9

DEPARTMENT OF COMMERCE

Bureau of Standards

S. W. Stratton, Director

Photographic Circulars

A PROPOSED ATLAS

OF

PHOTOGRAPHIC NEGATIVE EMULSIONS

(For the confidential and exclusive use of the United States Government, and later to be revised and issued as a Scientific Paper of the Bureau of Standards,

by

Raymond Davis, Photographic Technologist

and

F. M. Walters, Jr., Associate Physicist

Bureau of Standards.)

~~CONFIDENTIAL~~

(Issued Sept. 23, 1920)

RD:MP

Sept. 25, 1930

NOTICE

This circular was prepared for the information of the officers and employees of the United States Government who have to deal with photographic materials in the execution of their official duties.

The object of this circular is to supply information of the characteristics of the various makes and types of photographic plates and films, which information up to this time has not been available from any source.

The text is rather brief and probably is not as complete as may be desired, particularly to those who are not familiar with the methods of testing such materials.

Those who are interested in this work can assist very materially in the final edition if they will send their criticisms and comments to this Bureau. These comments will not only be of assistance in the final preparation of the work, but will aid in determining its practical value.

BUREAU OF STANDARDS.

CONTENTS CONFIDENTIAL.

Part I. Introduction

Part II. Apparatus and Methods

Part III. Data

Part I. Introduction

The purpose of this Atlas is to make available information which will enable one to select the best photographic material for a given use. No complete collection of data on photographic negative materials has ever been available to the government departments and scientific institutions. This is due to the fact that the apparatus for making complete tests is not generally accessible. Several manufacturers have expressed a desire that photographic materials should in some measure be standardized. (The Optical Society of America has appointed a committee for this purpose.)

This Atlas is not intended to give a complete discussion of the methods of sensitometry, but an attempt has been made to explain in sufficient detail the methods here employed that the user of these results may judge to what extent they are applicable to his problems.

This Atlas deals with the characteristics of that photographic material which is coated on a transparent base such as glass or celluloid. This type of material is used for making negatives and transparencies.

To account for the variations to be met with in different plates, a brief description of the preparation of an emulsion is given. This is followed by a discussion of the different classes into which plates may be divided according to speed and according to color sensitiveness. The relation between exposure and the density of the negative is discussed, together with the development characteristics of plates. The apparatus used in testing is described and the reasons for the adoption of the light source used are given. The methods of studying the color sensitiveness are explained. The method of testing resolution is described and the effects of irradiation and halation are discussed. A discussion of the results and interpretation of the graphs, precedes the charts which show the data on all of the plates and films made in the United States.

Preparation of Emulsions

The light sensitive material consists of small particles of silver bromide (some slow plates contain the chloride and some rapid plates a moderate amount of iodide) imbedded in gelatine.

To show the reason for the differences among the various types of plates, a brief description of the typical method of manufacture is given. To a solution of gelatine which contains soluble halides is added a solution of a silver salt (usually the nitrate). This mixing produces an insoluble silver halide which is suspended in the gelatine in a finely divided state. The emulsion thus formed is comparatively insensitive and it is necessary to "ripen" it. This is accomplished by maintaining the emulsion at a definite temperature until it develops the desired characteristics. In addition to the silver halide, the emulsion contains other salts which are detrimental to the working of the emulsion. These salts are removed by washing the emulsion in cold water after it has been "set" and shredded. After washing, the emulsion may be ripened further by allowing it to stand at ordinary temperatures, or it may be melted and coated at once. The coating is done by a machine which flows the emulsion in a thin layer on the glass or celluloid. The machine then passes the plate into a cooling chamber and the thin coating is allowed to set. The plate is then set on edge to dry.

The character of the finished material is influenced by all of the processes of its manufacture. For example, the purity of the salts used, the proportions used, the rate and temperature of mixing, the concentration of the solutions used, the character of the gelatine, the temperature and time of ripening, the character of the water used in washing the emulsion, and the rate of drying are some of the factors which must be controlled in the process. The formula used and most of the other conditions are trade secrets of the manufacturer.

Classification of Emulsions by
Speed and Use.

Plates and films may be classified by speed, color sensitiveness, and use to which they are best adapted.

They may be classified by speed and use as follows:

1. Ultra fast plates (For focal plate shutter cameras and portraits in dull light).
2. Fast plates. (Portraits, outdoor groups and slow moving objects.)
3. Medium speed plates (Landscapes and buildings).
4. Slow plates (Commercial wofk, copying photographs and line drawings.)
5. Very slow plates.

The extreme rapidity of the first group is obtained at the sacrifice of other qualities. Usually they are not very clean working, fog easily and have large grain and therefore do not have the best resolving power.

The fast plates are in general moderately clean working. They do not fog so easily and have slightly better grain.

Medium speed plates are usually clean working, give brilliant negatives and have good resolving power. These plates are generally used in photographing landscapes, buildings, machines, and in fact anything not having rapid motion.

Slow plates are usually very contrasty and short scaled.

Lantern slide, transparency and process plates fall in class 5. They are of moderately large contrasts and are very clean working and are thinly coated. The grain size is usually small and therefore they give excellent resolution.

Classification of Emulsions by Color Sensitiveness

Plates may be classified with respect to their sensitiveness to color as well as to their speed and use.

Ordinary photographic plates which owe their sensitiveness to the silver halides alone are affected only by the so-called chemical rays, ultra-violet, violet and blue, as shown in Fig. 1, which gives the distribution of spectral sensitivity of such a plate.

An ordinary photographic plate does not give the same color contrasts that the eye sees. On such a plate sky and clouds both photograph white, while green trees together with yellow and red flowers photograph as black.

The region of sensitiveness of a photographic plate may be extended by the addition of certain dyes, the so-called optical sensitizers or photo-sensitizing dyes. These dyes may be incorporated at various stages in the preparation of the emulsion, or the dry plates may be bathed in solutions of these dyes.

Plates which are sensitive to the yellow green in addition to the blue and violet are termed orthochromatic or isochromatic. Fig. 2 shows such a plate with its two regions of sensitiveness.

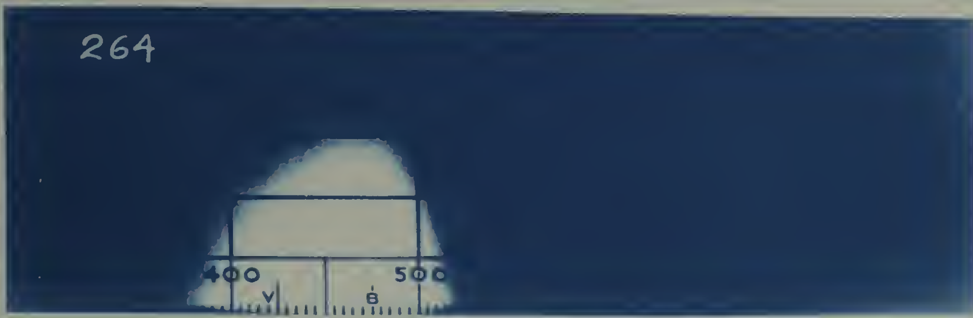


Fig. 1. Spectrogram of Ordinary Plate

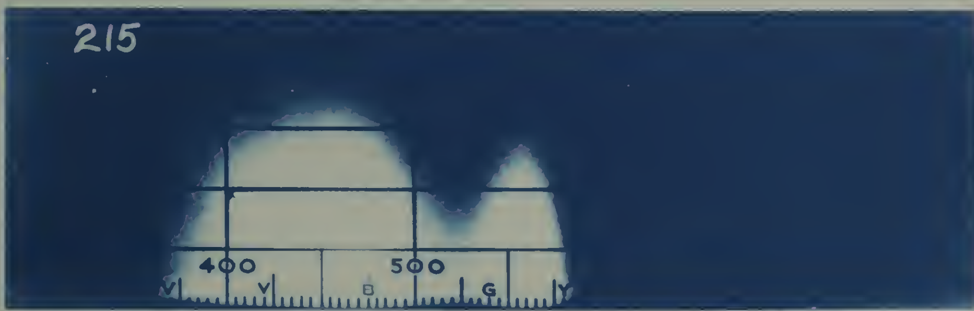


Fig. 2. Spectrogram of Orthochromatic Plate

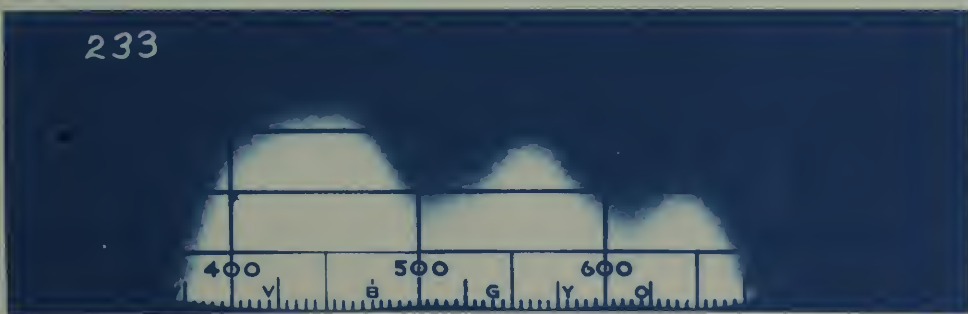


Fig. 3. Spectrogram of Panchromatic Plate.

The letters at the bottom of each spectrogram refer to the color of the light falling on the plate; UV, ultra-violet; V, violet; B, blue; G, green; Y, yellow; O, orange; and R, red. The numbers give the wave length of the light in millionths of a millimeter. For an explanation of the horizontal lines see page 29.

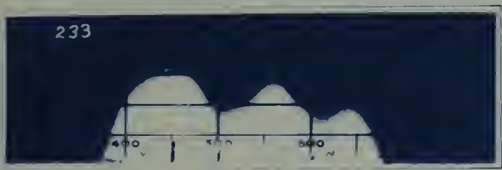
Panchromatic plates are those which are sensitive to all colors. The comparative lack of sensitiveness in the green is taken advantage of by the use of a green dark room light for developing these plates which fog readily with a red dark room light.

Photographic Filters

Orthochromatic and panchromatic plates however do not have the same spectral sensitiveness as does the eye, but their color rendering may be improved by the use of filters which diminish the intensity of certain colors before they reach the plate. This photographic filter or color screen is either colored glass, or a sheet of dyed transparent material such as gelatine which may either be used alone or cemented between two pieces of glass. Color filters are used extensively also to increase color contrasts and record on the plate color differences, which are visible to the eye, but which, without the filter, are of such luminosity as not to appear on the photographic plate. They are used also to eliminate colors, for example, in the case of three color work or in the copying of stained drawings and pictures.

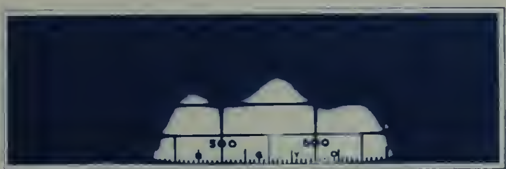
To show the effect of the filters used for testing the color sensitiveness of plates for this Atlas, a set of spectrograms was taken on a panchromatic plate. The chart on page 8 shows the spectrogram of a panchromatic plate without a filter and spectrograms of this plate with each of the eight Wratten filters in common use.

The red filters can be used only with panchromatic plates, while the others can be used on orthochromatic plates as well.

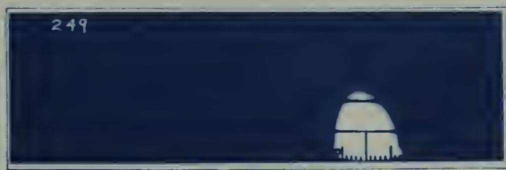


No Filter

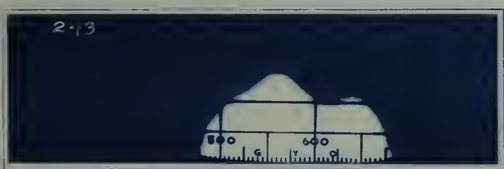
Chart to show the effect of Wratten filters on a panchromatic plate



K_1 Light Yellow — Cuts down violet



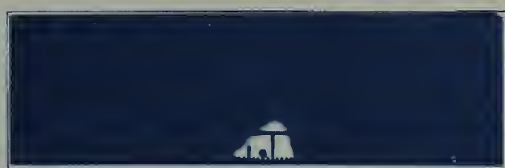
F Deep Red — Contrast filter to photograph red as white



K_2 Medium Yellow — Cuts down blue

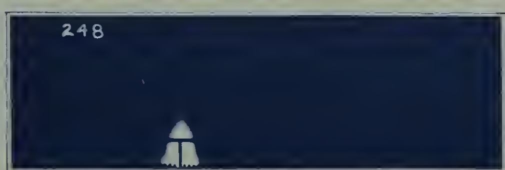
A Light Red for three color work

K_3 Deep Yellow — Cuts blue



B Green for three color work

G Orange — Contrast filter



C Blue for three color work

Fig. 4

Exposure and Density

Of fundamental importance in the study of the properties of photographic material is the relation between the quantity of light falling on the light sensitive material and the density resulting from development.

If a photographic print be compared with the subject it represents, it is found that the darkest tones of the print correspond to those parts of the subject from which the least light is coming and that the lightest tones correspond to the parts of the subject from which the most light is coming, while the intermediate tones of the print correspond to the intermediate tones of the subject.

On the other hand, the photographic negative is densest in those parts which correspond to those of the subject which reflect light most and that part of the negative which represents the shadows is least dense.

To study the characteristics of photographic materials, it is of considerable importance to make this idea of density precise by means of a mathematical definition. This definition is: "Density is equal to the logarithm of the opacity". Opacity is defined as the reciprocal of the transmission, and transmission, in turn, may be defined as the ratio of the transmitted to the incident light. If a portion of a negative transmits 1/10 of the light falling on it, its opacity is 10 and since the logarithm of 10 is 1, its density is 1. The following table shows the values of the opacities and densities for certain values of the transmission.

Transmission	Opacity	Density
1	1	0
1/2	2	0.3
1/10	10	1.0
1/20	20	1.3
1/100	100	2.0
1/1000	1000	3.0
1/10000	10000	4.0

If a plate which transmits 1/2 be placed in front of a plate which transmits 1/10 the transmission of the two will be 1/2 of 1/10 or 1/20.

In studying the relation between the density of a negative and the light exposure required to produce it, it is found most convenient to vary the exposure according to the law of geometrical progression. Usually the exposures are proportional to 1, 2, 4, 8, 16, 32, 64, . . .

Such a set of exposures may be produced in a variety of ways, the simplest method is to keep the intensity of the light constant and vary the time of exposure. The term exposure is here understood to mean the product of the intensity of light and the time of exposure. This product, while not exactly constant, may be so regarded when the variation in one of the factors is less than say a thousand. Scharzschild observed that the photographic effect of a light of small intensity was less than that of one of a much greater intensity.

Let such a set of exposures be made and the plate developed, fixed, washed and dried in the usual manner. Now if the densities be measured, it is observed that within certain limits the differences in density are constant. For example, one might obtain a record something like this:

Exposure	Log E.	Density	Difference
1/10 c.m.s.	9.0	0.40	
2/10	9.3	0.65	0.25
4/10	9.6	0.90	0.25
8/10	9.9	1.15	0.25
16/10	0.2	1.40	0.25
32/10	0.5	1.65	0.25
64/10	0.8	1.90	0.25

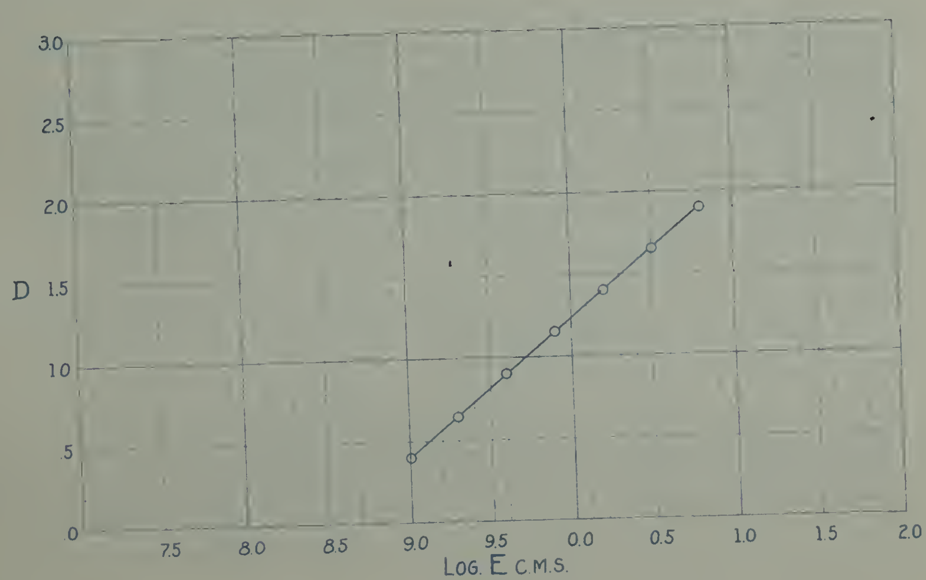


Fig. 5. Part of the density-exposure curve

If a graph be made to show the relation between the density and exposure, it is found more convenient to plot the logarithm of the exposure because the range n exposure is often as great as 1 to 1000 and plotting the exposure would make the scale too small.

This constant difference relation of the density holds true however only for intermediate exposures. For example, if exposures longer and shorter than those given above be made, the corresponding densities will not show constant differences and the points will not lie on a straight line, when density is plotted against the logarithm of exposure. One might obtain observations like this, for example:

Exposure	Log E.	Density	Difference
1/160	7.8	0.00	
1/80	8.1	0.03	0.03
1/40	8.4	0.08	0.05
1/20	8.7	0.20	0.12
1/10	9.0	0.40	0.20
. . .	. . .	. . .	
64/10	0.8	1.90	
128/10	1.1	2.13	0.23
256/10	1.4	2.30	0.17
512/10	1.7	2.45	0.15
1024/10	2.0	2.55	0.10

Here successive doubling of the exposure does not give a constant increase in the density, that is, the opacity is not proportional to the exposure. The complete graph is shown in Fig. 6. This curve which shows the relation between density and exposure is known as the "characteristic curve" of the plate. It is also called the "H & D" curve after Hurter and Driffield who were the first to state the relation between density and exposure. The underexposure part of the characteristic curve is called the "toe". The overexposure region is sometimes referred to as the "shoulder".

Since in the correct representation of the light and shade of the subject photographed, the opacity of the negative should be proportional to the quantity of light coming from the subject, it follows that the time of exposure should be such as to give densities on the plate which lie on the straight line portion of the density exposure curve. It is found that if the exposure is too short, there is no detail in the shadows, although there may be a slight deposit of silver all over the plate, or if the development has been such that detail does show, the representation of light and dark in the picture does not correspond to the light and dark of the subject.

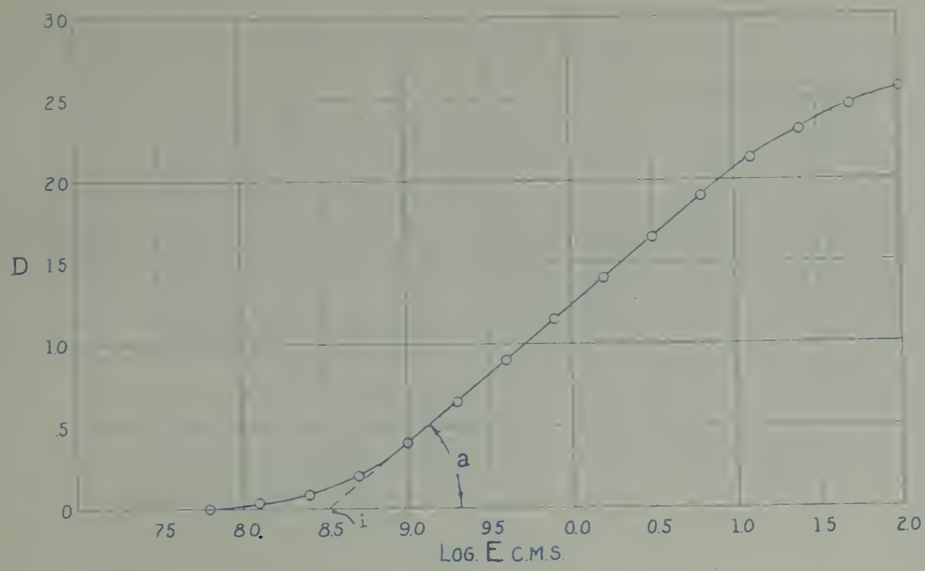


Fig. 6. Density-exposure curve showing toe, straight-line and shoulder.

When the exposure is too long, there is not sufficient difference in density to give detail in the portions of the negative which represent the brightest parts of the subject.

Hurter and Driffield, who were the first to express the relation between the darkening of the negative and the light coming from the subject in terms of density and exposure, have expressed this fundamental law of photography as follows: "In a theoretically perfect negative, the amounts of silver deposited in the various parts are proportional to the logarithms of the intensities of light proceding from the corresponding parts of the object."

That the density of a negative is proportional to the quantity of silver reduced by the developer has been corroborated by many independent investigators.

Contrast and Development

It is a matter of common experience that the longer a plate is developed, the more contrast and density it has. This is shown very clearly by means of the following experiment. A number of strips of the same plate are given identical step exposures, then each strip is developed for a different length of time, the plate fixed, washed and dried, and the density measured. Fig. 7 shows development for 3, 6 and 12 minutes respectively. It is to be noticed that the density for a given exposure becomes greater with the time of development as should of course be expected. It is also to be observed that the straight line portion of the plate curve becomes steeper with the time of development. This is in accord with the idea of greater contrast, since with long development there is a greater difference in density for the same difference in exposure. The idea of contrast is made definite by giving it a numerical definition. If the straight line portion of the characteristic curve is continued downward until it cuts the exposure axis, it will make an angle a with it; the contrast is defined as equal to the tangent of a. This is called gamma (γ), so that

$$\gamma = \tan \underline{a}$$

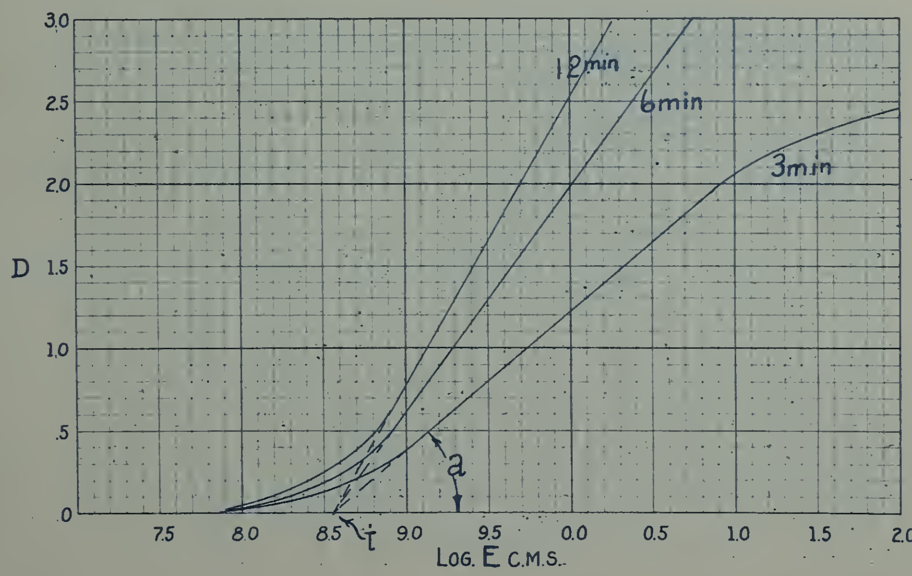


Fig. 7. Density-exposure curves for developments of 3, 6 and 12 minutes.

Thus a gamma of 1 means that the ratio of the densities in the negative is the same as the corresponding ratio of the logarithms of the intensity of light coming from the subject. Or expressed in another way, the degree of contrast indicated by the number expressing gamma, is the separation of the intensities of light coming from the subject as recorded on the negative. A gamma of 2 means that the plate shows twice the contrast of the subject, and a gamma of 0.5 means that the plate shows half the contrast of the subject.

Contrast and Time of Development

If the values of the contrast (γ) be measured from the graph, interesting information can be obtained by plotting them against the time of development. (Fig.8) There is a certain period before the deposit of silver becomes visible, then the contrast increases rapidly with the time, and finally more slowly, so that after a certain time, the negative gains very little in contrast by further increasing the time of development.

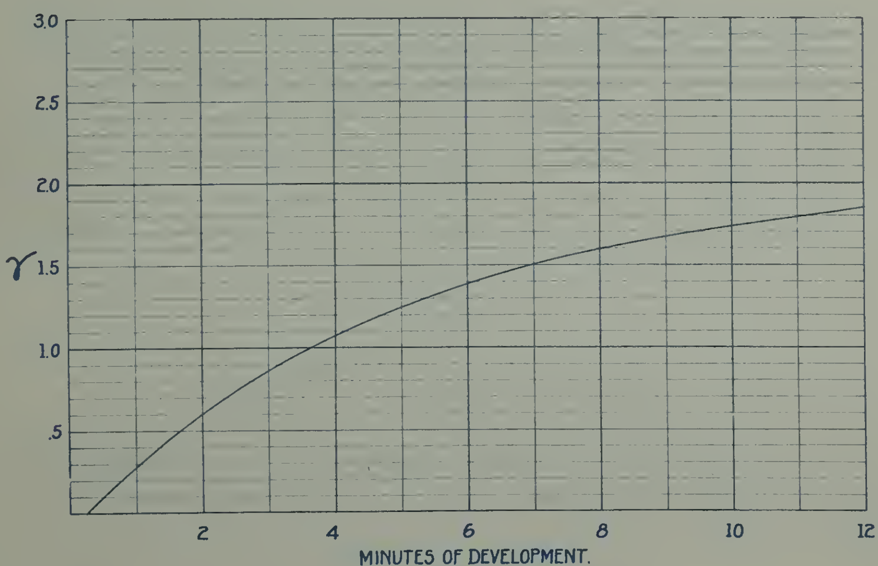


Fig. 8. Curve showing growth on contrast with time of development.

The statement is sometimes made that all negatives should be developed to give unit contrast. But it must be remembered in controlling development that the print is the basis upon which the correct rendering of the subject is to be judged. If printing papers gave gammas of 1, then a negative might well be developed to unit contrast, but most of the papers in use have gammas greater than one when developed to give the proper tone, so that negatives are developed not to unit contrast, but to a less contrast. It must be bourne in mind that the scale of a paper is commonly much less than the scale of the usual subject, so that the development of a negative must be stopped when the highest and lowest tones of the subject it is desired to reproduce have reached the limit of representation of the paper used. With studio lighting, it is often desired to soften the contrasts which occur in lighting the subject, and for this reason the use of a plate which is not capable of reaching an extreme gamma in development is no detriment. In the reproduction of line drawings, it is desirable to increase the contrasts presented by the ink and paper of the drawing, and to get the variation of light on the surface of the paper recorded on the negative by a density so great that the scale (See page 16) of the printing paper has no chance to show it.

Speed and Inertia

It is observed in Fig. 7 that if the straight line portion of each development curve be continued until it cuts the exposure axis, all lines cut the axis in the same place. (This always occurs, provided there is no free bromide in the plate or in the developer and that the plate does not fog badly.) This fact leads to the idea that there is a beginning to the exposure, which will give a negative in which density is proportional to the logarithm of the exposure. This least exposure is called the "inertia" of the plate. The faster a plate, the shorter the time required to give an image, and hence the less its inertia. However, one's idea of speed is such that the greater the speed, the larger must be the number representing it, so that to indicate speed, the reciprocal of the inertia is taken. This was Hurter's original idea, but to fit an actinometer of his design, he took 34/i (34 divided by the inertia) which is the usual H & D number. The Bureau of Standards, however, has taken 10/i as its definition of speed. The number 1/i would have been more logical, but 10/i was chosen so that all usual speed numbers might be represented by integers and the confusion of fractions be avoided.

As an illustration of the process of obtaining plate speeds from the plate curves, Fig. 7 and Fig. 9 may be studied. In Fig. 7 the logarithm of the inertia is 8.56. This is the logarithm of the number 0.0363. The reciprocal of 0.0363 is 1/0.0363 which is 27.5, and 10 times the reciprocal would be 275, the Bureau of Standards speed. As an example, in Fig. 9 the data for the two plates are:

Log i	i	1/i	B.S. Speed
8.42	0.0263	38.0	380
8.77	0.0589	17.0	170

Scale and Latitude

From the characteristic curve the "scale" of the plate may be obtained. By scale is understood the range of light intensity that a plate is able to record correctly. Latitude is the variation which it is possible to make in the time of exposure and still retain a correct representation of the subject.

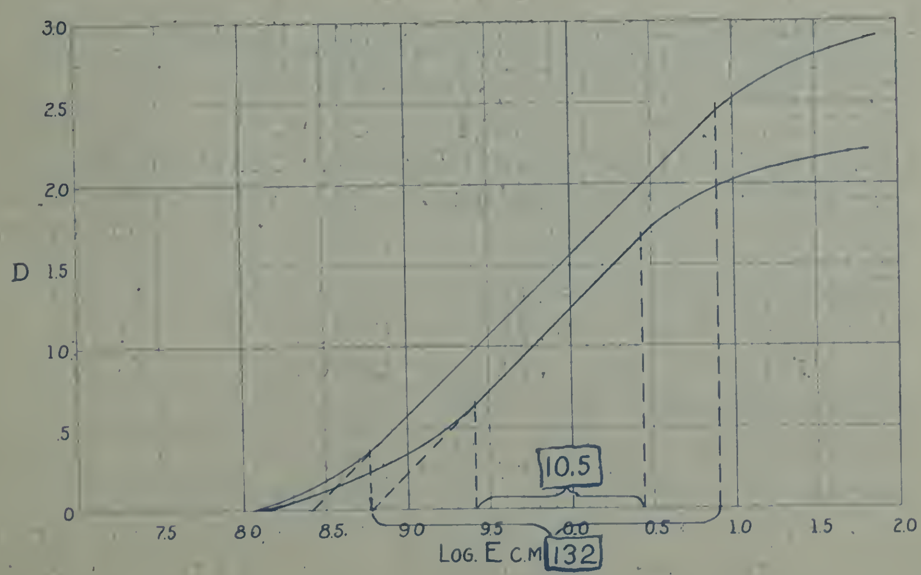


Fig. 9. Plates with different scales.

The scale is measured by the projection on the exposure axis of the straight line part of the characteristic curve. The difference of the logarithms of the two extremes is taken and the number corresponding is the scale. Thus the curve to the left represents a plate which has a scale of 132 and that to the right a scale of 10.5.

$0.90 - 8.78 = 2.12 = \log 132$ for the first plate
$0.43 - 9.41 = 1.02 = \log 10.4$ for the second plate.

If the subject photographed on the plate with a scale of 132 has a range of light intensity from 1 to 132 (the brightest part of the subject gives 132 times as much light as the darkest part) the exposure would have to be precise, for an under or over exposure would shift the negative from the straight line part of the characteristic curve so that the reproduction of light and shade would no longer be correct. If, however, the subject had an intensity range of 1 to 33, the plate would have a latitude of 4 for this subject, so that if 1 second were the shortest correct exposure, 4 seconds could be given and the plate would still show a correct tone representation.

Other Methods of Measuring Plate Speeds

A method often used for comparing plate speeds is to measure the exposure required to give a visible image on the plate. In actual application, the plate to be tested may be exposed either behind a set of standard densities, or behind a sector wheel. There are, however, several objections to this method: (1) it depends upon the observer as to what density is just visible, (2) the density upon which speed is judged is too small to have a printing value, hence actually plays no part in the average negative, (3) a quick developing plate is judged to be faster than a slow developing plate, although when developed to the same contrast, the latter would require the smaller exposure. A more serious objection (4) is that a plate with a long toe appears to be much faster than it really is. For example, by this method, the two plates of Fig.9 would be classed as having the same speed but when correct tone rendering is considered, as shown above, one is actually more than twice as fast as the other.

In plate factories, speeds are frequently tested under actual working conditions. A negative of a standard test object is made in the camera and developed under standard conditions. An observer who is trained through long familiarity with the appearance of the type of plate which he desires to reproduce, is able to judge very exactly whether or not the plate under test comes up to standard in speed, scale and contrast.

Effect of Bromide

Typical development curves of clean working emulsions which are free from bromide show the straight line portions intersecting in a point on the exposure axis for all times of development. On the other hand, the presence of potassium bromide in the developer or emulsion produces a marked effect on the properties of photographic emulsions. The inertia becomes less as the time of development increases, shown in Fig. 10. The addition of potassium bromide is necessary with some developing agents, particularly metol. It retards the appearance of chemical fog and permits the development of a higher degree of contrast. However, its presence produces a marked decrease in speed. Figure 11 shows the decrease in apparent speed of three brands of plates with increasing amounts of bromide in pyro developer of tray strength.

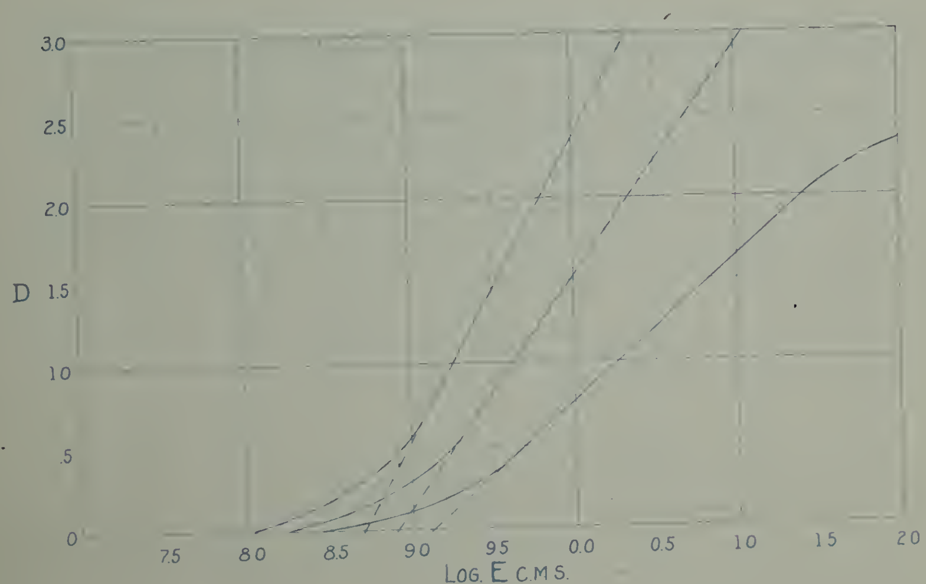


Fig. 10. Decrease of inertia with time of development with a developer containing potassium bromide.

Fig. 11. Decrease of speed with increasing amounts of bromide in the developer.

Development

There are two methods in general use for judging when the development of a negative is complete: (1) that of the amateur who feels that development must be carried until the image comes through the back or until the unexposed edges begin to fog, and (2) that of the professional who is able to tell when the negative has the desired brilliance and printing quality as he views it by the transmitted light of his dark room lamp. The method of the amateur is unsatisfactory since it depends upon the thickness of the emulsion and since it does not take account of the variation in the natural contrast of the subject.

The use of tank development is to be recommended for the production of negatives of subjects which have the same degree of contrast. Tank development takes care of small differences in exposure without disturbing contrast ratios. For example, a plate which is slightly over exposed will merely require longer to print. In addition to the time of development, and the temperature and concentration of the developer, account must be taken also of the development characteristics of the plate used.

Equally important, though not mentioned in the manuals of photography, is the necessity of adapting the length of development to the intrinsic contrast of th. subject and the character of the printing medium.

In developing it is important to keep the rate and method of stirring constant unless the negatives are examined for contrast. By proper rocking, the time of development may be cut in half of that required for no motion of the developer.

Part II. Apparatus and Methods

A description of the methods and apparatus used in the tests made for this Atlas will now be given.

The sensitometer or apparatus for obtaining the exposure density curves consists of two parts, (1) the source of light and (2) the means of obtaining graduated exposures.

Light Source

The sun is the natural source of light. Other sources differ from it not only in intensity but in the relative amounts of the various colors which they contain. Accordingly an object owes its color not only to its selective reflection and absorption, but also to the nature of the light falling on it. (As an extreme example, may be taken the appearance of objects when viewed in the light of a mercury vapor lamp.)

Daylight is sunlight reflected from the sky and clouds. In general it varies with the time of day and year and geographical location. Sunlight itself changes with the time of day and time of year. Its color is changed by the altitude of the sun and the condition of the atmosphere.

Of the two, sunlight is by far the most constant, so that it was decided to reproduce in color average yearly, noon, sunlight at the latitude of Washington as the source of energy for the sensitometry of photographic materials.

Since an exposure of 100 candle meters for 1 second gives a greater photographic effect than 1 candle meter for 100 seconds (the effect referred to as the failure of the reciprocity law), the intensity of the light source must be specified as well as its color. In accordance with Hurter and Driffield, this is taken as one candle meter (visual), that is, the light at the plate shall be equal in intensity to that of a source of 1 candle power at a distance of one meter. The intrinsic brilliancy of the source should lie between 1 and 4 candle power, since an intensity less than 1 c.p. would make the distance to the test plate too small to give a sufficiently uniform distribution of intensity and a candle power greater than four, would make the apparatus cumbersome. The considerations of intensity and constancy have led to the adoption as a source of the 6 to 8 volt Mazda C automobile headlight, operating on approximately 2.4 amperes. A Brooks' deflection potentiometer is used in order to regulate the current accurately. These lamps were first standardized by the

Colorimetry Section of this Bureau, so that when used with a special blue glass filter, they gave a light closely approximating the color of average noon sunlight. The lamps were then measured for visual candlepower by the Photometric Section, and the special blue glass filter measured for its visual transmission when used with these lamps. The lamps without filter gave an average of 15 c.p., the filter transmission was 18.2 per cent, making an average intensity of the lamps seen through the filter of 2.73 c.p.

Sensitometer

The sensitometer is of the sector disk type. The disk contains nine apertures, the angle of each being twice as great as the preceding (See Fig.12), and their radial length 1/2 inch. The disk is about 18 inches in diameter, being twice the usual size in order to cut the small angles more accurately. The following table gives the calibration in parts of 360°:

Intended Aperture	Actual Aperture	Per cent Error
0.001953	0.001834	- 5.7
0.003906	0.003937	+ 1.5
0.007812	0.007698	- 1.1
0.015625	0.015529	- 0.6
0.03125	0.03104	- 0.7
0.0625	0.06238	- 0.2
0.125	0.1222	- 2.2
0.25	0.2502	+ 0.1
0.50	0.4997	- 0.1

Fig. 12. Sector Wheel.

The disk which was carefully balanced and mounted on a shaft with cone bearings, is shown with its light tight box in Fig. 13 (section on G-G).

Connected to this box is a light tunnel, provided at one end with an electrically operated shutter and the compensating color filter, the light source being in front of the shutter.

On the shaft of the sector wheel are two commutators. One of these, which is adjustable, is connected through a battery to a pair of telephone receivers so that a "tick" is heard for each revolution of the wheel. These ticks are compared with those received from a seconds pendulum clock through a microphone circuit. The wheel speed is regulated so that the clock beats and the ticks of the wheel contact coincide. The telephone receivers may be replaced by a chronograph to obtain a graphical record.

