Sylvania

PHOSPHORS

For Color Television

For Black and White Television

For Radar and Oscilloscopes

SECTION 1

COLOR TELEVISION PHOSPHORS

SECTION 2

BLACK AND WHITE TELEVISION PHOSPHORS

SECTION 3

OTHER CATHODE RAY PHOSPHORS

SECTION 4

CHEMICALS FOR SCREEN SETTLING

Whether you need phosphors for black-and-white or color picture tubes or other cathode ray tube applications, Sylvania's long experience, highly developed production facilities and exacting quality control add up to dependability. All Sylvania phosphors are rigidly inspected for particle size, purity, good settling characteristics, brightness and uniformity of color. There is a full range of phosphor formulations available to meet your requirements, including special blends for maximum cross-burn resistance. SYLVANIA is your dependable source for ALL television and cathode ray phosphors.

SECTION 1

Color Television Picture Tube Phosphors

A standard series of Red, Green, and Blue color television phosphors is available for the preparation of color TV screens. The standard series covers the types most commonly used for color TV, but other types of phosphors are available for use when desired as alternates for those in the regular series:

Type No.	Color	Composition	Approximate Chromaticity Coordinates		Average Particle Size in Microns
Standard:			x	y	
151	Red	Zinc Phosphate:Mn	0.668	0.332	3-6
161	Green	Zinc o-Silicate:Mn	0.223	0.700	3-6
131	Blue	Zinc Sulfide:Ag	0.156	0.078	4-8
Alternate:					
110	Red	Zinc Cadmium Sulfide:Ag	0.665	0.335	10-20
170	Blue	Calcium Magnesium Silicate:Ti	0.171	0.120	3-5

History

Sylvania originally announced two series of color TV phosphors; namely, the SULFIDE series consisting of types 110 red, 120 green, 130 blue; and the OXIDE series consisting of types 150 red (zinc phosphate:Mn), 160 green (zinc o-silicate:Mn), 170 blue (Ca Mg silicate:Ti), with an alternate red no. 155 (cadmium borate:Mn). At the present time, types 155 red and 120 green are not being used.

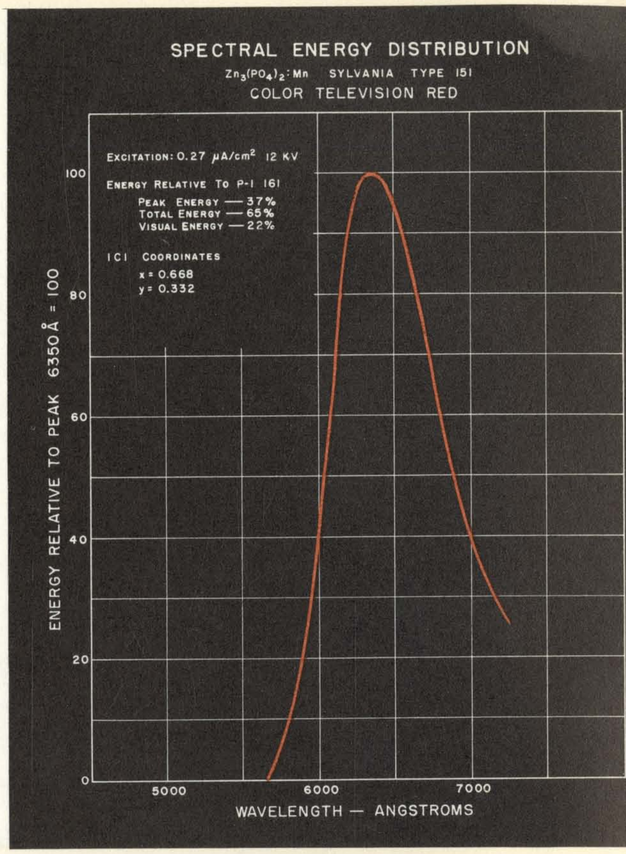
The type 130 sulfide blue, being a brighter and more saturated blue than the 170 blue, gradually came to be used with the 150 red and 160 green. Because of the fine particle size of the 160 and the large particle size of the 130 in comparison to the 150, types 161 green and 131 blue were developed—having particle size ranges closer to that of the 150 red zinc phosphate. These three phosphors, i.e. 150, 161, and 131 were offered as pastes for the silk screen method.

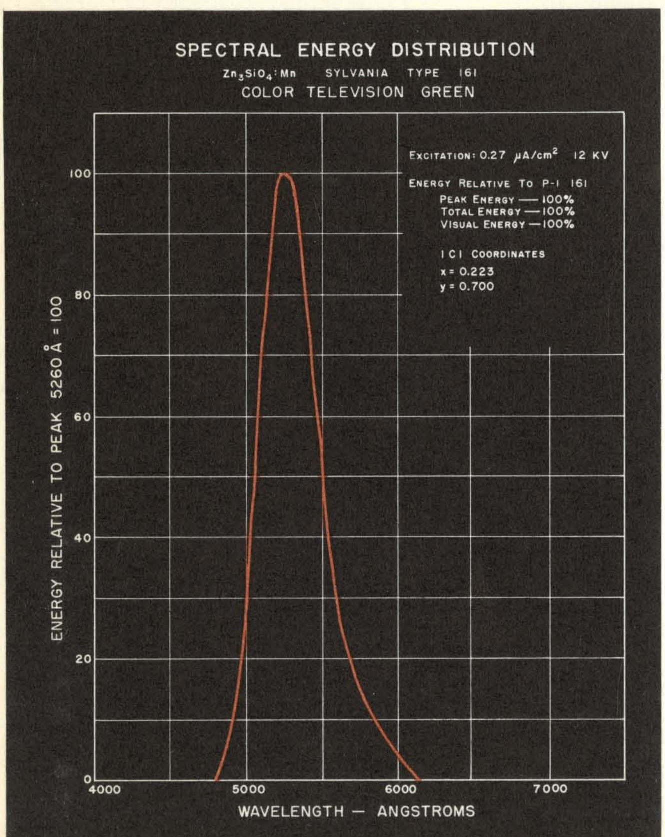
In the photosensitive resist methods of screen deposition, Sylvania type 170 blue has been preferred by some companies over the type 131 sulfide blue. Although the 170 is less bright and less saturated in color initially, it is somewhat more stable to the conditions of processing in the photoresist method than the sulfide. Recently, however, the 131 sulfide blue is being used satisfactorily, so that it is believed that the trend will ultimately be to the sulfide.

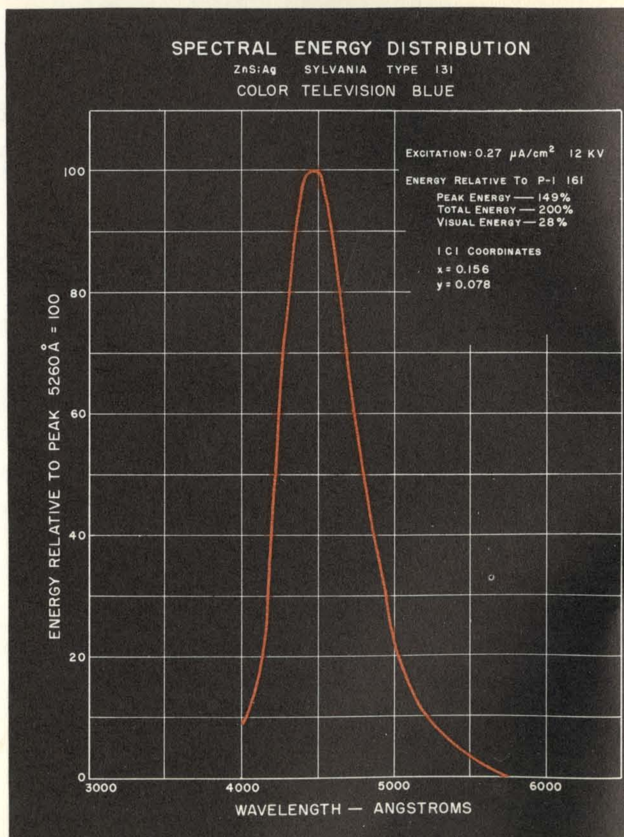
Type 151 has largely superceded type 150 and is preferred by most of our customers. Type 151 is a fine particle size version of type 150, and—though it is slightly less efficient—it gives better dot structure.

Spectral Energy Distribution

The spectral energy distribution of the standard and alternate types of color television phosphors are shown in the curves on these pages. For ease of comparison of the energy at different wavelength, the first five curves for the individual phosphors have been normalized on a basis of peak intensity equal to 100. On each graph are noted the peak energy (height of the curve), total energy (area under the curve), and visual energy, in percent relative to the green phosphor type no. 161.







Type 110 red is not now commonly used, though it is listed for those who may wish a sulfide red. Its particle size is larger than that of type 151, and its body color is orange-tan.

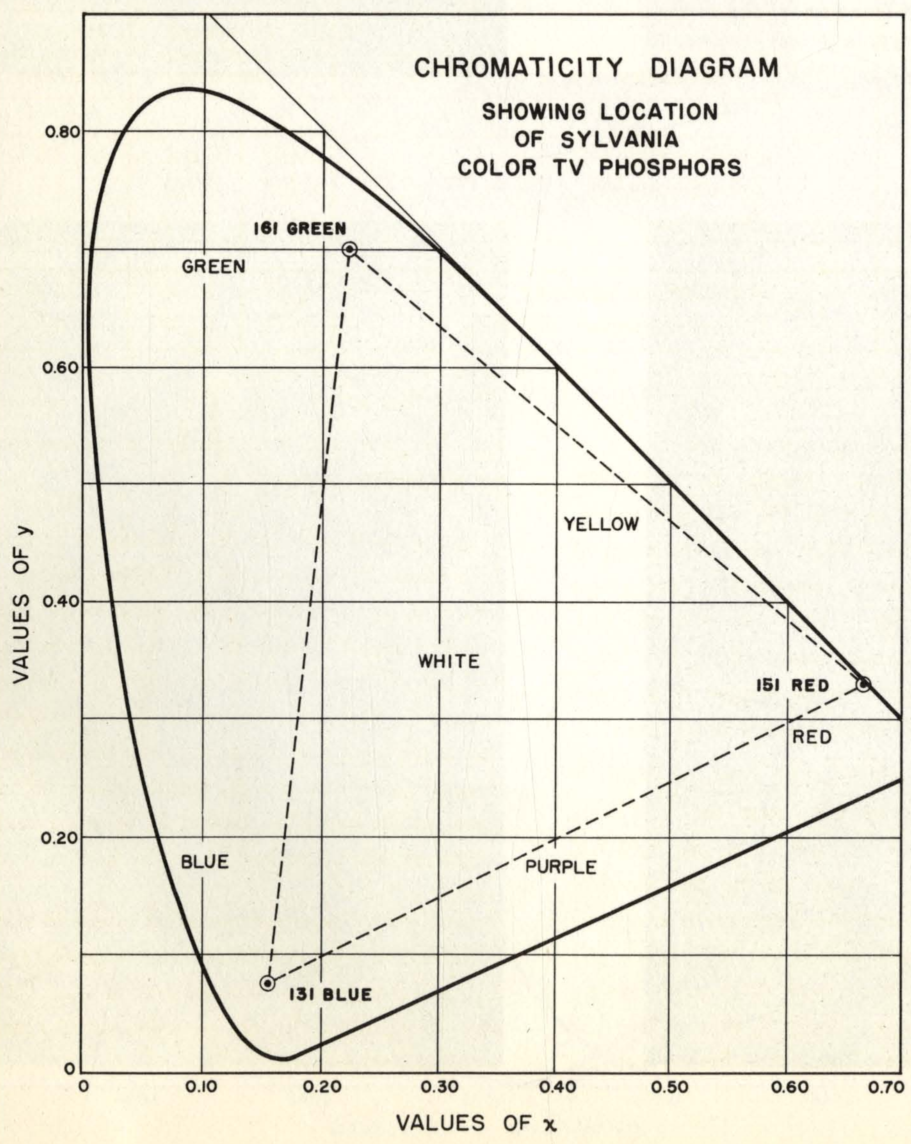
A variation of type 161 green is type 162, which is similar to 161 in particle size and color, but has lower brightness and shorter afterglow. It may be used in some types of tubes to reduce brightness ratio of green to that of other colors.

Discussion

Three problems that arise in preparing color TV screens by the photoresist process are (1) contamination of one set of phosphor dots by the phosphor or phosphors settled after, (2) contamination of a phosphor by the phosphor settled before it in the event the initial phosphor was not washed out entirely between the exposed dots, (3) ragged edges and rough surfaces of dots. The screen deposition procedure as well as the phosphor has a bearing on these factors; but the particle size, distribution, aggregation, etc. are of importance. These attributes of the phosphor can be varied to a degree.

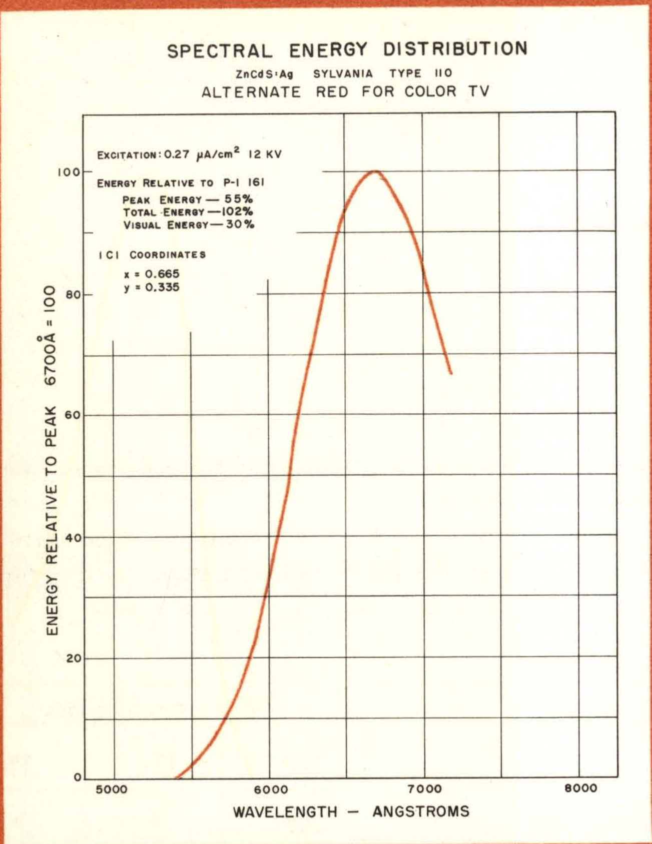
Sylvania is very glad to work with your company in supplying variations which would seem to be helpful.

