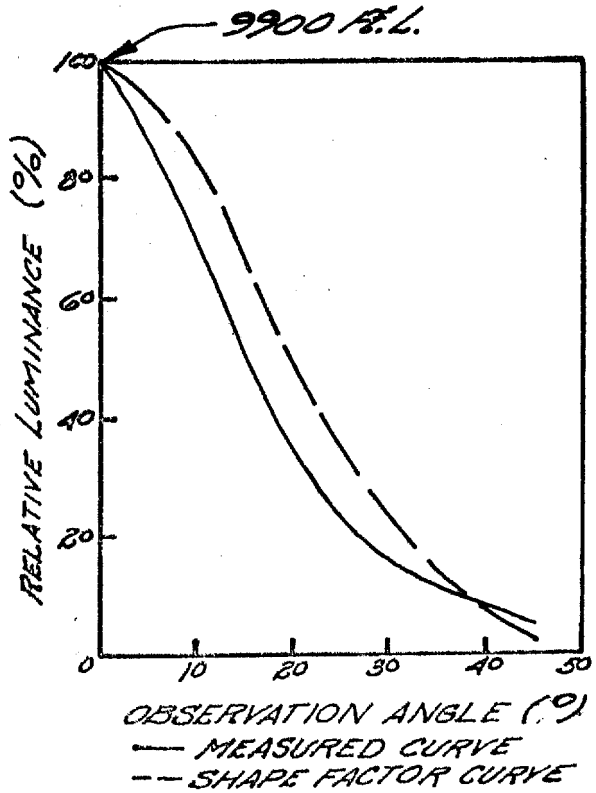
THICKNESS — .130 INCHES

ANGLE (50% REL. LUM.) — 16°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #14

STAT

MANUFACTURER

DESIGNATION — LENSCREEN LS 75 G

PHYSICAL STRUCTURE: 18-25 RMS PROFILOMETER READING — GLASS
.030 STROKE / ASA 46.1-1955 7: SURFACE ROUGHNESS.

TRANSMISSION (MATTE) — 61.5%

TRANSMISSION (SMOOTH) — 60 %

AXIAL GAIN — 8.75

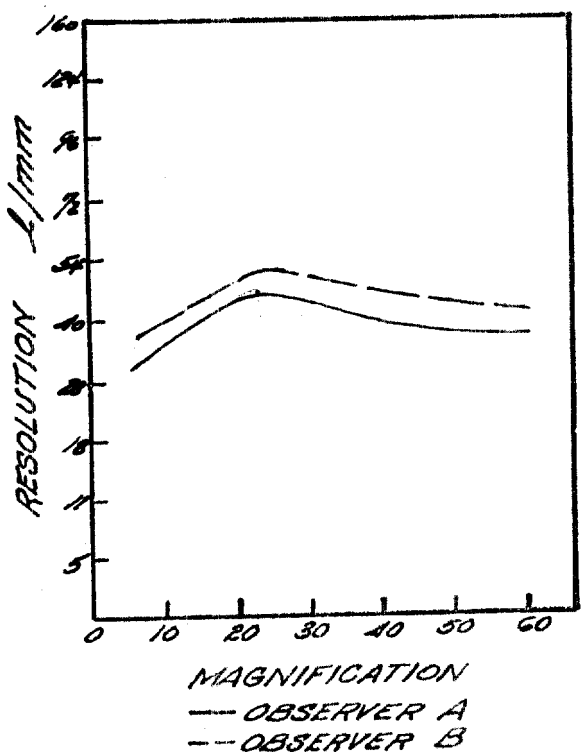
IMAGE BREAKUP MAGNIFICATION — 29.0X

POLARIZATION QUALITIES (Ft. L.) PERPENDICULAR / PARALLEL — 89 / 3200

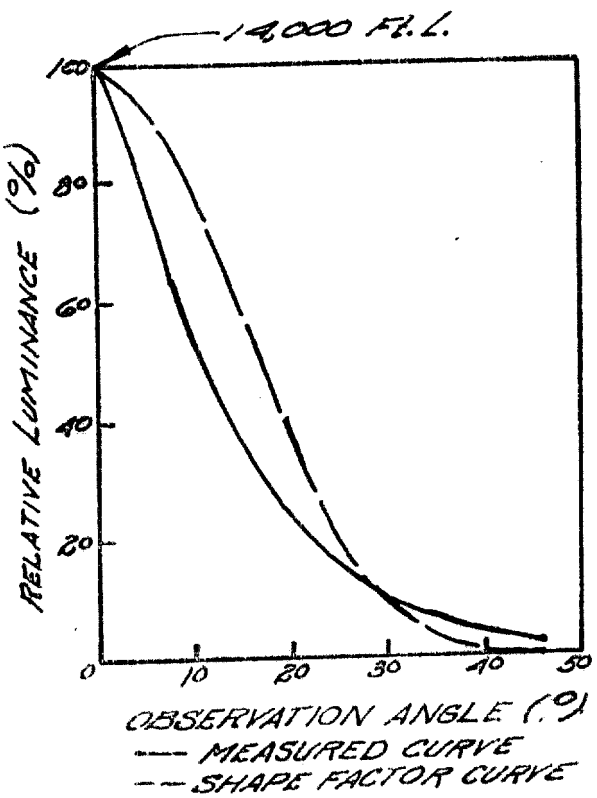
THICKNESS — .127 INCHES

ANGLE (50% REL. LUM.) — 12°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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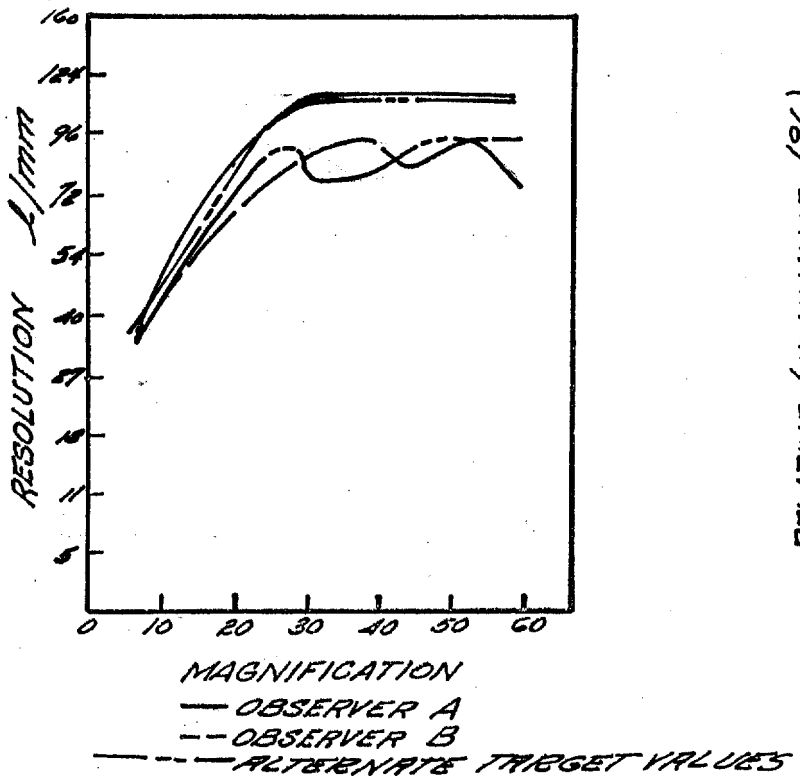
SAMPLE #15

STAT

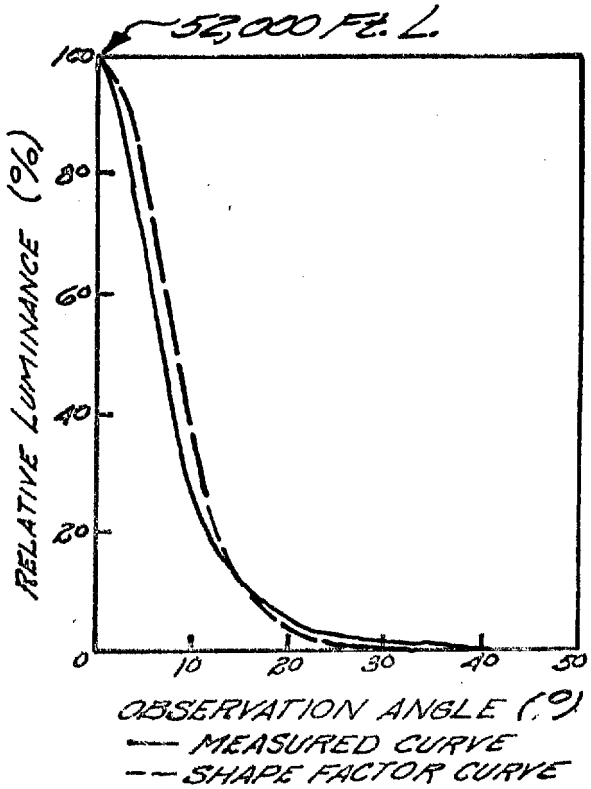
MANUFACTURER
DESIGNATION S 719
PHYSICAL STRUCTURE ACETATE COLOR E001

TRANSMISSION (MATTE) — 87%
TRANSMISSION (SMOOTH) — 81%
AXIAL GAIN — 32.5
IMAGE BREAKUP MAGNIFICATION — 28.0X
POLARIZATION QUALITIES —
THICKNESS — .0105 INCHES
ANGLE (50% REL. LUM.) — 6°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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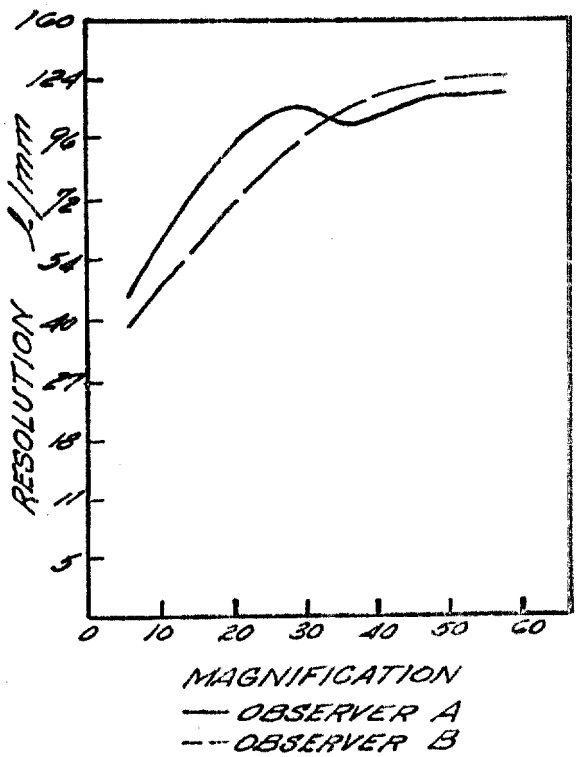
SAMPLE #16

STAT

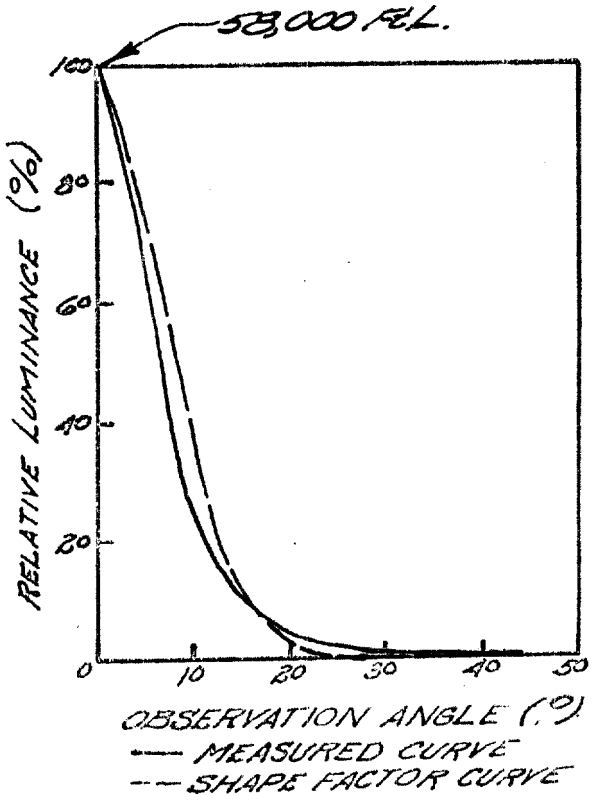
MANUFACTURER
DESIGNATION S 704
PHYSICAL STRUCTURE ACETATE COLOR E 001

TRANSMISSION (MATTE) — 86.5%
TRANSMISSION (SMOOTH) — 76 %
AXIAL GAIN — 36.25
IMAGE BREAKUP MAGNIFICATION — 18.0 X
POLARIZATION QUALITIES —
THICKNESS — .041 INCHES
ANGLE (50% REL. LUM.) — 5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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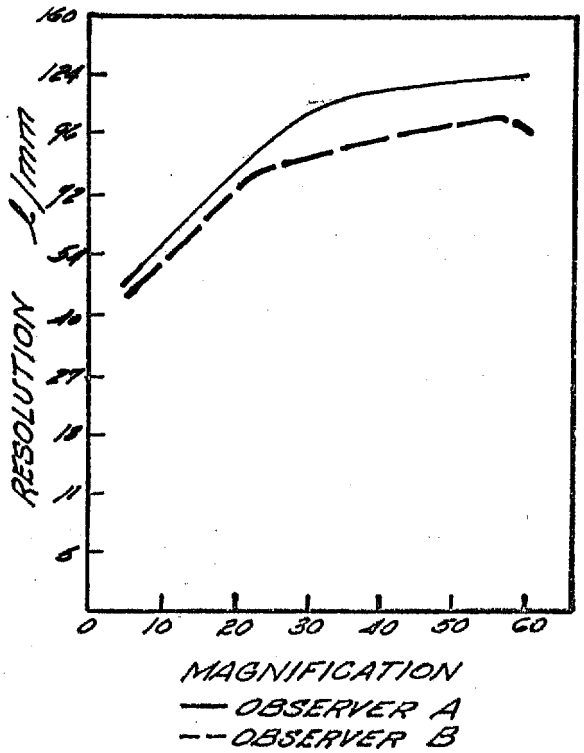
SAMPLE #17

STAT

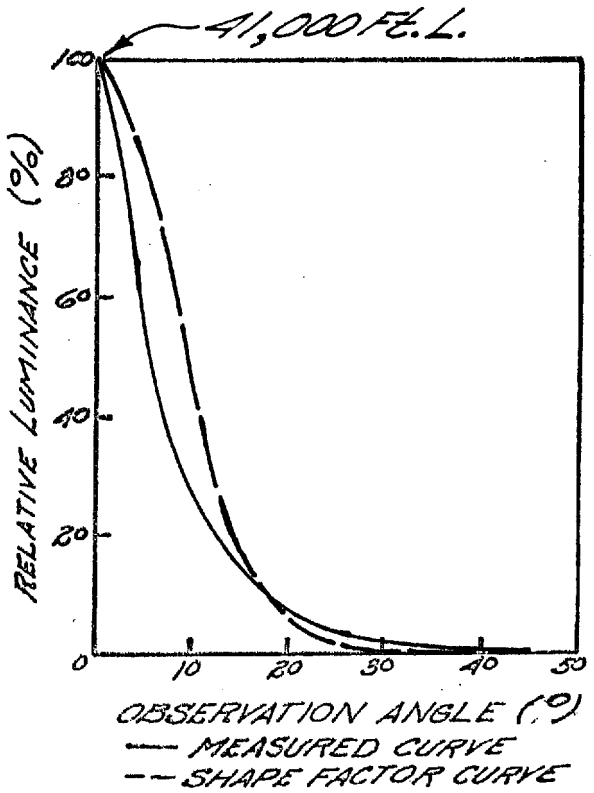
MANUFACTURER	
DESIGNATION	ACETATE A-78 L822
PHYSICAL STRUCTURE	ACETATE

TRANSMISSION (MATTE)	86 %
TRANSMISSION (SMOOTH)	80 %
AXIAL GAIN	25.6
IMAGE BREAKUP MAGNIFICATION	29.5X
POLARIZATION QUALITIES	
THICKNESS	.010 INCHES
ANGLE (50% REL. LUM.)	6.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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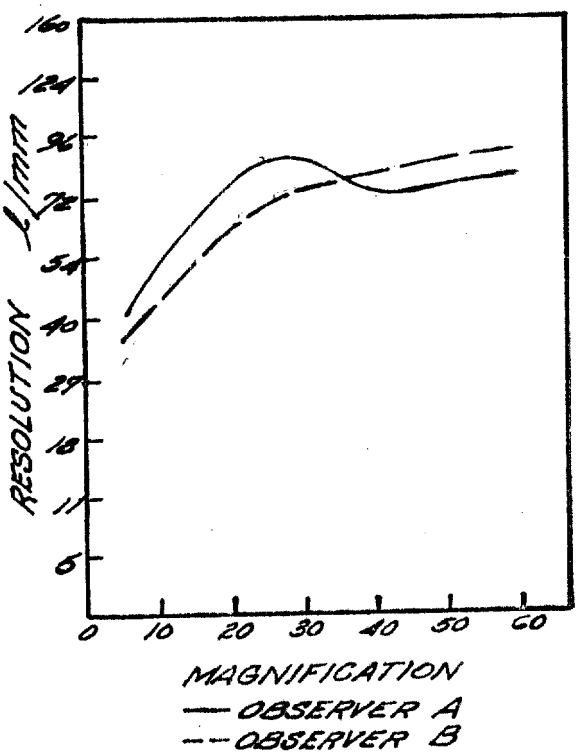
SAMPLE #18

STAT

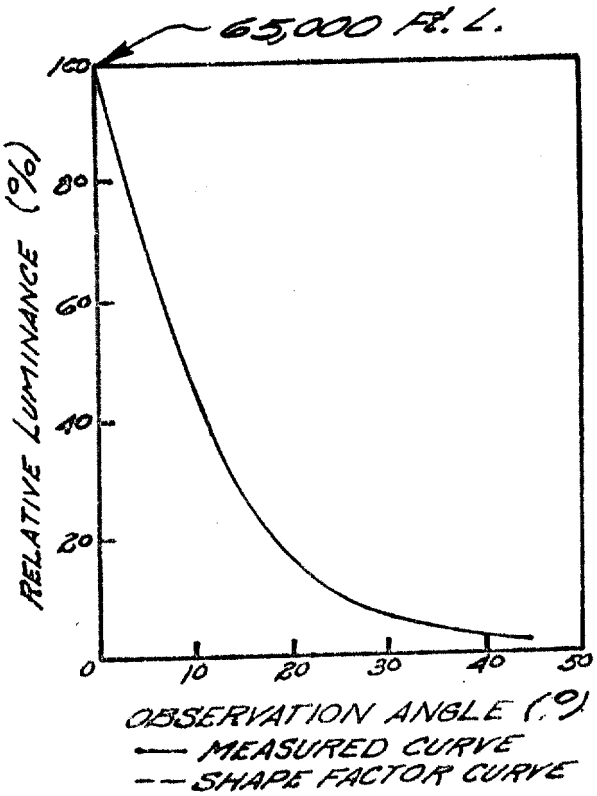
MANUFACTURER
DESIGNATION UNKNOWN
PHYSICAL STRUCTURE FLEXIBLE WHITE PLASTIC MAT'L

TRANSMISSION (MATTE) — 81 %
TRANSMISSION (SMOOTH) — 78 %
AXIAL GAIN — 40.6
IMAGE BREAKUP MAGNIFICATION — 24.5X
POLARIZATION QUALITIES —
THICKNESS — .0045 INCHES
ANGLE (50% REL. LUM.) — 10°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE # 19

STAT

MANUFACTURER [redacted]

DESIGNATION UNKNOWN

PHYSICAL STRUCTURE FLEXIBLE WHITE PLASTIC MAT'L

TRANSMISSION (MATTE) — 85 %

TRANSMISSION (SMOOTH) — 82.5 %

AXIAL GAIN — 43.8

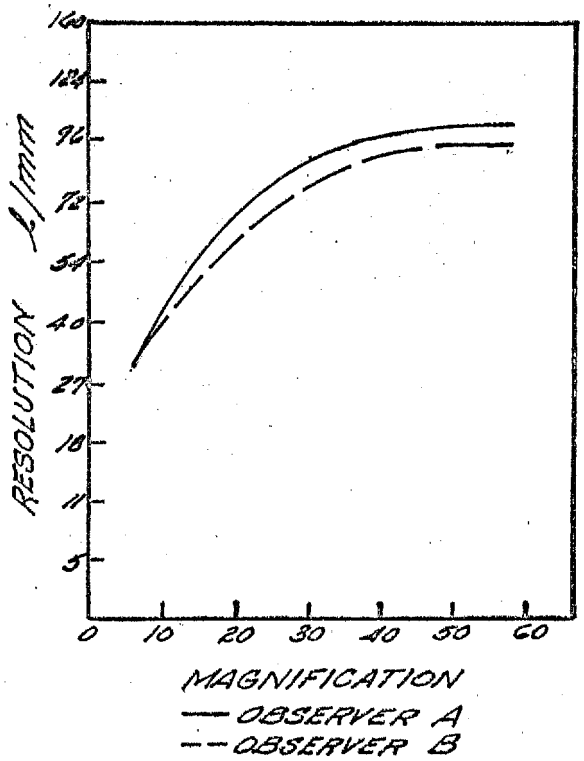
IMAGE BREAKUP MAGNIFICATION — 24.5X

POLARIZATION QUALITIES —

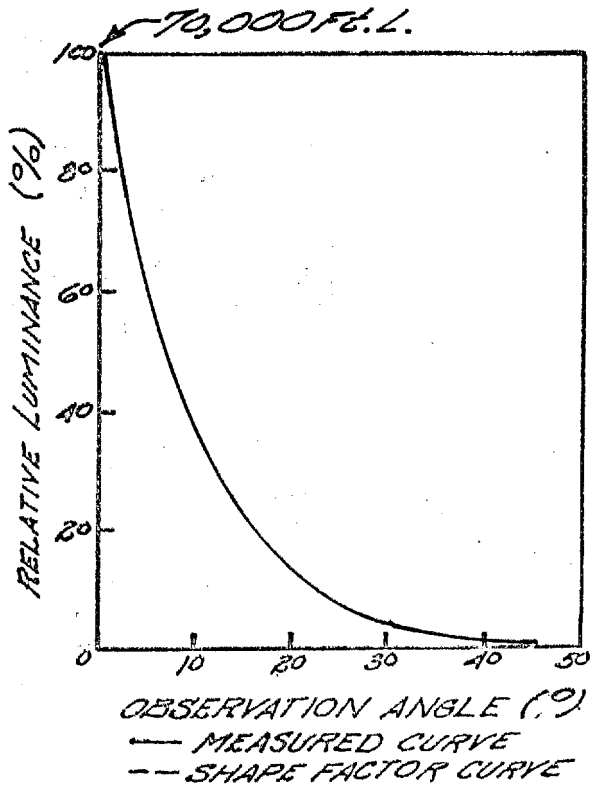
THICKNESS — .005 INCHES

ANGLE (50% REL. LUM.) — 7.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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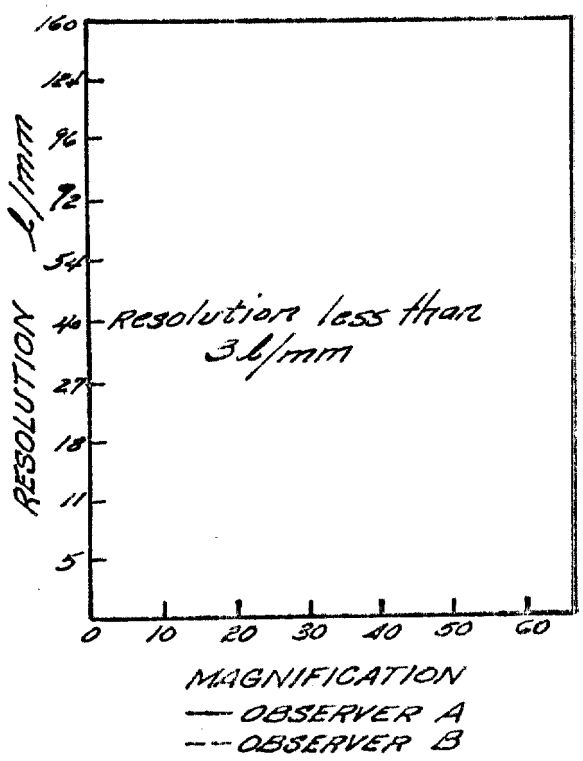
SAMPLE #20

STAT

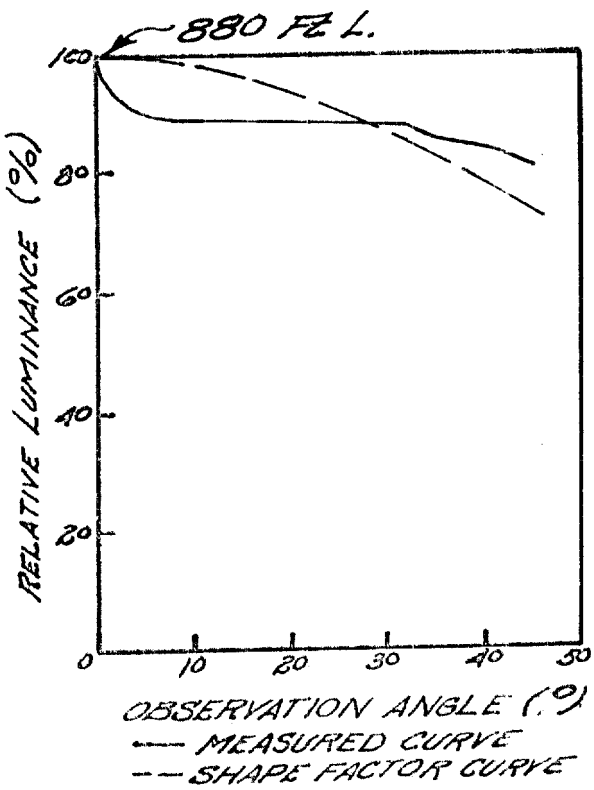
MANUFACTURER
DESIGNATION — VCU 3047 15
PHYSICAL STRUCTURE — WHITE TRANSLUCENT VINYL

TRANSMISSION (MATTE) — 31 %
TRANSMISSION (SMOOTH) — 35.5 %
AXIAL GAIN — 0.55
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .015 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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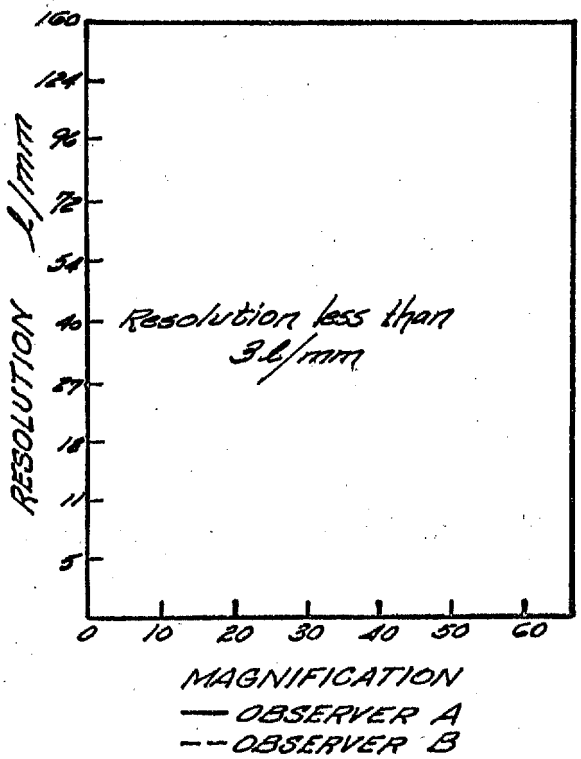
SAMPLE #21

STAT

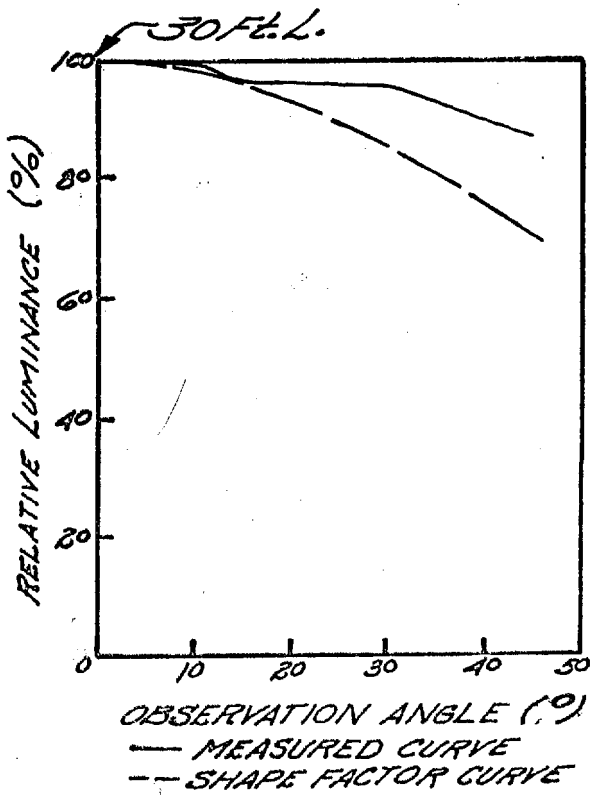
MANUFACTURER
DESIGNATION CX 9642
PHYSICAL STRUCTURE RED TRANSLUCENT ACETATE

TRANSMISSION (MATTE) — 3 %
TRANSMISSION (SMOOTH) — 1 %
AXIAL GAIN — 0.01875
IMAGE BREAKUP MAGNIFICATION — 40 X
POLARIZATION QUALITIES —
THICKNESS — .0305 INCHES
ANGLE (50% REL LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #22

STAT

MANUFACTURER [redacted]

DESIGNATION CX 9643

PHYSICAL STRUCTURE WHITE TRANSLUCENT ACETATE

TRANSMISSION (MATTE) — 8 %

TRANSMISSION (SMOOTH) — 8 %

AXIAL GAIN — 0.1625

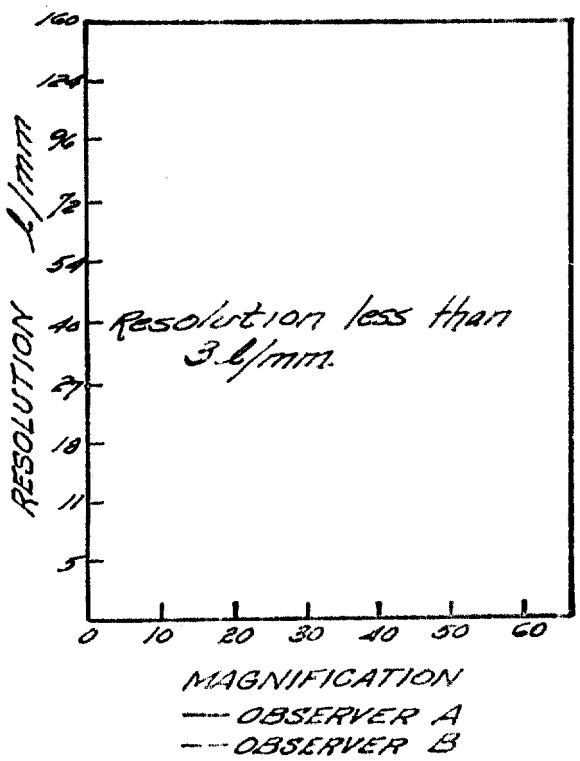
IMAGE BREAKUP MAGNIFICATION — 40 X

POLARIZATION QUALITIES —

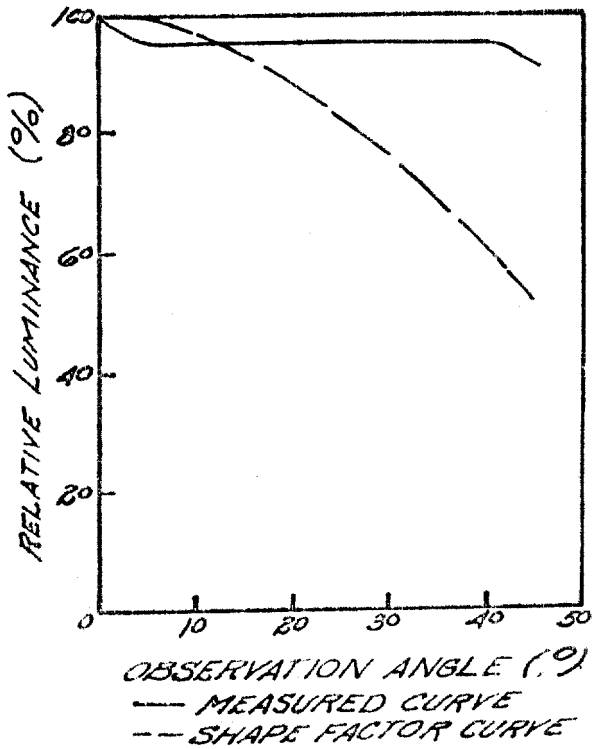
THICKNESS — .031 INCHES

ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #23

STAT

MANUFACTURER

DESIGNATION CX9644

PHYSICAL STRUCTURE BLUE TRANSPARENT ACETATE

TRANSMISSION (MATTE) — 4 %

TRANSMISSION (SMOOTH) — 3 %

AXIAL GAIN — 0.0106

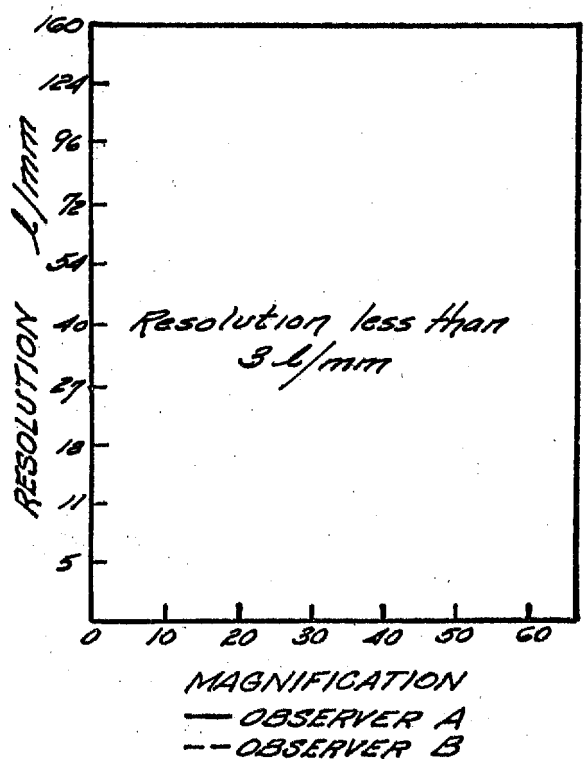
IMAGE BREAKUP MAGNIFICATION — 40X

POLARIZATION QUALITIES —

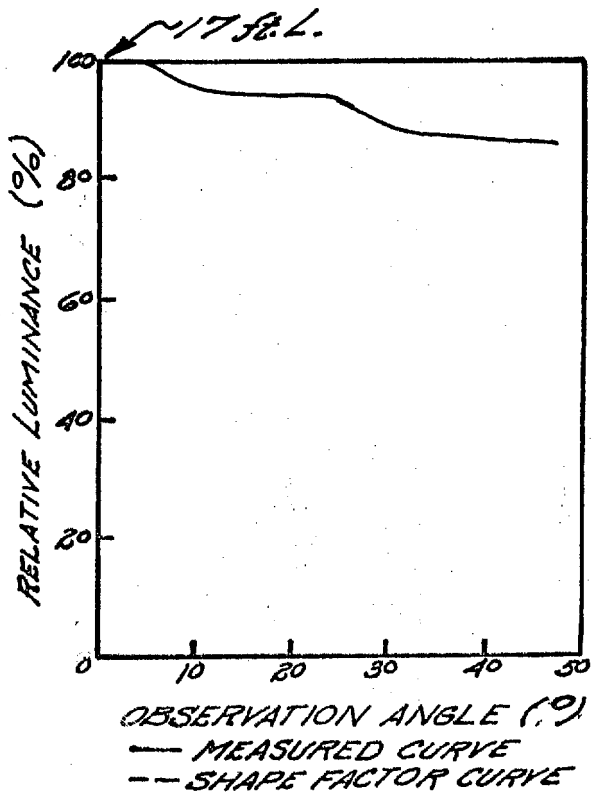
THICKNESS — .0295 INCHES

ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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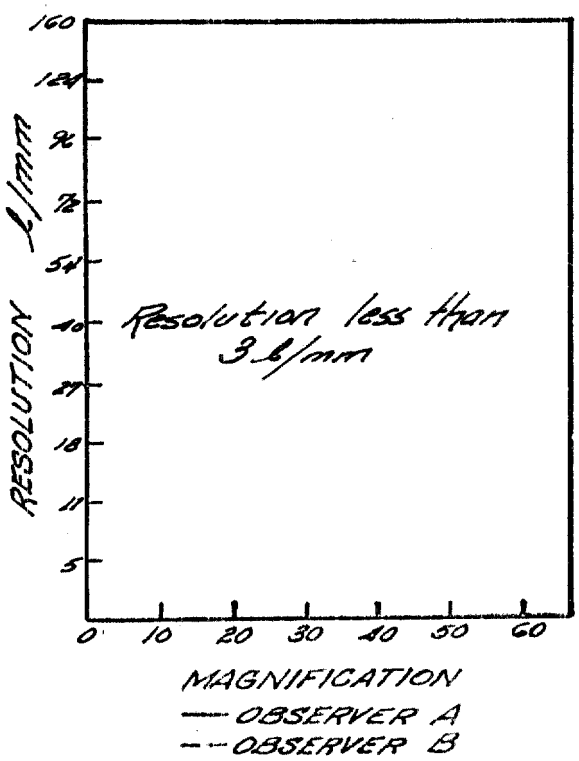
SAMPLE # 24

STAT

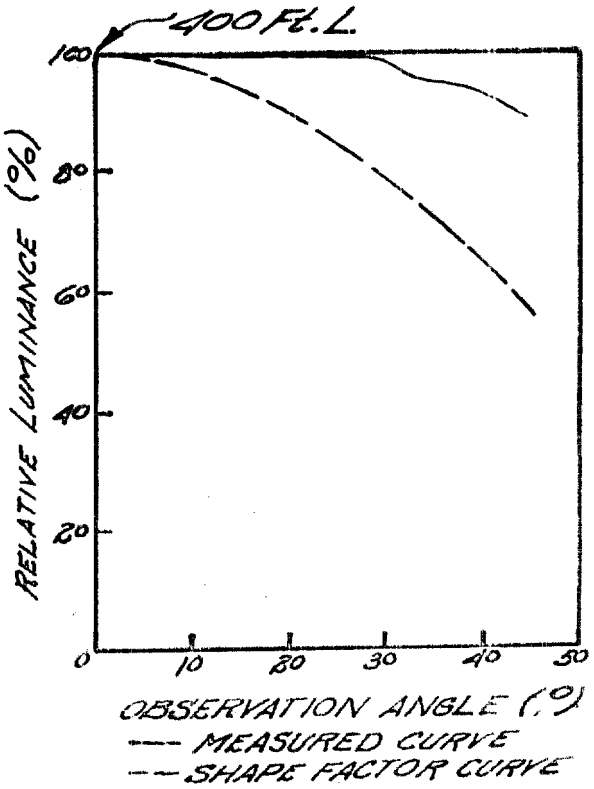
MANUFACTURER
DESIGNATION CX 9645
PHYSICAL STRUCTURE GREEN TRANSLUCENT ACETATE

TRANSMISSION (MATTE) — 11 %
TRANSMISSION (SMOOTH) — 11 %
AXIAL GAIN — 0.25
IMAGE BREAKUP MAGNIFICATION — 40 X
POLARIZATION QUALITIES —
THICKNESS — .031 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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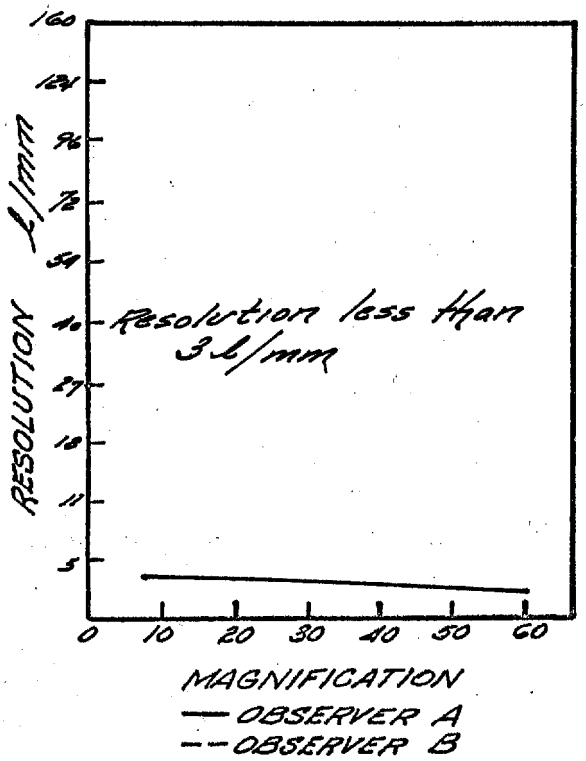
SAMPLE #25

STAT

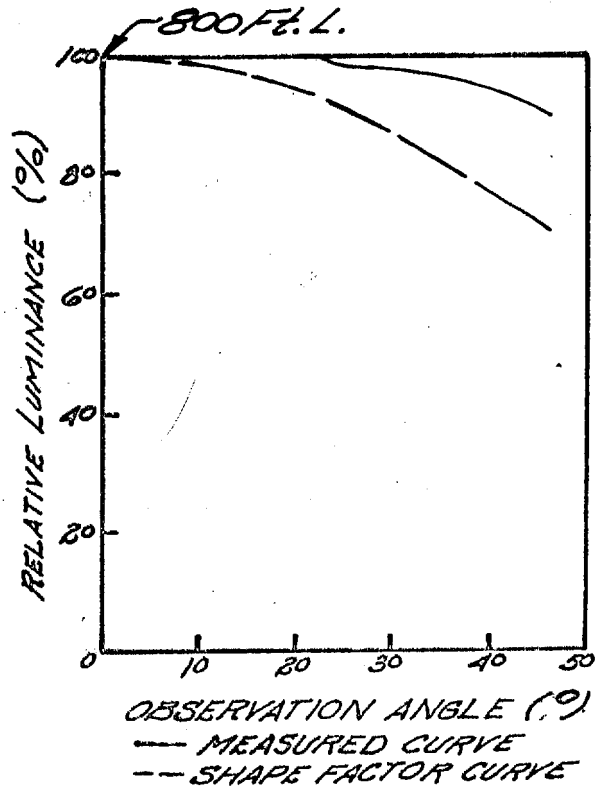
MANUFACTURER [redacted]
DESIGNATION KDA 2905 WHITE 164
PHYSICAL STRUCTURE "KRENE" VINYL FLEXIBLE

TRANSMISSION (MATTE) — 27 %
TRANSMISSION (SMOOTH) — 27 %
AXIAL GAIN — 0.05
IMAGE BREAKUP MAGNIFICATION — 40.0X
POLARIZATION QUALITIES —
THICKNESS — .0075 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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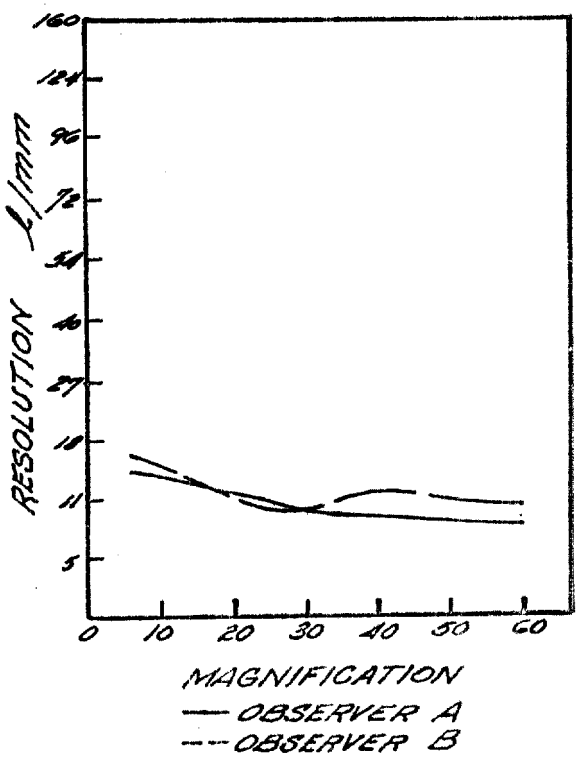
SAMPLE #26

STAT

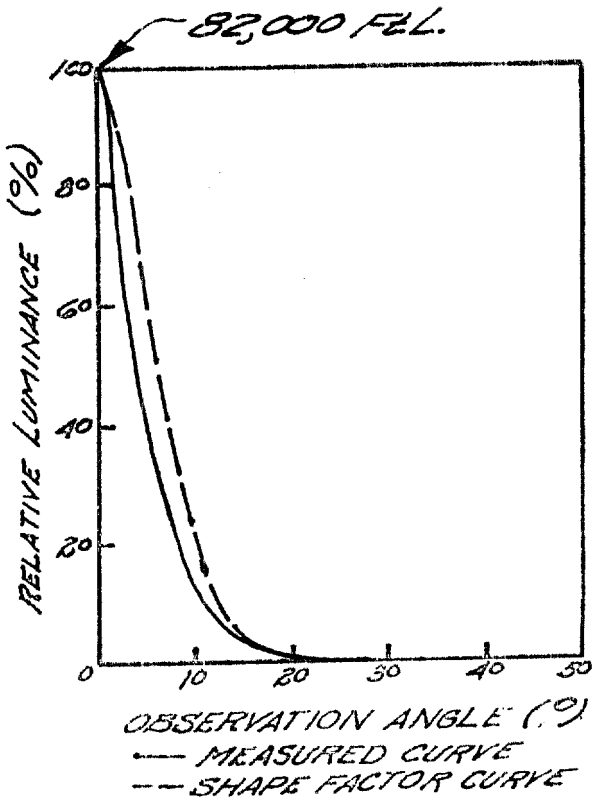
MANUFACTURER [redacted]
DESIGNATION KOD 2930 BLUE 811
PHYSICAL STRUCTURE "KRENE" VINYL FLEXIBLE

TRANSMISSION (MATTE) — 76 %
TRANSMISSION (SMOOTH) — 76 %
AXIAL GAIN — 51.3
IMAGE BREAKUP MAGNIFICATION — 35.0X
POLARIZATION QUALITIES —
THICKNESS — .0135 INCHES
ANGLE (50% REL. LUM.) — 4.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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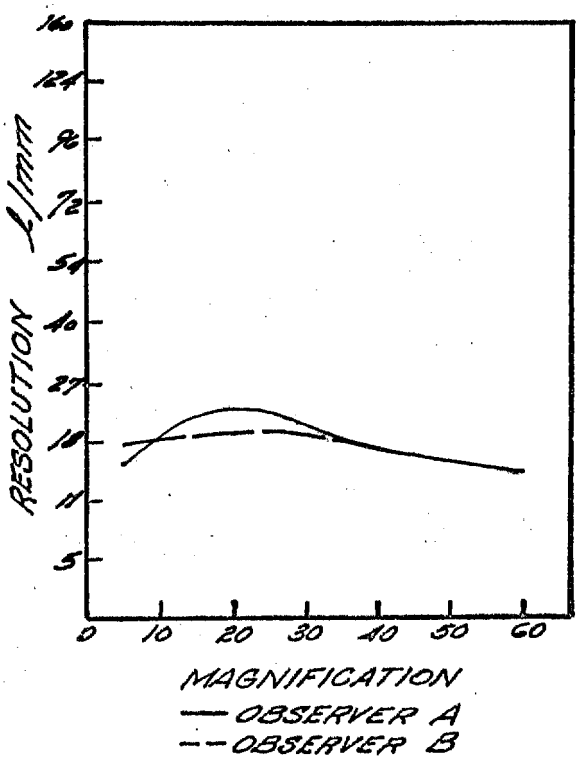
SAMPLE #27

STAT

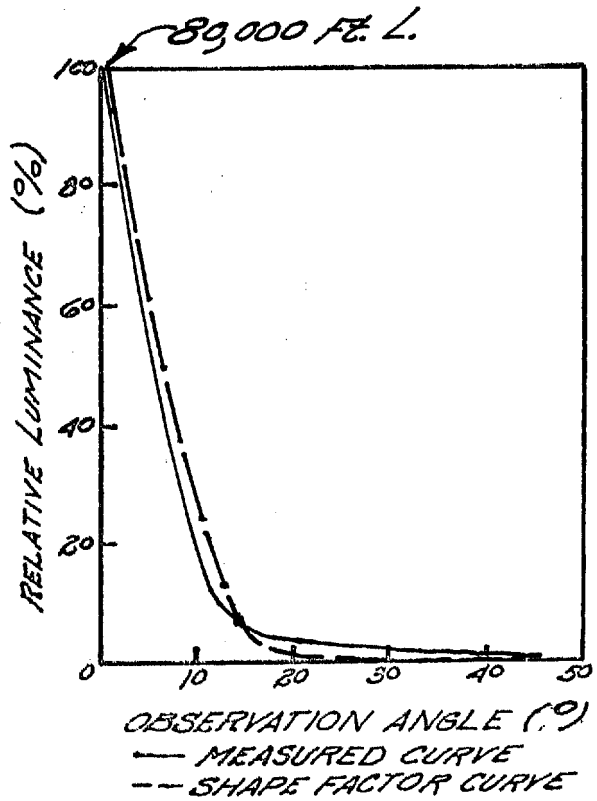
MANUFACTURER	[redacted]
DESIGNATION	KOR 2930 CLEAR – 21
PHYSICAL STRUCTURE	"KREENE" FLEXIBLE VINYL

TRANSMISSION (MATTE)	88 %
TRANSMISSION (SMOOTH)	86 %
AXIAL GAIN	50.0
IMAGE BREAKUP MAGNIFICATION	3/.5X
POLARIZATION QUALITIES	
THICKNESS	.012 INCHES
ANGLE (50% REL. LUM.)	5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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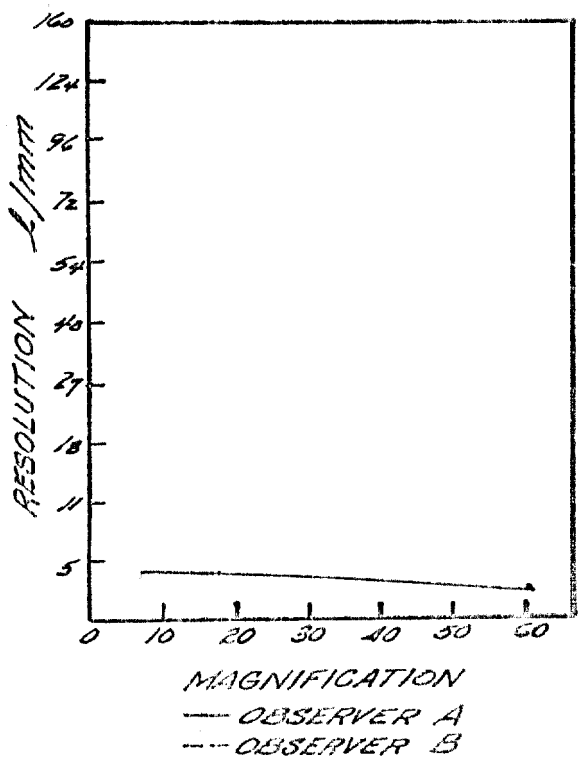
SAMPLE #28