The second commutator is fixed in position and is connected through a battery to the timing device, this (Fig.14) consisting of a toothed wheel W driven by a spring S and is operated through the electromagnet M by the escapement E. At each revolution of the sector wheel, the toothed wheel of the timing device is moved

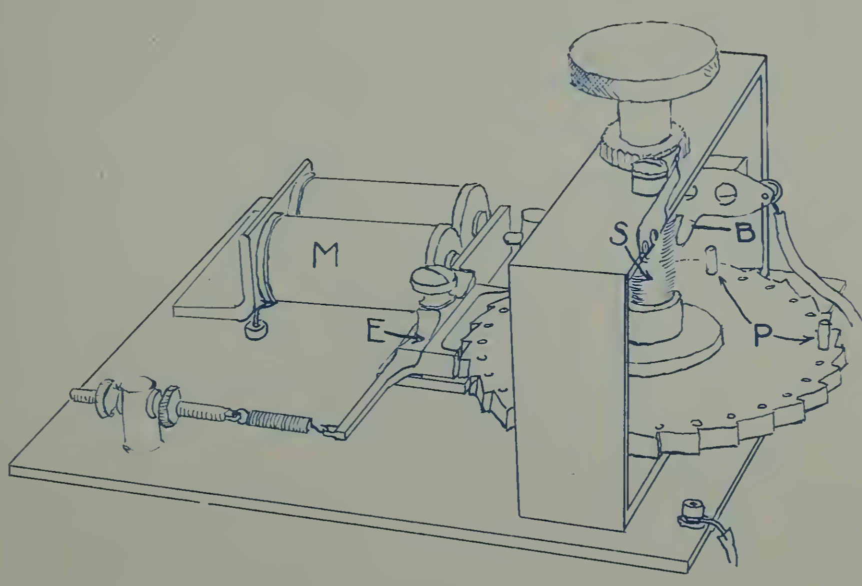
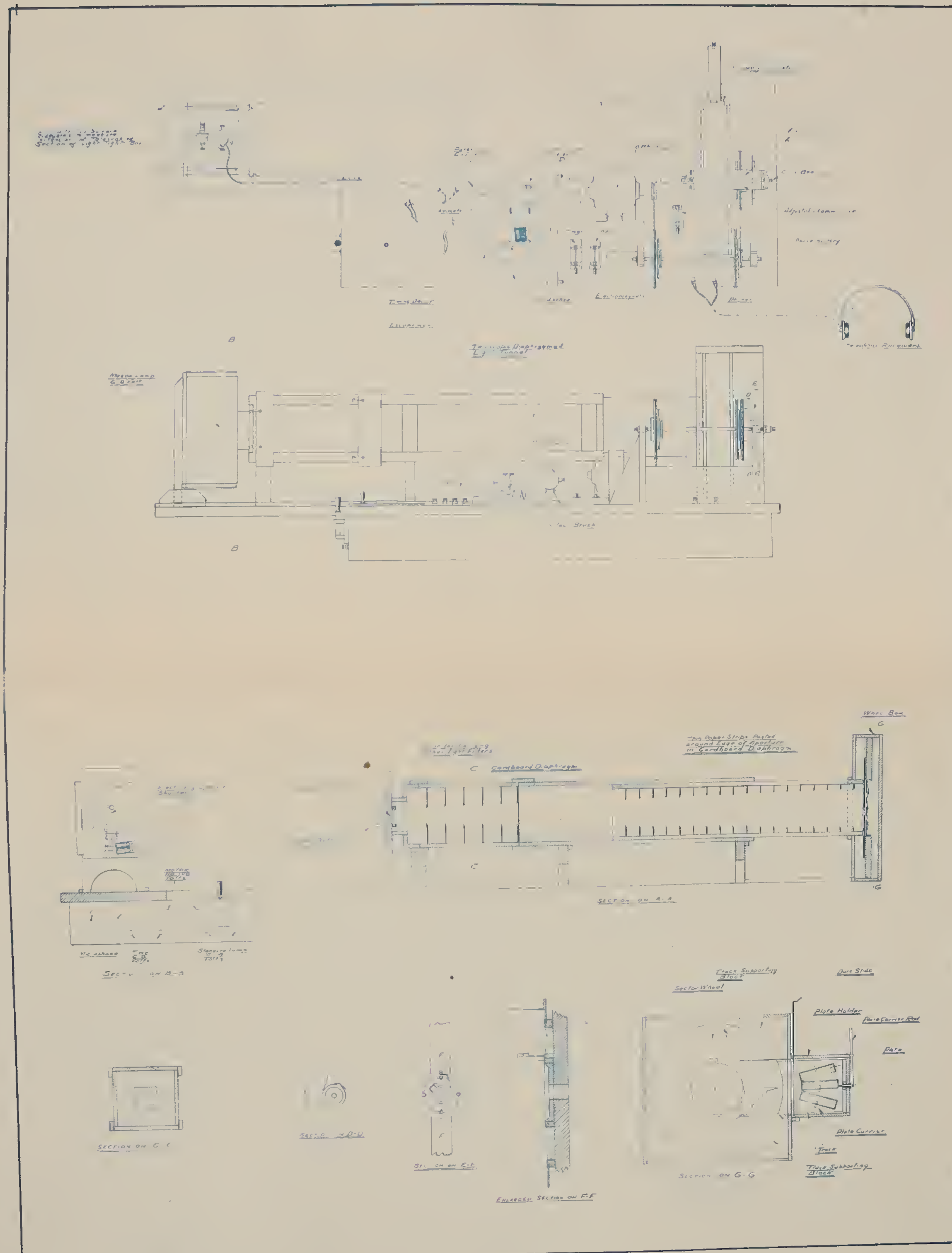


Fig. 14. Timing device of Sensitometer.

Fig. 13. Diagram of Sensitometer



forward one tooth, half a tooth when the current is made and the other half when the current is broken. A hole is drilled opposite each tooth, and in two of these holes are placed contact pins P. These pins make contact with the brush B which is placed so that the contact pin moves under it when the current is broken. The frame of the timing device and the contact brush are connected to the electrically operated shutter and the circuit which operates the timer.

The shutter is opened when the first pin moves under the contact brush, at the instant the circuit is made by the commutator on the sector wheel shaft. It remains open until the second pin comes under the contact brush and the circuit is closed by the commutator. The commutator is placed on the shaft of the shutter wheel in such a position that the shutter is both opened and closed while one of the solid quadrants of the wheel covers the test plates. This sensitometer is distinctive in that the sector wheel gives not only the graduated exposure, but the total exposure as well.

The sector wheel is driven by a one-eighth h.p. shunt motor connected as shown in Fig. 15. This arrangement gives excellent speed control continuously from 0 to 1700 R.P.M. The current is supplied by storage batteries.

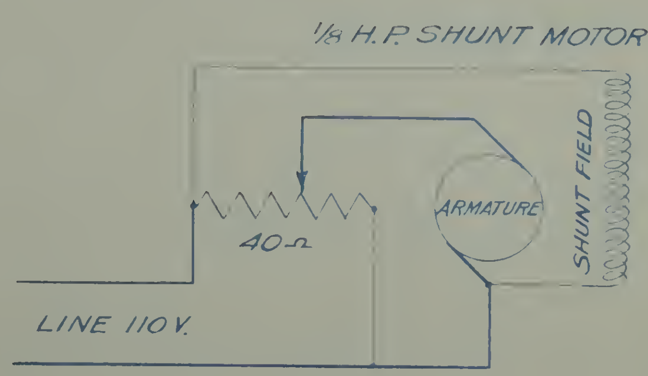


Fig. 15. Wiring diagram of Speed Control of Sensitometer Motor.

The test strips (1 1/8" by 5") are put into a holder specially designed to display the three plates radially from the center of the wheel (Fig.13). A track is so arranged that the plates are slid up to within 2 millimeters of the back of the sector wheel, since it is important to have the plates as close to the apertures of the sector wheel as possible, in order to get the true effective aperture and to eliminate partially illuminated shadows.

In the method of testing plates employed here it is assumed that the exposure is equal to the product of the intensity and the time of exposure, whatever their values. This is not strictly true, for example, an exposure of 10 c.m. for 1 second will give a greater photographic effect than an exposure of 1/100 c.m. for 1000 seconds. It may be thought that a sensitometer which gives exposures of varying intensity for the same exposure time would be preferable. There are however two objections to such a method: first, speeds so determined would be applicable only to the time of exposure used, and second, the apparatus required would be very complicated if accuracy in the measurement of time and intensity of light were attempted. The method of a constant intensity and varying time of exposure offers the advantages of ease of operation and exactness in the measurement of time and intensity.

A criticism made of the sector disk method as usually employed is that the effect of an intermittent exposure is less than a continuous exposure of the same duration (that is, 100 exposures of 1/10 second are not equivalent to a single exposure of 10 seconds). Tests showed that this effect is inappreciable (not more than a few per cent and considerably less than the variation due to coating) with the number of revolutions of the disk usually used (16), the intensity of the light (1 candle meter visual), and the comparatively slow rate of the wheel (1 revolution per second).

Development of Test Plates

Development is carried out in silver plated cans placed in a water bath, the temperature of which is kept constant by a thermostat regulator which controls the heating units through a relay. The test plates are put in silver cages, each holding four, and stirred in the developer by rotating the cages at the rate of 40 revolutions per minute.

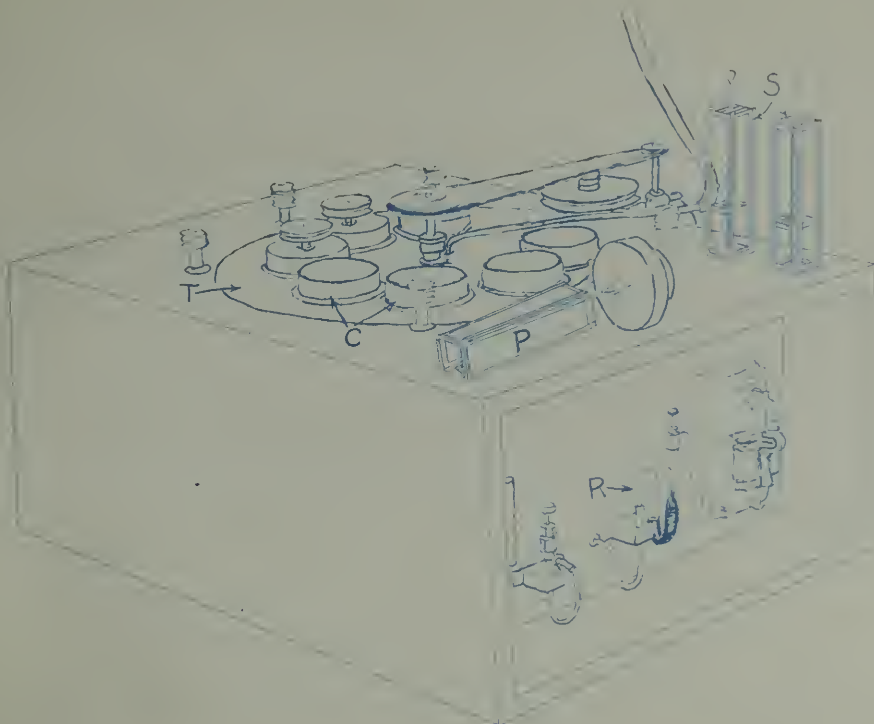


Fig. 16. Thermostat for developing
Test Plates.

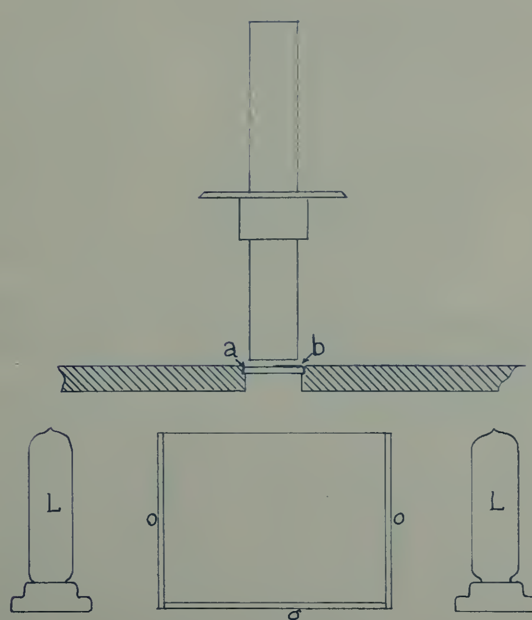


Fig. 17. Photometer and illumination box
for Measuring the Density of Test Plates.

Measurement of Density of Test Plates

The photometer used in measuring the density of the test strips is a polarization instrument of the Martens type (Fig.17). One beam of light passes through the square (a) the density of which is to be measured, while the other beam passes through the fog strip (b). By this means, the effect of the density of the glass and gelatine and also of chemical fog is automatically eliminated, so that the measured density is due solely to the exposure. The illumination is diffuse, the light is reflected from ground surface opal glass (g), surrounded by opal glass (o, o), outside of which are placed electric lamps (L, L) symmetrically arranged so as to give uniform illumination. The test strip is placed in a sliding holder which, by means of stops, brings the center of each square under the photometer. The angular readings of the polarization instrument are reduced to densities by means of a table computed for the purpose.

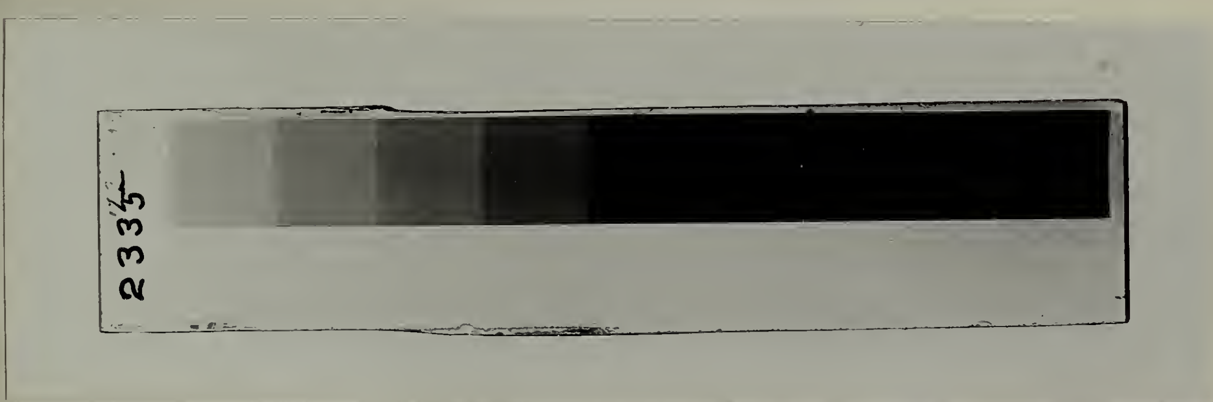


Fig. 18. Test strip (full size) showing the nine densities due to exposure and the fog strip.

It may be remarked that densities measured visually do not represent photographic densities. The photographic density depends upon the region of sensitiveness of the printing medium, the quality of the light used to print and the manner of printing, whether it be contact printing or enlarging. The plates measured in this work are neutral in color, although developed with pyro, and the only results which may be affected materially by the difference between visual and photographic density are the values of the contrast, but in that case they still give reliable comparative data.

Spectrograph

Two methods are used in studying the color sensitivity: first, a spectrum is photographed on the plate, and second, the filter factors of the plate are measured. The first method is excellent for determining if the plate is sensitive to a particular color, and the second from a practical standpoint in determining how one plate compares with another in speed when used with a particular filter.

The apparatus for projecting a spectrum on the plate may be described as follows (Fig.19). The light source (L) is a 100 watt tungsten lamp whose brightness is kept constant by adjusting a rheostat to maintain a constant current through the filament. Around the lamp is a white reflector (R), while in front of the slit is a piece of ground glass, to give uniform illumination along the slit which is 2 inches high. Between the ground glass and the slit is placed a rotating disk (D) out of which is cut a variable aperture such that the brightness of the slit varies with the distance from its ends. The horizontal lines on the spectrograms indicate geometrically diminishing exposures.

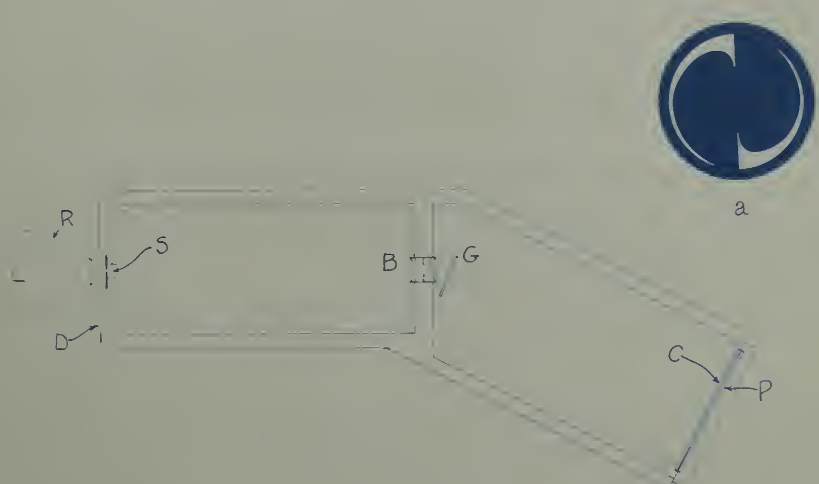


Fig. 19. Diagram of spectrograph (a) Disk for varying exposure along the slit.

The exposure at the first line from the bottom is 1/4 that at the bottom, at the second line 1/16, at the third, 1/64, at the fourth 1/256, and at the top 1/1024. The light from the slit passes through first a photographic lens (B) then a replica of a diffraction grating (G) which disperses it into a normal spectrum. Just in front of the plate (P) is a screen (C) bearing on it reference lines to mark intensities, and also wave lengths on the plate. The end of this plate through which the red part of the spectrum passes is stained with a yellow filter dye to screen out the second order violet light which in the grating spectrum is superposed on the first order red.

The tungsten lamp is used without any correcting screen because the red and yellow sensitiveness of any plate is so small compared with its blue sensitiveness that the humps showing the orthochromatism of the plates would have been too small to compare readily. It should be kept in mind therefore, that the spectrograms do not represent rigorously the spectral sensitiveness of the plates to average noon sunlight but to a light, rather, which is deficient in the violet and blue.

Filter Factor Apparatus

A filter factor is the ratio of exposure time required with a given filter to the exposure without a filter, hence to obtain the proper time of exposure when using a filter, the correct exposure time required without a filter must be multiplied by the filter factor in order to get an equivalent negative.

The apparatus for measuring filter factors (Fig.20) is constructed as follows: Light from the two sides of a standard metal filament lamp L is reflected by similar mirrors M_1, M_2, M_3, M_4, and by similar prisms, P_1 and P_2, so that the two beams fall side by side on the photographic plate, E, the filter factors of which are to be determined. In front of the plate is a simple shutter. The source of light, L, is movable along the line joining M_1 and M_2. At F, between M_3 and M_4, carriers to hold the filters may be inserted.

The method of procedure is as follows: The lamp initially at the position, a, gives two beams of equal intensity at the photographic plate, provided the distances traversed by the two beams are the same and identical optical conditions of reflection and absorption obtain for the various media through which the beams pass.

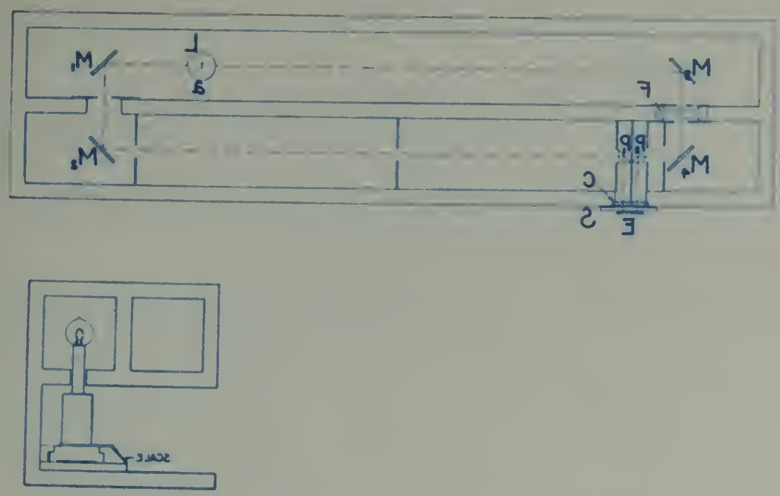


Fig. 20. Diagram of Apparatus for Measuring the Filter Factors.

If a filter be inserted in one path, the intensity of that beam is decreased. Equal illumination on the plate is obtained by shifting the lamp toward the filter, thus shortening that path and increasing the other. Since the intensity of illumination varies as the square of the distance from the source, the ratio by which the filter cuts down the intensity of the light is equal to the square of the length of the path containing the filter divided by the square of the length of the other path. The filter factor is the inverse of this ratio.

In practice the point of balance is obtained by making a series of exposures on the plate with the lamp set at arbitrary distances from the center position a, choosing these distances so that some are one side of the point of balance and some on the other. The plate is then developed and fixed and the density differences measured on the photometer. These differences are finally plotted against the distance as positive or negative according to whether the setting made the lamp distance too large or too small, and the setting for a balance is obtained from this curve.

In the apparatus the two paths are each one meter long when balanced without a filter and the lamp has a movement of about 69 centimeters so that the range of factors which can be measured is from one to thirty. The filters used must be larger than 1/2" square. The strips of the photographic plate to be tested are 1 1/8" by 5" and exposures for two filter factors may be conveniently recorded on each.

In order to get filter factors applicable to out of door use, it is necessary to modify the distribution of spectral energy of the metal filament lamp, by placing in both beams a suitable screen. It is also necessary to burn the lamp at a constant and specified current, so as to keep constant its spectral distribution of energy. The combination of lamp and filter is identical with that used as the standard source of the Bureau of Standards sensitometer. How successful the apparatus described has proven, together with the closeness of the light source to sunlight is shown in Fig. 21. Exposure times were given which were proportional to the filter factors as measured and the two plates on which the eight exposures were made were developed together for the same length of time and printed together on one sheet of paper. If the negatives had not been similar in density (the result of a small error in exposure), it would not have been possible to secure prints equal in depth.

Resolution

It is common experience that when a negative is to be enlarged, there is a limit beyond which the enlargement takes on a granular appearance and the tones instead of being smooth become discontinuous. The same effect is observed when examining a negative under a microscope. There is a limit to the detail which can be recorded with a given photographic material. This limit may be expressed as the distance by which two points of light must be separated on the sensitive film so that they will be recorded as two images and not as one. For ordinary photographic negatives, this limit lies between 4 and 16 ten-thousandths of an inch (1 to 4 hundredths of a millimeter). As a general rule, the faster a plate, the larger will be its grain size and the poorer its resolution, while the slower plates (such as lantern slides, transparency and process plates) give the best resolution. But this is not strictly true, and it is often desirable to use that brand of a given class of plates which has the highest resolving power.

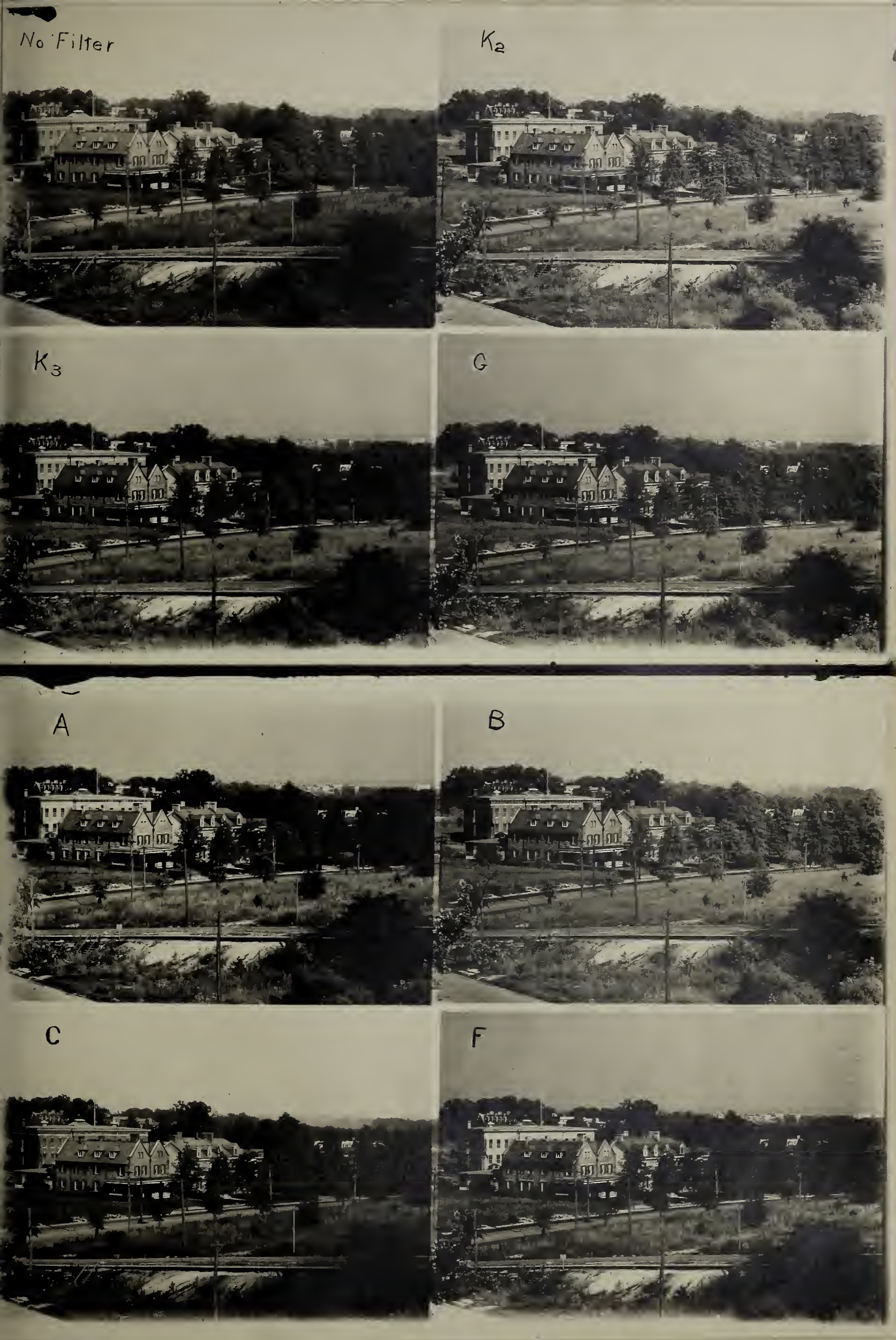


Fig. 21. Test of Filter Factor Apparatus.

Fig. 21. Test of Filter Factor Apparatus.

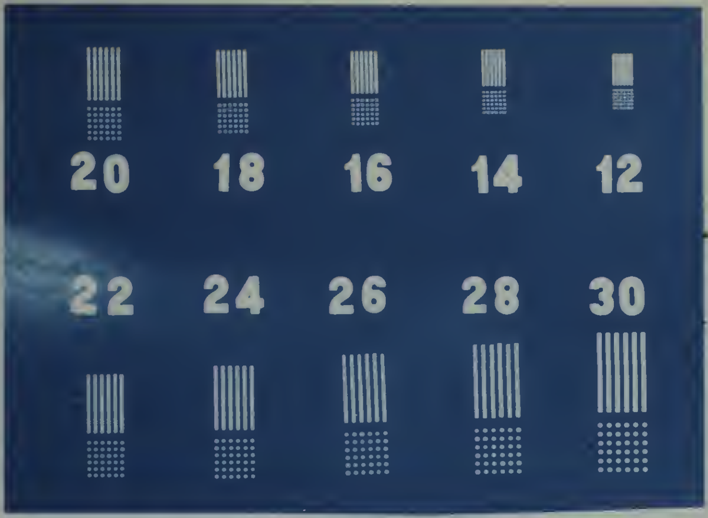


Fig. 22. Test Chart (reduced) used in determining the Resolving Power.

To compare the resolving power of the plates and films being studied, a test object was made which consisted of a glass plate with a series of apertures equal in width to the spaces separating them, evenly illuminated from behind by electric lamps. The test object was photographed on the plate to be tested by means of a 50 mm Zeiss Tessar (the resolving power of which exceeded that of the plates tested) carefully focussed and stopped down to f/16. The size of the test object and its distance from the lens were so chosen that the distance from center to center of the various sets of lines and dots when projected on the photographic plate were, 0.012, 0.014, 0.016, 0.018, 0.020, 0.022, 0.024, 0.025, 0.028, and 0.030 millimeters. The various brands of plates were given a series of exposures in geometrical progression, so that on each plate there would be at least one exposure near the threshold value, i.e., on the toe of the characteristic curve. The plates were developed uniformly for six minutes in pyro developer, tray strength. This development represents fairly the conditions under which plates are used since a portrait plate is developed for a low contrast which it reaches in about the same time that a slow plate reaches the high contrast for which it is used.

The plates were examined with a microscope under a fairly high power and the resolution "number" taken as the separation which the plate is just able to make. Thus a resolution number of 18 means that the plate was able to resolve lines whose centers on the plate were 0.018 mm apart, when the plate had received an average development and a low exposure. The principle used in deciding when the lines were resolved was whether or not the number of lines of the test pattern could be distinctly counted.

Besides the grain size, other factors which affect the resolving power of a plate are irradiation and the spreading of the image in development. Irradiation is the spreading of the image due to the reflection of light in the film from one silver grain to another. It is found that the greater the exposure, the lower the resolution of a plate.

Halation

A careful distinction must be made between irradiation and halation. Halation (which may be noticed in the "halo" surrounding the image of a bright point of light against a dark background) is due to the total reflection of light inside the glass or celluloid support. The silver grains spread or diffuse the light in all directions. The light passes into the glass at all angles; that which strikes the second surface of the glass at less than the so-called critical angle of total reflection is mostly transmitted, while that which strikes the second surface at an angle equal to or greater than the critical angle is all reflected back into the glass and its coating. It is this reflected light that causes the halo. The size of the halo is determined by the thickness of the glass and its critical angle, which may be calculated from its refractive index.

Halation may be avoided by the use of backed plates, or by surface development. If the back surface of the glass plate is coated with a substance having practically the same index of refraction as glass, but containing absorbing materials, the light which would otherwise be reflected is absorbed, and halation thereby prevented. For this purpose caramel containing burnt sienna or lamp black is commonly used. A backing which dries quickly and which does not come off in the developer consists of lamp black in alcoholic shellac. All the plates used in the sensitometric work of this Atlas were backed with the black shellac.

Halation occurs in the same way with films, but since the film support is thinner, the spreading is smaller. A film is difficult to back for the purpose of preventing halation.

Fog

The fog which occurs in development is one of the properties of a plate which is of importance to the user. It is well known that the density of chemical fog increases with the time of development, and accordingly with the increase of contrast. The latter is the most important factor in choosing a plate. Since the photographer must develop a plate to a certain contrast, what he wants to know is whether one plate fogs worse than another in being developed to a given contrast. For this reason chemical fog in this work is plotted against the contrast (gamma) and not against the time of development.

Part III Data

Explanation of Charts.

Density Exposure Curves (Fig. 1 of the charts)

The three characteristic curves represent developments of 3, 6 and 12 minutes in pyro developer of tray strength at 20°C, rate of stirring, 40 R.P.M. Each curve is the graphical mean of the density measurements of three test strips. The usual exposure time was 16 seconds (the squares received respectively 8, 4, 2, 1, 1/2, 1/4, 1/8, 1/16 and 1/32 seconds) and the intensity on the light at the test strip was one candle meter. In case the 16 second exposure did not include all of the toe and shoulder of the curve, shorter or longer exposures were made.

Contrast-Development Curve (Fig.2 of the charts)

The values of gamma were obtained from Fig.1 and plotted against time of development. From this curve may be obtained the time required to reach a given contrast, for example, in chart 1, 8 3/4 minutes development would be required to give unit contrast ($\gamma = 1$) under the conditions of development employed in making this test. With different developers, or the same developer and a different time of development would be required for a given contrast. Some idea of the contrast which it is possible to obtain with a given plate may be found from this curve since 12 minutes development with tray strength developer marks the time limit of practical development.

Fog-Contrast Curve (Fig.3 of charts)

In this diagram are plotted the values of the fog (exclusive of glass and gelatine) for the various contrasts which the plate reached in development. Plates may thus be compared for freedom from fog at a desired contrast.

Spectrogram (Figure 4 of charts)

In comparing the color sensitiveness of different plates by means of their spectrograms it must be remembered that the ratio of blue sensitiveness to yellow or red sensitiveness for a given plate must be made the basis of comparison. For example, the yellow "hump" of one plate must not be compared directly with the magnitude of the yellow hump of another plate.

Filter Factors

The filters referred to by letter are Wratten filters. Those referred to by name are Cramer filters. In some cases where the value of the filter factor is greater than 30, it has been omitted.

Emulsion Number

The emulsion number refers to the particular batch of plates which was used to obtain the data given on the charts.

Speed

The number gives the Bureau of Standards speed which is defined as 10/i. The speed given is calculated from the average of the inertias of the three development times. The intensity and color of the light used in these measurements is different from that of other observers and accordingly B.S. speed numbers cannot be converted into H.& D. numbers, particularly in the case of color sensitive plates.

Scale

The scale was measured on the straight line portion of the characteristic curve from the toe to the shoulder.

Resolution Number

The resolution number represents the smallest distance from center to center of the lines on the negative which was resolved. The numbers correspond to distances in millimeters and in inches approximately as follows:

12	0.012 mm	0.00047 in.
14	0.014	0.00055
16	0.016	0.00063
18	0.018	0.00071
20	0.020	0.00079
22	0.022	0.00087
24	0.024	0.00094
26	0.026	0.00102
28	0.028	0.00110
30	0.030	0.00118

Developer Formula

The letter indicates one of the four formulas. These formulas are those recommended by the maker for most of his plates.

Developer Formula W

A	Water	1000 cc	
	Sodium Bisulphite	10.2 g	
	Pyro	60 g	
B	Water	1000 cc	
	Sodium Sulphite (dry)	120 g	Test 60
C	Water	1000 cc	
	Sodium Carbonate (dry)	60 g	Test 30

To develop take one part each of A, B and C and seven parts of water.

Developer Formula X

A	Water	1000 cc	
	Potassium Metabisulphite	12 g	
	Pyro	60 g	
B	Water	1000 cc	
	Sodium Sulphite (dry)	90 g	Test 55
C	Water	1000 cc	
	Sodium Carbonate (dry)	75 g	Test 40

To develop take one part each of A, B and C and seven parts of water.

Developer Formula Y

A	Water	1000 cc	
	Oxalic acid	1.4 g	
	Pyro	40 g	
B	Water	1000 cc	
	Sodium Sulphite (dry)	135 g	Test 80
C	Water	1000 cc	
	Sodium Carbonate (dry)	75 g	Test 40

To develop take one part each of A, B and C and twelve parts of water.

Developer Formula Z

A	Water	1000 cc	
	Potassium Metabisulphite	7.8 g	
	Pyro	60 g	
B	Water	1000 cc	
	Sodium Sulphite	105 g	Test 50
C	Water	1000 cc	
	Sodium Carbonate	120 g	Test 40

To develop take one part of A, B and C and seven parts of water.

INDEX TO CHARTS

		Chart No.
Eastman	Seed's 30	50
"	Seed's 26X	51
"	Seed's 23	52
"	Seed's L-Ortho	53
"	Seed's L-Ortho N.H.	54
"	Seed's Panchromatic	55
"	Seed's Process	56
"	Seed's Lantern Slide	57
"	Standard Extra Imperial	58
"	Standard Post Card	59
"	Standard Orthonon	60
"	Standard Polychrome	61
"	Standard Lantern Slide	62
"	Standard Slow Lantern Slide	63
"	Stanley 50	64
"	Stanley Commercial	65
"	Wratten Panchromatic	67
"	Wratten M	68
"	Wratten Process Panchromatic	69
HAMMER		
Special Extra		71
Hammer	Postal	72
"	Extra Fast	73
"	Aurora	74
"	Slow	75
"	Ortho N.H.	76
"	Ortho Extra Fast	77
"	Ortho Special N.H.	78
"	Ortho Commercial	79
"	Ortho Slow	80
"	Lantern Slide	81
"	Transparency	82
PROGRESSIVE		
Progressive	Studio No. 1	83
"	Ortho No. 1	84
"	Ortho No. 2	85
"	Panchromatic No. 1 Yellow Em.	86
"	Panchromatic No. 2 Red Em.	87
"	Panchromatic No. 3 Blue Em.	88

BURKE & JAMES
REXO RECORD FILM

EMULSION No. 060-0351

DEVELOPER FORMULA. X

COLOR SENSITIVITY

FIGURE 4

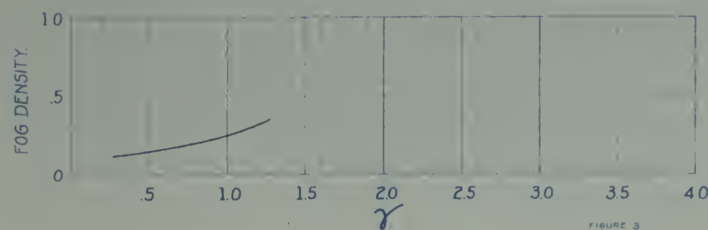


FIGURE 3

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
3.7	13.0	22.3					

SPEED B.S. 240

SCALE 10

RESOLUTION NUMBER 20

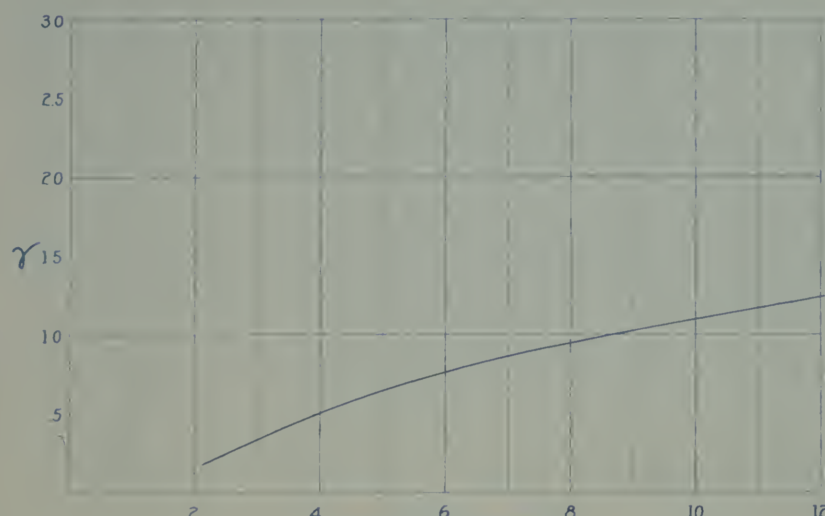


FIGURE 2

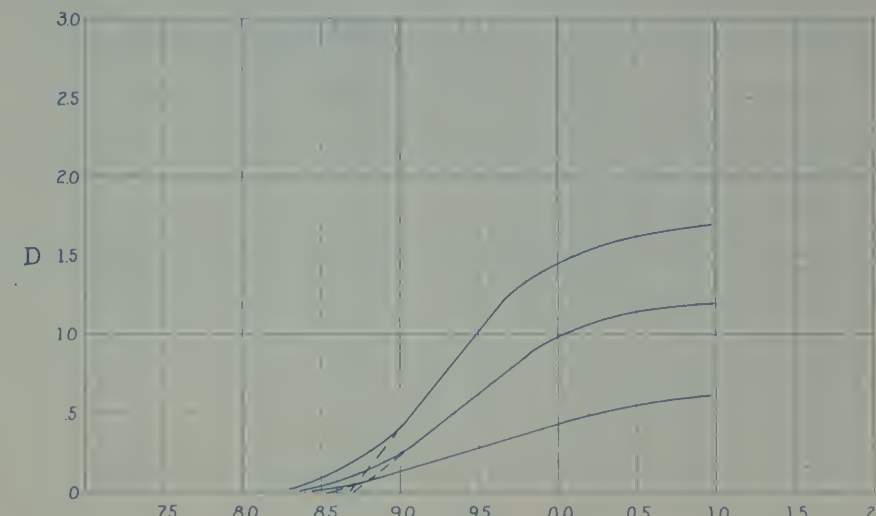


FIGURE 1

PHOTOGRAPHIC LABORATORY

CENTRAL SPECIAL

COLOR SENSITIVITY

FIGURE 4

EMULSION No. 8307

DEVELOPER FORMULA. Z

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 230

SCALE 100

RESOLUTION NUMBER 23

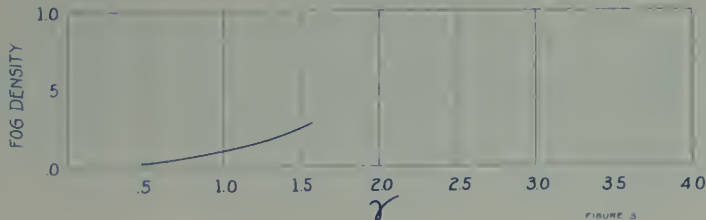


FIGURE 3

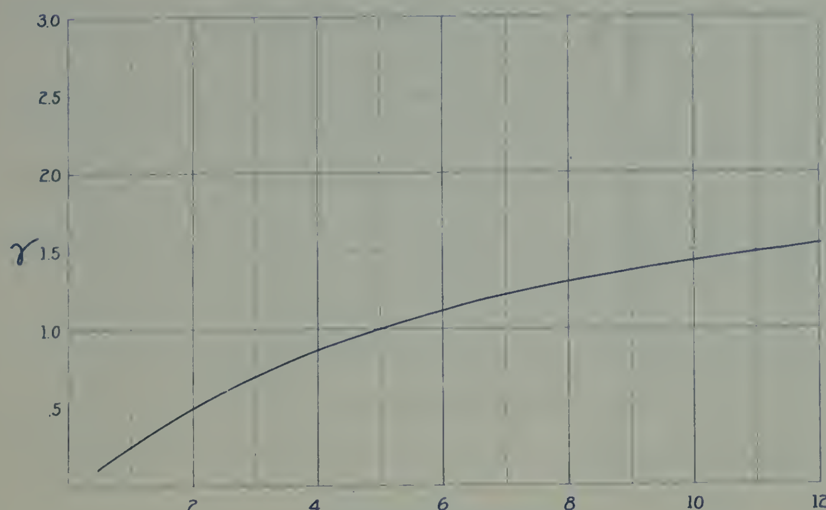


FIGURE 2

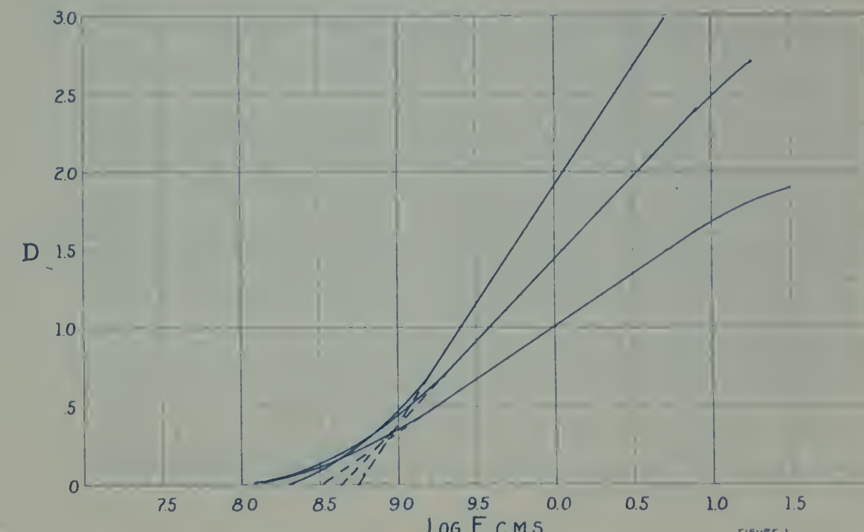
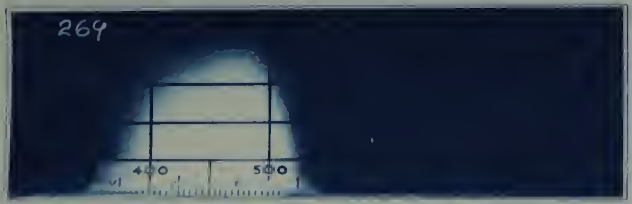


FIGURE 1

CENTRAL
SPECIAL N.H.