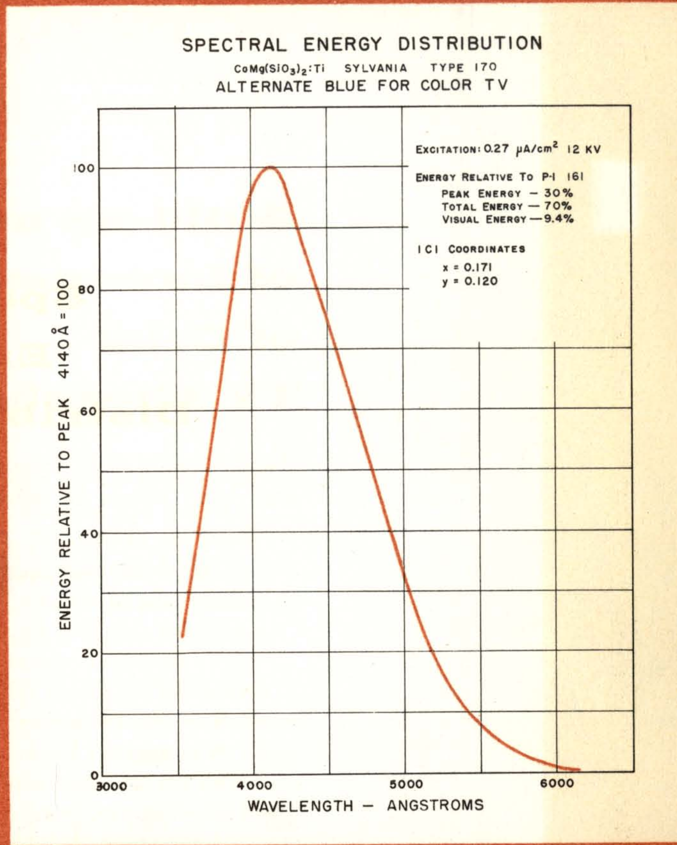
In general, it is believed that fine particle size and freedom from aggregation contribute to good smooth dot structure which resists contamination by phosphors settled subsequently. On the other hand, finer powder is more difficult to wash out between the dots, and has a greater tendency to contaminate or stick to phosphors settled previously.

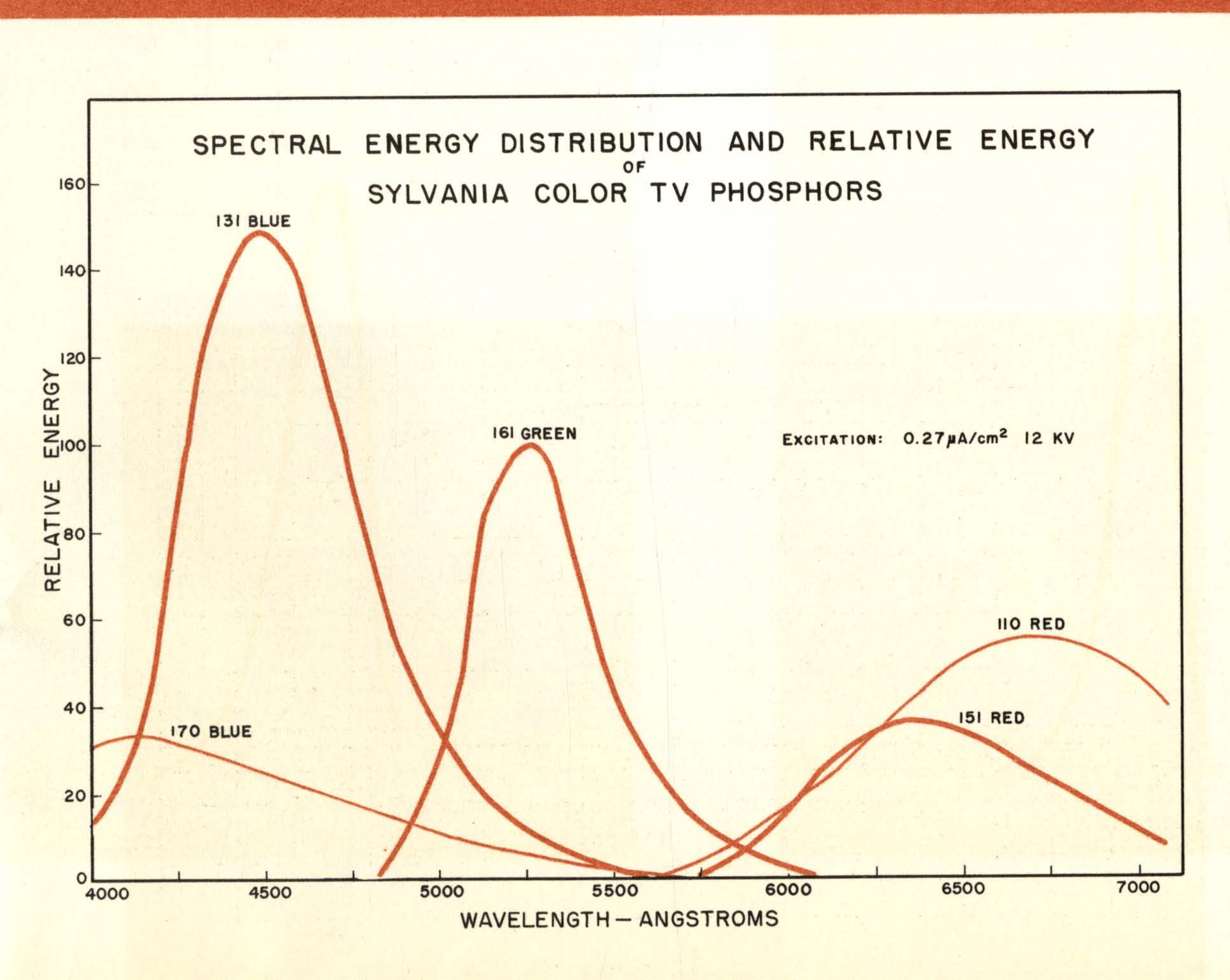


Chromaticity Diagram

The location of the red, green, and blue TV phosphors are shown on the trichromatic chromaticity diagram. This means that the color television picture tube can reproduce any color within the large dotted triangle.







On this graph are shown the curves for all five color TV phosphors determined under the same excitation and recording conditions. From these curves, the relative energies, etc., may be observed and compared.

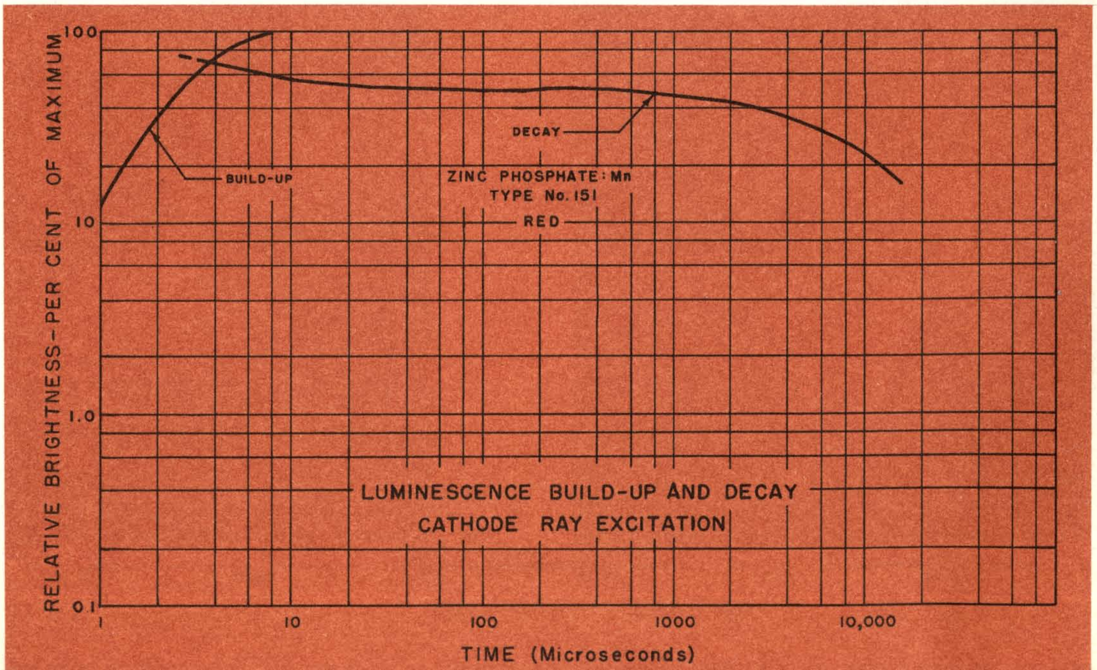
Build-up and Decay of Luminescence of Color TV Phosphors

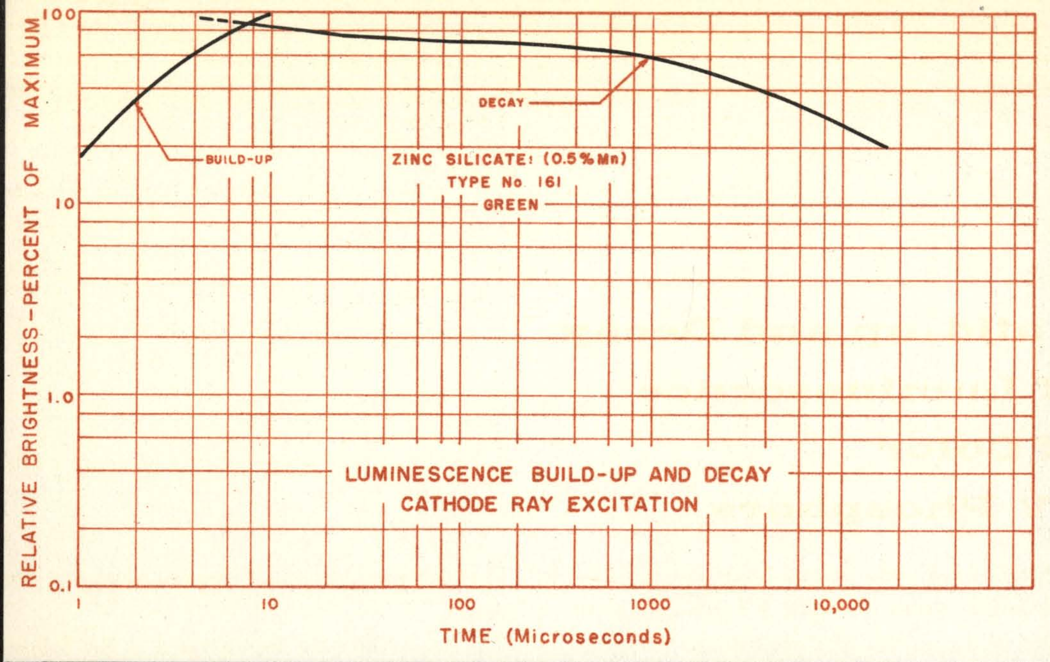
The following eight graphs show the build-up and decay curves for color TV phosphors. In addition to curves for phosphors discussed above, we have also included that for zinc cadmium selenide (red). It is very sensitive to processing and cannot be baked in air over 385°C.

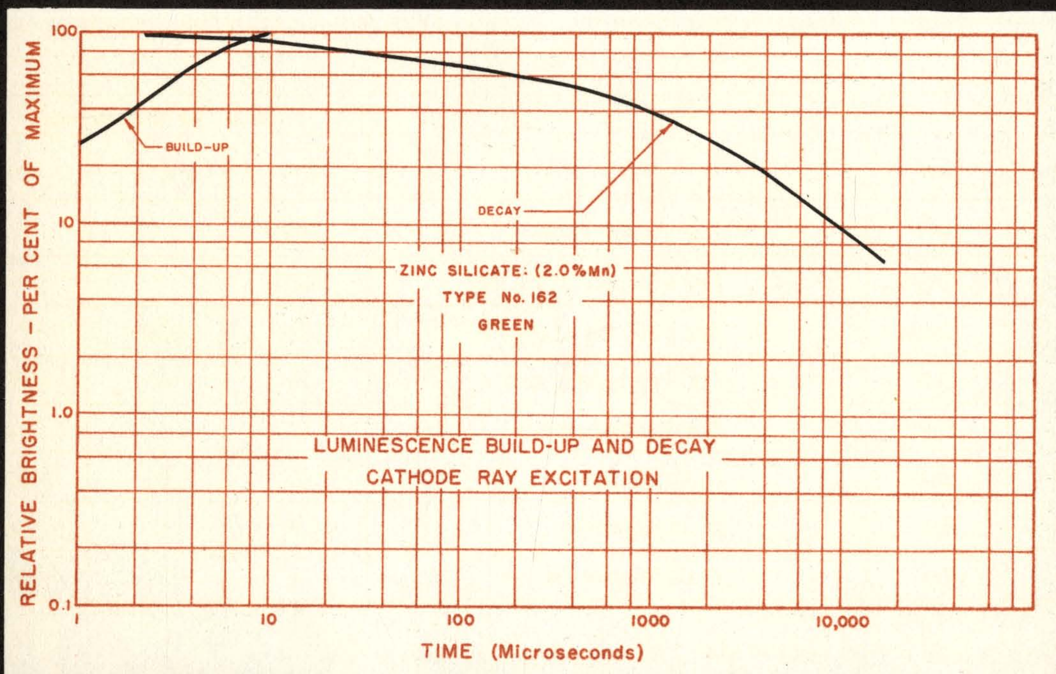
The decay data are summarized in the following table showing the time elapsed to decay to 37%, 10%, and 1% of initial intensity:

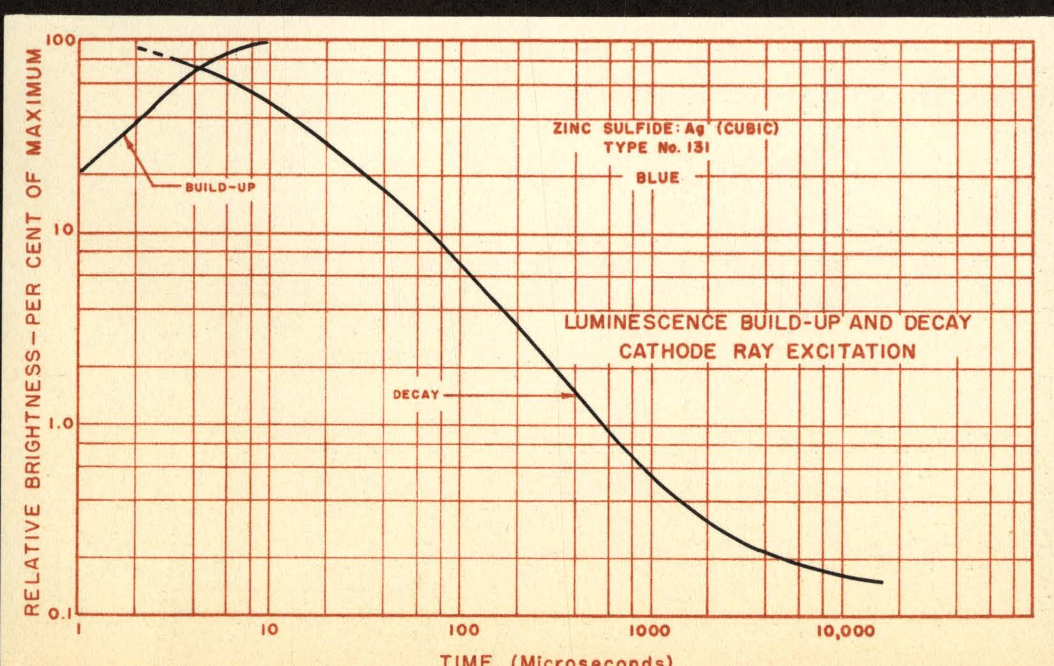
			Decay Time (microseconds)		
Type	Color		37%	10%	1%
151	Red	Zinc Phosphate:Mn	3500	*	*
161	Green	Zinc o-Silicate: (0.5% Mn)	4600	*	*
162	Green	Zinc o-Silicate: (2.0% Mn)	1050	9300	*
131	Blue	Zinc Sulfide:Ag (cubic)	14	67	540
130	Blue	Zinc Sulfide:Ag (hex.)	12	50	640
170	Blue	Ca Mg Silicate:Ti	25	56	160
110	Red	Zn Cd Sulfide:Ag	9	42	350
—	Red	Zn Cd Selenide:Cu	8	32	190

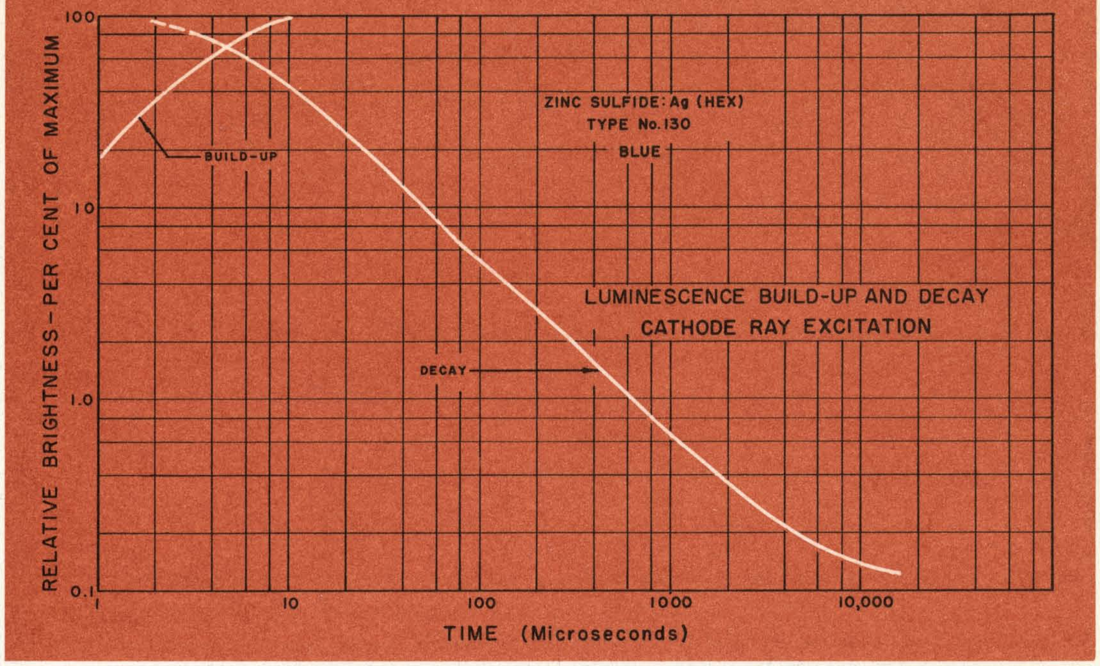
*Intensity level not yet reached after 1/60 second measurement period.