STAT

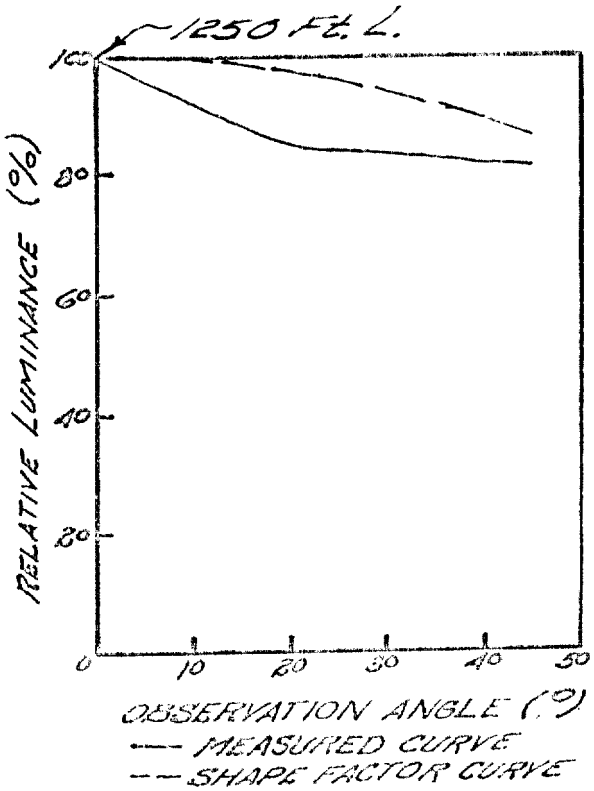
MANUFACTURER
DESIGNATION — VCA 3353 WHITE 154
PHYSICAL STRUCTURE — BAKELITE RIGID VINYL

TRANSMISSION (MATTE) — 39 %
TRANSMISSION (SMOOTH) — 40 %
AXIAL GAIN — 0.7825
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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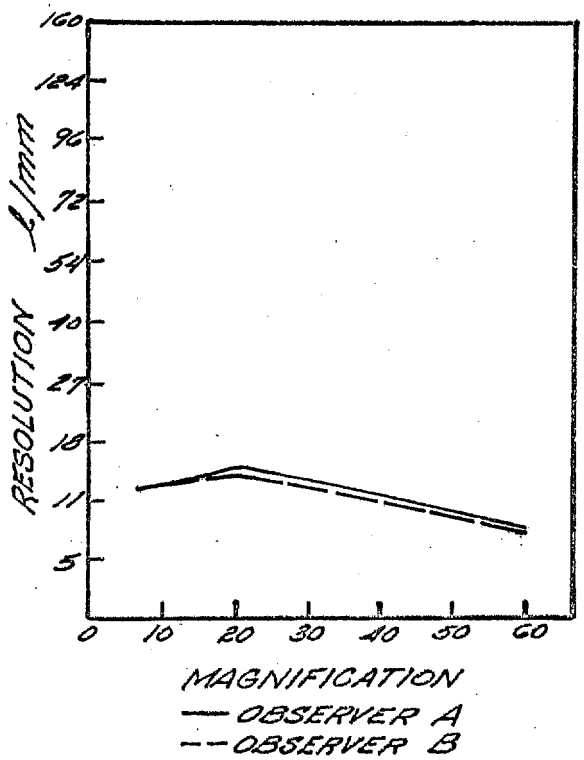
SAMPLE #29

STAT

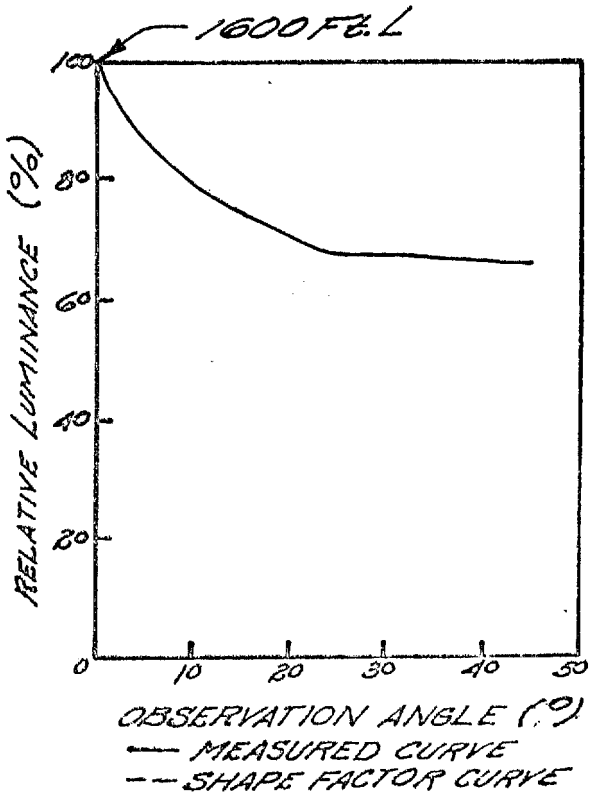
MANUFACTURER	
DESIGNATION	VCA 3353 WHITE 203
PHYSICAL STRUCTURE	BAKELITE RIGID VINYL

TRANSMISSION (MATTE) — 42.5 %
TRANSMISSION (SMOOTH) — 42.5 %
AXIAL GAIN — 1.0
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .010 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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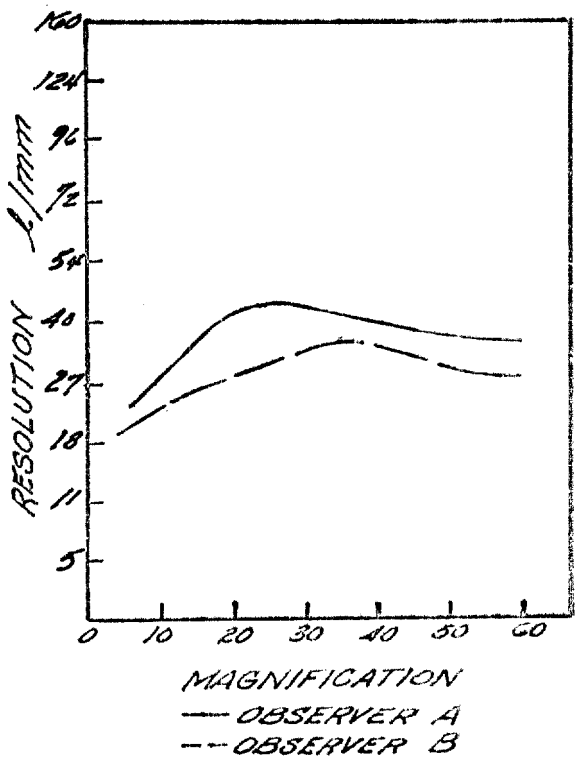
SAMPLE #30

STAT

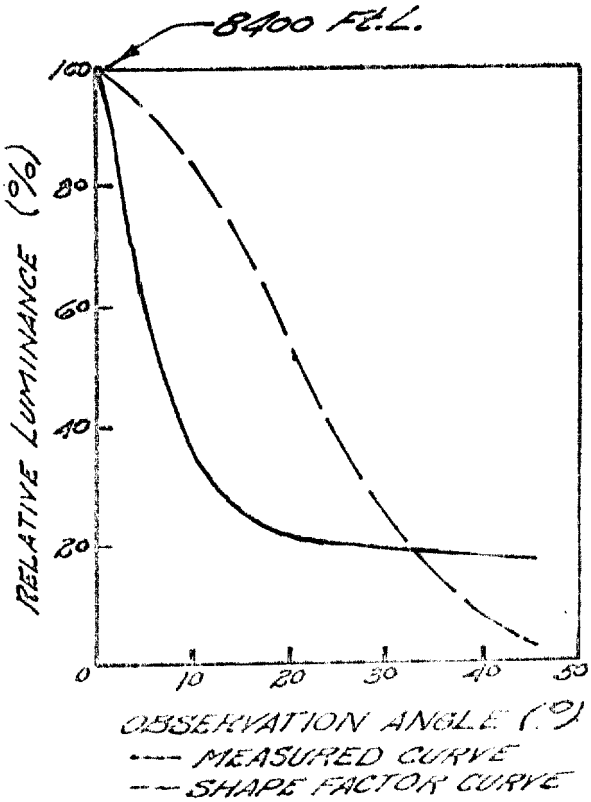
MANUFACTURER	
DESIGNATION	VCR 3353 WHITE 363 MATTE 02
PHYSICAL STRUCTURE	BAKELITE RIGID VINYL

TRANSMISSION (MATTE) — 53 %
TRANSMISSION (SMOOTH) — 53.5 %
AXIAL GAIN — 1.0
IMAGE BREAKUP MAGNIFICATION — 37.5X
POLARIZATION QUALITIES —
THICKNESS — .0075 INCHES
ANGLE (50% REL. LUM.) — 7°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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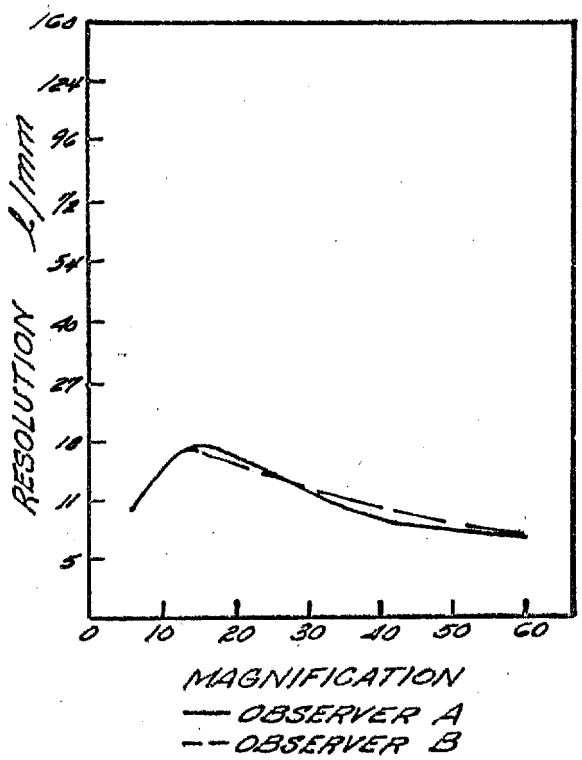
SAMPLE #31

STAT

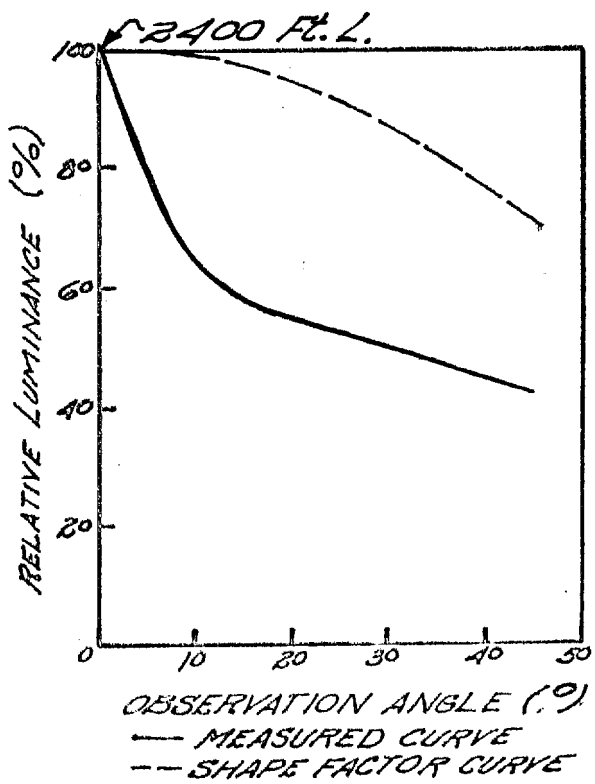
MANUFACTURER [redacted]
DESIGNATION VCR 3353 WHITE 363
PHYSICAL STRUCTURE BAKELITE RIGID VINYL

TRANSMISSION (MATTE) — 44.5 %
TRANSMISSION (SMOOTH) — 45 %
AXIAL GAIN — 1.5
IMAGE BREAKUP MAGNIFICATION — 40 X
POLARIZATION QUALITIES —
THICKNESS — .0105 INCHES
ANGLE (50% REL. LUM.) — 30°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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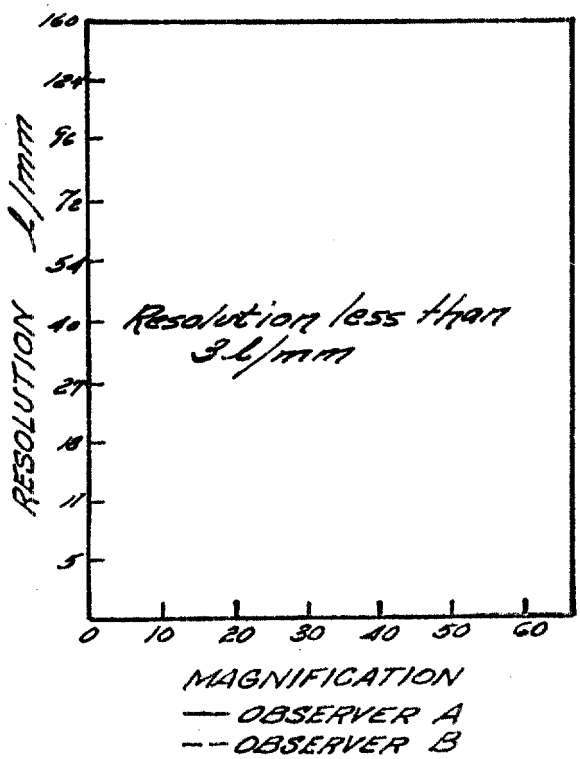
SAMPLE #32

STAT

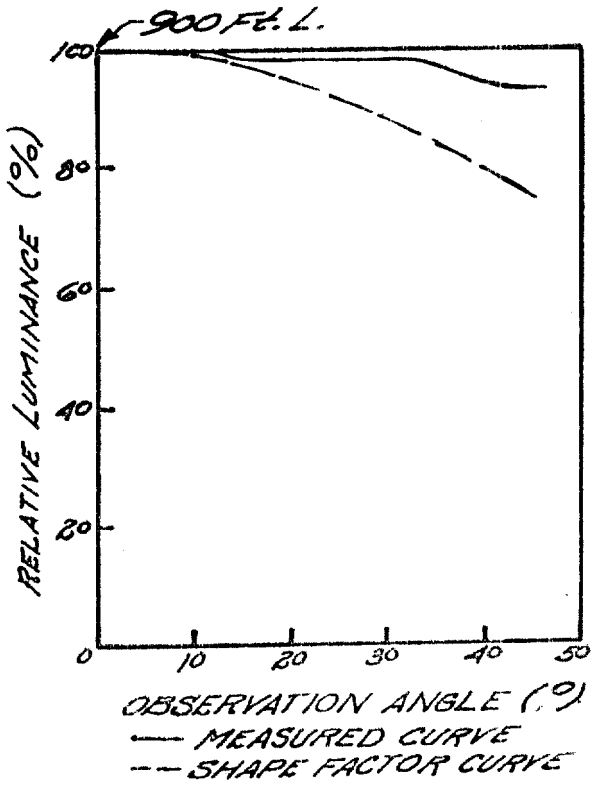
MANUFACTURER
DESIGNATION — VCA 3604 WHITE/023
PHYSICAL STRUCTURE — BAKELITE RIGID VINYL

TRANSMISSION (MATTE) — 31 %
TRANSMISSION (SMOOTH) — 30 %
AXIAL GAIN — 0.562
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .015 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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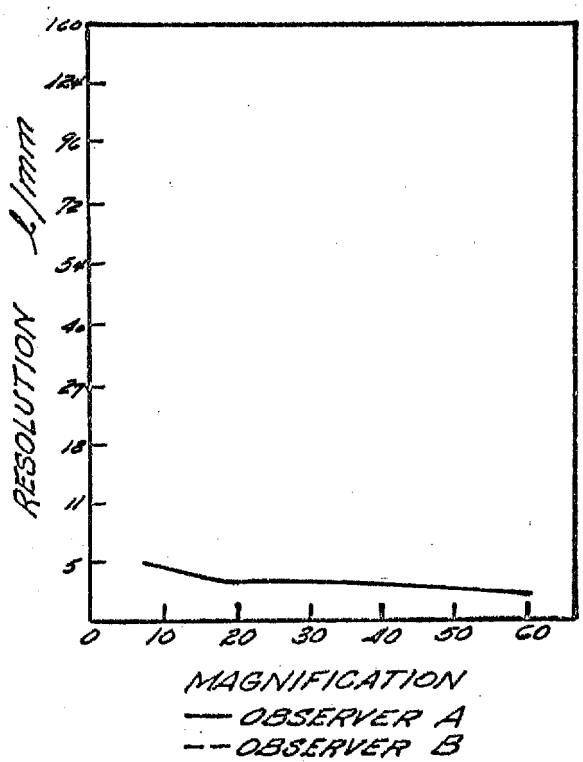
SAMPLE #33

STAT

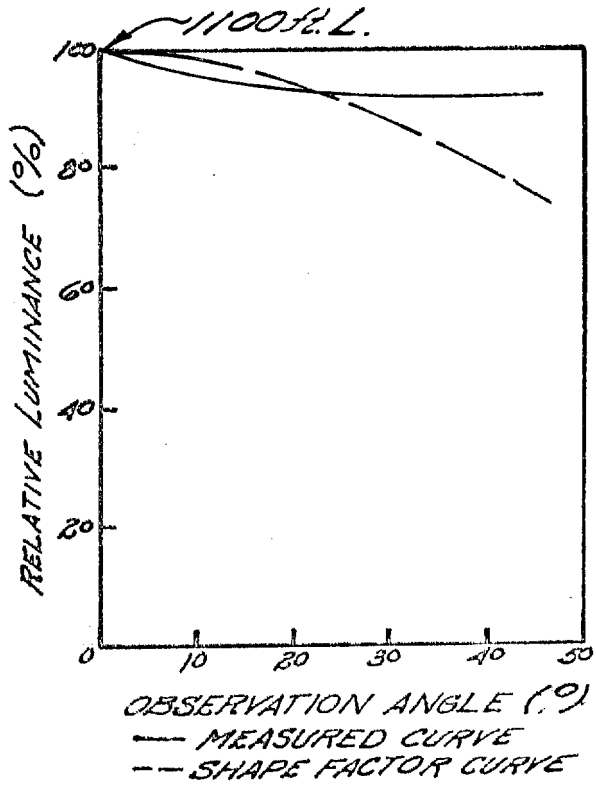
MANUFACTURER [redacted]
DESIGNATION VCH 3604 WHITE 1023
PHYSICAL STRUCTURE BAKELITE RIGID VINYL

TRANSMISSION (MATTE) — 38 %
TRANSMISSION (SMOOTH) — 39 %
AXIAL GAIN — 0.688
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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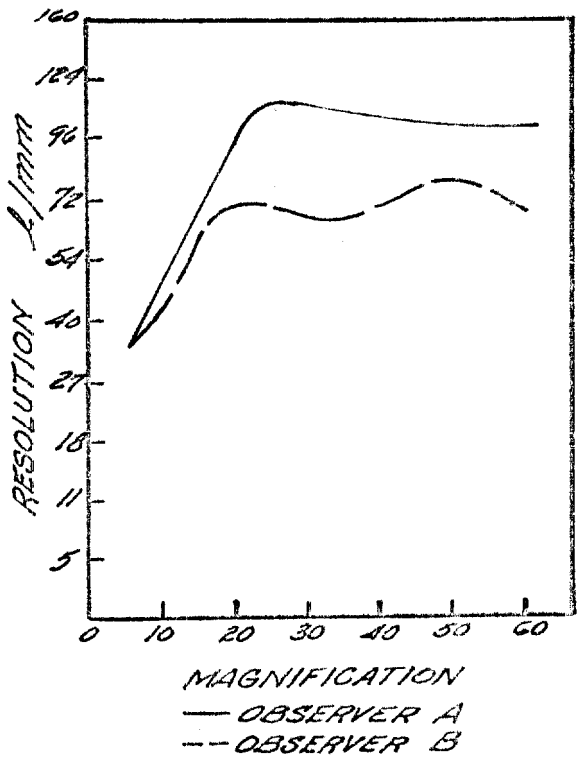
SAMPLE #34

STAT

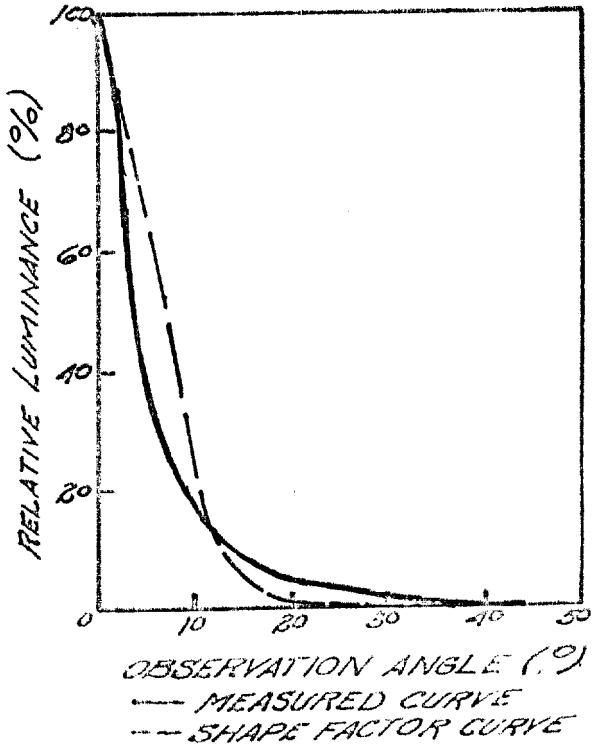
MANUFACTURER	
DESIGNATION	STABILENE FILM 130
PHYSICAL STRUCTURE	duPont MYLAR TRANSPARENT FILM

TRANSMISSION (MATTE)	85 %
TRANSMISSION (SMOOTH)	82 %
AXIAL GAIN	48.75
IMAGE BREAKUP MAGNIFICATION	25.5X
POLARIZATION QUALITIES	
THICKNESS	.005 INCHES
ANGLE (50% REL. LUM.)	4°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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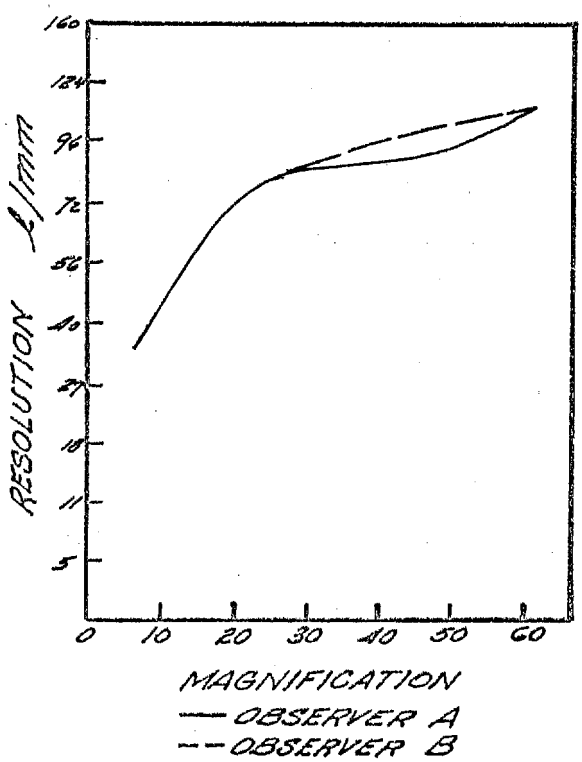
SAMPLE #35

STAT

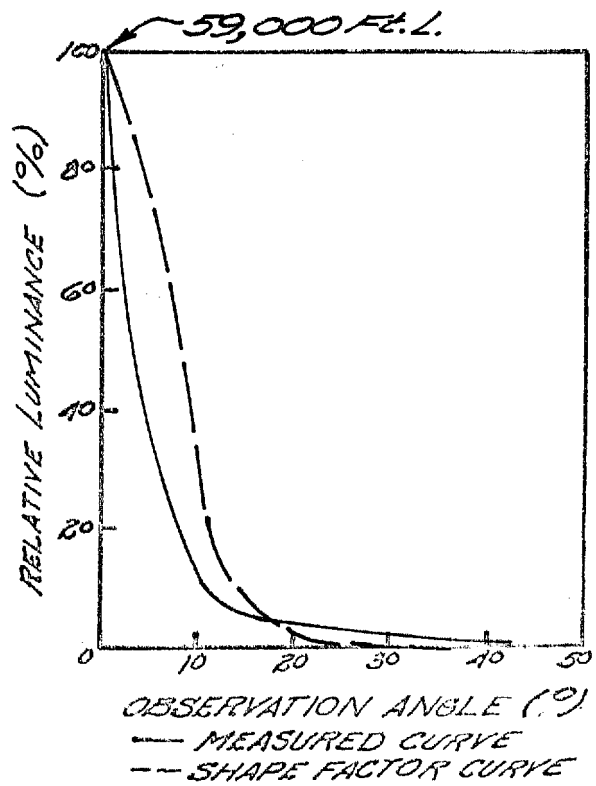
MANUFACTURER
DESIGNATION G 133 H
PHYSICAL STRUCTURE duPont MYLAR GREEN TRANSPARENT

TRANSMISSION (MATTE) — 54 %
TRANSMISSION (SMOOTH) — 54 %
AXIAL GAIN — 36.9
IMAGE BREAKUP MAGNIFICATION — 11 X
POLARIZATION QUALITIES —
THICKNESS — .008 INCHES
ANGLE (50% REL. LUM.) — 3°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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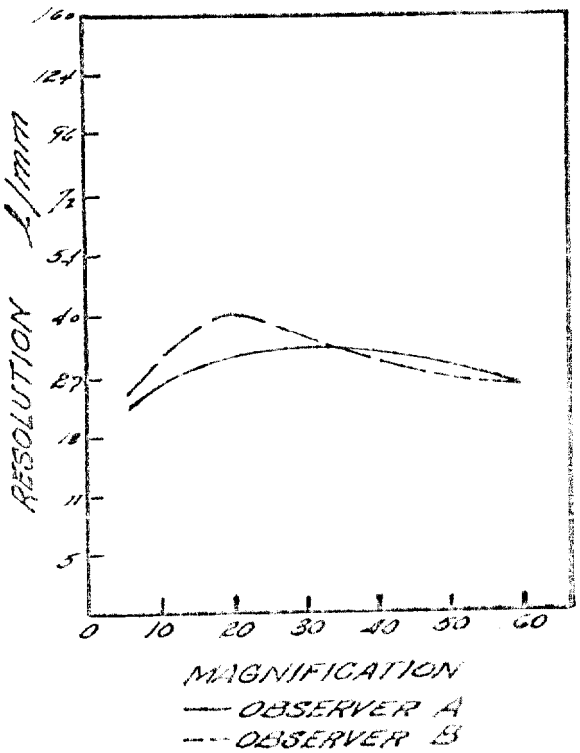
SAMPLE #36

STAT

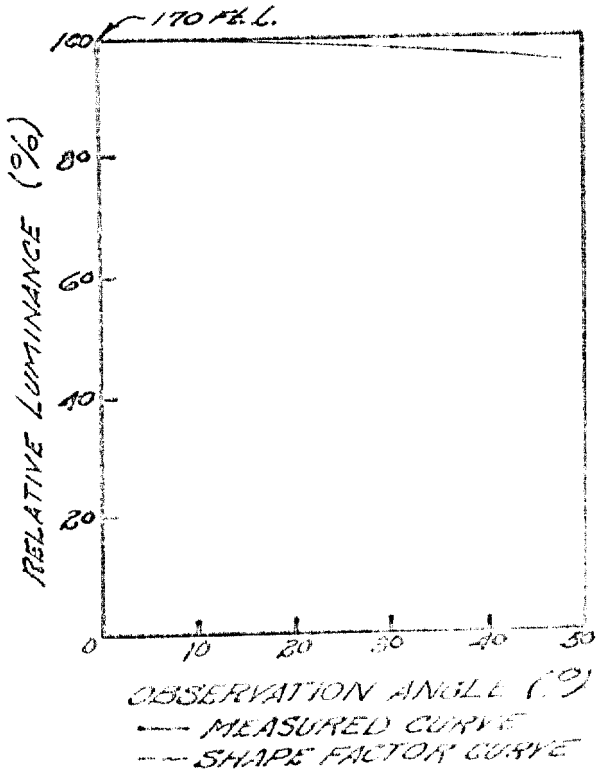
MANUFACTURER
DESIGNATION R 132 H
PHYSICAL STRUCTURE duPont MYLAR BEST TRANSPARENT

TRANSMISSION (MATTE) — 5 %
TRANSMISSION (SMOOTH) — 4 %
AXIAL GAIN — 0.106
IMAGE BREAKUP MAGNIFICATION — 39 X
POLARIZATION QUALITIES —
THICKNESS — .0075 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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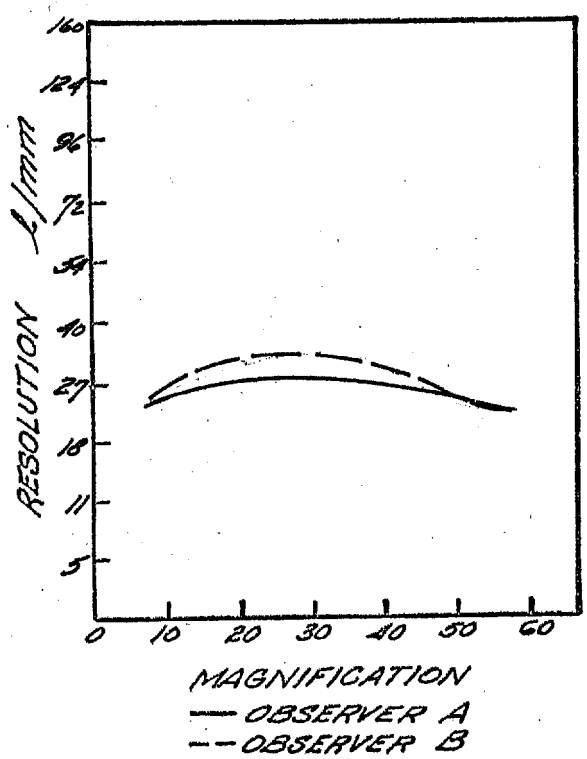
SAMPLE #37

STAT

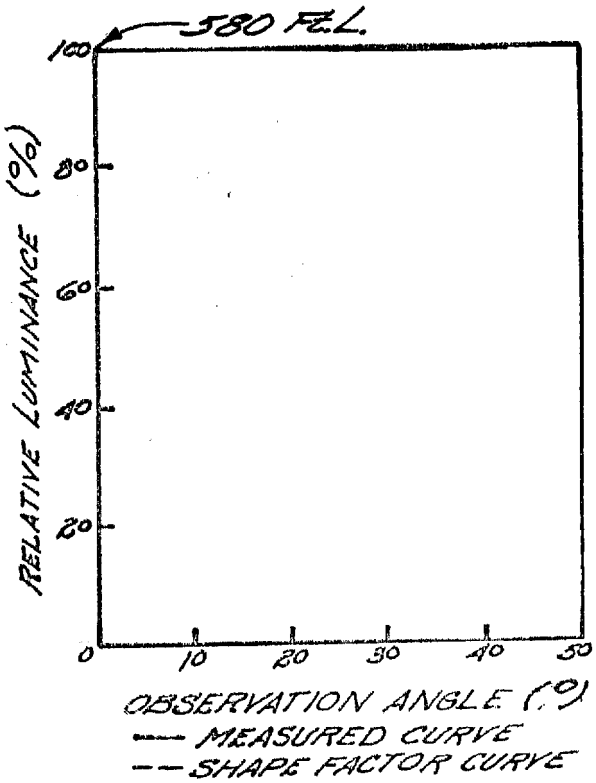
MANUFACTURER
DESIGNATION Y 132 H
PHYSICAL STRUCTURE duPont MYLAR YELLOW TRANSPARENT

TRANSMISSION (MATTE) — 15 %
TRANSMISSION (SMOOTH) — 15 %
AXIAL GAIN — 0.362
IMAGE BREAKUP MAGNIFICATION — 39 X
POLARIZATION QUALITIES —
THICKNESS — .0075 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #38

STAT

MANUFACTURER [redacted]

DESIGNATION 130T

PHYSICAL STRUCTURE duPont MYLAR CLEAR TRANSPARENT

TRANSMISSION (MATTE) — 80 %

TRANSMISSION (SMOOTH) — 77.5 %

AXIAL GAIN — 38.2

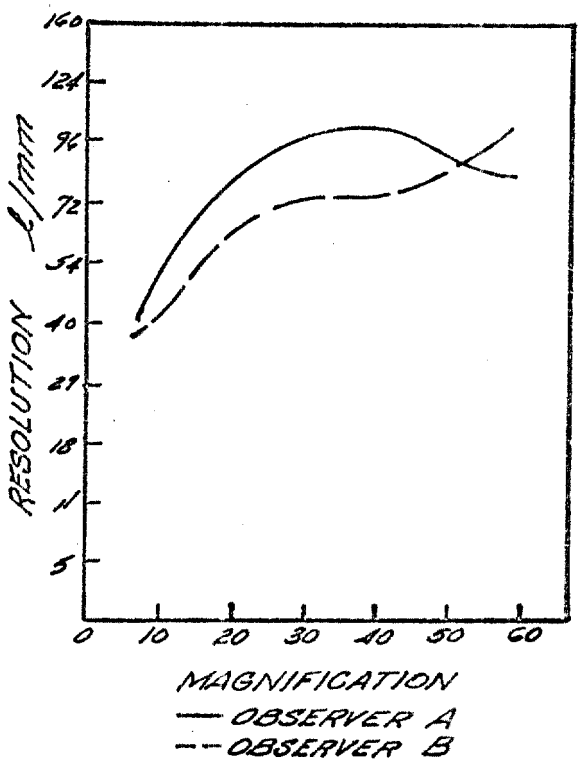
IMAGE BREAKUP MAGNIFICATION — 37.5 X

POLARIZATION QUALITIES —

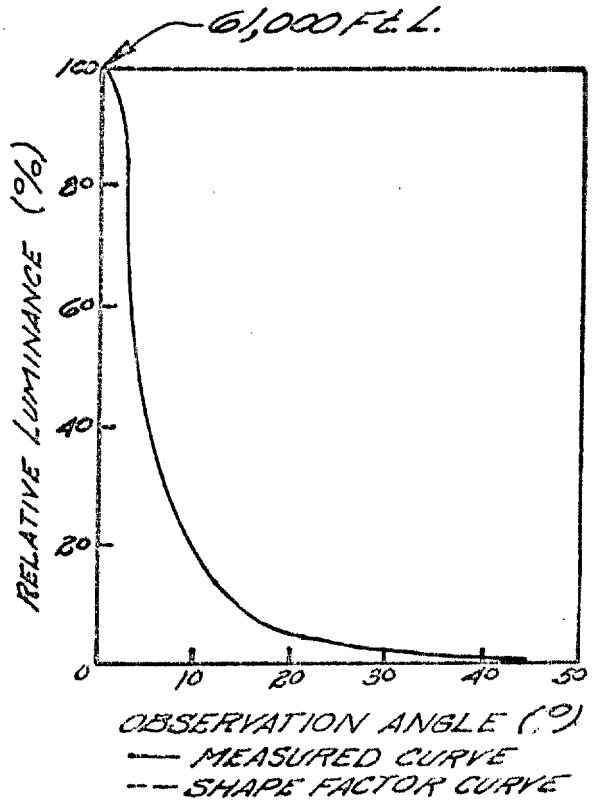
THICKNESS — .0035 INCHES

ANGLE (50% REL. LUM.) — 3.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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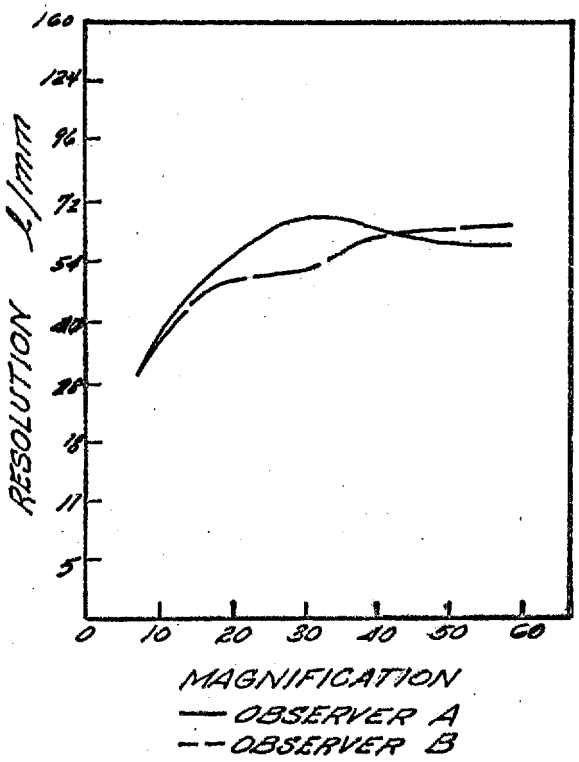
SAMPLE #39

STAT

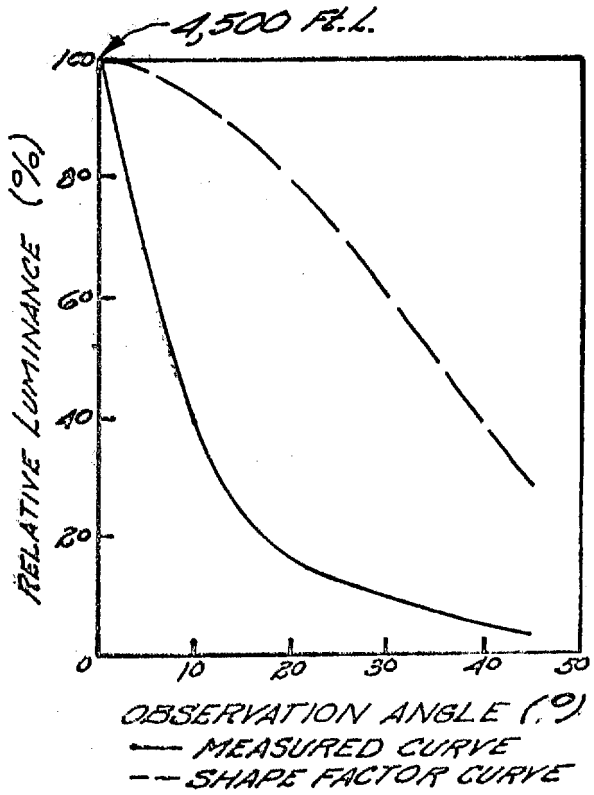
MANUFACTURER	
DESIGNATION	R 133 H
PHYSICAL STRUCTURE	duPont MYLAR RUST TRANSPARENT

TRANSMISSION (MATTE)	14 %
TRANSMISSION (SMOOTH)	13 %
AXIAL GAIN	2.81
IMAGE BREAKUP MAGNIFICATION	19.5X
POLARIZATION QUALITIES	
THICKNESS	.008 INCHES
ANGLE (50% REL. LUM.)	8°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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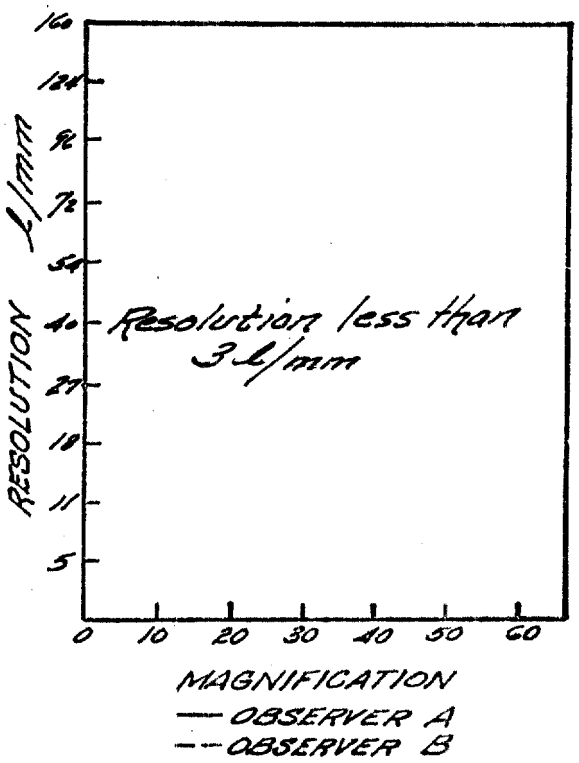
SAMPLE #40

STAT

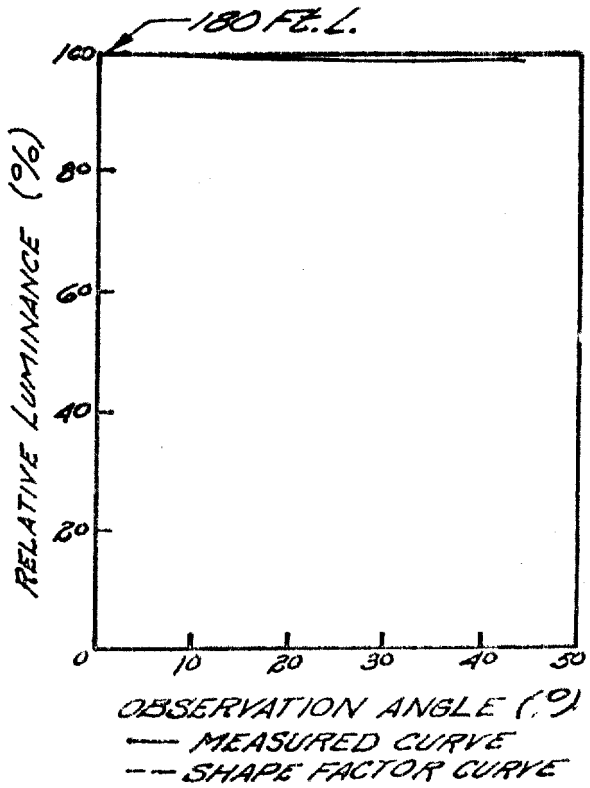
MANUFACTURER	
DESIGNATION	OPAQUE DRAWING SURFACE
PHYSICAL STRUCTURE	duPont MYLAR (BUFF)

TRANSMISSION (MATTE) — 5 %
TRANSMISSION (SMOOTH) — 5 %
AXIAL GAIN — 0.03
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .009 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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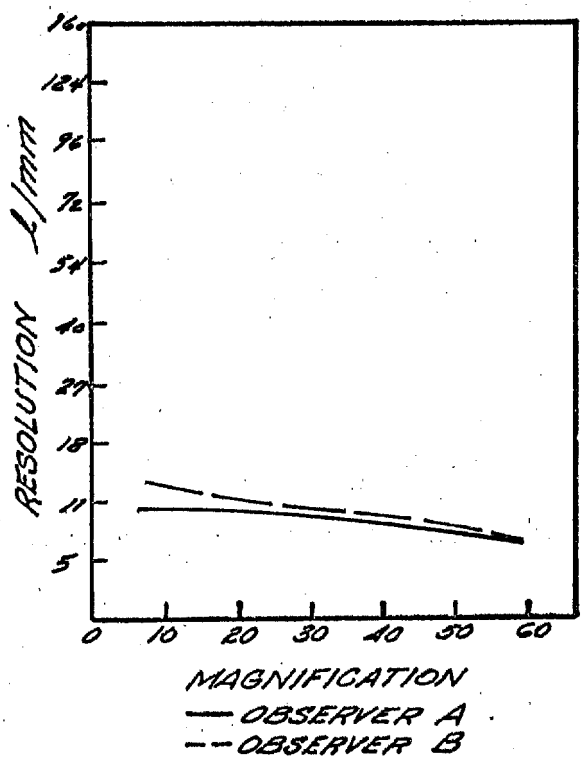
SAMPLE # 41

STAT

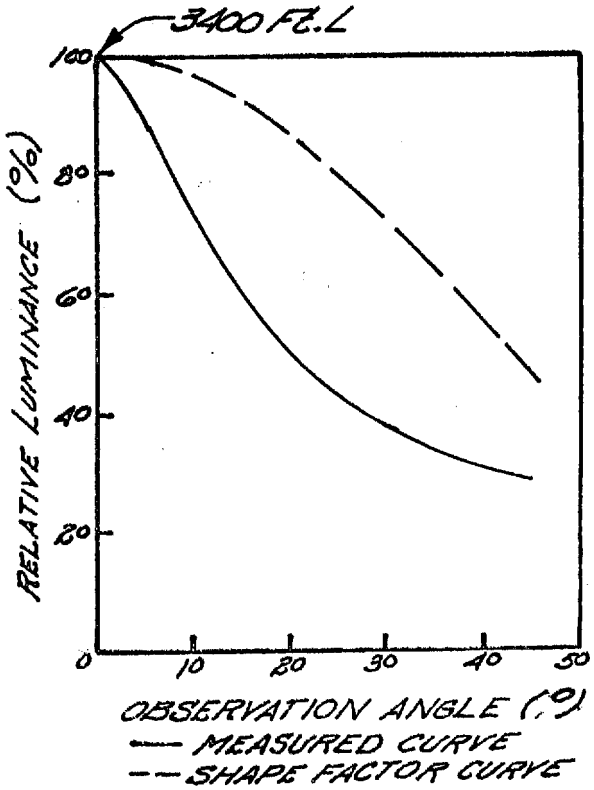
MANUFACTURER
DESIGNATION 3326E-1
PHYSICAL STRUCTURE WHITE

TRANSMISSION (MATTE) — 51 %
TRANSMISSION (SMOOTH) — 50.5%
AXIAL GAIN — 2.125
IMAGE BREAKUP MAGNIFICATION — 15.5X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) — 21°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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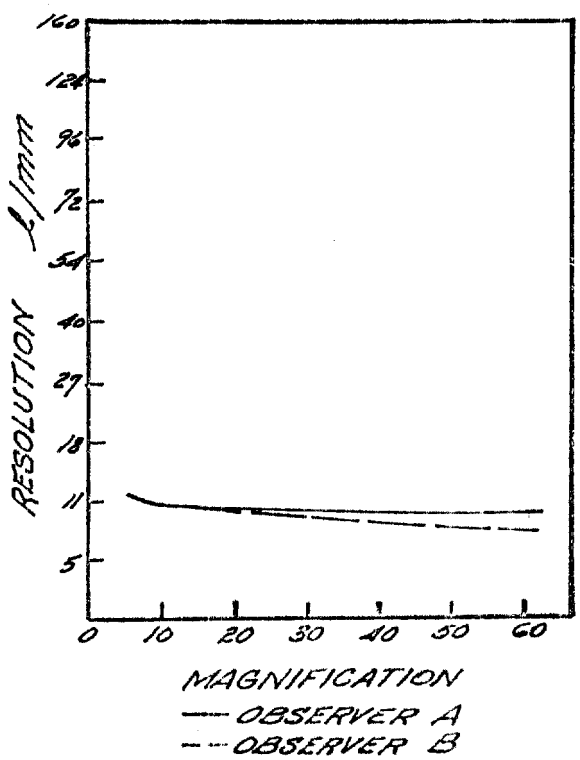
SAMPLE #42

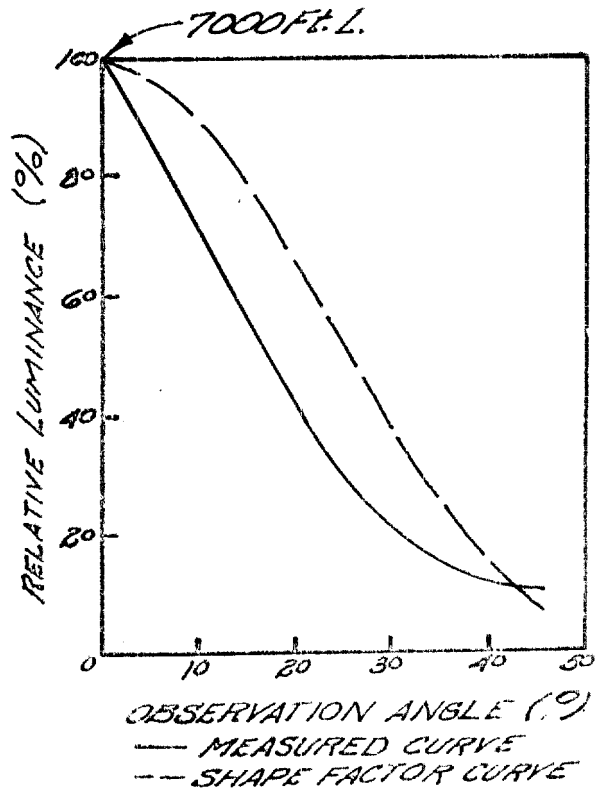
STAT

MANUFACTURER	
DESIGNATION	332GE - 2
PHYSICAL STRUCTURE	GREY
TRANSMISSION (MATTE)	55 %
TRANSMISSION (SMOOTH)	56 %
AXIAL GAIN	4.375
IMAGE BREAKUP MAGNIFICATION	17X
POLARIZATION QUALITIES	
THICKNESS	.011 INCHES
ANGLE (50% REL. LUM.)	17°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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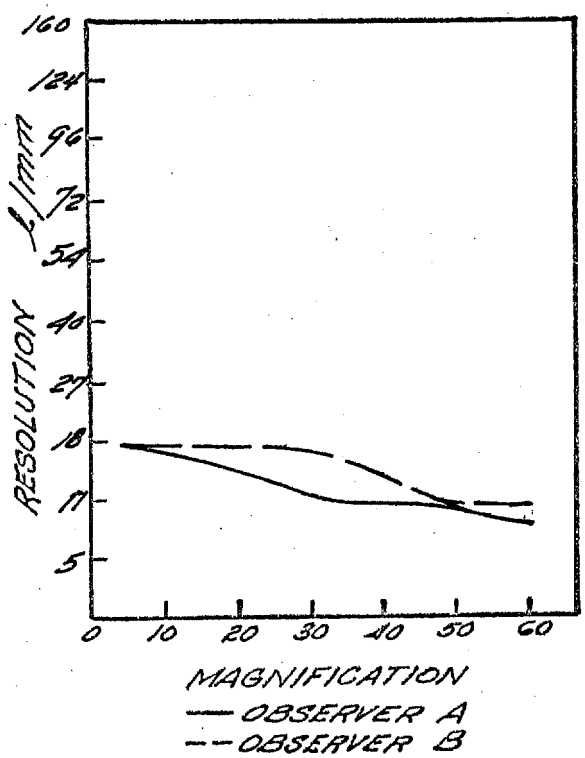
SAMPLE #43

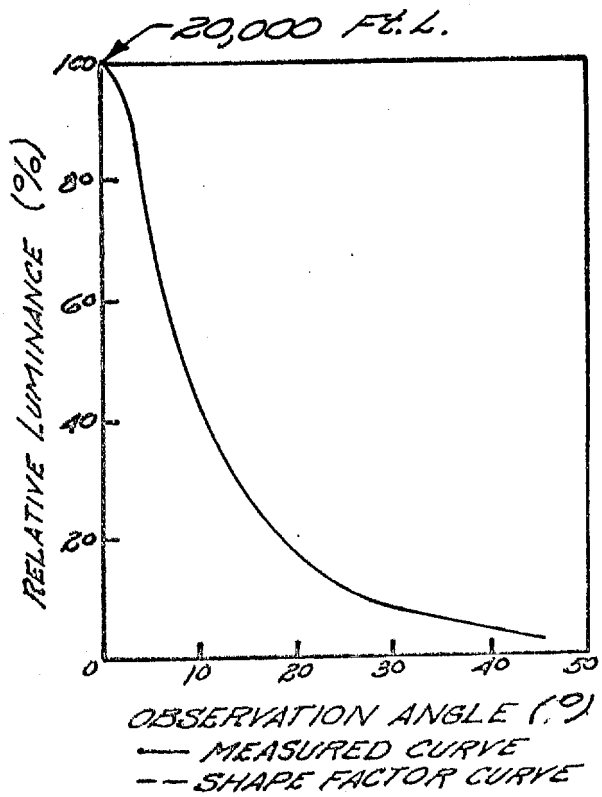
STAT

MANUFACTURER	
DESIGNATION	3D-3326E — 3
PHYSICAL STRUCTURE	WHITE
TRANSMISSION (MATTE)	77 %
TRANSMISSION (SMOOTH)	75 %
AXIAL GAIN	12.5
IMAGE BREAKUP MAGNIFICATION	21 X
POLARIZATION QUALITIES	
THICKNESS	.011 INCHES
ANGLE (50% REL. LUM.)	9°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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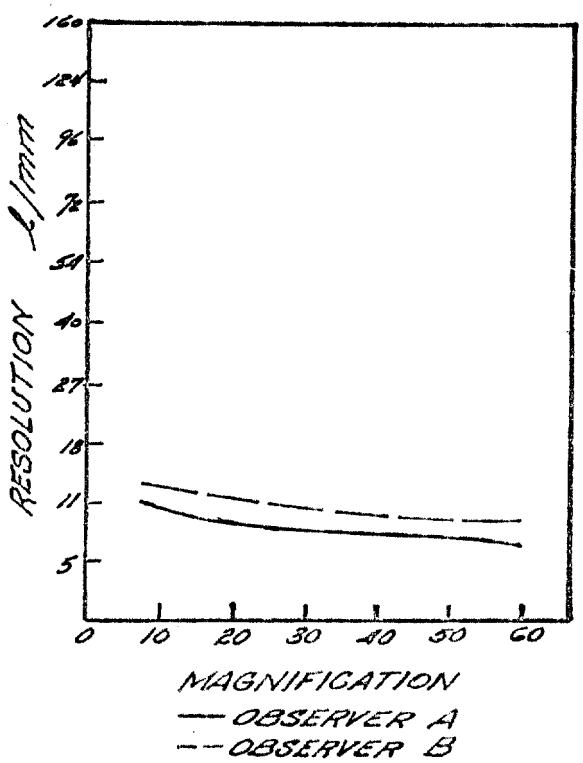
SAMPLE #44