COLOR SENSITIVITY.

FIGURE 4

EMULSION No. 8262

DEVELOPER FORMULA. Z

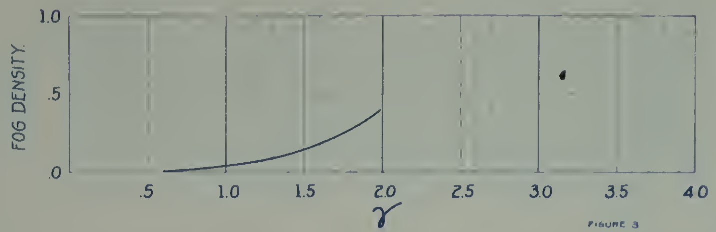


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 155

SCALE 80

RESOLUTION NUMBER 20

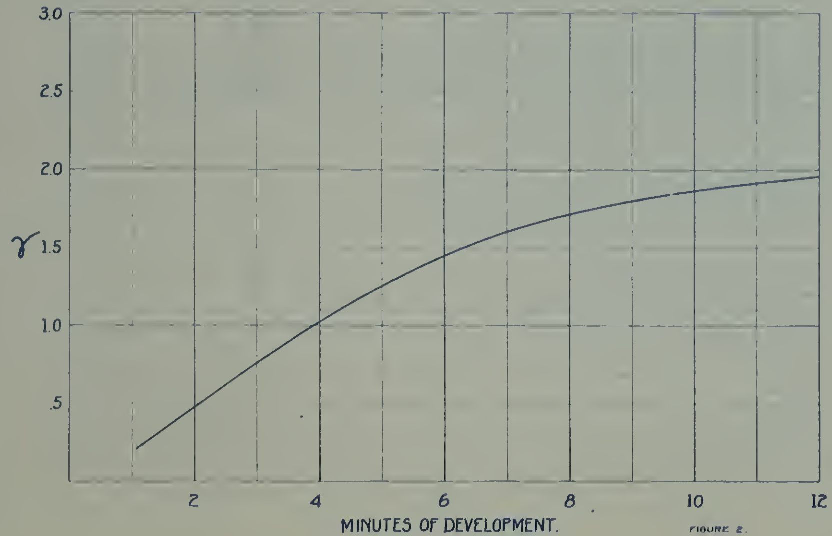


FIGURE 2.

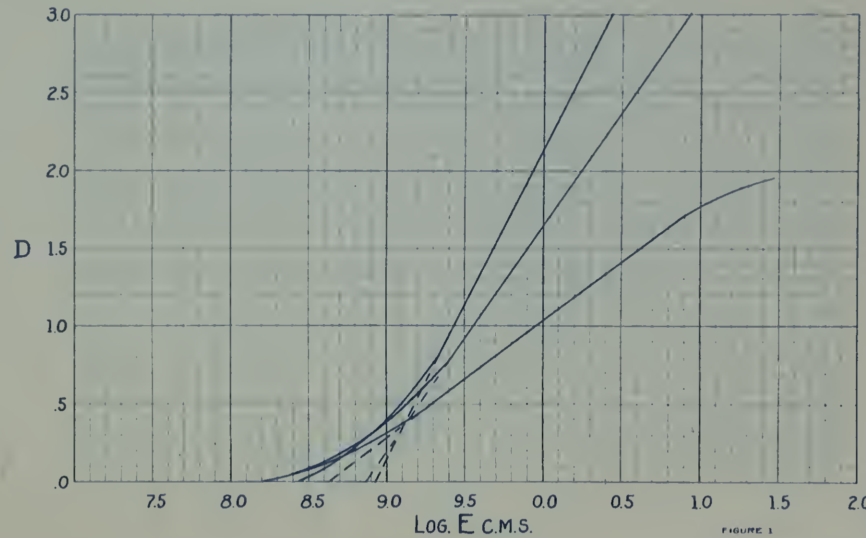


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

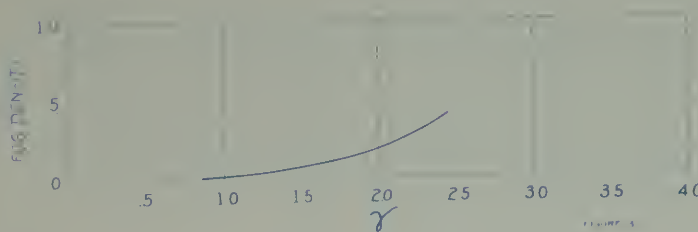
3

CENTRAL COMET

EMULSION No 8274

DEVELOPER FORMULA. Z

COLOR SENSITIVITY



FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 145

SCALE 90

RESOLUTION NUMBER 20

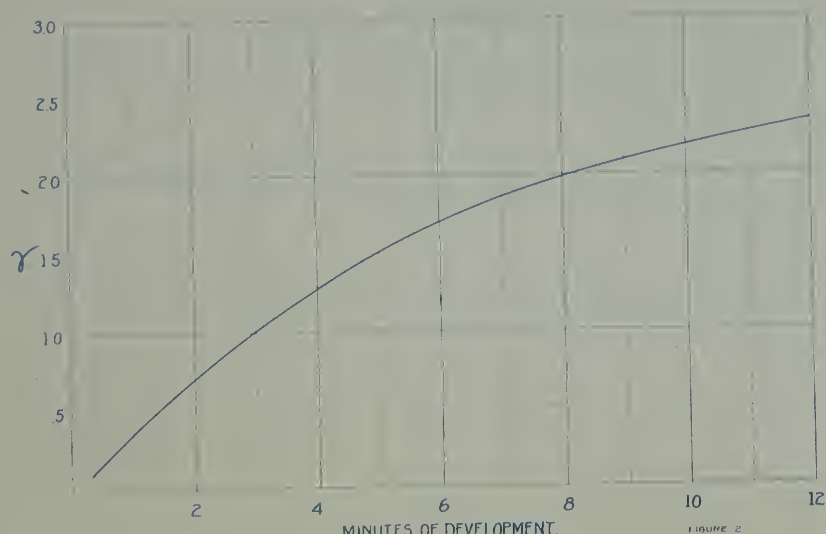


FIGURE 2

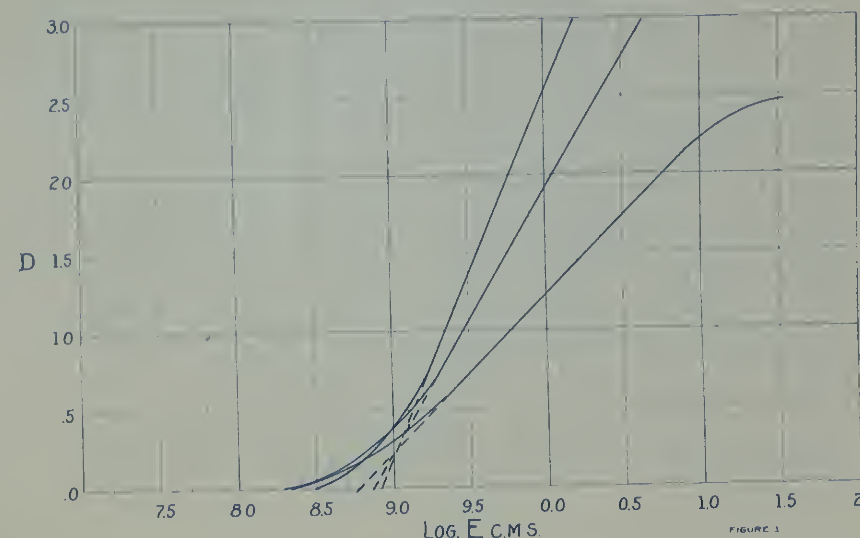


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

CENTRAL SPECIAL XX

COLOR SENSITIVITY

EMULSION No 8321

DEVELOPER FORMULA. Z

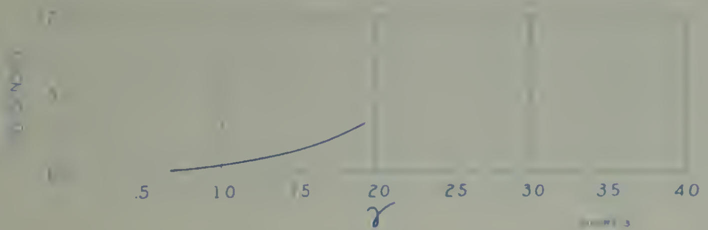
FILTER FACTORS

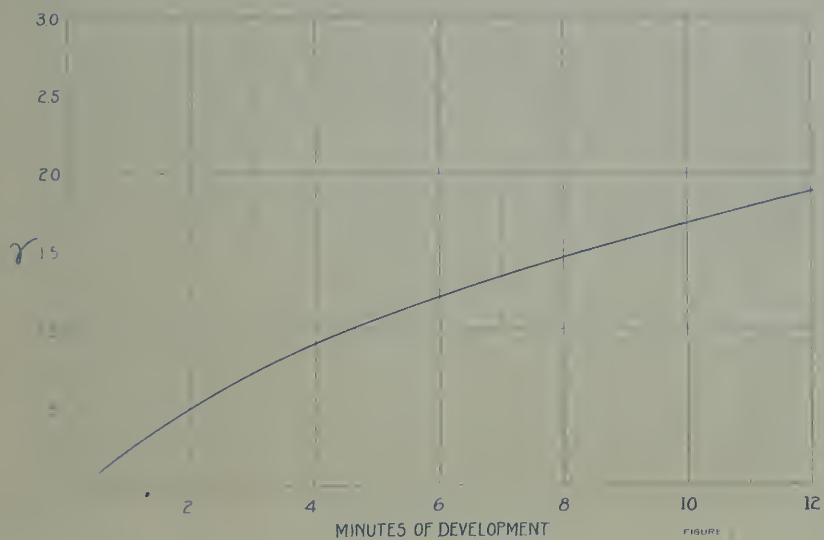
K_1	K_2	K_3	G	A	B	C	F
3.0	9.2	12 8	28 9				

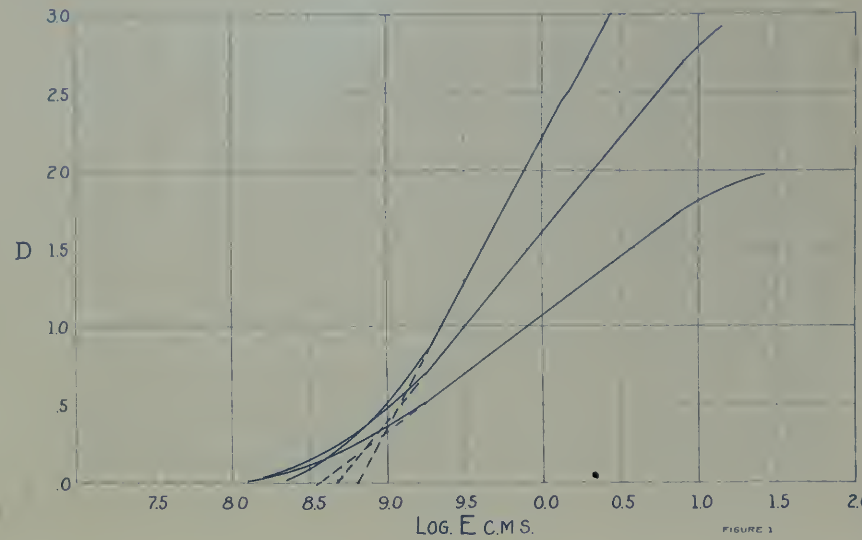
SPEED B.S 210

SCALE 100

RESOLUTION NUMBER 20







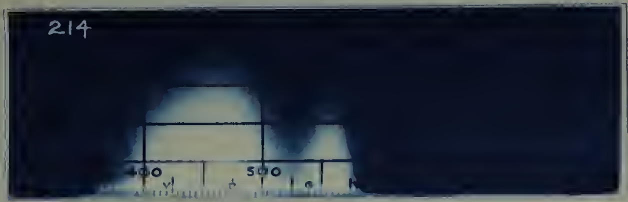
PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS

5

CENTRAL COLORNON

EMULSION No 8267

DEVELOPER FORMULA. Z



COLOR SENSITIVITY

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.5	6.4	9.3	15.0				

SPEED B.S. 215

SCALE 100

RESOLUTION NUMBER 22

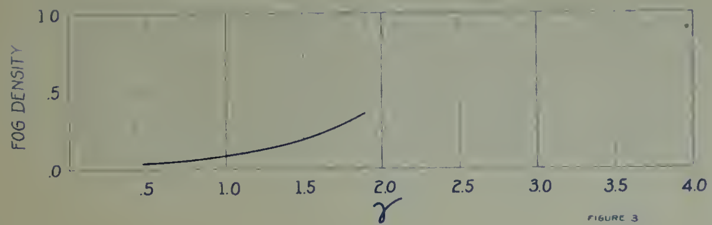


FIGURE 3

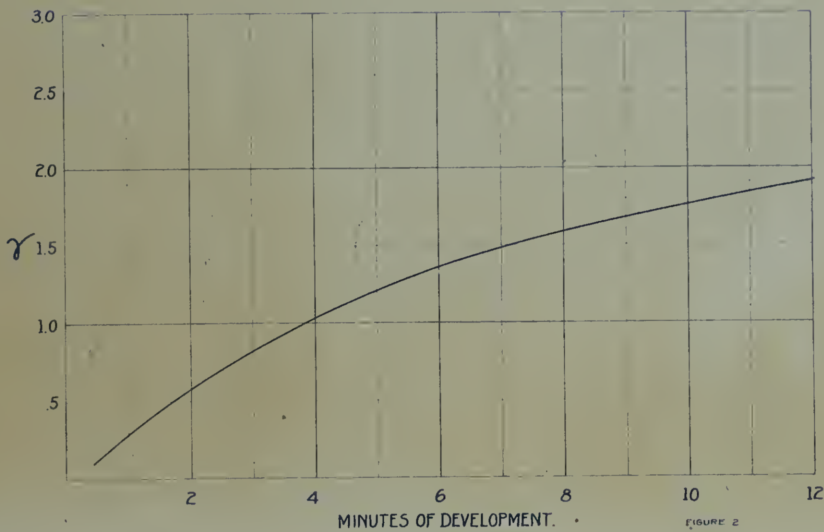


FIGURE 2

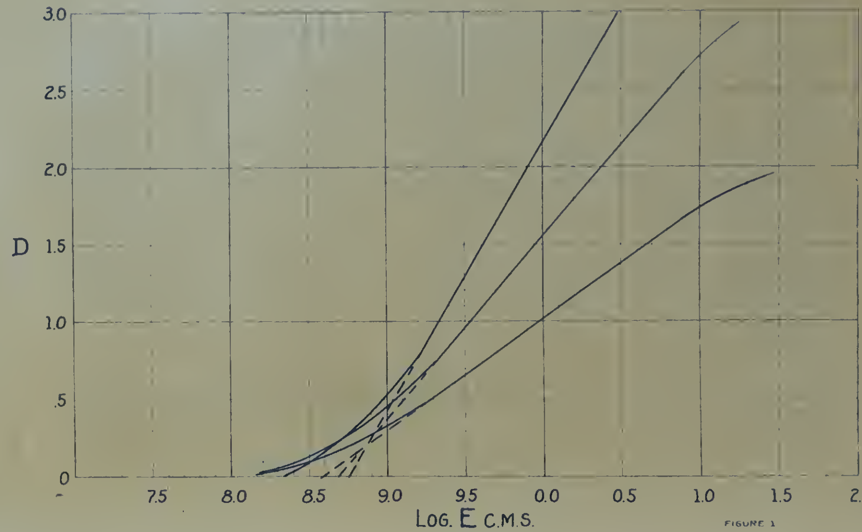


FIGURE 1

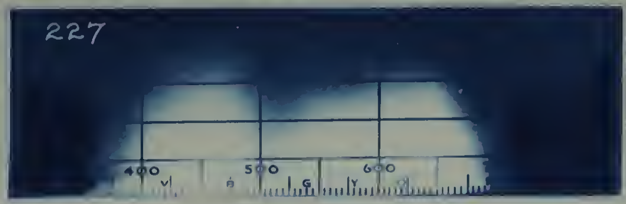
PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

6

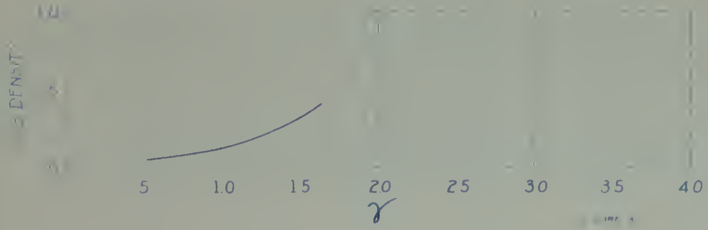
CENTRAL
PAN-ORTHO

EMULSION No. 8247

DEVELOPER FORMULA. Z



COLOR SENSITIVITY



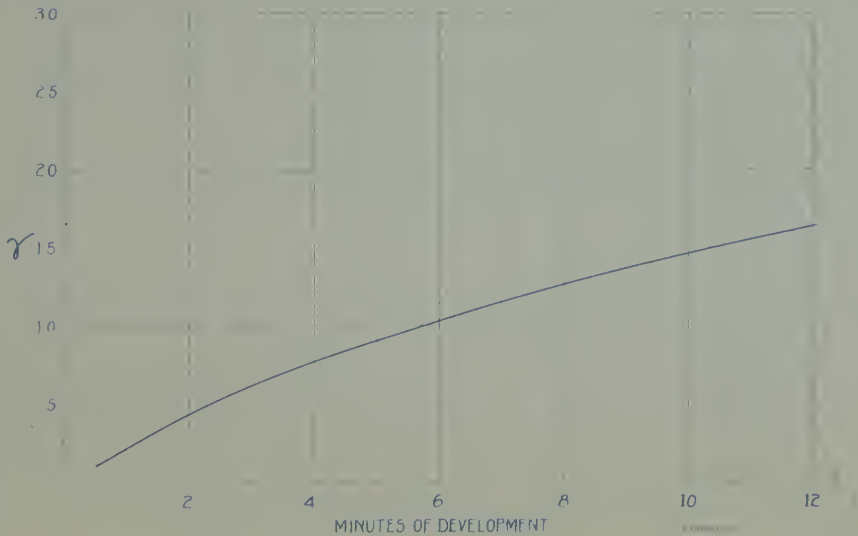
FILTER FACTORS

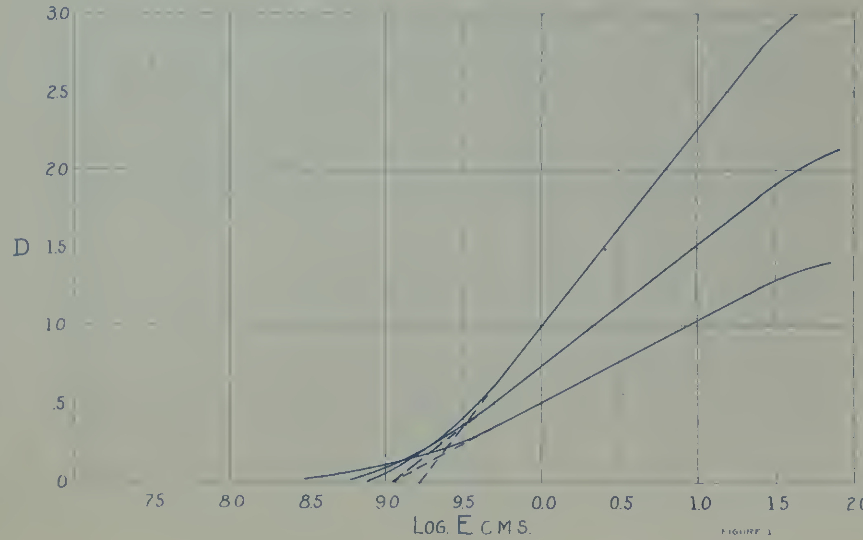
K_1	K_2	K_3	G	A	B	C	· F
2.4	3.7	4.4	5.8	11.1	13.8	14.6	18.4

SPEED B.S. 80

SCALE 100

RESOLUTION NUMBER 20





PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS

7

CENTRAL
PAN-ORTHO D.C.

EMULSION No. 8247

DEVELOPER FORMULA. Z

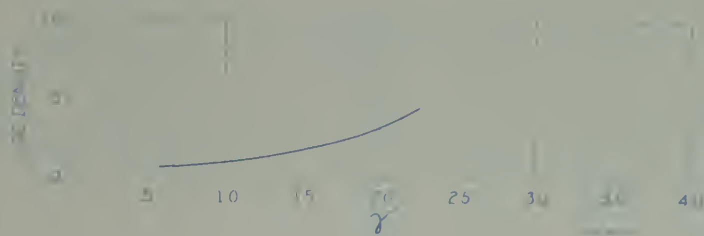
FILTER FACTORS

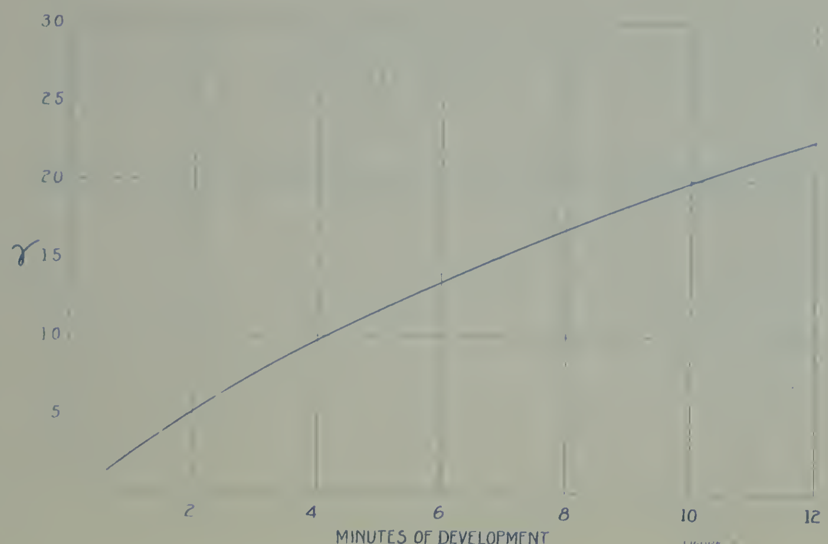
K_1	K_2	K_3	G	A	B	C	F
2.2	3.6	42	4.7	10.4	11.9	12.1	14.0

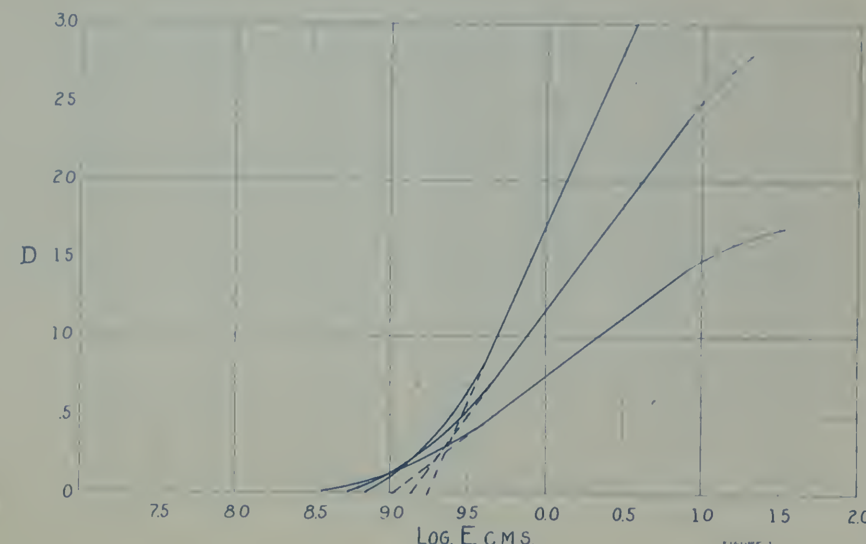
SPEED BS 75

SCALE 50

RESOLUTION NUMBER 20







8

COLOR SENSITIVITY

CENTRAL TRANSPARENCY

EMULSION No 8243

DEVELOPER FORMULA. Z

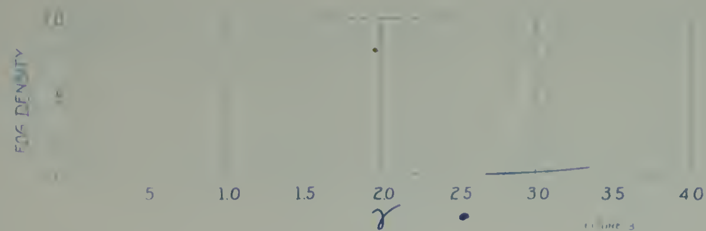


FIGURE 3

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F

SPEED BS 32

SCALE 7

RESOLUTION NUMBER 12

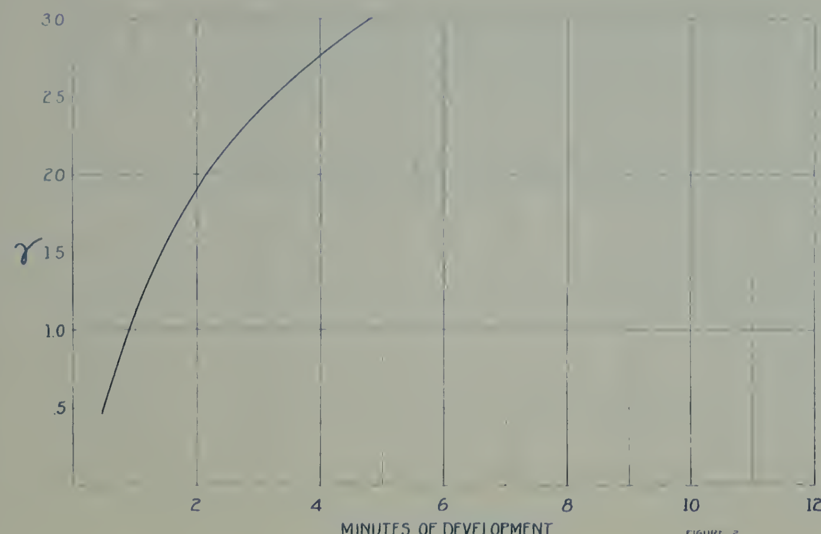


FIGURE 2

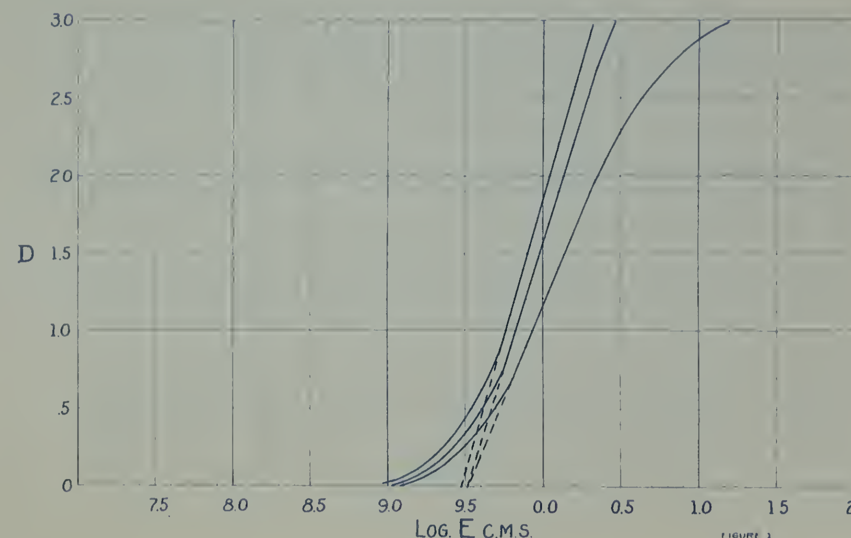


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

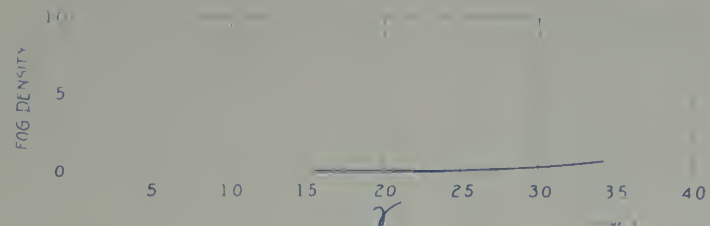
(9)

CENTRAL
CONTRAST LANTERN SLIDE

EMULSION No 8295

DEVELOPER FORMULA. Z

COLOR SENSITIVITY



FILTER FACTORS

K1	K2	K3	G	A	B	C	F

SPEED BS 33

SCALE 10

RESOLUTION NUMBER 12

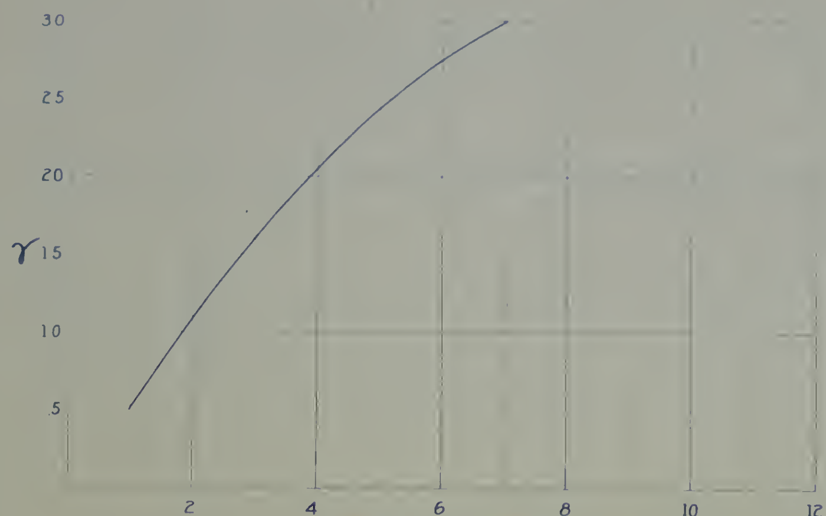


FIGURE 2

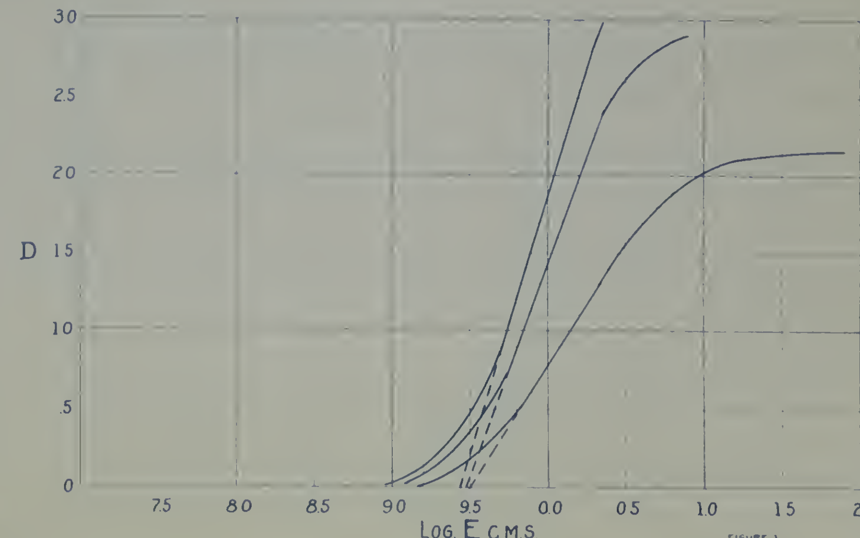
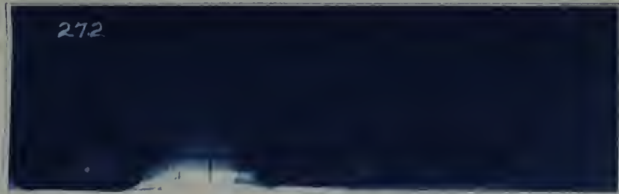


FIGURE 1

PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS

CENTRAL PROCESS



COLOR SENSITIVITY. FIGURE 4

EMULSION No. 8294

DEVELOPER FORMULA. Z

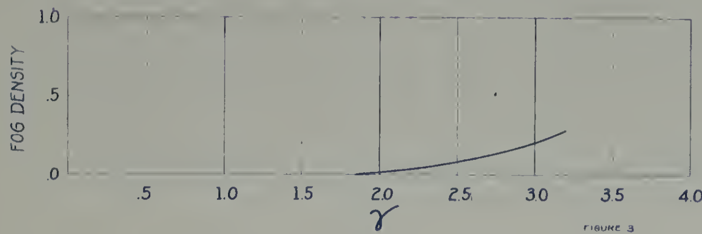


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 7

SCALE 5

RESOLUTION NUMBER 18

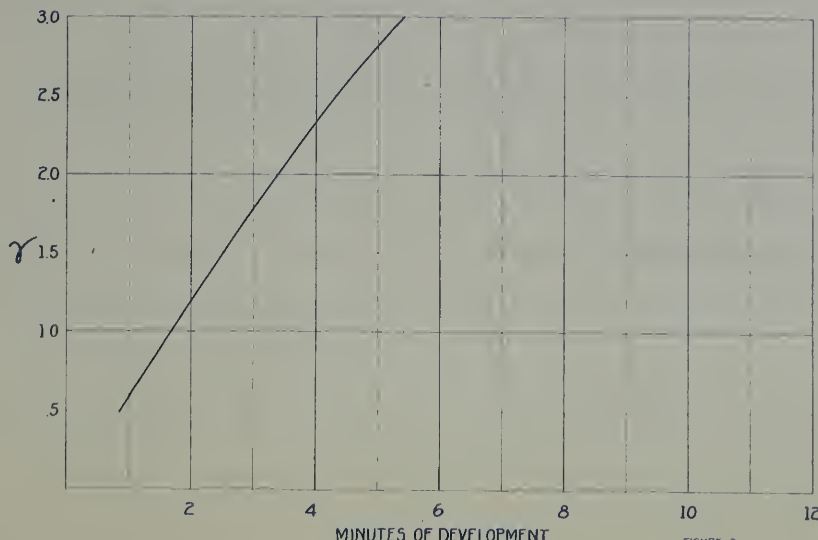


FIGURE 2

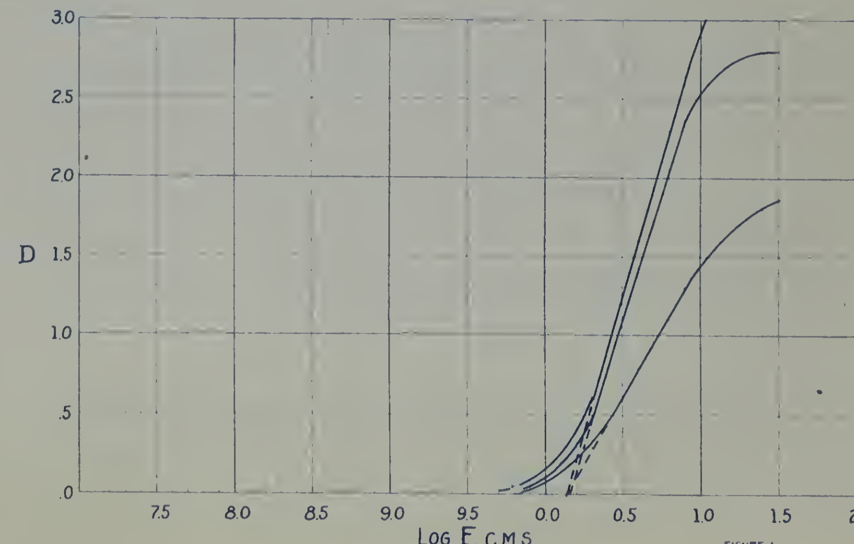


FIGURE 1

COLOR SENSITIVITY. FIGURE 4

CENTRAL
SEPATONE TRANSPARENCY

EMULSION No. 3811

DEVELOPER FORMULA. Z

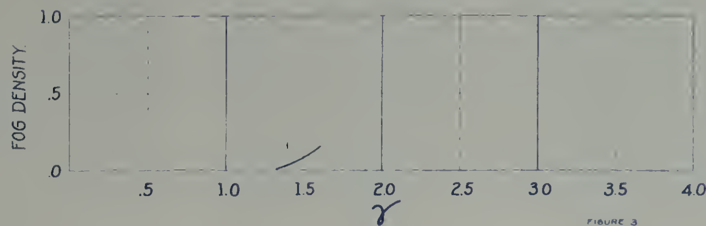


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. $3\frac{1}{2}$

SCALE 40

RESOLUTION NUMBER 15

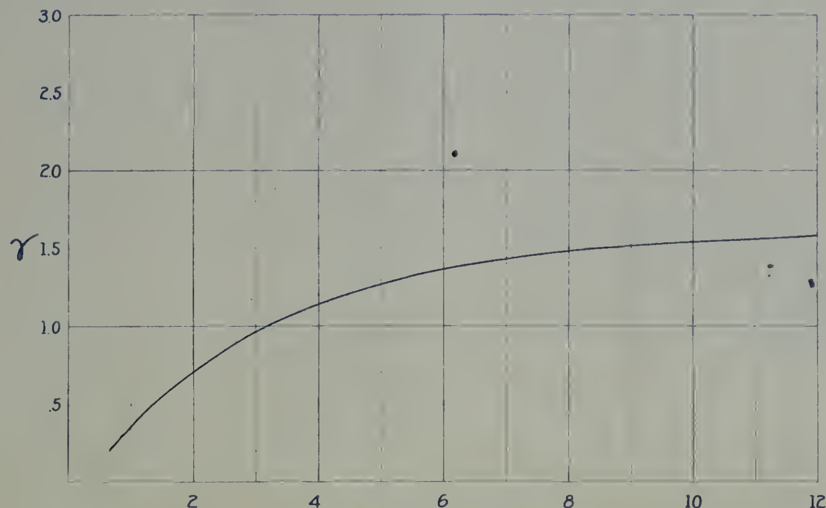


FIGURE 2

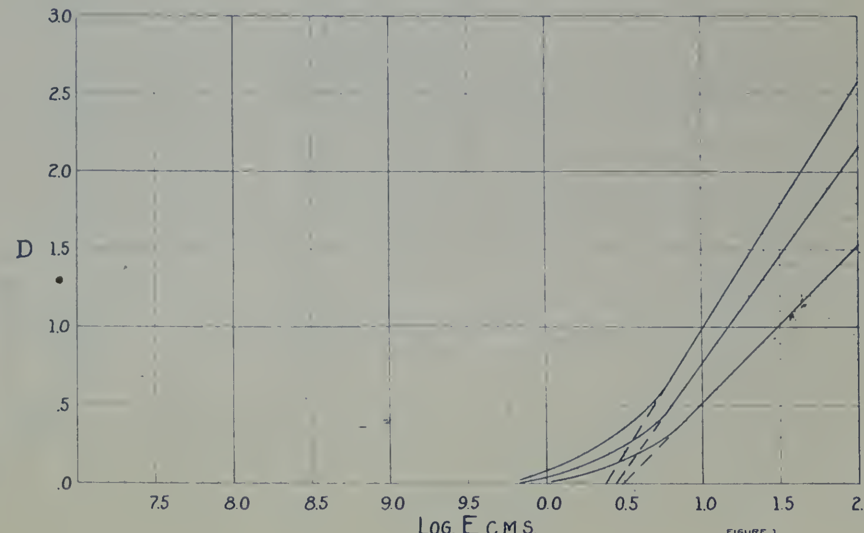
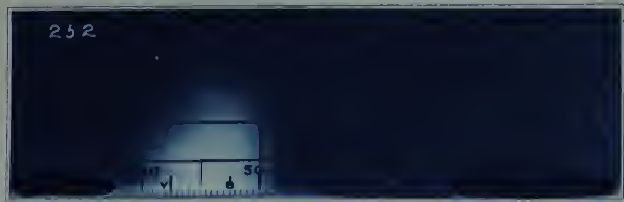