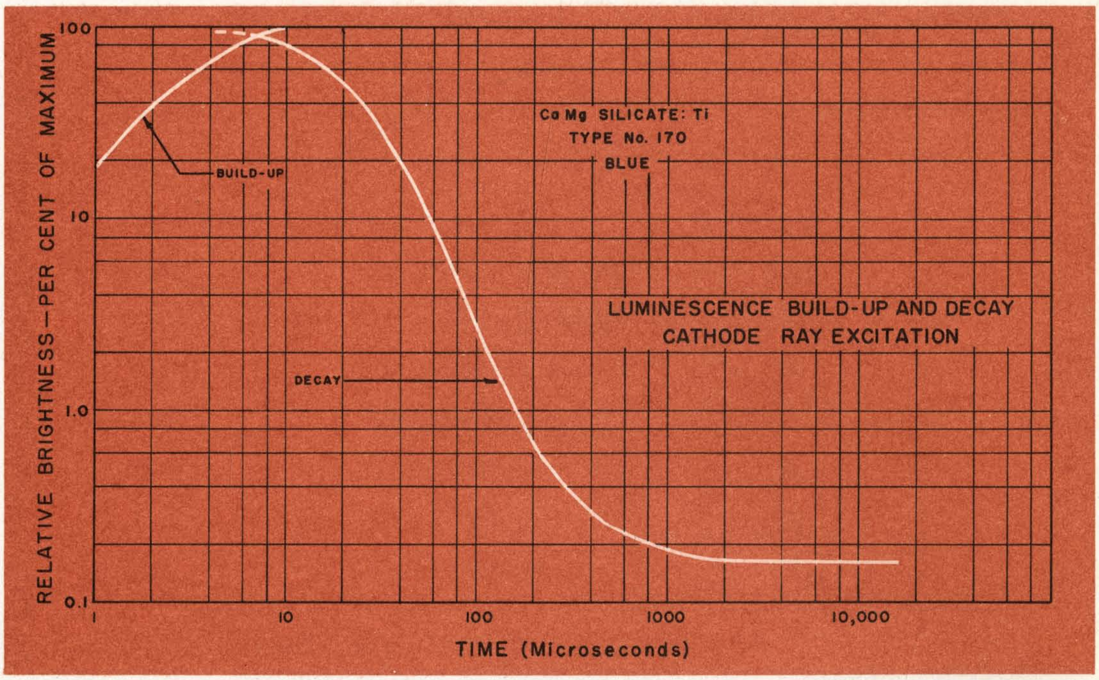


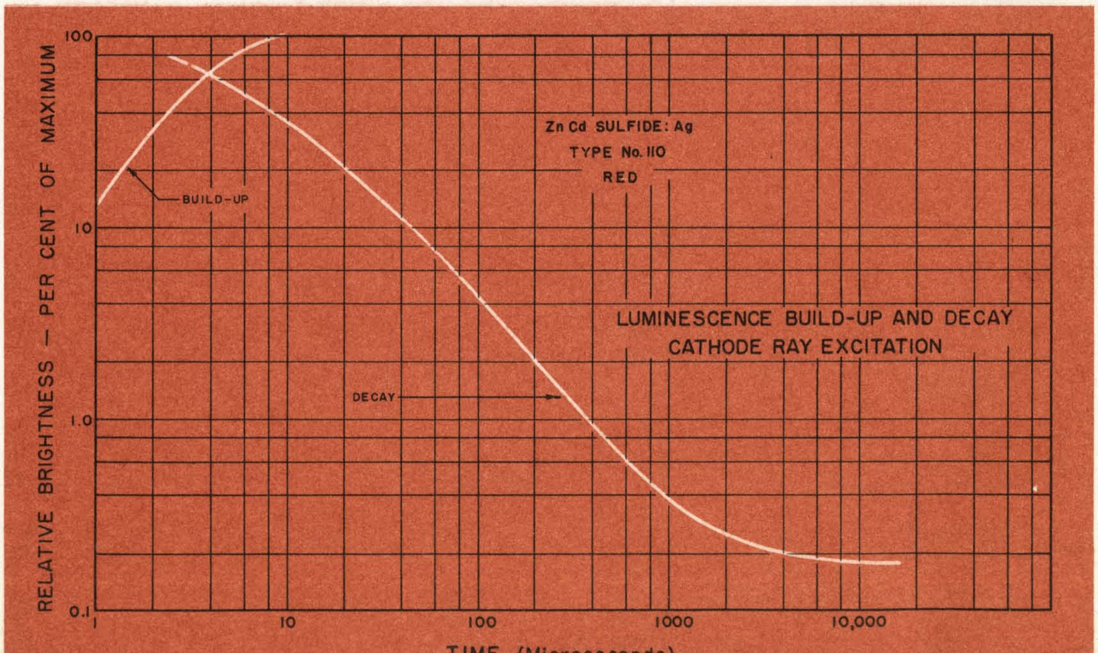

RELATIVE BRIGHTNESS-PERCENT OF MAXIMUM
100
10
1.0
0.1
1
10
100
1000
10,000
TIME (Microseconds)
BUILD-UP
DECAY
ZINC SILICATE: (0.5% Mn)
TYPE No. 161
GREEN
LUMINESCENCE BUILD-UP AND DECAY
CATHODE RAY EXCITATION

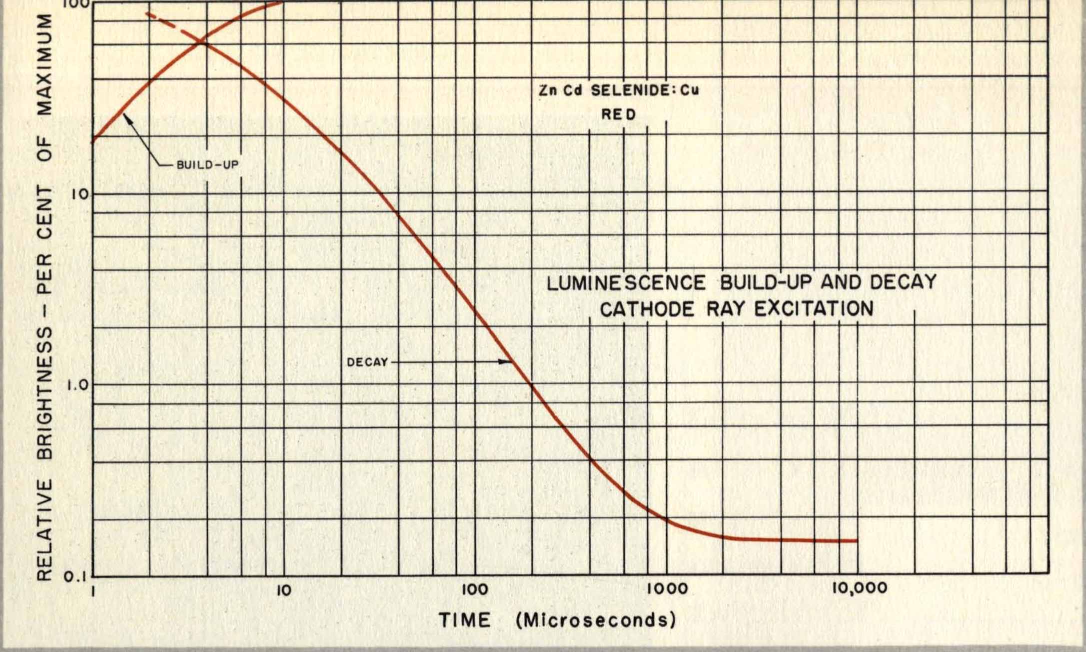

RELATIVE BRIGHTNESS - PER CENT OF MAXIMUM
100
10
1.0
0.1
1
10
100
1000
10,000
TIME (Microseconds)
BUILD-UP
DECAY
ZINC SILICATE: (2.0% Mn)
TYPE No. 162
GREEN
LUMINESCENCE BUILD-UP AND DECAY
CATHODE RAY EXCITATION


RELATIVE BRIGHTNESS-PER CENT OF MAXIMUM
100
10
1.0
0.1
1
10
100
1000
10,000
TIME (Microseconds)
BUILD-UP
DECAY
ZINC SULFIDE: Ag (CUBIC)
TYPE No. 131
BLUE
LUMINESCENCE BUILD-UP AND DECAY
CATHODE RAY EXCITATION


ZINC SULFIDE: Ag (HEX)
TYPE No. 130
BLUE
LUMINESCENCE BUILD-UP AND DECAY
CATHODE RAY EXCITATION
BUILD-UP
DECAY
RELATIVE BRIGHTNESS—PER CENT OF MAXIMUM
100
10
1.0
0.1
1
10
100
1000
10,000
TIME (Microseconds)

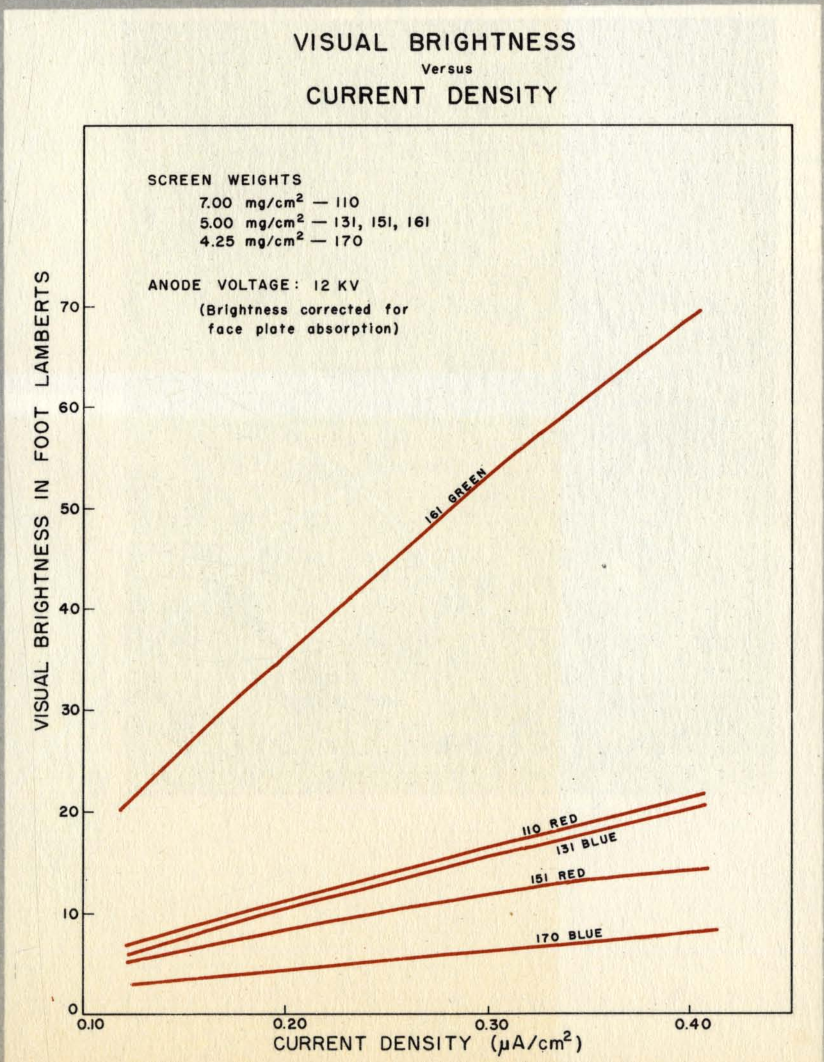

Ca Mg SILICATE: Ti
TYPE No. 170
BLUE
LUMINESCENCE BUILD-UP AND DECAY
CATHODE RAY EXCITATION
BUILD-UP
DECAY
RELATIVE BRIGHTNESS—PER CENT OF MAXIMUM
100
10
1.0
0.1
1
10
100
1000
10,000
TIME (Microseconds)


Zn Cd SULFIDE: Ag
TYPE No. 110
RED
LUMINESCENCE BUILD-UP AND DECAY
CATHODE RAY EXCITATION
BUILD-UP
DECAY
RELATIVE BRIGHTNESS — PER CENT OF MAXIMUM
100
10
1.0
0.1
1
10
100
1000
10,000



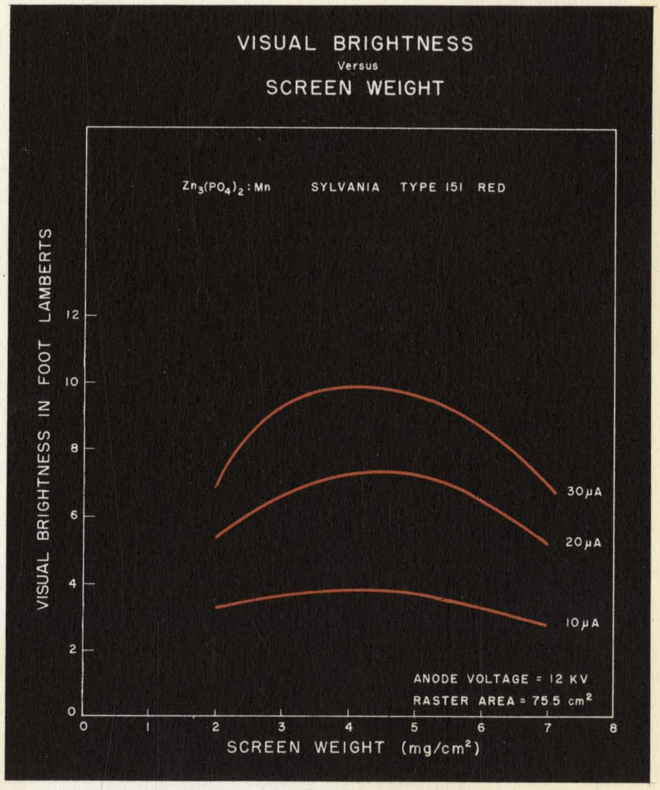
Visual Brightness versus Current Density