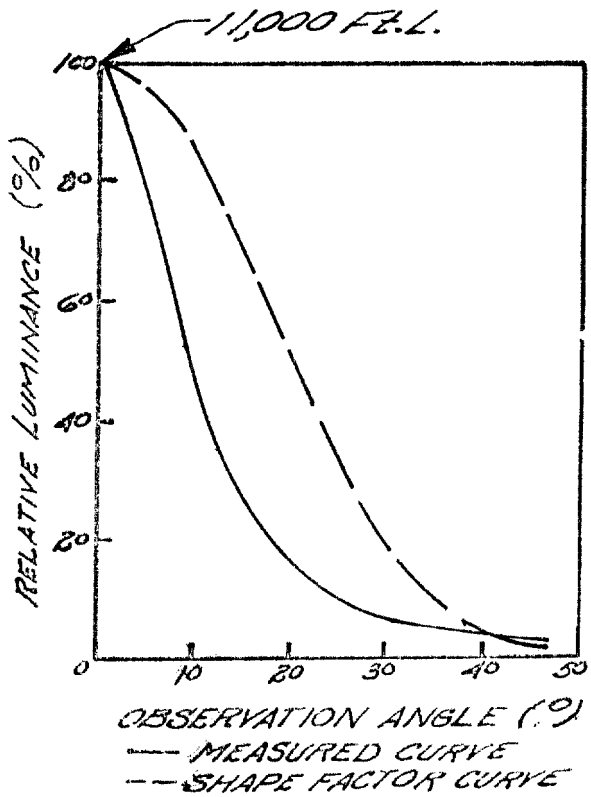
STAT

MANUFACTURER	
DESIGNATION	3D 332GE-4
PHYSICAL STRUCTURE	BLACK
TRANSMISSION (MATTE)	34.5%
TRANSMISSION (SMOOTH)	35 %
AXIAL GAIN	6.875
IMAGE BREAKUP MAGNIFICATION	29.5X
POLARIZATION QUALITIES	
THICKNESS	.009 INCHES
ANGLE (50% REL. LUM.)	9°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #45

STAT

MANUFACTURER

DESIGNATION — WHITE STEREO 3326E-5

PHYSICAL STRUCTURE — BASE MATERIAL UNKNOWN

300-450 RMS PROFILOMETER SURFACE ROUGHNESS / ASA 46.1-1955 (.030 STROKE)

TRANSMISSION (MATTE) — 73 %

TRANSMISSION (SMOOTH) — 73 %

AXIAL GAIN — 9.055

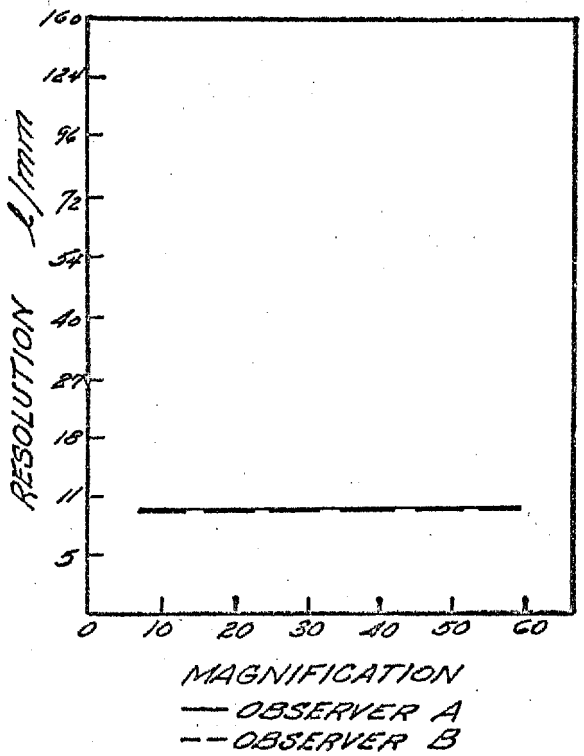
IMAGE BREAKUP MAGNIFICATION — 40X

POLARIZATION QUALITIES —

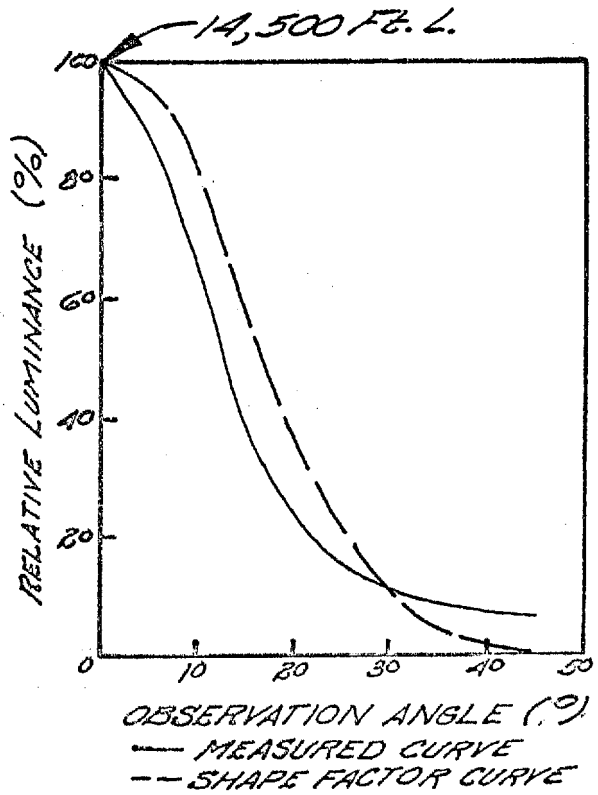
THICKNESS — .012 INCHES

ANGLE (50% REL. LUM.) — 13°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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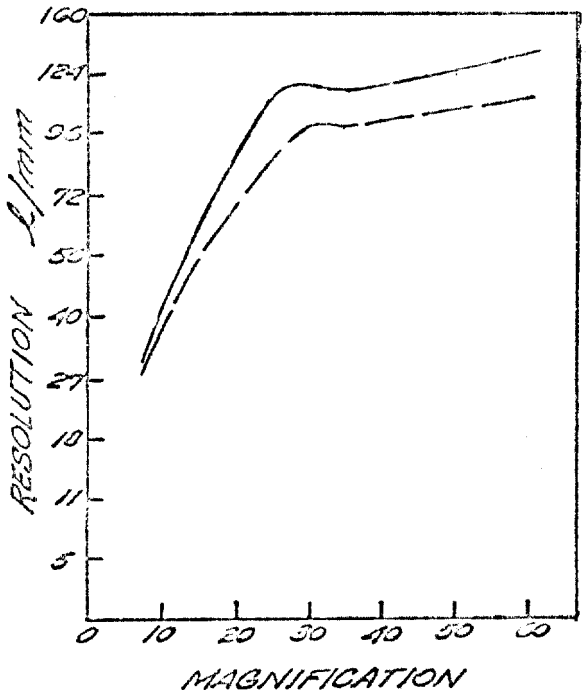
SAMPLE #46

STAT

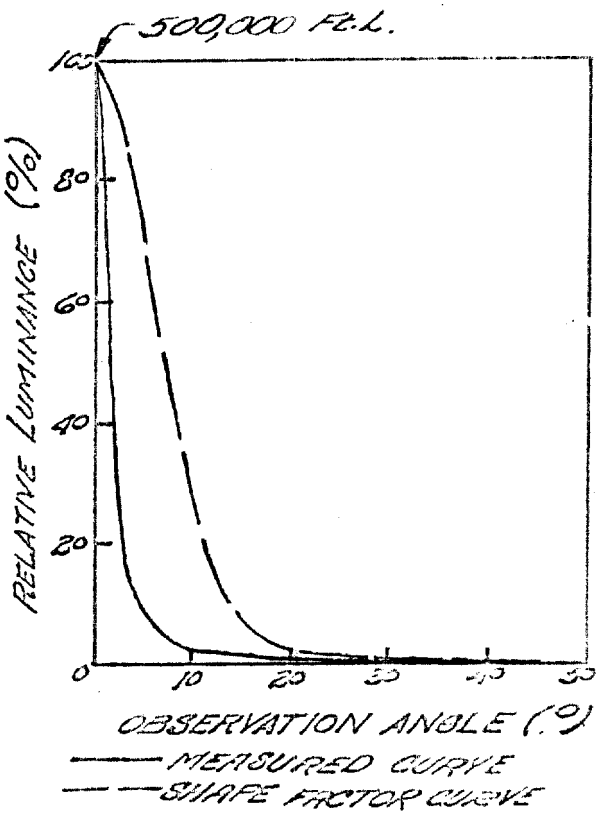
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TiO_2-1

TRANSMISSION (MATTE) — 82 %
TRANSMISSION (SMOOTH) — 81.5 %
AXIAL GAIN — 312.5
IMAGE BREAKUP MAGNIFICATION — 22 X
POLARIZATION QUALITIES —
THICKNESS — .005 INCHES
ANGLE (50% REL. LUM.) — 2°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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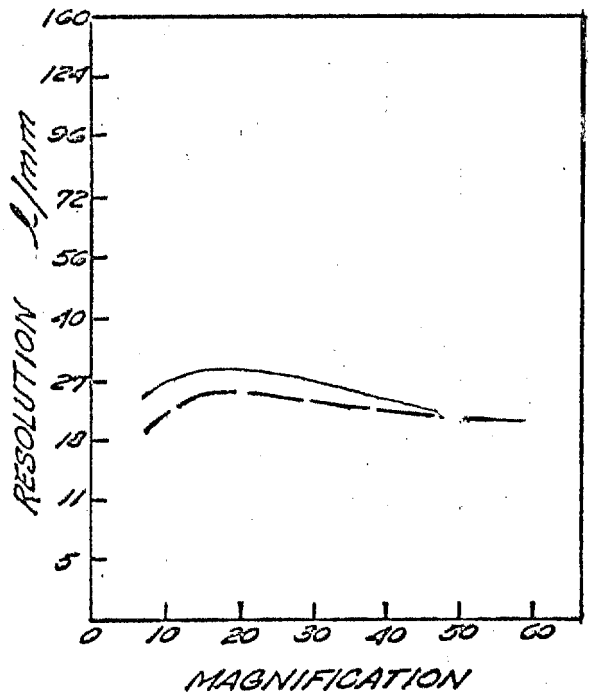
SAMPLE #47

STAT

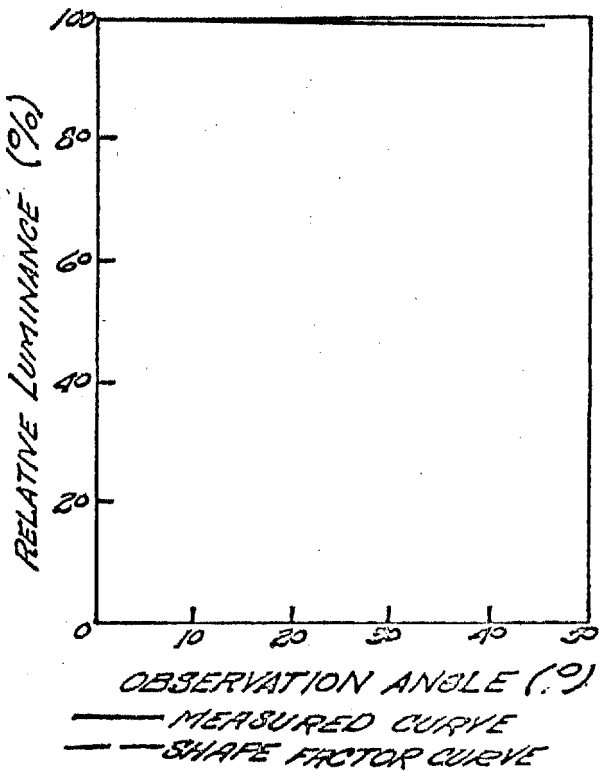
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TiO_2-2

TRANSMISSION (MATTE) — 38 %
TRANSMISSION (SMOOTH) — 38 %
AXIAL GAIN — 0.625
IMAGE BREAKUP MAGNIFICATION — 39 ×
POLARIZATION QUALITIES —
THICKNESS — .005 INCHES
ANGLE (50% REL. LUM) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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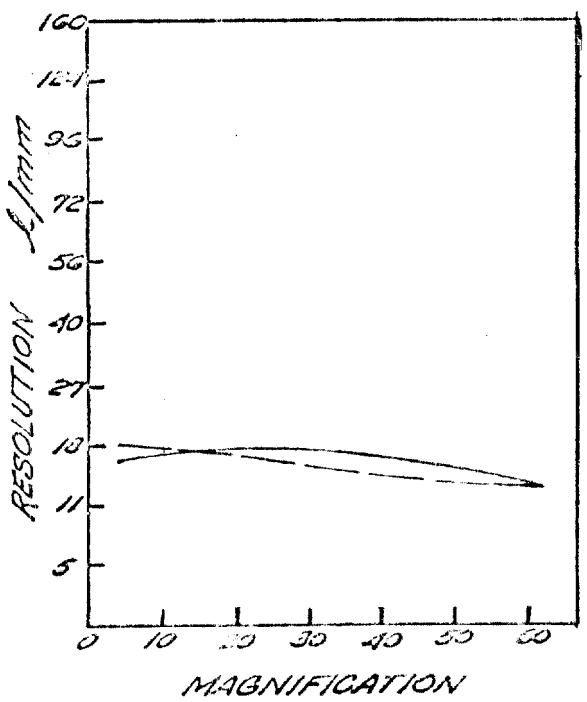
SAMPLE #48

STAT

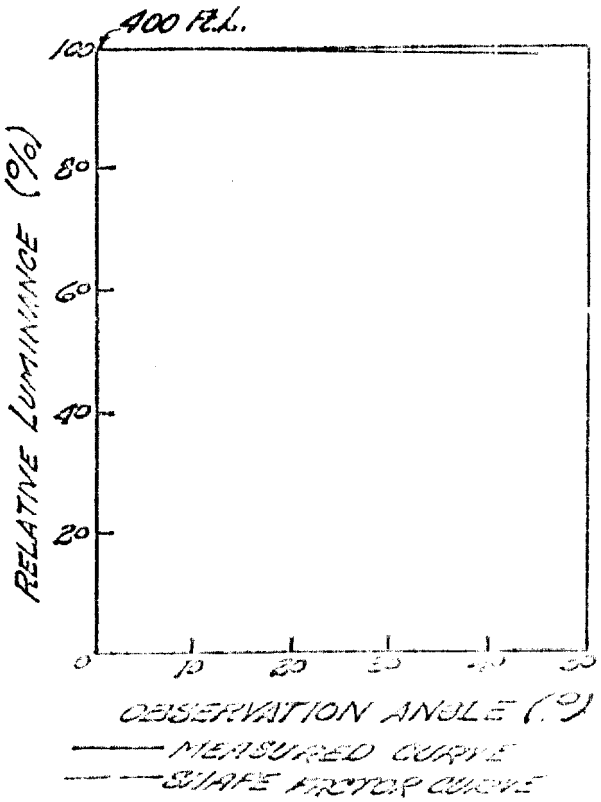
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TiO_2-3

TRANSMISSION (MATTE) — 14 %
TRANSMISSION (SMOOTH) — 14 %
AXIAL GAIN — 0.25
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .005 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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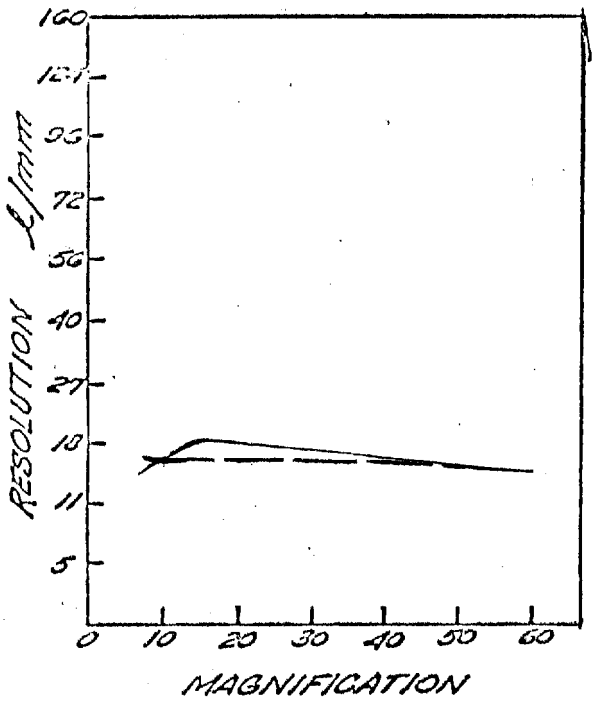
SAMPLE #49

STAT

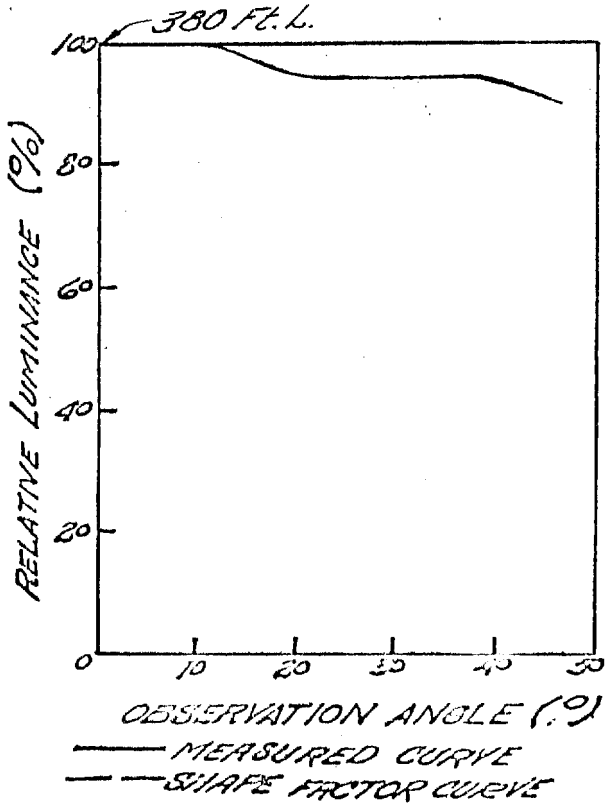
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TiO_2-4

TRANSMISSION (MATTE) — 12.5 %
TRANSMISSION (SMOOTH) — 12.5 %
AXIAL GAIN — 0.2375
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .006 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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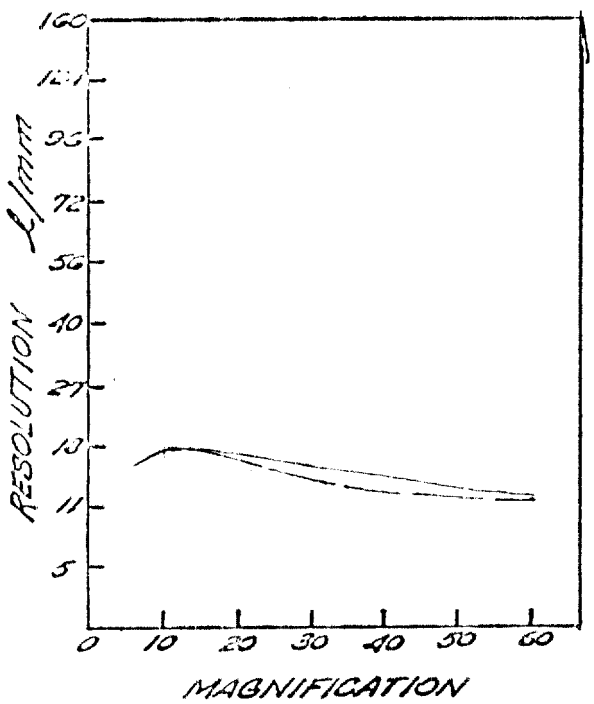
SAMPLE #50

STAT

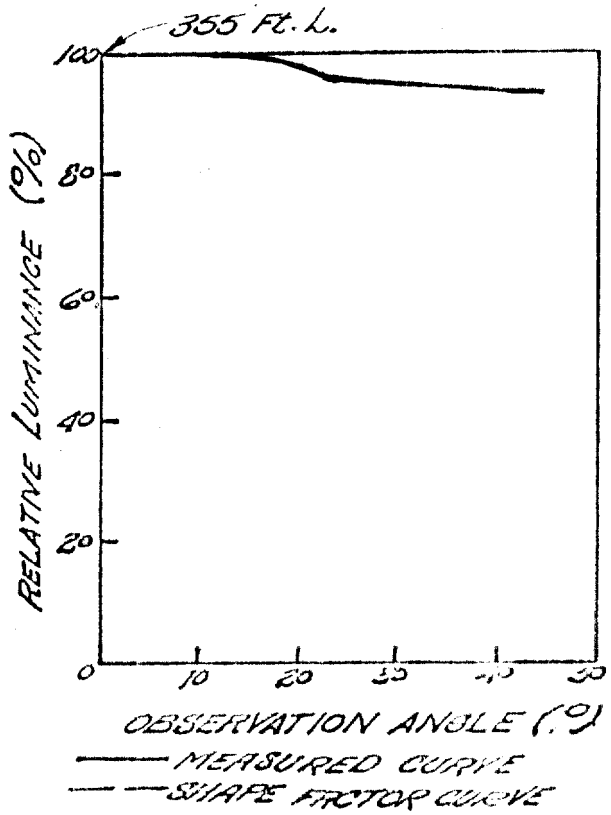
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TiO_2 - 5

TRANSMISSION (MATTE) — 11.5 %
TRANSMISSION (SMOOTH) — 11.5 %
AXIAL GAIN — 0.222
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .006 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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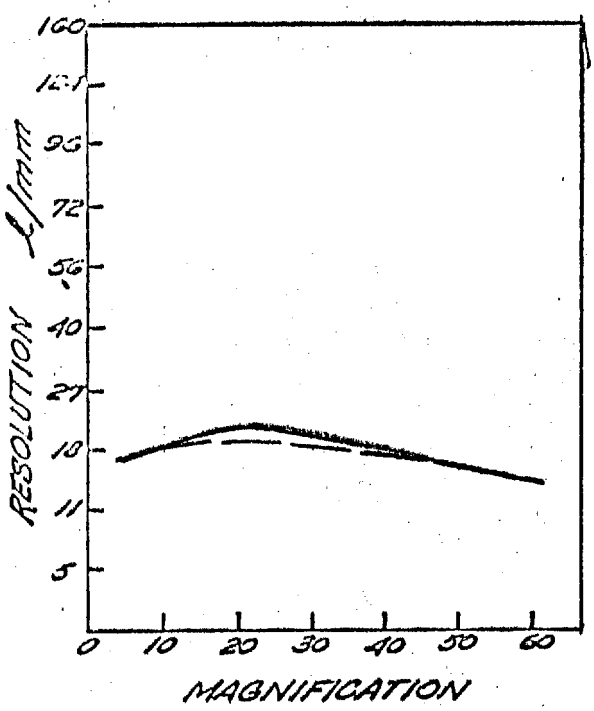
SAMPLE #51

STAT

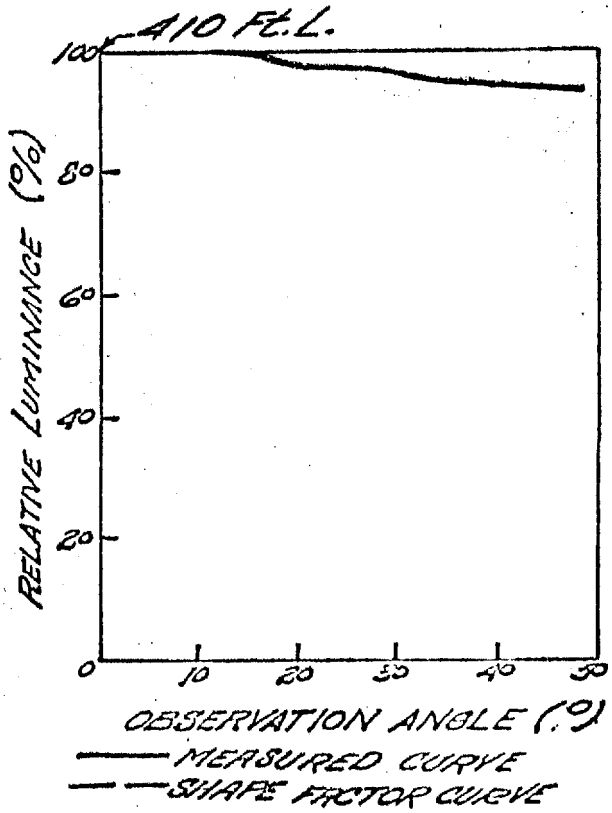
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TiO_2-6

TRANSMISSION (MATTE) — 14 %
TRANSMISSION (SMOOTH) — 13.5%
AXIAL GAIN — 0.256
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .0055 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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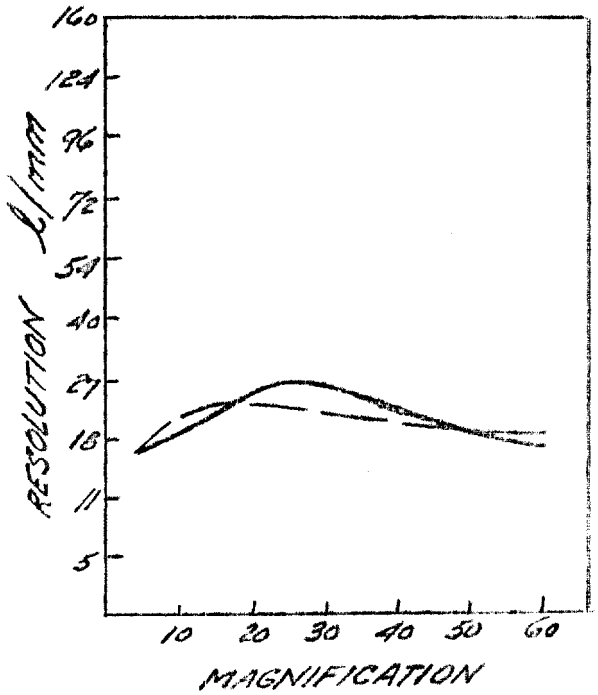
SAMPLE #52

STAT

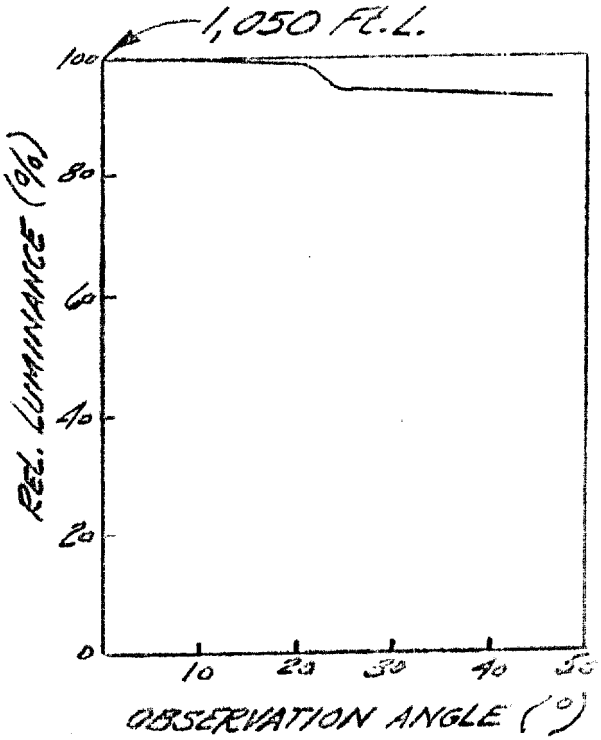
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — ZnO

TRANSMISSION (MATTE) — 37.5%
TRANSMISSION (SMOOTH) — 37.5%
AXIAL GAIN — 0.656
IMAGE BREAKUP MAGNIFICATION — 38.5
POLARIZATION QUALITIES —
THICKNESS — .005 INCHES
ANGLE (50% REL. LUM) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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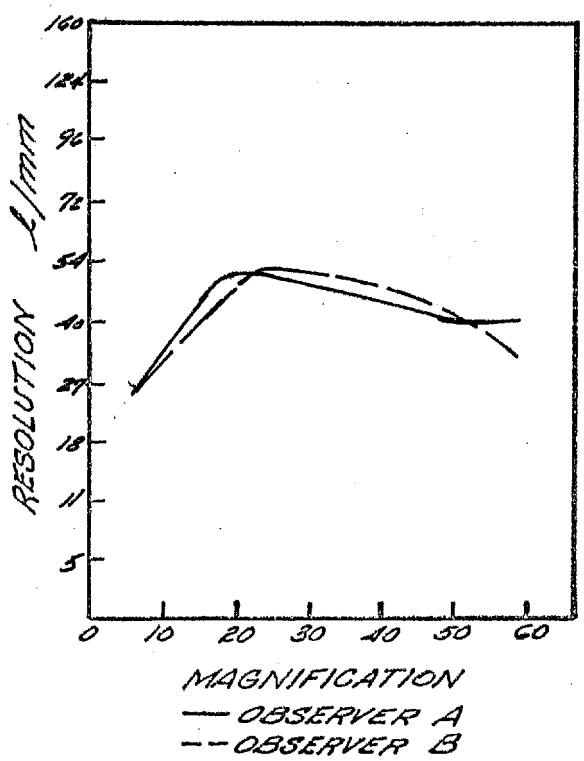
SAMPLE #53

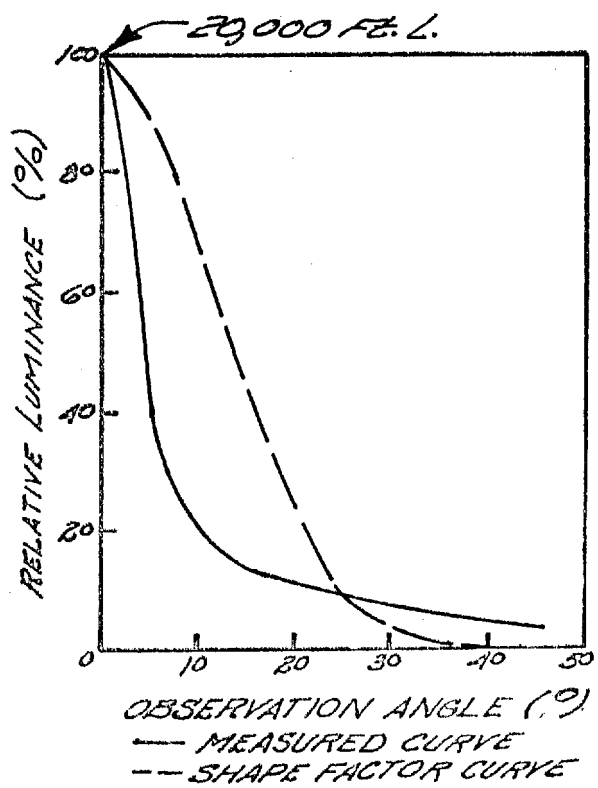
STAT

MANUFACTURER	
DESIGNATION	ULTRON UL-3
PHYSICAL STRUCTURE	FLEXIBLE VINYL
TRANSMISSION (MATTE)	66 %
TRANSMISSION (SMOOTH)	64 %
AXIAL GAIN	12.5
IMAGE BREAKUP MAGNIFICATION	26.5X
POLARIZATION QUALITIES	
THICKNESS	.003 INCHES
ANGLE (50% REL. LUM.)	5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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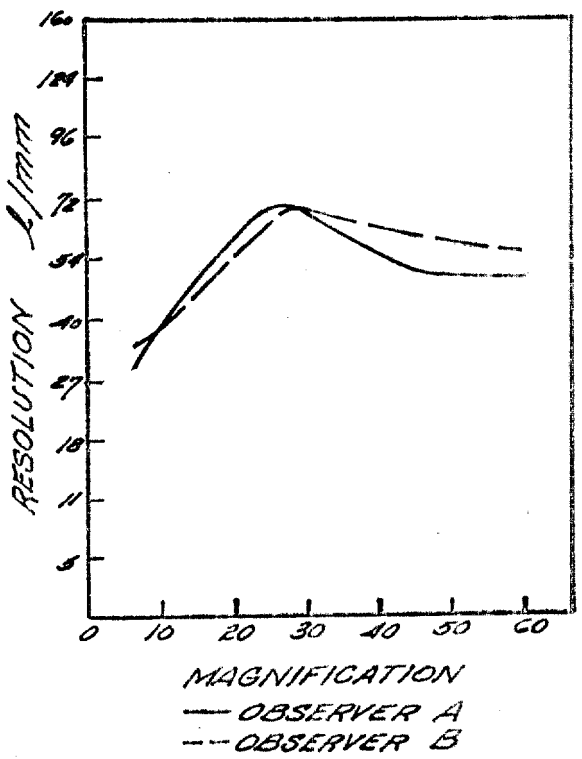
SAMPLE #54

STAT

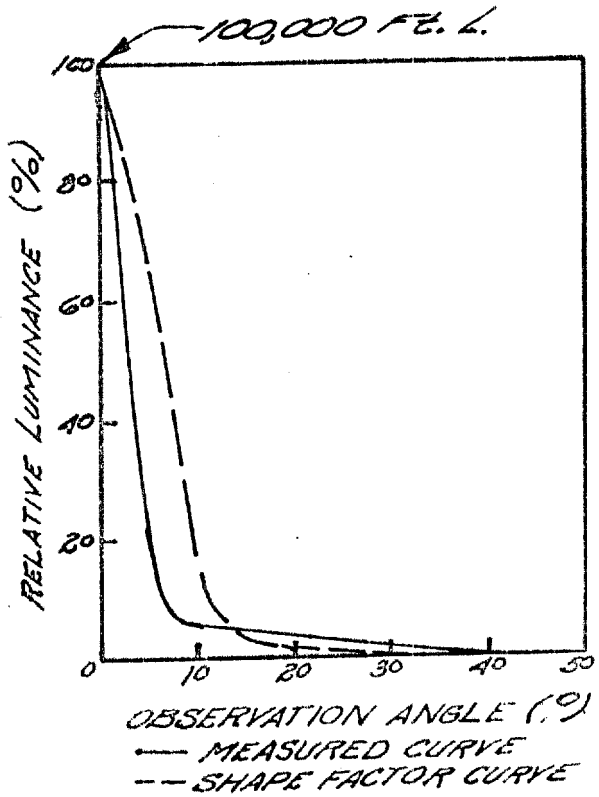
MANUFACTURER
DESIGNATION — ULTRON UL-15
PHYSICAL STRUCTURE — FLEXIBLE VINYL

TRANSMISSION (MATTE) — 75 %
TRANSMISSION (SMOOTH) — 74.5 %
AXIAL GAIN — 62.5
IMAGE BREAKUP MAGNIFICATION — 34 X
POLARIZATION QUALITIES —
THICKNESS — .004 INCHES
ANGLE (50% REL. LUM.) — 4°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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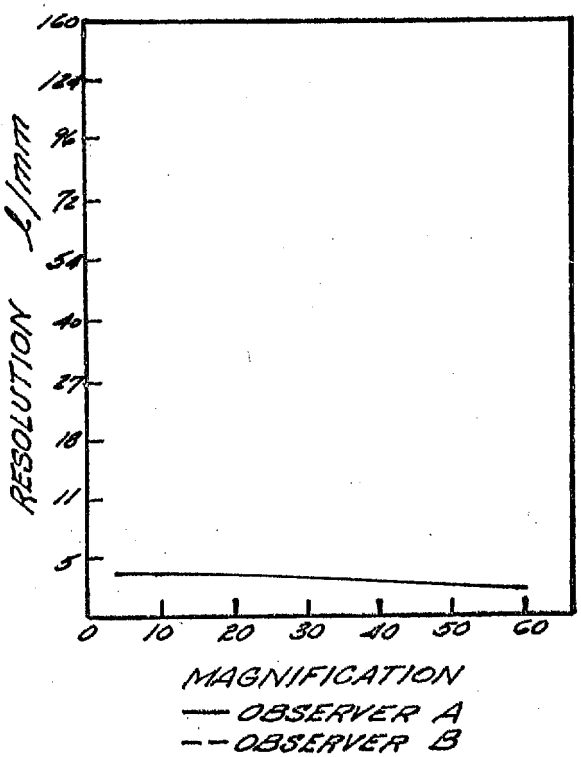
SAMPLE #55

STAT

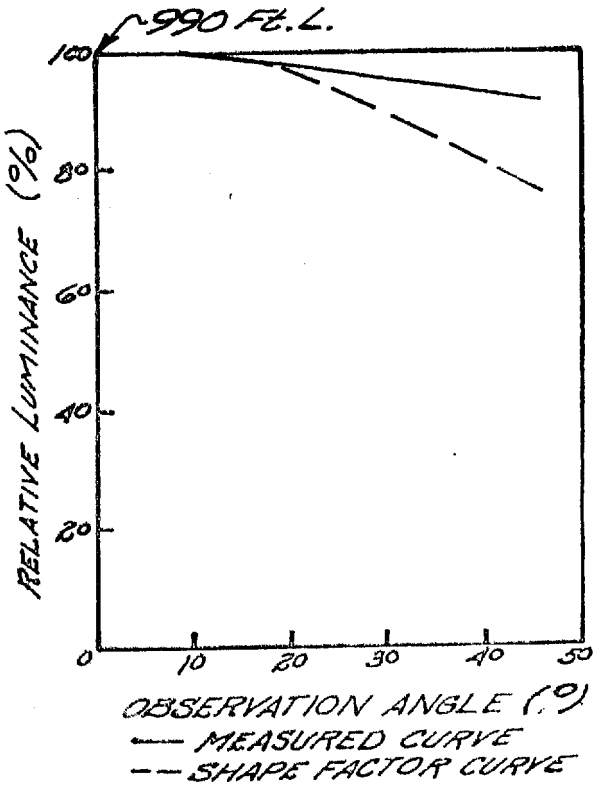
MANUFACTURER
DESIGNATION — ULTRON UL-50
PHYSICAL STRUCTURE — RIGID VINYL

TRANSMISSION (MATTE) — 30 %
TRANSMISSION (SMOOTH) — 33.5%
AXIAL GAIN — 0.618
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .009 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #56

STAT

MANUFACTURER

DESIGNATION VCA 3310 MATTE

PHYSICAL STRUCTURE : PROFILOMETER READING 35-45 RMS MATTE ACETATE SURFACE ROUGHNESS / ASA 46.1-1955, .030" STROKE

TRANSMISSION (MATTE) — 87 %

TRANSMISSION (SMOOTH) — 82 %

AXIAL GAIN — 52.5

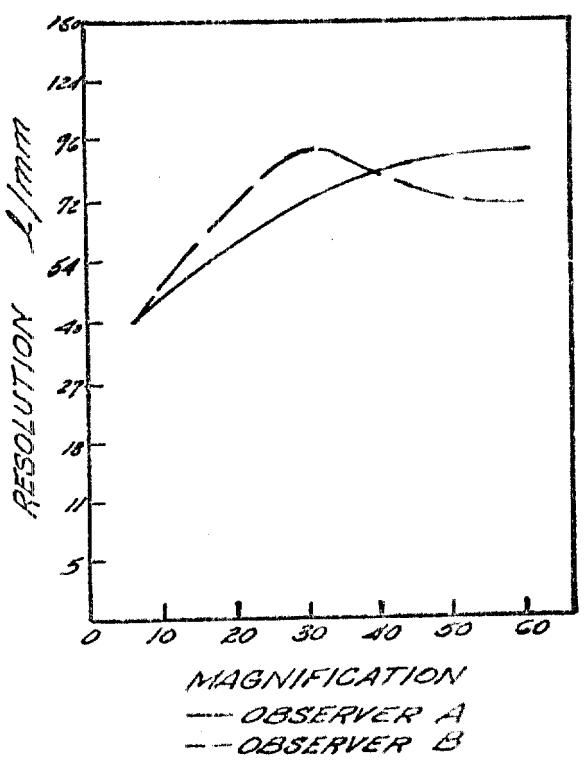
IMAGE BREAKUP MAGNIFICATION — 37.5X

POLARIZATION QUALITIES: (Ft. L) PERPENDICULAR / PARALLEL 8/2,000

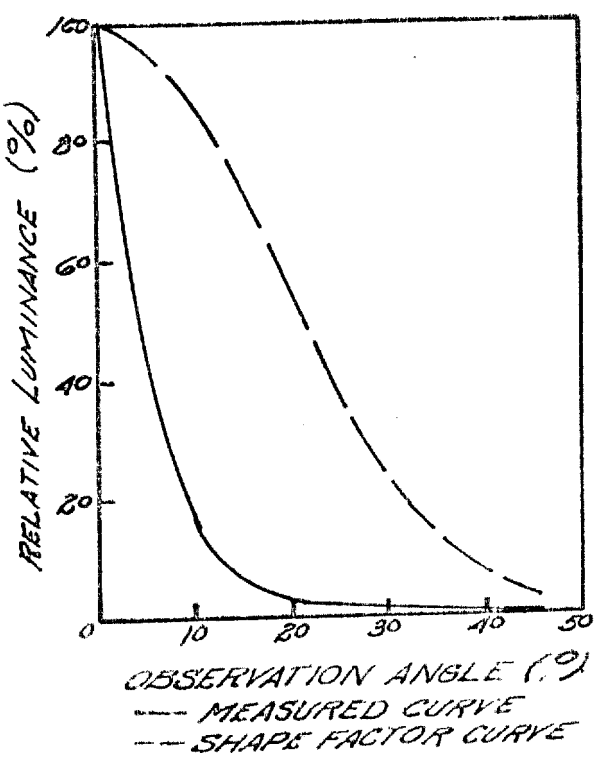
THICKNESS — .005 INCHES

ANGLE (50% REL. LUM.) — 5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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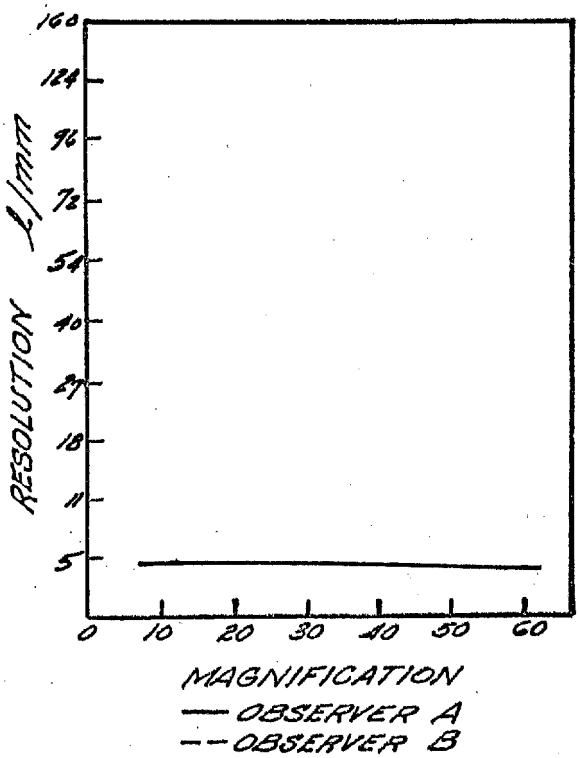
SAMPLE #57

STAT

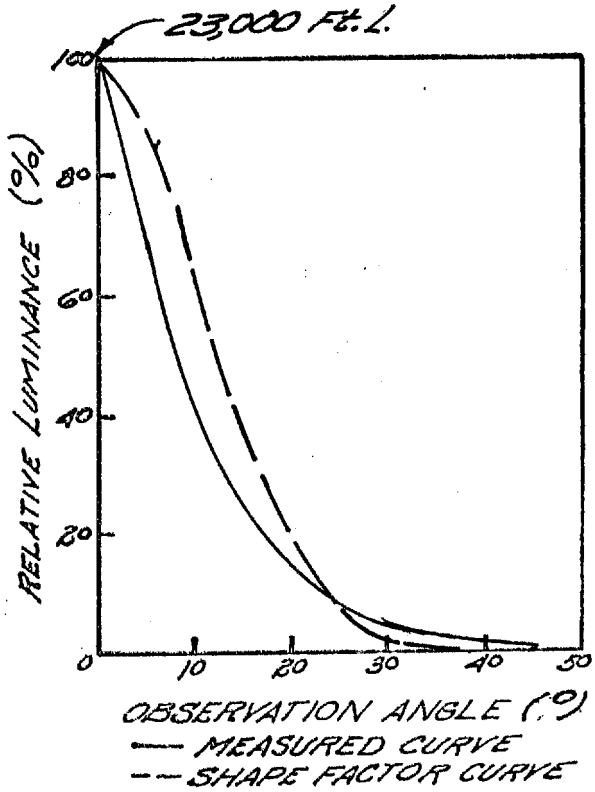
MANUFACTURER
DESIGNATION VSA3310
PHYSICAL STRUCTURE VINYL MATTE TWO SURFACES

TRANSMISSION (MATTE) — 73 %
TRANSMISSION (SMOOTH) — 74 %
AXIAL GAIN — 14.375
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES: (Ft.L.) PERPENDICULAR / PARALLEL 7/6,000
THICKNESS — .050 INCHES
ANGLE (50% REL. LUM) — 9°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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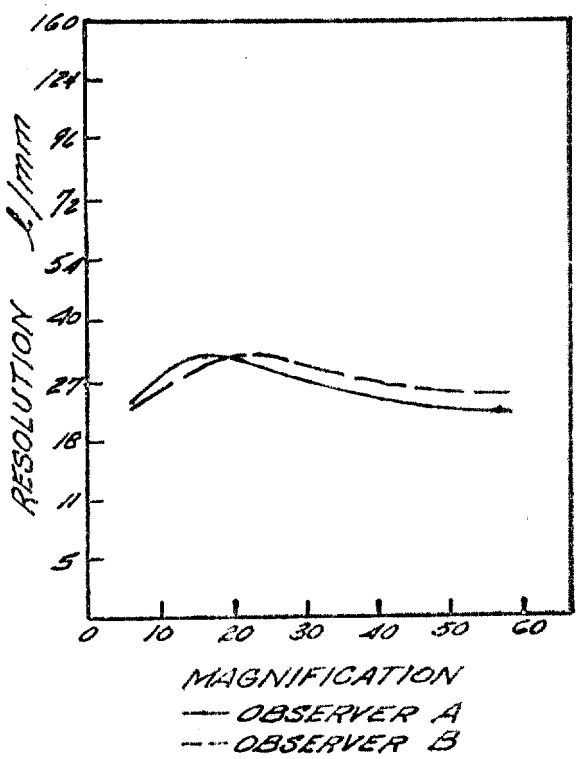
SAMPLE #58

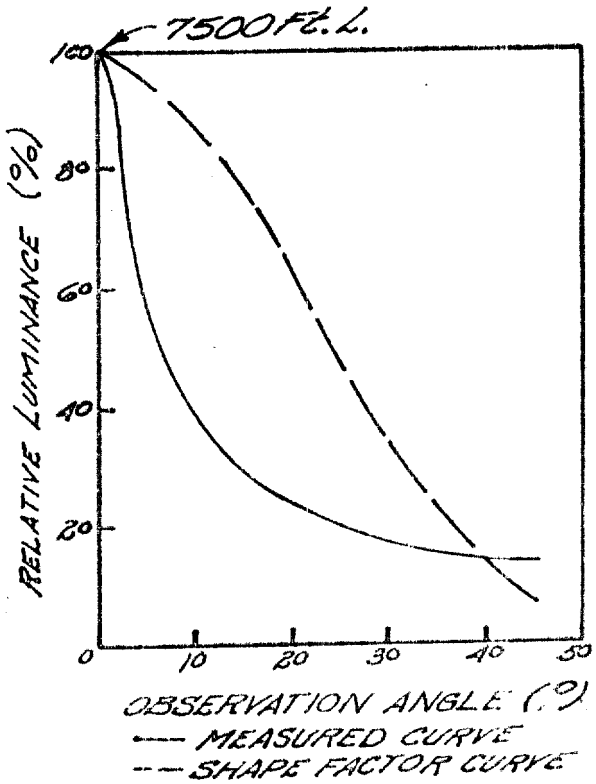
STAT

MANUFACTURER	
DESIGNATION	SOLARBRITE
PHYSICAL STRUCTURE	FLEXIBLE
TRANSMISSION (MATTE)	57.5 %
TRANSMISSION (SMOOTH)	60 %
AXIAL GAIN	4.685
IMAGE BREAKUP MAGNIFICATION	27.5 X
POLARIZATION QUALITIES	
THICKNESS	.004 INCHES
ANGLE (50% REL. LUM.)	6°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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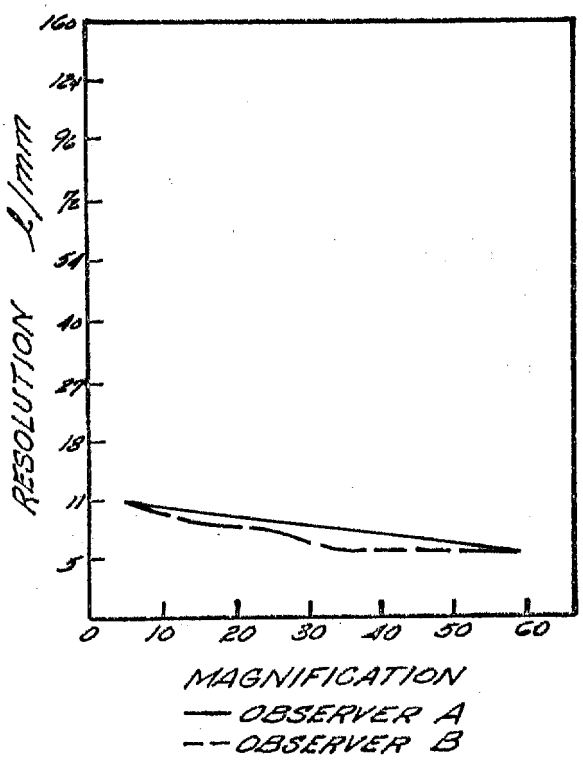
SAMPLE #59