FIGURE 1

CRAMER
HI-SPEED



COLOR SENSITIVITY. FIGURE 4

EMULSION No. 23525

DEVELOPER FORMULA. W

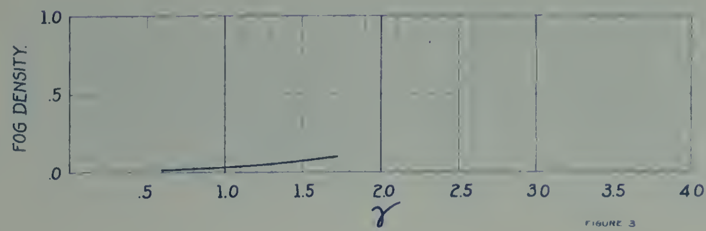


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 1050

SCALE

RESOLUTION NUMBER 28

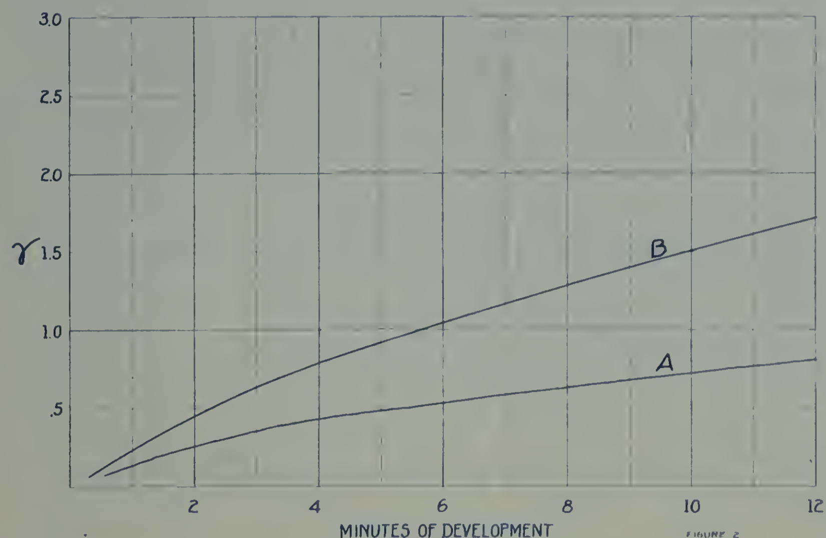


FIGURE 2

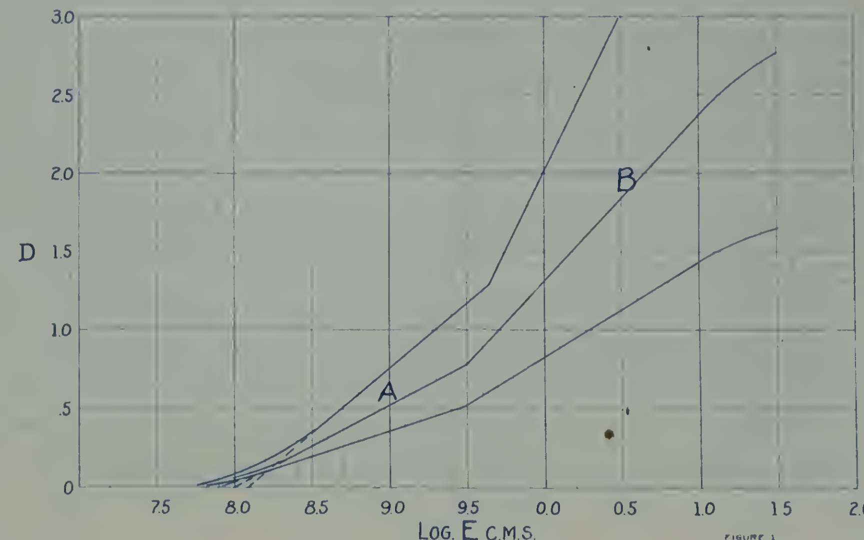


FIGURE 1

CRAMER
CROWN D.C.

COLOR SENSITIVITY

FIGURE 4

EMULSION No. 23451

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F

SPEED B S 650

SCALE

RESOLUTION NUMBER 25

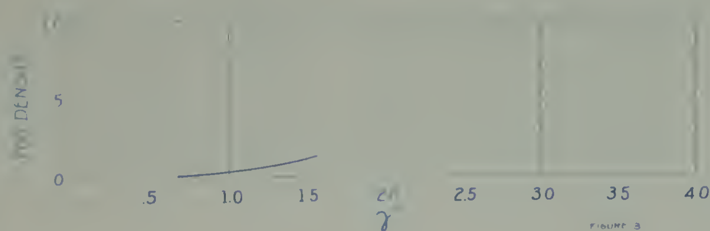


FIGURE 3

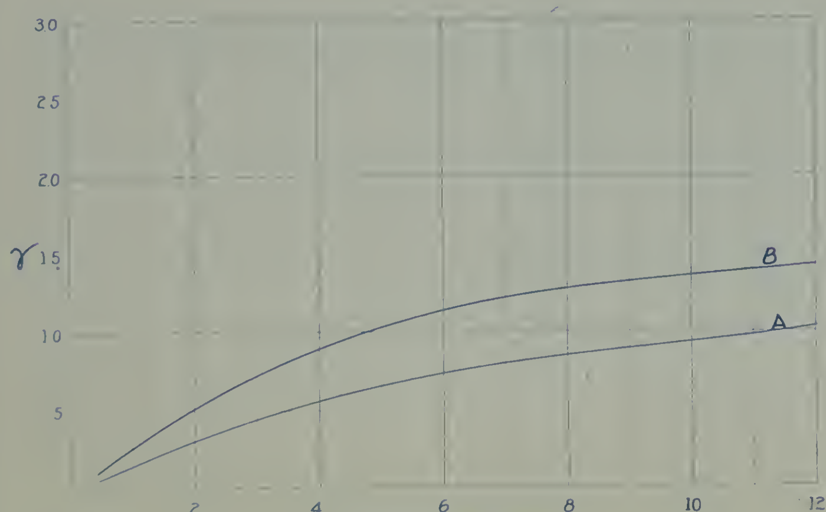


FIGURE 2

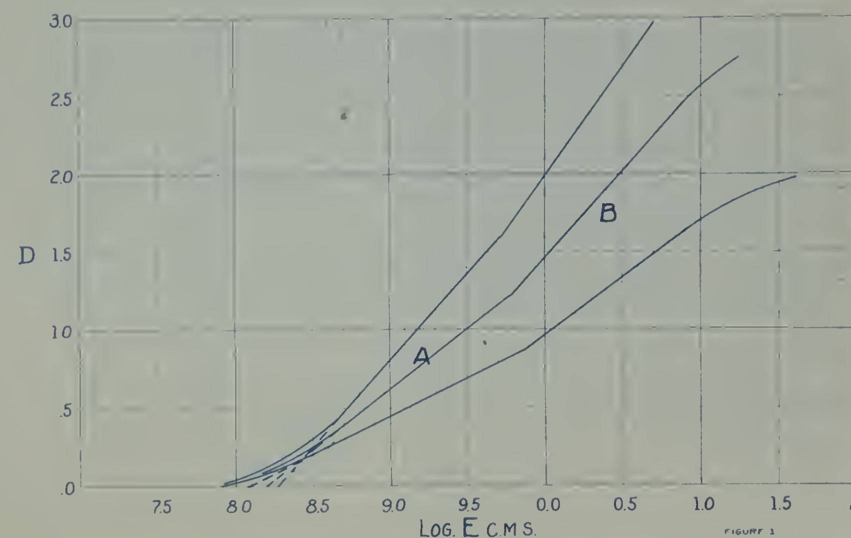
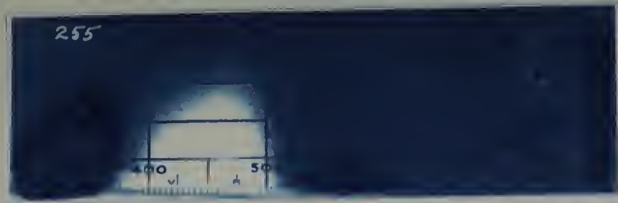


FIGURE 1

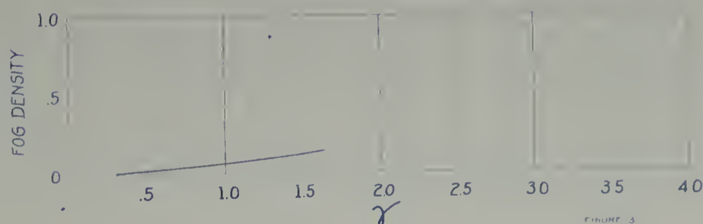
CRAMER
CROWN

EMULSION No. 23517

DEVELOPER FORMULA. W



COLOR SENSITIVITY



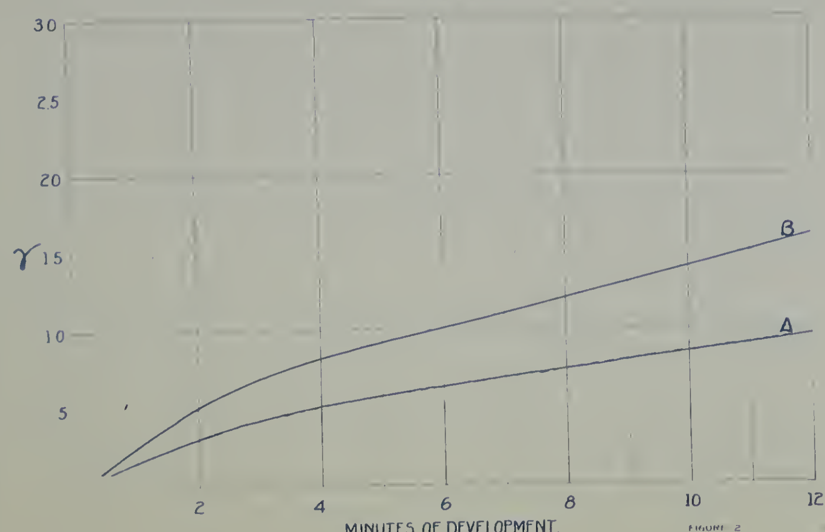
FILTER FACTORS

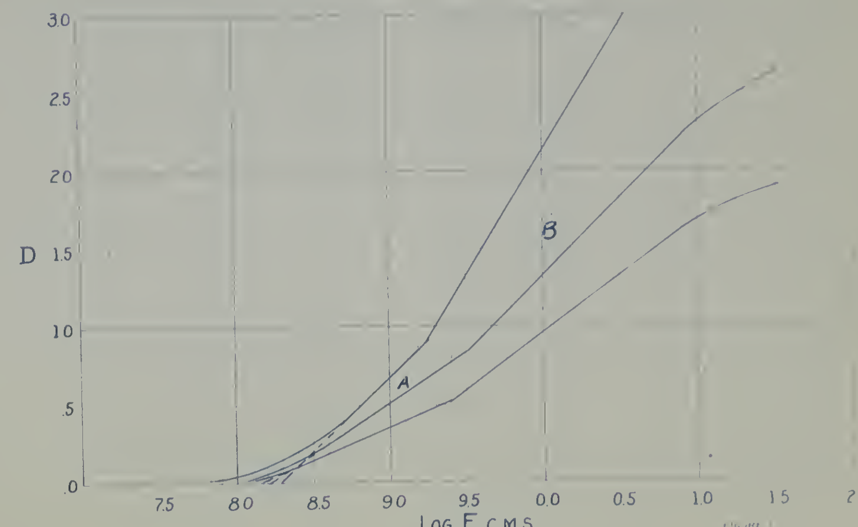
K_1	K_2	K_3	G	A	B	C	F

SPEED B S 60

SCALE

RESOLUTION NUMBER 24





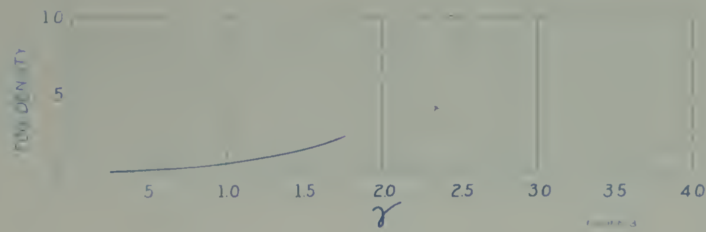
PHOTOGRAPHIC LABORATORY

CRAMER COMMERCIAL

EMULSION No 23318

DEVELOPER FORMULA. W

COLOR SENSITIVITY



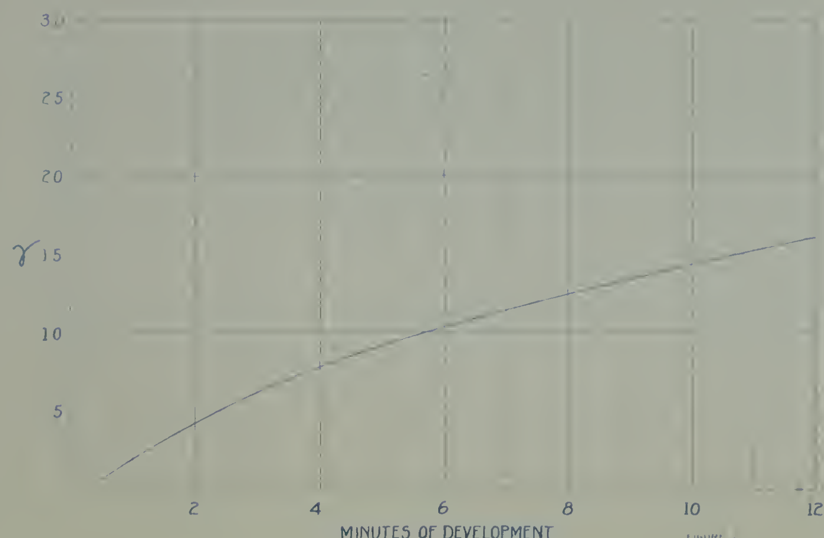
FILTER FACTORS.

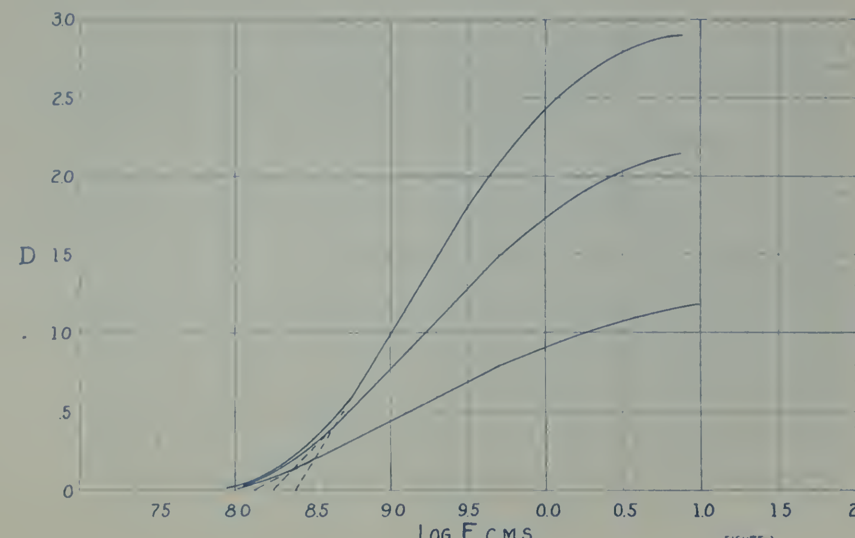
K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 550

SCALE 20

RESOLUTION NUMBER 19

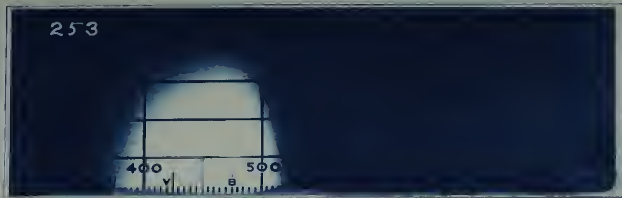




CRAMER ANCHOR

EMULSION No. 23512

DEVELOPER FORMULA. W



COLOR SENSITIVITY. FIGURE 4.

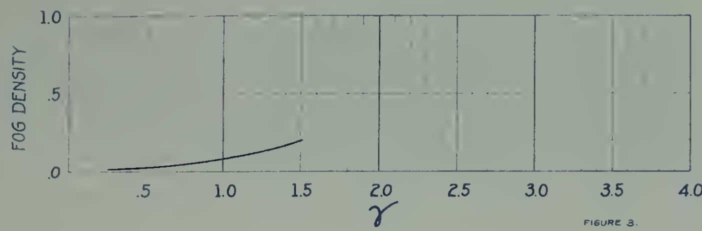


FIGURE 3.

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 520

SCALE 20

RESOLUTION NUMBER 22

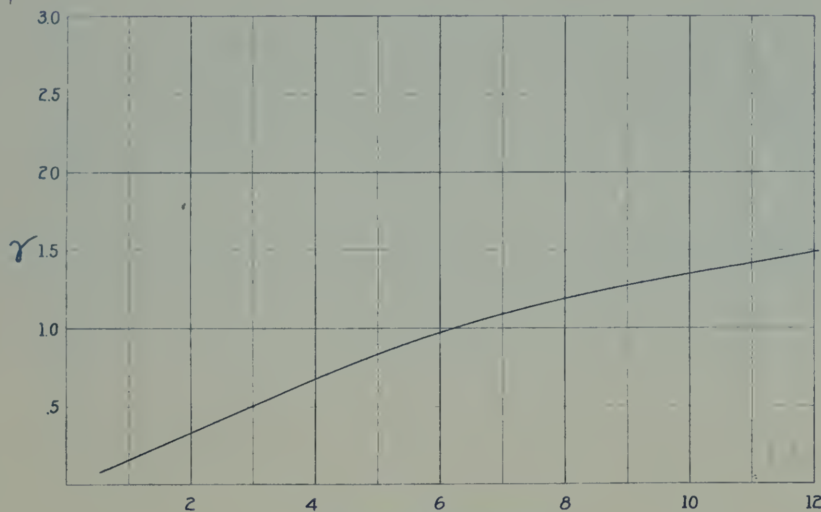


FIGURE 2

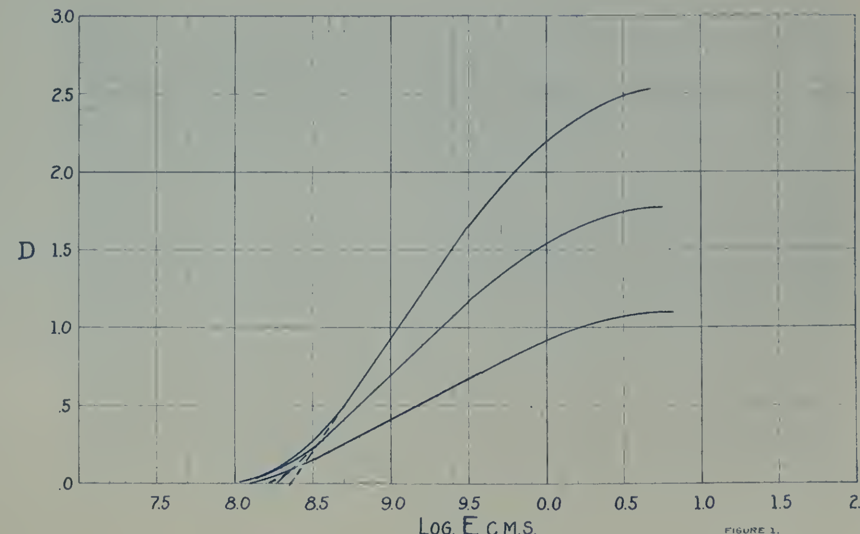


FIGURE 1.

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

CRAMER POSTAL

EMULSION No. 1458

DEVELOPER FORMULA. W

COLOR SENSITIVITY

FIGURE 4

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S 520

SCALE 18

RESOLUTION NUMBER 22

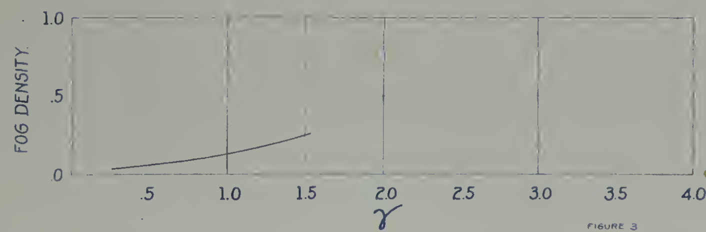


FIGURE 3

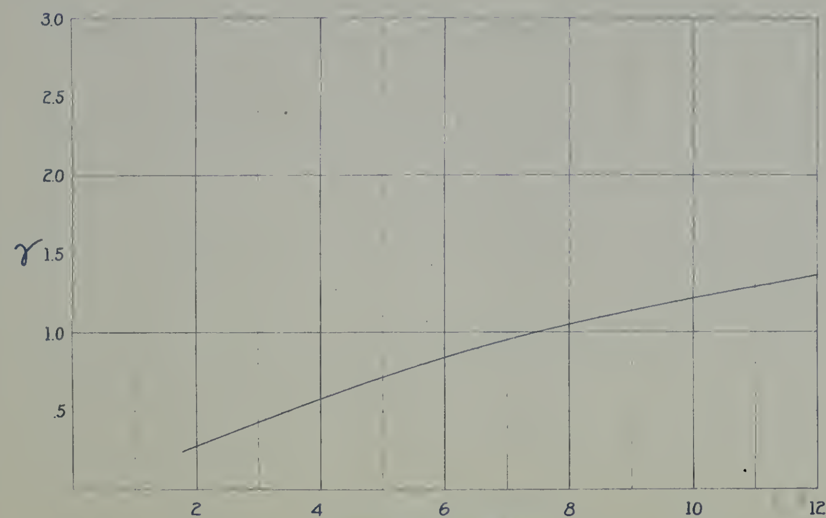


FIGURE 2

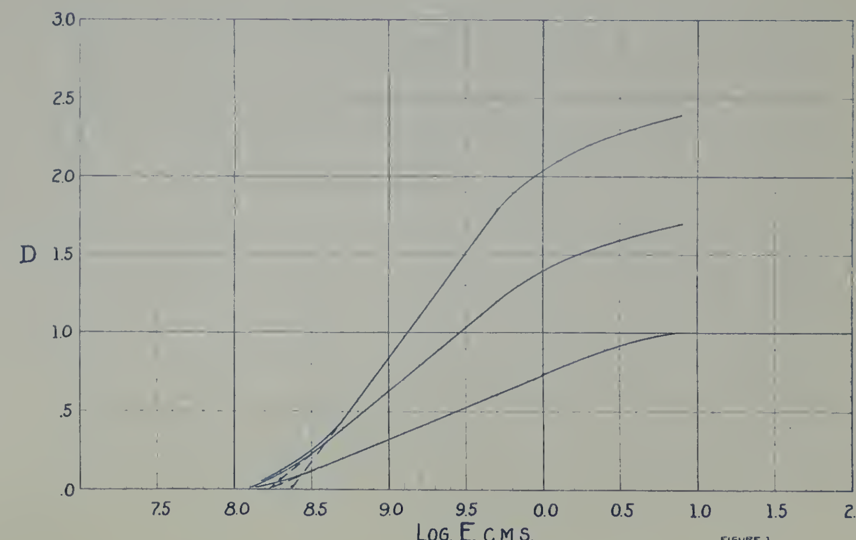
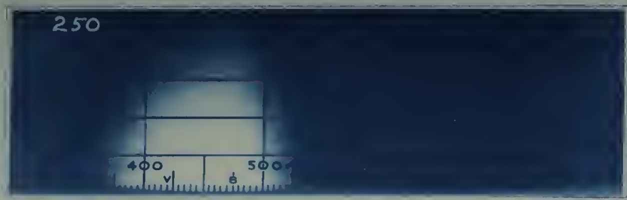


FIGURE 1

CRAMER
BANNER X D.C.



COLOR SENSITIVITY. FIGURE 4

EMULSION No. 23452

DEVELOPER FORMULA. W

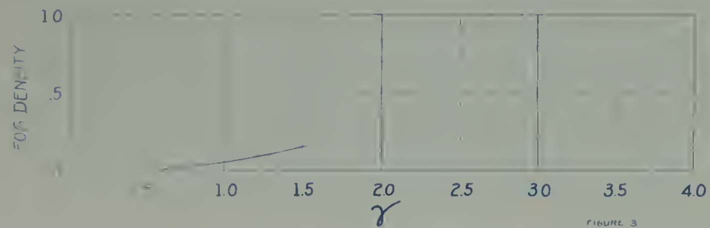


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S 350

SCALE 150

RESOLUTION NUMBER 24

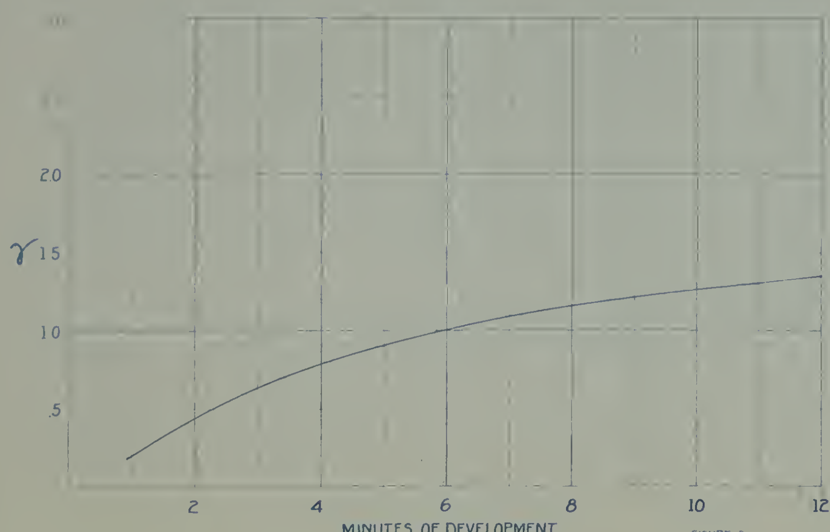


FIGURE 2

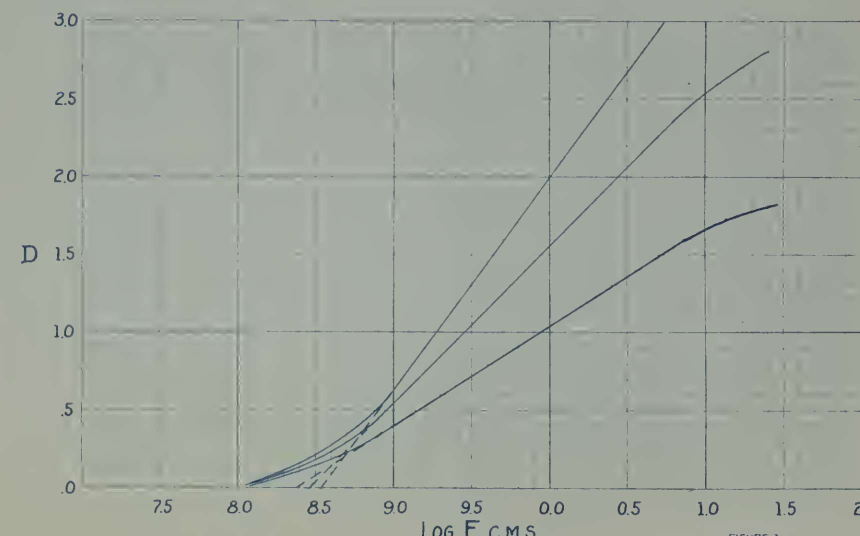
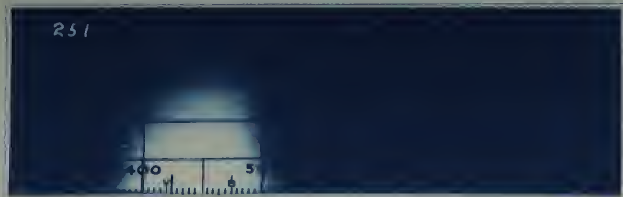


FIGURE 1

CRAMER
BANNER X



COLOR SENSITIVITY. FIGURE 4

EMULSION No. 23514

DEVELOPER FORMULA. W

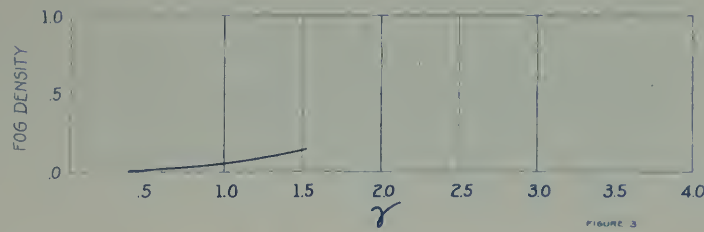


FIGURE 3

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F

SPEED BS 275

SCALE 100

RESOLUTION NUMBER 21

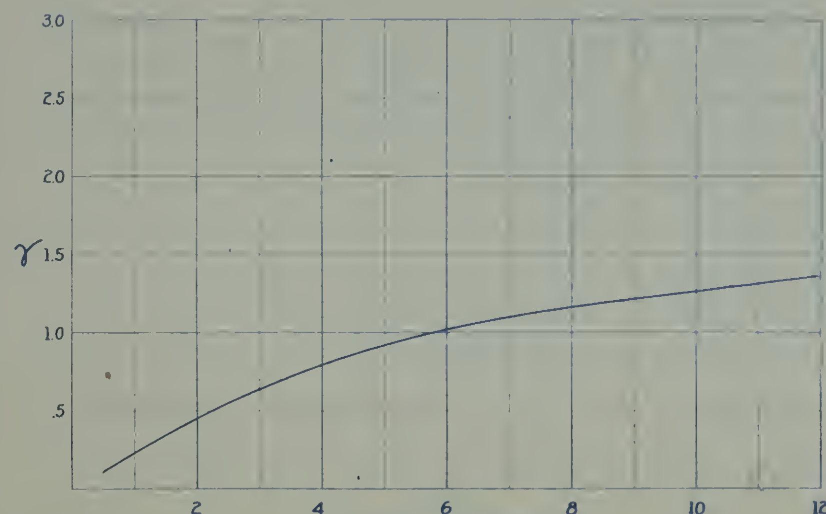


FIGURE 2

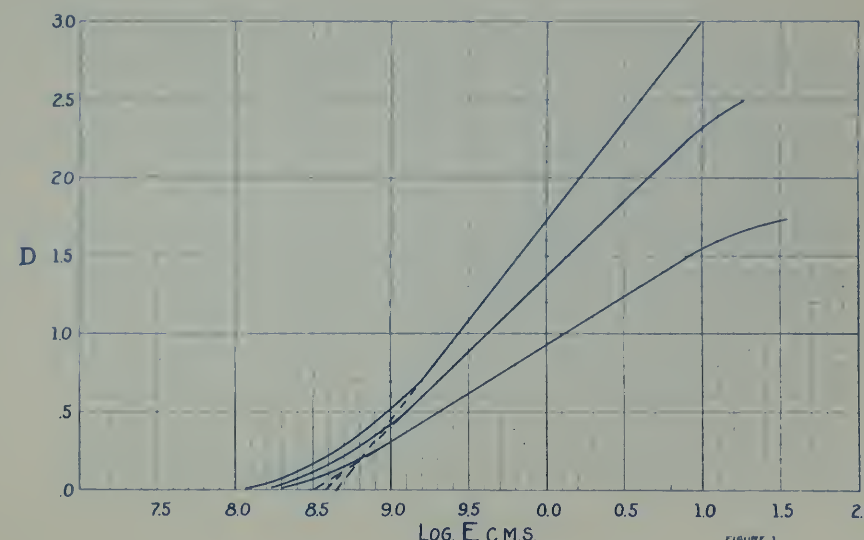
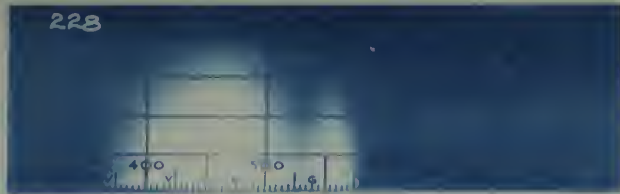


FIGURE 1.

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS



COLOR SENSITIVITY

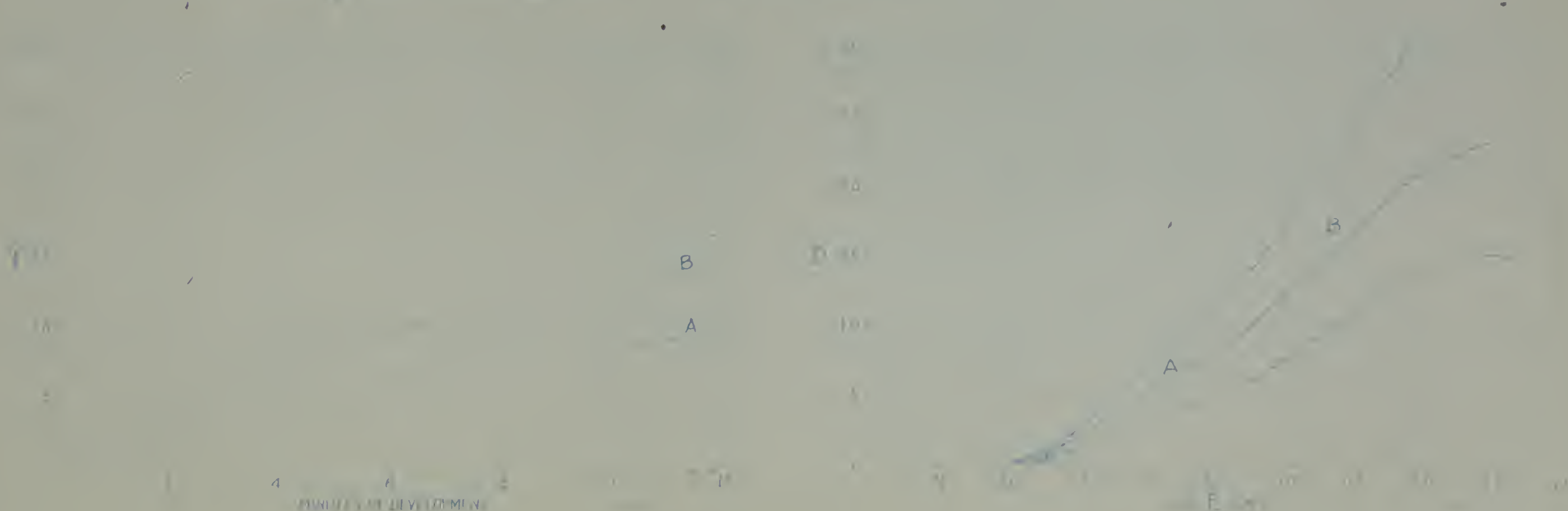
CRAMER
SPEED-O-KROME

EMULSION No. 2351 W

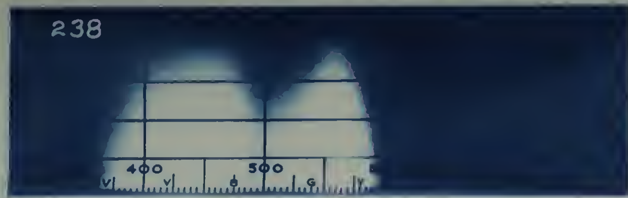
31 71 91 19.9 600

28

3.5 4.6 7.6



CRAMER
ISO INST. D.C.