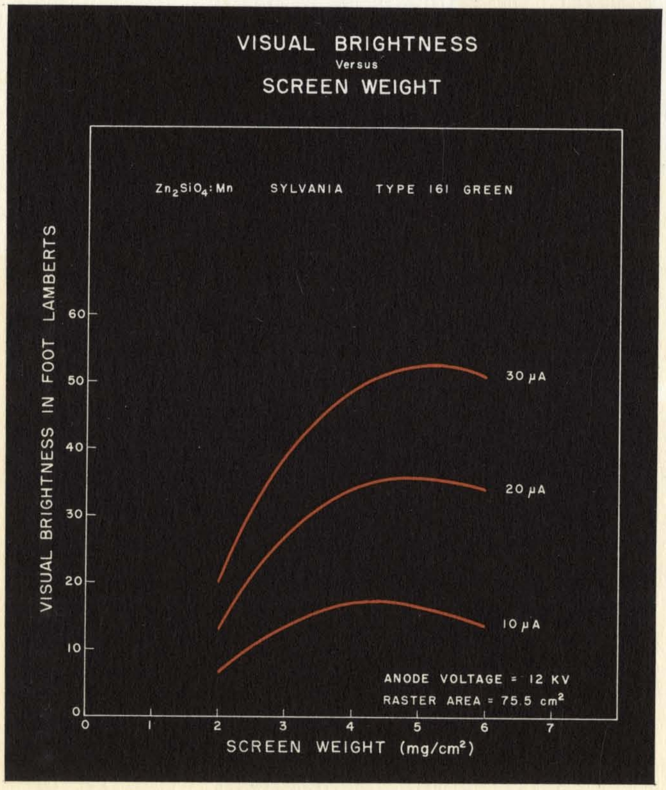
The following graph of brightness vs current density affords a comparison of the standard and alternate Sylvania color TV phosphors. (The screen weights employed were at or near the optimum values.)

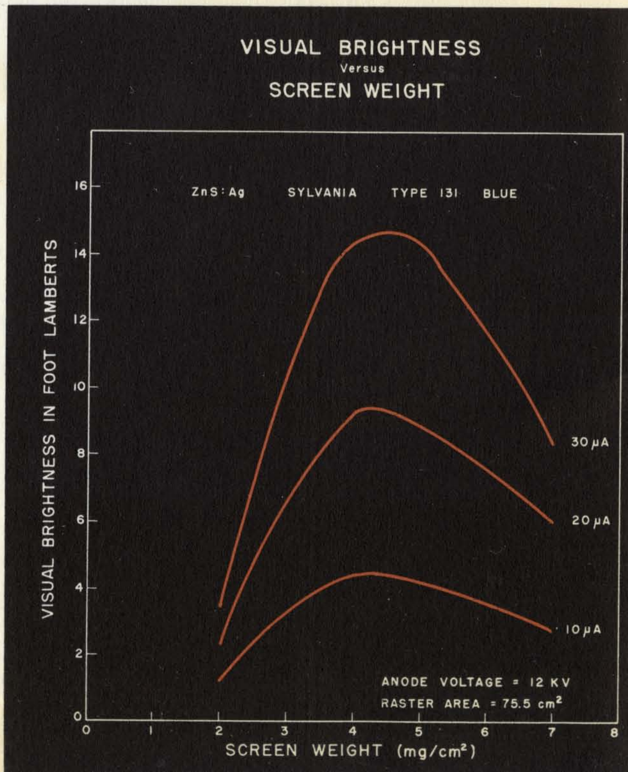


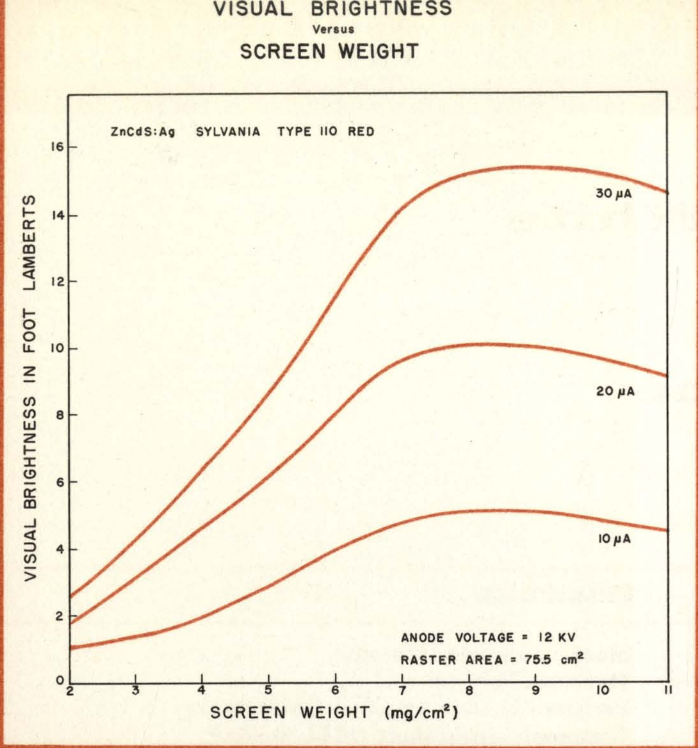
Visual Brightness versus Screen Weight

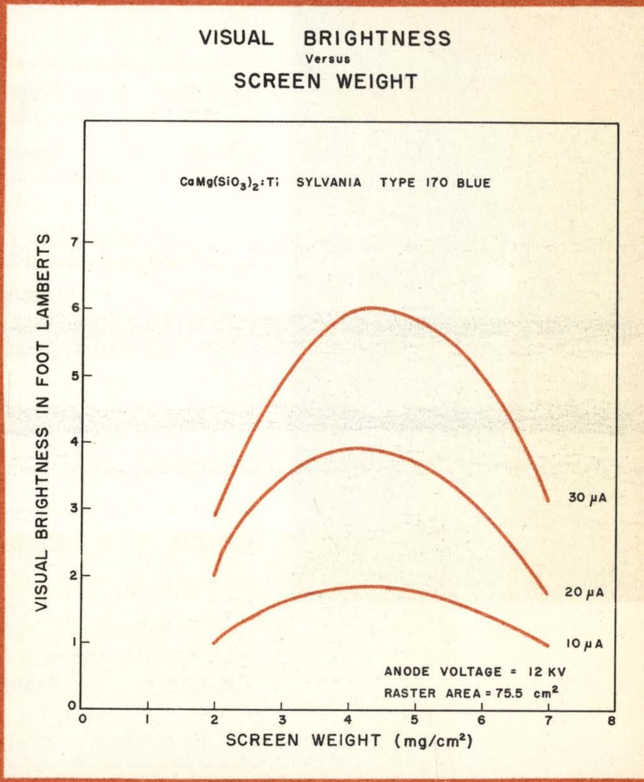
The family of curves on each of the five graphs on these pages shows the variation of visual brightness with screen weight at various beam currents. It may be observed that the optimum screen weight remains the same as beam current is varied.

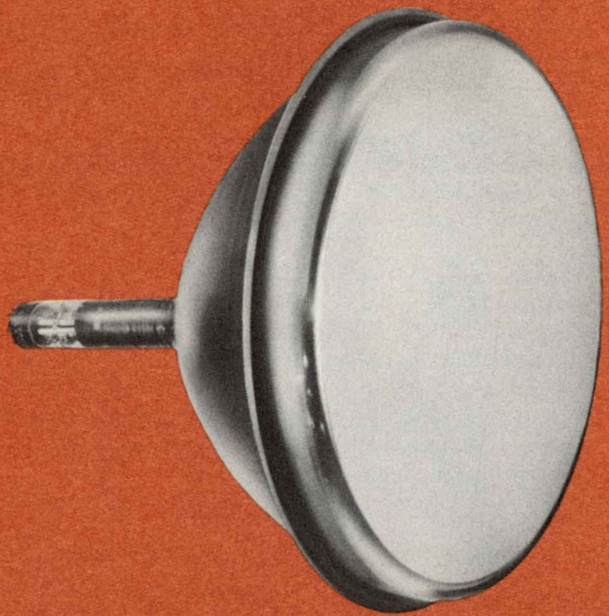


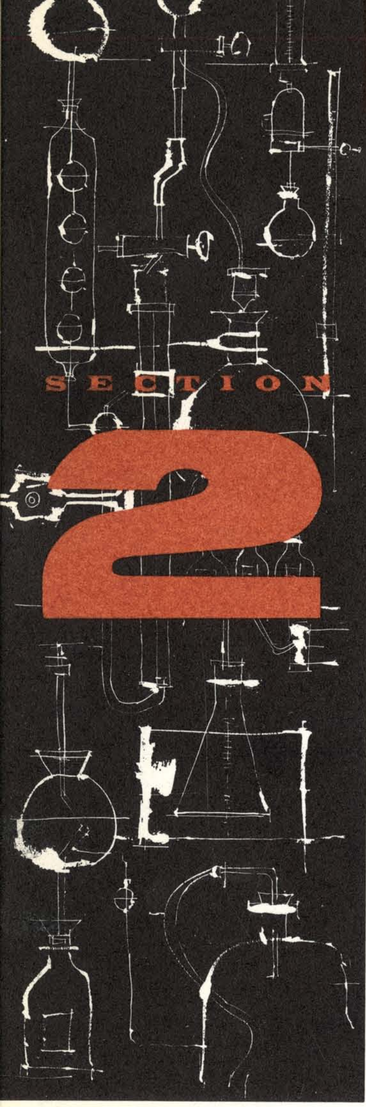





VISUAL BRIGHTNESS
Versus
SCREEN WEIGHT
ZnCdS:Ag SYLVANIA TYPE 110 RED
30 μA
20 μA
10 μA
ANODE VOLTAGE = 12 KV
RASTER AREA = 75.5 cm²
VISUAL BRIGHTNESS IN FOOT LAMBERTS
SCREEN WEIGHT (mg/cm²)


VISUAL BRIGHTNESS
Versus
SCREEN WEIGHT
CaMg(SiO3)2:Ti SYLVANIA TYPE 170 BLUE
30 μA
20 μA
10 μA
ANODE VOLTAGE = 12 KV
RASTER AREA = 75.5 cm²
VISUAL BRIGHTNESS IN FOOT LAMBERTS
SCREEN WEIGHT (mg/cm²)





Black and White Television Picture Tube Phosphors

Type No.	Processing	Characteristics
CR-40	Uncoated	Standard uncoated phosphor. Maximum light output. Preferred by some for aluminized screens. Commonly given short pebble milling.
CR-401	Uncoated	Essentially the same as CR-40, except pebble milling is not required. Specially processed to obtain optimum wet and dry screen strengths. Recommended for aluminized screens. Generally gives better screen adherence for aluminized picture tubes, with good uniformity across the screen and a minimum of yellow centers.
CR-421	Protectively Coated	Standard coated phosphor. Designed for maximum cross-burn resistance. Approximately 5% less light output than CR-40. Recommended for non-aluminized tubes.
CR-422	Protectively Coated	A coated phosphor similar to CR-421, having slightly better light output but slightly less cross-burn resistance. Recommended for non-aluminized tubes.

These phosphors can be supplied to meet customers' color requirements at any color temperature desired, usually some temperature between 7600° and 9000°K.

Discussion

As is well known, a thin layer of fluorescent or phosphorescent powder forms the phosphor screen on the inner face of the TV picture tubes and other cathode ray tubes to convert the exciting electron beam into visible light.

A P-4 sulfide screen is used for "black and white" (i.e. monochromatic) TV picture tubes. These Sylvania P-4 phosphors are superior because of the carefully controlled production processing as well as control of particle size and purity, assuring good settling characteristics, uniformity of color, stability, and efficiency.

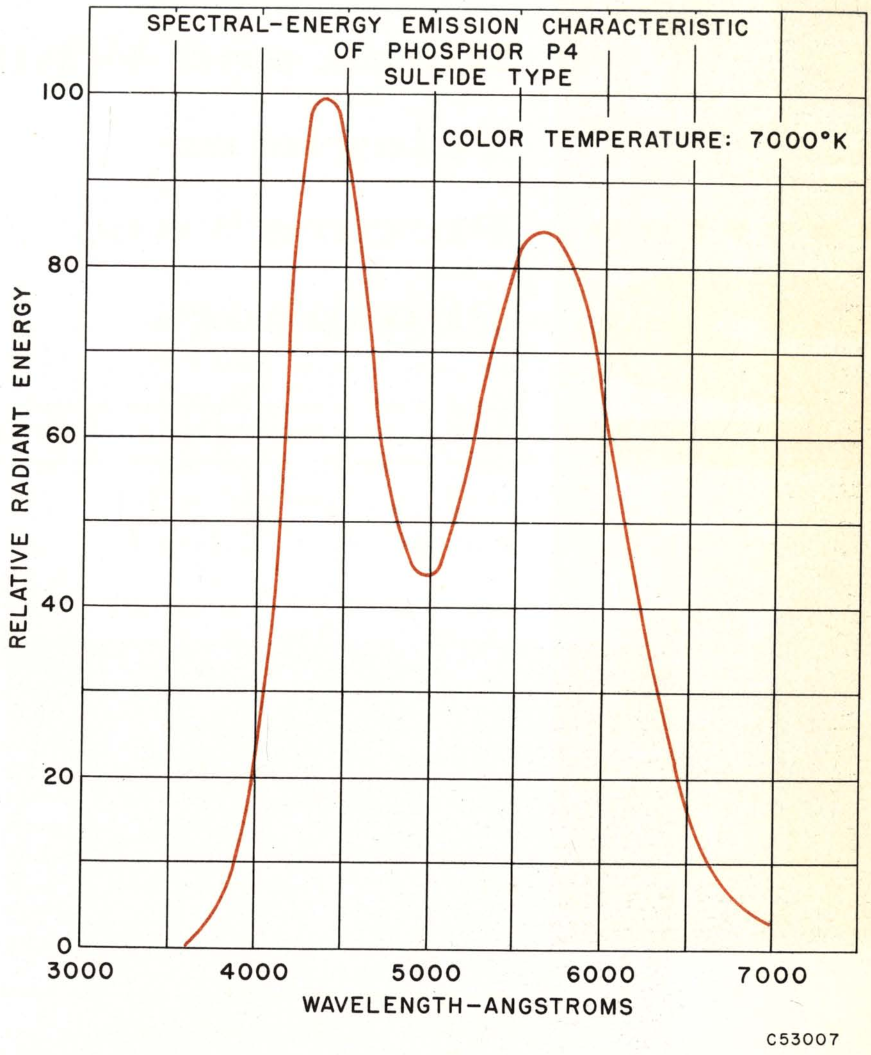
Picture tube screens may be formed in various ways, settling from a water suspension containing potassium silicate and barium acetate being one of the most widely used methods.

These sulfide phosphors are supplied at the proper particle size for use and require little processing to prepare the suspension for dispersing to the tubes. A short period of pebble milling may be employed with CR-40, though this is not recommended for CR-401 nor for the protectively coated phosphors (CR-421 & 422).