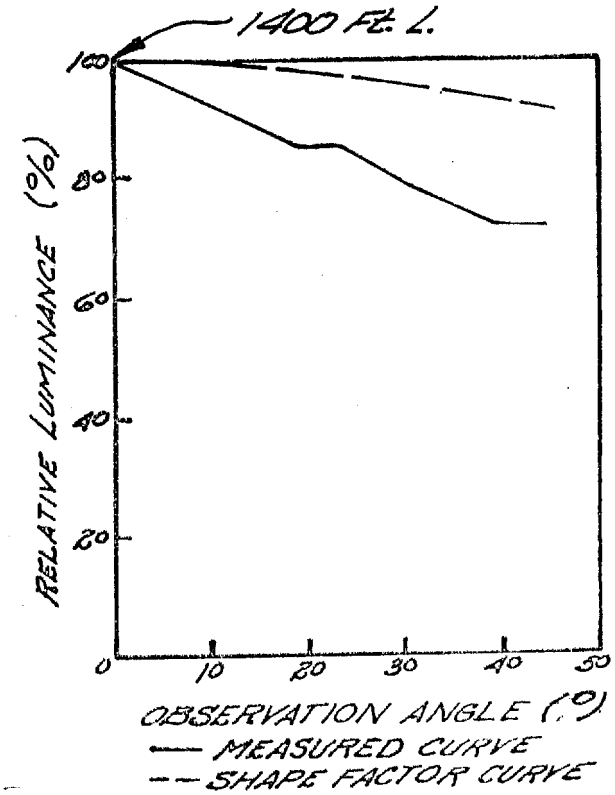
MANUFACTURER
DESIGNATION — DRAFTING PAPER
PHYSICAL STRUCTURE — WHITE FIBROUS

TRANSMISSION (MATTE) — 40 %
TRANSMISSION (SMOOTH) — 40.5%
AXIAL GAIN — 0.875
IMAGE BREAKUP MAGNIFICATION — 28X
POLARIZATION QUALITIES —
THICKNESS — .002 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #60

STAT

MANUFACTURER

DESIGNATION KALVAR

PHYSICAL STRUCTURE AERIAL TRANSPARENCY CHARACTERIZED BY N_2 BUBBLES IN SUSPENSION

TRANSMISSION (MATTE) — 46 %

TRANSMISSION (SMOOTH) — 51 %

AXIAL GAIN — NOT APPLICABLE

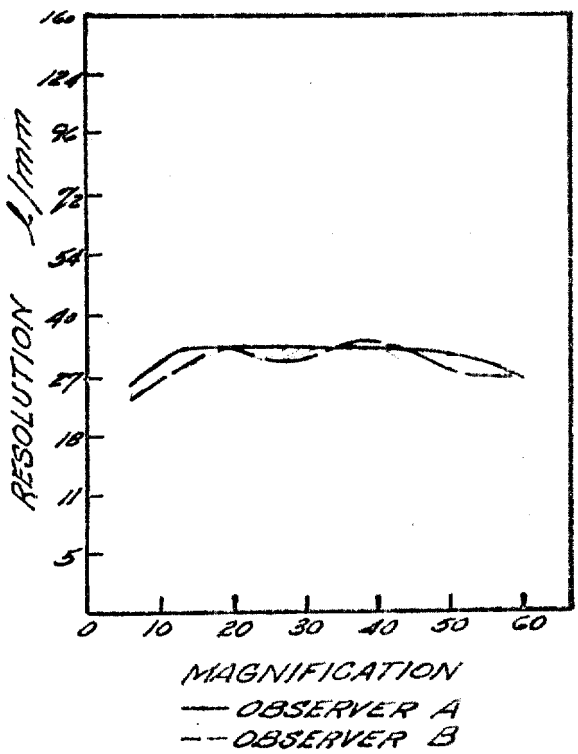
IMAGE BREAKUP MAGNIFICATION —

POLARIZATION QUALITIES —

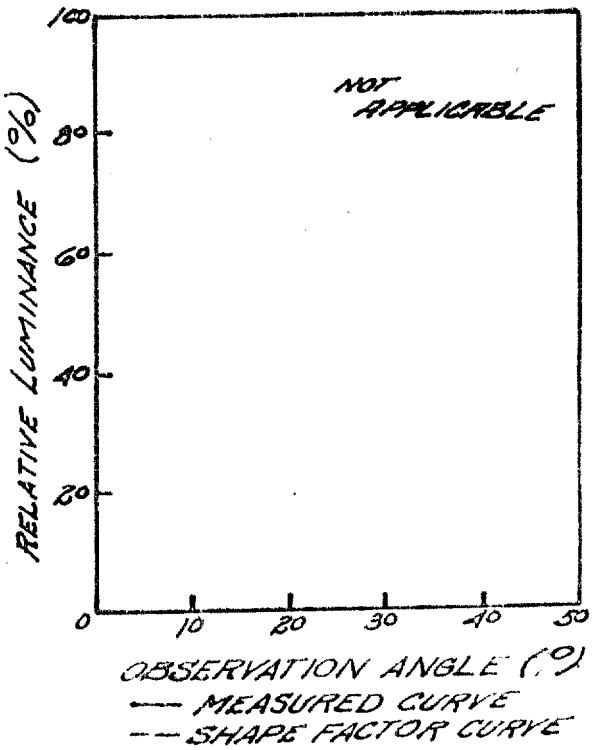
THICKNESS — .0035 INCHES

ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #61

STAT

MANUFACTURER [redacted]

DESIGNATION [redacted] DAYVIEW BLACK STAT

PHYSICAL STRUCTURE EMULSION WITH A PROTECTIVE COATING ON GLASS

TRANSMISSION (MATTE) — 28 %

TRANSMISSION (SMOOTH) — 25 %

AXIAL GAIN — 2.500

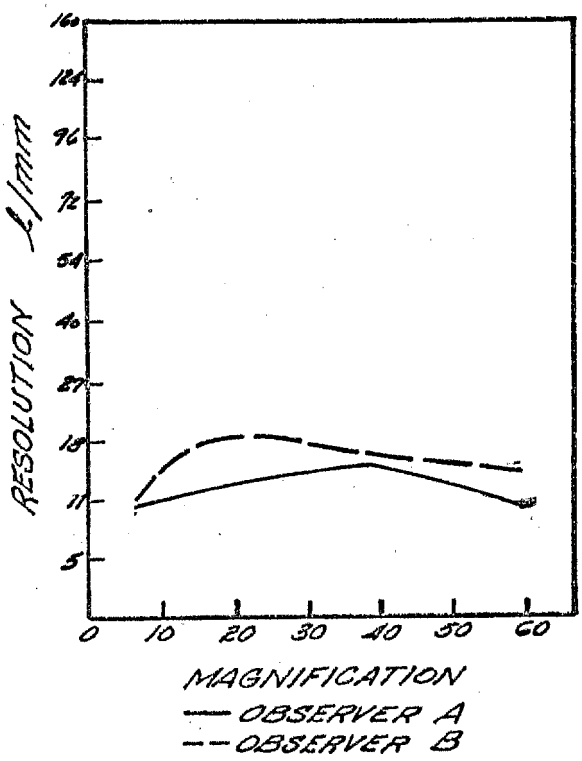
IMAGE BREAKUP MAGNIFICATION — 15.5X

POLARIZATION QUALITIES PERPENDICULAR/PARALLEL (Ft. L.) 2.6/1300

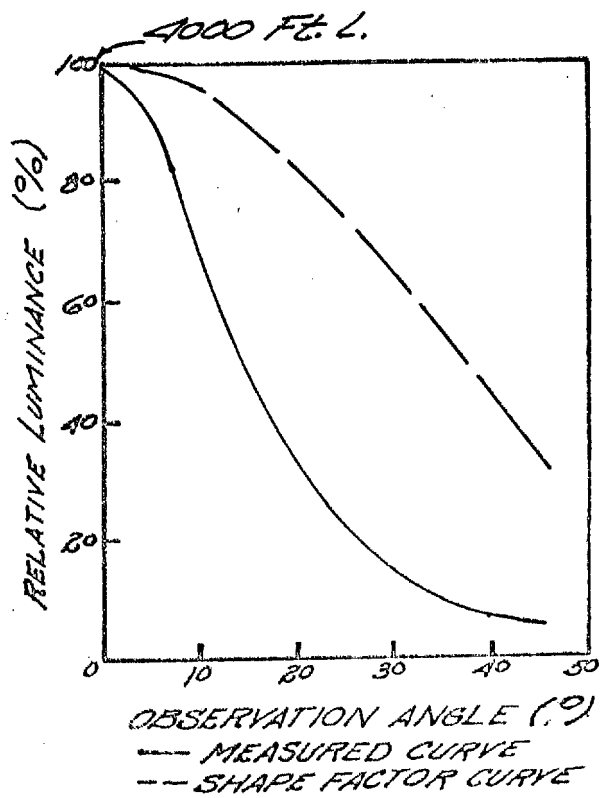
THICKNESS — .120 INCHES

ANGLE (50% REL. LUM.) — 15°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #62

STAT

MANUFACTURER [redacted]

DESIGNATION [redacted] DAYVIEW TYPE AR STAT

PHYSICAL STRUCTURE: EMULSION WITH PROTECTIVE COATING ON GLASS (GREEN)

TRANSMISSION (MATTE) — 55 %

TRANSMISSION (SMOOTH) — 48 %

AXIAL GAIN — 2.875

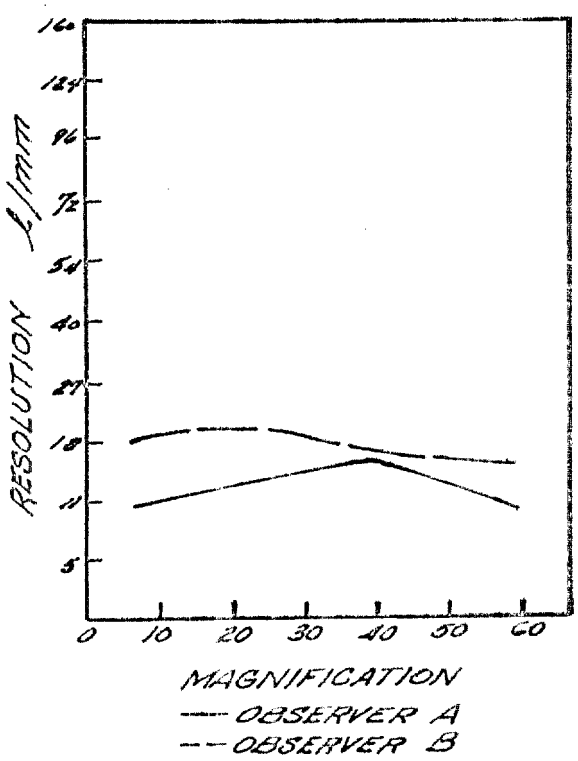
IMAGE BREAKUP MAGNIFICATION — 15.5X

POLARIZATION QUALITIES: (FL. L.) PERPENDICULAR / PARALLEL — 5 / 1500

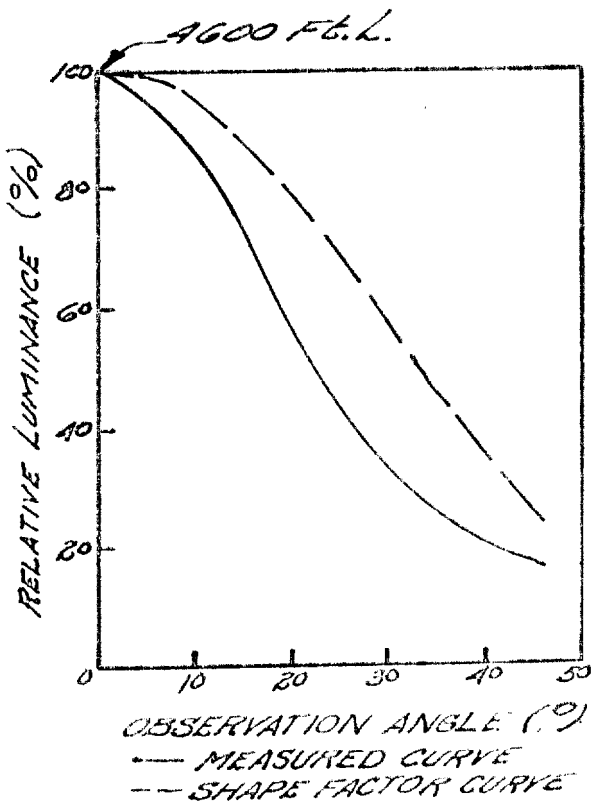
THICKNESS — .122 INCHES

ANGLE (50% REL. LUM.) — 22°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #63

STAT

MANUFACTURER [redacted]

DESIGNATION [redacted] DAYVIEW TYPE I STAT

PHYSICAL STRUCTURE—EMULSION WITH PROTECTIVE COATING ON GLASS. (WHITE)

TRANSMISSION (MATTE) — 82 %

TRANSMISSION (SMOOTH) — 80 %

AXIAL GAIN — 10.625

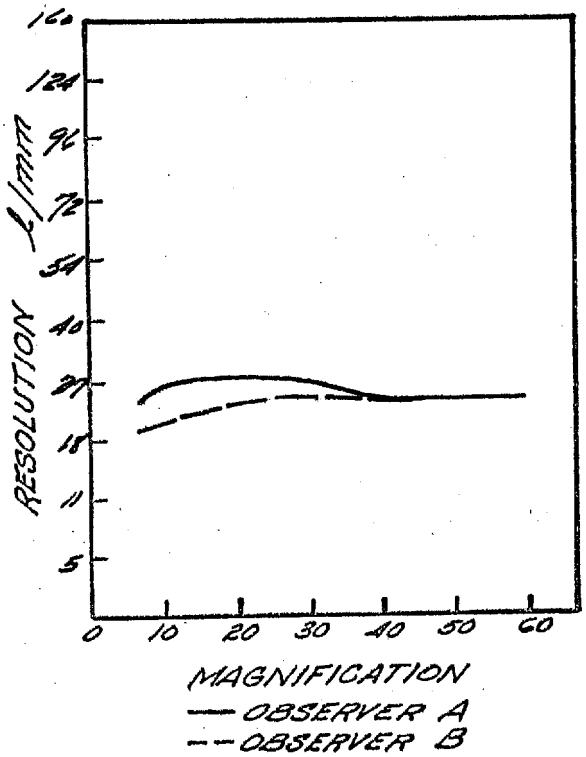
IMAGE BREAKUP MAGNIFICATION — 17 X

POLARIZATION QUALITIES (Ft.L) $\frac{\text{PERPENDICULAR}}{\text{PARALLEL}}$ = 6/5800

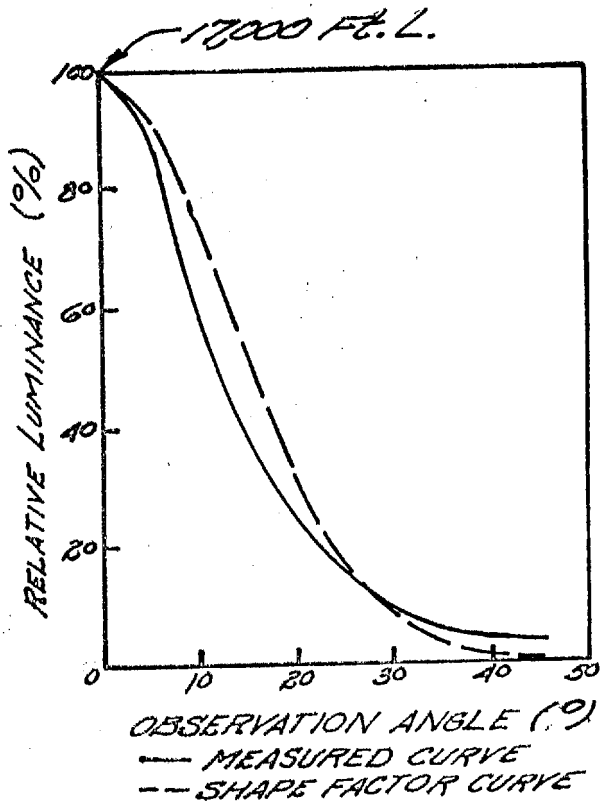
THICKNESS — .125 INCHES

ANGLE (50% REL. LUM.) — 12°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #64

STAT

MANUFACTURER [redacted]

DESIGNATION [redacted] DAYVIEW STAT

PHYSICAL STRUCTURE — EMULSION WITH PROTECTIVE COATING ON GLASS (WHITE)

TRANSMISSION (MATTE) — 80 %

TRANSMISSION (SMOOTH) — 78 %

AXIAL GAIN — 9.375

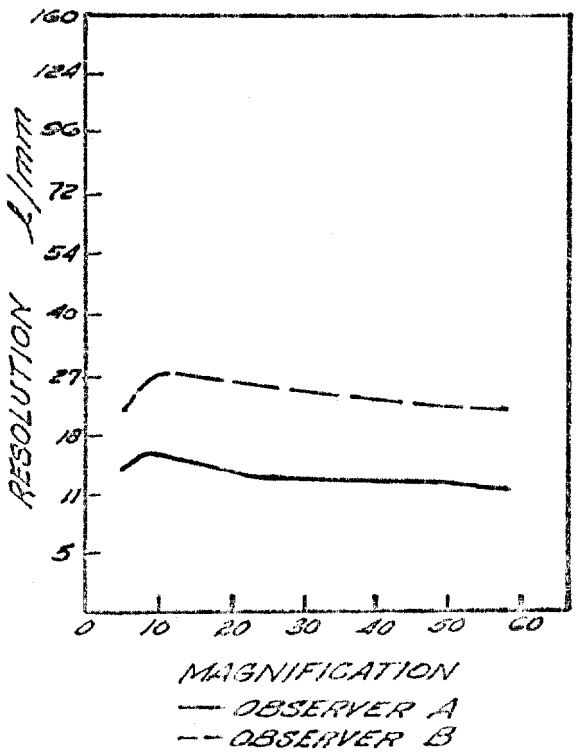
IMAGE BREAKUP MAGNIFICATION — 16.5X

POLARIZATION QUALITIES: (Ft. L) PERPENDICULAR / PARALLEL — 8 / 5000

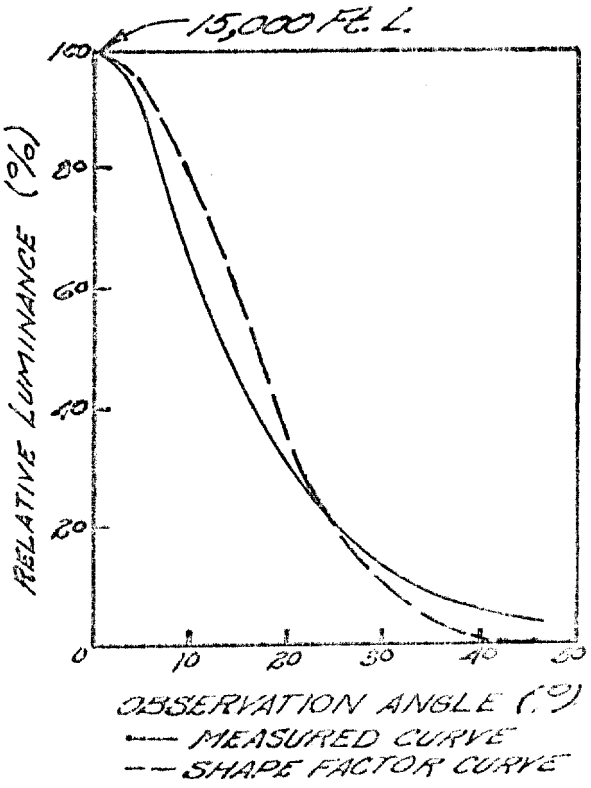
THICKNESS — .124 INCHES

ANGLE (50% REL. LUM.) — 13°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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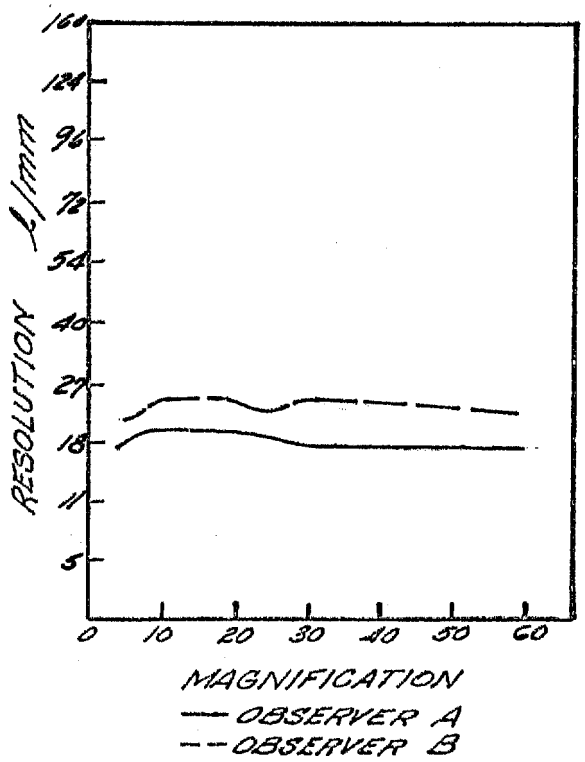
SAMPLE #65

STAT

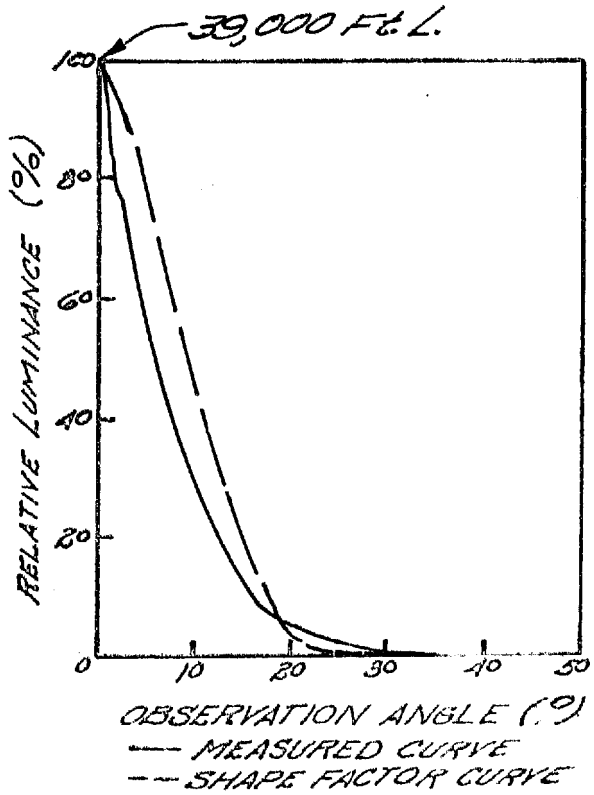
MANUFACTURER
DESIGNATION HE 1169
PHYSICAL STRUCTURE LUCITE MATTE ONE SURFACE

TRANSMISSION (MATTE) — 83.5%
TRANSMISSION (SMOOTH) — 73.5%
AXIAL GAIN — 24.375
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .112 INCHES
ANGLE (50% REL. LUM.) — 7°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #66

STAT

MANUFACTURER — [redacted]

DESIGNATION — (GREY BAKELITE/SAMPLE #30) VINYLITE (CLEAR)

PHYSICAL STRUCTURE — VINYL WITH GREY PLASTIC FOR CONTRAST IMPROVEMENT

TRANSMISSION (MATTE) — 25 %

TRANSMISSION (SMOOTH) — 22 %

AXIAL GAIN — 0.75

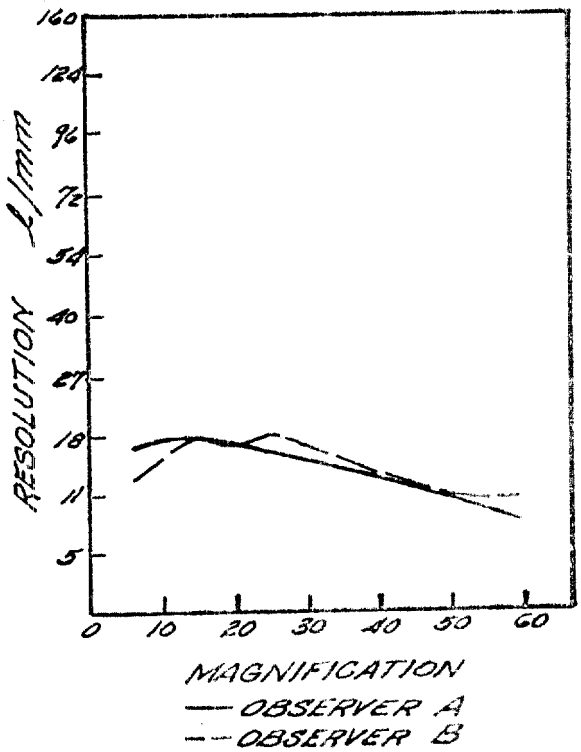
IMAGE BREAKUP MAGNIFICATION — 37X

POLARIZATION QUALITIES —

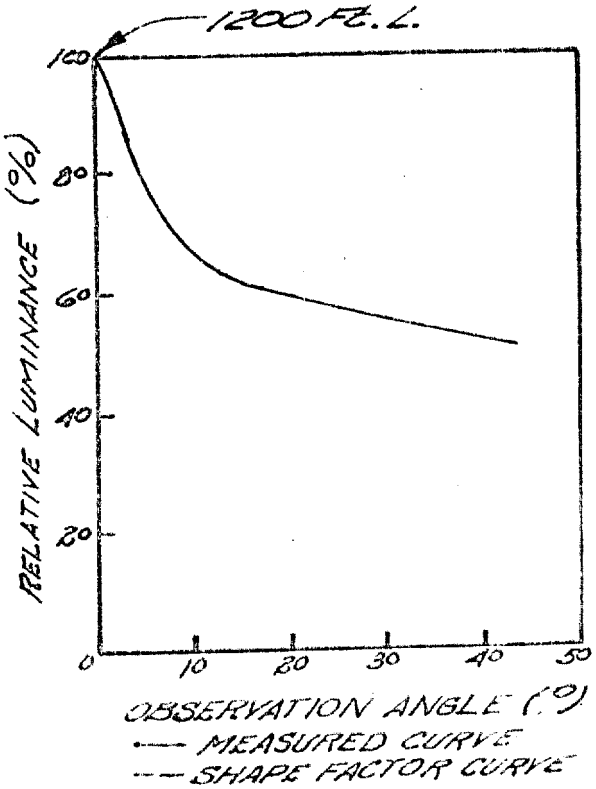
THICKNESS — .038 INCHES

ANGLE (50% REL LUM) — 45°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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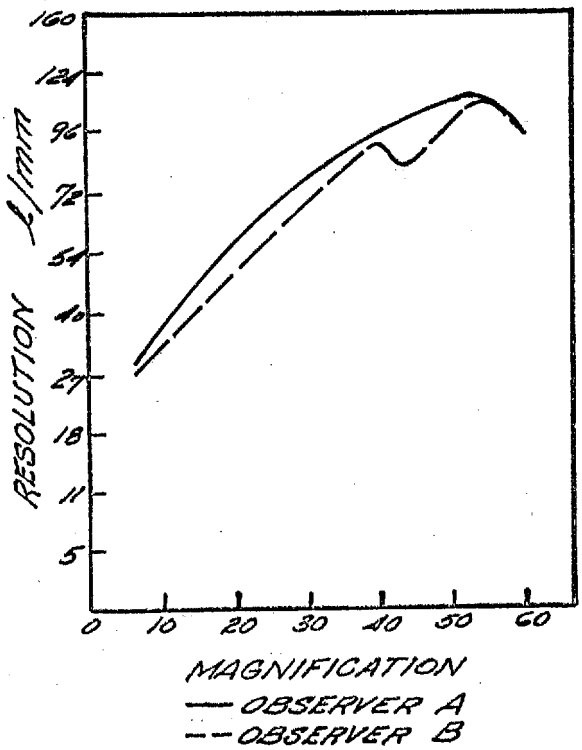
SAMPLE #67

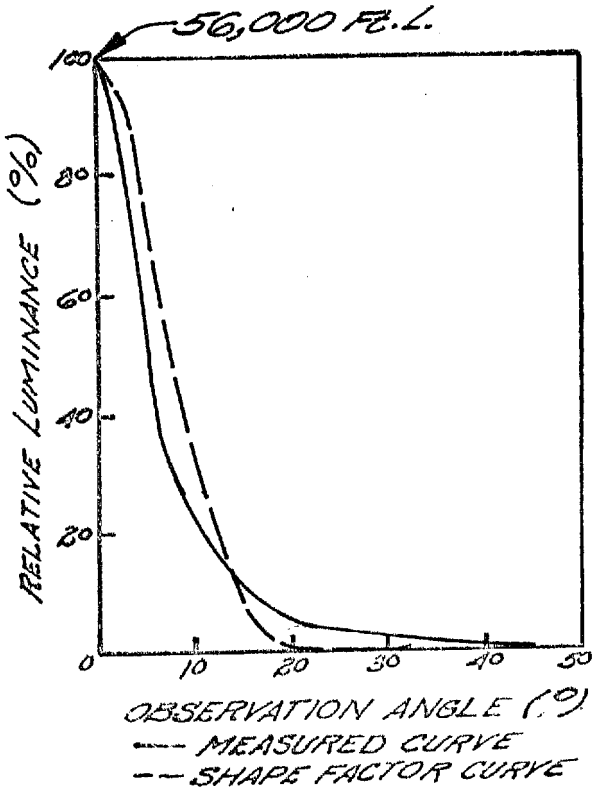
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE SEMI RIGID ACETATE, MATTE ONE SIDE

TRANSMISSION (MATTE) — 84 %
TRANSMISSION (SMOOTH) — 77.5 %
AXIAL GAIN — 35
IMAGE BREAKUP MAGNIFICATION — 32X
POLARIZATION QUALITIES —
THICKNESS — .015 INCHES
ANGLE (50% REL. LUM.) — 7°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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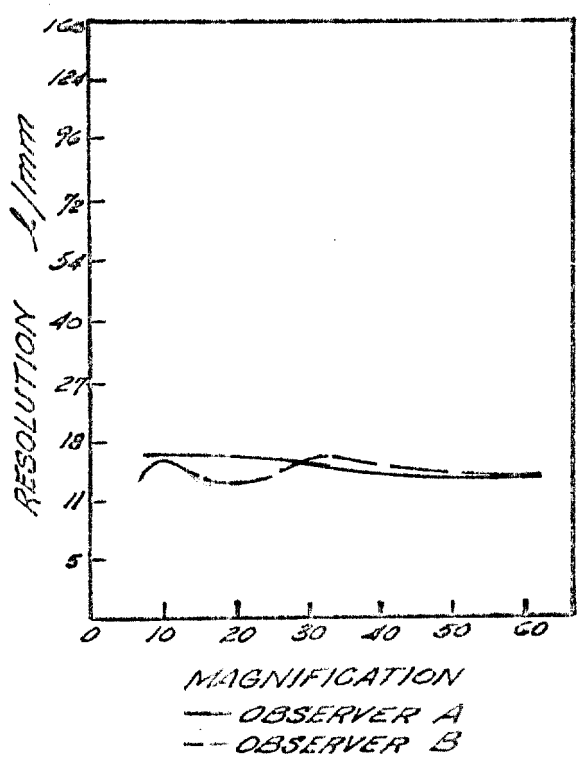
SAMPLE #68

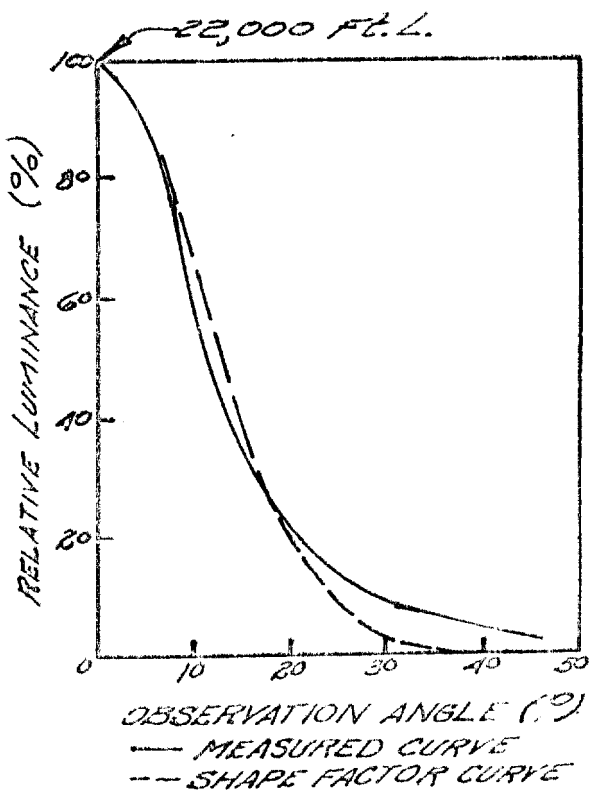
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE SEMI RIGID ACETATE MATTE 2 SURFACES

TRANSMISSION (MATTE) — 78 %
TRANSMISSION (SMOOTH) — 79.5 %
AXIAL GAIN — 13.75
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .0105 INCHES
ANGLE (50% REL. LUM.) — 11°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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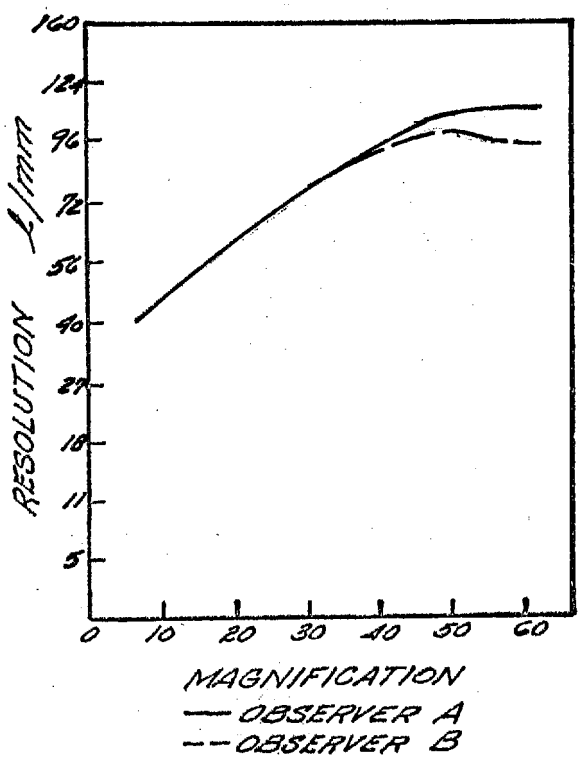
SAMPLE #69

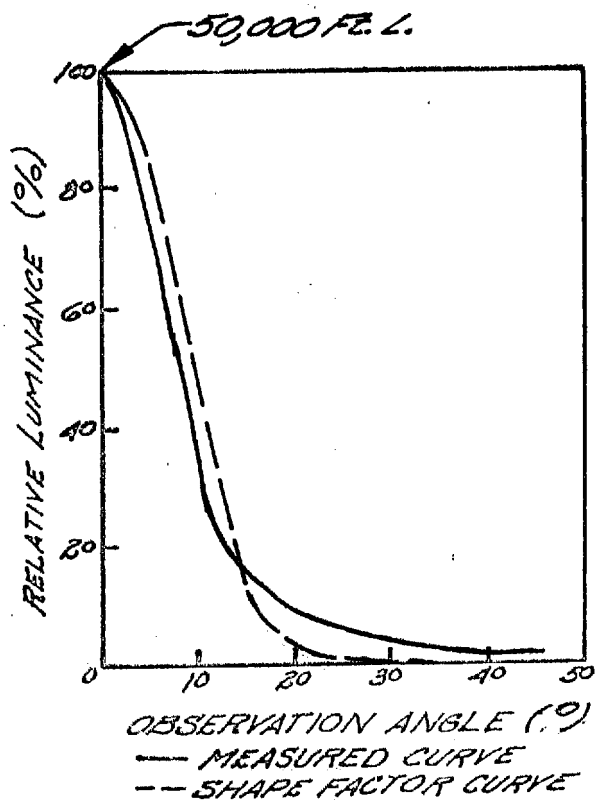
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE——SEMI RIGID ACETATE MATTE ONE SURFACE

TRANSMISSION (MATTE)————————————87 %
TRANSMISSION (SMOOTH)————————————81 %
AXIAL GAIN————————————33.33
IMAGE BREAKUP MAGNIFICATION————————39.5X
POLARIZATION QUALITIES————————————
THICKNESS————————————.0105 INCHES
ANGLE (50% REL. LUM.)————————————7.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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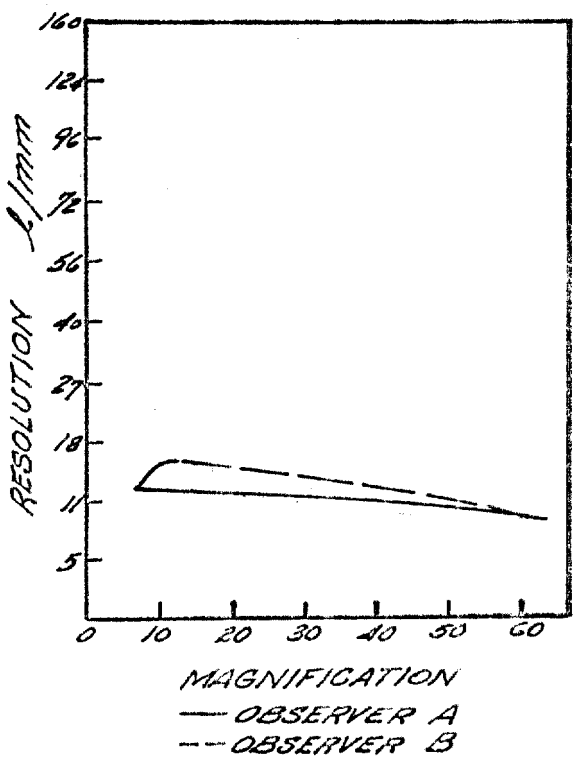
SAMPLE #70

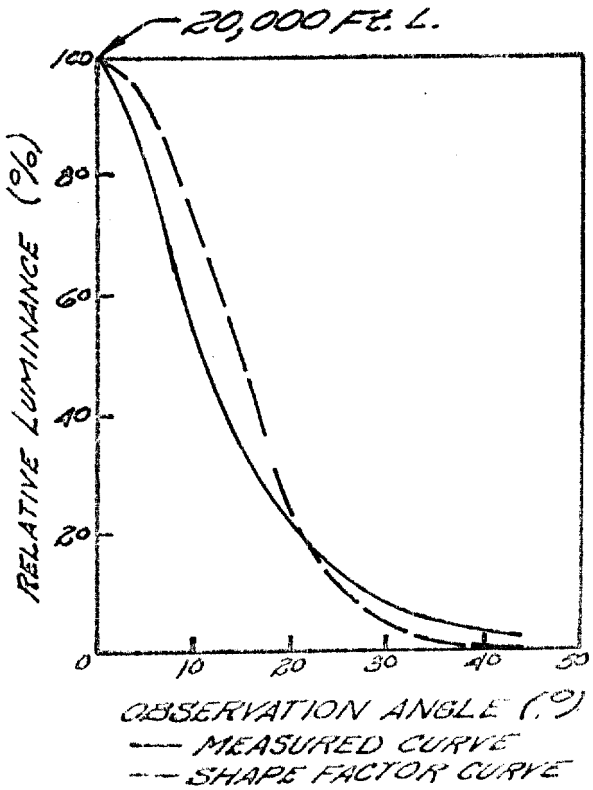
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE SEMI RIGID ACETATE, MATTE TWO SURFACES

TRANSMISSION (MATTE) — 77 %
TRANSMISSION (SMOOTH) — 76.5 %
AXIAL GAIN — 12.5
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .0145 INCHES
ANGLE (50% REL. LUM) — 12°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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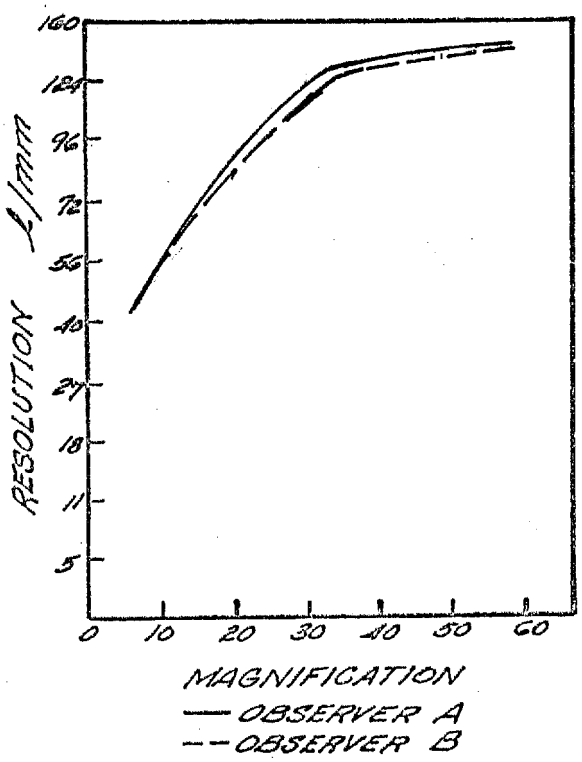
SAMPLE #71

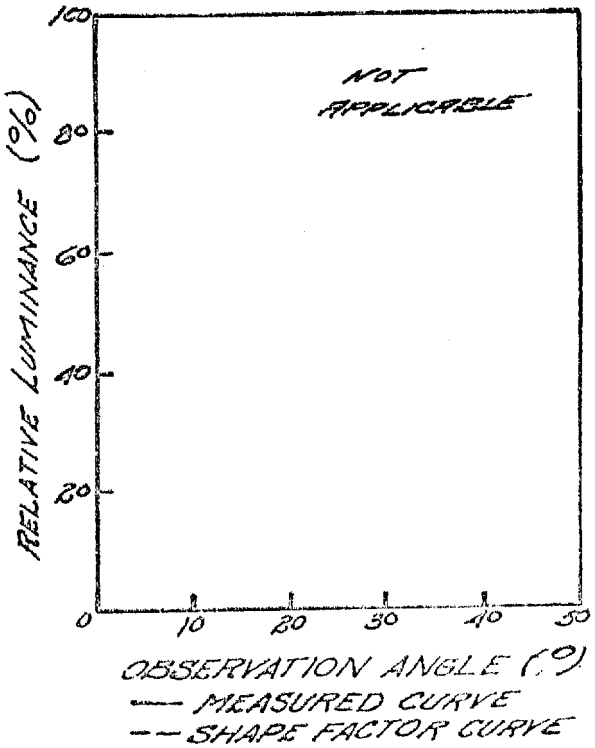
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — POLAROID MATERIAL

TRANSMISSION (MATTE) — 37 %
TRANSMISSION (SMOOTH) — 36 %
AXIAL GAIN — NOT APPLICABLE
IMAGE BREAKUP MAGNIFICATION —
POLARIZATION QUALITIES
THICKNESS — .030 INCHES

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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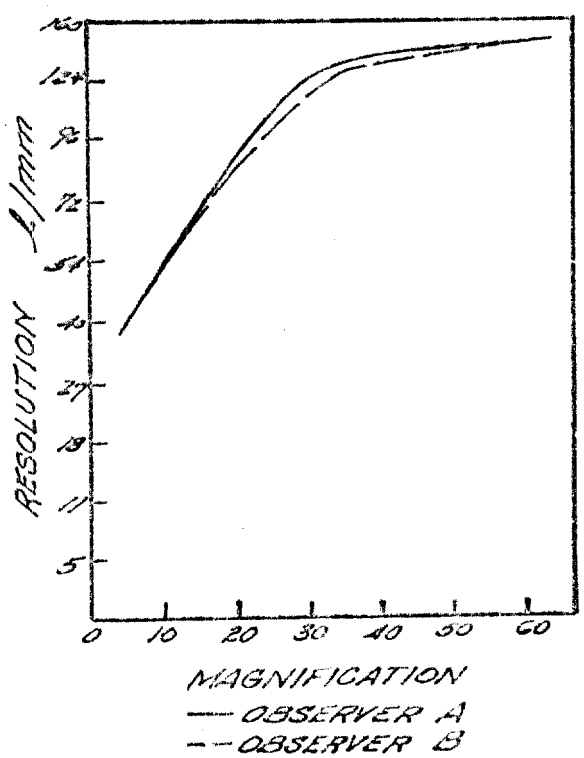
SAMPLE # 72

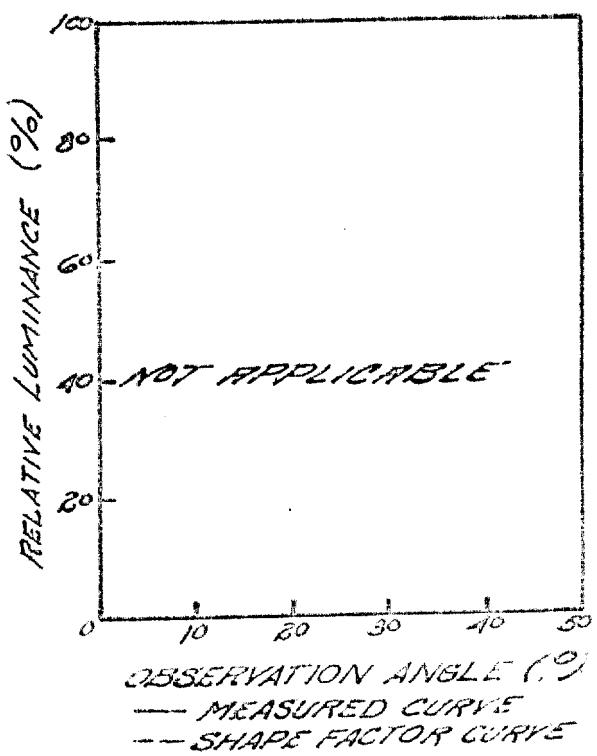
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — POLAROID MATERIAL

TRANSMISSION (MATTE) — 36.5%
TRANSMISSION (SMOOTH) — 35.5%
AXIAL GAIN — NOT APPLICABLE
IMAGE BREAKUP MAGNIFICATION —
POLARIZATION QUALITIES
THICKNESS — .030 INCHES

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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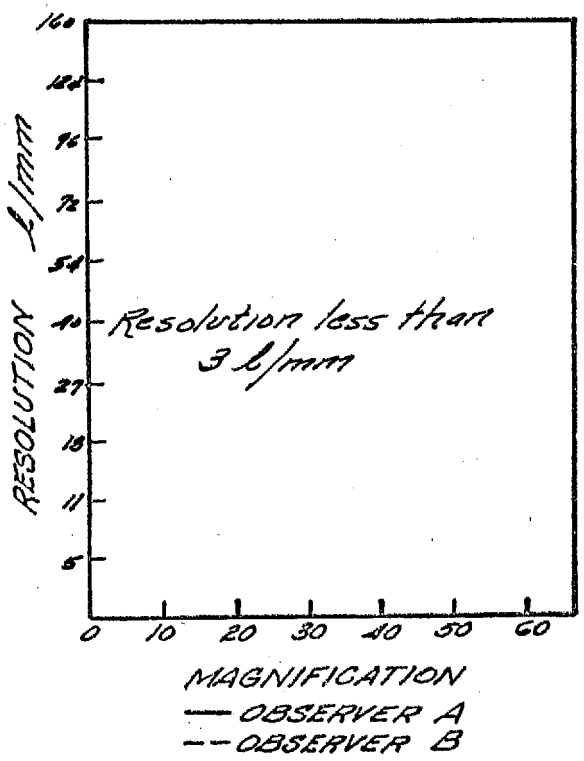
SAMPLE #73

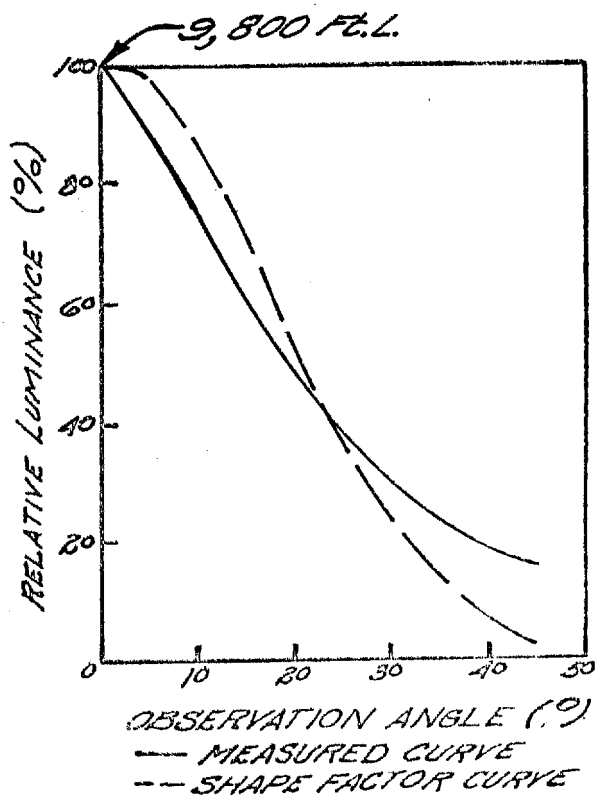
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TRANSLUCENT PLEXIGLASS

TRANSMISSION (MATTE) — 77 %
TRANSMISSION (SMOOTH) — 77.5 %
AXIAL GAIN — 6.125
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .128 INCHES
ANGLE (50% REL. LUM.) — 20°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE # 74

MANUFACTURER

DESIGNATION

PHYSICAL STRUCTURE: 30-40 RMS / ASA B46.1 for .030 STROKE, GROUND GLASS PROFILOMETER READING of SURFACE ROUGHNESS

TRANSMISSION (MATTE) ---------- 73 %

TRANSMISSION (SMOOTH) ---------- 72 %

AXIAL GAIN ---------- 10.625

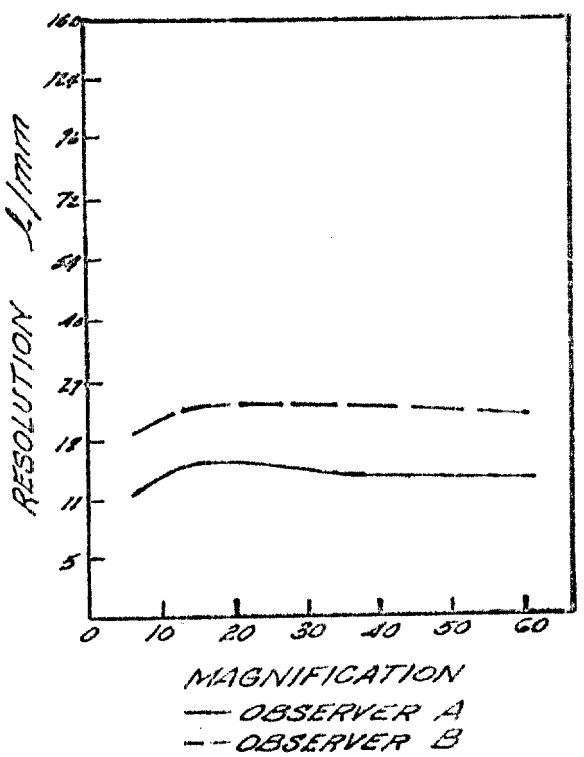
IMAGE BREAKUP MAGNIFICATION ---------- 21.5X

POLARIZATION QUALITIES: (Ft. L) PERPENDICULAR / PARALLEL 4.8 / 4800

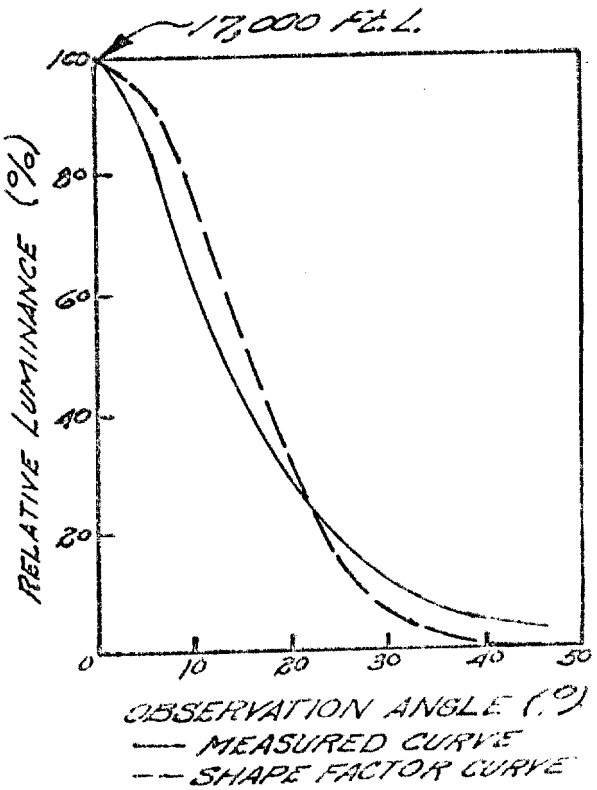
THICKNESS ---------- .131 INCHES

ANGLE (50% REL. LUM.) ---------- 12.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #75