COLOR SENSITIVITY

EMULSION No. 10146

DEVELOPER FORMULA W

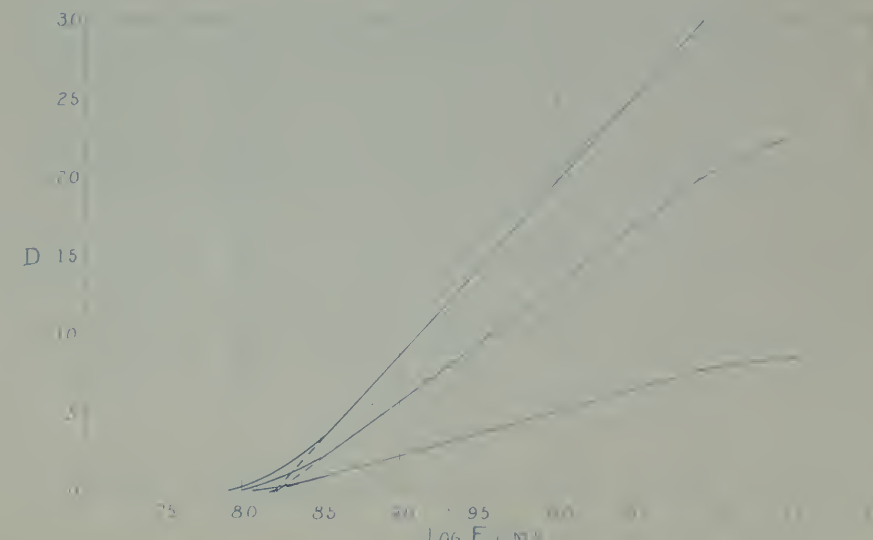
2.8	4.7	5.7	6.4

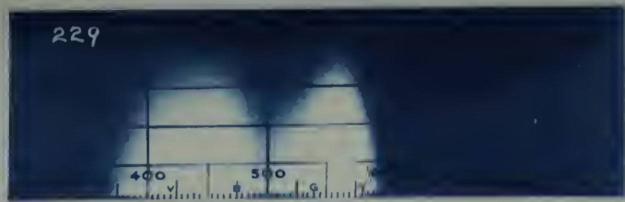
o. 0

300

RESOLUTION NUMBER 28

2.2	3.2	3.6	12.1



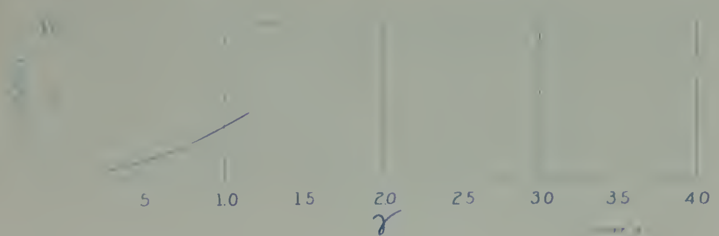


COLOR SENSITIVITY

CRAMER
PORTRAIT ISONON

EMULSION No. 10177

DEVELOPER FORMULA W

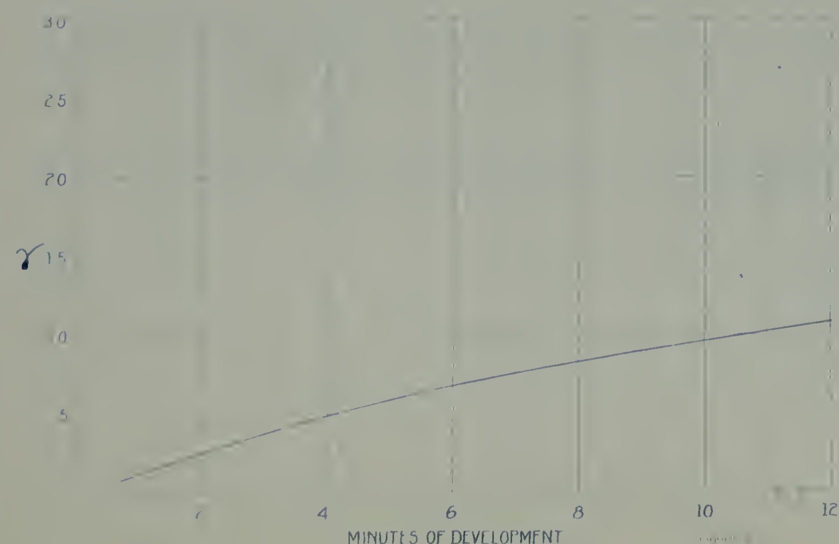


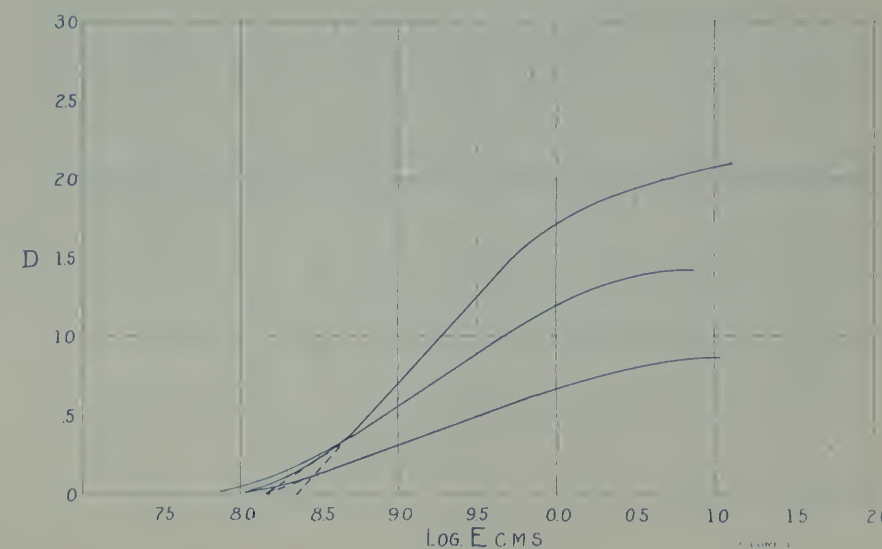
2.4	3.9	4.2	4.7
2.6	3.8	4.1	12.5

SPEED B.S 560

SCALE 30

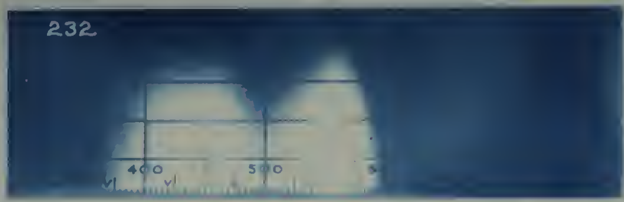
RESOLUTION NUMBER 24





(23)

CRAMER
ISO INST.



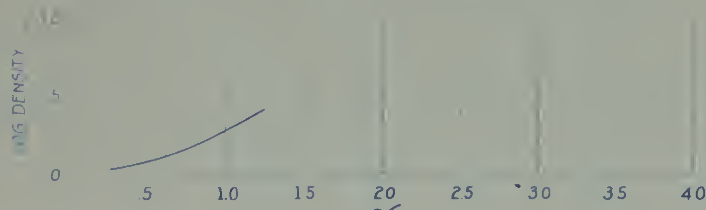


FIGURE 3

EMULSION No 10172

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.0	3.2	4.4	4.7				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.1	3.1	3.7	11.9			

SPEED B.S.450

SCALE 20

RESOLUTION NUMBER 25

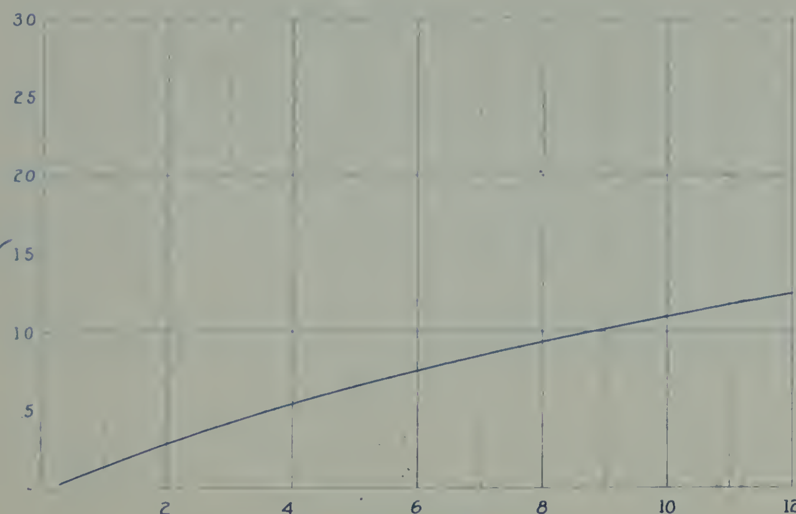


FIGURE 2

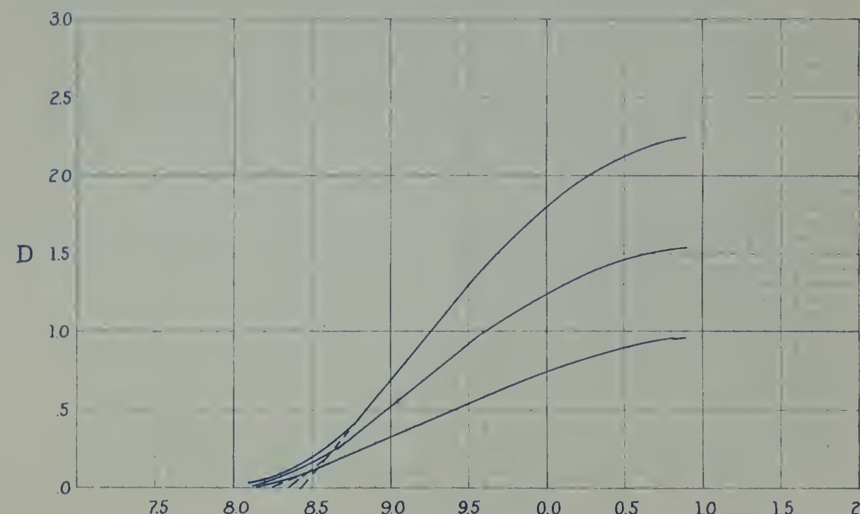


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

COLOR SENSITIVITY.

FIGURE 4

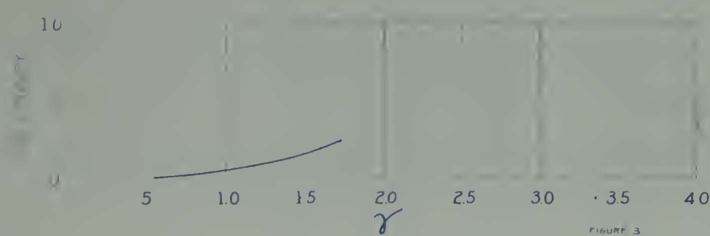


FIGURE 3

CRAMER
150 MED. D.C.

EMULSION No. 10103

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.7	4.4	4.6	5.8				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.2	2.6	4.4	12.7			

SPEED B.S. 380

SCALE 50

RESOLUTION NUMBER 24

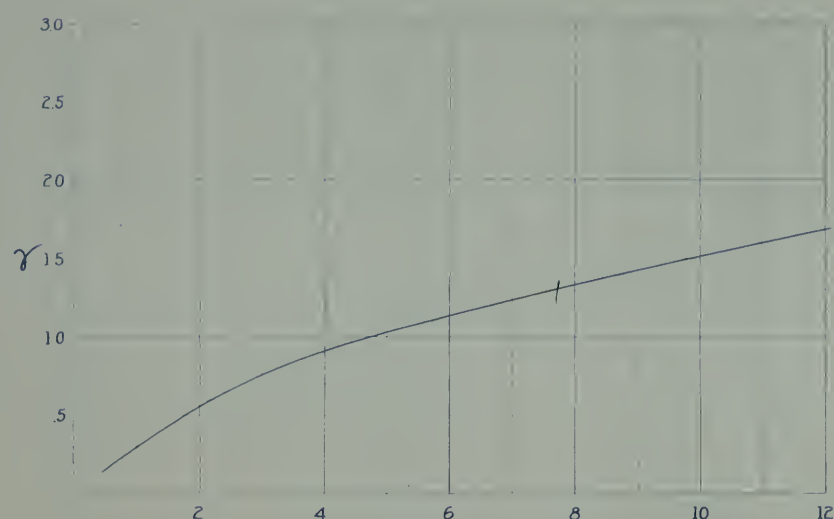


FIGURE 2

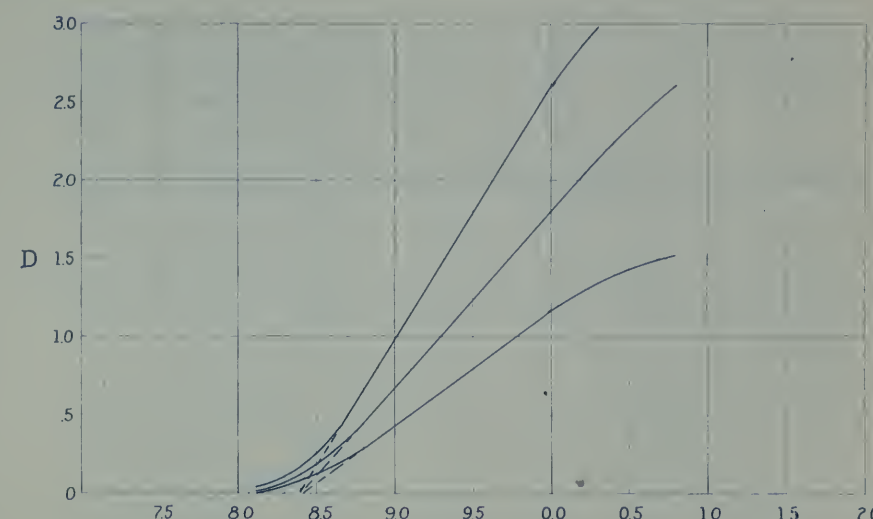
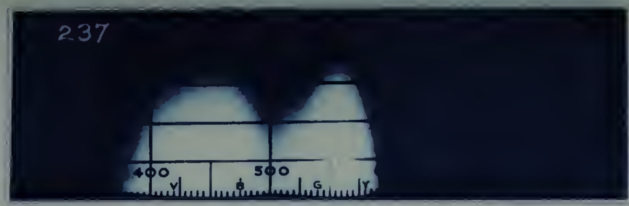


FIGURE 1

PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS.

CRAMER
150 MED.



COLOR SENSITIVITY

FIGURE 4

EMULSION No. 10181

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.6	4.6	5.3	5.8				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.1	3.0	4.3	12.5			

SPEED B.S. 330

SCALE 30

RESOLUTION NUMBER 21

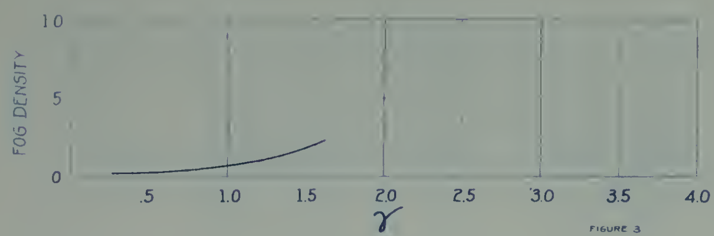
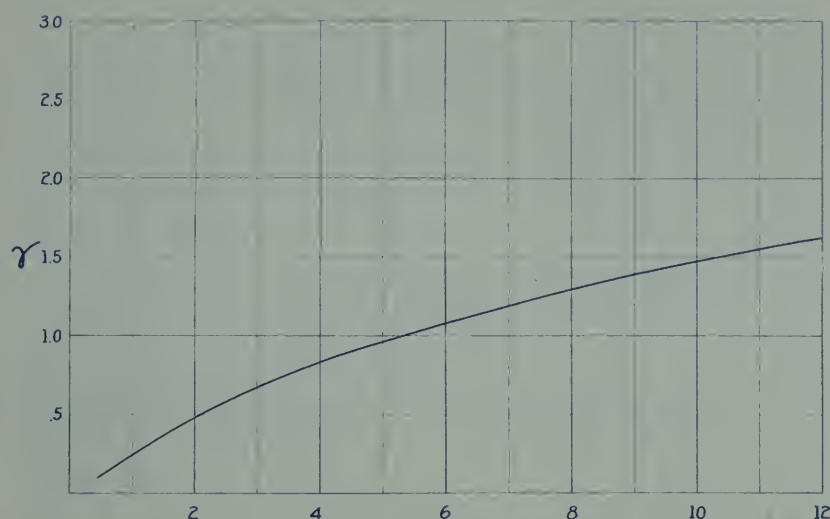
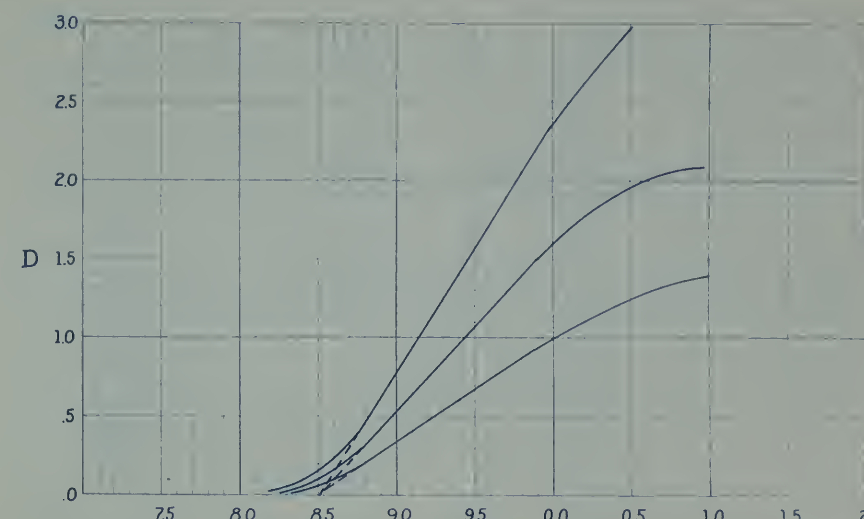


FIGURE 3



MINUTES OF DEVELOPMENT.

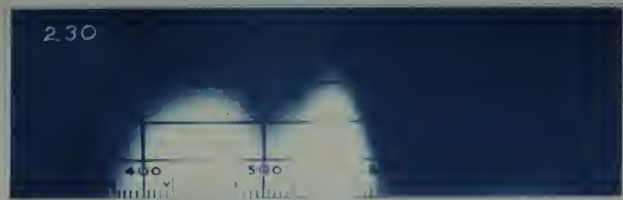
FIGURE 2



LOG. E C.M.S.

FIGURE 1

PHOTOGRAPHIC LABORATORY —



COLOR SENSITIVITY

CRAMER
COMMERCIAL ISONON

EMULSION No. 10179

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.7	4.2	5.2	5.6				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.1	3.3	4.2	15.8			

SPEED B.S 330

SCALE 15

RESOLUTION NUMBER 22

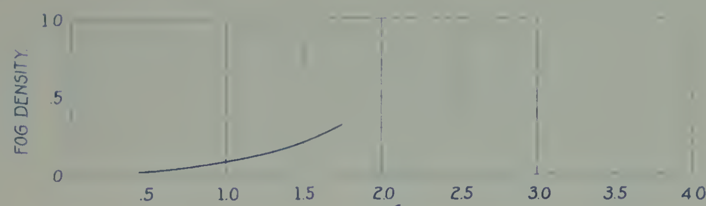


FIGURE 3

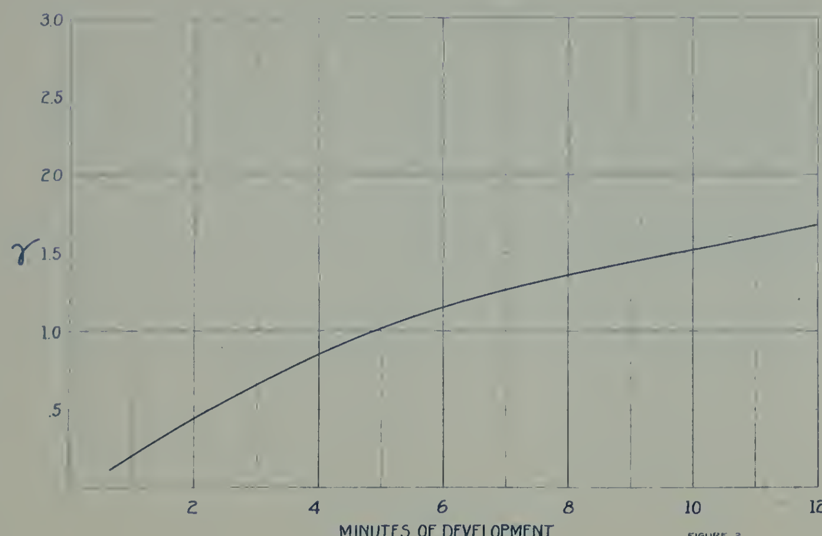


FIGURE 2

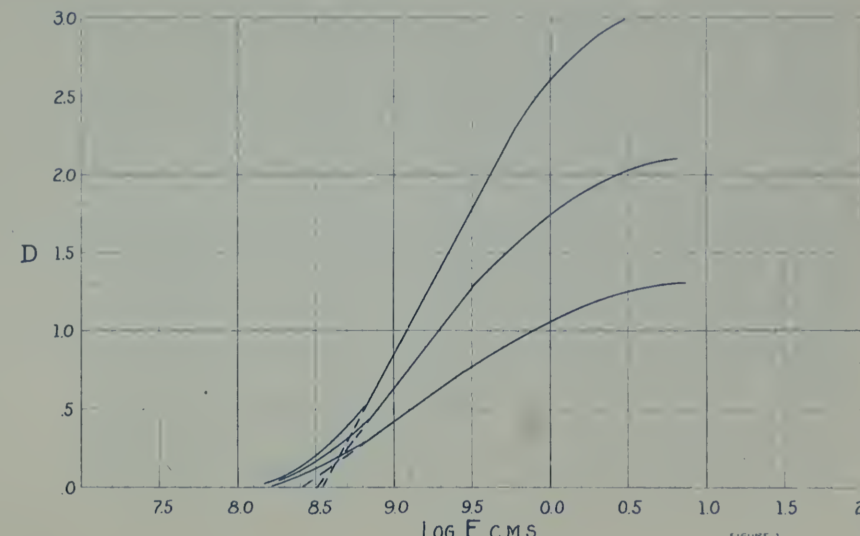
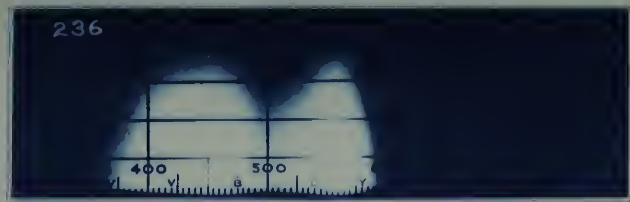


FIGURE 1

CRAMER
ISO PROCESS



COLOR SENSITIVITY. FIGURE 4

EMULSION No. 10090

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.4	3.7	4.7	5.3				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.1	3.2	4.5	10.0			

SPEED B.S. 320

SCALE 10

RESOLUTION NUMBER 19

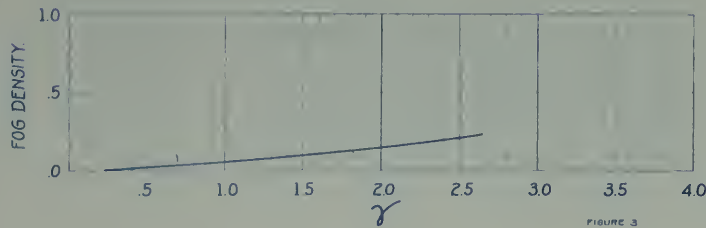


FIGURE 3

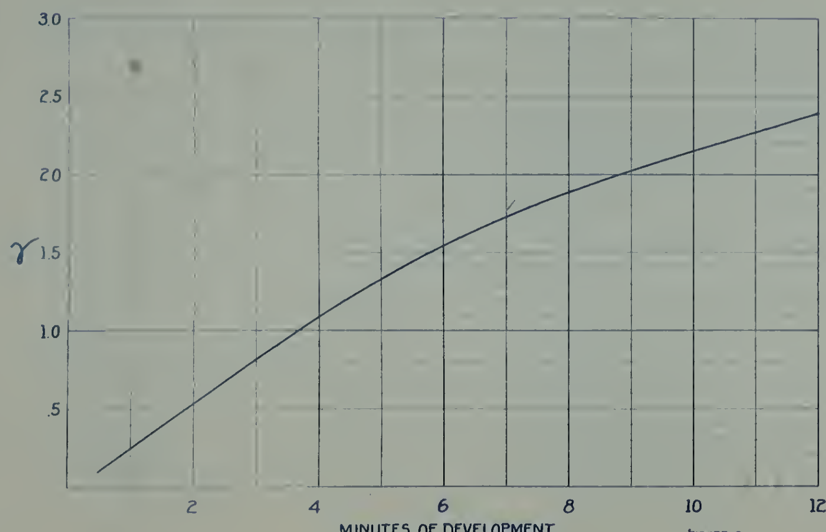


FIGURE 2

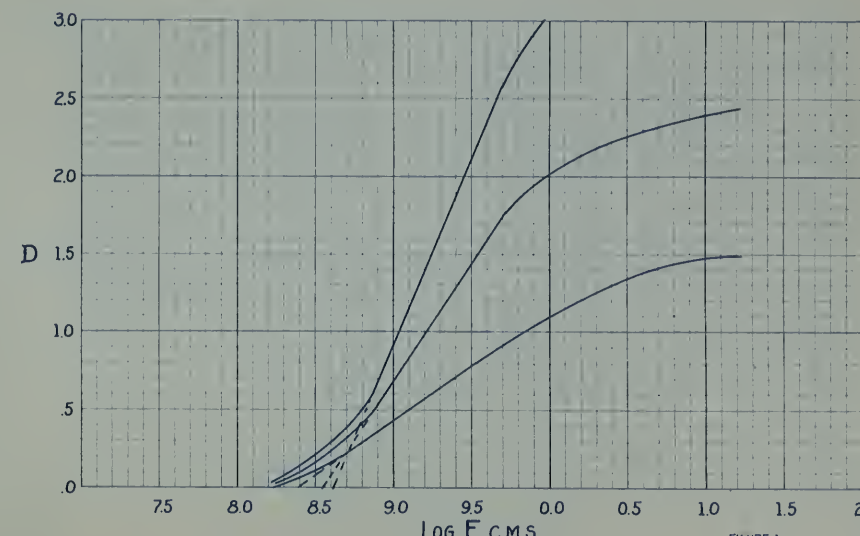


FIGURE 1.

CRAMER TRICHROMATIC

COLOR SENSITIVITY. FIGURE 4

EMULSION No. 1590

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
3.1	5.1	5.4	6.0				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.0	3.2	4.2	14.3			

SPEED BS 260

SCALE 20

RESOLUTION NUMBER 26

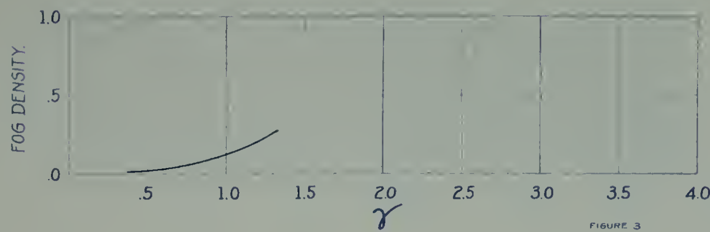


FIGURE 3

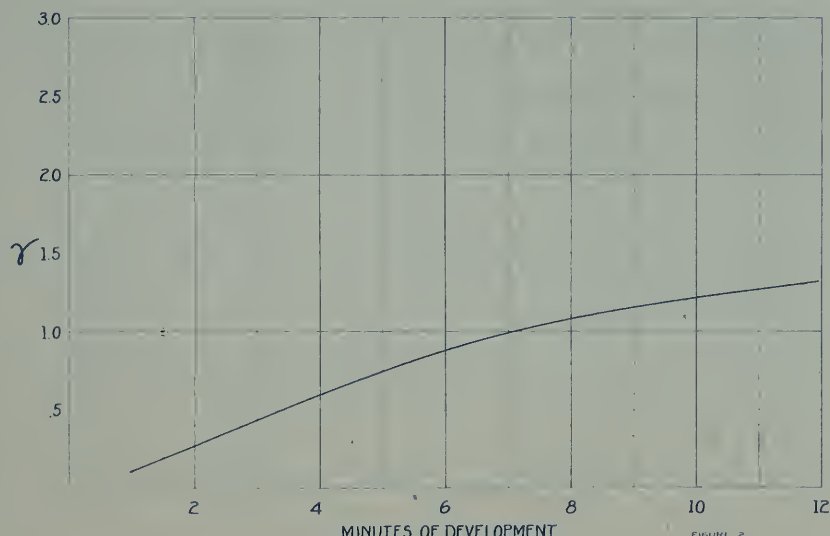
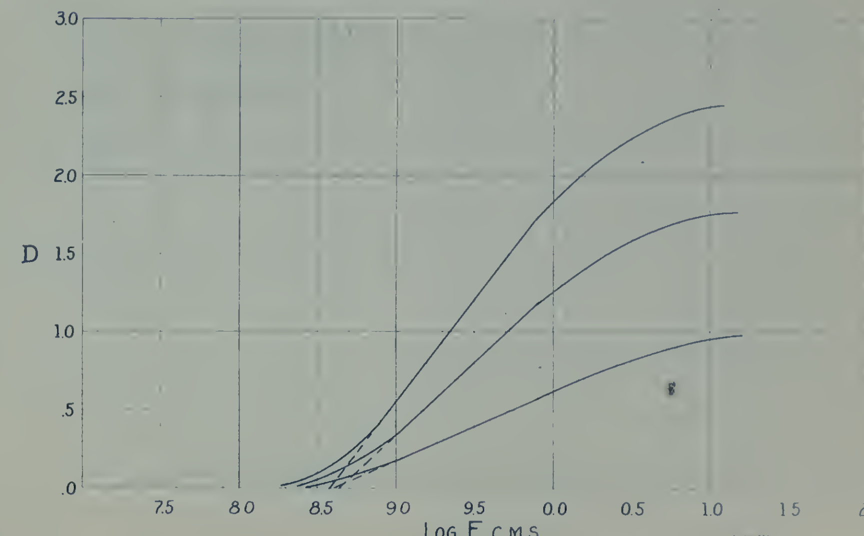


FIGURE 2



COLOR SENSITIVITY. FIGURE 4

CRAMER
ISO SLOW D.C.

EMULSION No. 10159

DEVELOPER FORMULA. W

FILTER FACTORS

K$_1$	K$_2$	K$_3$	G	A	B	C	F
1.9	2.4	2.7	3.1				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.1	2.5	2.6	7.2			

SPEED B.S. 120

SCALE 40

RESOLUTION NUMBER 22

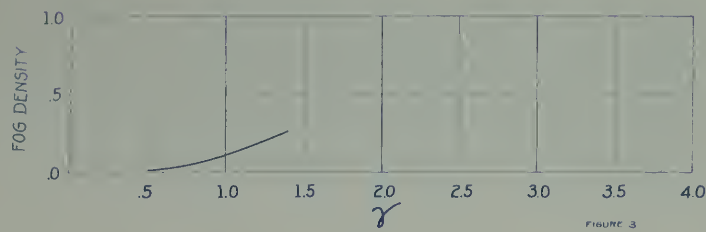


FIGURE 3

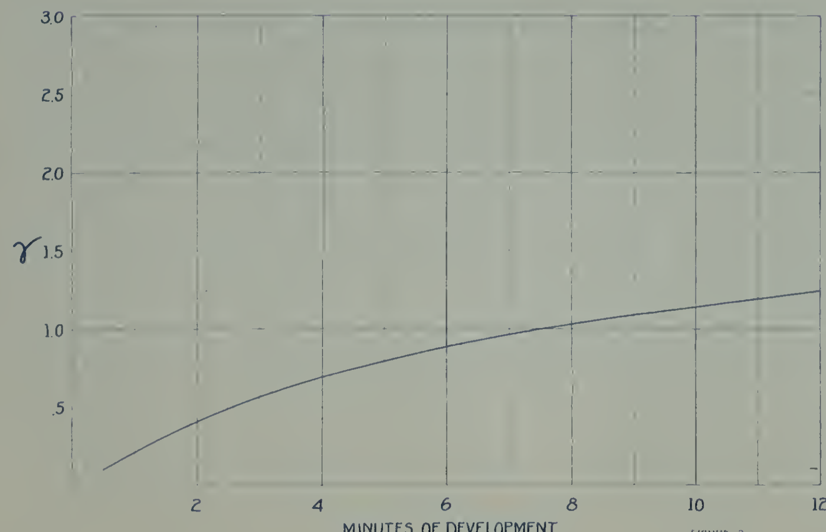


FIGURE 2

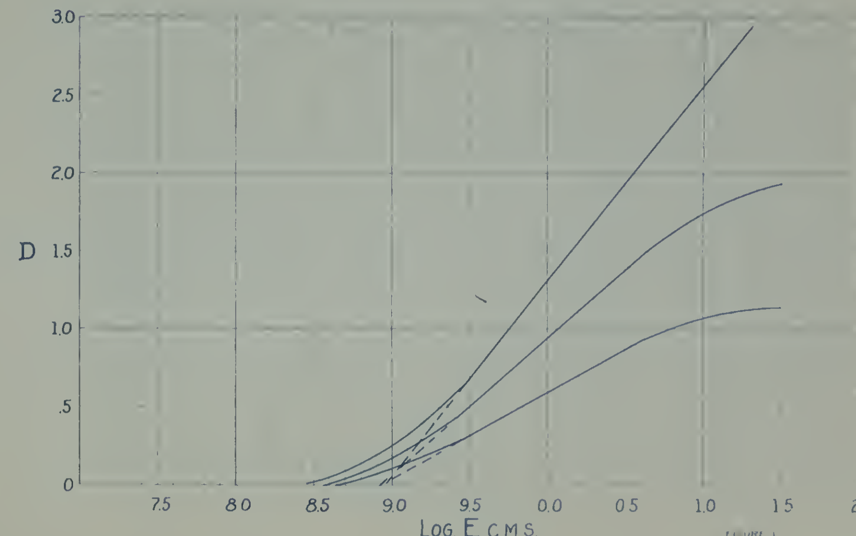


FIGURE 1

CRAMER
ISO SLOW

COLOR SENSITIVITY

EMULSION No. 10159

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
1.9	2.3	2.4	2.6				

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.0	2.1	2.1	7.2			

SPEED B S 78

SCALE 15

RESOLUTION NUMBER 20

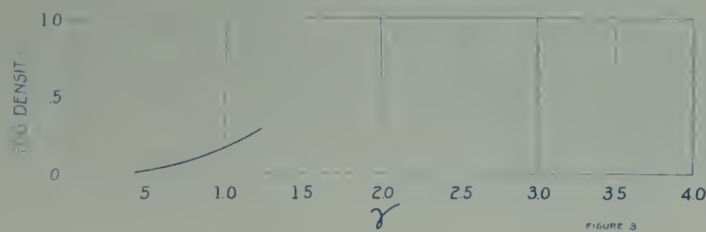
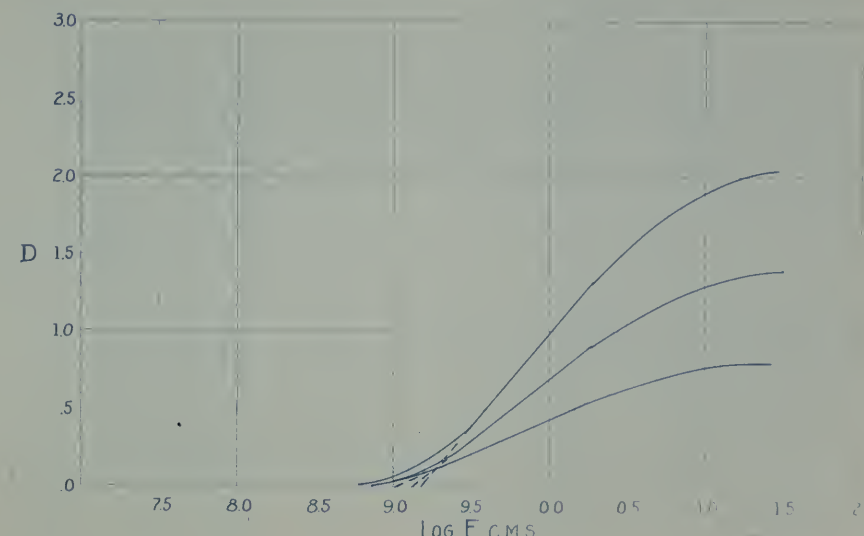
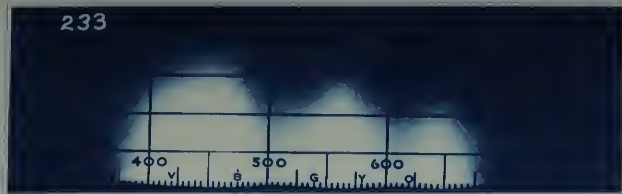


FIGURE 3

FIGURE 2



CRAMER SPECTRUM



COLOR SENSITIVITY

FIGURE 4

EMULSION No. 1588

DEVELOPER FORMULA. W

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.2	3.9	4.5	5.7	20.0	12.0	12.6	30.0

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.6	3.8	4.2	10.1	20.4	36.0	11.0

SPEED B.S. 180

SCALE 30

RESOLUTION NUMBER 22

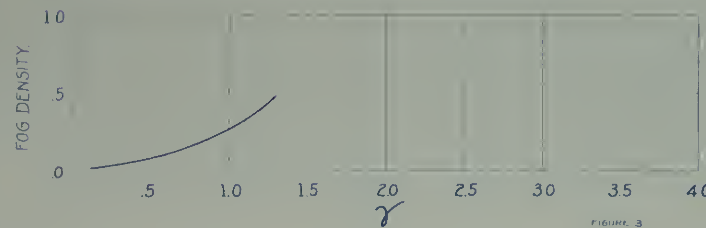


FIGURE 3

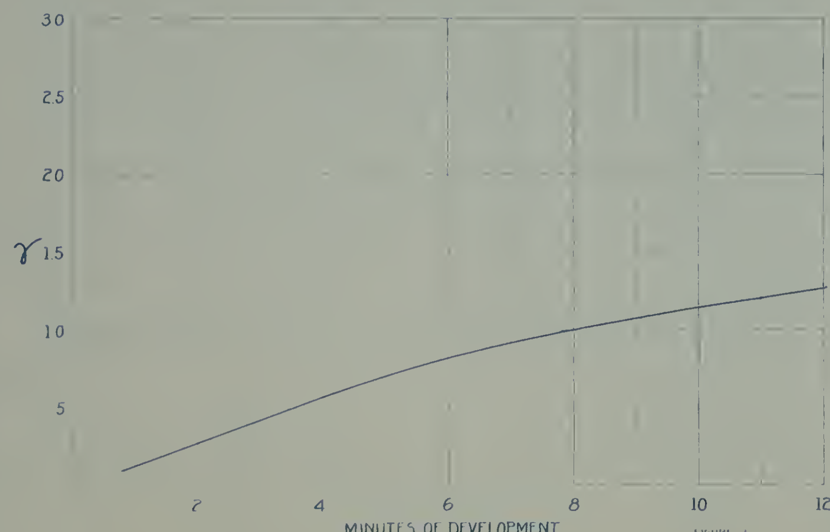
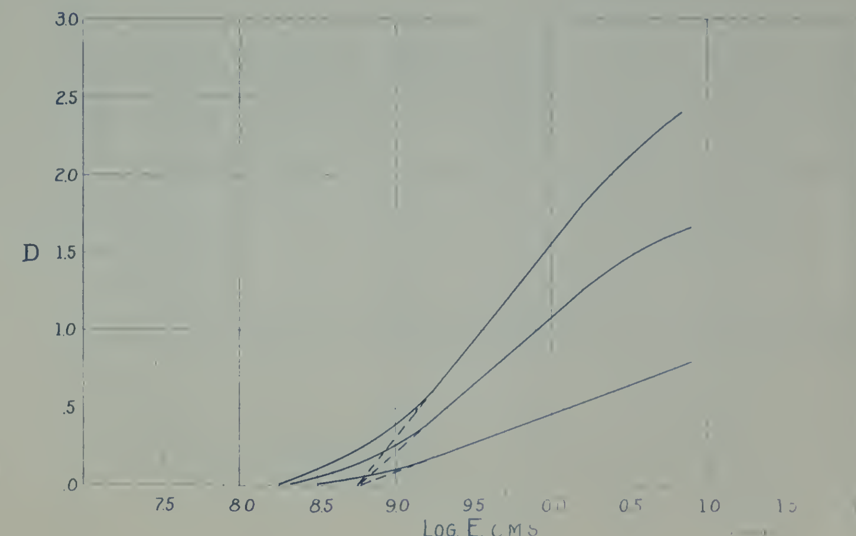