Spectral Energy Distribution

The P-4 phosphor is a "white" blend of blue ZnS: Ag and Yellow (Zn,Cd)S:Ag.

The emission is shown on the spectral energy curve on the graph at the right.

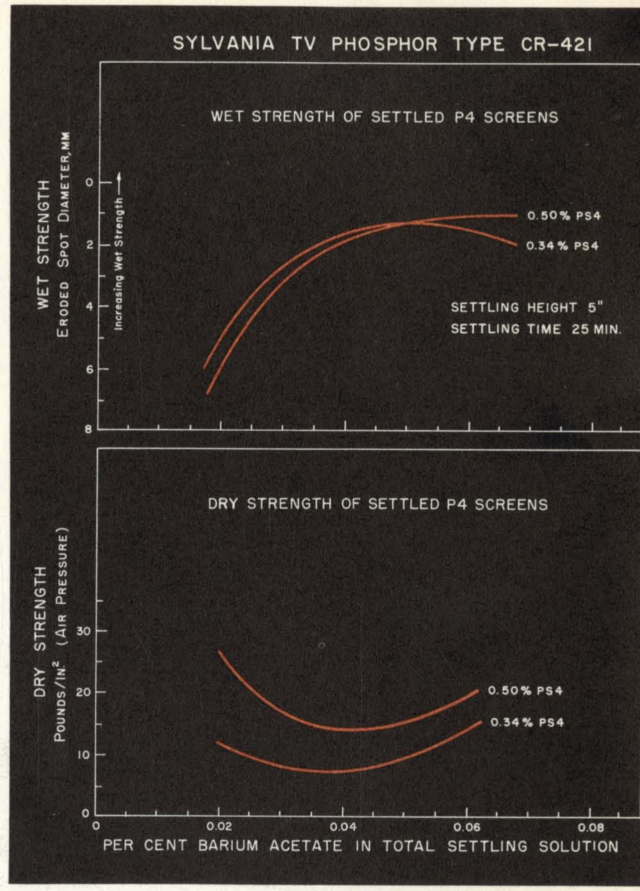


Screen Strength

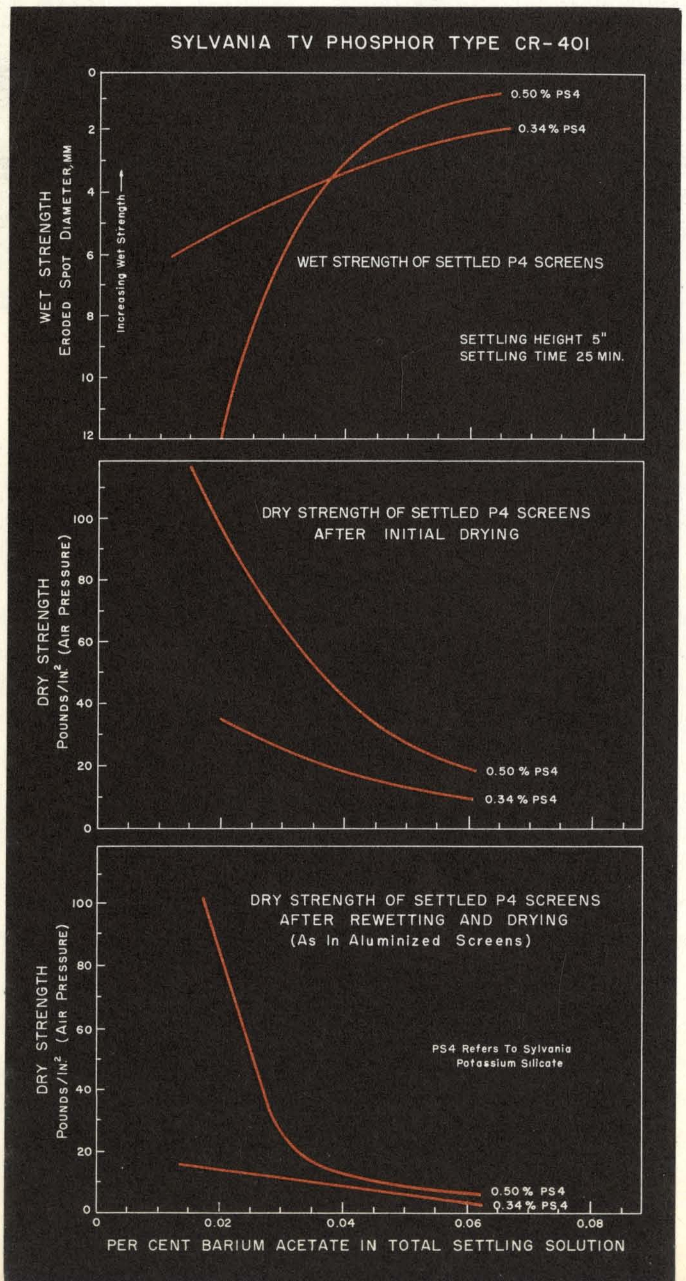
Because of the great importance of the adherence of the phosphor to the inner face of a television tube, methods have been developed in Sylvania's laboratories to evaluate this adherence. The adherence of the original screen after settling must be sufficient to permit the settling solution to be decanted without causing imperfections or sliding of the screen. The dry strength after air drying of the original screen is ordinarily no problem, being sufficient to assure good adherence during processing, shipment, and use.

A common processing sequence in making aluminized screens consists—after settling the screen and decanting the solution—of air drying, rewetting the screen for the purpose of applying the lacquer film, decanting, air drying, evacuating, aluminizing, and baking. In this case, the strength of the rewet screen also is no problem, the adherence ordinarily being sufficient to allow water to be added. However, the strength of the screen upon redrying and evacuation is of great importance since the adherence must be sufficient to prevent the lacquer film from pulling the powder away from the face of the tube.

Wet strength is determined by measuring the diameter of holes eroded in the screen by a submerged jet of water operated for a standard time at a standard height and having a constant pressure. Thus, smaller diameter values indicate higher wet strength, and vice versa.



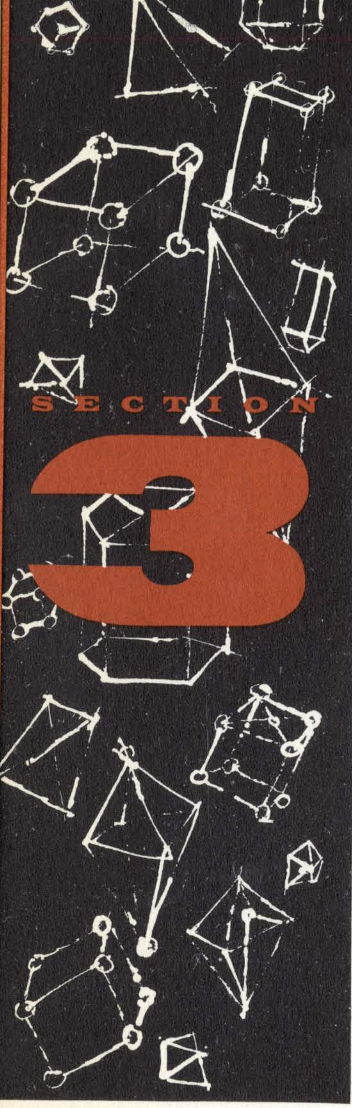
Dry strength is determined by noting the pressure in pounds per square inch required to blow a hole in a screen. A standard jet is used at a standard distance and the air pressure is increased until the screen "blows." This does not occur gradually, but suddenly at a quite definite pressure for a given screen.



The settling solution is usually a dilute solution of potassium silicate with a gelling agent such as barium acetate, which effects the gelation of silica gel on the powder particles so that they will bond to the glass surface of the tube, forming the phosphor screen. This solution also has an important effect on the adhesion of the screen after baking and on the behavior of the screen under electron bombardment.

Characteristic screen strengths for Sylvania's aluminizing and non-aluminizing types are shown on the curves on this page for two concentrations of potassium silicate (Sylvania type no. PS-4) at various concentrations of barium acetate. The two percentages of PS-4 shown on the curves refer to per cent of $K_2O.SiO_2$ in the total settling solution. In general it is indicated that better dry strength is obtained at the higher potassium silicate concentration and at low barium acetate concentrations, though high wet strength is favored by higher barium acetate concentrations. These curves are intended to indicate trends and not to establish absolute values.

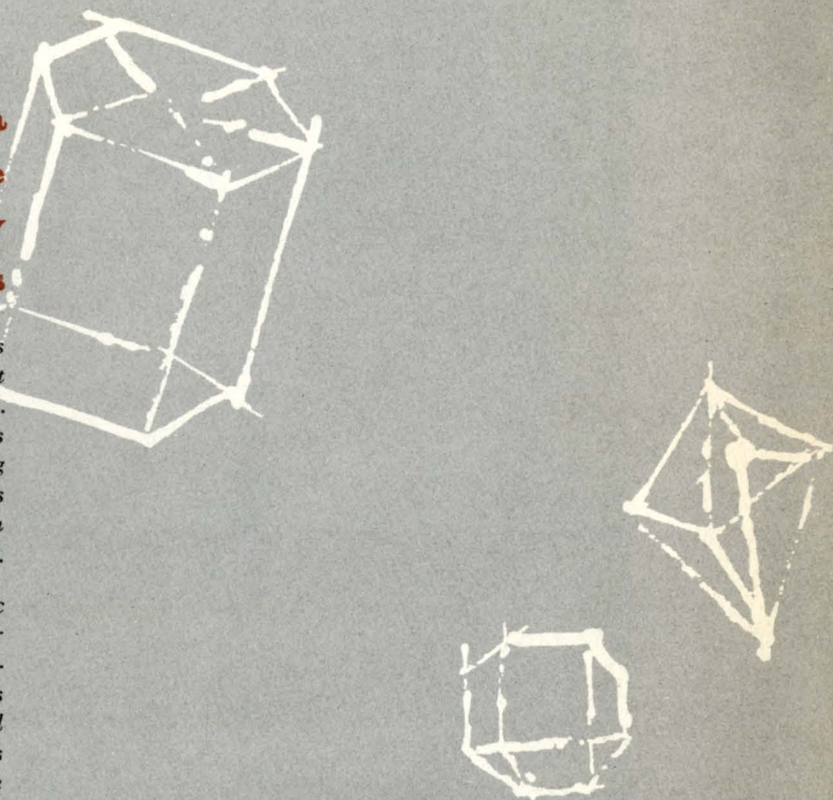

SYLVANIA
SILVER SCREEN 85



Phosphors for Radar and Oscilloscopes

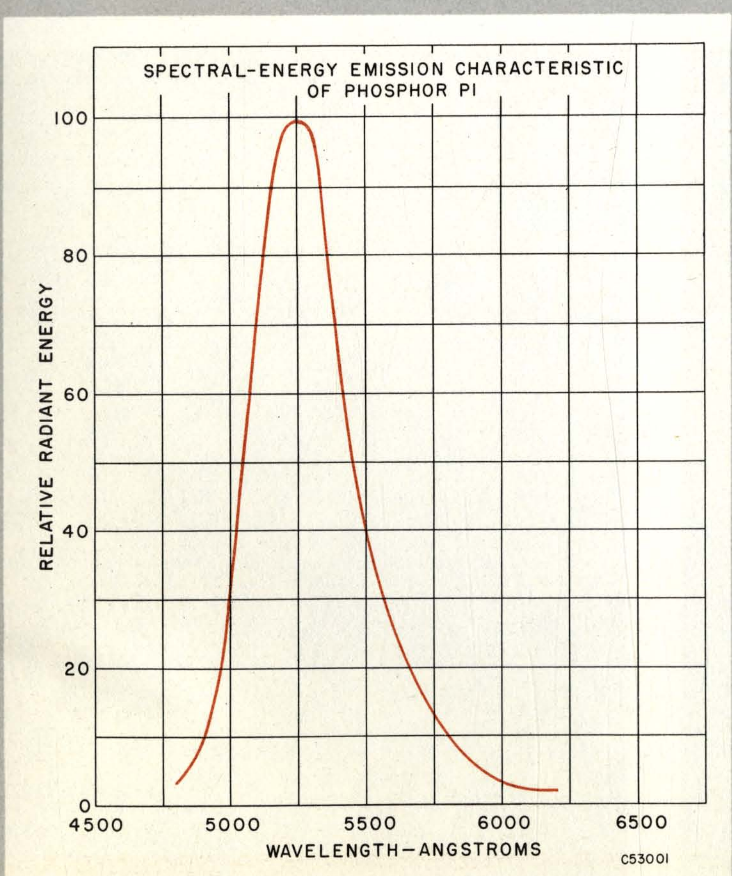
RETMA No.	Sylvania Type Number	Material	Fluorescent Color	Phosphorescent Color	Persistence	Approx. Avg. Particle Size In Microns	Remarks	Application
P-1	160	Zn_2SiO_4:Mn	Green	Green	Medium	2	Small Particle Size	Oscilloscopes
P-1	161	Zn_2SiO_4:Mn	Green	Green	Medium	5		Oscilloscopes
P-1	221	Zn_2SiO_4:Mn	Green	Green	Medium	10	Large Particle Size	Oscilloscopes
P-2	145	ZnS:Cu	Blue-Green	Green	Long	30		Oscilloscopes and radar
P-4	CR-40 & 401	ZnS:Ag and (Zn,Cd)S:Ag	White	Blue-White	Medium-Short	10		Television Receivers
P-4	CR-421 & 422	ZnS:Ag and (Zn,Cd)S:Ag	White	Blue-White	Medium-Short	10	Silica Coated	Television Receivers
P-5	135	$CaWO_4$	Blue	Blue	Very Short	8		Special oscilloscopes (fast photography)
P-7	130 140	ZnS:Ag (Zn,Cd)S:Cu	Blue Yellow	 Yellow	Medium-Short Long	15 30	Two layer (cascade) Screen	Radar
P-11	132	ZnS:Ag	Blue	Blue	Short	5		Oscilloscopes for visual or photographic observation
P-12	144	(Zn,Mg)F_2:Mn	Orange	Orange	Medium-Long	6		Radar
P-13	211	$MgSiO_3$:Mn	Red	Red	Medium	2		
P-14	130 146	ZnS:Ag (Zn,Cd)S:Cu	Blue Orange	 Orange	Medium-Short Long	15 30	Two layer (cascade) Screen	Radar
P-15	137	ZnO:Zn	Blue-Green	Blue-Green	Very Short	4		Flying spot scanners
P-22	151 161 131 110 170	$Zn_3(PO_4)_2$:Mn Zn_2SiO_4:Mn ZnS:Ag (Zn,Cd)S:Ag $CaMg(SiO_3)_2$:Ti	Red Green Blue Red Blue	Red Green Blue Red Blue	Medium Medium Medium-Short Medium-Short Medium-Short	3 - 6 3 - 6 4 - 8 10-20 3 - 5		Color TV Receivers