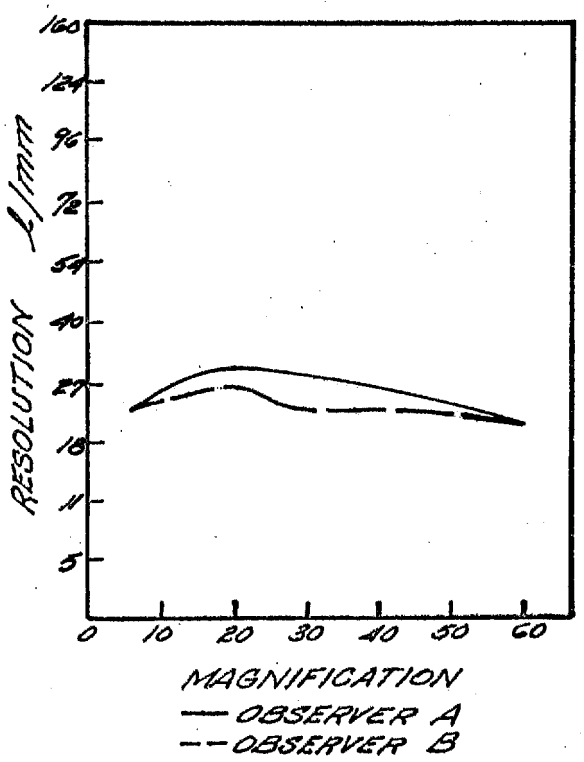
MANUFACTURER

DESIGNATION

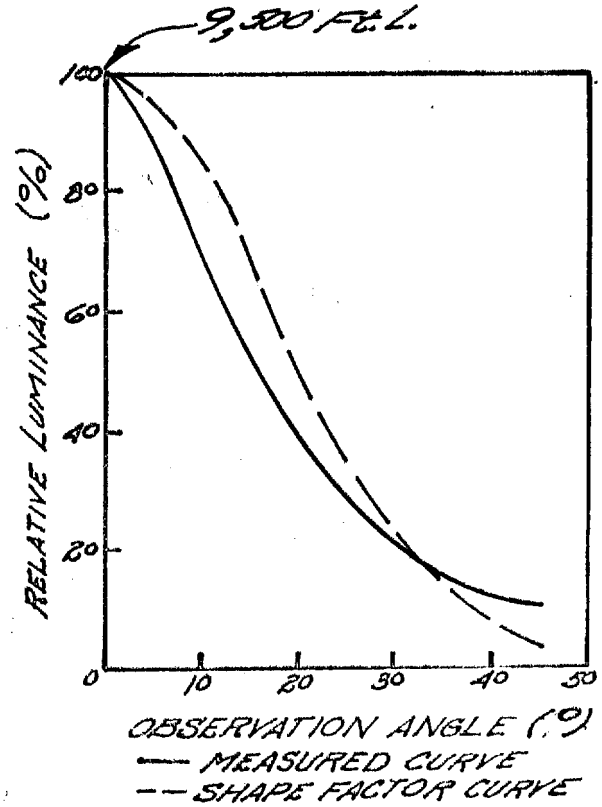
PHYSICAL STRUCTURE: 15-18 RMS/ASA 46.1-1955 ——— GROUND GLASS
.030 STROKE PROFILOMETER READING of SURF. ROUGHNESS

TRANSMISSION (MATTE) ——————————— 59 %
TRANSMISSION (SMOOTH) ——————————— 58.5 %
AXIAL GAIN ——————————————————— 5.9375
IMAGE BREAKUP MAGNIFICATION ——————————— 22 X
POLARIZATION QUALITIES: (Ft.L) PERPENDICULAR/PARALLEL 28/6,500
THICKNESS ——————————————————. 126 INCHES
ANGLE (50% REL. LUM.) ——————————— 15°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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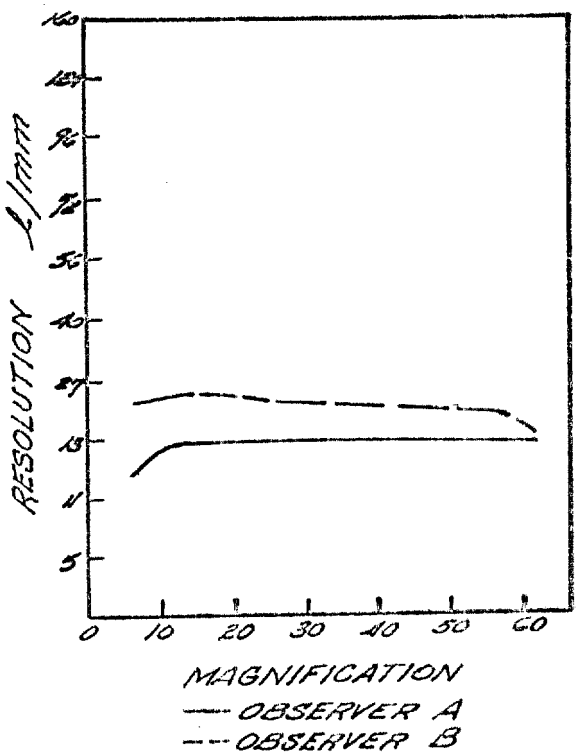
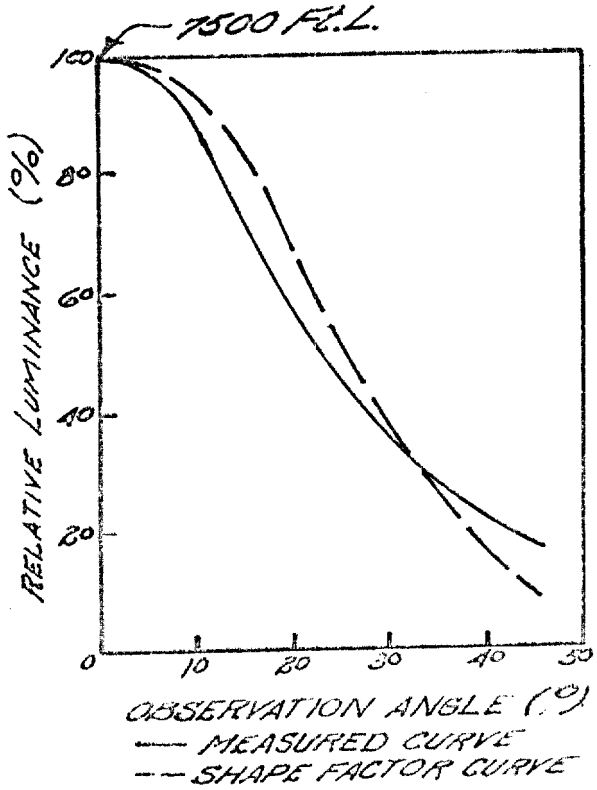
SAMPLE #76

MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE: 20-25 AMS/ASA 46.1-1955 — GROUND GLASS
.030 STROKE PROFILOMETER READING of SURFACE ROUGHNESS.
TRANSMISSION (MATTE) — 65 %
TRANSMISSION (SMOOTH) — 63 %
AXIAL GAIN — 4.685
IMAGE BREAKUP MAGNIFICATION — 21.5X
POLARIZATION QUALITIES: (Ft.L.) PERPENDICULAR / PARALLEL 7/2200
THICKNESS — .129 INCHES
ANGLE (50% REL. LUM.) — 21.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #77

MANUFACTURER

DESIGNATION

PHYSICAL STRUCTURE: 35-40 RMS / ASA 46.1-1955 — GROUND GLASS
.030 STROKE PROFILOMETER READING of SURFACE ROUGHNESS

TRANSMISSION (MATTE) — 83 %

TRANSMISSION (SMOOTH) — 75.5%

AXIAL GAIN — 28.1125

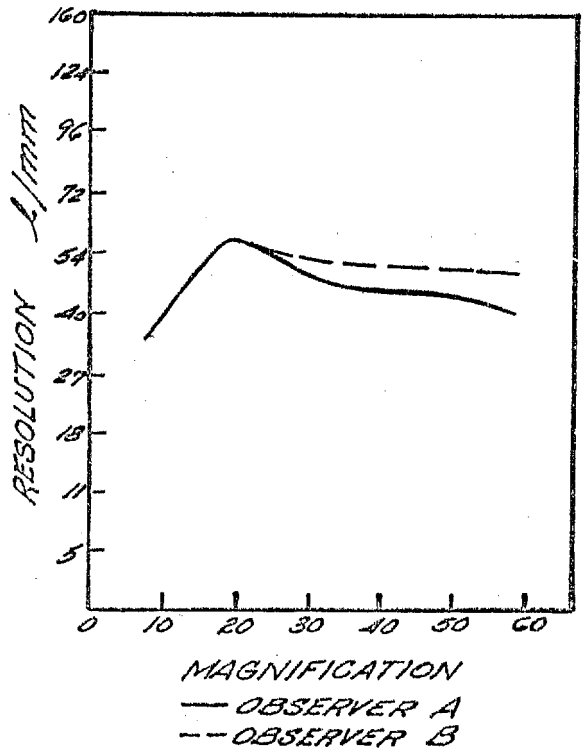
IMAGE BREAKUP MAGNIFICATION — 39X

POLARIZATION QUALITIES (Ft.L.) PERPENDICULAR / PARALLEL 9/12,000

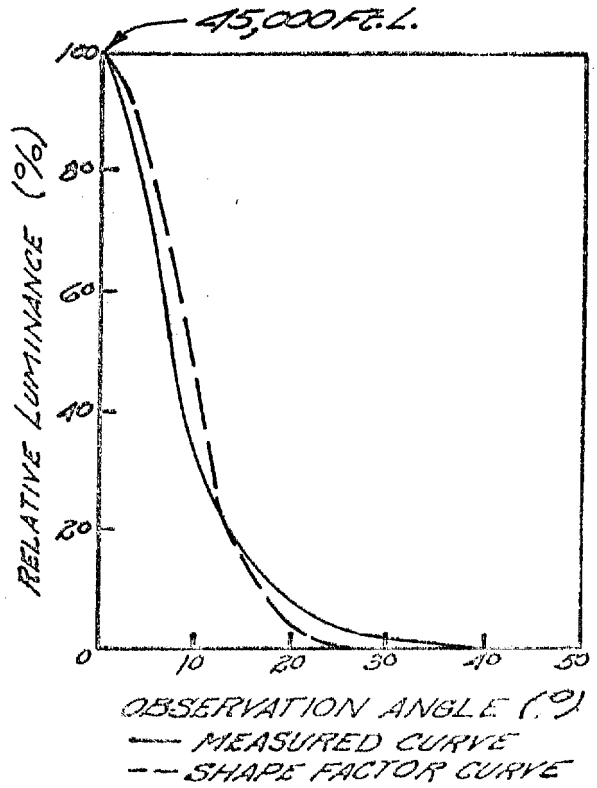
THICKNESS — .092 INCHES

ANGLE (50% REL. LUM.) — 7.5%

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE # 78

MANUFACTURER

DESIGNATION

PHYSICAL STRUCTURE : 5-6 RMS / ASA 46.1-1955 ——— GROUND GLASS
.030 STROKE PROFILOMETER READING of SURFACE ROUGHNESS.

TRANSMISSION (MATTE) ——— 90 %

TRANSMISSION (SMOOTH) ——— 90 %

AXIAL GAIN ——— NOT APPLICABLE

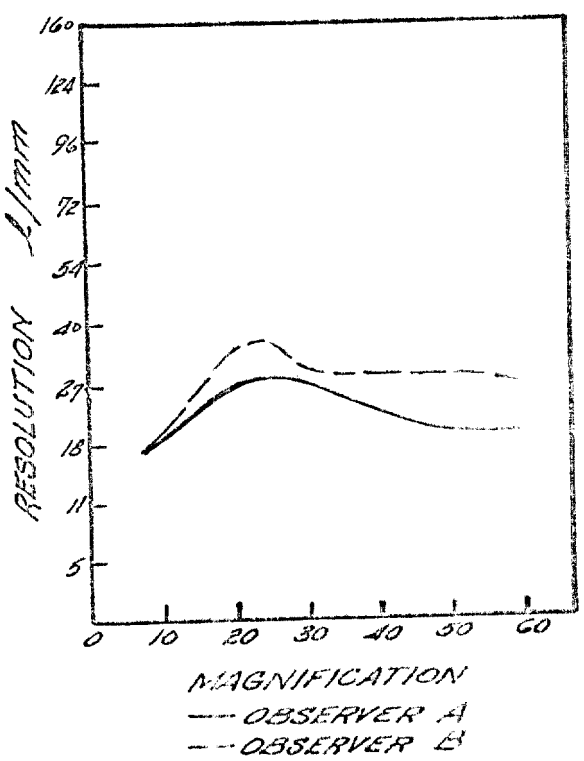
IMAGE BREAKUP MAGNIFICATION ——— 40 X

POLARIZATION QUALITIES: (Ft. L.) PERPENDICULAR / PARALLEL 20/200,000

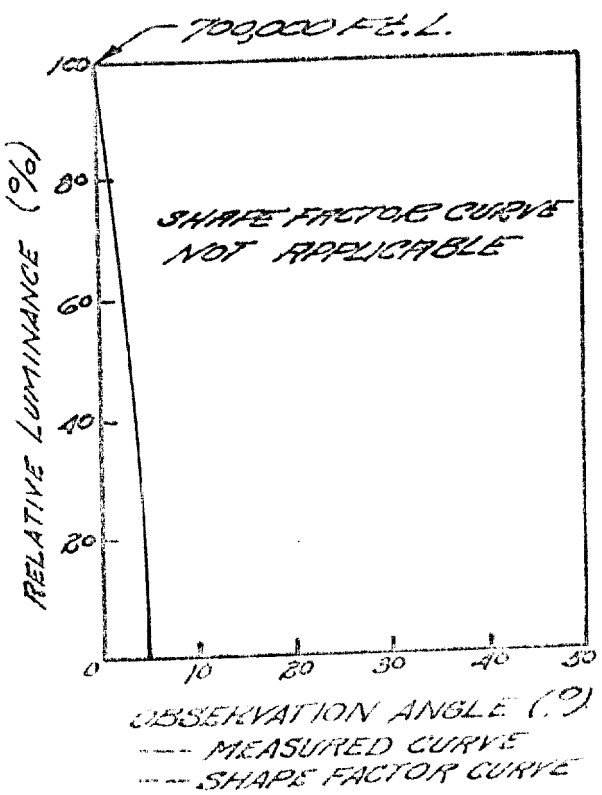
THICKNESS ——— .088 INCHES

ANGLE (50% REL. LUM) ——— 2.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #79

MANUFACTURER

DESIGNATION

PHYSICAL STRUCTURE: 28-30 RMS / ASA 46.1-1955 — GROUND GLASS
.030 STROKE PROFILOMETER READING of SURFACE ROUGHNESS

TRANSMISSION (MATTE) — 84%

TRANSMISSION (SMOOTH) — 77%

AXIAL GAIN — 30.00

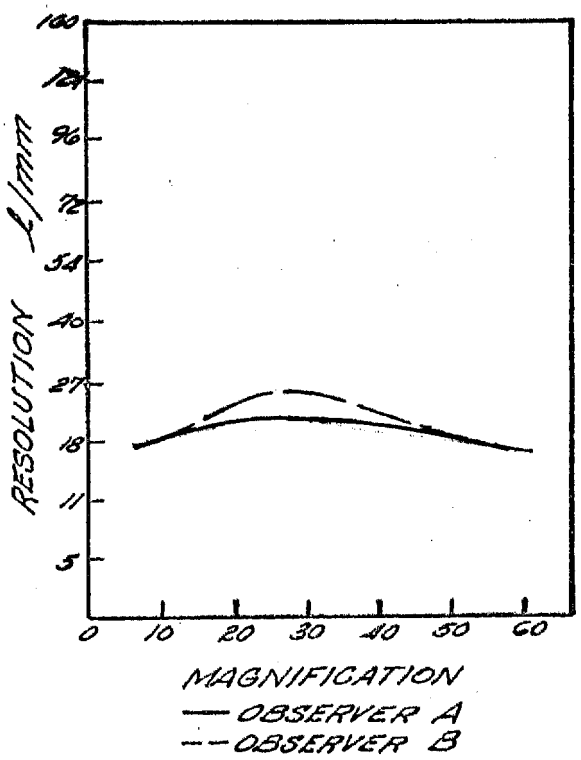
IMAGE BREAKUP MAGNIFICATION — 40X

POLARIZATION QUALITIES: (Ft.L.) PERPENDICULAR / PARALLEL 9/13,000

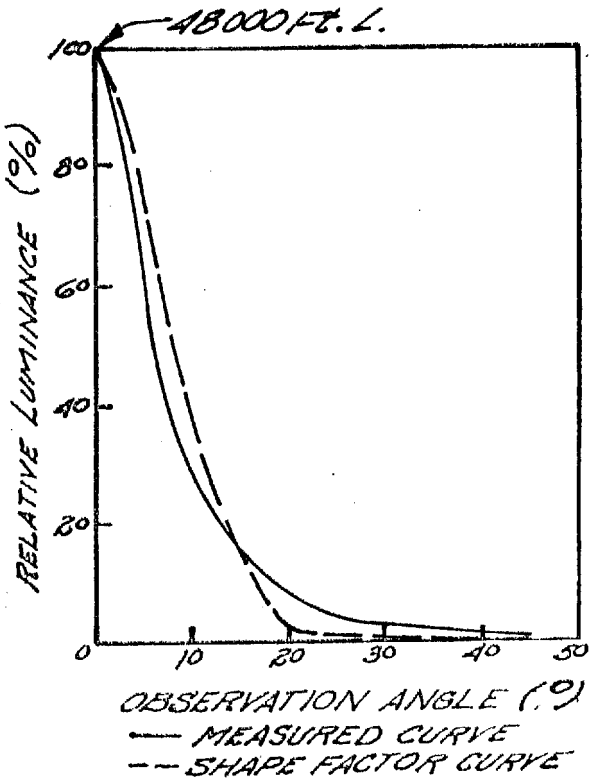
THICKNESS — .129 INCHES

ANGLE 50% REL. LUM. — 7°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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SAMPLE #80

MANUFACTURER

DESIGNATION

PHYSICAL STRUCTURE: 30-35 RMS / ASA 46.1-1955 - GROUND GLASS
.030 STYLUS PROFILOMETER READING of SURF. ROUGHNESS.

TRANSMISSION (MATTE) — 62 %

TRANSMISSION (SMOOTH) — 58 %

AXIAL GAIN — 4.375

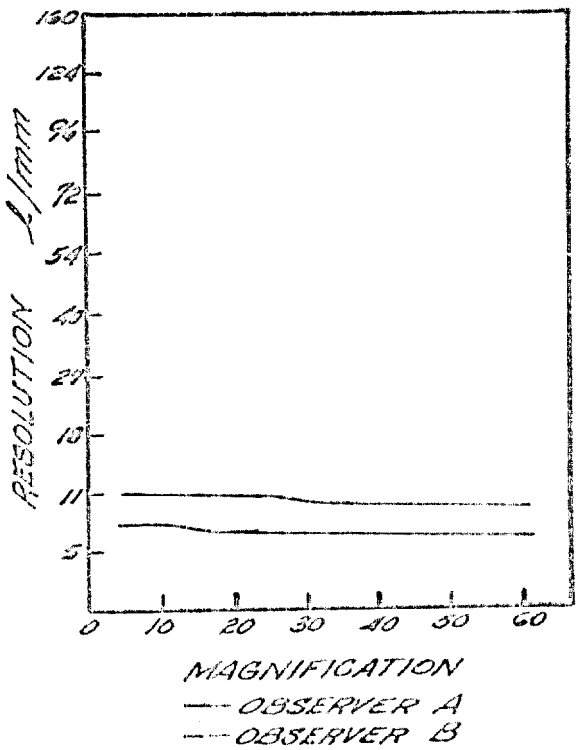
IMAGE BREAKUP MAGNIFICATION — 33.5X

POLARIZATION QUALITIES: (Ft.L.) PERPENDICULAR / PARALLEL 9/2000

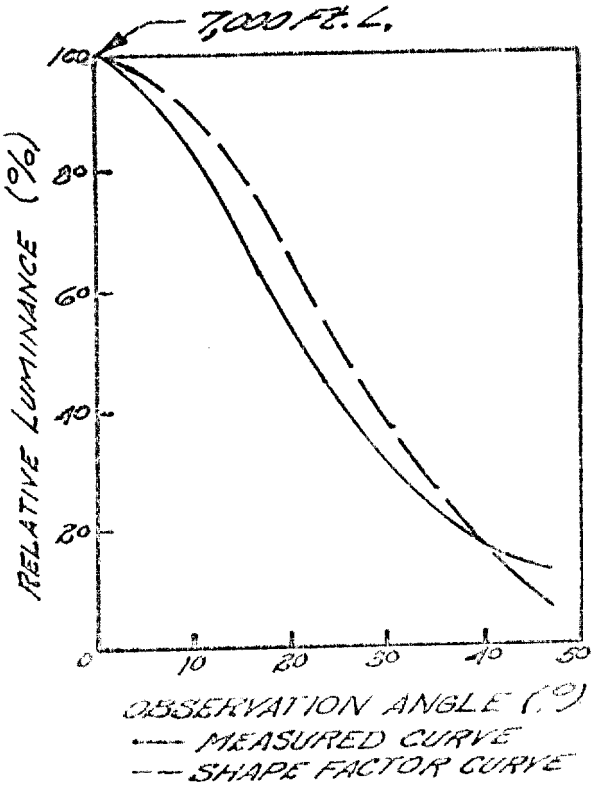
THICKNESS — .127 INCHES

ANGLE 50% REL. LUM. — 20°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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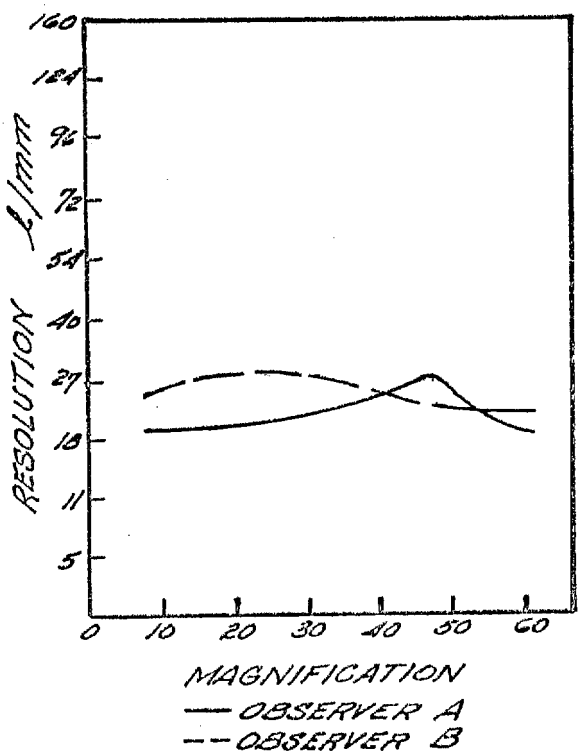
SAMPLE #81

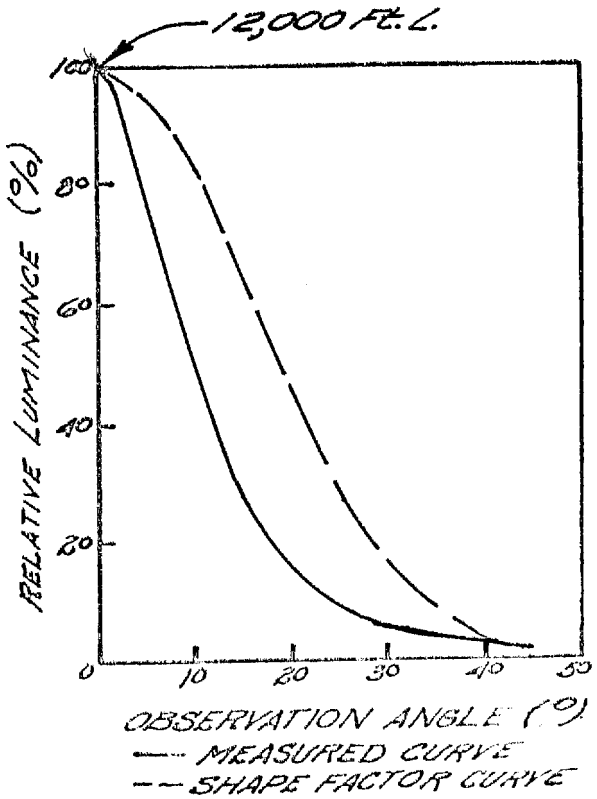
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — EMULSION ON GLASS

TRANSMISSION (MATTE) — 41 %
TRANSMISSION (SMOOTH) — 50.5 %
AXIAL GAIN — 7.5
IMAGE BREAKUP MAGNIFICATION — 30 X
POLARIZATION QUALITIES: (Ft.L.) PERPENDICULAR / PARALLEL — 2.5 / 3,400
THICKNESS — .126 INCHES
ANGLE (50% REL. LUM.) — 10°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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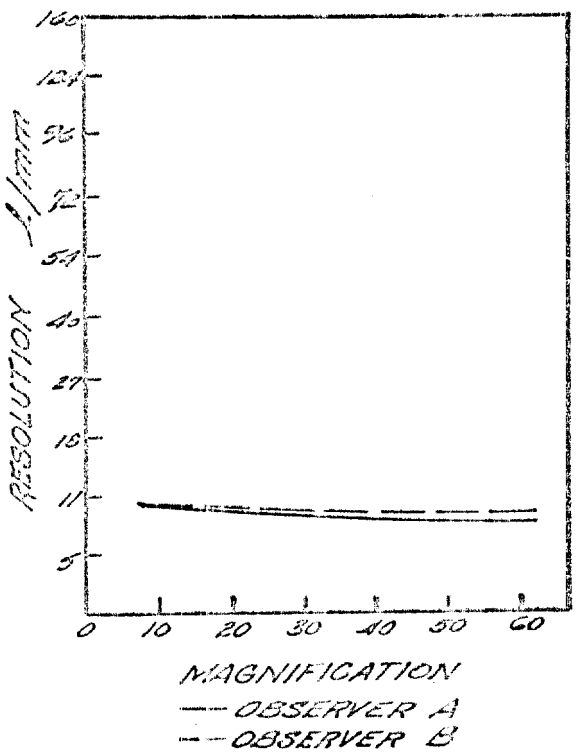
SAMPLE #82

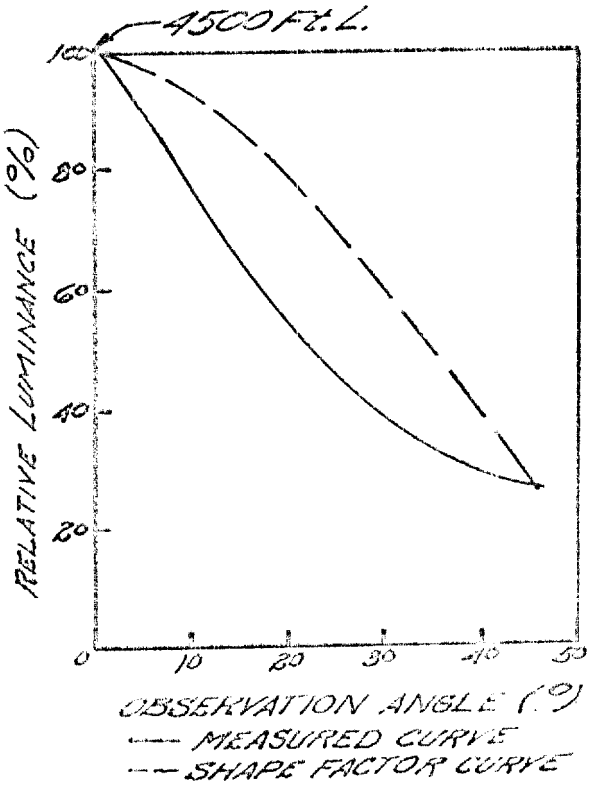
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — WHITE COATING ON GLASS

TRANSMISSION (MATTE) — 52.5%
TRANSMISSION (SMOOTH) — 52%
AXIAL GAIN — 2.8/25
IMAGE BREAKUP MAGNIFICATION — 24X
POLARIZATION QUALITIES:
THICKNESS — .153 INCHES
ANGLE (50% REL. LUM.) — 23°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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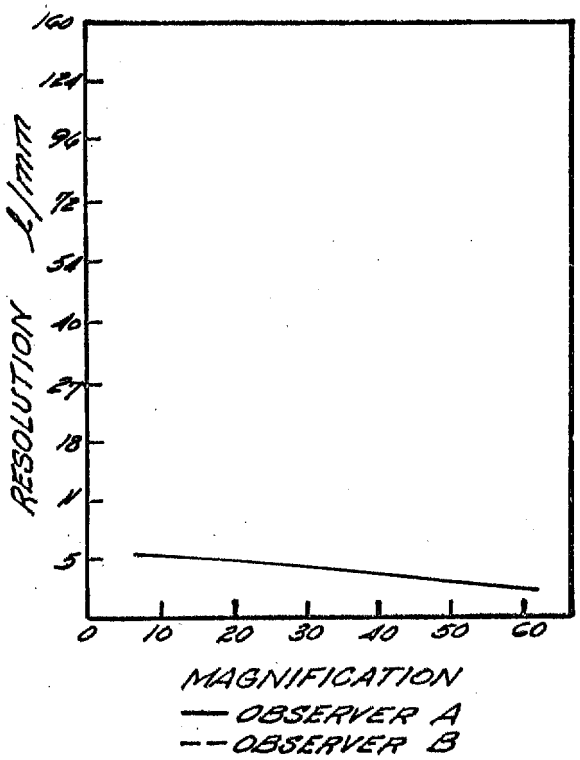
SAMPLE #83

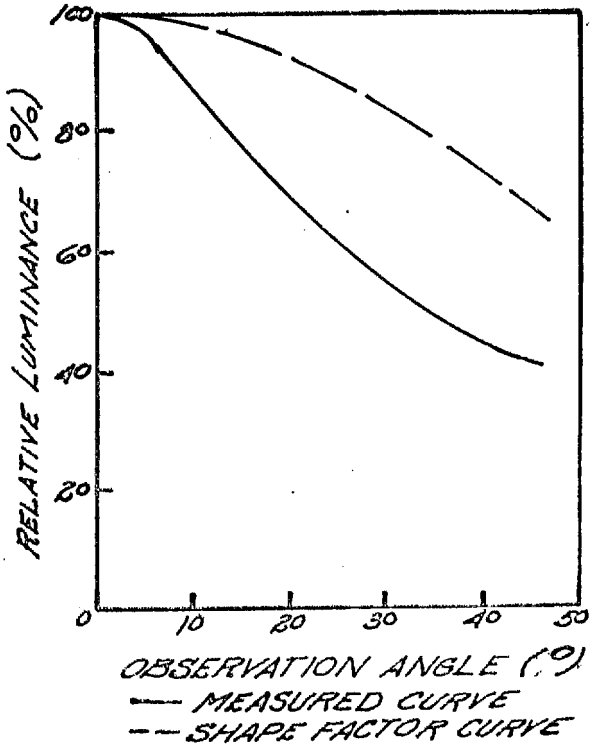
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — BLUE EMULSION OR COATING ON GLASS

TRANSMISSION (MATTE) — 44 %
TRANSMISSION (SMOOTH) — 41 %
AXIAL GAIN — 1.5625
IMAGE BREAKUP MAGNIFICATION — 27.5°
POLARIZATION QUALITIES —
THICKNESS — .134 INCHES
ANGLE (50% REL. LUM.) — 33.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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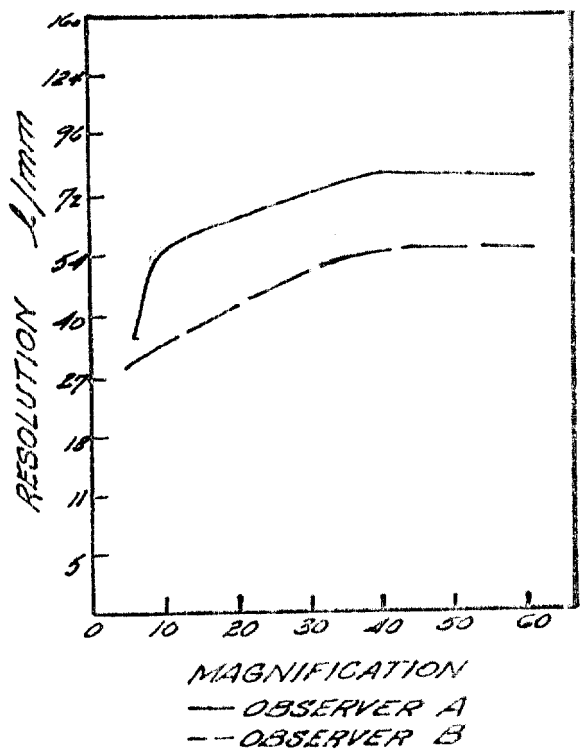
SAMPLE #84

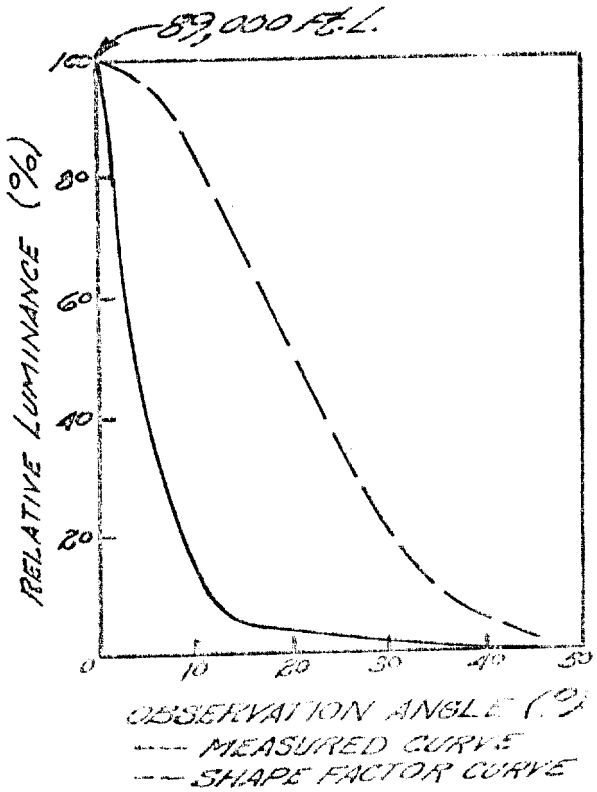
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE

TRANSMISSION (MATTE) ---------- 84 %
TRANSMISSION (SMOOTH) ---------- 79 %
AXIAL GAIN ---------- 55.625
IMAGE BREAKUP MAGNIFICATION ---------- 40X
POLARIZATION QUALITIES: (Ft.L) PERPENDICULAR / PARALLEL 9/26,000
THICKNESS ---------- .0075 INCHES
ANGLE (50% REL. LUM.) ---------- 5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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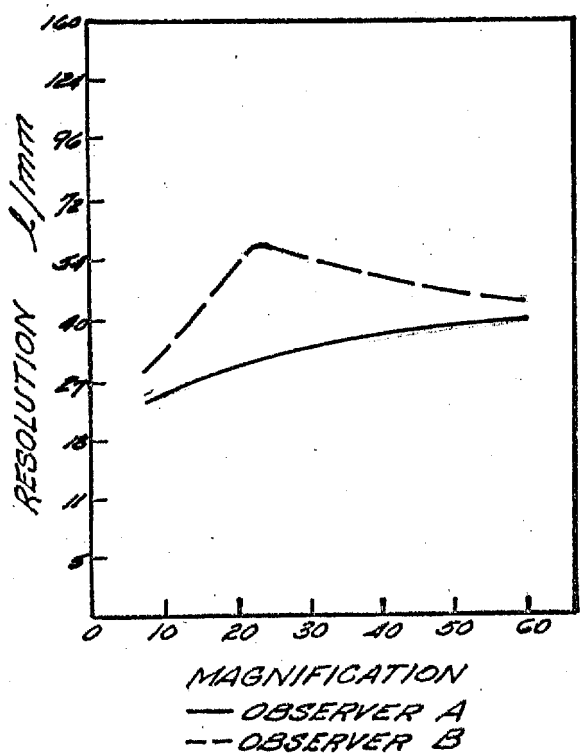
SAMPLE #85

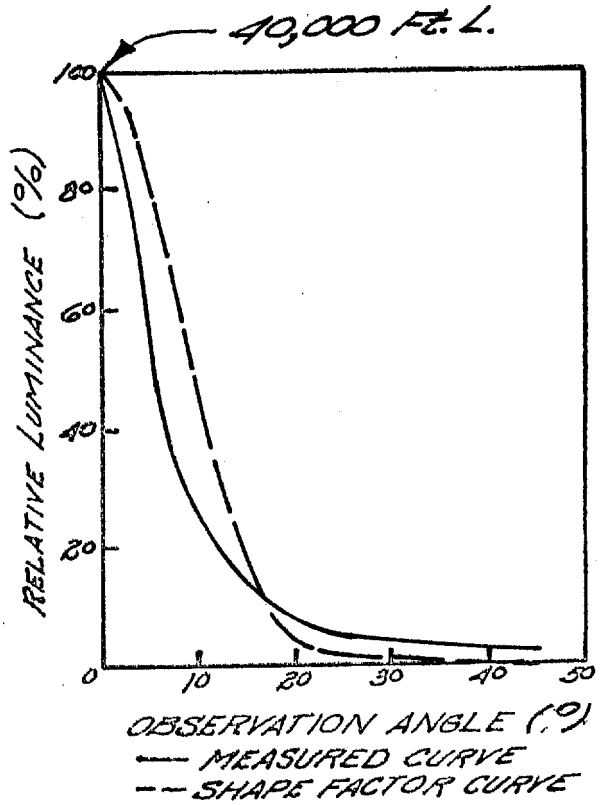
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE

TRANSMISSION (MATTE) — 74 %
TRANSMISSION (SMOOTH) — 70 %
AXIAL GAIN — 25
IMAGE BREAKUP MAGNIFICATION — 25.5X
POLARIZATION QUALITIES —
THICKNESS — .051 INCHES
ANGLE 50% REL. LUM. — 6°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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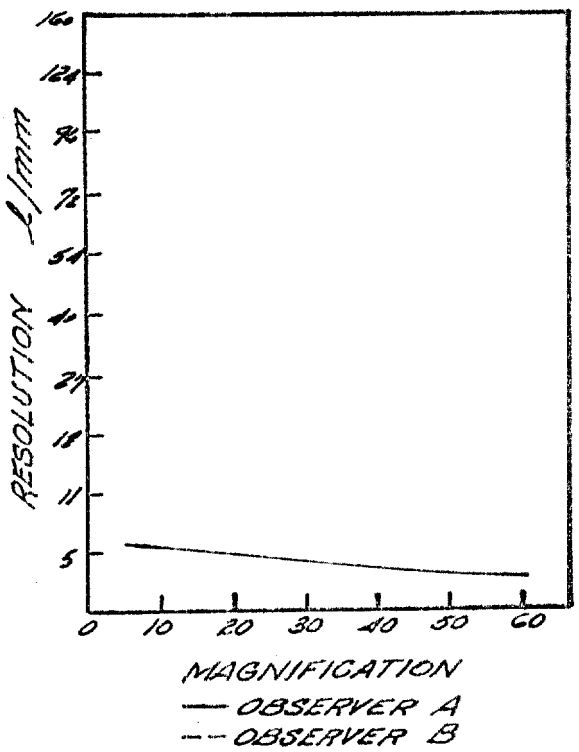
SAMPLE #86

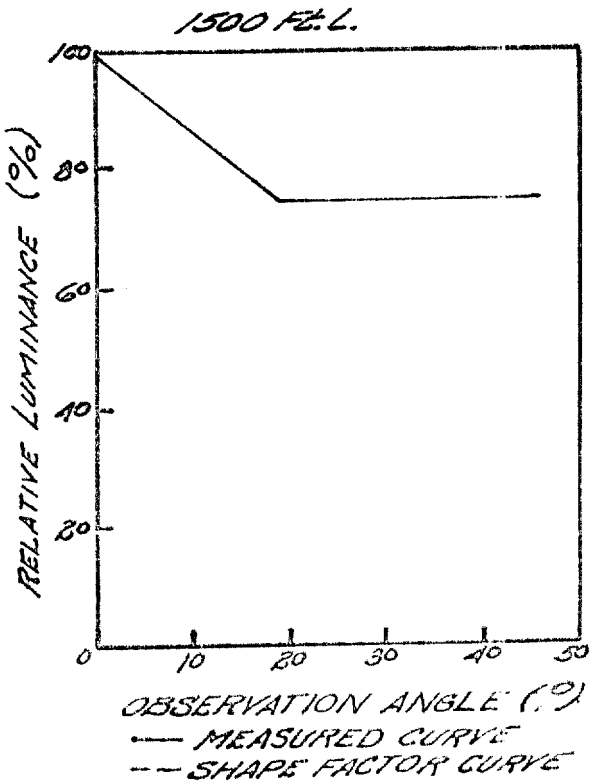
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — RIGID WHITE MAT'L

TRANSMISSION (MATTE) — 39.5 %
TRANSMISSION (SMOOTH) — 39.5 %
AXIAL GAIN — 0.9375
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .010 INCHES
ANGLE 50% REL. LUM. —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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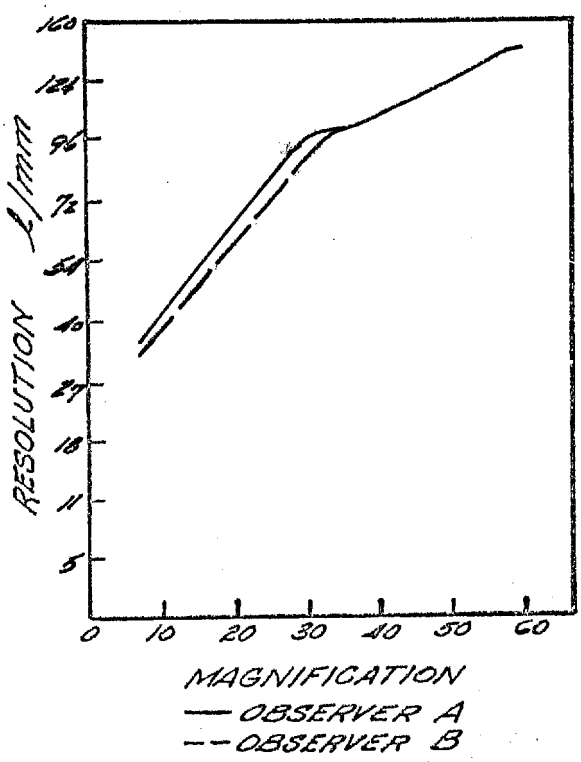
SAMPLE #87

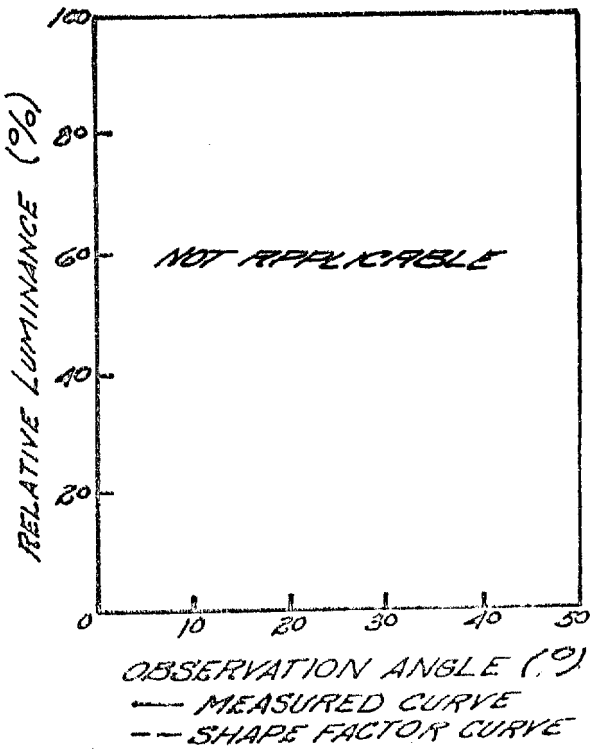
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — TRANSPARENT

TRANSMISSION (MATTE) — 52.5%
TRANSMISSION (SMOOTH) — 52.5%
AXIAL GAIN — NOT APPLICABLE
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .030 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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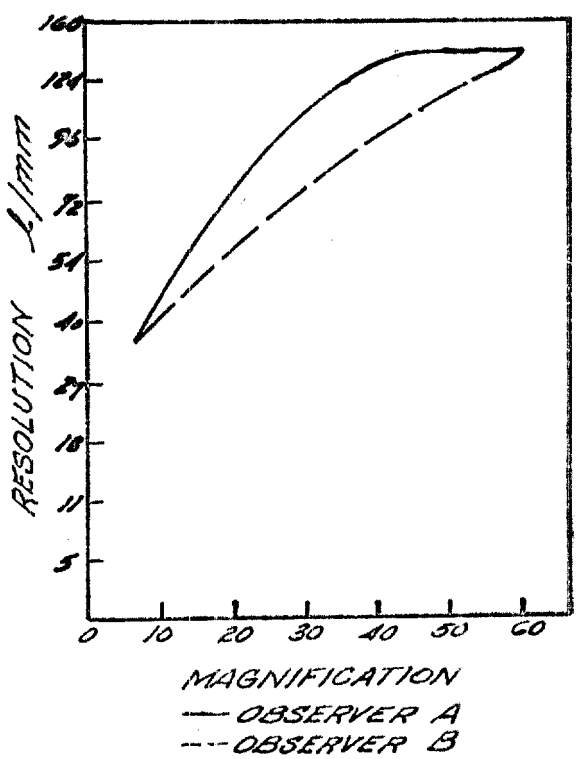
SAMPLE #88

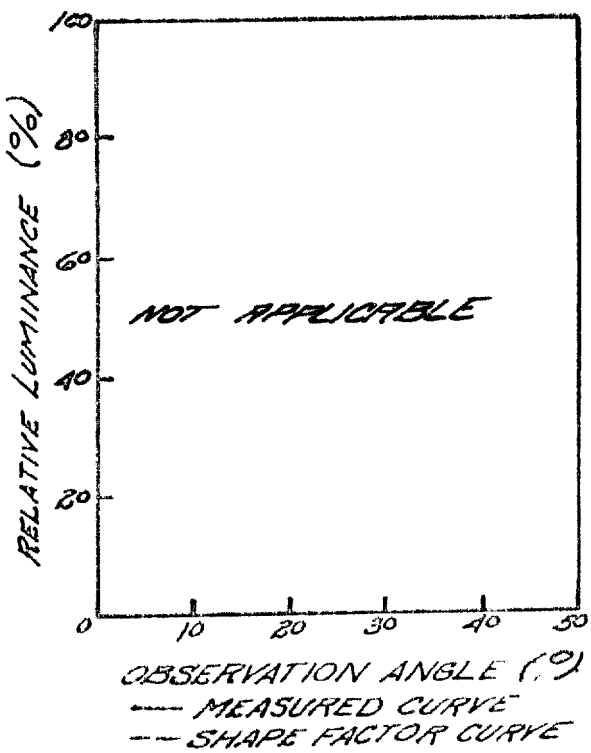
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — GREEN

TRANSMISSION (MATTE) — 48.5 %
TRANSMISSION (SMOOTH) — 48 %
AXIAL GAIN — NOT APPLICABLE
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .021 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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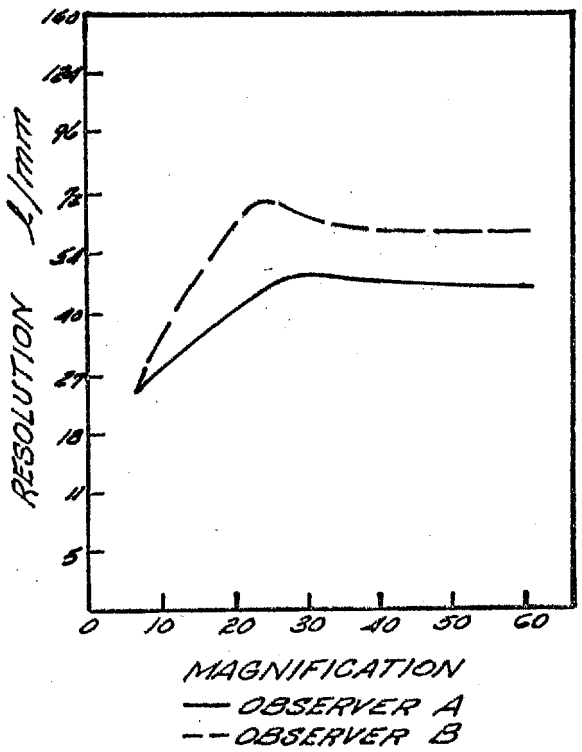
SAMPLE #89

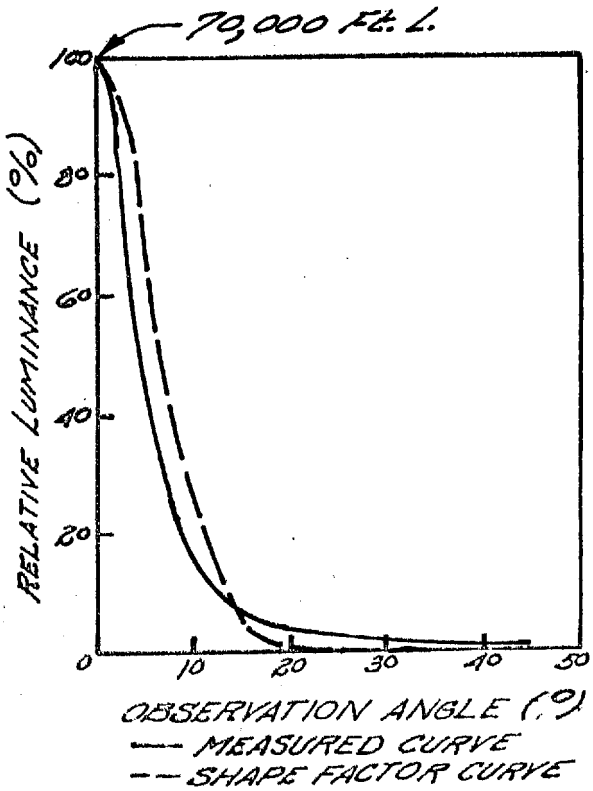
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — LUCITE OR PLEXIGLASS

TRANSMISSION (MATTE) — 78 %
TRANSMISSION (SMOOTH) — 79 %
AXIAL GAIN — 43.75
IMAGE BREAKUP MAGNIFICATION — 2/.5X
POLARIZATION QUALITIES —
THICKNESS — .122 INCHES
ANGLE 50% REL. LUM. — 5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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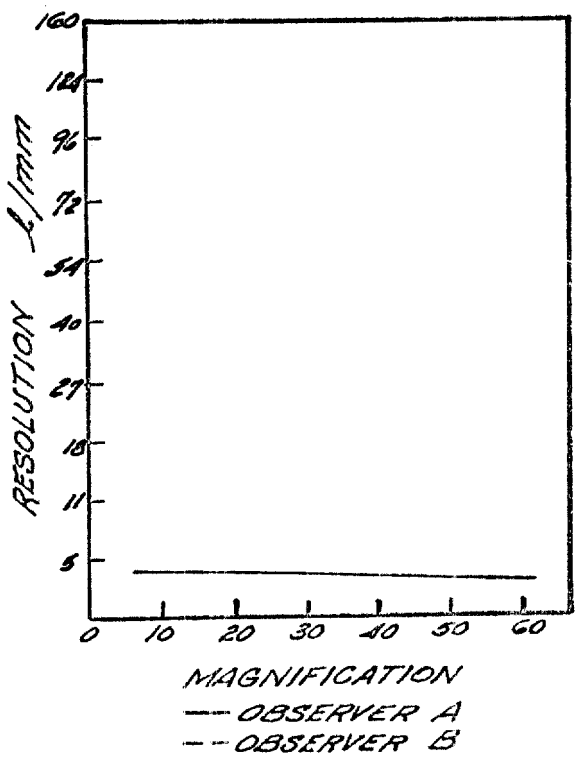
SAMPLE #90