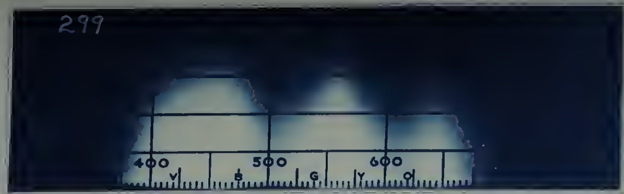
FIGURE 2



CRAMER SPECTRUM PROCESS

EMULSION No. 1555

DEVELOPER FORMULA W



COLOR SENSITIVITY

K_1	K_2	K_3	G	A	B	C	F
2.7	4.7	5.6	9.5	18.3	13.8	13.3	32.3

ISOS I	ISOS II	ISOS III	CHROMOS	TRI-COLOR RED	TRI-COLOR GREEN	TRI-COLOR BLUE
2.6	3.9	4.4	11.5	23.5	40.0	10.4

SPEED BS 110

SCALE 12

RESOLUTION NUMBER 20

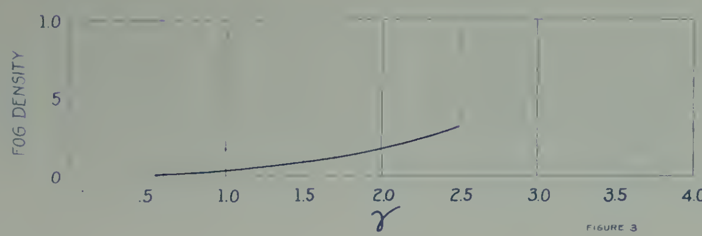
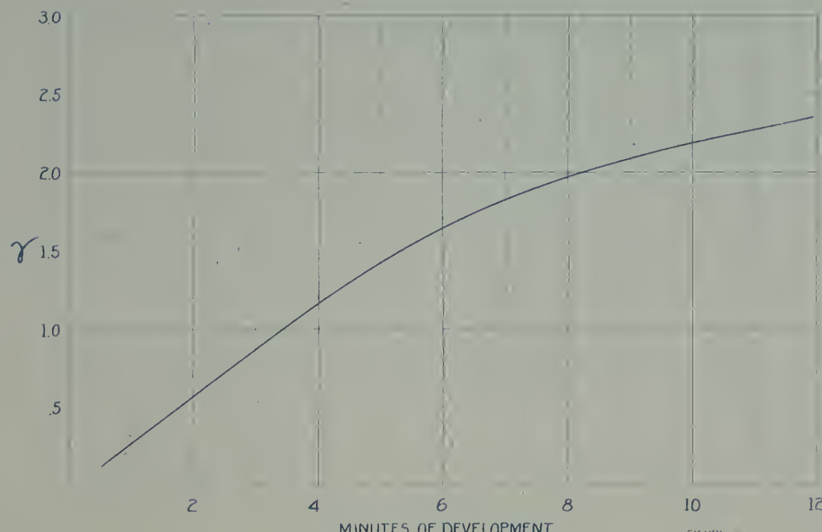
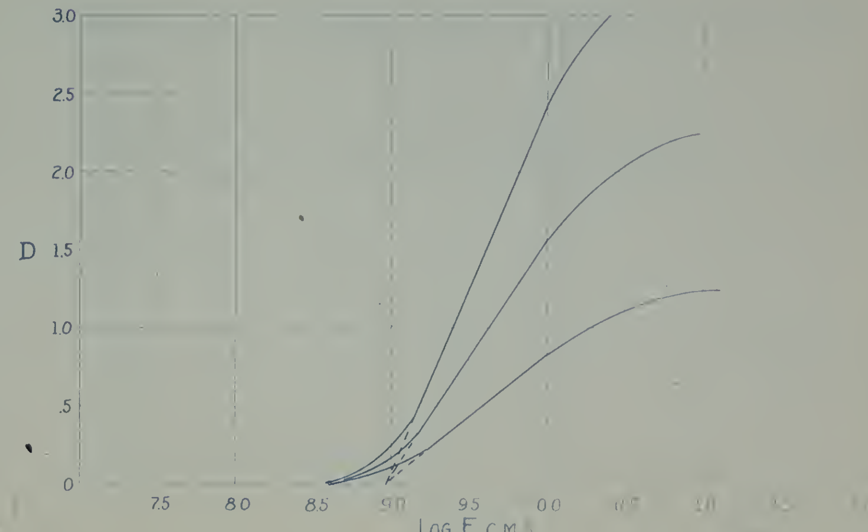


FIGURE 3





CRAMER
LANTERN SLIDE

EMULSION No. 4248

DEVELOPER FORMULA. W

COLOR SENSITIVITY

FIGURE 4

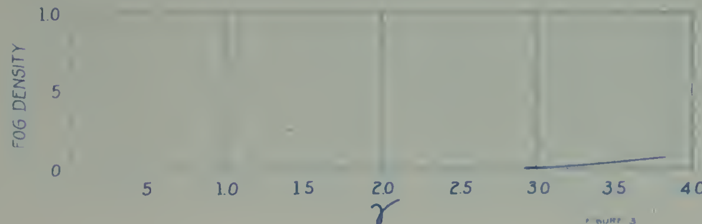


FIGURE 3

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F

SPEED BS 45

SCALE 7

RESOLUTION NUMBER 14

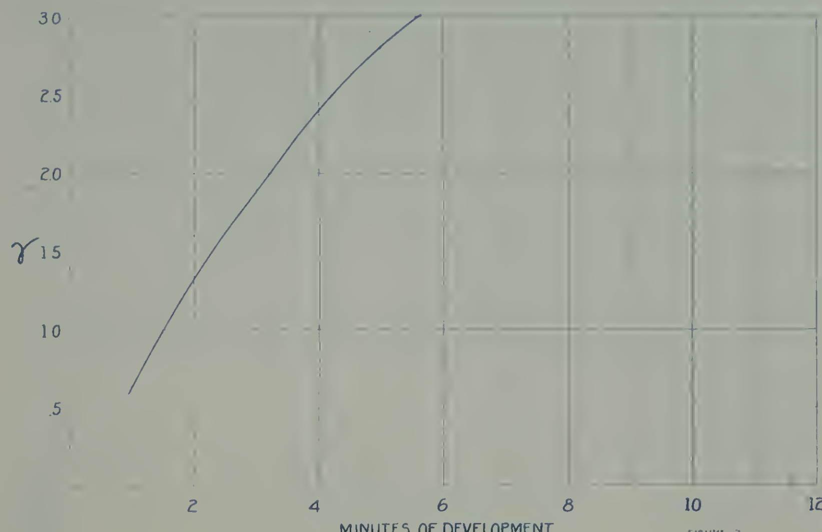


FIGURE 2

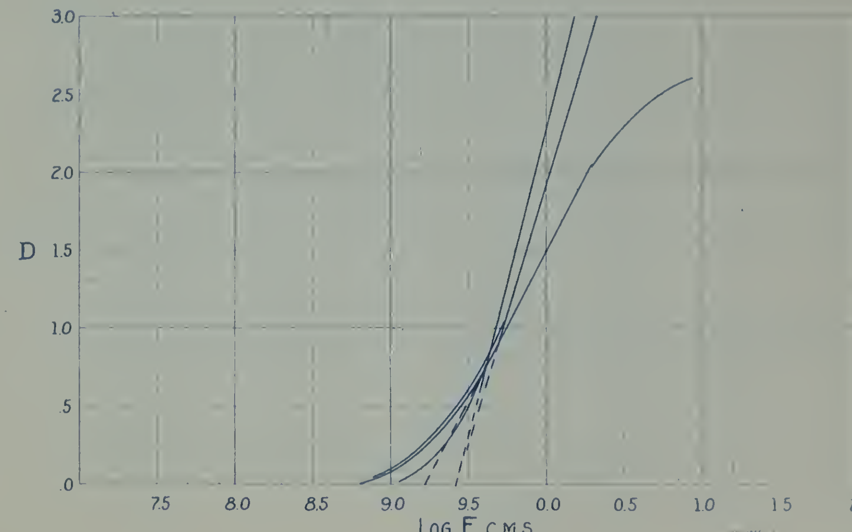


FIGURE 1

CRAMER TRANSPARENCY

COLOR SENSITIVITY. FIGURE 4.

EMULSION No. 4248

DEVELOPER FORMULA. W

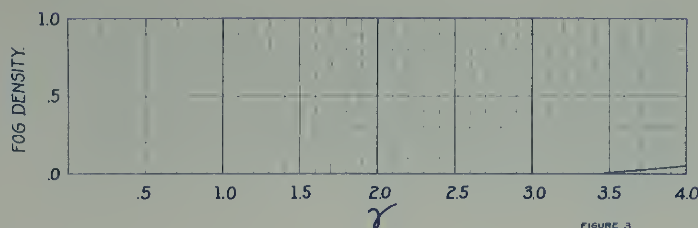


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 38

SCALE 6

RESOLUTION NUMBER 12

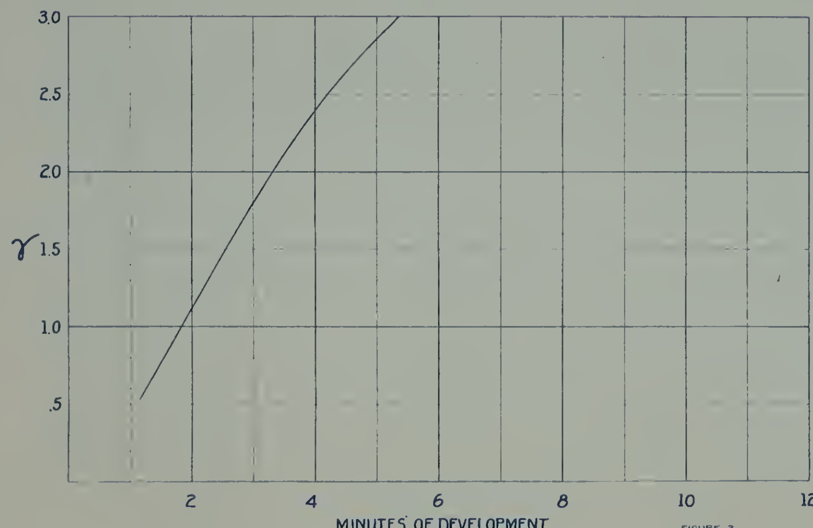
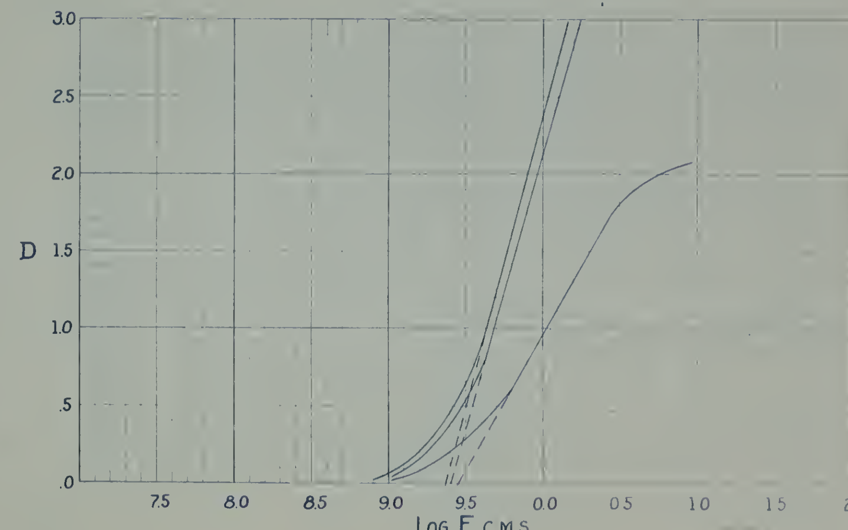


FIGURE 2



35

CRAMER
CONTRAST PROCESS

EMULSION No. 4253

DEVELOPER FORMULA. W

COLOR SENSITIVITY. FIGURE 4

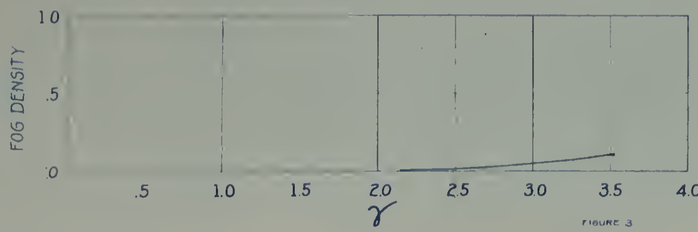


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S 38

SCALE 7

RESOLUTION NUMBER 13

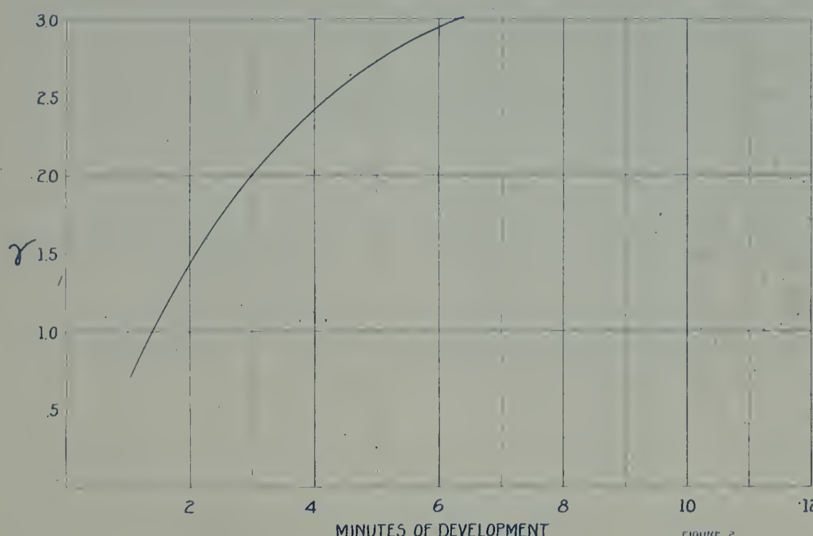
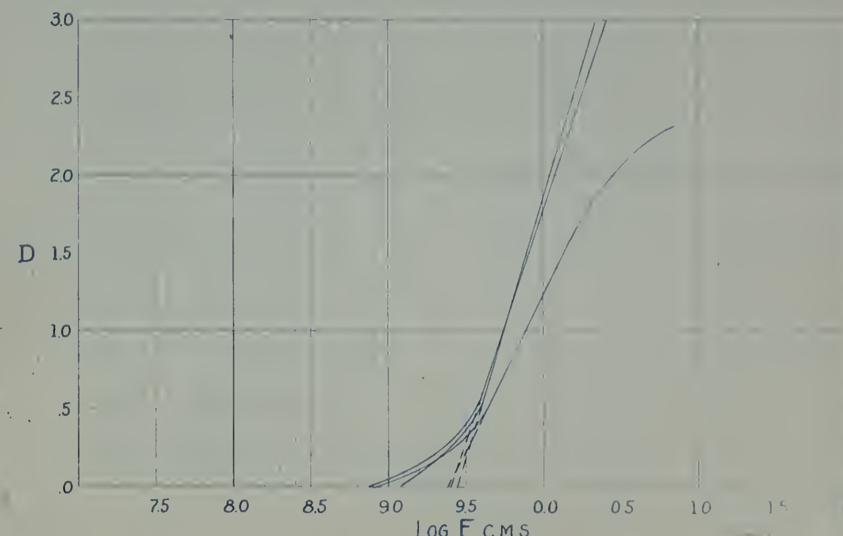


FIGURE 2



36

CRAMER
CONTRAST

EMULSION No. 4316

DEVELOPER FORMULA. W

COLOR SENSITIVITY

FIGURE 4

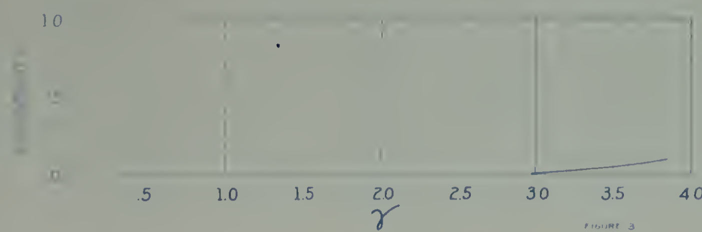


FIGURE 3

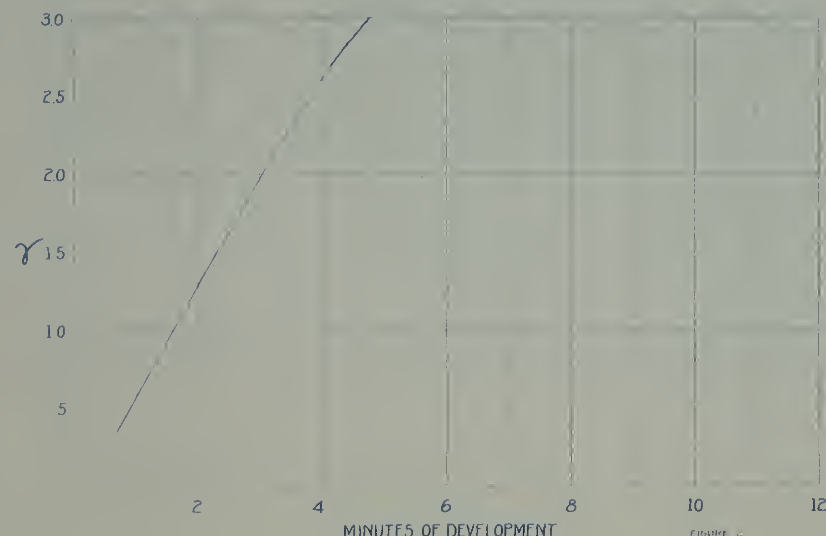
FILTER FACTORS.

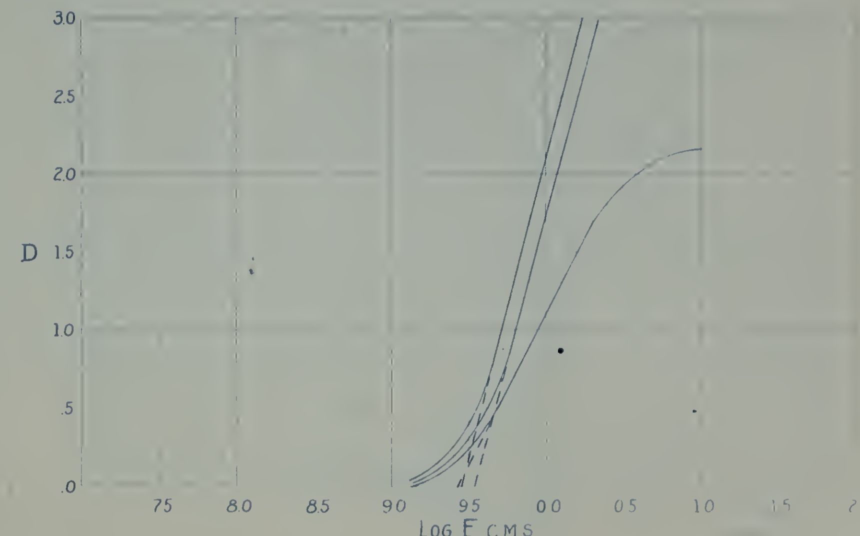
K_1	K_2	K_3	G	A	B	C	F

SPEED BS 33

SCALE 7

RESOLUTION NUMBER 12





DUPONT
POSITIVE MOTION PICTURE FILM

EMULSION No 748

DEVELOPER FORMULA. X

COLOR SENSITIVITY

FOG DENSITY

FILTER FACTORS

K1	K2	K3	G	A	B	C	F

SPEED B.S 50

SCALE 50

RESOLUTION NUMBER 22

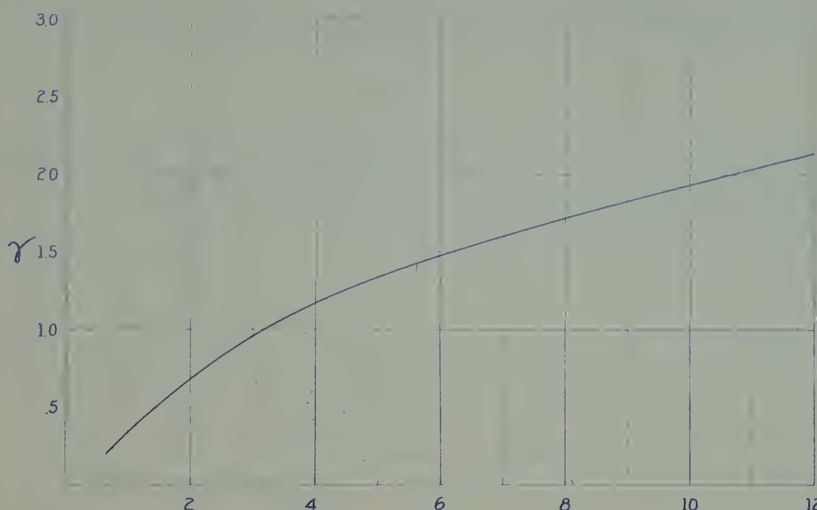


FIGURE 2

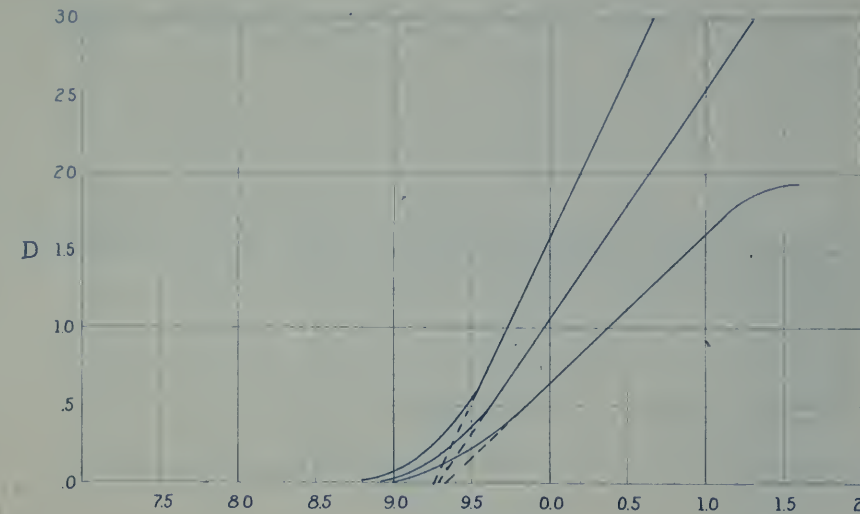


FIGURE 1.

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

EASTMAN PORTRAIT FILM

COLOR SENSITIVITY. FIGURE 4

EMULSION No. 9951

DEVELOPER FORMULA. X

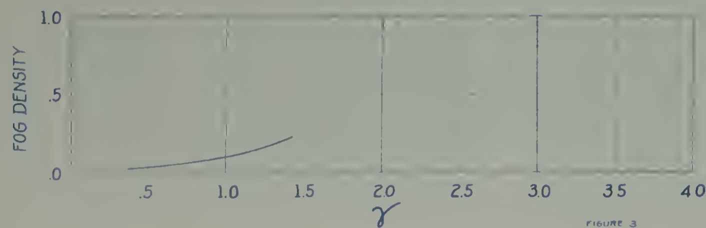


FIGURE 3

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.7	8.7	14.7	40.0				

SPEED B.S. 355

SCALE 200

RESOLUTION NUMBER 24

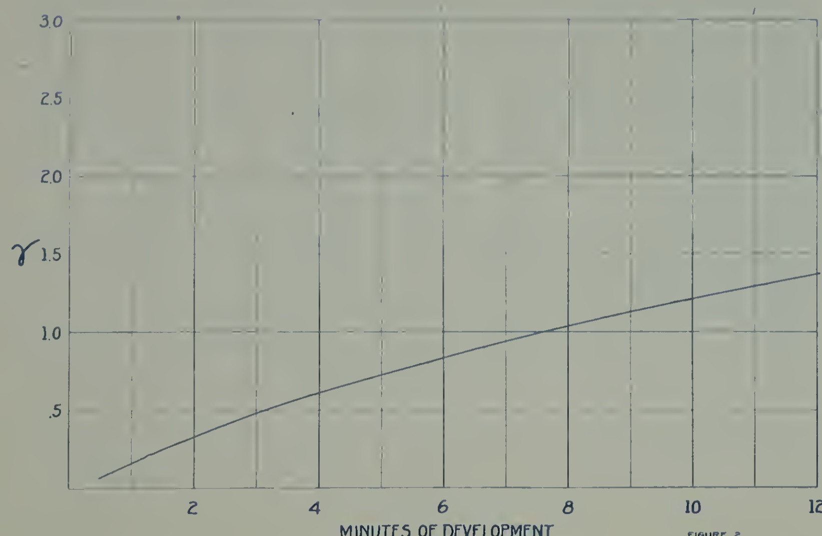


FIGURE 2

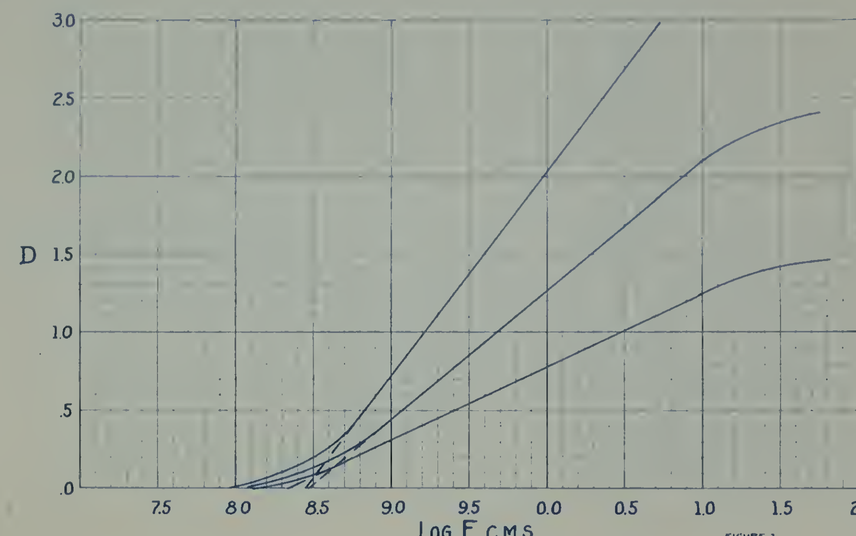


FIGURE 1.

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

EASTMAN COMMERCIAL FILM

EMULSION No. 266

DEVELOPER FORMULA. X

COLOR SENSITIVITY. FIGURE 4

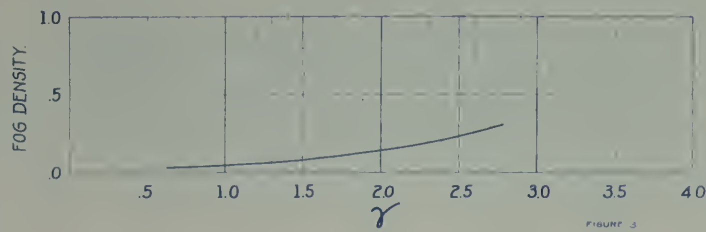


FIGURE 3

FILTER FACTORS.

K$_1$	K$_2$	K$_3$	G	A	B	C	F

SPEED B.S. 130

SCALE 50

RESOLUTION NUMBER 20

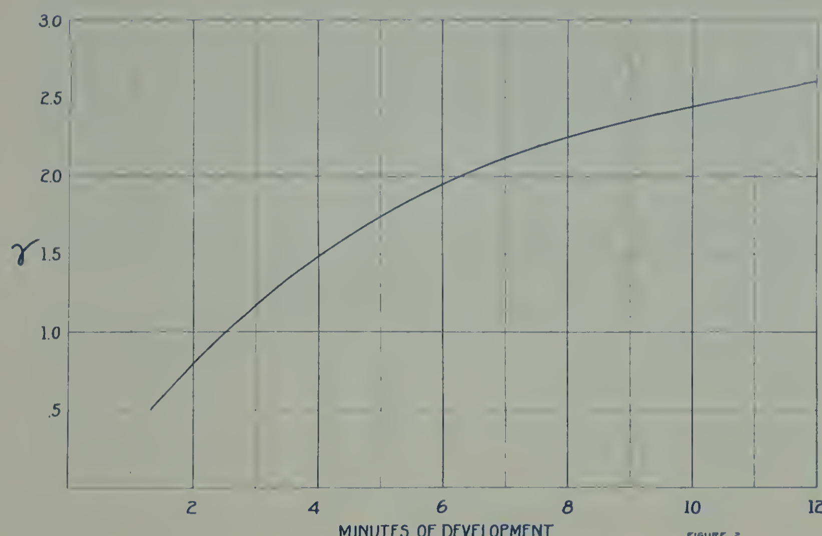


FIGURE 2

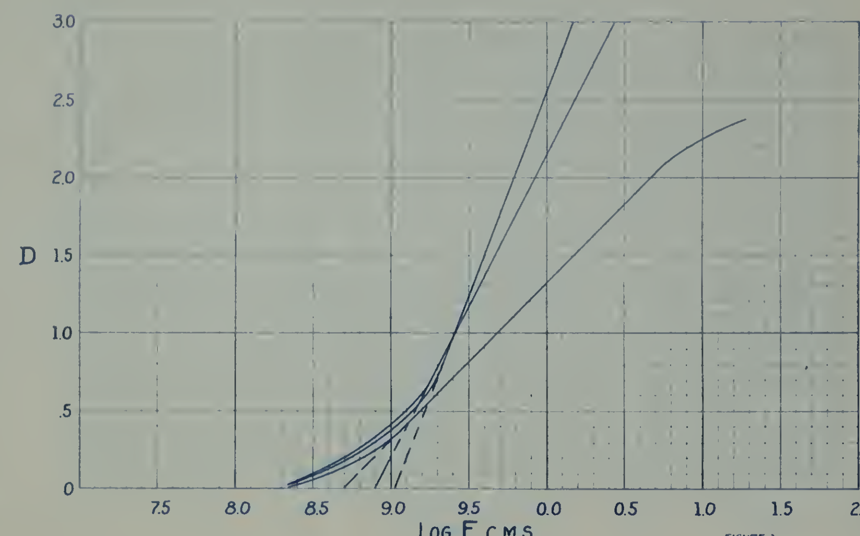


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

EASTMAN
COMMERCIAL ORTHO FILM

EMULSION No. 557

DEVELOPER FORMULA. X

COLOR SENSITIVITY. FIGURE 4

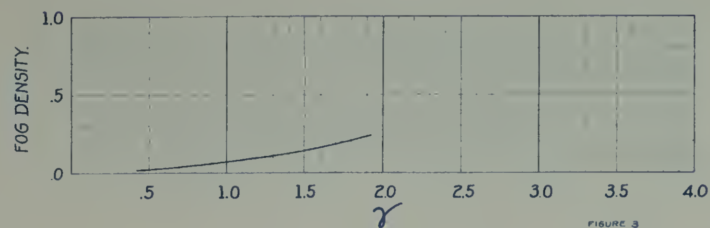


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.0	7.6	11.2	24.3				

SPEED B.S. 250

SCALE 120

RESOLUTION NUMBER 23

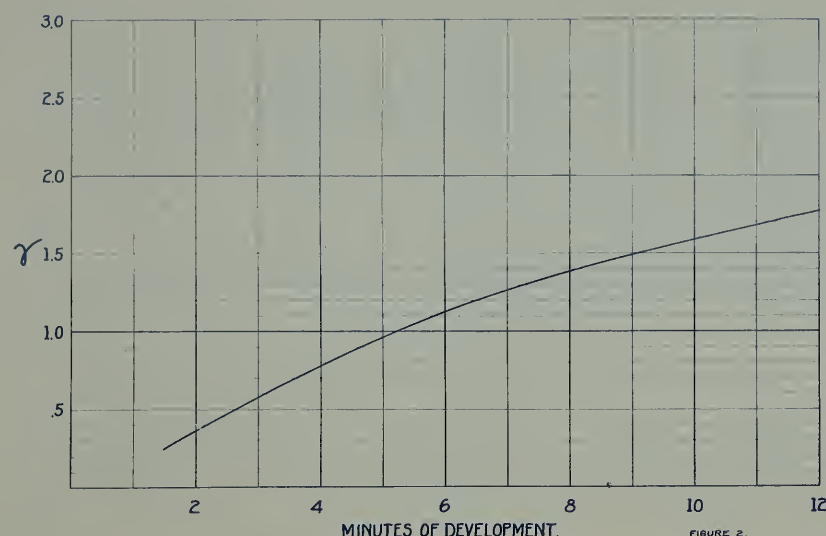


FIGURE 2.

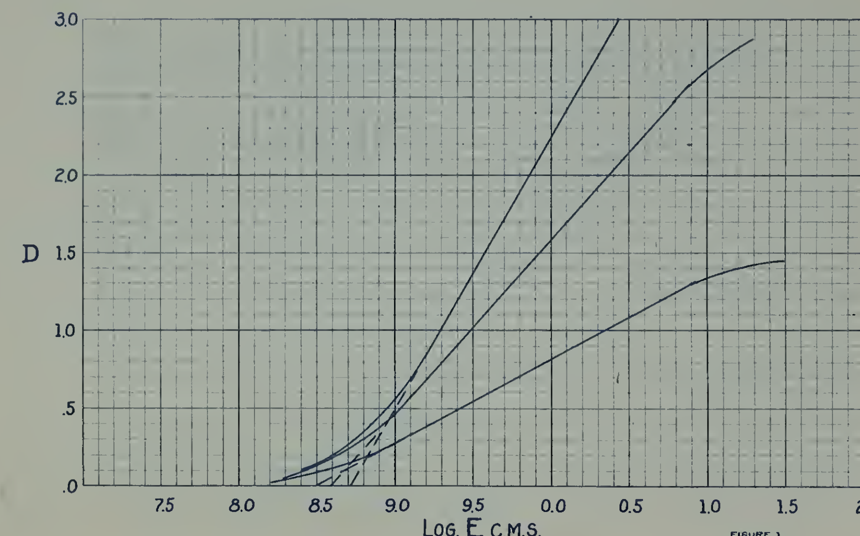
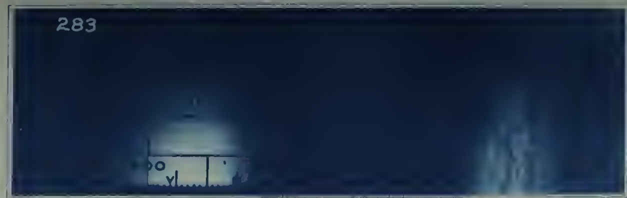


FIGURE 1.

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS.

EASTMAN PROCESS FILM



COLOR SENSITIVITY.

EMULSION No. 9707

DEVELOPER FORMULA. X

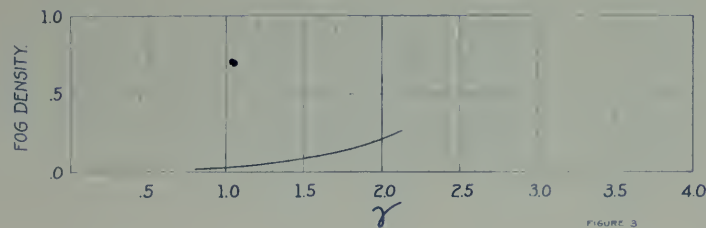


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 60

SCALE 25

RESOLUTION NUMBER 21

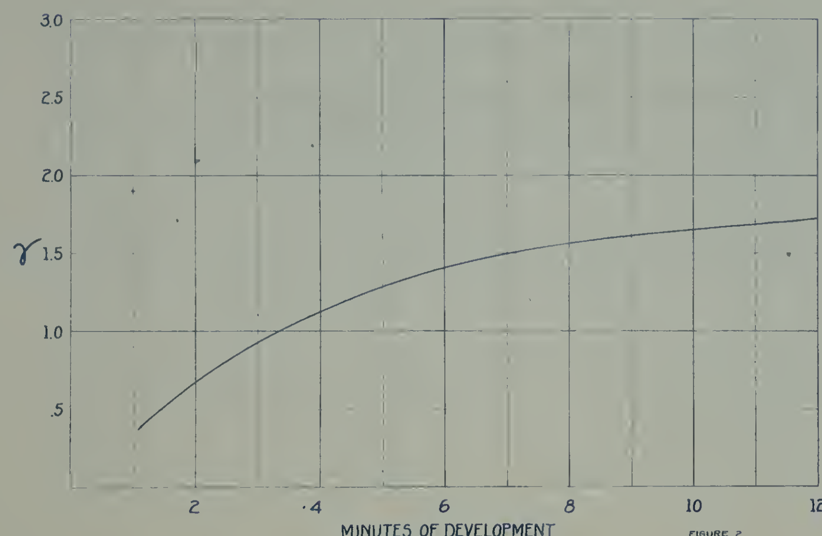


FIGURE 2

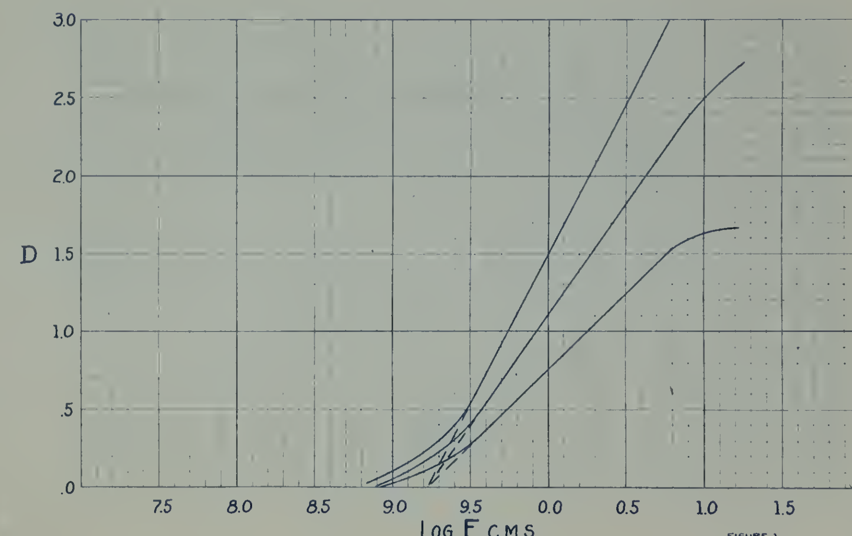
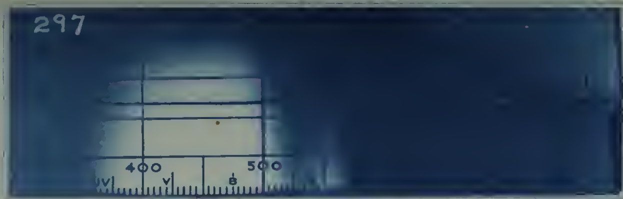


FIGURE 1.