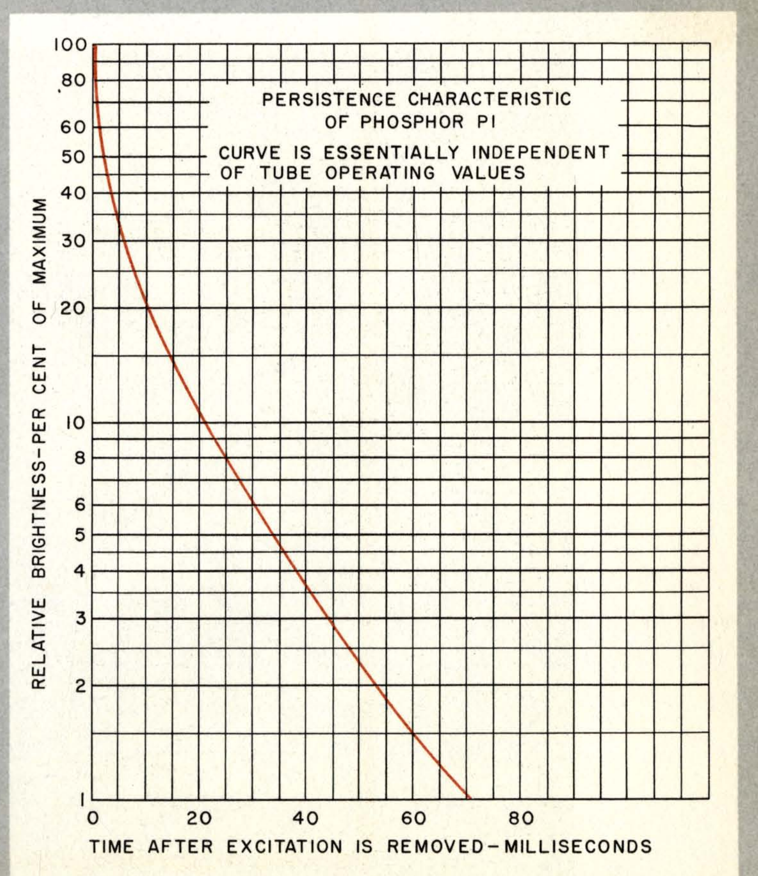
Sylvania Cathode Ray Phosphors

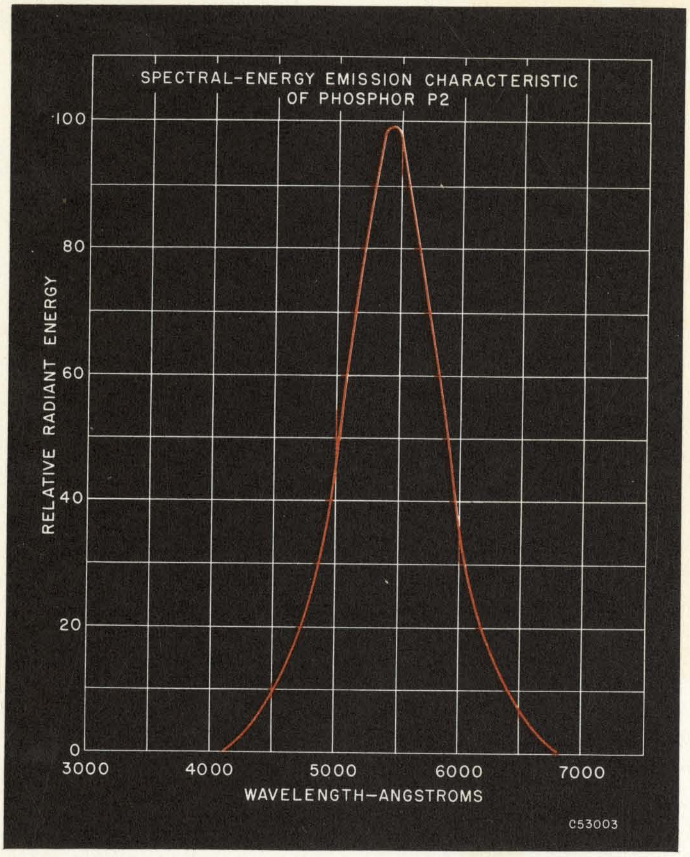


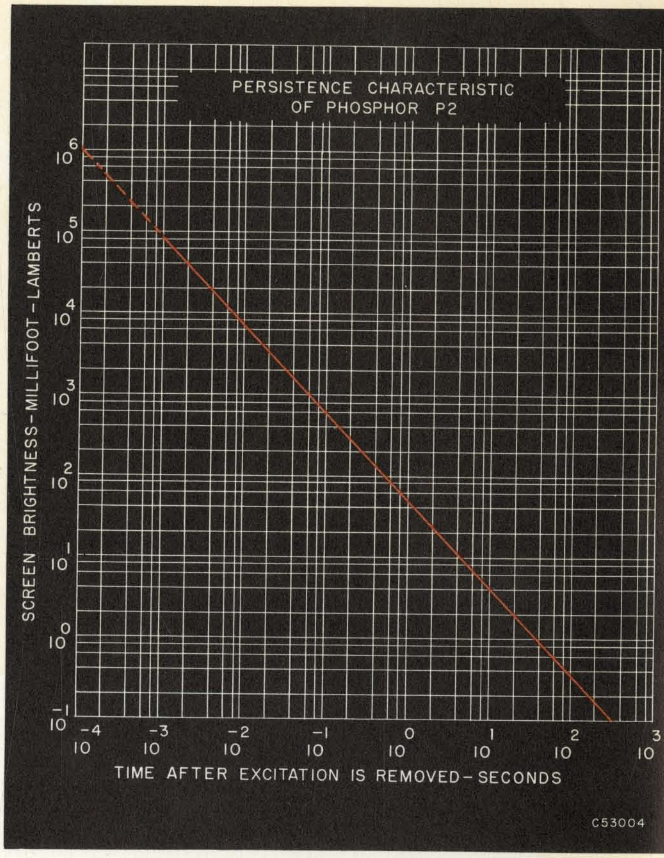
The table on the opposite page lists the phosphors for sale by Sylvania at the time of the publication of this book. Inquiries are invited from customers interested in phosphors not appearing on the list, since others will be added as needs arise and as their preparation is developed in our laboratories.

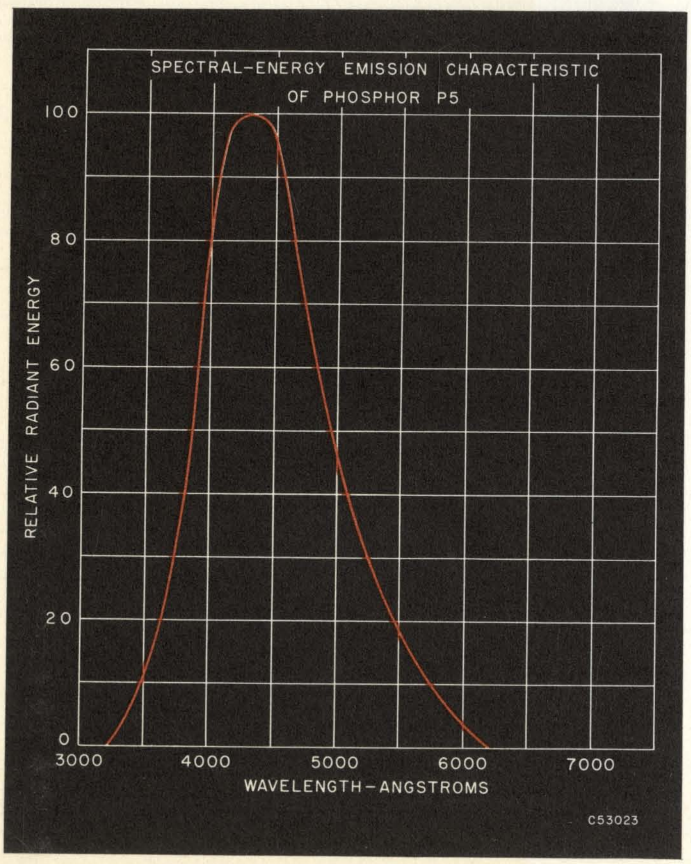
The Sylvania P-4 monochromatic television phosphors and the P-22 color television phosphors have been discussed on the preceeding pages. Curves for spectral energy emission and persistence for the remaining phosphors for oscilloscopes, radar, etc., are shown on the following pages.

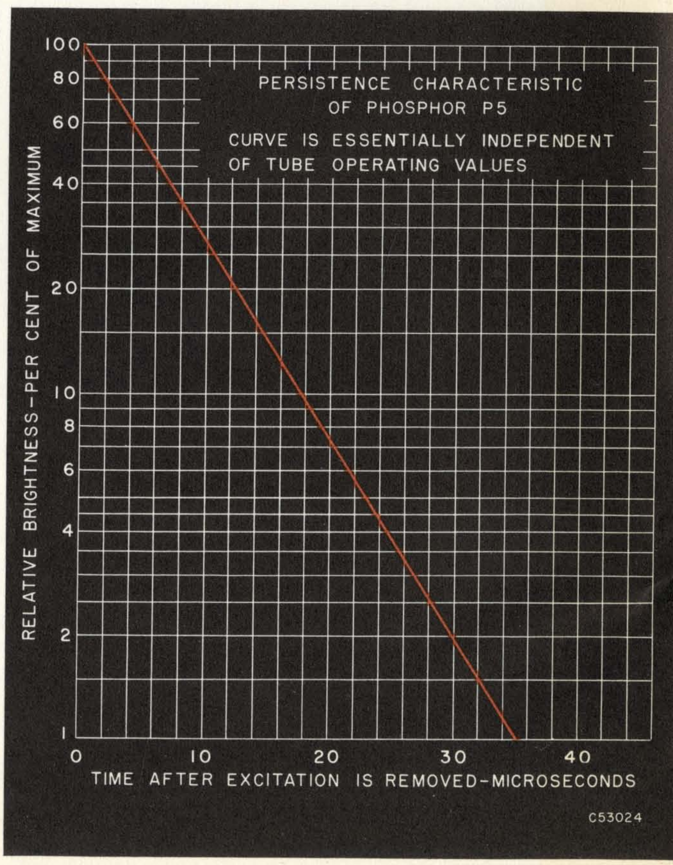


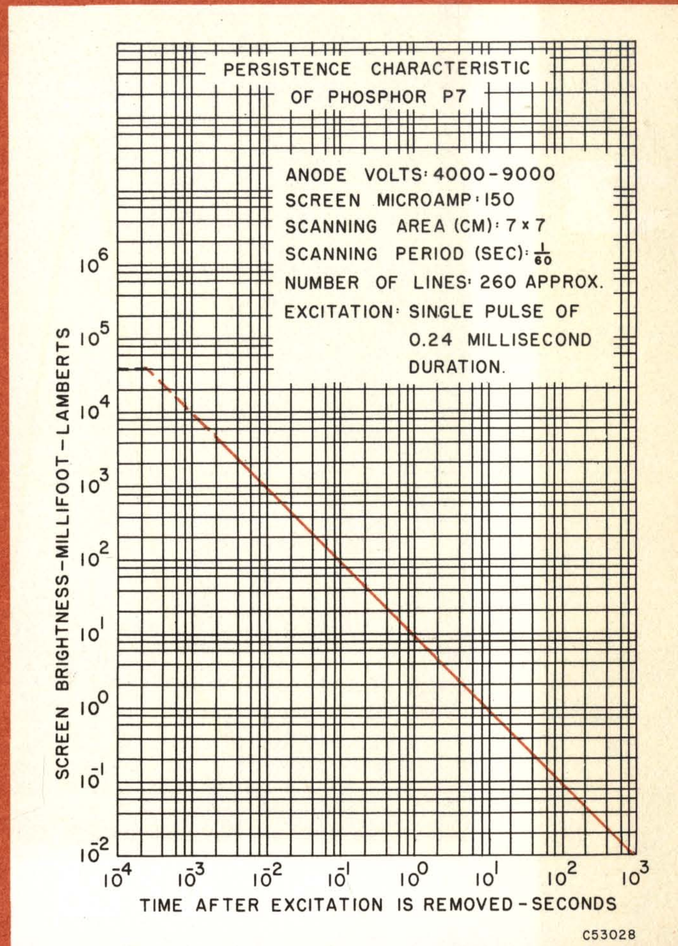


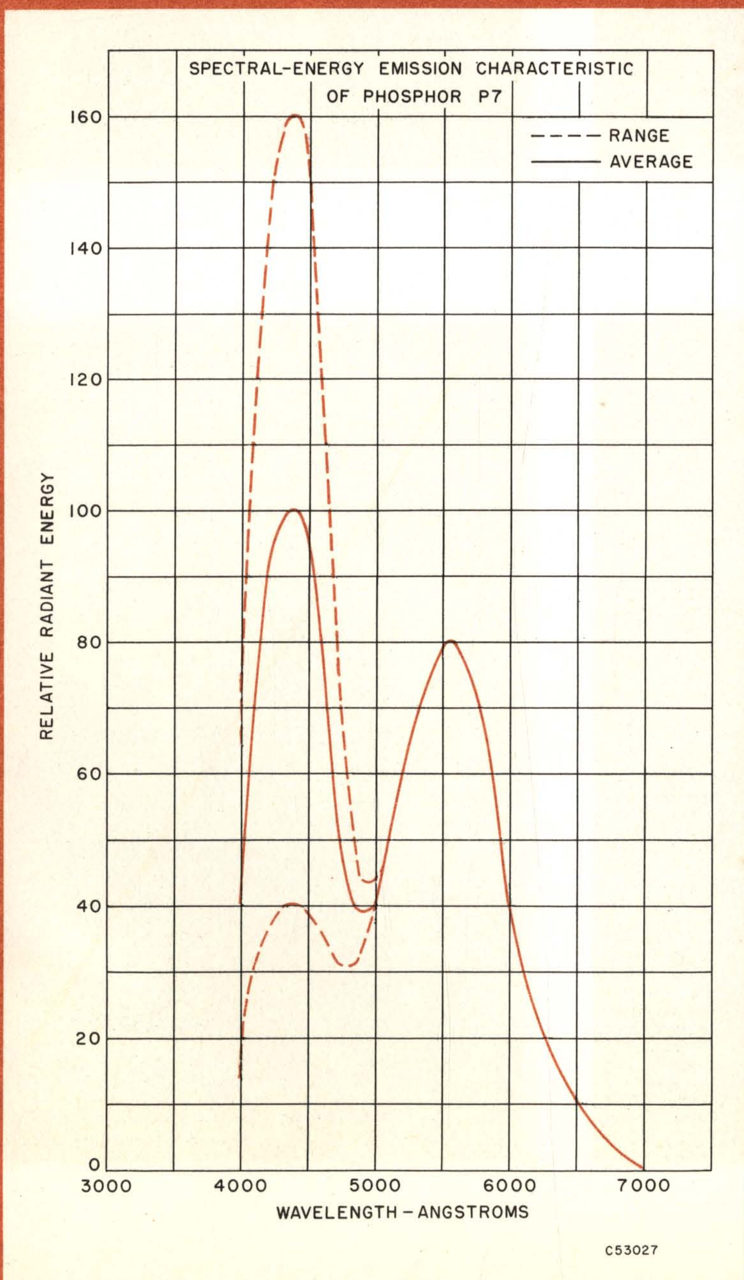

SPECTRAL-ENERGY EMISSION CHARACTERISTIC OF PHOSPHOR P2
RELATIVE RADIANT ENERGY
0
20
40
60
80
100
3000
4000
5000
6000
7000
WAVELENGTH-ANGSTROMS
C53003


PERSISTENCE CHARACTERISTIC OF PHOSPHOR P2
SCREEN BRIGHTNESS-MILLIFOOT-LAMBERTS
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-4
10^-3
10^-2
10^-1
10^0
10^1
10^2
10^3
TIME AFTER EXCITATION IS REMOVED-SECONDS
C53004