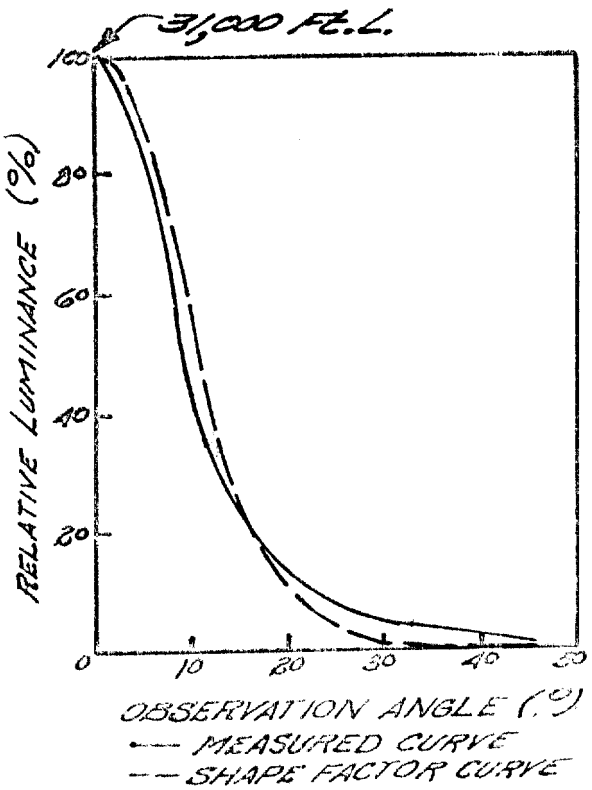
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — RIGID PLASTIC MATTE BOTH SIDES

TRANSMISSION (MATTE) — 69 %
TRANSMISSION (SMOOTH) — 68.5 %
AXIAL GAIN — 19.375
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .067 INCHES
ANGLE (50% REL. LUM.) — 10°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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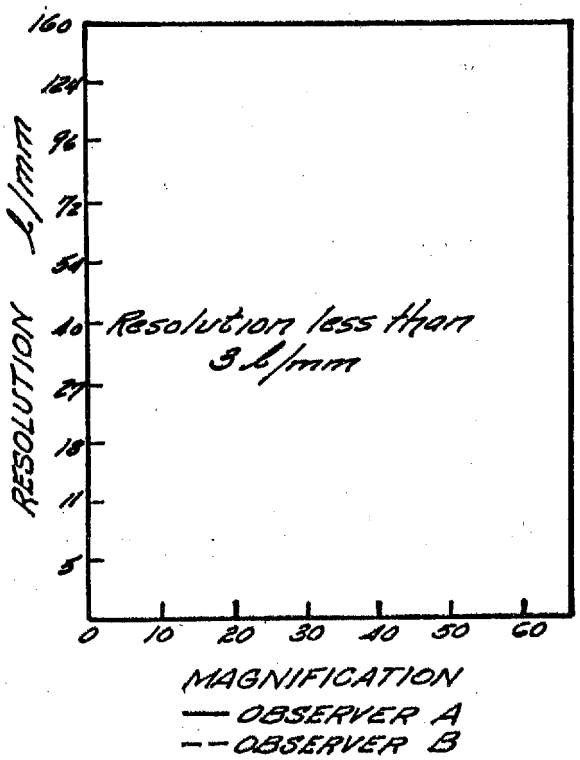
SAMPLE #91

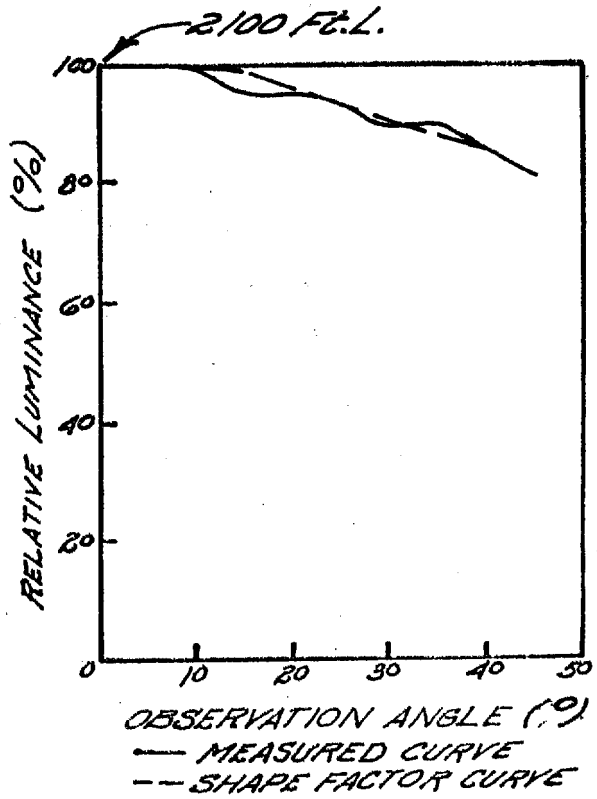
MANUFACTURER
DESIGNATION — W2447
PHYSICAL STRUCTURE — WHITE TRANSLUCENT

TRANSMISSION (MATTE) — 53 %
TRANSMISSION (SMOOTH) — 54 %
AXIAL GAIN — 1.3125
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .132 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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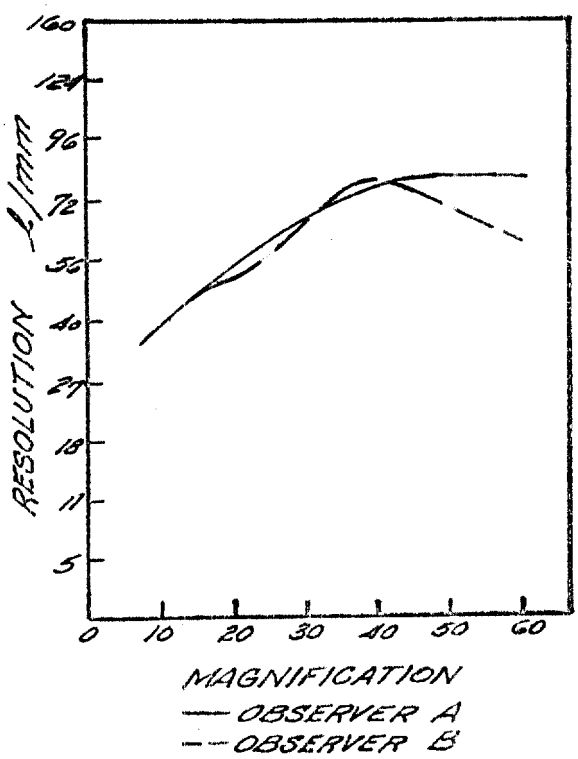
SAMPLE #92

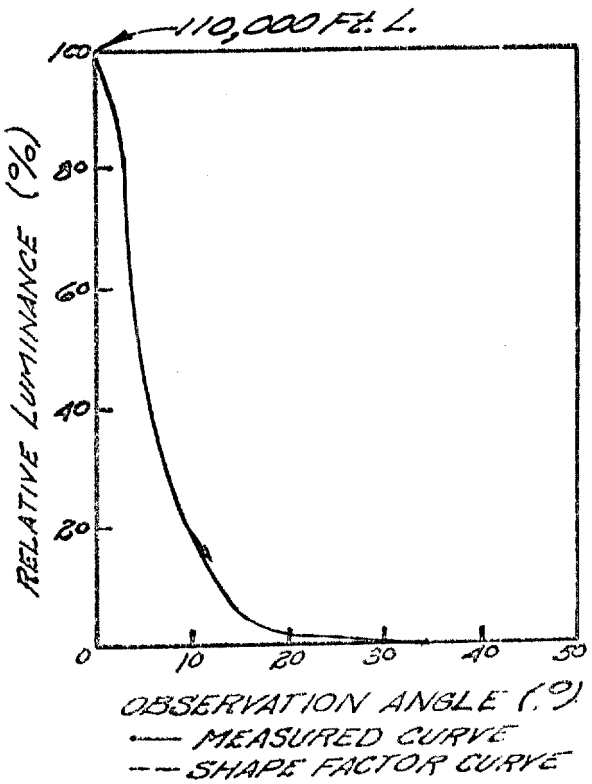
MANUFACTURER
DESIGNATION — LUCITE
PHYSICAL STRUCTURE — MATTE ONE SURFACE

TRANSMISSION (MATTE) — 86 %
TRANSMISSION (SMOOTH) — 79 %
AXIAL GAIN — 68.75
IMAGE BREAKUP MAGNIFICATION — 21.5 X
POLARIZATION QUALITIES: (Ft. L) PERPENDICULAR / PARALLEL — 19/30,000
THICKNESS — .255 INCHES
ANGLE (50% REL. LUM.) — 6°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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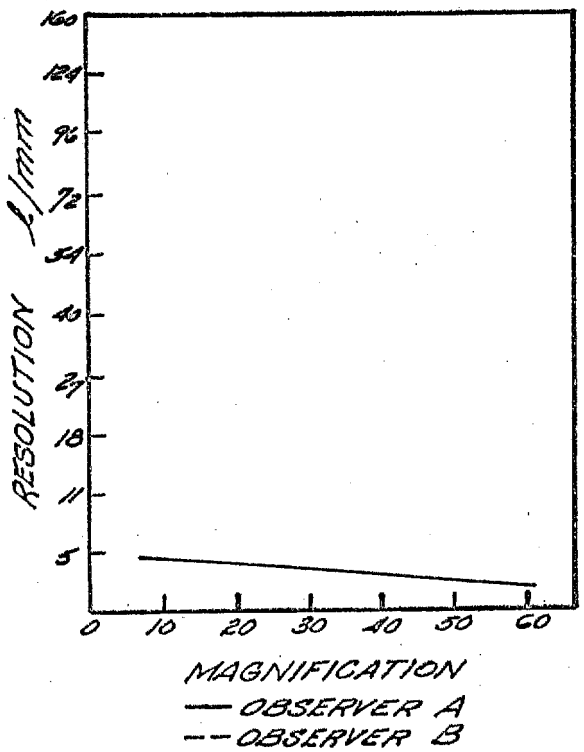
SAMPLE #93

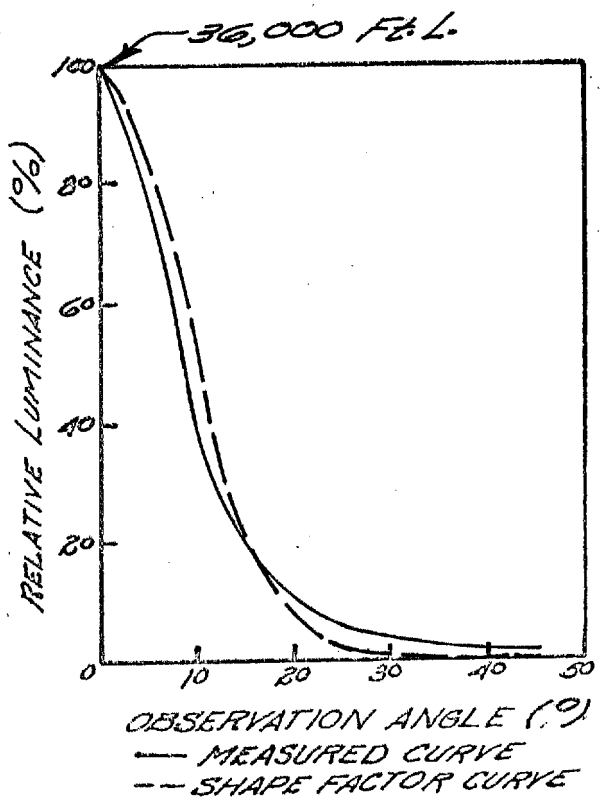
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE MATTE TWO SURFACES

TRANSMISSION (MATTE) — 74.5%
TRANSMISSION (SMOOTH) — 72.5%
AXIAL GAIN — 22.5
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES: (Ft. L) PERPENDICULAR / PARALLEL 29/11,000
THICKNESS — .071 INCHES
ANGLE (50% REL. LUM.) — 9°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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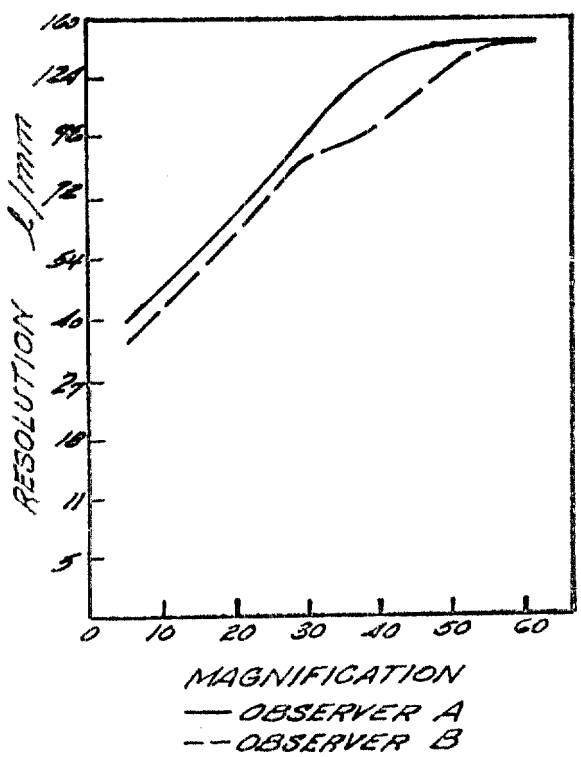
SAMPLE #94

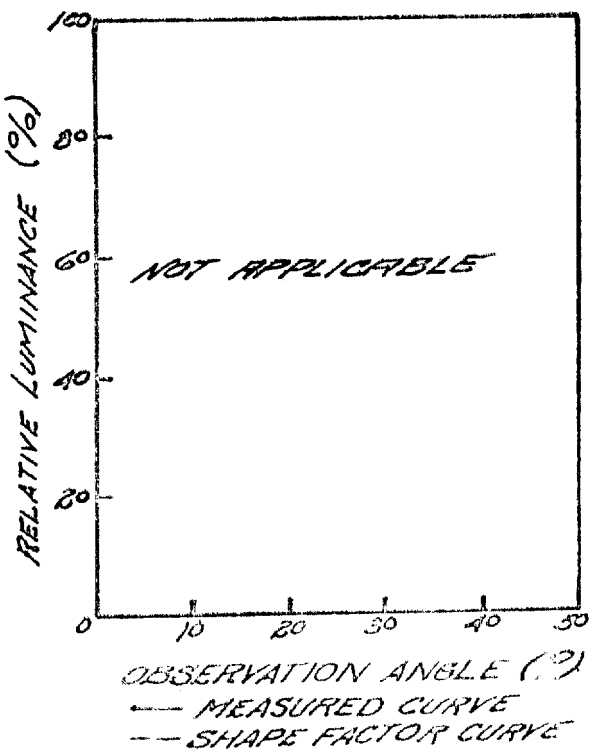
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — GREEN TRANSPARENT

TRANSMISSION (MATTE) — 14 %
TRANSMISSION (SMOOTH) — 14 %
AXIAL GAIN — NOT APPLICABLE
IMAGE BREAKUP MAGNIFICATION — 40 X
POLARIZATION QUALITIES —
THICKNESS — .148 INCHES
ANGLE (50% REL. LUM.) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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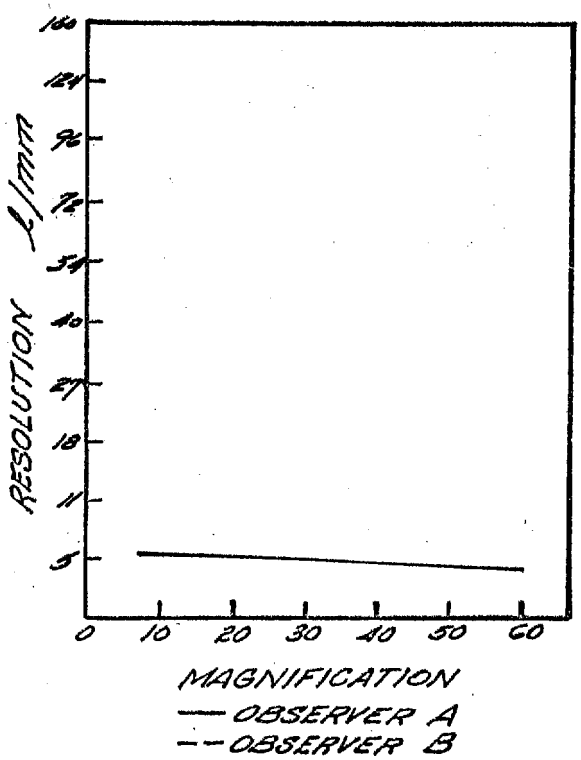
SAMPLE #95

STAT

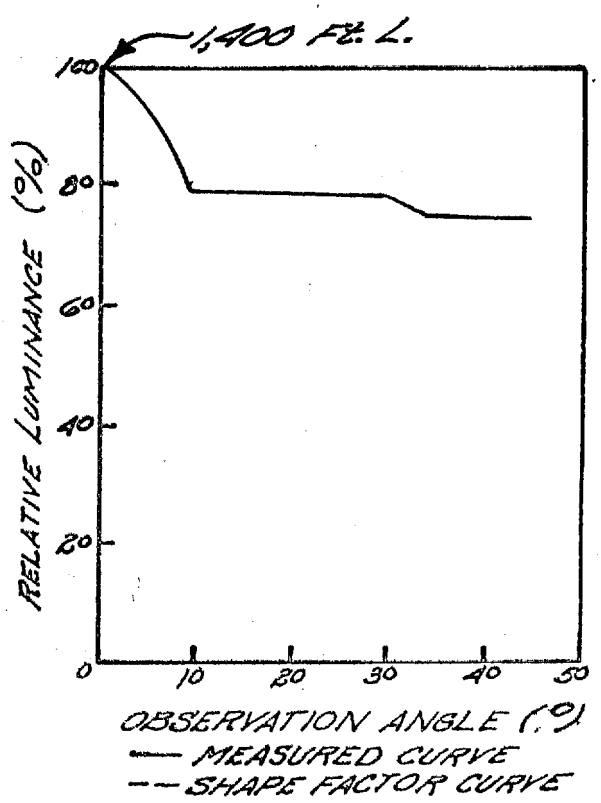
MANUFACTURER
DESIGNATION — VCAL 3354 WHITE 64
PHYSICAL STRUCTURE — RIGID VINYL

TRANSMISSION (MATTE) — 38.5%
TRANSMISSION (SMOOTH) — 38.5%
AXIAL GAIN — 0.875
IMAGE BREAKUP MAGNIFICATION — 40X
POLARIZATION QUALITIES —
THICKNESS — .010 INCHES
ANGLE (50% REL. LUMA) —

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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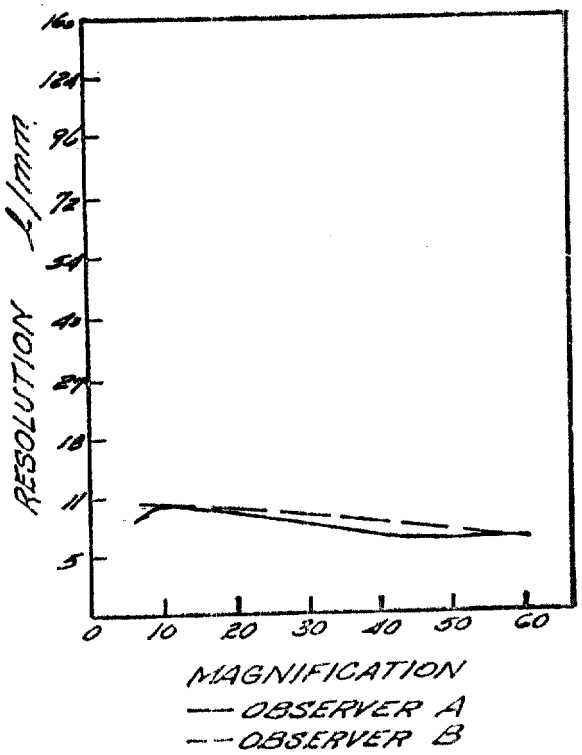
SAMPLE #96

STAT

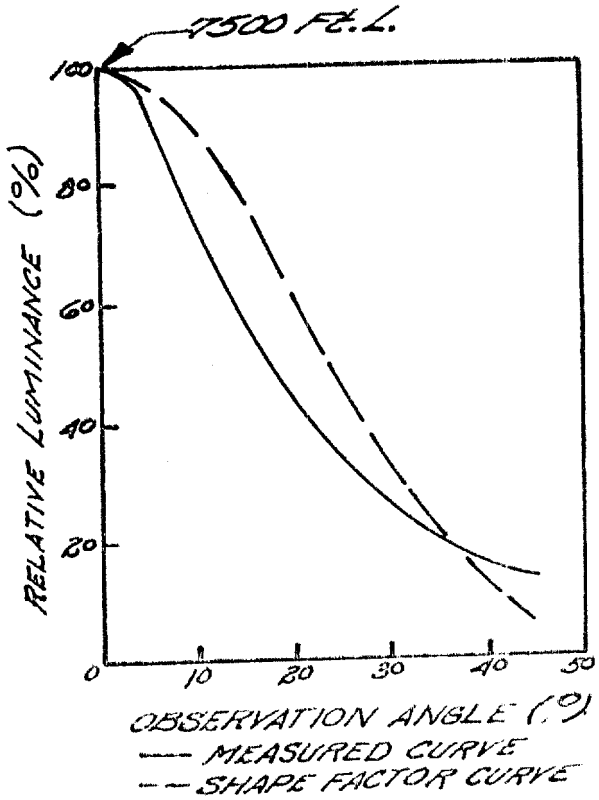
MANUFACTURER
DESIGNATION
PHYSICAL STRUCTURE — FLEXIBLE GREY VINYL LATEX

TRANSMISSION (MATTE) — 53 %
TRANSMISSION (SMOOTH) — 49 %
AXIAL GAIN — 4.6875
IMAGE BREAKUP MAGNIFICATION — 23.5X
POLARIZATION QUALITIES —
THICKNESS — .011 INCHES
ANGLE (50% REL. LUM.) — 19°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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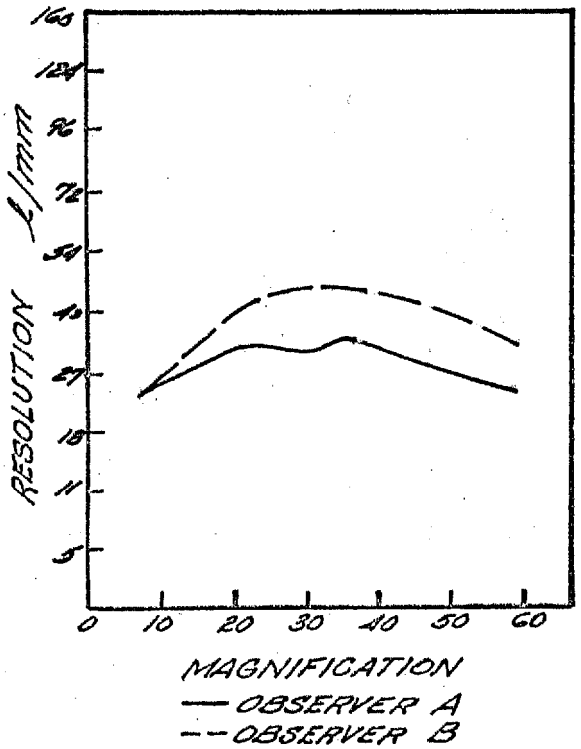
SAMPLE #97

STAT

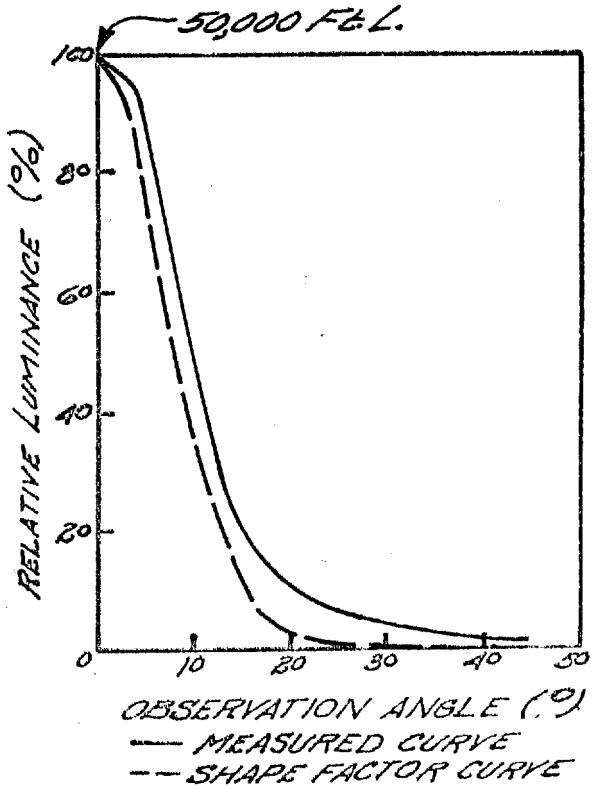
MANUFACTURER
DESIGNATION — TRANSLUCENT PLATE TYPE 3
PHYSICAL STRUCTURE — EMULSION on GLASS

TRANSMISSION (MATTE) — not measurable %
TRANSMISSION (SMOOTH) — not measurable %
AXIAL GAIN — 31.25
IMAGE BREAKUP MAGNIFICATION — 17.5X
POLARIZATION QUALITIES —
THICKNESS — .122 INCHES
ANGLE 50% REL. LUM. — 10°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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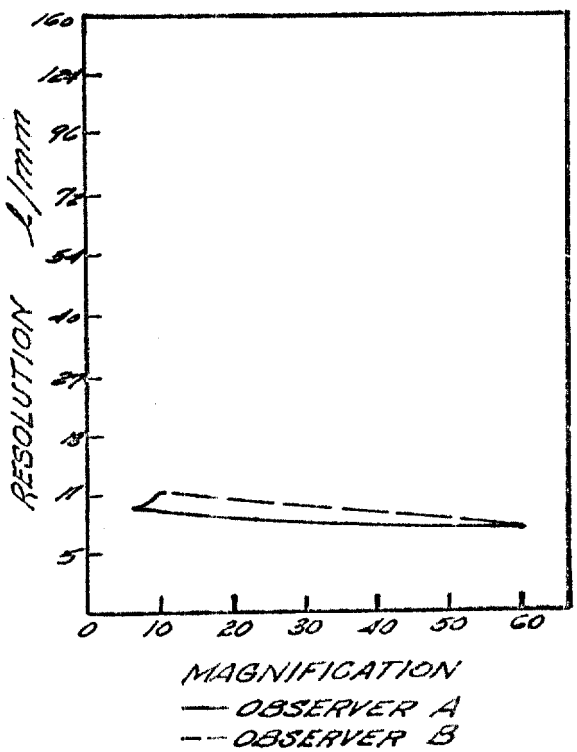
SAMPLE # 98

STAT

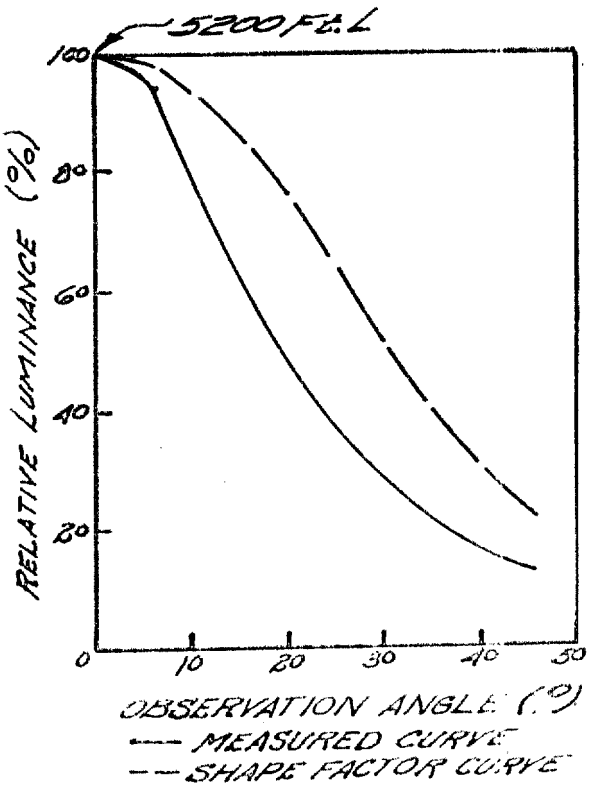
MANUFACTURER	
DESIGNATION	POLAVUE PV-60
PHYSICAL STRUCTURE	FLEXIBLE GREY

TRANSMISSION (MATTE)	56.5%
TRANSMISSION (SMOOTH)	53 %
AXIAL GAIN	3.25
IMAGE BREAKUP MAGNIFICATION	19.5 X
POLARIZATION QUALITIES	
THICKNESS	.011 INCHES
ANGLE (50% REL. LUM.)	19.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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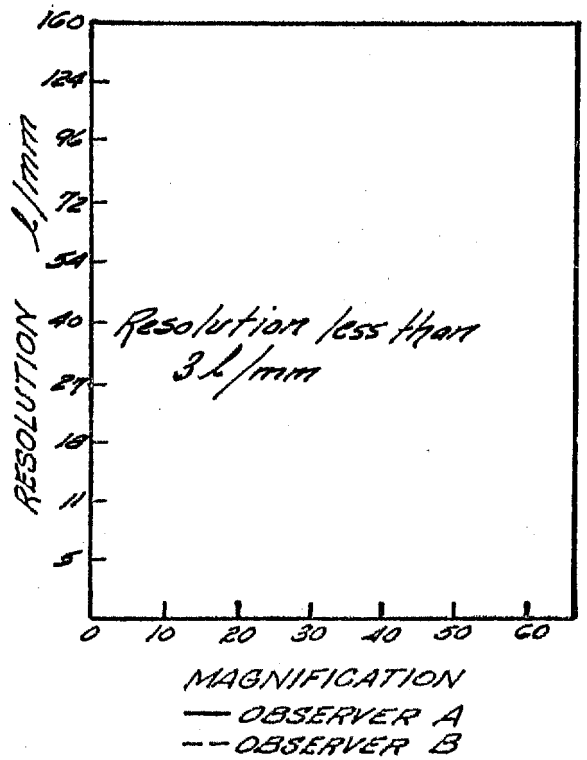
SAMPLE #99

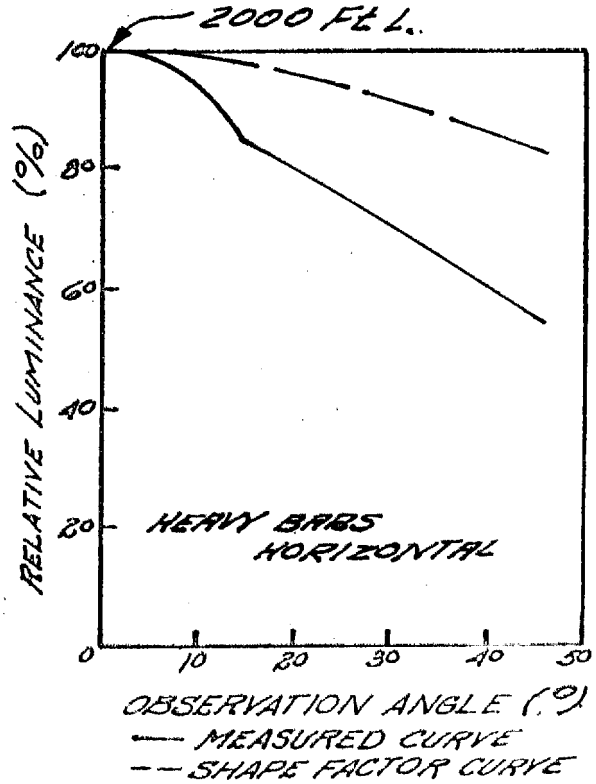
STAT

MANUFACTURER	
DESIGNATION	THRUVISION
PHYSICAL STRUCTURE	LENTICULAR WHITE
TRANSMISSION (MATTE)	52 %
TRANSMISSION (SMOOTH)	52.0 %
AXIAL GAIN	1.25
IMAGE BREAKUP MAGNIFICATION	40X
POLARIZATION QUALITIES	
THICKNESS	.008 INCHES
ANGLE 50% REL. LUM.	

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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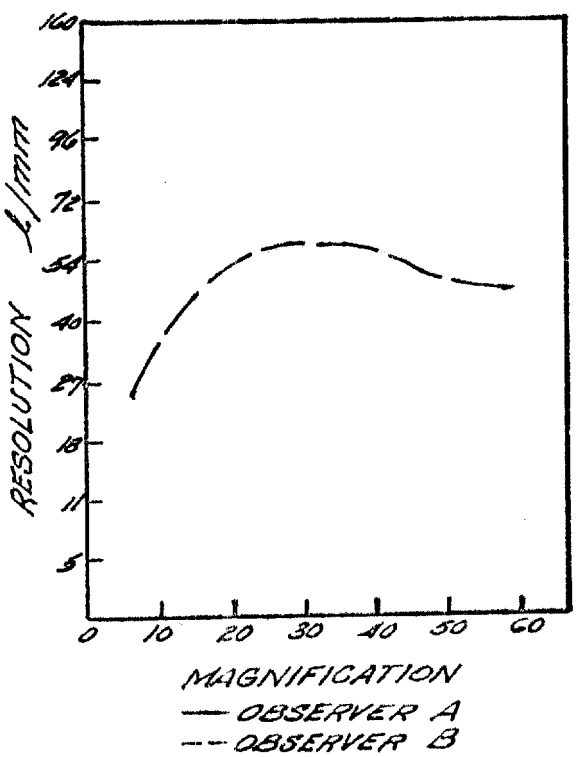
SAMPLE #100

STAT

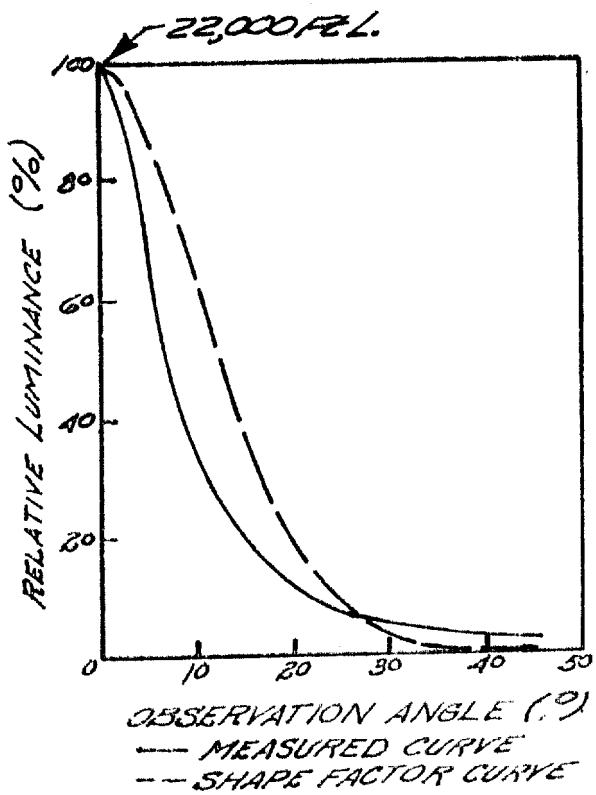
MANUFACTURER
DESIGNATION — TRACING PAPER; HERCULENE 1630
PHYSICAL STRUCTURE — FLEXIBLE MATTE ONE SIDE

TRANSMISSION (MATTE) — 69 %
TRANSMISSION (SMOOTH) — 67.5 %
AXIAL GAIN — 13.75
IMAGE BREAKUP MAGNIFICATION — 22 X
POLARIZATION QUALITIES —
THICKNESS — .003 INCHES
ANGLE (50% REL. LUM.) — 8°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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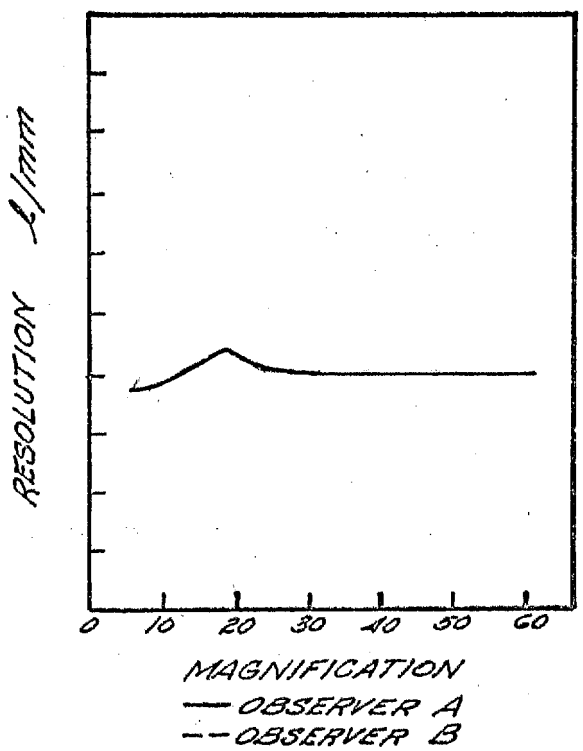
SAMPLE #101

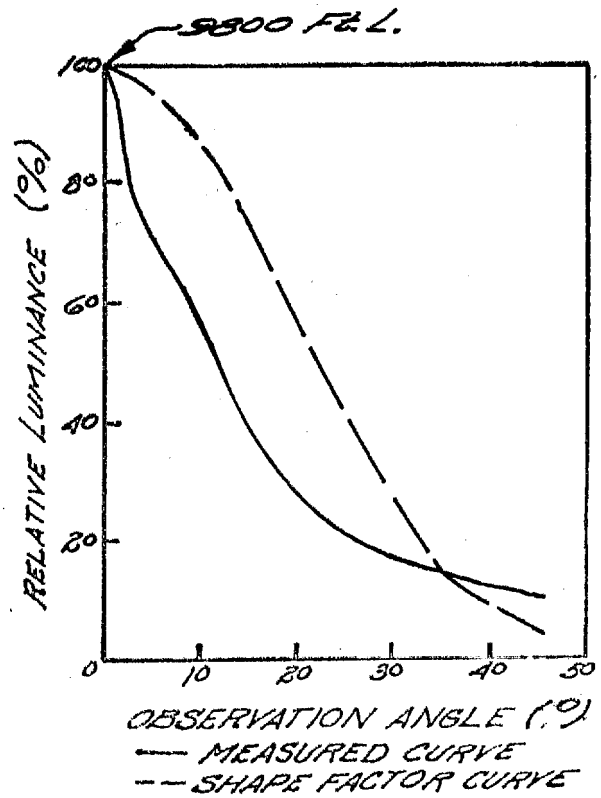
STAT

MANUFACTURER	
DESIGNATION	E 132 H
PHYSICAL STRUCTURE	MATTE ONE SIDE - SEMI RIGID
TRANSMISSION (MATTE)	69.5 %
TRANSMISSION (SMOOTH)	67.5 %
AXIAL GAIN	6.125
IMAGE BREAKUP MAGNIFICATION	24.5
POLARIZATION QUALITIES	
THICKNESS	.0075 INCHES
ANGLE (50% REL. LUM.)	12.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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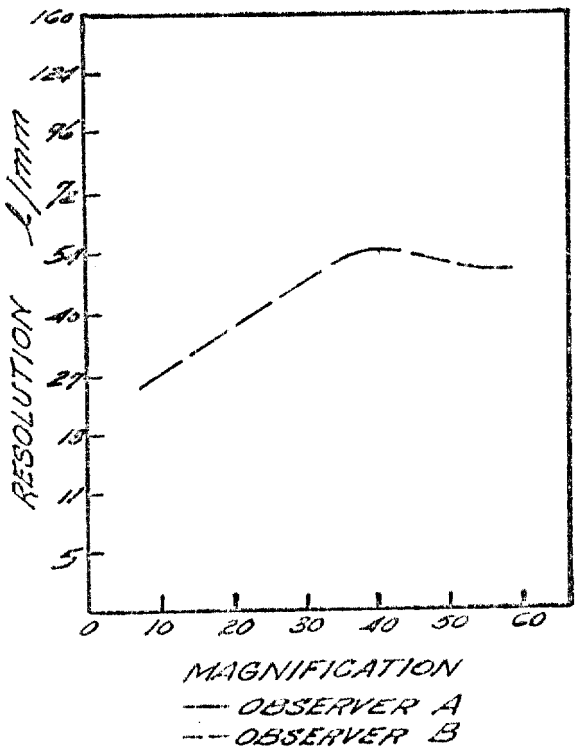
SAMPLE #102

STAT

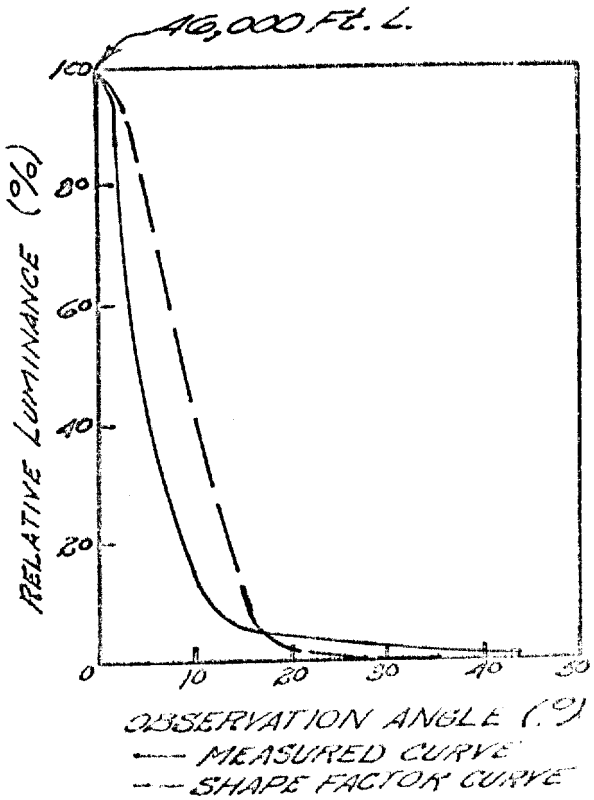
MANUFACTURER
DESIGNATION 130
PHYSICAL STRUCTURE FLEXIBLE MATTE ONE SIDE

TRANSMISSION (MATTE) — 72 %
TRANSMISSION (SMOOTH) — 70 %
AXIAL GAIN — 28.75
IMAGE BREAKUP MAGNIFICATION — 25X
POLARIZATION QUALITIES —
THICKNESS — .005 INCHES
ANGLE 50% REL. LUM. — 4.5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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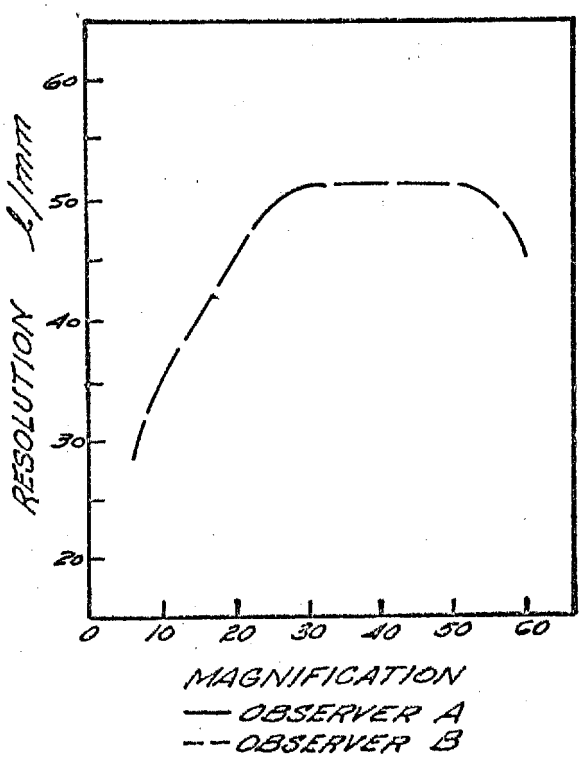
SAMPLE #103

STAT

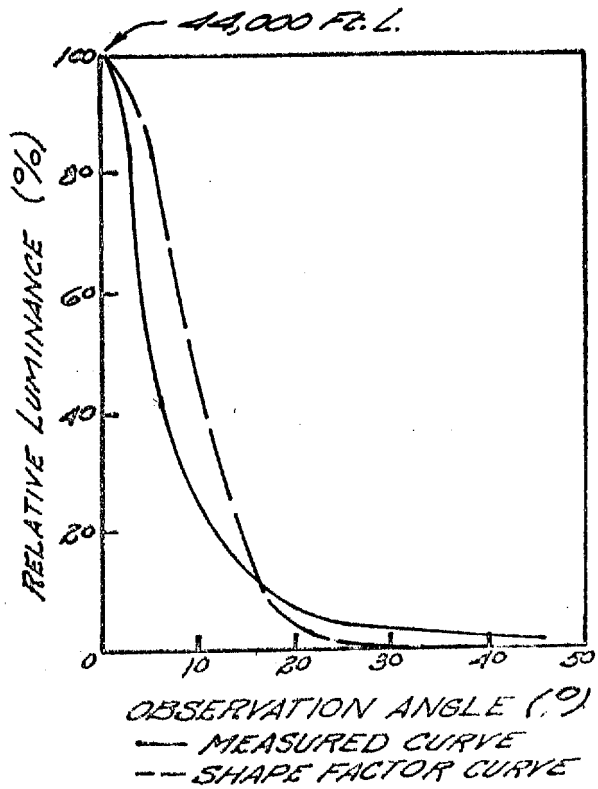
MANUFACTURER — [redacted]
DESIGNATION — 130 H
PHYSICAL STRUCTURE — FLEXIBLE GREY MATTE ONE SIDE

TRANSMISSION (MATTE) — 75 %
TRANSMISSION (SMOOTH) — 74 %
AXIAL GAIN — 27.5
IMAGE BREAKUP MAGNIFICATION — 22.5 X
POLARIZATION QUALITIES —
THICKNESS — .0075 INCHES
ANGLE (50% REL. LUM.) — 5°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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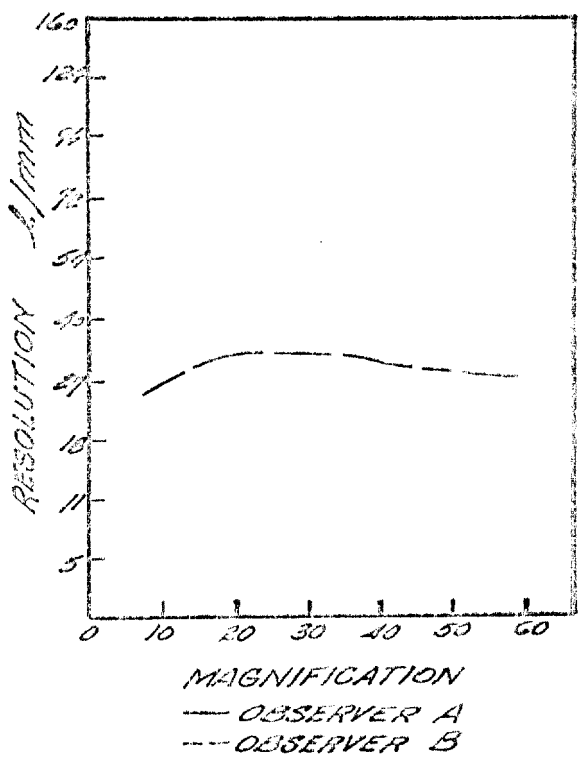
SAMPLE #104

STAT

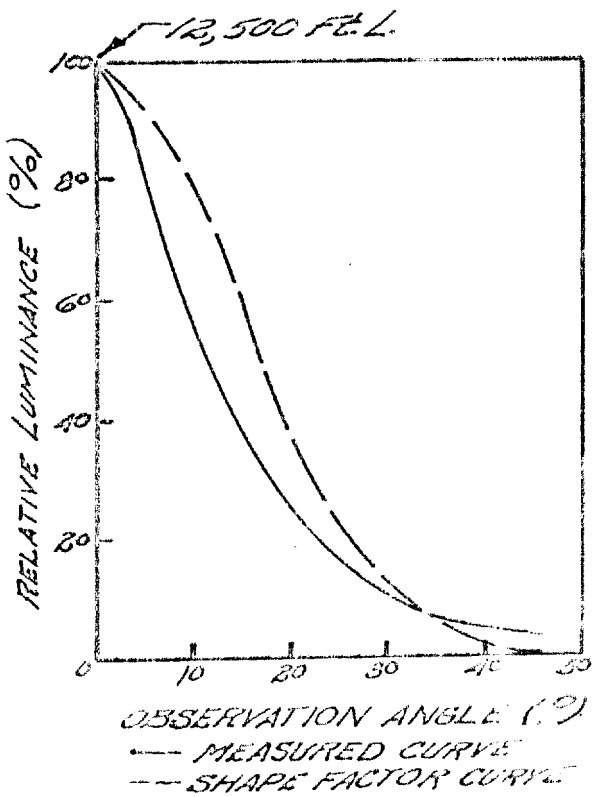
MANUFACTURER	[redacted]
DESIGNATION	LENSCREEN LS60STG.
PHYSICAL STRUCTURE	GLASS WITH EMULSION COATING

TRANSMISSION (MATTE) — 55 %
TRANSMISSION (SMOOTH) — 53 %
AXIAL GAIN — 7.825
IMAGE BREAKUP MAGNIFICATION — 15.0X
POLARIZATION QUALITIES —
THICKNESS — .125 INCHES
ANGLE (50% REL. LUM.) — 12°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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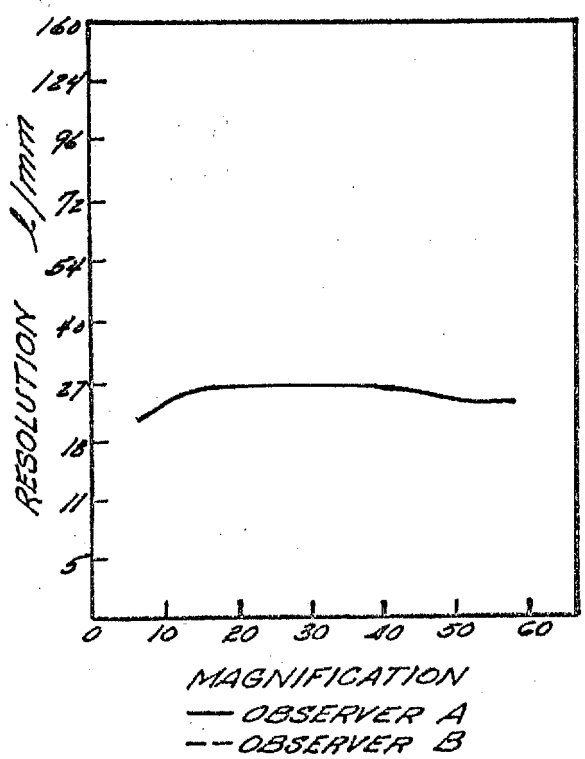
SAMPLE #105