EASTMAN
NEGATIVE FILM FOR MOTION PICTURES

EMULSION No. 6964

DEVELOPER FORMULA. X



COLOR SENSITIVITY. FIGURE 4

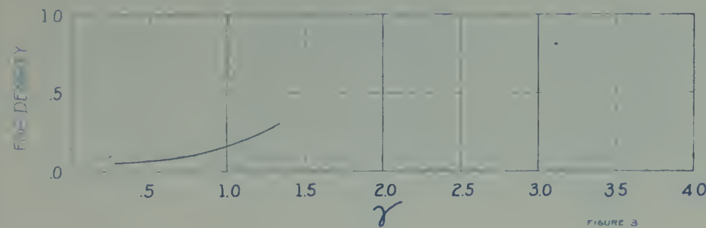


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.2	11.6	18.9					

SPEED B.S. 400

SCALE 50

RESOLUTION NUMBER 26

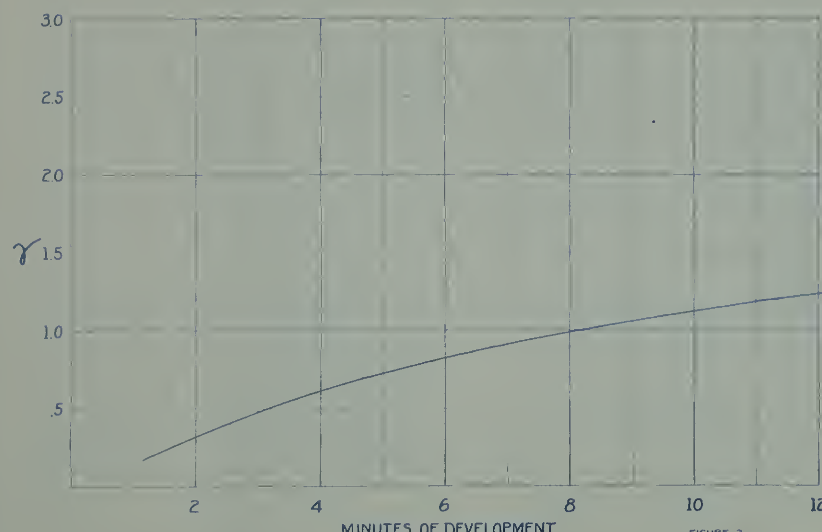


FIGURE 2

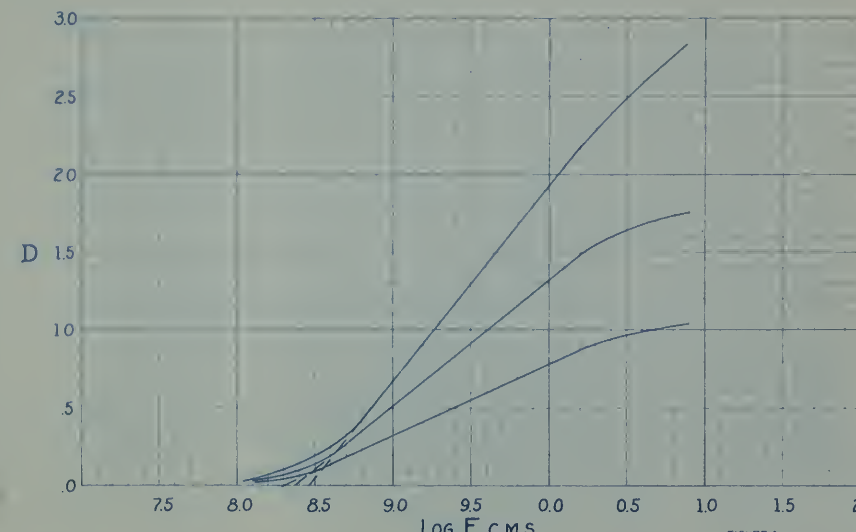


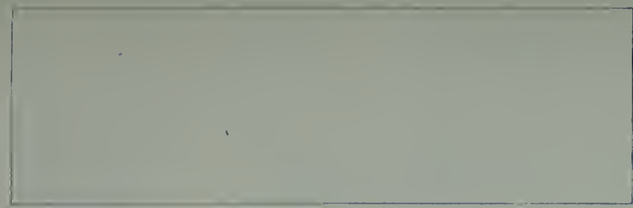
FIGURE 1.

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

EASTMAN
POSITIVE FILM FOR MOTION PICTURES

EMULSION No. 11223

DEVELOPER FORMULA. X



COLOR SENSITIVITY. FIGURE 4

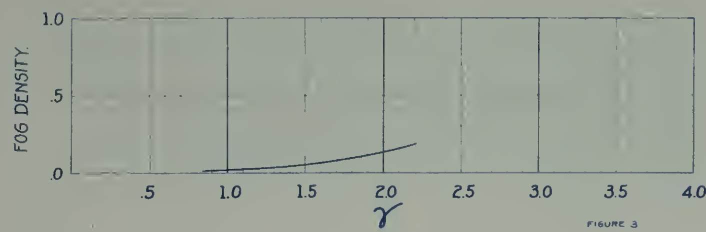


FIGURE 3

FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 38

SCALE 20

RESOLUTION NUMBER 21

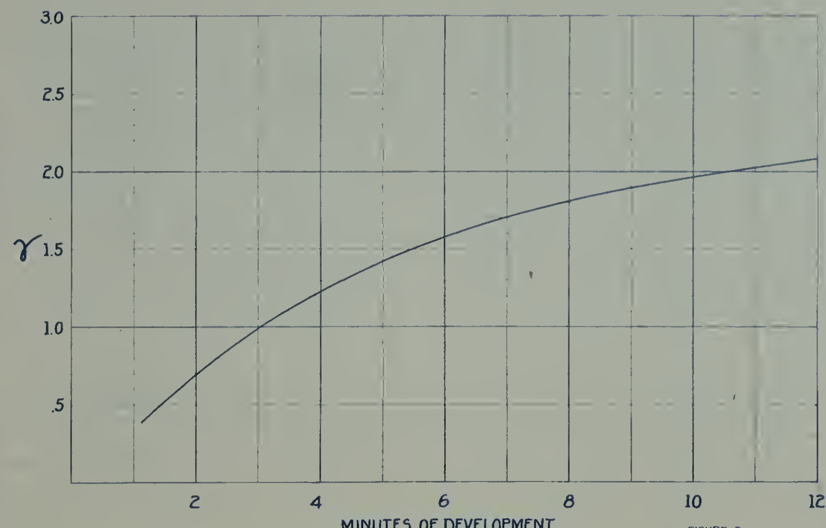


FIGURE 2

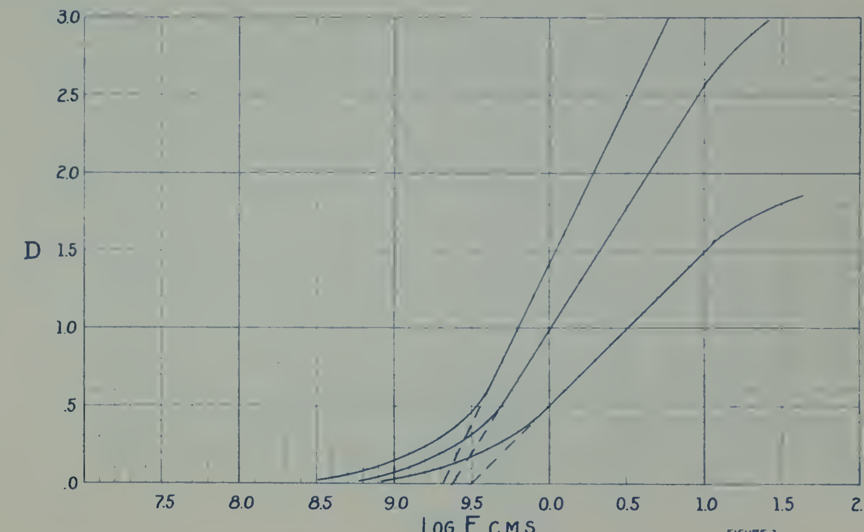


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

EASTMAN AUTOGRAPHIC FILM

COLOR SENSITIVITY FIGURE 4

EMULSION No. 16742

DEVELOPER FORMULA. X

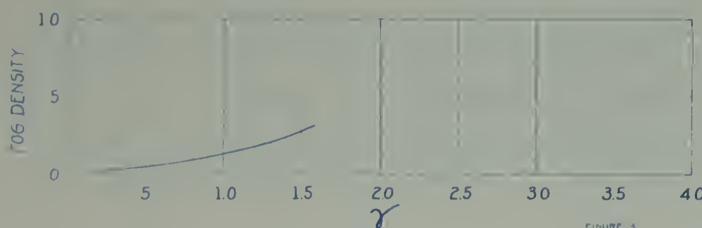


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.3	12.0	21.4	48.0				

SPEED B S 350

SCALE 100

RESOLUTION NUMBER 22

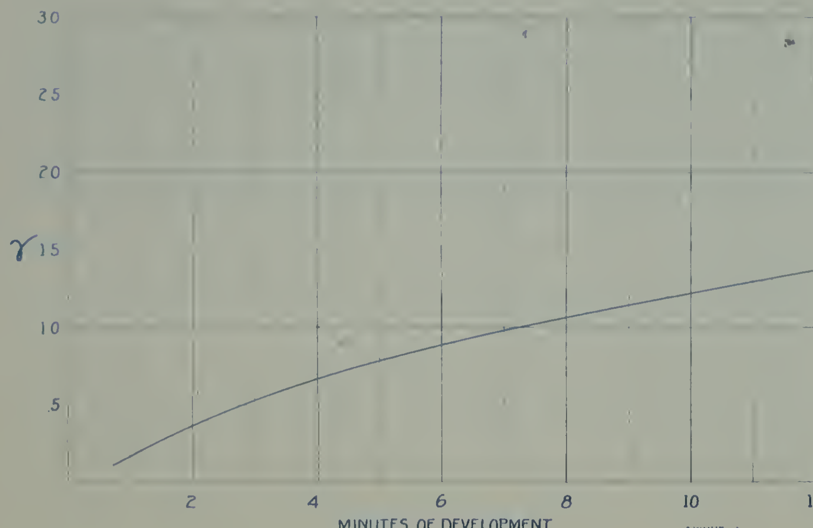


FIGURE 2

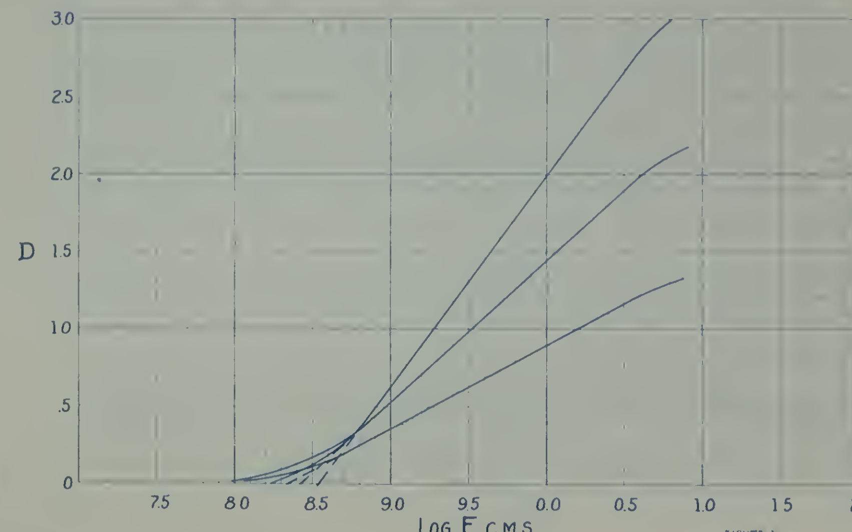


FIGURE 1

EASTMAN
PREMO FILM PACK

COLOR SENSITIVITY

EMULSION No. 16327

DEVELOPER FORMULA. X

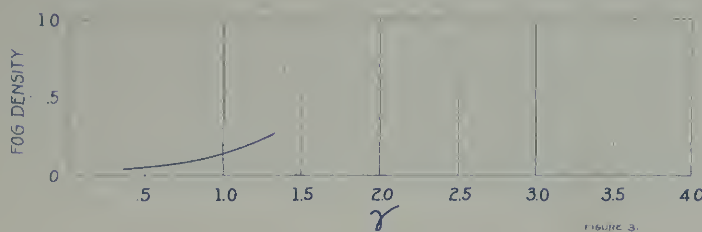


FIGURE 3.

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
2.9	10.0	19.4					

SPEED B.S. 350

SCALE 40

RESOLUTION NUMBER 24

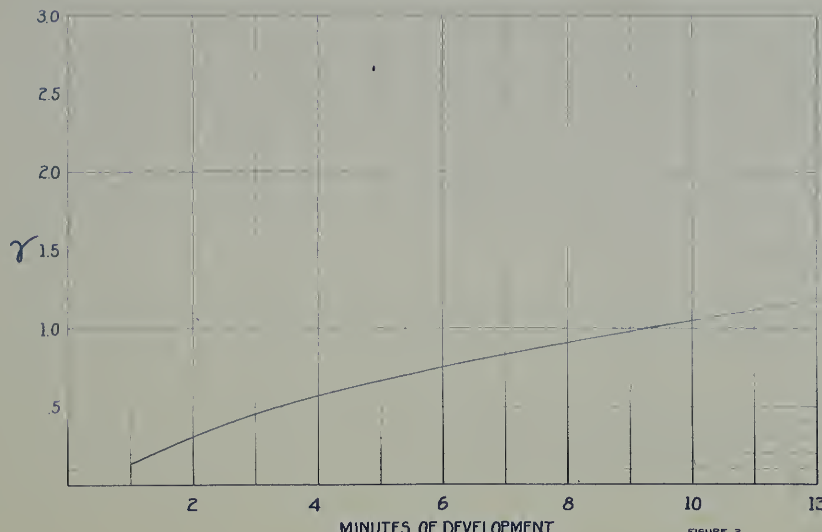


FIGURE 2.

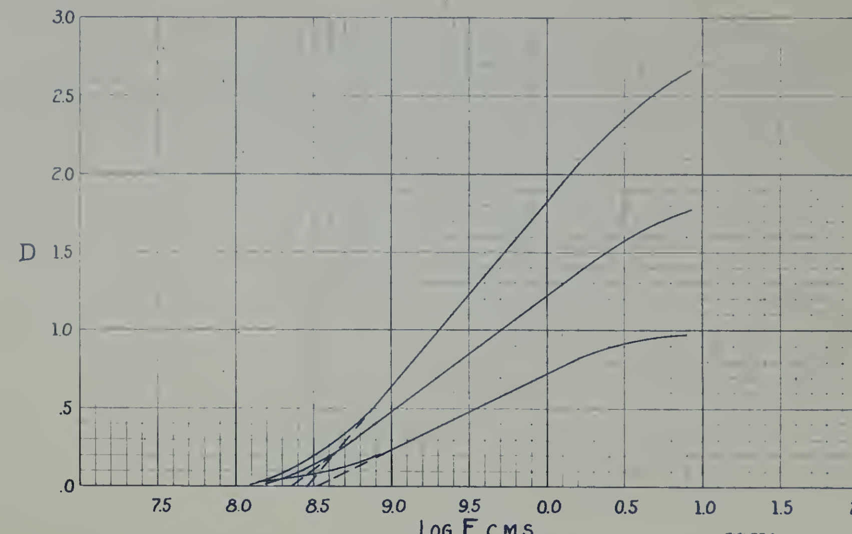


FIGURE 1.

46

EASTMAN
VULCAN FILM

COLOR SENSITIVITY. FIGURE 4

EMULSION No. 8214

DEVELOPER FORMULA. X

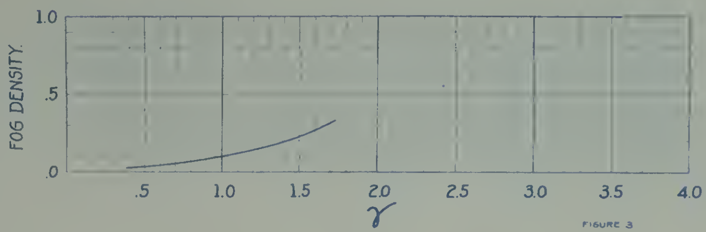


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 400

SCALE 50

RESOLUTION NUMBER 26

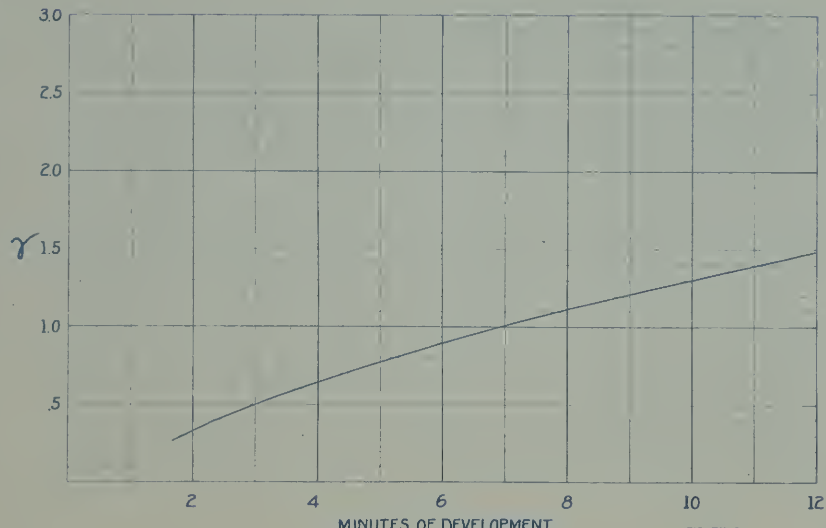


FIGURE 2

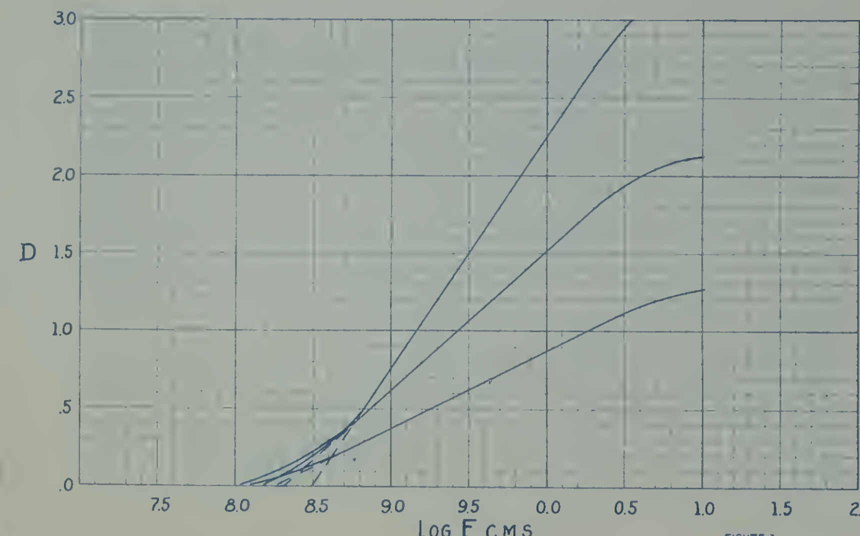


FIGURE 1.

EASTMAN
AERO ORTHO FILM

EMULSION No. 59374

DEVELOPER FORMULA. X

COLOR SENSITIVITY. FIGURE 4.

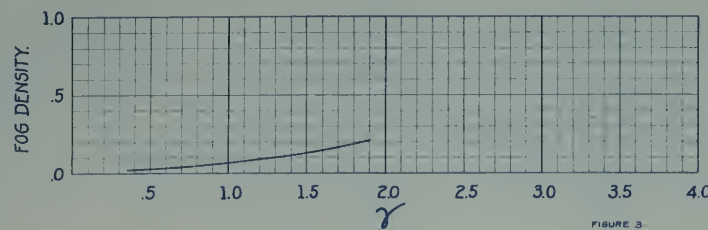


FIGURE 3.

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.0	9.8	15.2	20.2				

SPEED B.S. 210

SCALE 30

RESOLUTION NUMBER 26

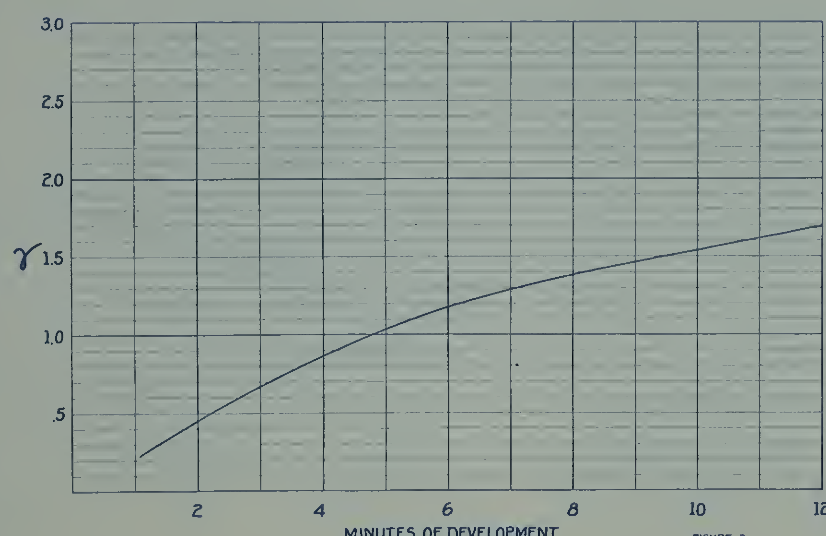


FIGURE 2

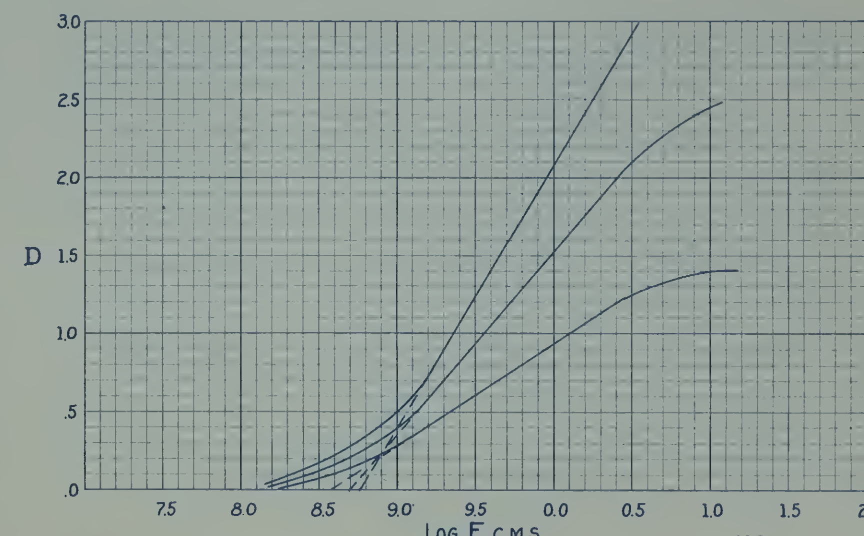
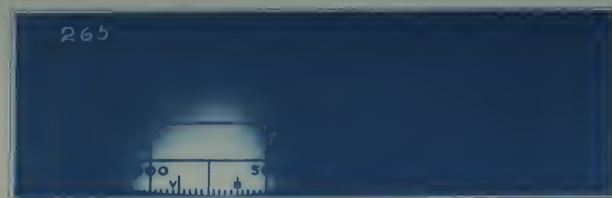


FIGURE 1.

EASTMAN
SEED'S GRAFLEX

EMULSION No. 3705

DEVELOPER FORMULA. X



COLOR SENSITIVITY. FIGURE 4

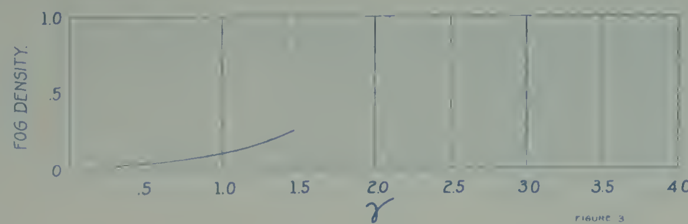


FIGURE 3

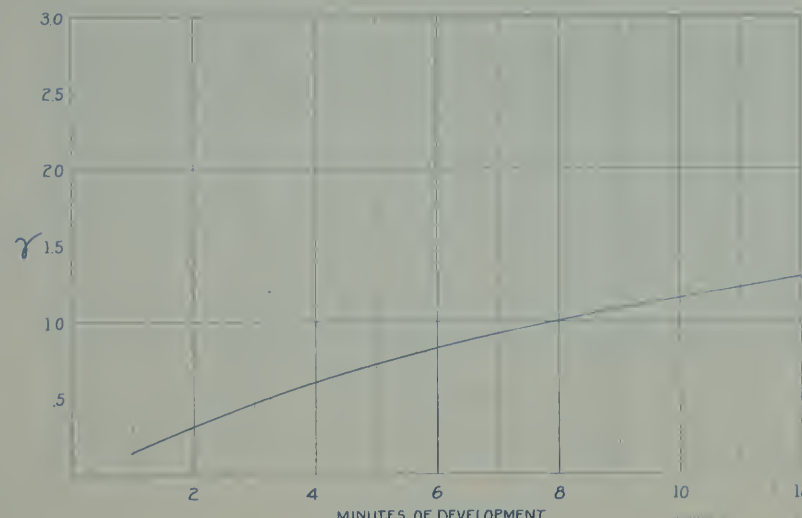
FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S 1000

SCALE 12

RESOLUTION NUMBER 24



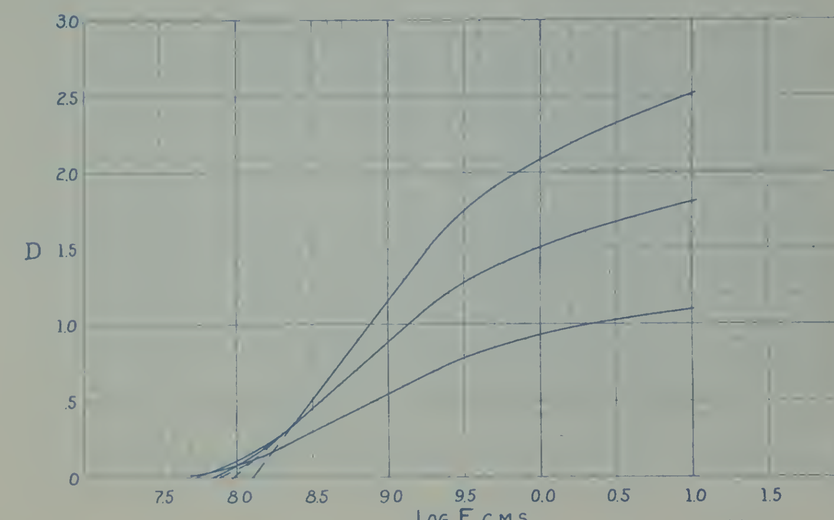
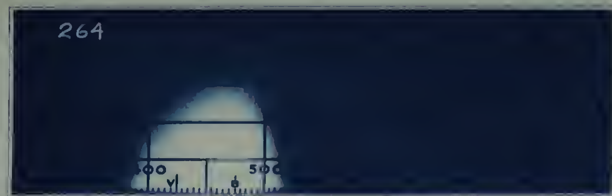


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

EASTMAN
SEED'S 30



COLOR SENSITIVITY. FIGURE 4

EMULSION No. 3863

DEVELOPER FORMULA. X

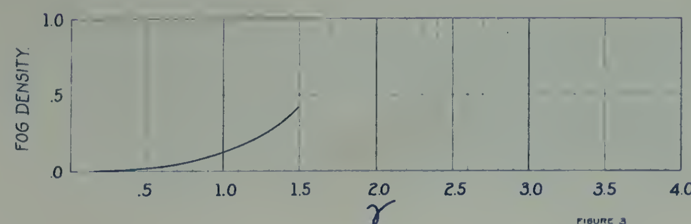


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 650

SCALE 80

RESOLUTION NUMBER 20

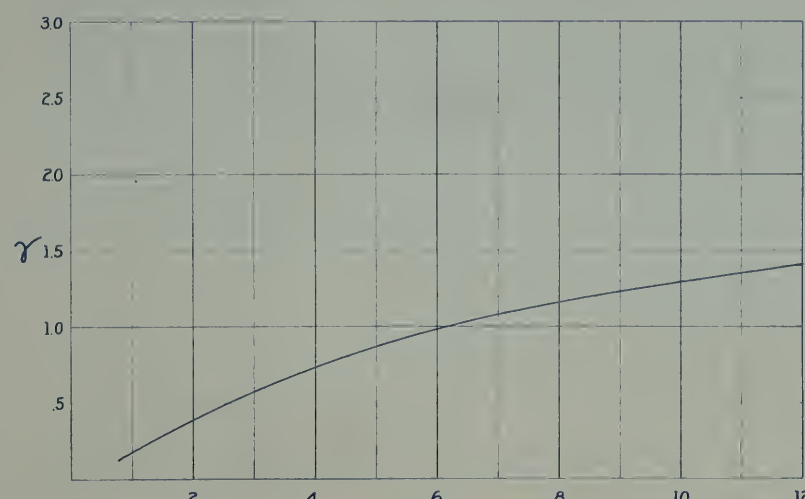


FIGURE 2

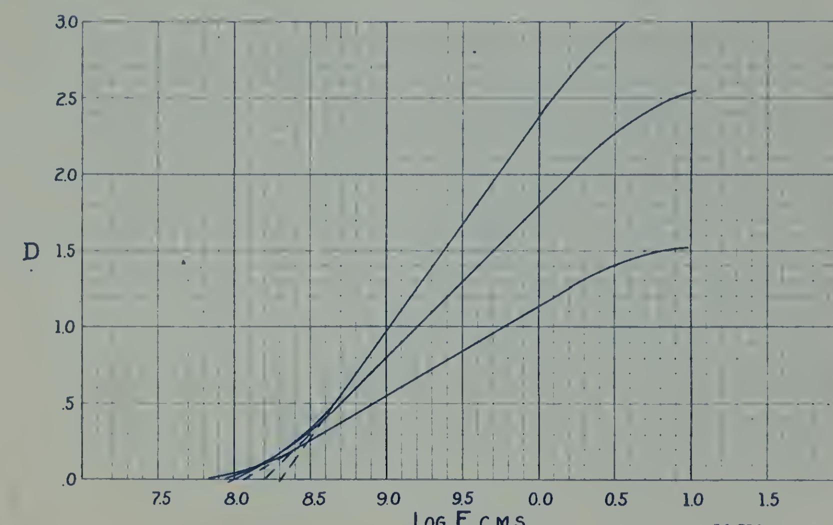
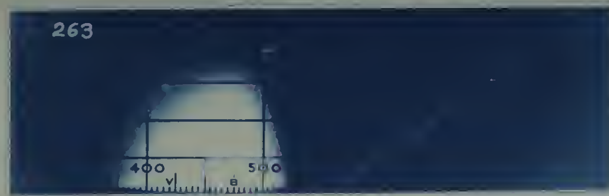


FIGURE 1.

EASTMAN
SEED'S 26X



COLOR SENSITIVITY

EMULSION No. 3696

DEVELOPER FORMULA X

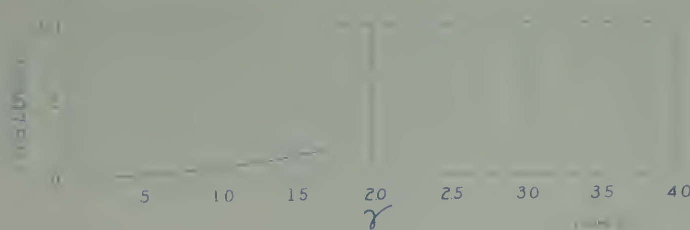
FILTER FACTORS

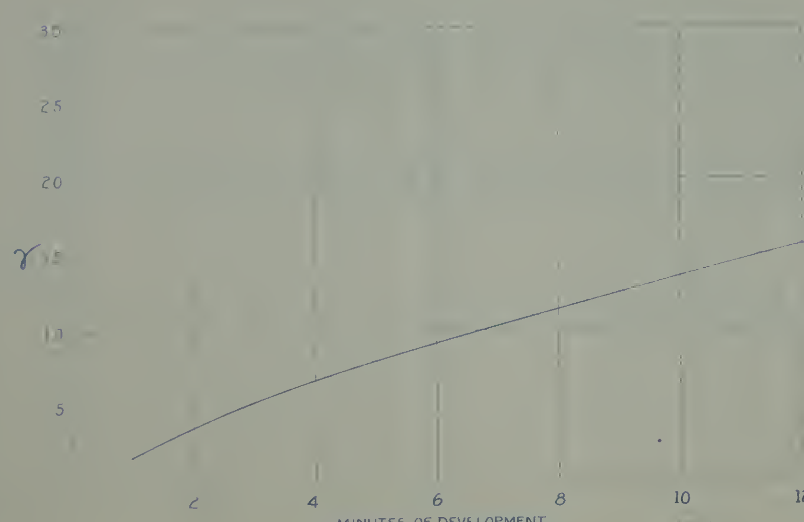
K_1	K_2	K_3	G	A	B	C	F

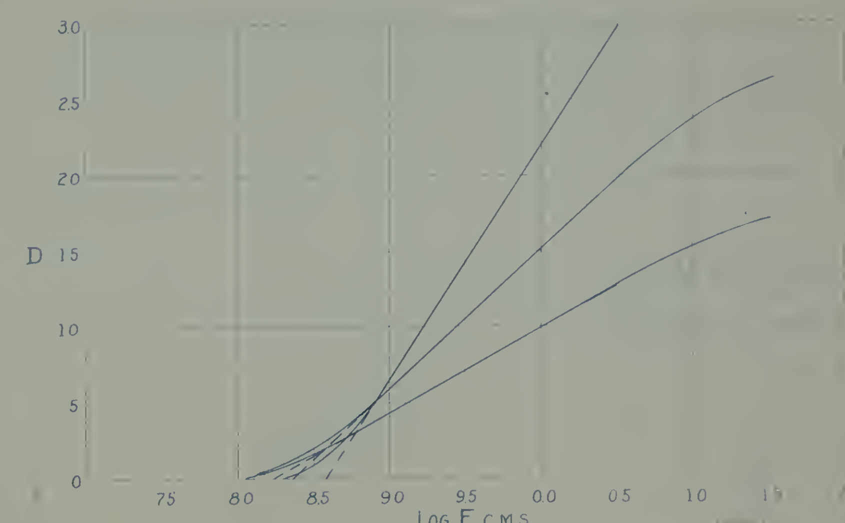
SPEED B 400

SCALE 80

RESOLUTION NUMBER 20



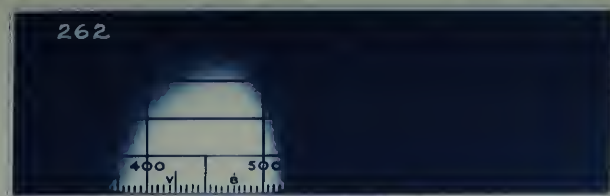




EASTMAN
SEED'S 23

EMULSION No 3746

DEVELOPER FORMULA. X



COLOR SENSITIVITY

FIGURE 4

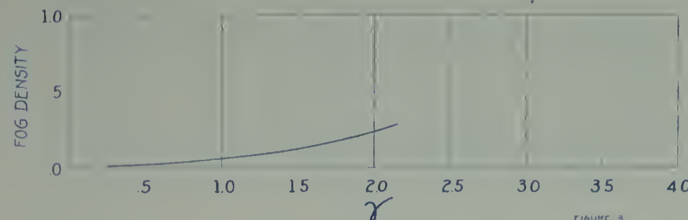


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S 180

SCALE 35

RESOLUTION NUMBER 20

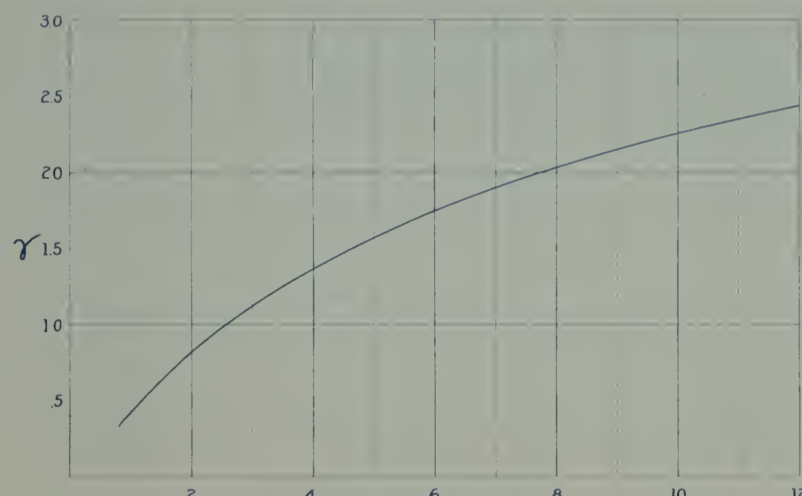


FIGURE 2

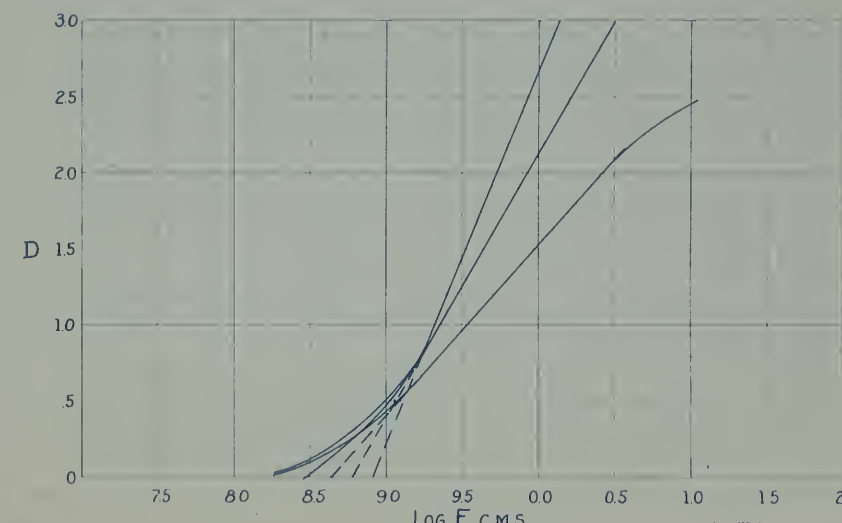


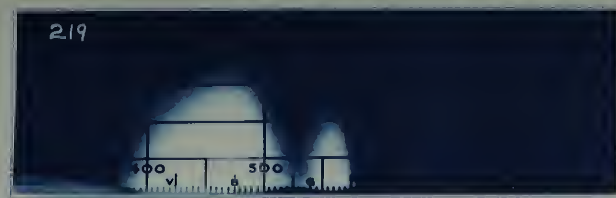
FIGURE 1

PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS.

EASTMAN
SEED'S L-ORTHO

EMULSION No. 3593

DEVELOPER FORMULA. X



COLOR SENSITIVITY

FIGURE 4

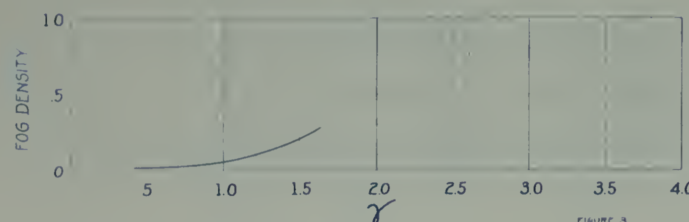


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
2.7	7.7	9.7	13.0				

SPEED B.S. 460

SCALE 200

RESOLUTION NUMBER 18

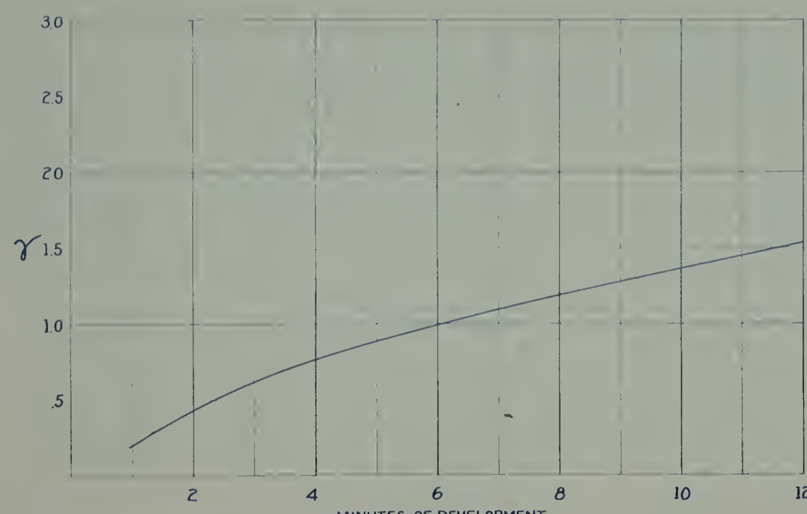


FIGURE 2

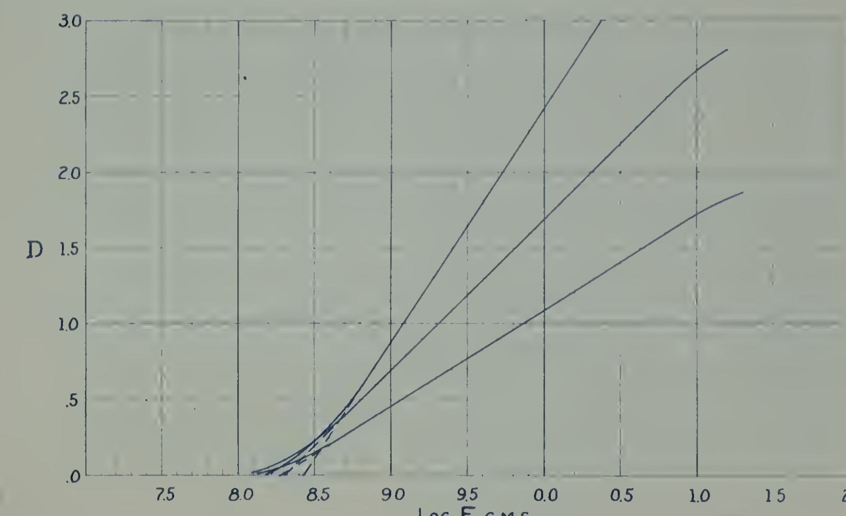


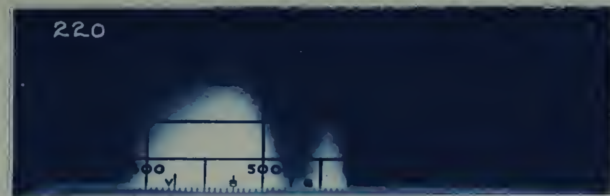
FIGURE 1

PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS

EASTMAN
SEED'S L-ORTHO N.H.