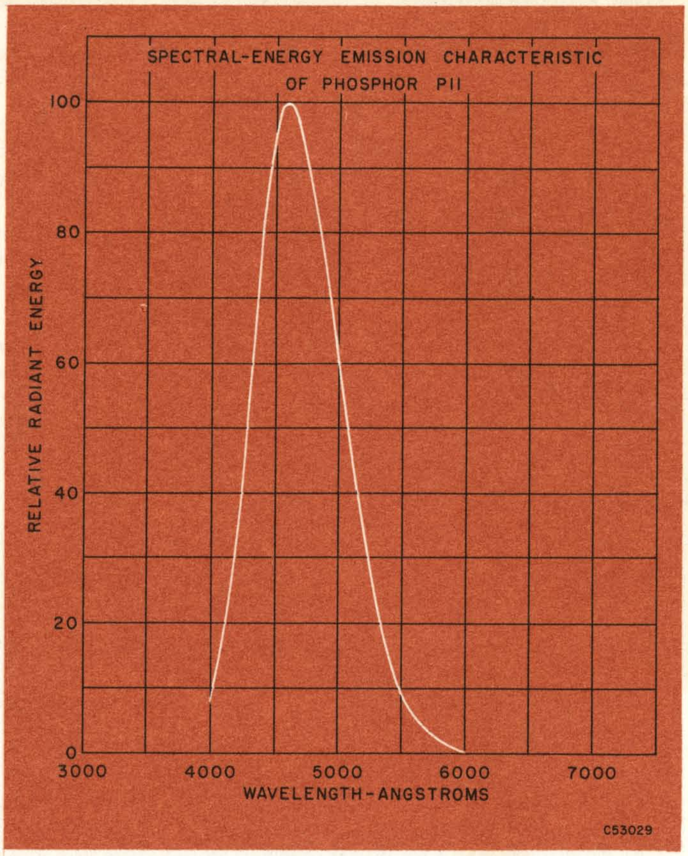

SPECTRAL-ENERGY EMISSION CHARACTERISTIC OF PHOSPHOR P5
RELATIVE RADIANT ENERGY
0
20
40
60
80
100
3000
4000
5000
6000
7000
WAVELENGTH-ANGSTROMS
C53023

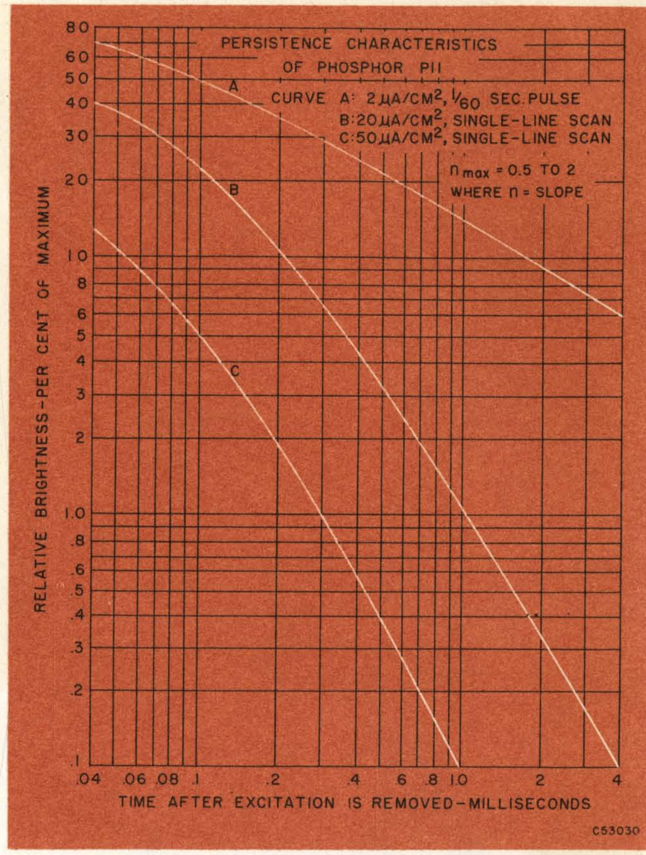

PERSISTENCE CHARACTERISTIC OF PHOSPHOR P5
CURVE IS ESSENTIALLY INDEPENDENT OF TUBE OPERATING VALUES
RELATIVE BRIGHTNESS-PER CENT OF MAXIMUM
100
80
60
40
20
10
8
6
4
2
1
0
10
20
30
40
TIME AFTER EXCITATION IS REMOVED-MICROSECONDS
C53024

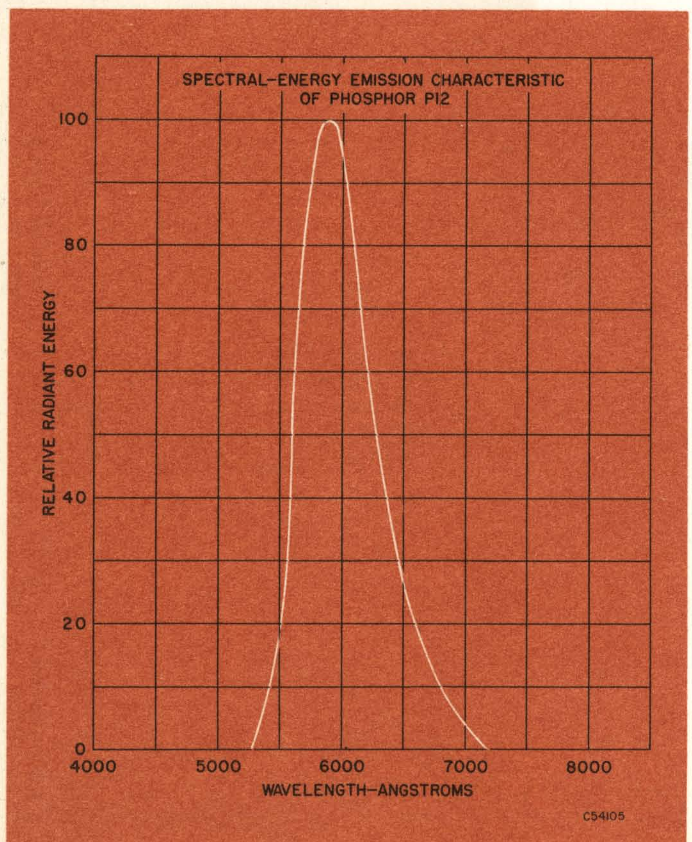


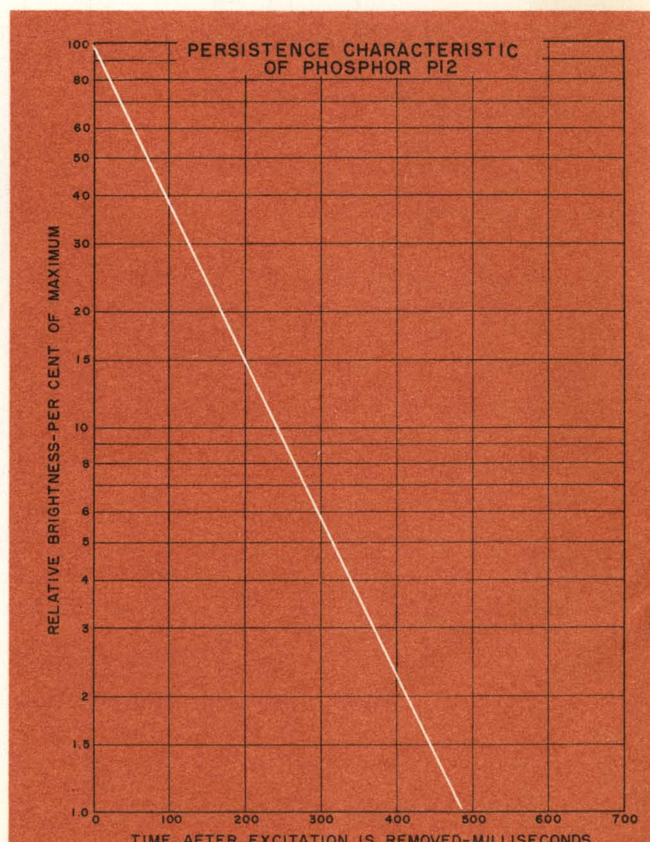


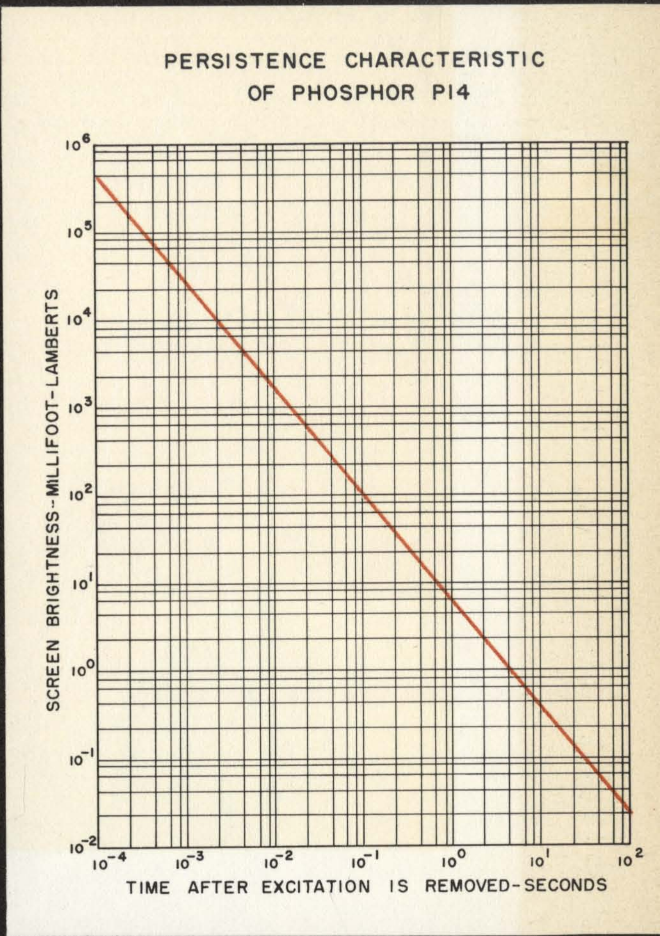
The P-7 (and P-14) screens are the so-called cascade screens and consist of two layers of phosphor—an innermost layer of ZnS:Ag which is subject to the electron stream, and another layer consisting of (Zn,Cd)S:Cu next to the glass face of the tube. The ZnS:Ag fluoresces with a brilliant blue light with a fairly rapid decay. The second layer, i.e. the (Zn,Cd)S:Cu, is in turn excited by the blue radiation from the first layer and fluoresces with a yellow light which persists for several seconds after excitation ceases. In many military radar systems the time between successive scans may be a second or more, thus only by the use of such cascade screen can the image be retained for this period of non-excitation.

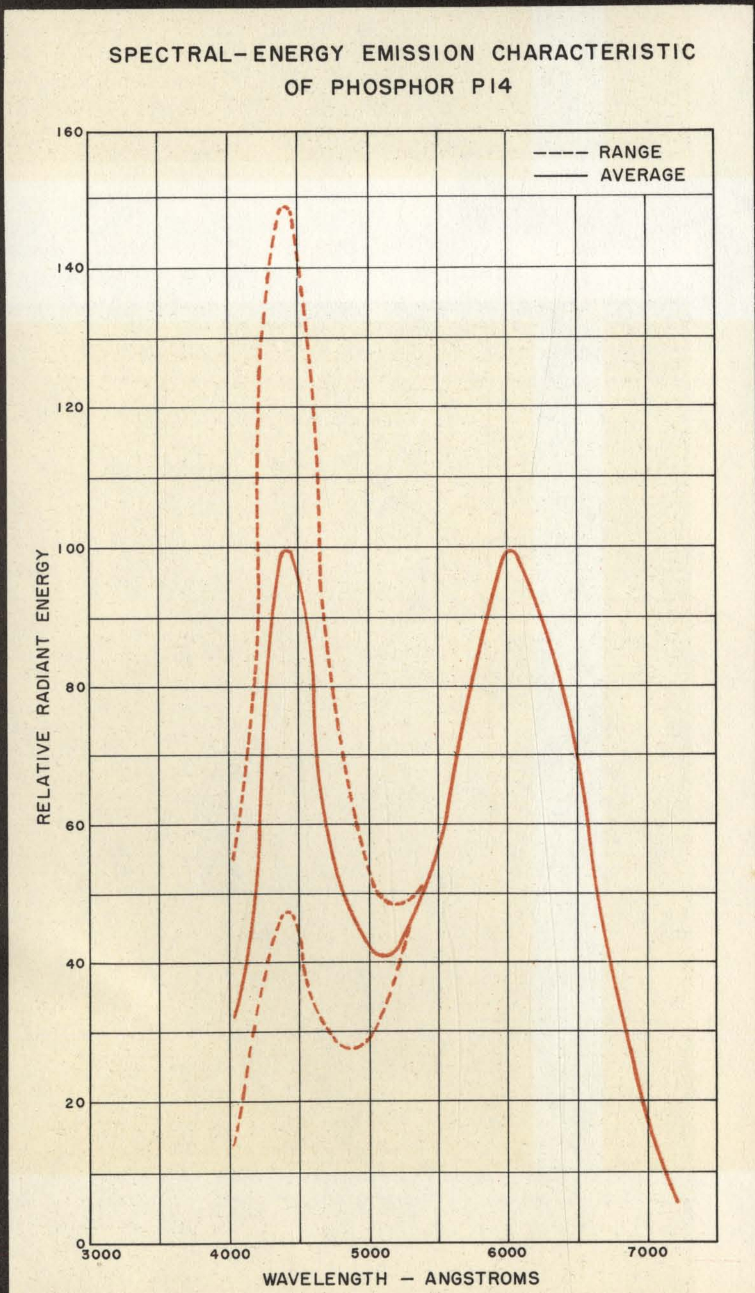

SPECTRAL-ENERGY EMISSION CHARACTERISTIC
OF PHOSPHOR P11
RELATIVE RADIANT ENERGY
0
20
40
60
80
100
3000
4000
5000
6000
7000
WAVELENGTH-ANGSTROMS
C53029

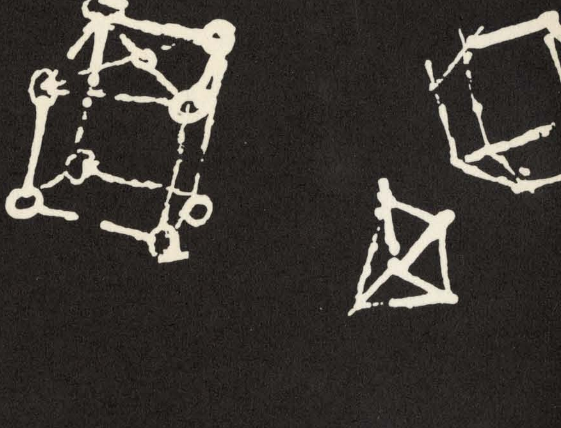

PERSISTENCE CHARACTERISTICS
OF PHOSPHOR P11
CURVE A: 2 μA/CM², 1/60 SEC. PULSE
B: 20 μA/CM², SINGLE-LINE SCAN
C: 50 μA/CM², SINGLE-LINE SCAN
n max = 0.5 TO 2
WHERE n = SLOPE
A
B
C
RELATIVE BRIGHTNESS-PER CENT OF MAXIMUM
80
60
50
40
30
20
10
8
6
5
4
3
2
1.0
.8
.6
.5
.4
.3
.2
.1
.04
.06
.08
.1
.2
.4
.6
.8
1.0
2
4
TIME AFTER EXCITATION IS REMOVED-MILLISECONDS
C53030