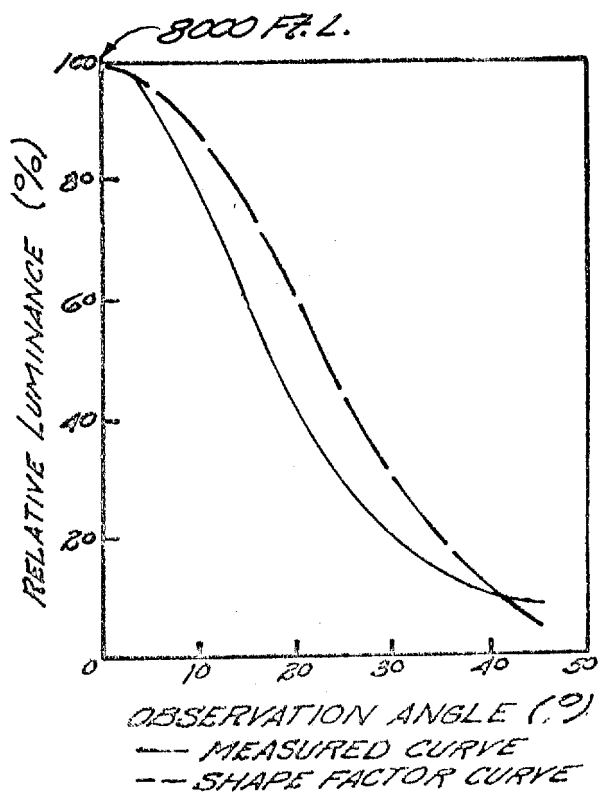
STAT

MANUFACTURER	
DESIGNATION	LENSCREEN LS 60VR
PHYSICAL STRUCTURE	VINYL, RIGID EMULSION COATED
TRANSMISSION (MATTE)	58.5 %
TRANSMISSION (SMOOTH)	55.5 %
AXIAL GAIN	5.0
IMAGE BREAKUP MAGNIFICATION	15.5X
POLARIZATION QUALITIES	
THICKNESS	.025 INCHES
ANGLE (50% REL. LUM.)	18°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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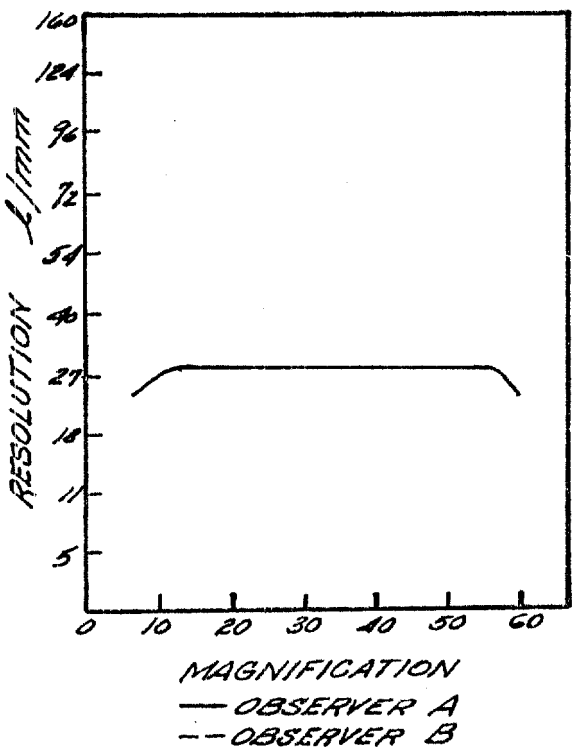
SAMPLE #106

STAT

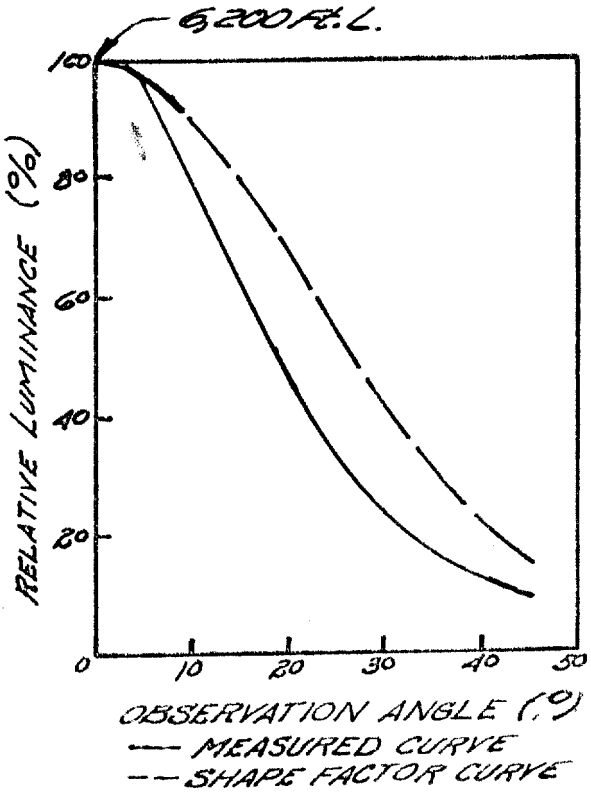
MANUFACTURER	
DESIGNATION	LENSCREEN LS 60 GPL
PHYSICAL STRUCTURE	GREEN COATING ON VINYL-RIGID

TRANSMISSION (MATTE)	51.5 %
TRANSMISSION (SMOOTH)	50.5 %
AXIAL GAIN	3.875
IMAGE BREAKUP MAGNIFICATION	16.5X
POLARIZATION QUALITIES	
THICKNESS	.0625 INCHES
ANGLE (50% REL. LUM.)	19°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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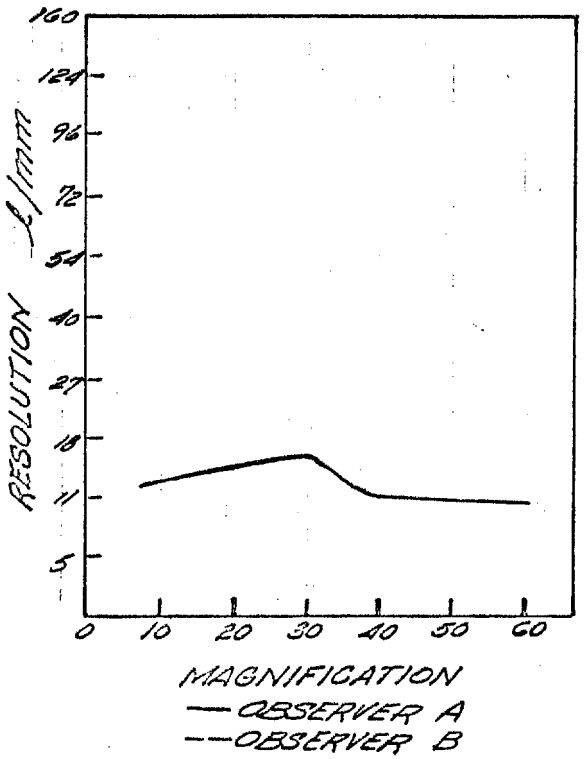
SAMPLE #107

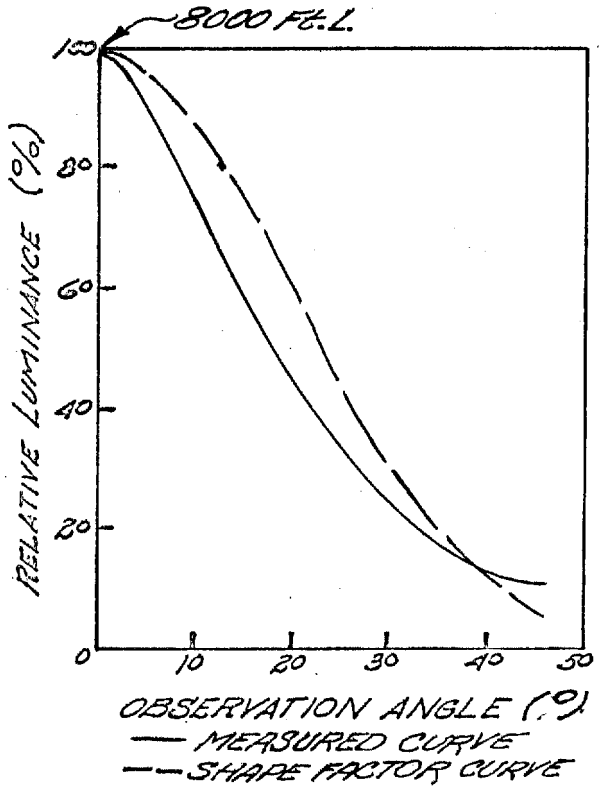
STAT

MANUFACTURER	
DESIGNATION	LENSCREEN LS 60 NG
PHYSICAL STRUCTURE	NEUTRAL GREY GLASS COATED
TRANSMISSION (MATTE)	59 %
TRANSMISSION (SMOOTH)	57 %
AXIAL GAIN	5.0
IMAGE BREAKUP MAGNIFICATION	26X
POLARIZATION QUALITIES	
THICKNESS	.125 INCHES
ANGLE (50% REL. LUM.)	18°

CONTACT RESOLVING POWER.



LUMINANCE GAIN PROFILE



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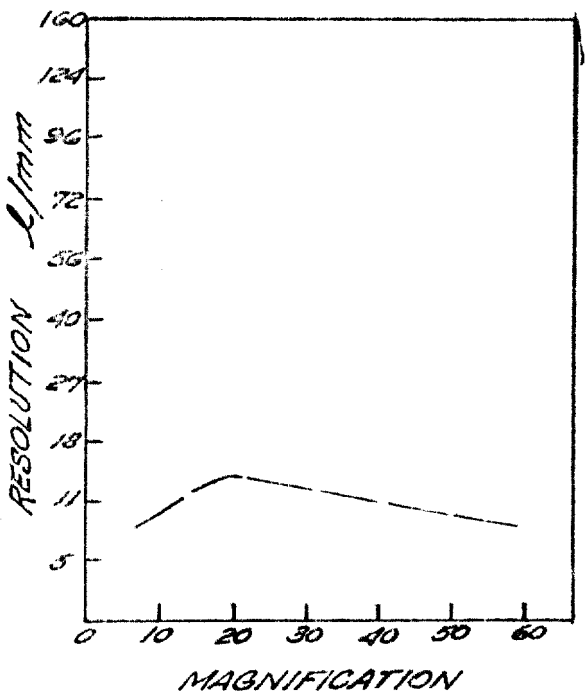
SAMPLE #108

STAT

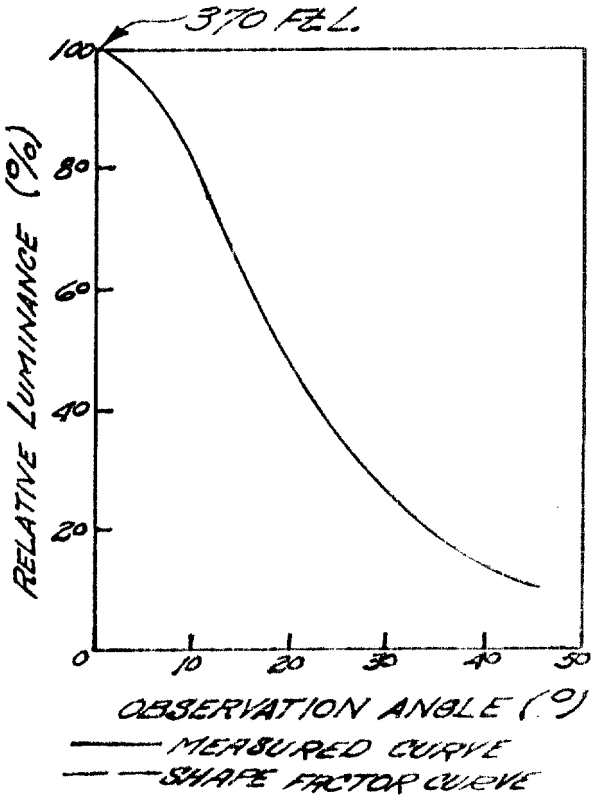
MANUFACTURER	
DESIGNATION	LENSCREEN LS60PL.
PHYSICAL STRUCTURE	RED PLASTIC

TRANSMISSION (MATTE)	4 %
TRANSMISSION (SMOOTH)	4 %
AXIAL GAIN	0.23/25
IMAGE BREAKUP MAGNIFICATION	25X
POLARIZATION QUALITIES	
THICKNESS	.065 INCHES
ANGLE (50% REL. LUM.)	20°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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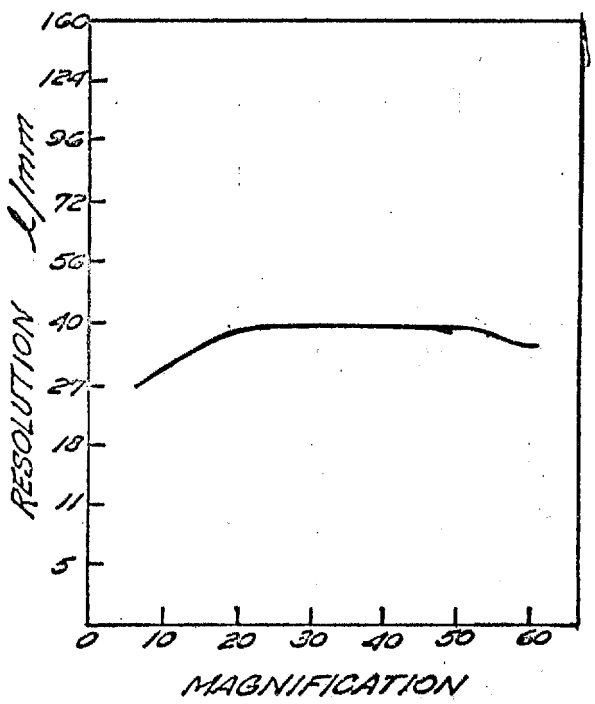
SAMPLE #109

STAT

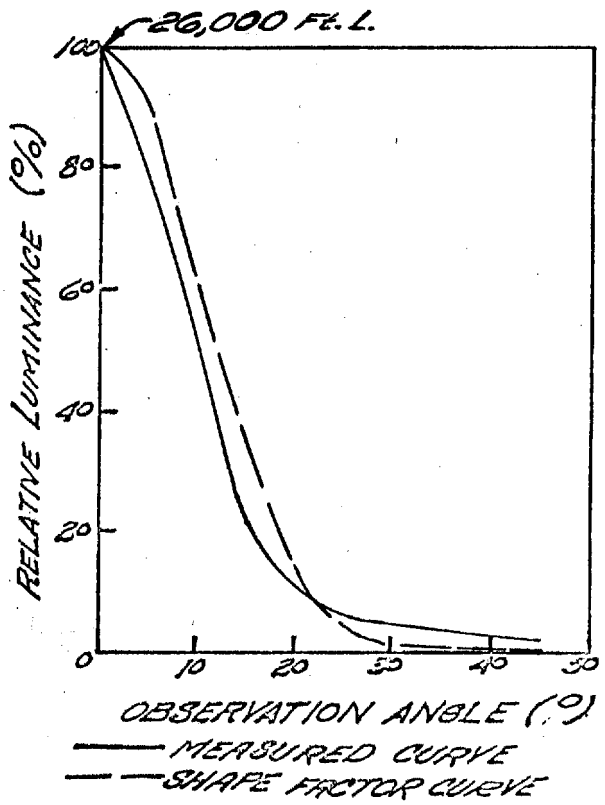
MANUFACTURER	
DESIGNATION	LENSCREEN LS 75G
PHYSICAL STRUCTURE	GREEN GLASS

TRANSMISSION (MATTE)	69 %
TRANSMISSION (SMOOTH)	66.5 %
AXIAL GAIN	16.25
IMAGE BREAKUP MAGNIFICATION	23 X
POLARIZATION QUALITIES	
THICKNESS	.125 INCHES
ANGLE (50% REL. LUM.)	10°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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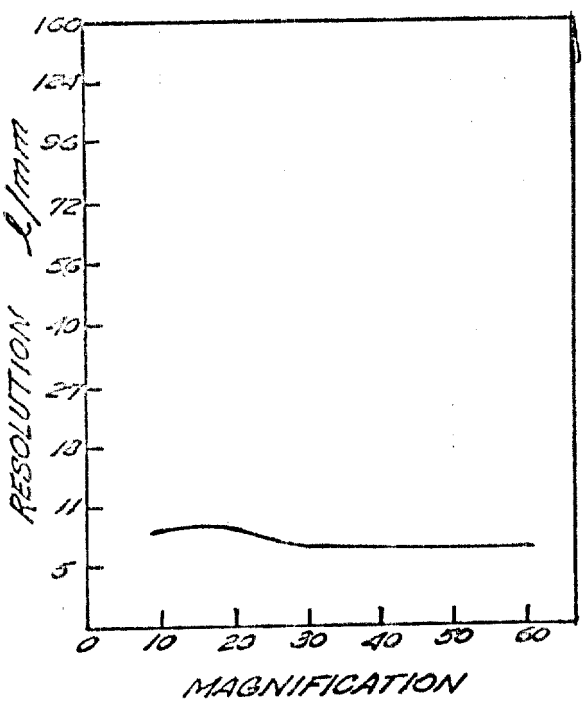
SAMPLE #110

STAT

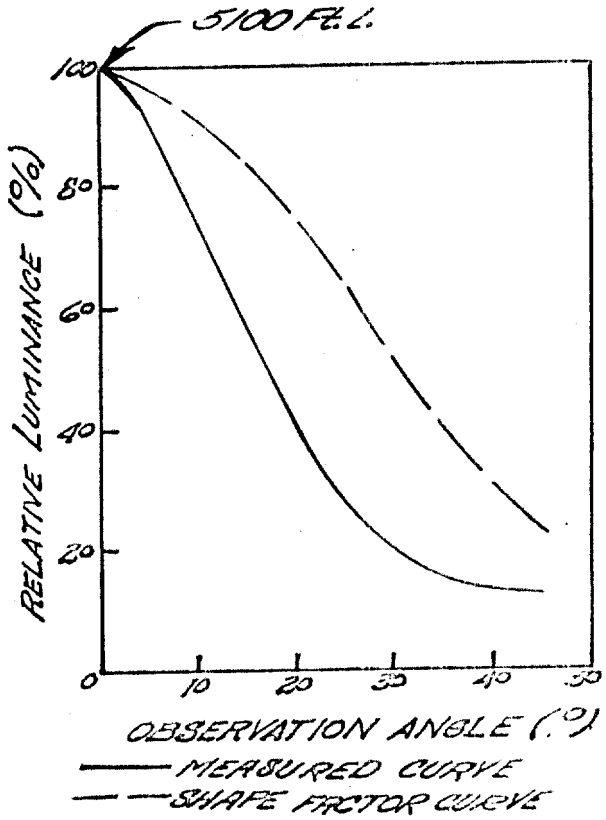
MANUFACTURER	LENSCREEN
DESIGNATION	LS 40 BFM
PHYSICAL STRUCTURE	FLEXIBLE BLACK

TRANSMISSION (MATTE)	40 %
TRANSMISSION (SMOOTH)	38 %
AXIAL GAIN	3.185
IMAGE BREAKUP MAGNIFICATION	24X
POLARIZATION QUALITIES	
THICKNESS	.010 INCHES
ANGLE (50% REL. LUM.)	17°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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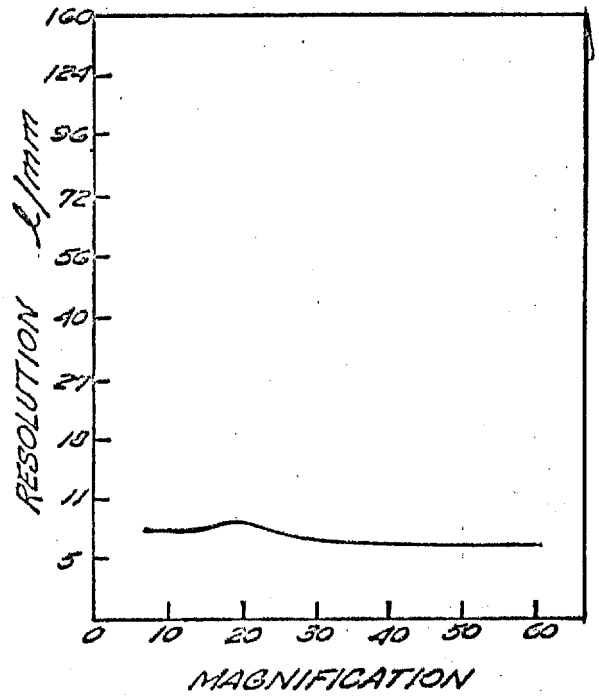
SAMPLE #111

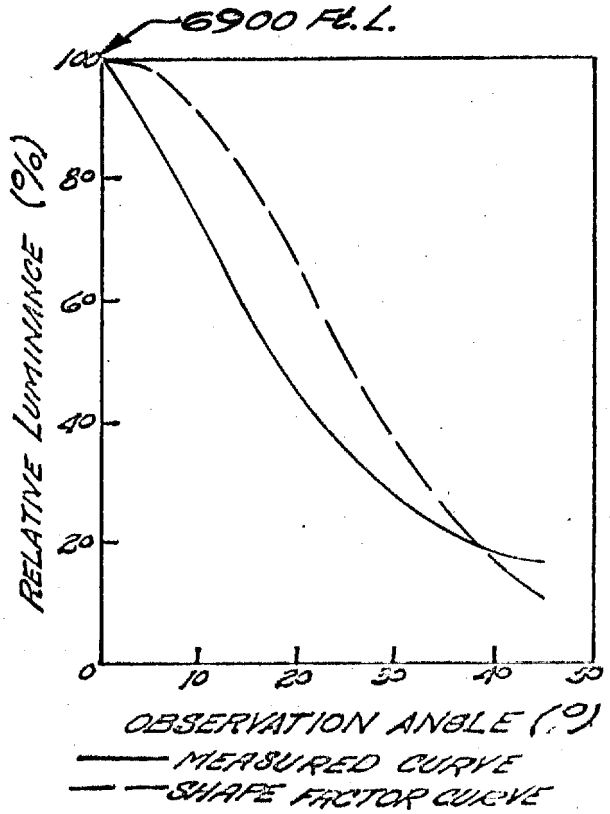
STAT

MANUFACTURER	
DESIGNATION	LENSCREEN OC 50 FM
PHYSICAL STRUCTURE	FLEXIBLE WHITE
TRANSMISSION (MATTE)	59 %
TRANSMISSION (SMOOTH)	57.5 %
AXIAL GAIN	4.3125
IMAGE BREAKUP MAGNIFICATION	22.5X
POLARIZATION QUALITIES	
THICKNESS	.125 INCHES
ANGLE (50% REL. LUM.)	19°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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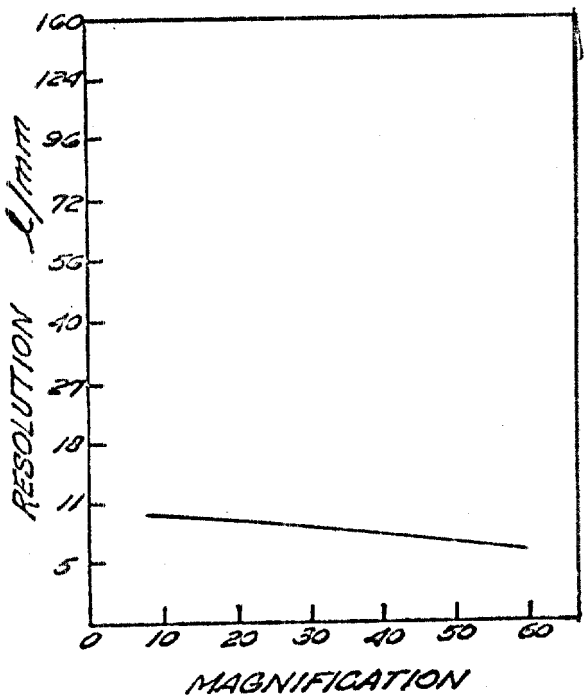
SAMPLE #112

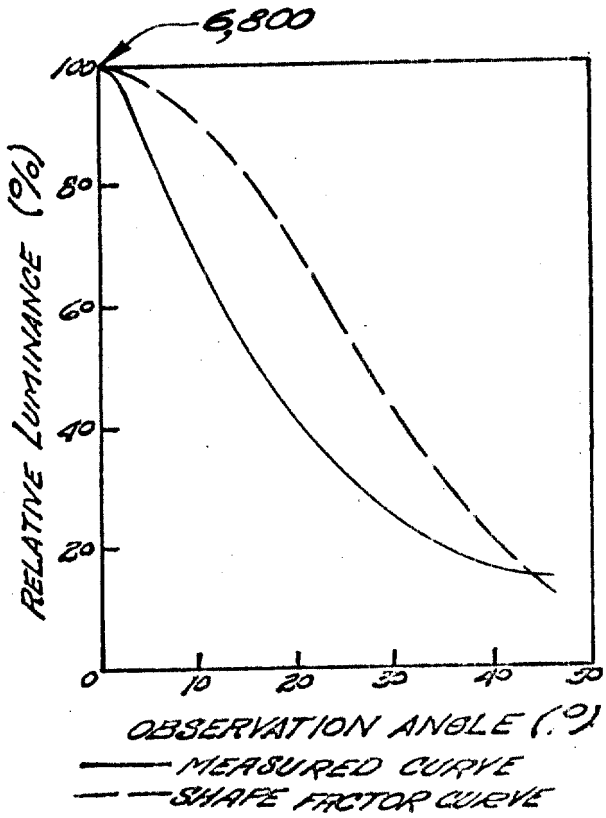
STAT

MANUFACTURER	
DESIGNATION	LS 60 BFM
PHYSICAL STRUCTURE	FLEXIBLE BLUE
TRANSMISSION (MATTE)	51 %
TRANSMISSION (SMOOTH)	52.5 %
AXIAL GAIN	4.25
IMAGE BREAKUP MAGNIFICATION	23.5X
POLARIZATION QUALITIES	
THICKNESS	.125 INCHES
ANGLE (50% REL. LUM.)	16°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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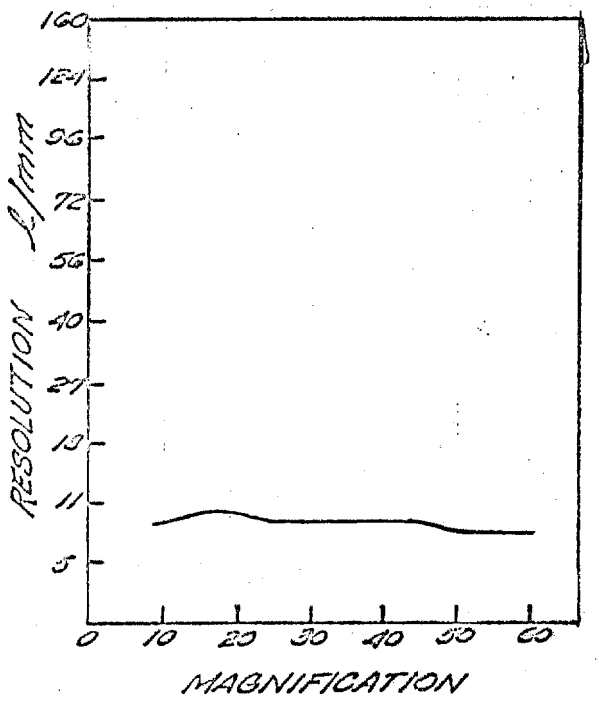
SAMPLE #113

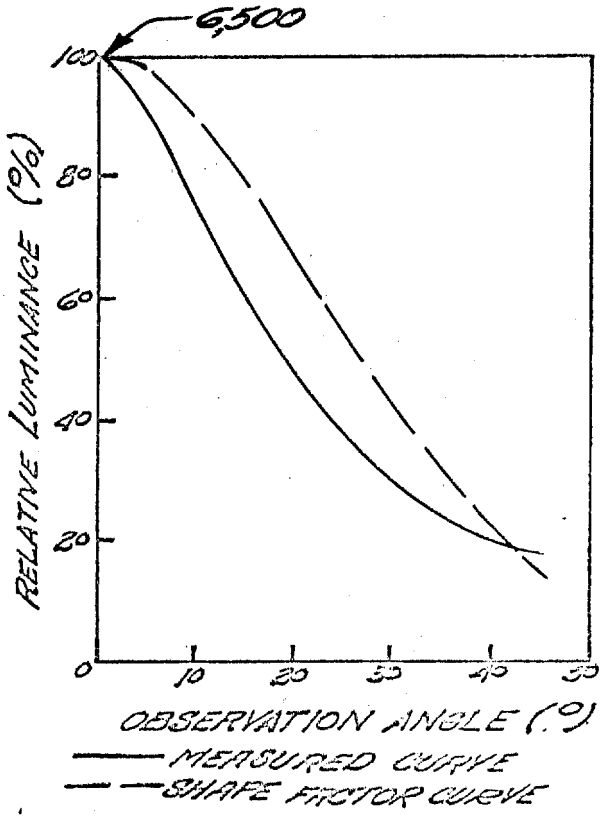
STAT

MANUFACTURER	
DESIGNATION	LS 60 FM
PHYSICAL STRUCTURE	FLEXIBLE GREY
TRANSMISSION (MATTE)	47 %
TRANSMISSION (SMOOTH)	43 %
AXIAL GAIN	4.0625
IMAGE BREAKUP MAGNIFICATION	19.5X
POLARIZATION QUALITIES	
THICKNESS	.125 INCHES
ANGLE (50% REL. LUM.)	19°

CONTACT RESOLVING POWER



LUMINANCE GAIN PROFILE



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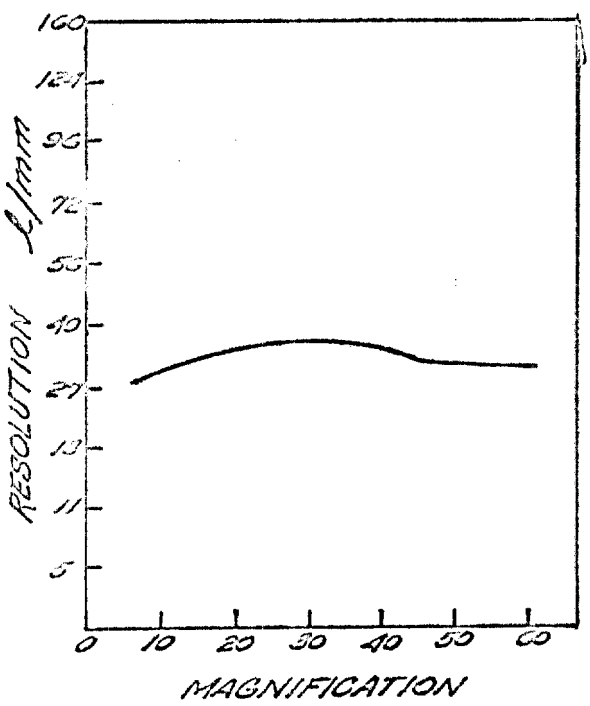
SAMPLE #114

STAT

MANUFACTURER	
DESIGNATION	LS 75 BG
PHYSICAL STRUCTURE	AQUA GLASS
TRANSMISSION (MATTE)	67.5%
TRANSMISSION (SMOOTH)	65%
AXIAL GAIN	10.0
IMAGE BREAKUP MAGNIFICATION	18.0 X
POLARIZATION QUALITIES	
THICKNESS	.125 INCHES
ANGLE (50% REL. LUM.)	13°

CONTACT RESOLVING POWER



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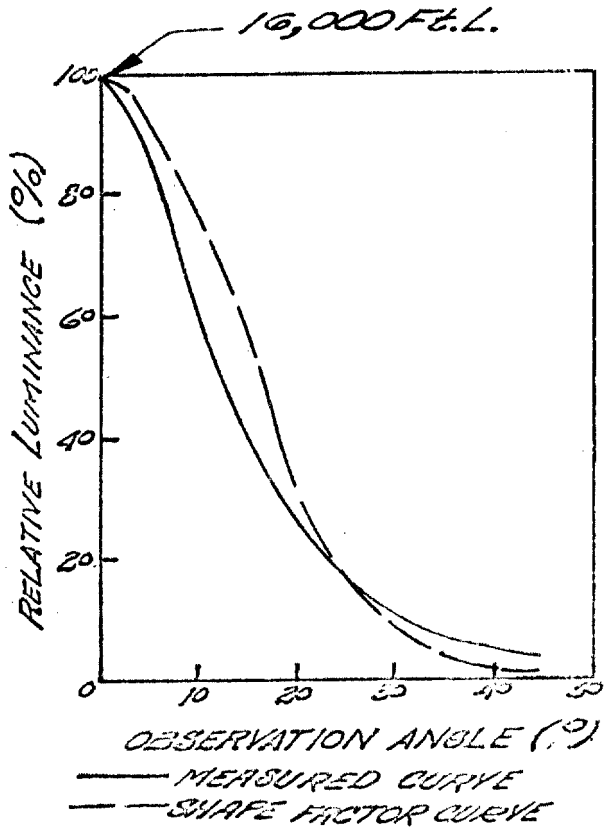

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APPENDIX C

PHOTOMICROGRAPHS and MICRODENSITOMETRIC TRACES

Following are photographs of the photomicrographic and microdensitometric spot scan results, which have been described in Section II G 2 and 3 of the report.

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Ratio values of measurements from the recording traces of the microdensitometer spot scan as described in sections II G-2 of test. The values are at the 50% (relative to peak of individual scan)

		Ratio
Aerial Image		1.00
Sample	#7	3.82
	13	1.82
	14	1.64
	27	12.18
	47	1.09
	56	3.64
	61	1.00
	65	1.82
	68	2.54
	73	6.45
	78	1.36
	81	1.09
	97	1.00
	110	1.46
	111	6.64

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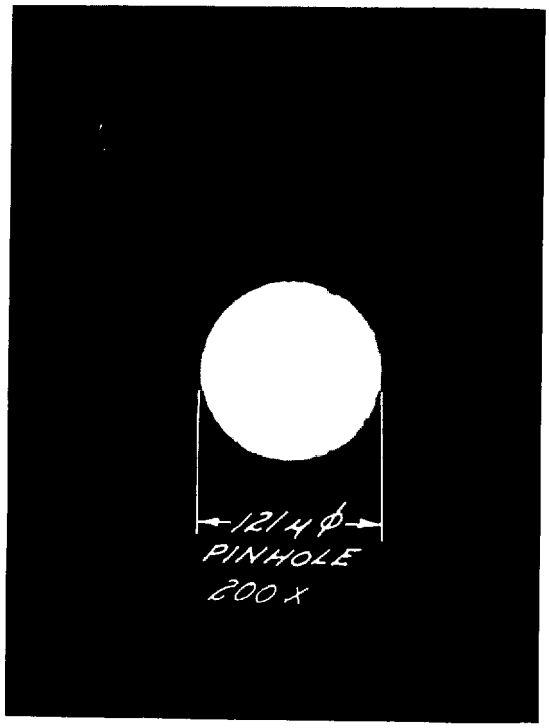

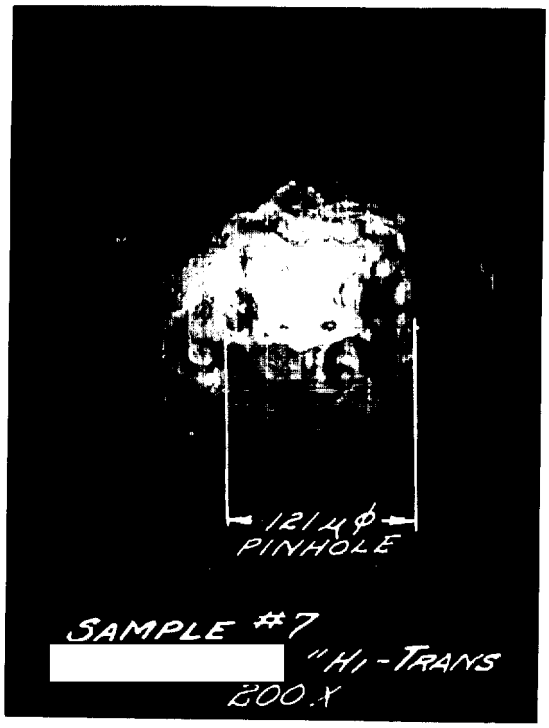

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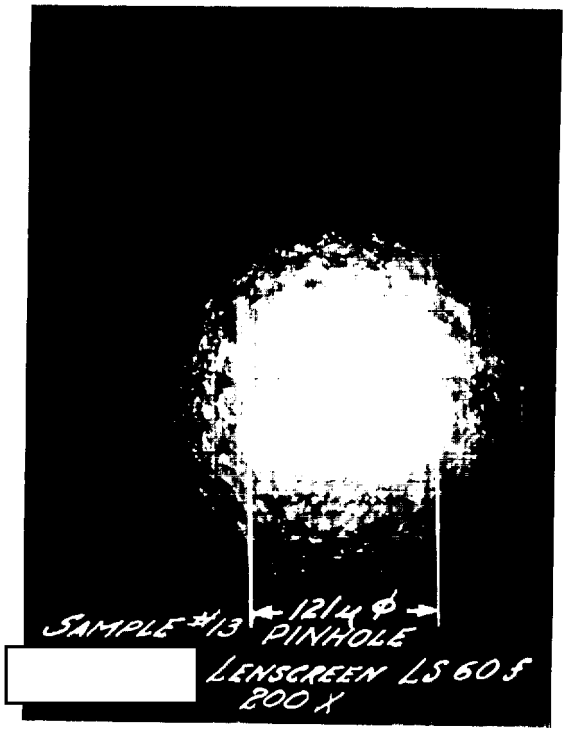

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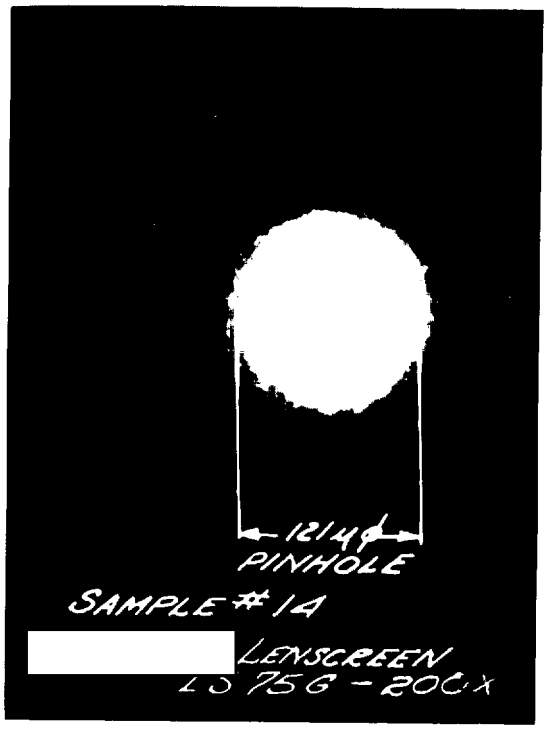

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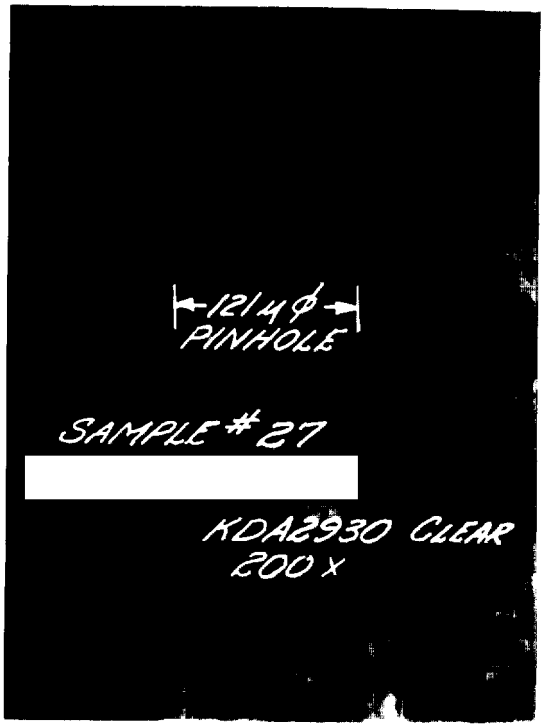

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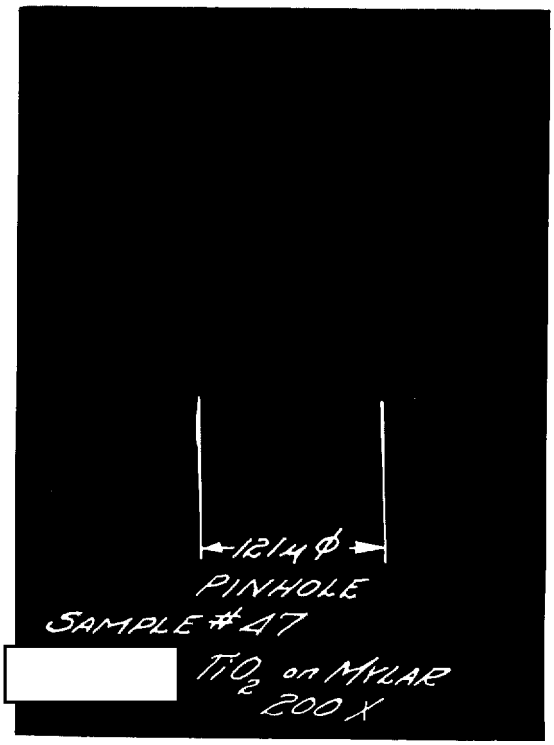

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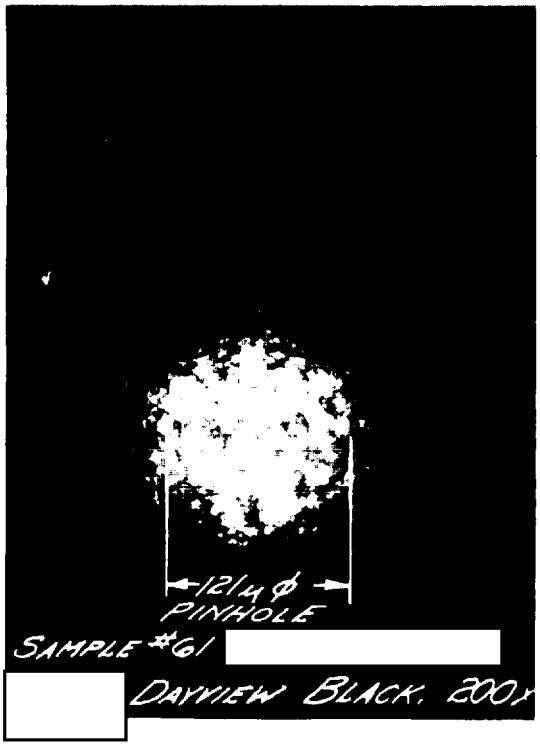

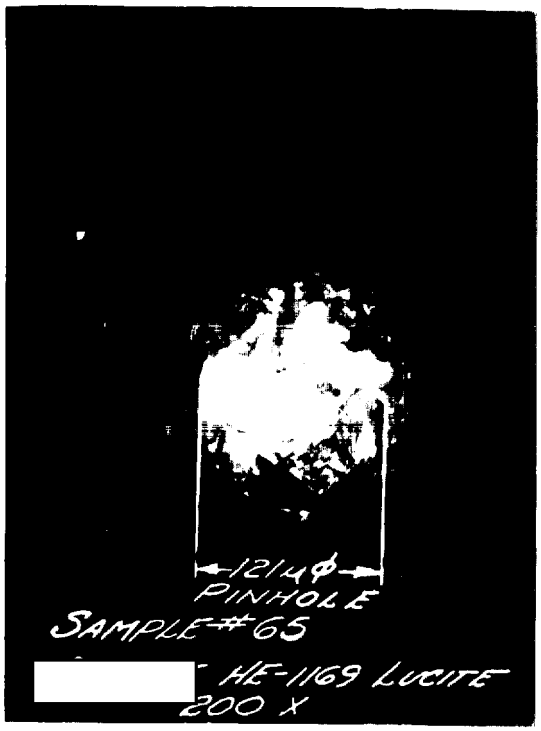

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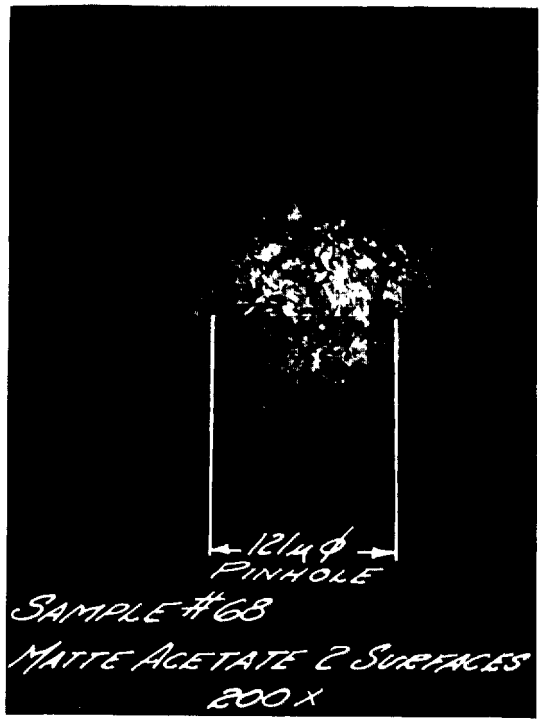

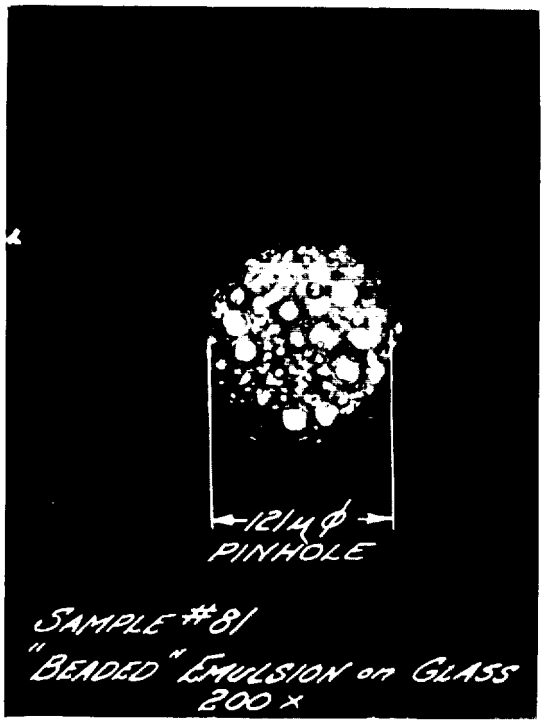

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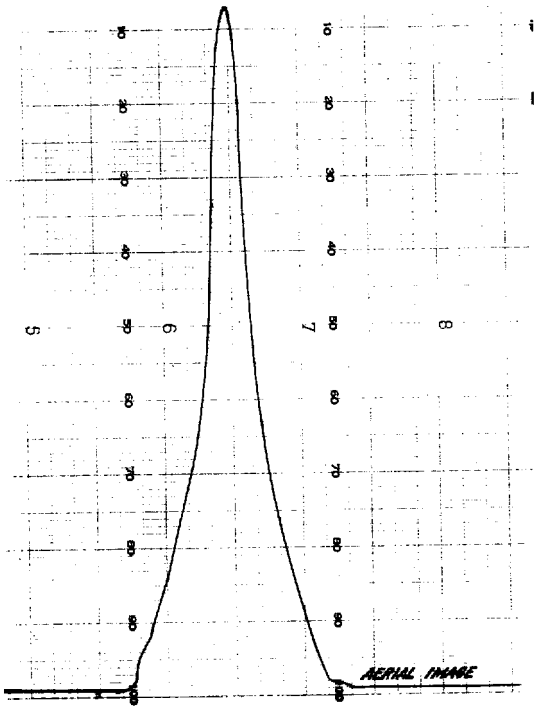

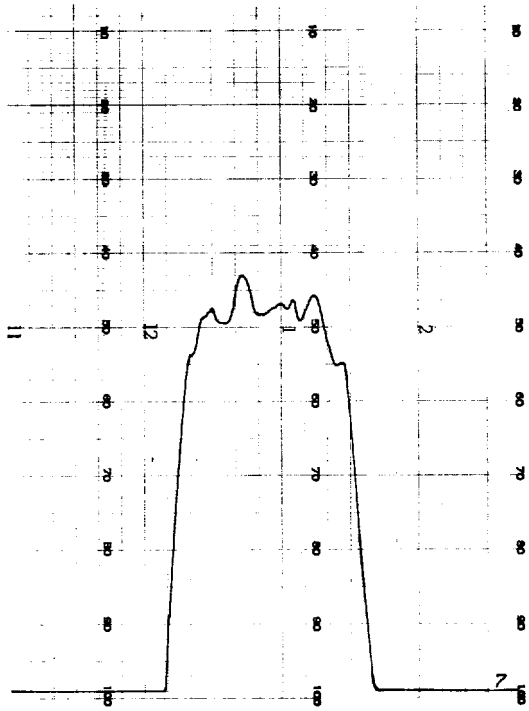

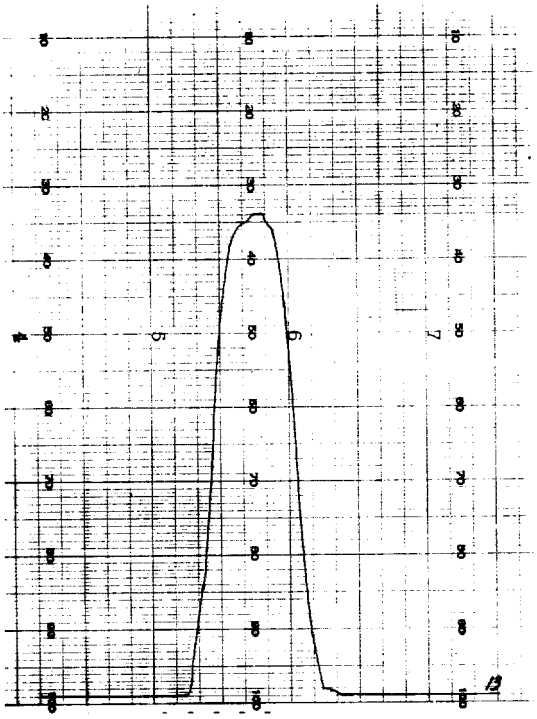

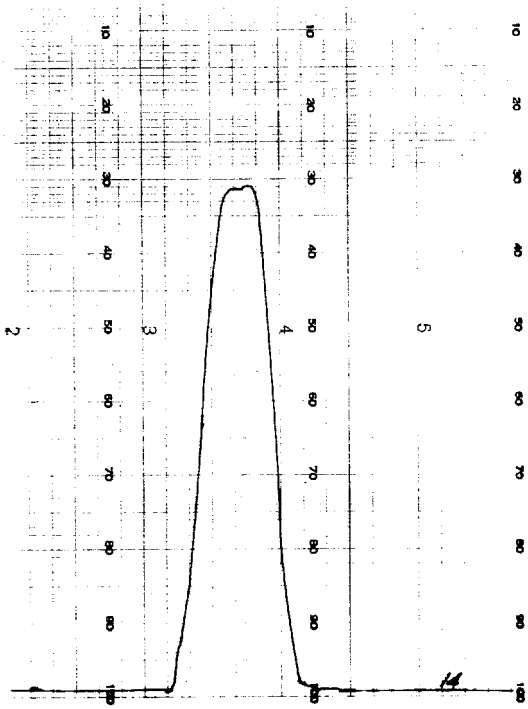

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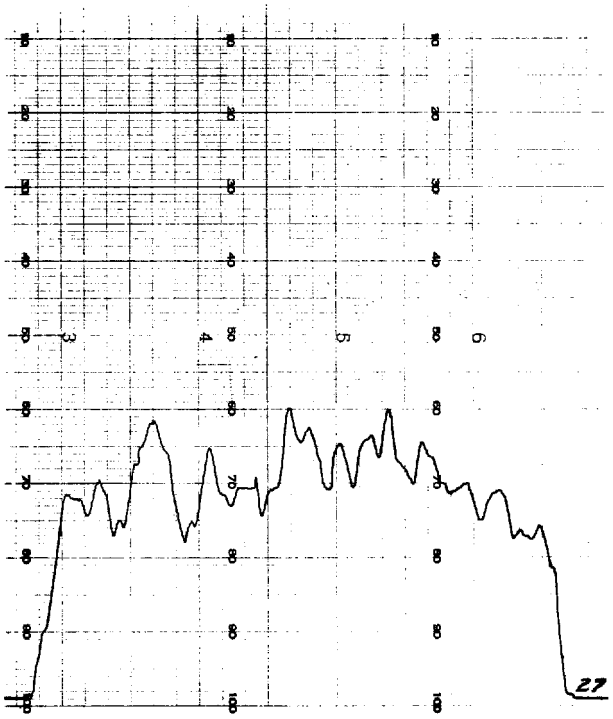