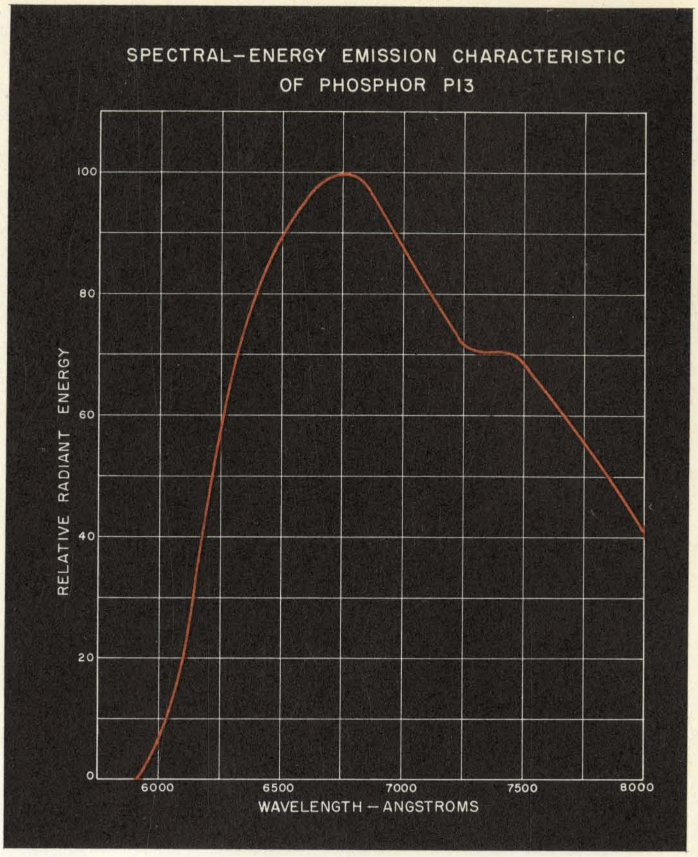

SPECTRAL-ENERGY EMISSION CHARACTERISTIC
OF PHOSPHOR P12
RELATIVE RADIANT ENERGY
0
20
40
60
80
100
4000
5000
6000
7000
8000
WAVELENGTH-ANGSTROMS
C54105

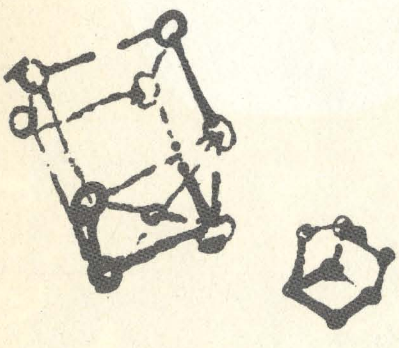

PERSISTENCE CHARACTERISTIC
OF PHOSPHOR P12
RELATIVE BRIGHTNESS-PER CENT OF MAXIMUM
100
80
60
50
40
30
20
15
10
8
6
5
4
3
2
1.5
1.0
0
100
200
300
400
500
600
700
TIME AFTER EXCITATION IS REMOVED-MILLISECONDS

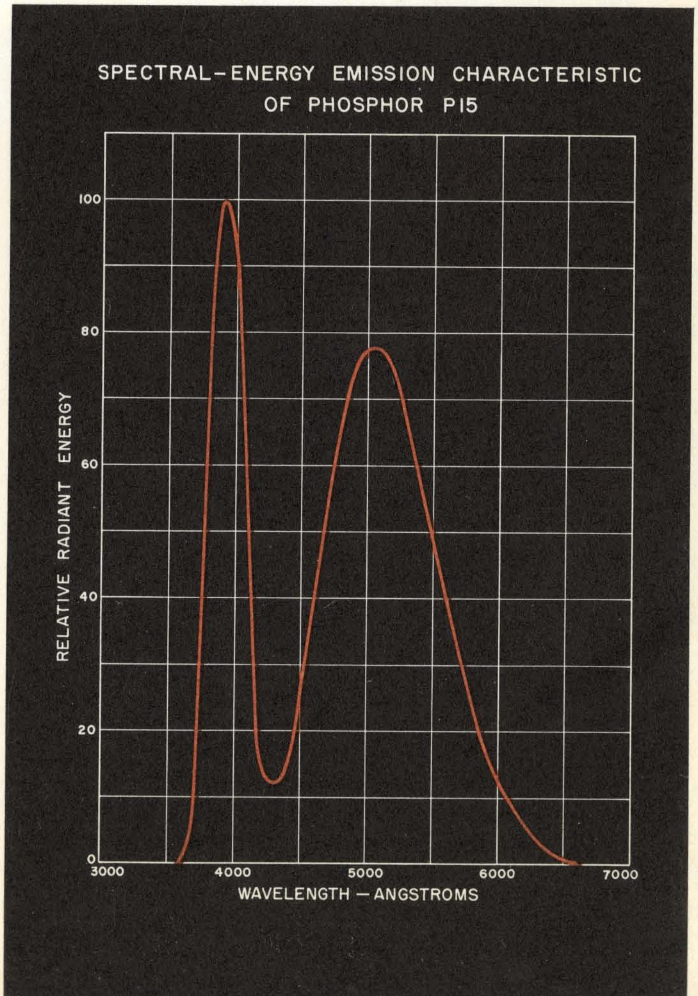

PERSISTENCE CHARACTERISTIC
OF PHOSPHOR P14
SCREEN BRIGHTNESS-MILLIFOOT-LAMBERTS
TIME AFTER EXCITATION IS REMOVED-SECONDS

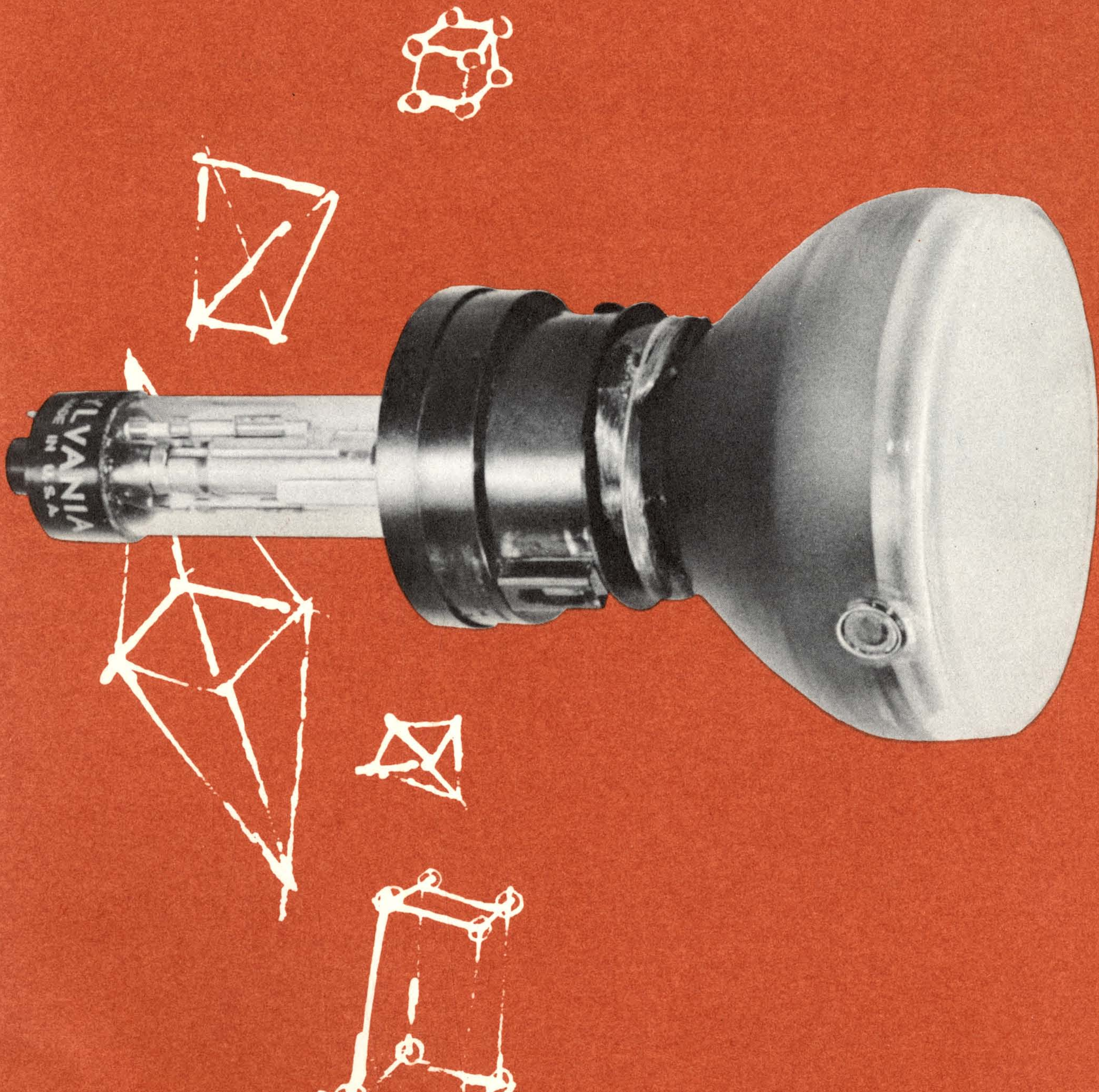

SPECTRAL-ENERGY EMISSION CHARACTERISTIC
OF PHOSPHOR P14
RANGE
AVERAGE
RELATIVE RADIANT ENERGY
WAVELENGTH — ANGSTROMS




SPECTRAL-ENERGY EMISSION CHARACTERISTIC
OF PHOSPHOR P13
RELATIVE RADIANT ENERGY
0
20
40
60
80
100
6000
6500
7000
7500
8000
WAVELENGTH — ANGSTROMS




SPECTRAL-ENERGY EMISSION CHARACTERISTIC
OF PHOSPHOR P15
RELATIVE RADIANT ENERGY
0
20
40
60
80
100
3000
4000
5000
6000
7000
WAVELENGTH — ANGSTROMS



As stated above, the settling solution commonly used for television screens and other cathode ray screens consists of potassium silicate with barium acetate as a gelling agent. Sylvania offers both of these materials carefully and specially prepared for this purpose.

Potassium Silicate

SYLVANIA Potassium Silicate was developed primarily for preparing TV and other cathode ray tube screens. It is used to supply the bonding material to bind the phosphor to the glass face of the tubes. Since TV screen defects are readily apparent, it is essential that a uniform phosphor layer be deposited and that the binding gel be carefully controlled. Thus, it is imperative that the ratio of alkali to silica and the total solids concentration be carefully controlled so that there is sufficient binding to assure optimum wet screen strength and to prevent the sliding of the screen. SYLVANIA Potassium Silicate is a high purity material in which ratio and total solids are carefully controlled and impurities content kept low so that contamination of the phosphors is avoided.

For use in TV tube coating, the Potassium Silicate is diluted with deionized or distilled water to form a solution containing 0.5 to 3% by volume of the 28% stock solution, depending upon the coating system in use by the manufacturer.

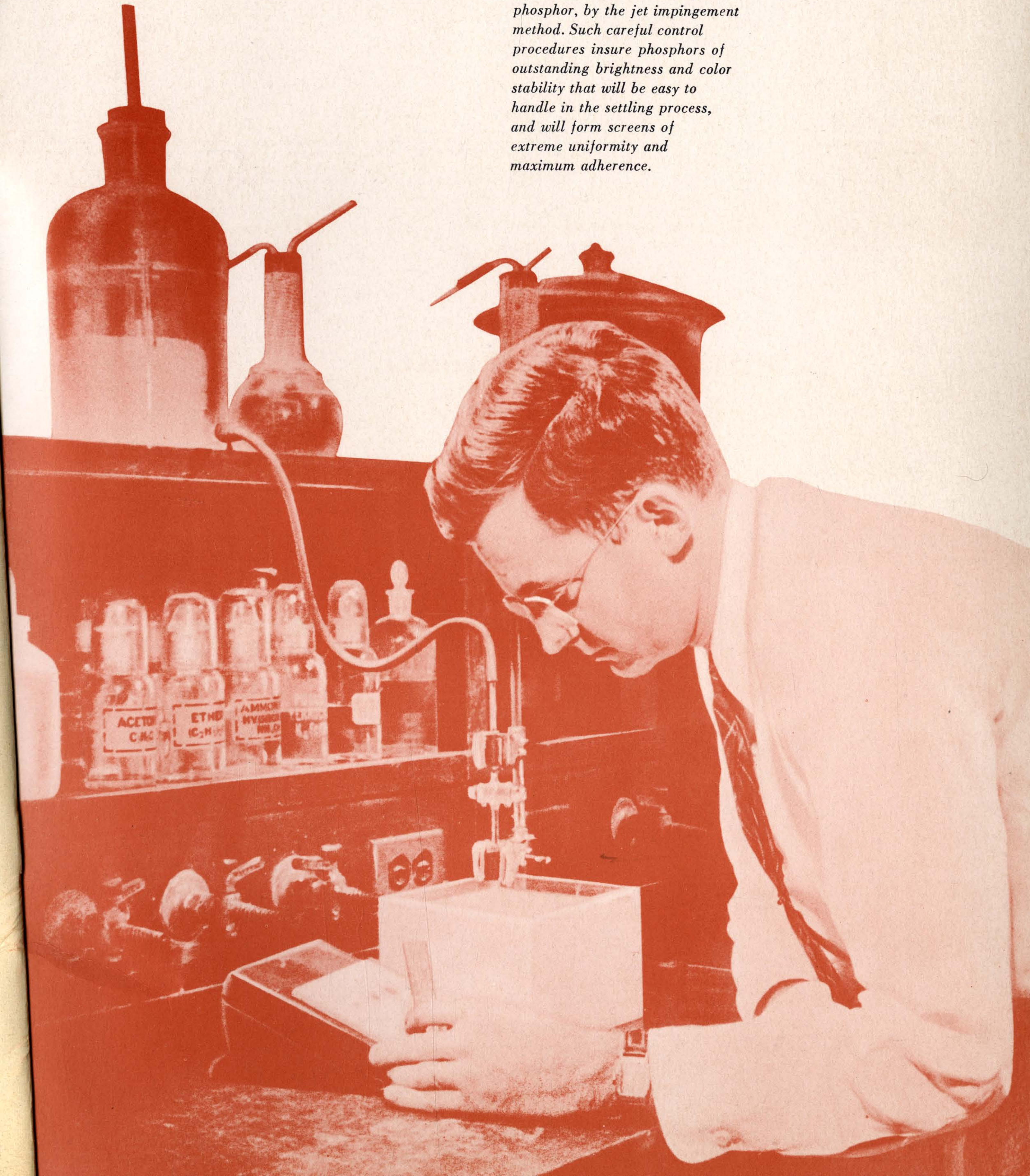
Clear "water white" liquid
Specific Gravity, 60°/60°F......1.249 ± 0.003
pH—11.2

Total Solids ....28 ± 0.5%
Molecular ratio $K_2O:SiO_2$ *...........1:3.4 ± 0.1*

Barium Acetate

Sylvania electronic grade Barium Acetate has been developed to meet the exacting requirements necessary for use in screen settling. The Barium Acetate is dissolved in water to form a solution usually containing one percent or less of the salt. This solution is ordinarily dispensed to the tube together with the other constituents so that the final percentage of Barium Acetate is 0.02% to 0.05%.

Barium Acetate is an electrolyte which effects the gelation of silica gel on the powder particles so that they will bond to the glass surface of the tube, forming the phosphor screen.



The engineer is shown testing the wet screen strength of a typical Sylvania cathode ray tube phosphor, by the jet impingement method. Such careful control procedures insure phosphors of outstanding brightness and color stability that will be easy to handle in the settling process, and will form screens of extreme uniformity and maximum adherence.

Sylvania Electric Products Inc.

tungsten and chemical division

TOWANDA, PENNA.

NP-130-6-55