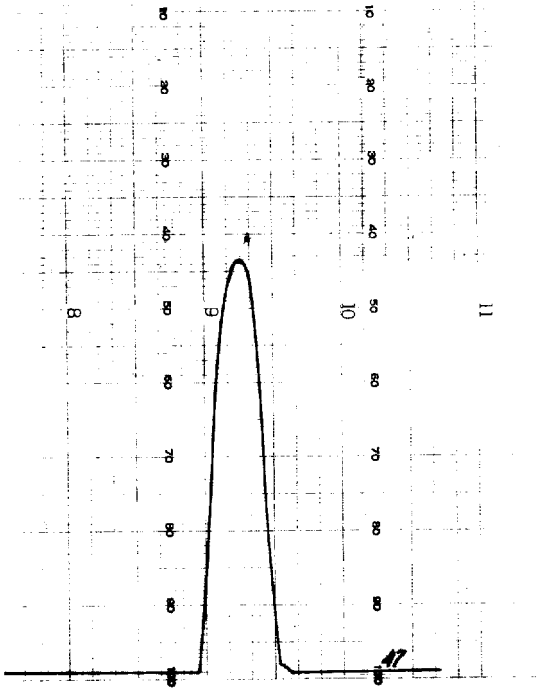

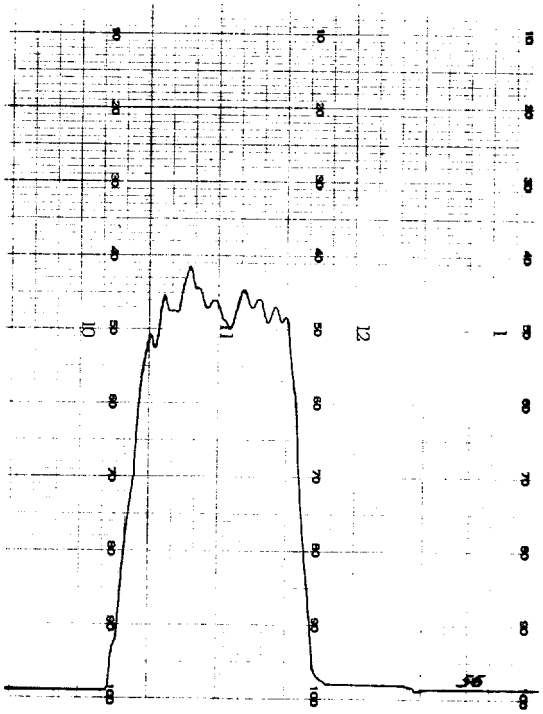

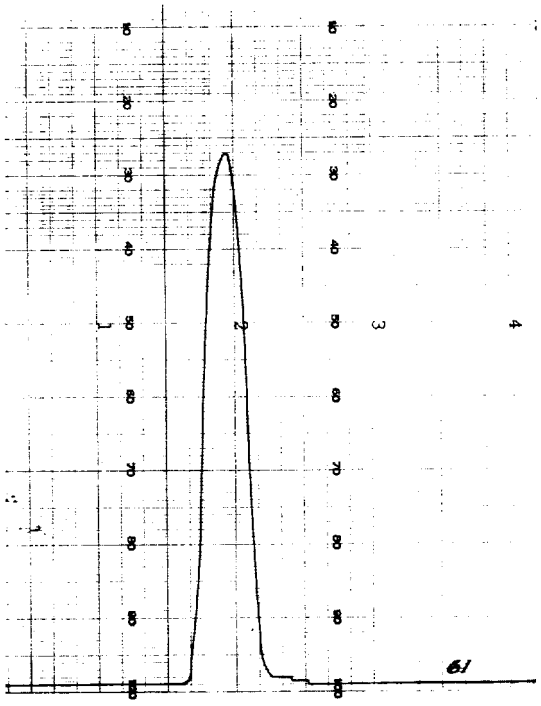

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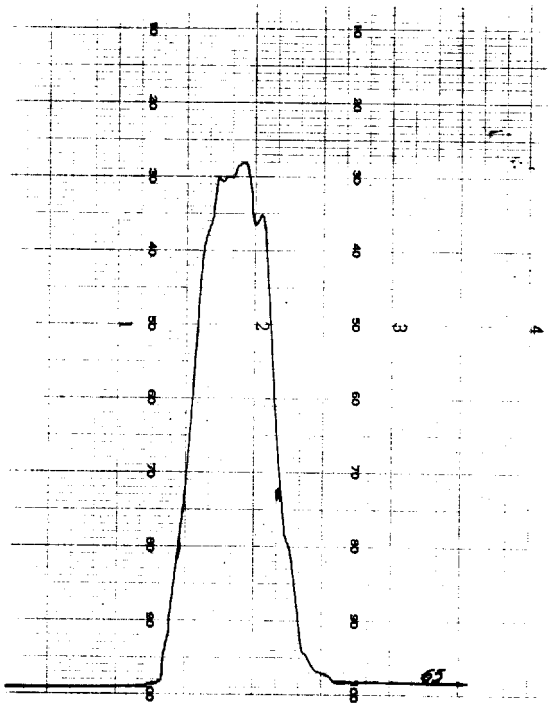

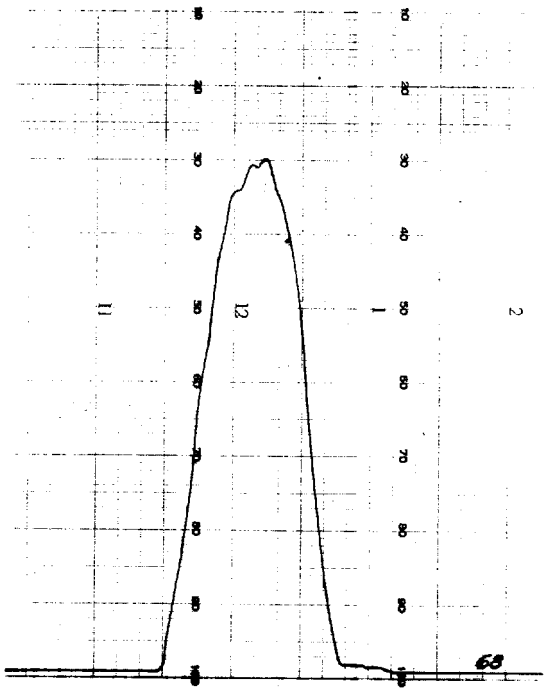

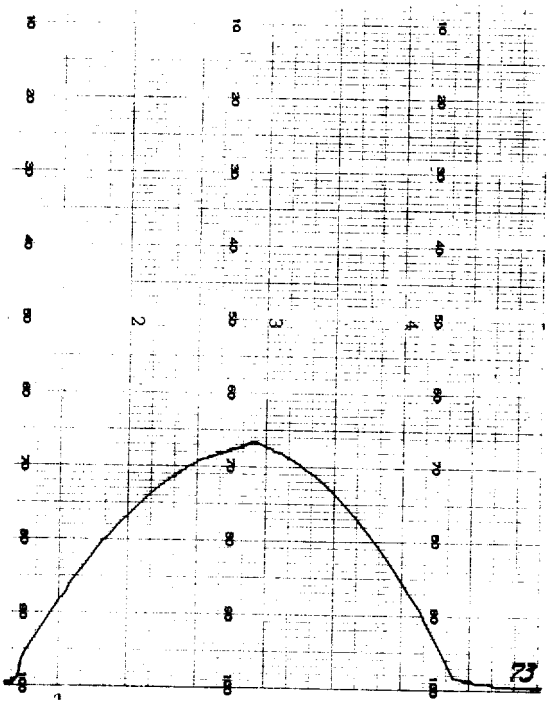

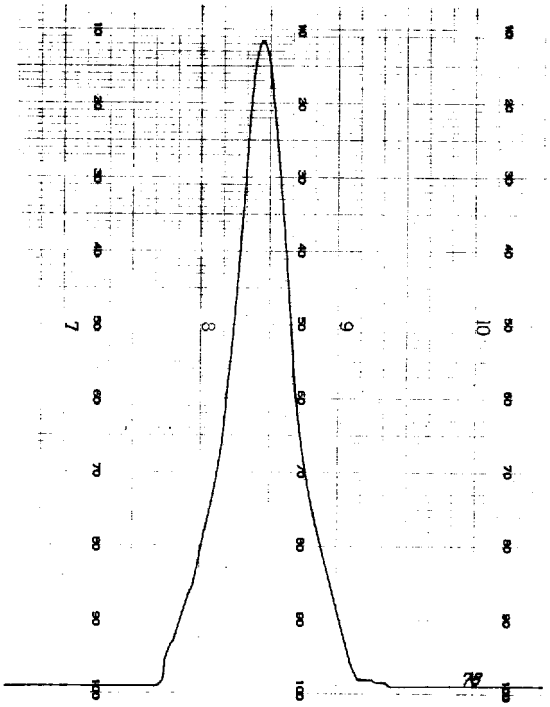

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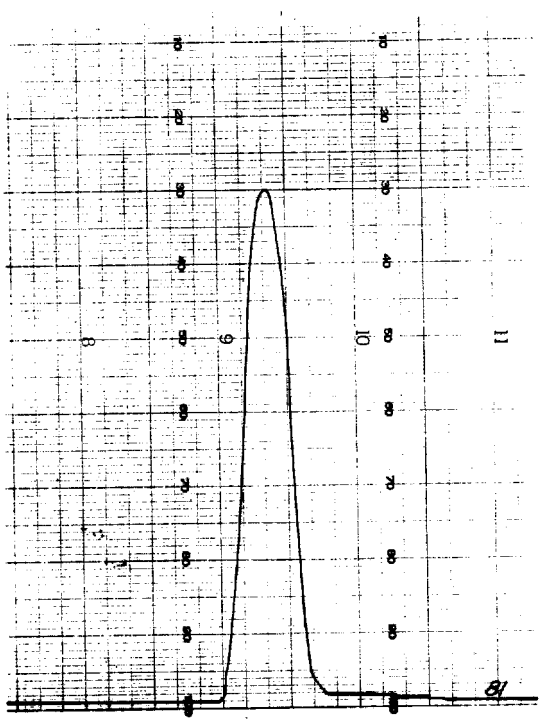

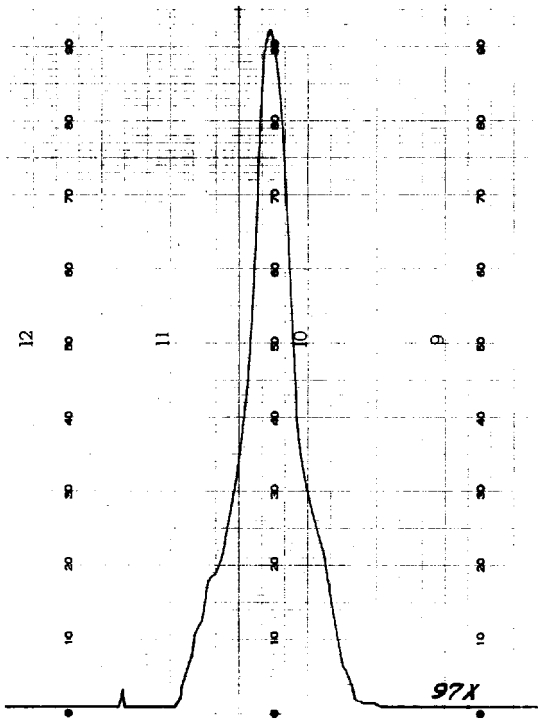

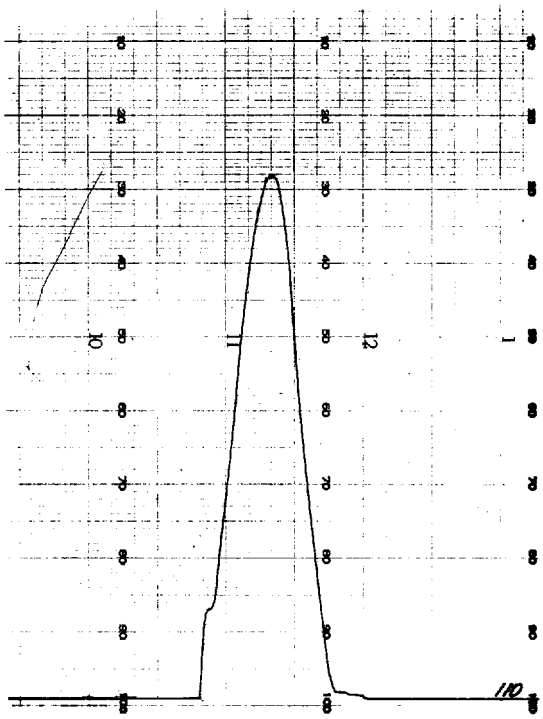

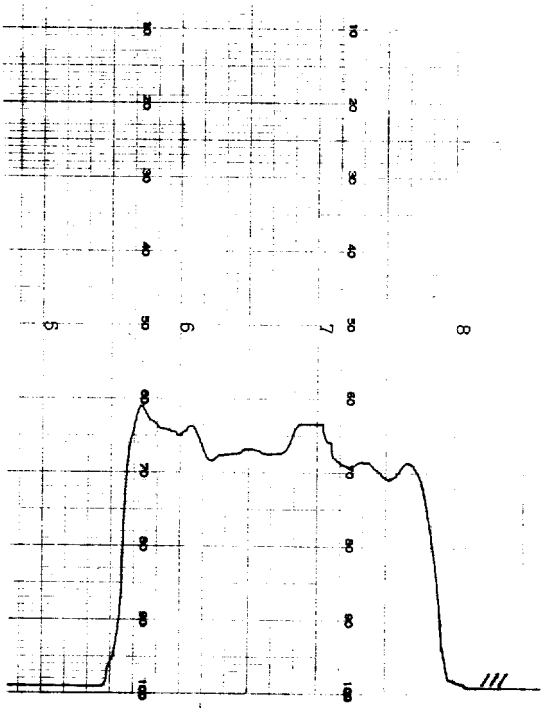

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APPENDIX D

DIFFUSING SCREENS PROPERTIES

In order to properly investigate, understand, and evaluate rear projection screen material performance, a visualization of the process of image formation in a turbid or diffusing medium must be firmly grasped. This intuition crosses many of the boundaries of theory and practice and avoids tangential deviations from the purpose of the task.

Light from an object is incident on a lens either as a plane wave front, if the object is at infinity, or as a spherical wave front with the radius of the sphere at the object. The plane or spherical wave fronts are re-formed by the imaging lens into spherical wave fronts concentric about the image point, that is, if the lens is perfect, these waves are spherical. An imperfect lens, with aberrations,causes the converging waves to be distorted or aspherized such that all the light is not imaged at a point, or, in this analogy, the focal points for the various areas of the wave front are positioned at the center of curvature of each wave front area.

The eye can be and is a lens, so, in an object-lens-image-eye sequence the eye can be used to image the wave fronts formed by the lens, if the eye is able, with its limited accommodation range, to re-form the spherical or aspheric waves such that the intra-ocular waves are in turn centered on the retina and thus "in focus." The difference in this condition is that the object appears to be at the primary lens focus and is thus a virtual image if the eye must be moved away from this image point in order that the waves coming through the lens image point are of long enough radius for eye accommodation. If the eye is placed at the focal point of the lens it sees only the lens filled with light as the lens waves have essentially no "front" at this point and the eye lens acts as a field lens only.

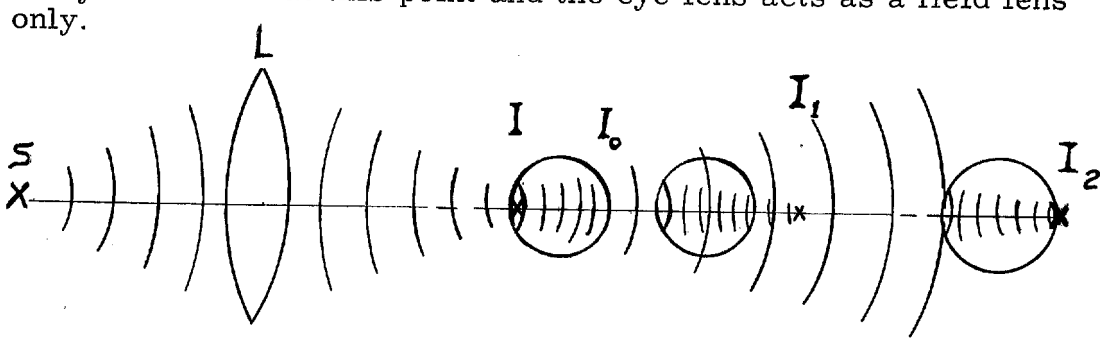

Figure D1

Thus as in Figure D1 we have no visual image at either I_o or I_1 and a virtual inverted, minified image at I_2.

This general condition is that under which the rear projection system must operate, that is, the image if formed at I under either 1:1 conditions or magnified by the ratio of the L to I throw distance. If a lenticular "screen" is placed at I so the light is refocused and the wave fronts are compatible with the eye accommodation the image is seen

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as an enlarged, upright (non virtual) image. The material is a screen in one sense and an eyepiece in another. It is apparent this set-up is very directional in that the line of sight from eye to object is more or less straight and the eye cannot move too far from the system axis and still see the image. Also two eyes see different aspects of the image and, unless the lens (L) is large both eyes may not see the object (or image) at the same time.

The diffusing screen, on the other hand, is an image "retaining" material. The optical system forms a pattern on the screen and this pattern, because of scattering of light within the material, is seen multidirectionally through the screen. The various ramifications of this scattering process deserve some detailed attention.

There is a direct analogy between the rear projection and front projection screen which should be borne in mind. If we place a polished, plane parallel plate or sheet in the image plane described above all wave fronts will pass through without change, except for the 4% reflection losses at each air-glass surface, so no image is seen at the image plane of the system. A mirror surface in the front projection case gives the identical result, that is, a virtual and highly directional situation. This analogy, as well as the imaging requirement of diffuse properties on the part of the rear and front projection materials, is noted because of the greater literature volume treating the front screen case. It should also be emphasized at this point that the front and rear situation are basically similar only the the sense of long viewing distance conditions, that is, theater and mass display types of use cases for which the magnification at the screen ranges from 100 to 1000 with the observer located 50 to 500 feet away from the screen. High definition image quality is not a critical characteristic of the screen material in this sense. Under these conditions uniformity of diffuse reflectance or transmission or freedom from reillumination (light from one side of a deeply curved screen is partially reflected across to the other side, lowering contrast) are the primary concerns. The diffusing elements or grains can be very coarse, just so they are not visible as discrete particles from the observing position. The order of magnitude of particle size can be gauged on the fact that movie screens perforated for sound transmission (speakers behind the screen) have holes up to 1/4 inch in diameter throughout. The concern of the screen designer is for the reflection area lost due to these perforations thus lowering the screen efficiency.

The properties of front and rear projection materials differ also quite markedly as the finer points are approached in the optical analysis. An excellent front screen can be made of a good matte white paint or even matte paper. Both exhibit high diffuse efficiency in reflection. It is obvious, however, that neither of these can be used in rear projection because both are essentially opaque and therein lies one of the fundamentals of the problem.

The ground glass type of material offers a good example for thought. The mechanism of glass grinding is such that the abrasive particles and the brittle characteristics of glass result in a chipping action, not one of peeling or planing. Close examination of a scratch on a glass surface will show it to be a linear array of pits of varying diameter and depth, not a smooth, ruled line. By the same token a ground surface is a random array of such pits. The finer the abrasive particle size the finer or smaller the pits until one reaches the

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"shined" surface. It might be thought, in this continuity, that a polish results from very fine abrasive or rouge, however, there are indication the polishing action is different in that a sort of erosion occurs - that is, glass particles are not removed but displaced on a semi-fluid basis.

The ground surface thus has two optical characteristics - an array of microsurfaces of random tilt with respect to the datum and a random depth or layer thickness. A light ray bundle striking this surface is therefore scattered by a combine prismatic-lenticular action in that each micro surface deviates the rays intercepted by its area as defined by the products of air index of refraction, angle of incidence on the microsurface and the glass index and angle of refraction. Since these surfaces are essentially prismatic in nature, dispersion also occurs so each ray or small bundle is color dependent, however, the randomness of the refraction and dispersion tends to cover up, for relatively large bundles, any observable chromatism. If, however, a small pencil of light is defined by the object, the lens aperture, or the eye aperture such that a point-to-point association exists between image and screen texture micro-area, not only color but intensity "sparkle" will be seen as will be discussed below in more detail.

The random deviations direct the rays in all angles, from the points of incidence, within a random series of cones defined by the index of refraction properties and the angles of incident light rays. However, in passage through the thickness of glass between the ground surface and the polished side, the rays exceeding the critical angle from glass to air as defined by the indices of refraction of the two, will not emerge and are totally internally reflected. Thus there are two approximate cones defining the transmitted angular distribution of light.

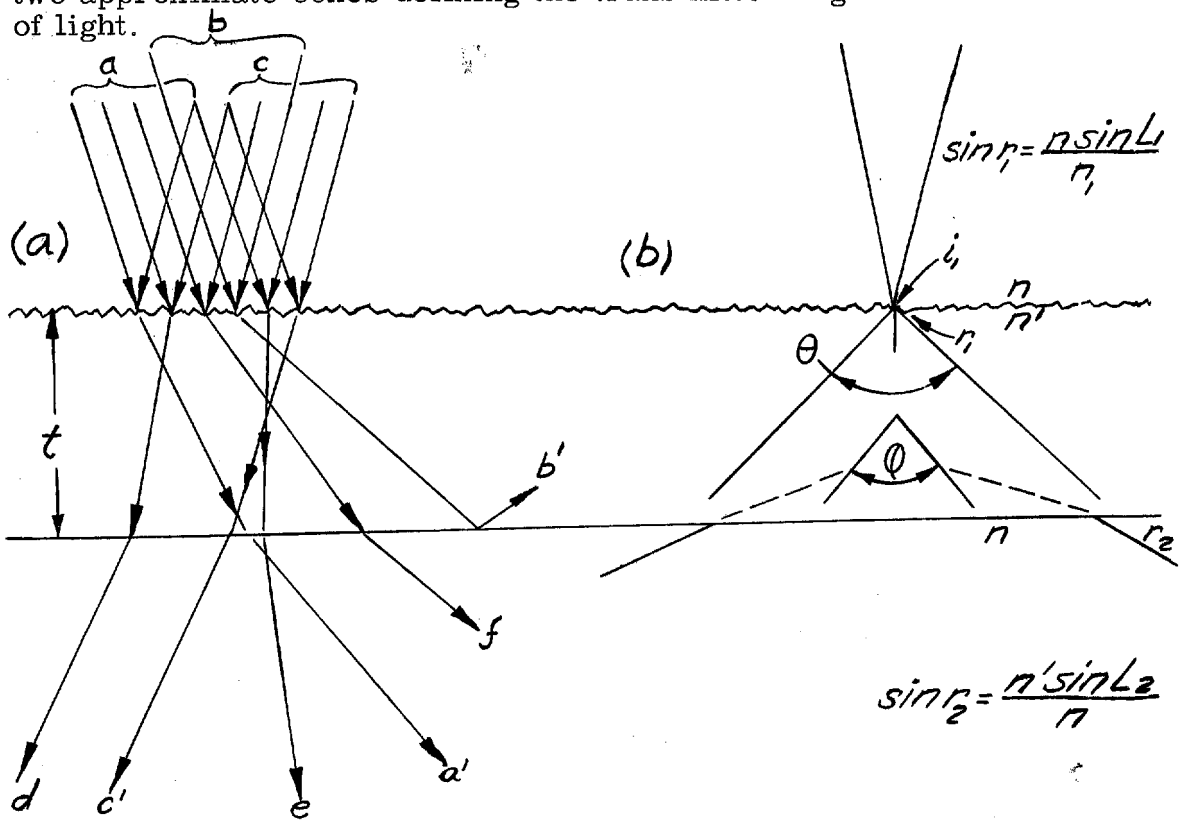

Figure D 2

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Figure D 3

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These cones, indicated as 0 and 1 in Figure D 2, define two different characteristics of the diffusing phenomenon: θ refers to the intra-material scattering while Φ sets limits on the uniformity of diffusion of the material as a function of obliquity. In other words, the emergent angle of the cone indicates the distance off the optical axis the observer can see the image.

In most cases the ground surface is thin with respect to the plate thickness t. Light focused on the surface is scattered additionally as indicated by the short lines in (a) because the small cone angle of incidence is preserved in passage through the small micro facets of the surface in each case. In some cases there may be secondary reflection by an adjacent facet for portions of sharply refracted cones such that a portion of the light is redirected toward the back polished surface instead of being lost by transmission the length of the plate. Thus the apparent source of the deviated ray is shifted with respect to the original incident ray point, introducing the concept of spreading to be discussed below.

Referring back to the previous sketch, the point-to-point aspects of sparkle can be visualized more clearly. Let us assume that all the light incident within the limits of the illustrated bundle is channeled into the emergent rays indicated, that is, the main intensity of each ray is in the direction and along the lines within the region d - f. If the pupil of the eye at the observing distance from the screen includes all of d - f, an integrated, uniform response will occur, that is, no discrete isolation of one ray with respect to the other will occur. If, on the other hand, the eye sees only one ray at a time in traveling laterally from d to f, the bundle will be seen only as isolated points of light emerging from different locations in the incident image. For example, the pencil c is seen at c', a at a' and b not at all. By the same token two eyes, one at d and the other at e will see two parts of the image simultaneously but if moved over (or "in") to see d and a', the same image area. Both highly idealistic representations (since scattering is never so pure and the angles involved are never so clearly defined) demonstrate the sparkling effect and the phenomenon of image break-up in a superficial sense.

We have assumed the ground surface to be thin up to this point and the most direct expansion is to consider a double ground piece. This can be dispensed with quickly from the quality aspect simply by noting the effect additional scattering would have on the rays shown in (a) and realization that ray b' would have a possibility of emerging if the micro-facet at its incidence point on the second surface were of the correct angle (dotted). But in consideration of this second ground surface another part of the diffusion process appears more prominently. If the only light striking the plate is that shown the intensity of the emergent bundle and the distribution within the angular cone Φ. If the area of the emergent bundle at the second surface is twice that of the incident area, the apparent brightness at the second surface will be half the incident less the losses due to rays internally reflected. If the brightness is measured at a distance from the rear surface only a portion of the emergent cone will be seen at one time so the brightness will be further reduced. As a result of these effects one method of measuring the efficiency of a diffusing screen might be based on the ratio of incident to emergent brightness with the latter measured at the rear surface and in terms of directionality of diffusion. If a small spot of light were to be imaged

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on the [illegible] of a [illegible] located at such a distance from a photocell of area large with respect to the spot so all light emergent from the plate is recorded and if the cell aperture could be closed down and recorded in terms of emergent area, both intensity and distribution would be measured. A photocell system having a small aperture could scan across the beam to obtain the same type of data. Obviously the transformation of a point or sharp disc image into a large disc is one of the critically undesirable characteristics of a screen material. If at the same time this large disc is uniformly visible throughout a large emergent cone angle, some of the image quality loss may be expendable in exchange for group visibility. If the difference between disc sizes is undetectable to the observer, that is, if the viewing distance is such that the limit of definition is eye-dependent, beyond the image quality threshold thus defined, the only characteristic of importance is the cone distribution. A critical factor which must be constantly borne in mind is therefore the condition of use and the visual response to both quality and brightness.

The ground glass condition in single and double layer forms has been taken as the simplest case of rear projection diffusion. Image spread of a rather restricted form is present in the single layer case. The random nature of the deviating facets implies two phenomena.

Most of the light will statistically pass straight through the scattering layer because, although relatively large deviations result from individual facets, the center of gravity is on the axis of the incident bundle. The emergent bundle is thus a collection of individual rays of sufficient departure from each other, angularly speaking, that the faceted surface appears to be the source of light rather than the object. The eye can therefore fix on this new plane as the scattered wavefronts appearing to originate there merge into a plane wave front or one of such long radius that the eye can accommodate as if it were a printed page at normal 10 inch reading distance or at conventional viewing dimensions. The most obvious spreading of a coarse ground surface is of the sparkle variety wherein the image is really broken up rather than diffused. Each small area contributes a section of the image but these sections must be integrated to present the whole. This sectional appearance is thus pseudo spreading in a sense and the fine structure of the image is either completely destroyed or is shifted by adjacency as mentioned above. It would appear, therefore, that a solution is to make the facets smaller, but as this is done the chipping action of abrasion becomes less, the angles of deviation decrease and the purely specular transmission of the clear plate is approached. As this occurs both diffusion effect and visual locatability of the image become less pronounced and screen effectiveness is lost.

Another method for producing a diffusion condition is that of suspending small particles in a thin layer of transparent material such that the particles are evenly spaced, semi-identical in form, and small enough to, in themselves, minimize the dissection of the image, and elementary form of this uniformity concept may be represented by a matrix of tiny glass or plastic spheres on the surface of a supporting substrate. A sphere has the property of focusing incident rays near its rear surface, and with proper selection of either index of the sphere or its suspending material, on the rear surface. Under this condition the sphere becomes an auto-collimating "cats eye" reflecting light back on itself from any direction. A matrix of these is used in the Scotchlite sign material. For rear projection purposes, however, the desire is the reverse of the beaded screen (front projection type) in that the incident light must be transmitted yet controlably refocused at a high f/number. The sphere with focus beyond the second surface

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does this and the high angle of convergence to the focal point results in diffusion. The only problem is to place as many small spheres close enough together that all the incident light is so treated. Since spheres do not truly nest there must be gaps between and the area of these voids is strictly a function of the sphere dimension. If several layers of spheres are overlaid the gaps are closed and all incident light passes through at least one sphere in transit. However, in the process the light may also be reflected off several other spheres before or after refraction.

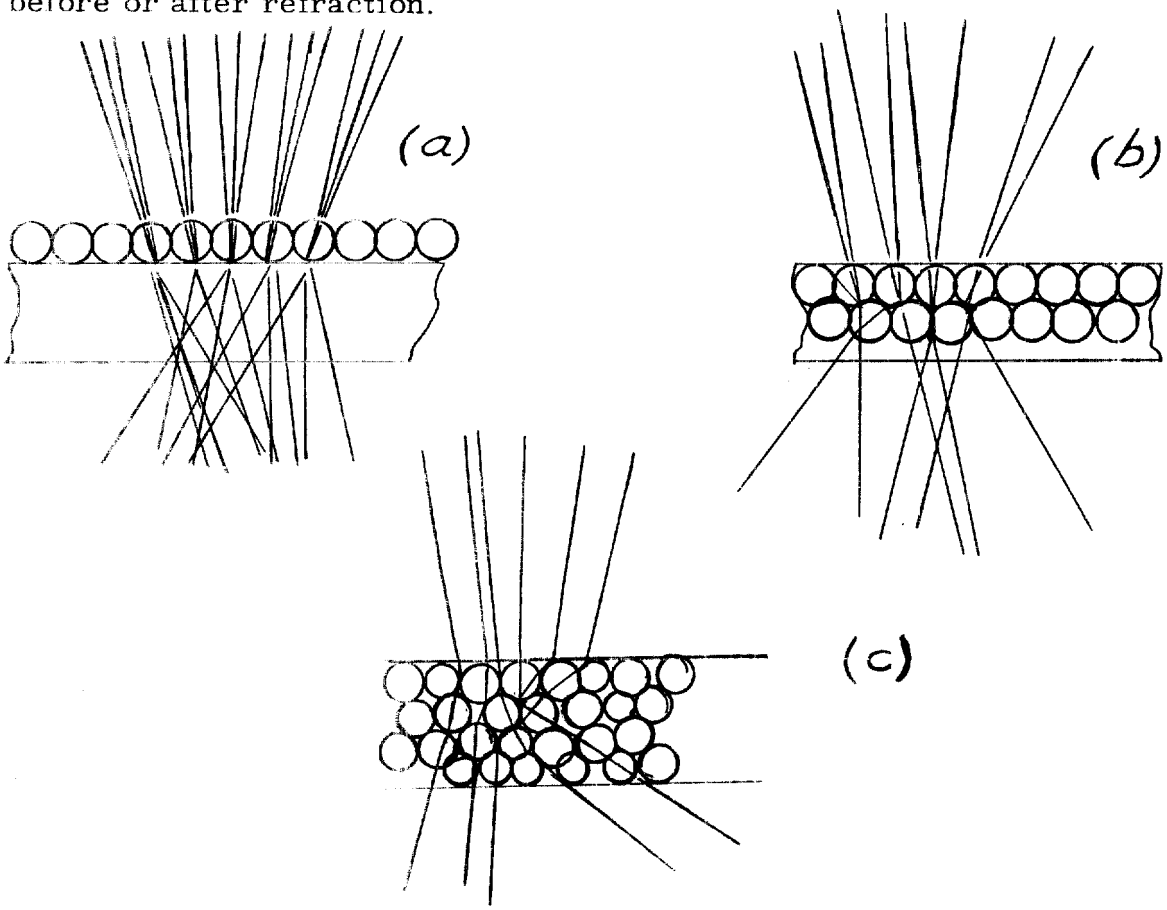

Figure D3

The preceding sketches show the progression from single layer to multiple reflection-refraction structures. It should be apparent that as the thickness of the layer increases and the particle size decreases the incident image is spread over a larger area on the emergent side. This type of true spreading causes the image to appear as a central peak with gradient edges - very similar to the spread of density exhibited by photographic and screen spreading caused by the randomness in both distribution (clumping) and size of the photographic particles whereas in some or all screens the particles are similar and evenly spaced. The basic similarity and analogy between the two spreads lies in the displacement of light from the primary image area resulting in a reduction of primary image intensity, hence contrast, and a gradient edge unsharpness.

As a result of these screen and image structural considerations the philosophy and methodology of test and evaluation were formed.

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APPENDIX E

DEFINITION THRESHOLD TEST EQUIPMENT

To evaluate the rear projection screen material samples for this project, an instrument was constructed which is described in the following text and sketch (Fig. E. 1).

A 50mm lens (a) and a double rail lens bench (b) nine feet in length was selected to facilitate the 40:1 to 1:1 magnification range. A slide (c) is traversed throughout this range by means of a crank and drum drive (d) through a cable to the slide and an idler pulley (e). The slide (c) is accurately guided along rails (b) by means of Vee Blacks (f) saddled to one rail and bolted to the slide carrier (h). To maintain a focused image (i) of the object on the sample (j) in the fixed sample holder (k) an autofocus cam (1) varies the lens (a) position by means of a cam follower (m) and link (n). The cam is rotated by means of a 3:1 gear reduction (gears o_1, o_2) carried on plate (p). Gear o_2 is keyed to a friction wheel (q) which is maintained in non slip contact to a friction rail (r) by means of a load adjustment bolt (s). Therefore as slide (c) is traversed, wheel q and drive gear o_2 rotate driving gear o_1 which is keyed to the cam (1). Cam follower (m) and link (n) are maintained in contact with the cam by means of a tension spring (t). Slight errors in the cam are compensated for by means of a fine focus adjustment crank(u) which translates the adjustment to the lens via a speedometer cable u. The object is illuminated by means of a fixed reflector lamp and condensing lens group (v). A fixed mirror (w) serves to direct the object illumination to the object. A second mirror and lamp x, x_1, fixed to slide (c) projects an image of the particular unit magnification index mark as dictated by the position of the slide on the rail. The projected image is viewed through a [redacted] Zoom Stereomicroscope (y) which may be pivoted about the vertical axis of the image AA' for off-axis viewing to 45° half angle. In an evaluation sequence the viewer is seated viewing the projected image through the microscope. To his lower left is the traversing crank (d) by which he may vary the image magnification. Also on his left is the fine focus adjustment. He may further vary the image magnification by means of the 14x to 50x range of the Zoom Stereo.Microscope. He may at any time determine the image magnification by sighting through the peepsight to his right at the reflected image of the magnification scale which is fixed to the friction rail.

STAT

Figure E1 is not an exact rendering of the instrument's appearance and is intended only to illustrate the mechanical and optical features.

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APPENDIX F

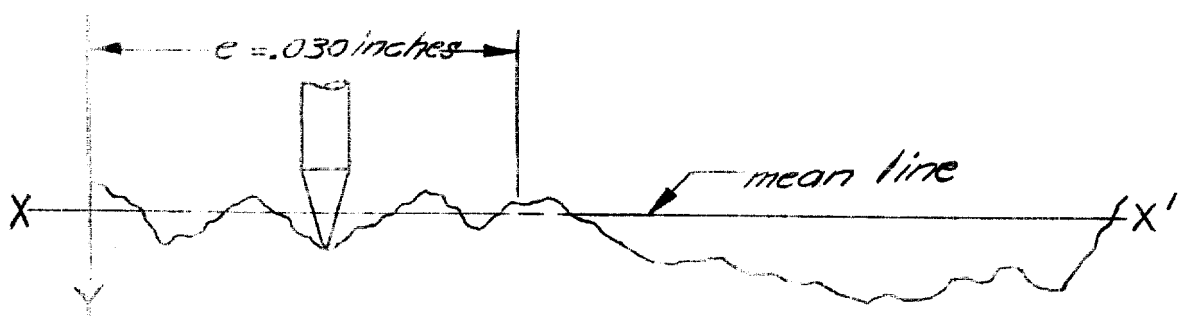
DESCRIPTION OF THE PROFILOMETER SURFACE ROUGHNESS VALUES FOR SAMPLES #74-80

A profilometer, made by [redacted] was used STAT
(per ASA Spec 46.1-1955)
(by S.A.E. & A.S.M.E.)
to determine surface roughness measurements

It gives integrated root mean square values of average deviation of the surface above and below a centerline which is a line parallel to the general profile of the surface. A sharply pointed stylus is moved over the surface to be tested, the irregularities of which translate the stylus in a direction perpendicular to the surface. This movement is electrically amplified and gives a proportional reading. A sufficient length is traversed by the stylus to insure a full reading characteristic of the surface. The values obtained are defined by the formula.

$$Y = \left[\frac{1}{e} \int_{X=0}^{X=e} y^2 dx \right]^{1/2} = \text{microinches (one millionth of an inch)}$$

where Y = the integrated root mean square value, e = length over which the measurement is taken, and y = the ordinate of the curve of the profile. - The reading does not indicate waviness of the surface over lengths greater than that traversed by the stylus.



To completely define a given ground glass sample the slope of the irregularities and the degree of polish after grinding or sand blasting would have to be known. The periferal speed of the wheel, speed of traverse rate of feed, grit size, type and amount of lubrication at the point of cutting, state of dress of the wheel, and physical characteristics of the material being ground all bear on the type of surface obtained in grinding. A variation in any one or more of these factors can produce marked differences in surfaces obtained. Similarly the blasted material, particle size, pressure, duration, volume, orifice characteristics and the angle of blasting bear directly on the results of a sand blasted glass surface. Therefore, it is felt that the profilometer values give the nearest approach to a specification of a ground glass surface used in conjunction with an optical - mechanical description of the sample glass.

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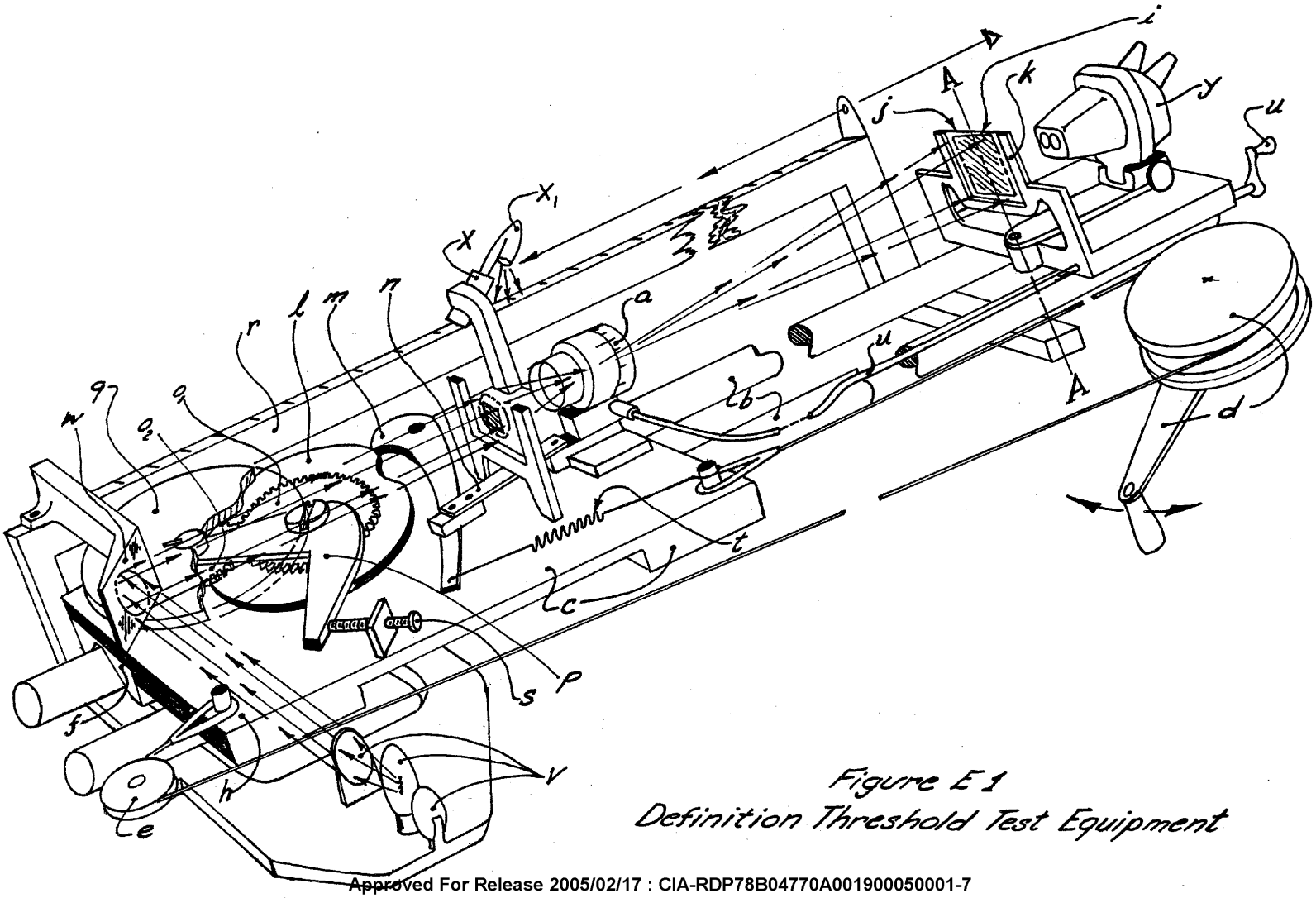

Figure E1
Definition Threshold Test Equipment

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APPENDIX G

DISCUSSION OF SHAPE FACTOR AS A FIGURE OF MERIT OF SCREEN BRIGHTNESS

The figure of merit investigated in this study was the so-called "shape factor" introduced by Dr. Armin J. Hill[1]. It is based upon an empirical formula derived by treating the screen as a type of diffuser which redistributes the light as some power of the cosine of the angle of observation. The formula is:

$$B_\theta = B_D \cos^{s-1} \theta \qquad (1)$$

where: B_θ = brightness at angle θ (other than 0°)

B_D = measured brightness at 0°

s = shape factor

The shape factor s is derived from the relation: $\frac{s+1}{2} = \frac{B_D}{BL}$ (2)

Where BL = brightness of a Lambert diffuser and s and B_D are the same as in formula 1.

Examination of formula 1 shows that where s is greater than 1, the B_θ will be same fraction of B_θ depending upon the angle θ. With s=1, b_θ is numerically equal to B_θ which would indicate even distribution of the light similar to that of a Lambert diffuser. The case when s is less than 1 indicates that B_θ is greater than B_D and s would fail as a figure of merit in this instance. However, as Hill points out, the shape factor is most suited for those screens which can be classified as directional diffusers, i.e. they possess high luminance on and near the axis but with a rapid fall off as θ increases. Comparison with brightness distribution measurements indicate that the more "directional" the diffuser, the more closely the distribution curve predicted by use of the shape factor, s, fits the actual measurements. For those curves where the measurements are more or less even over the angular range measured, the shape factor does not predict the curve. However, a plot of axial luminance vs. transmission for each sample, reveals that for all but a few samples a trend, as one would suspect, of high transmittance for screens that are more directional. Since the axial luminance is used to calculate the shape factor, s, this confirms the validity of using the factor as figure of merit. An example of a shape factor calculation follows.

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EXAMPLE OF "SHAPE FACTOR" CALCULATION

Sample #7

$B_D = 18,000$ ftL

$B_L = 1,600$ ftL

$$\frac{B_D}{B_L} = \frac{s+1}{2} \qquad s + 1 = \frac{36,000}{1,600} \doteq 22.5$$

$$s = 21.5 \qquad s - 1 = 20.5$$

$$B_\theta = B_D \cos^{s-1} \theta$$

$$B_{5°} = 18,000 \times \cos^{20.5} 5°$$

$$\log B_{5°} = \log (18 \times 10^3) \times \log (\cos^{20.5} 5°)$$

$$= \log 18 + \log 10^3 + 20.5 \log \cos 5°$$

$$\log 18 = 1.25525$$

$$\log 1000 = 3.00000$$

$$20.5 \log \cos 5° = \frac{204.96597 - 205}{209.22124 - 205}$$

$$4.22124$$

$$B_{5°} = \log^{-1} 4.22124$$

$$= 16,640 \text{ ftL}$$

. . . similarly for each 5° to 45°

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SHAPE FACTOR DATA FOR SCREEN SAMPLES

Sample #		Sample #		Sample #	
1.	4.75	39.	4.625	77.	55.25
2.	16.5	40.	(too low)	78.	(too high)
3.	12.75	41.	3.25	79.	59.0
4.	5.625	42.	7.75	80.	7.75
5.	3.375	43.	24.0	81.	14.0
6.	8.375	44.	12.75	82.	4.625
7.	21.5	45.	17.125	83.	2.125
8.	3.437	46.	624.0	84.	111.5
9.	9.0	47.	(too low)	85.	49.0
10.	6.625	48.	(too low)	86.	(too low)
11.	5.625	49.	(too low)	87.	N.A.
12.	17.75	50.	(too low)	88.	N.A.
13.	11.375	51.	(too low)	89.	36.5
14.	16.5	52.	(too low)	90.	37.75
15.	64.0	53.	24.0	91.	1.625
16.	71.5	54.	124.0	92.	(too high)
17.	50.25	55.	0.237	93.	44.0
18.	80.25	56.	104.0	94.	N.A.
19.	86.5	57.	27.75	95.	(too low)
20.	0.1	58.	8.375	96.	8.375
21.	0.062	59.	0.75	97.	31.0
22.	-0.675	60.	N.A.	98.	5.5
23.	(too low)	61.	4.0	99.	(H) 1.5 & 1.75(V)
24.	-0.5	62.	4.75	100.	26.5
25.	0.0	63.	20.25	101.	10.0
26.	101.5	64.	17.75	102.	56.5
27.	99.0	65.	47.75	103.	54.0
28.	0.562	66.	(too low)	104.	15.625
29.	1.0	67.	69.0	105.	9.0
30.	9.5	68.	26.5	106.	6.75
31.	2.0	69.	61.5	107.	9.0
32.	0.125	70.	24.0	108.	N.A.
33.	0.375	71.	N.A.	109.	31.5
34.	96.5	72.	N.A.	110.	5.375
35.	72.75	73.	11.25	111.	7.625
36.	-0.78	74.	20.25	112.	7.5
37.	-0.27	75.	10.875	113.	7.125
38.	75.25	76.	8.375	114.	19.0

NOTE: The values marked "too low," "too high," or N.A. are indicated as extremes therefore are unnecessary to include. In sample #99 (H) is horizontal position and (V) vertical.

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APPENDIX I

GLOSSARY OF TERMS

The following terms and definitions are provided as a common reference for use in rear projection screen study. Reference LD-2 and IES are respectively;

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A. Terms describing photometric processes.

Illumination - The density of luminous flux (I. E. S.).

(Luminous) Transmission - The ratio of transmitted light to incident light (LD-2).

Regular Transmission - That transmission in which the light is not diffused and there is a definite geometrical relation between the direction of the incident pencil of light and the direction of the transmitted pencil (LD-2).

Diffuse Transmission - That transmission in which the transmitted light is emitted in all directions from the transmitting body (LD-2).

(Luminous) Reflection - That reflection in which the angle of reflection is equal to the angle of incidence (LD-2).

Diffuse Reflection - That reflection in which the light is reflected in all directions (LD-2).

(Luminous) Absorption - That light which is neither reflected or transmitted or redirected diffusely by a body.

Diffusion - The process by which a surface breaks up the incident light and distributes it more or less in accordance with Lambert's cosine - law of emission (LD-2).

B. Terms describing photometric devices.

Photometer - Any device used to measure the photometric properties of a body by comparison with a standard.

C. Terms describing properties of devices.

Reflectance - Ratio of reflected light to incident light (I. E. S.).

D. Terms used to describe photometric quantities

1. Fundamental terms

Luminous Energy - The quantity of light, the product (I. E. S.). of Luminous flux by the time it is maintained.

Luminous Flux - Time rate of flow of light (I. E. S.).

Luminous Flux Density - Illuminance (illumination), the density of luminous flux incident upon a surface. It equals the ratio of the flux to the area of the surface when the flux is uniform over the area (I. E. S.).

Luminous Intensity - The solid angular flux density in a specified direction. It is the ratio of the flux of an element of surface to the solid angle subtended by the element when it is viewed from the source (I. E. S.).

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Luminance (Photometric Brightness) - The luminous intensity of any surface in a given direction, per unit of projected area of the surface viewed from that direction (I. E. S.).

2. Fundamental Units

Luminous Energy - Lumen Hour - Q

Luminous Flux - Lumen - F the flux emitted through a unit solid angle (one steradian) from a uniform point source of one candle.

Luminous Intensity - Candle - I - 1/60 of the intensity of one square centimeter of a blackbody radiator at the temperature of solidification of platinum.

Luminance - Foot - Lambert - B - same as the apparent foot-candle - 1 ft. L. equals $\frac{1}{\pi}$ candle per square foot or to the uniform photometric brightness of a perfectly diffusing surface or source emitting or reflecting light at the rate of one lumen per square foot or to the average photometric brightness of any surface emitting or reflecting light at that rate.

Gain - The ratio of luminance to illuminace at normal incidence (in units).

$$\text{Gain} = \frac{\text{Foot-Lamberts}}{\text{Foot Candles}} = \frac{B}{E} \quad \text{(Reference 46)}$$

Lambert Surface - A perfectly diffusing surface in which the intensity varies as the cosine of the angle between the emitted ray and the normal to the surface; i. e.

$$I_\theta = I_D \cos \theta$$

Since it is a perfect diffuser it appears equally bright at all angles, thus,

$$B_\theta = B_L$$

Directional Diffuser - A surface or media in which light is redirected at all angles but in which the intensity is noticeably greater over a narrow angle in the region near the normal.

Shape Factor - s - An empirically derived number used in a "figure of merit" concept to indicate to the user the directionality of a particular diffusing material. It is calculated from the following formula:

$$\frac{s+1}{2} = \frac{B_D}{B_L}$$

where B_D = luminance at the normal to the surface of the material

B_L = luminance of a Lambert surface under the same conditions of illumination

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The shape factor may also be used to predict a theoretical luminance profile of a material to compare with the measured profile by use of the following formula:

$$B_\theta = B_D \cos^{s-1}\theta$$

where B_θ = the luminance at a particular angle θ other than the normal and B_D and s are the same as in the above formula.

Luminance Profile - A plot of the luminance distribution over an angular sector about a point on a diffusing surface. It is obtained by plotting the relative luminance vs the angle of view.

Relative Luminance - The ratio of the luminance at any angle θ, to the luminance at the normal, expressed in percent. The relative luminance at the normal is 100% for any sample.

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FINAL REPORT

REAR PROJECTIONS SCREEN MATERIALS

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