EMULSION No. 3611

DEVELOPER FORMULA. X



COLOR SENSITIVITY

FIGURE 4

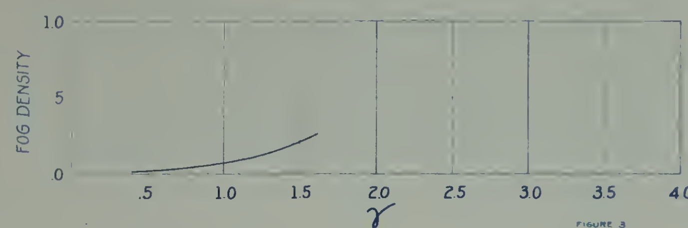


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
2.7	5.3	8.1	11.6				

SPEED BS 400

SCALE 200

RESOLUTION NUMBER 20

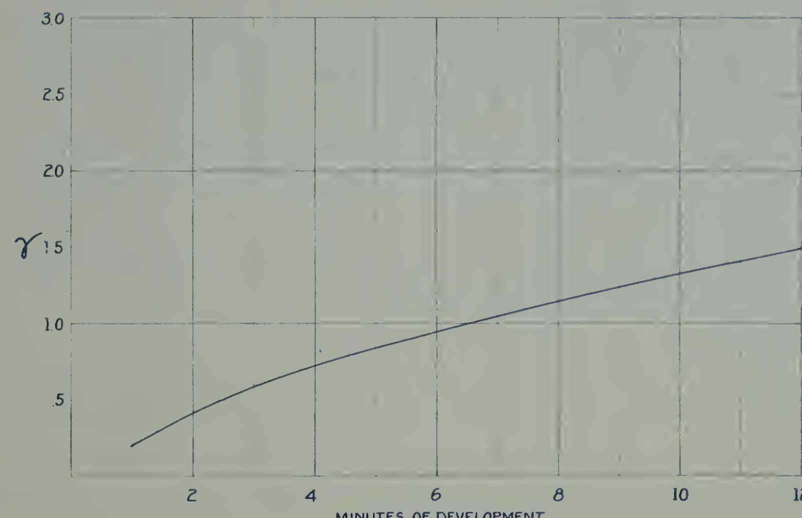


FIGURE 2

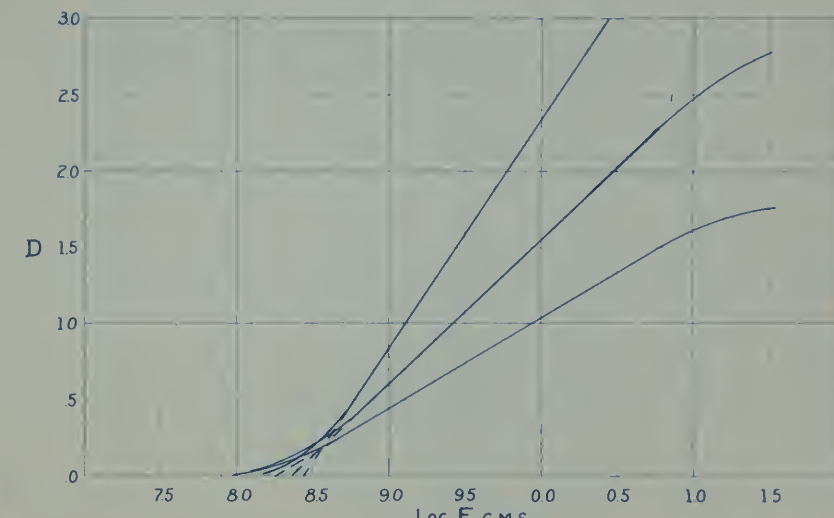


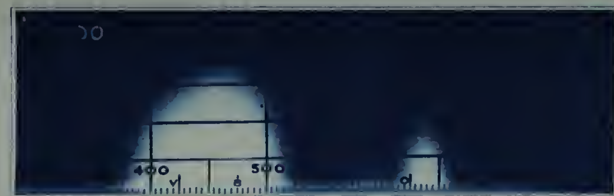
FIGURE 1

PHOTOGRAPHIC LABORATORY —

EASTMAN
SEED'S PANCHROMATIC

EMULSION No. 4071

DEVELOPER FORMULA. X



COLOR SENSITIVITY. FIGURE 4

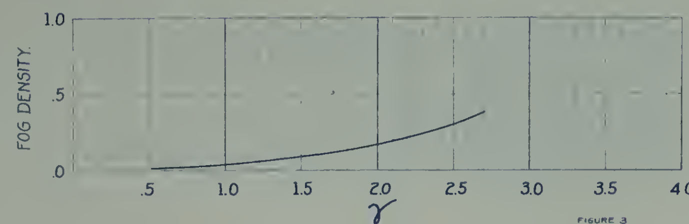


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.3	8.9	12.3	25.6	36.7	26.7	10.8	

SPEED B.S. 175

SCALE 25

RESOLUTION NUMBER 18

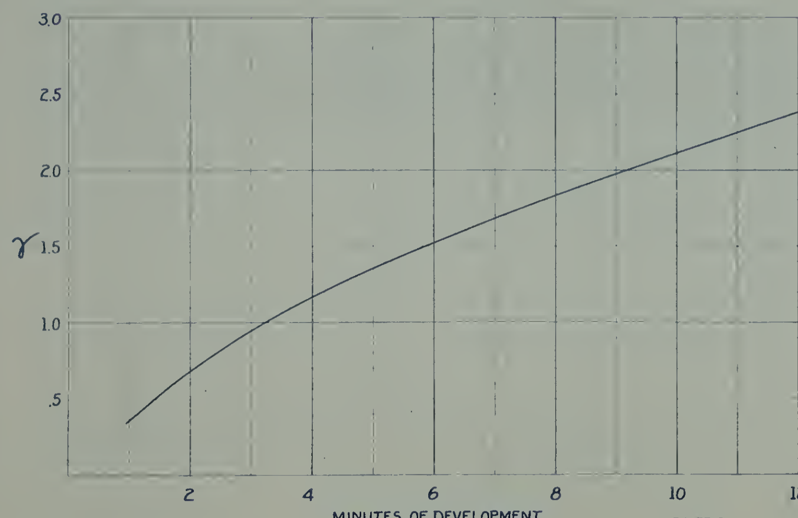


FIGURE 2

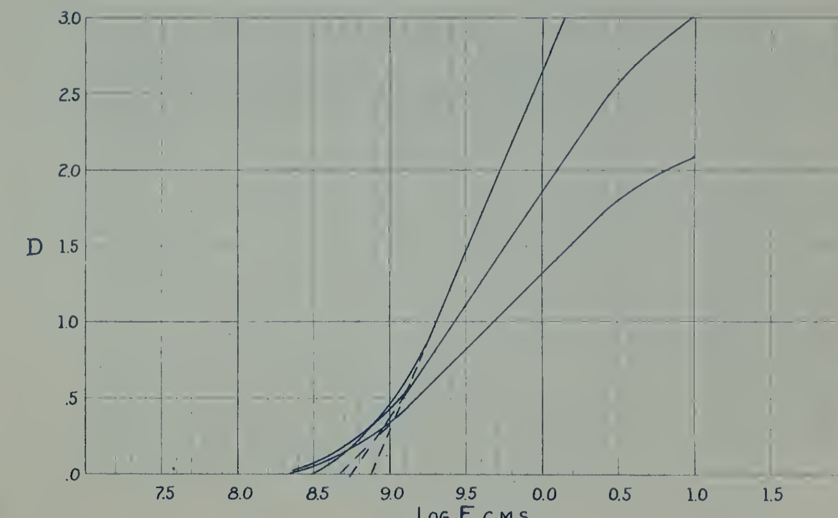


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

EASTMAN
SEED'S PROCESS

COLOR SENSITIVITY

FIGURE 4

EMULSION No. 3673

DEVELOPER FORMULA. X

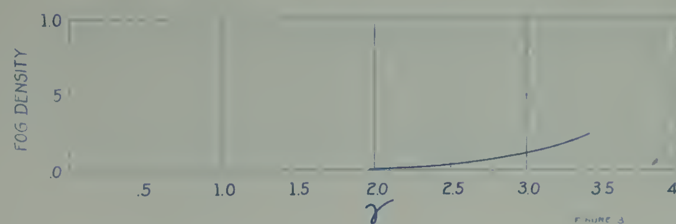


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 42

SCALE 6

RESOLUTION NUMBER 15

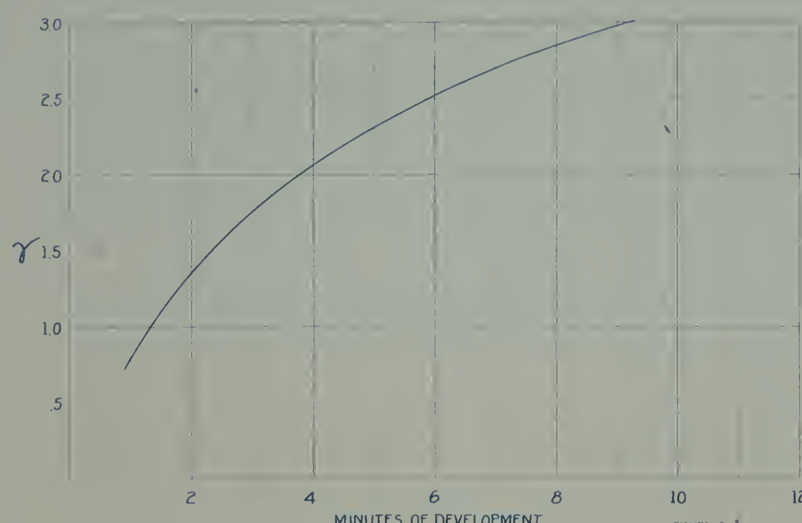


FIGURE 2

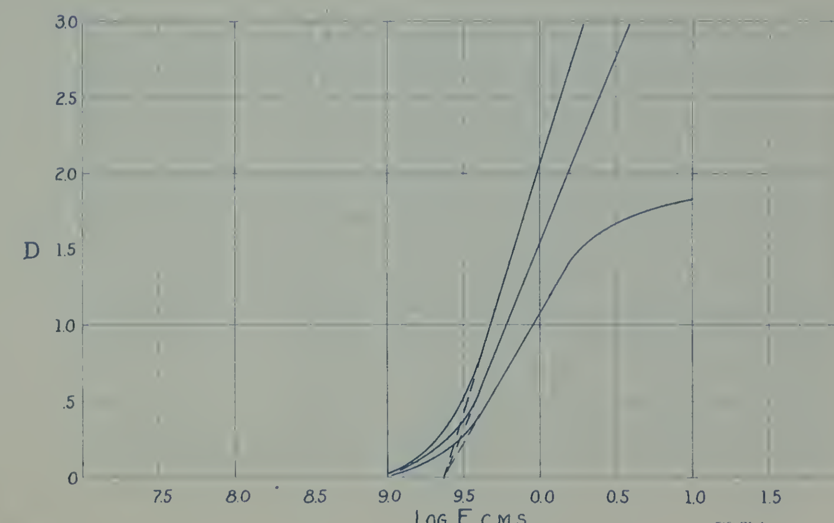


FIGURE 1

EASTMAN
SEED'S LANTERN SLIDE

EMULSION No. 3724

DEVELOPER FORMULA X

COLOR SENSITIVITY

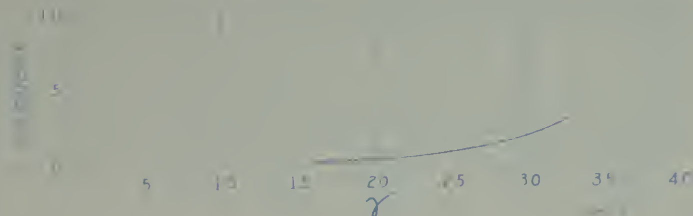
FILTER FACTORS

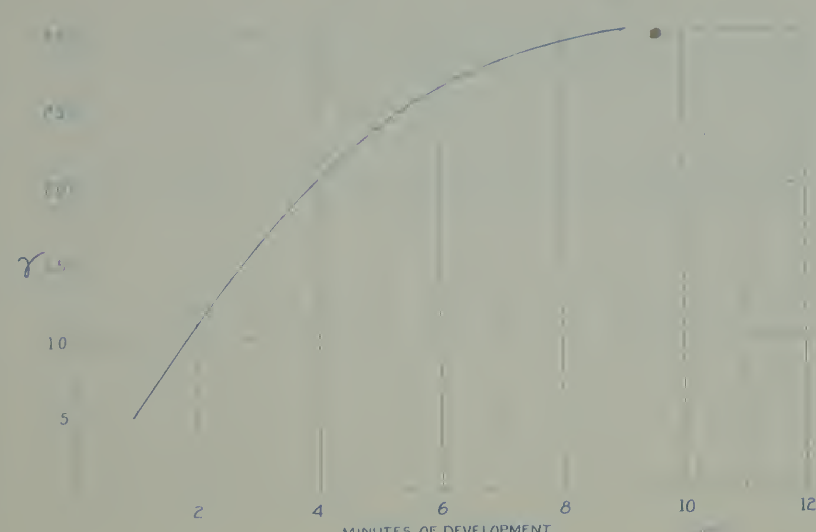
K_1	K_2	K_3	G	A	B	C	F

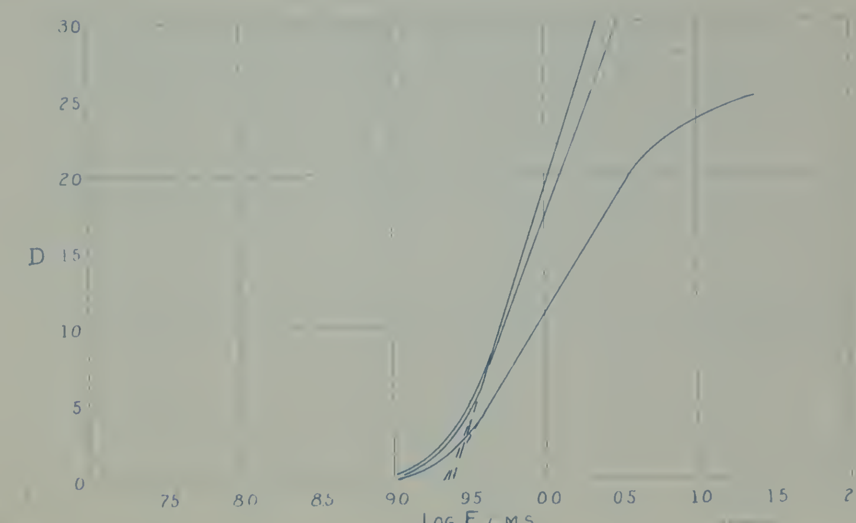
SPEED B.I. 40

SCALE 12

RESOLUTION NUMBER 15







EASTMAN
STANDARD EXTRA IMPERIAL

EMULSION No. 3166

DEVELOPER FORMULA. X

COLOR SENSITIVITY. FIGURE 4

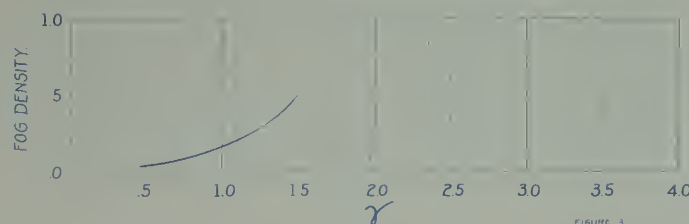


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 510

SCALE 100

RESOLUTION NUMBER 21

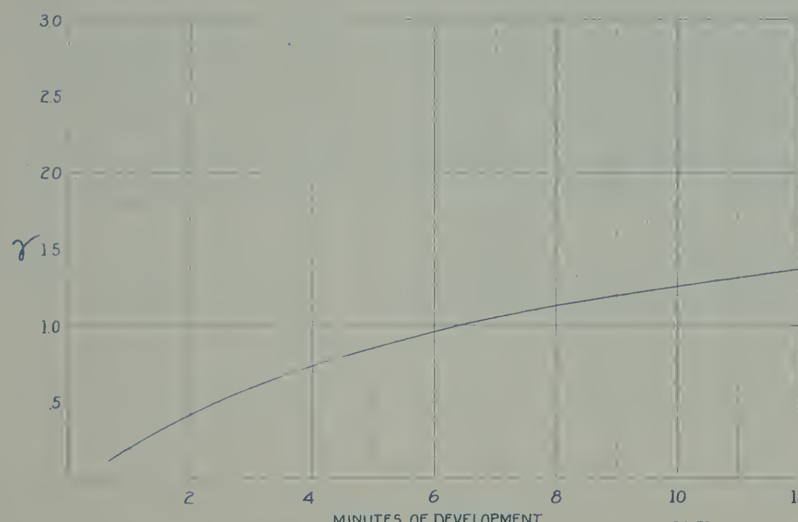


FIGURE 2

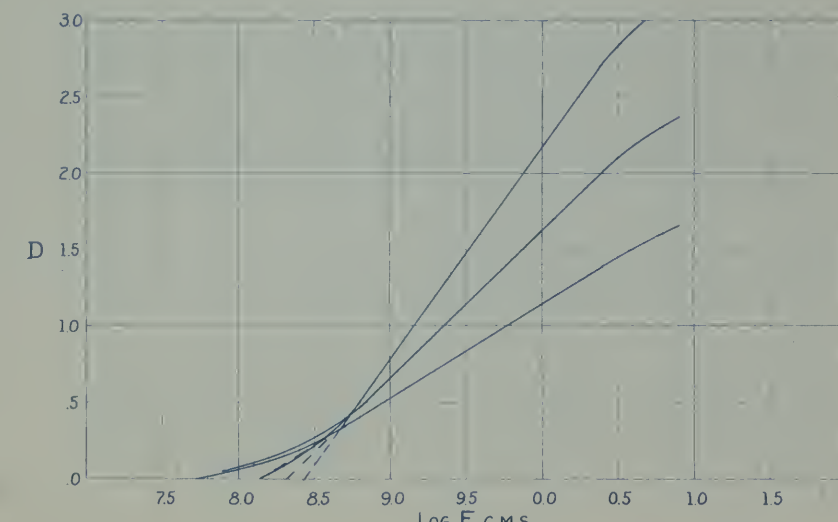
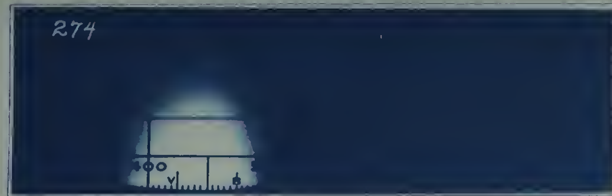


FIGURE 1

EASTMAN
STANDARD POST CARD

EMULSION No. 3354

DEVELOPER FORMULA. X



COLOR SENSITIVITY. FIGURE 4

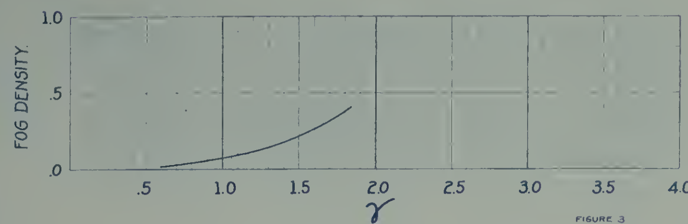


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S 330

SCALE 20

RESOLUTION NUMBER 19

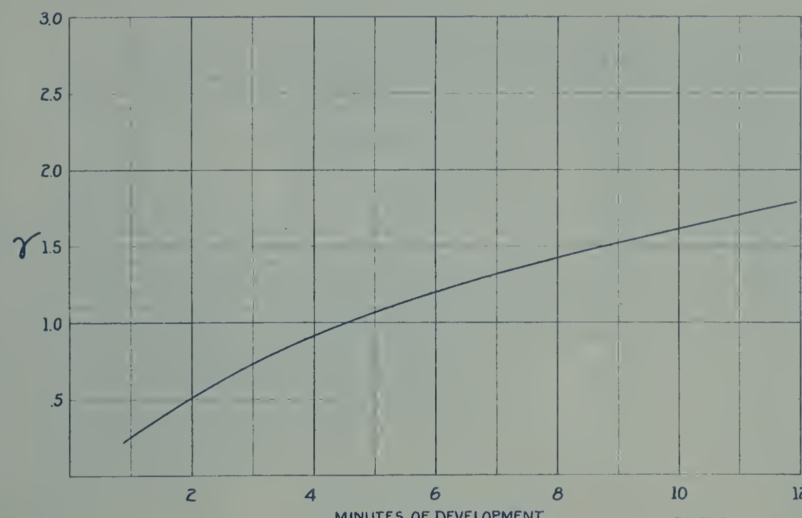


FIGURE 2

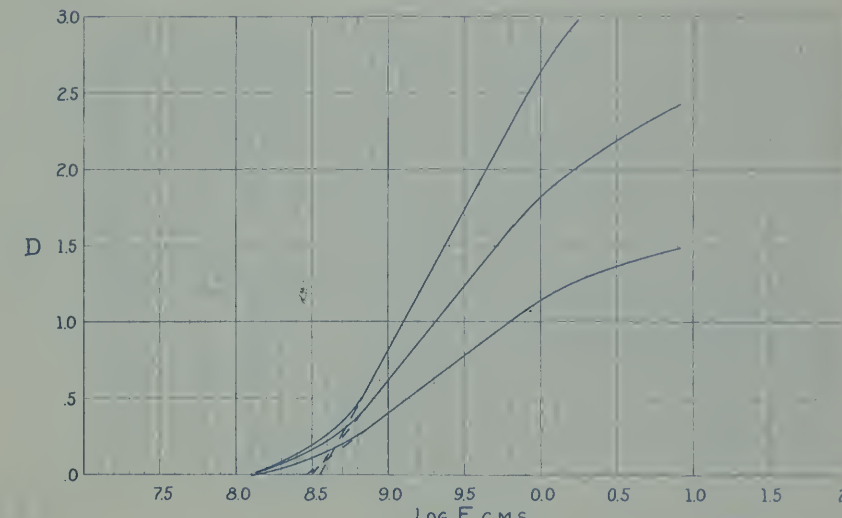
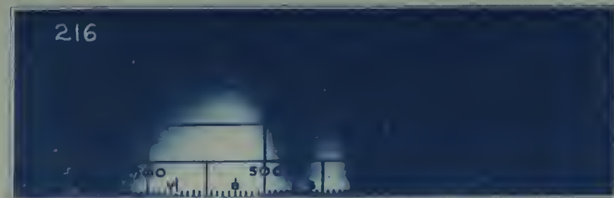


FIGURE 1

EASTMAN
STANDARD ORTHONON

EMULSION No. 3151

DEVELOPER FORMULA. X



COLOR SENSITIVITY

FIGURE 4

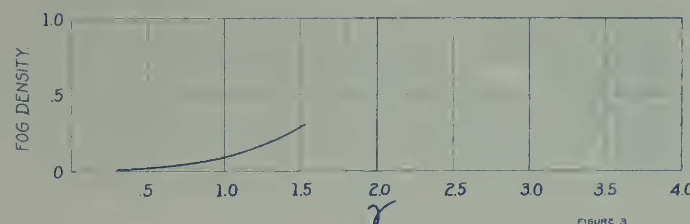


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
2.4	6.4	8.5	14.1				

SPEED B.S. 460

SCALE 200

RESOLUTION NUMBER 21

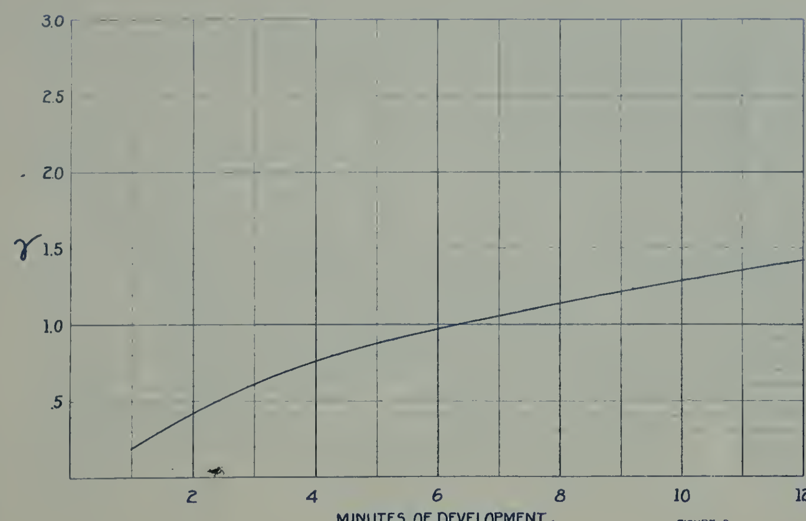


FIGURE 2

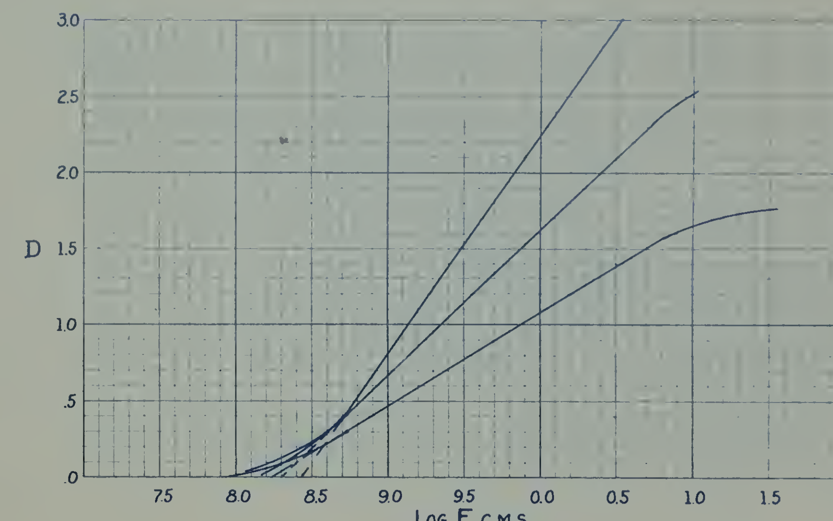


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS

60

EASTMAN
STANDARD POLYCHROME

EMULSION No. 3157

DEVELOPER FORMULA. X

COLOR SENSITIVITY. FIGURE 4

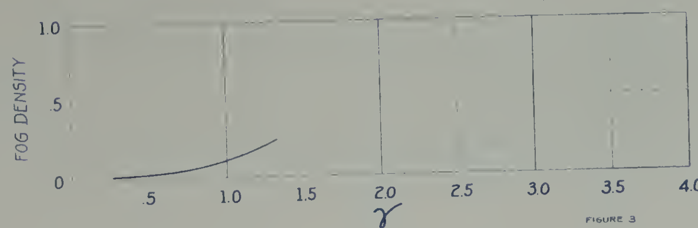


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
4.5	7.9	11.3	21.5				

SPEED B.S. 600

SCALE 55

RESOLUTION NUMBER 20

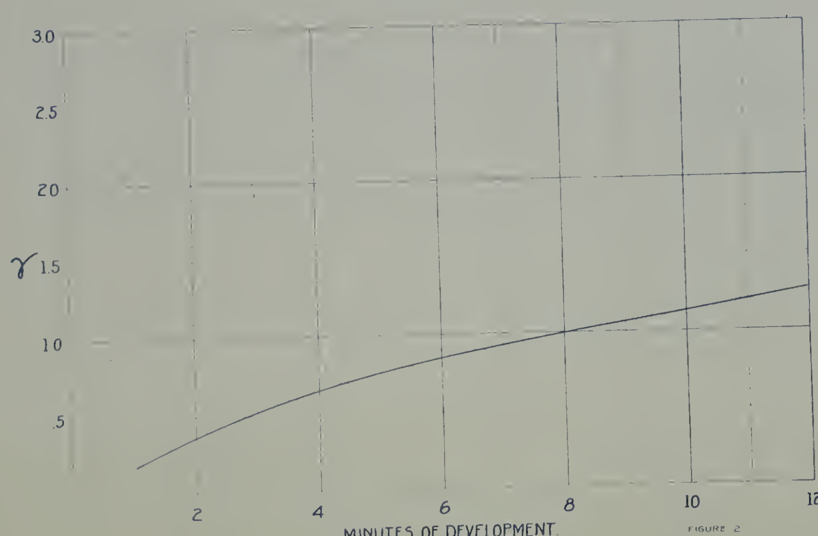


FIGURE 2

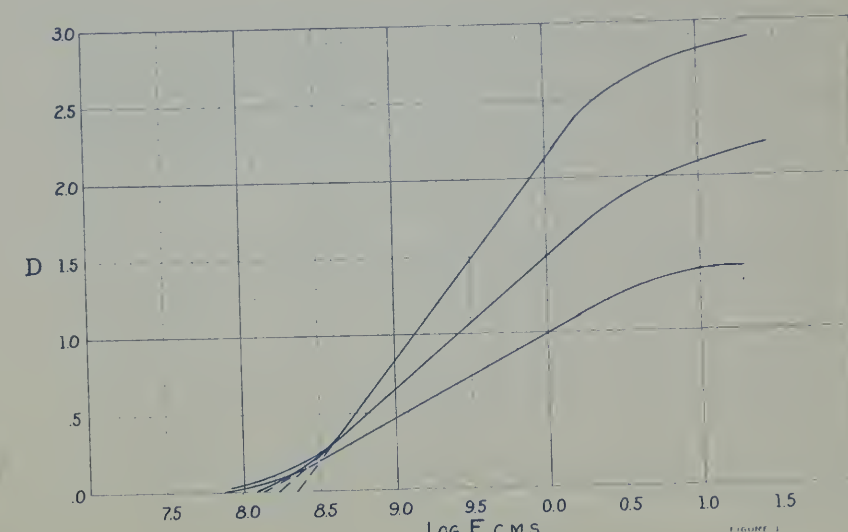


FIGURE 1

EASTMAN
STANDARD LANTERN SLIDE

EMULSION No. 3180

DEVELOPER FORMULA. X

COLOR SENSITIVITY. FIGURE 4

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 34

SCALE 8

RESOLUTION NUMBER 14

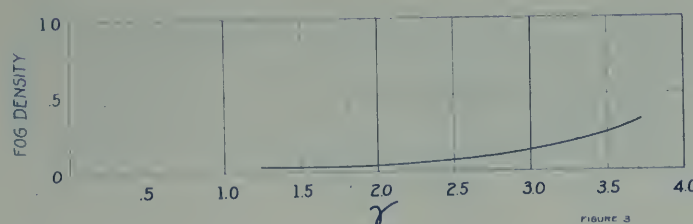


FIGURE 3

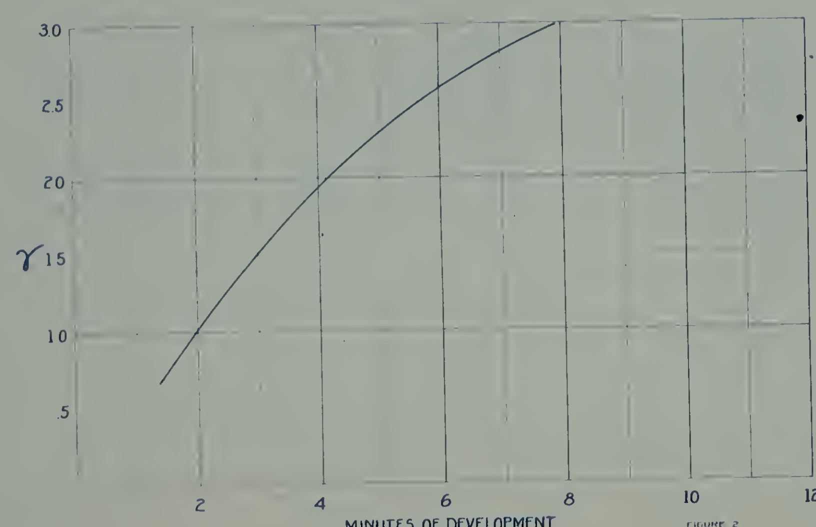


FIGURE 2

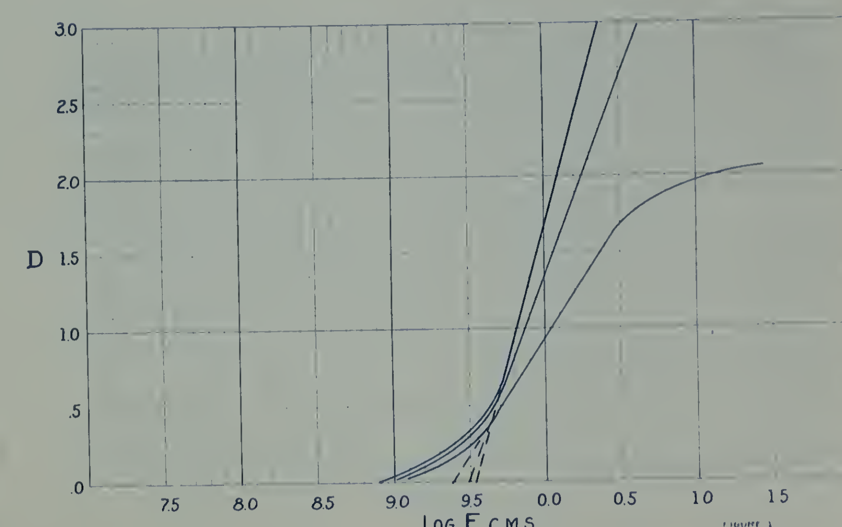
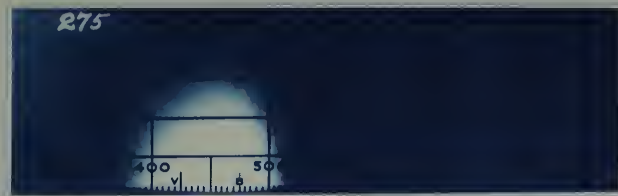


FIGURE 1

PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS.

EASTMAN
STANLEY 50



COLOR SENSITIVITY FIGURE 4

EMULSION No. 3171

DEVELOPER FORMULA. X

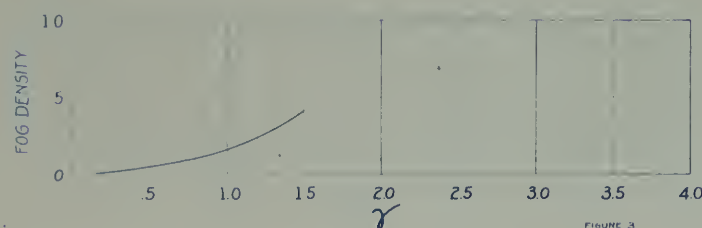


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 550

SCALE 50

RESOLUTION NUMBER 18

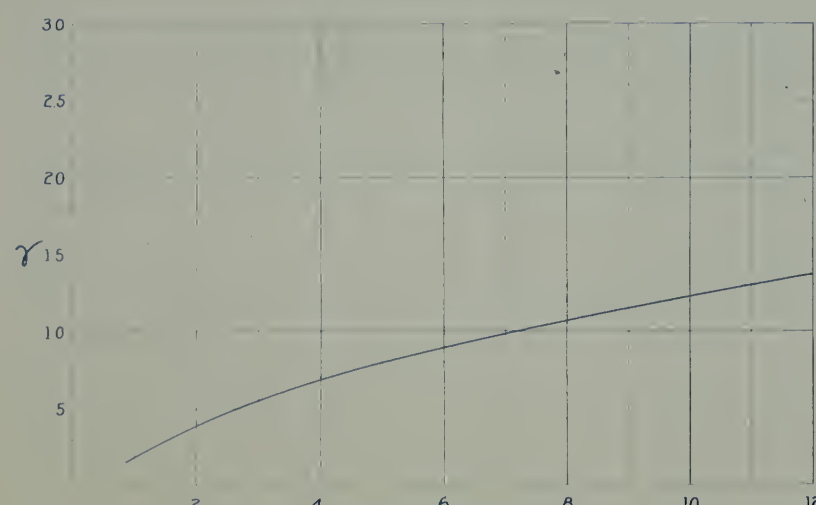


FIGURE 2

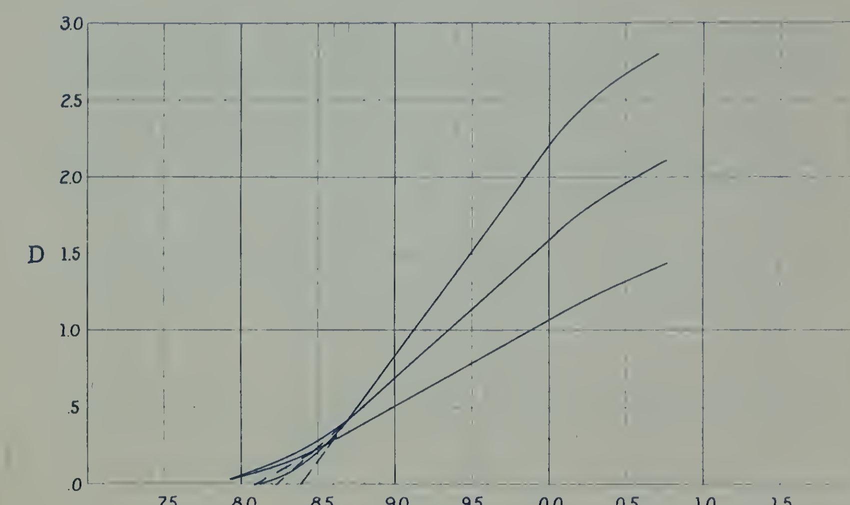
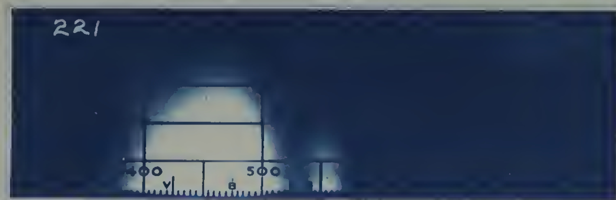


FIGURE 1

EASTMAN
STANDARD POLYCHROME



COLOR SENSITIVITY

FIGURE 4

EMULSION No. 3157

DEVELOPER FORMULA. X

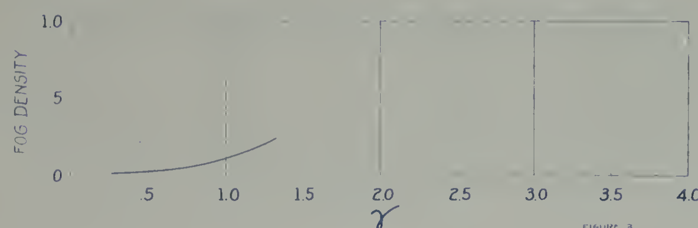


FIGURE 3

FILTER FACTORS.

K1	K2	K3	G	A	B	C	F
4.5	7.9	11.3	21.5				

SPEED B.S 600

SCALE 55

RESOLUTION NUMBER 20

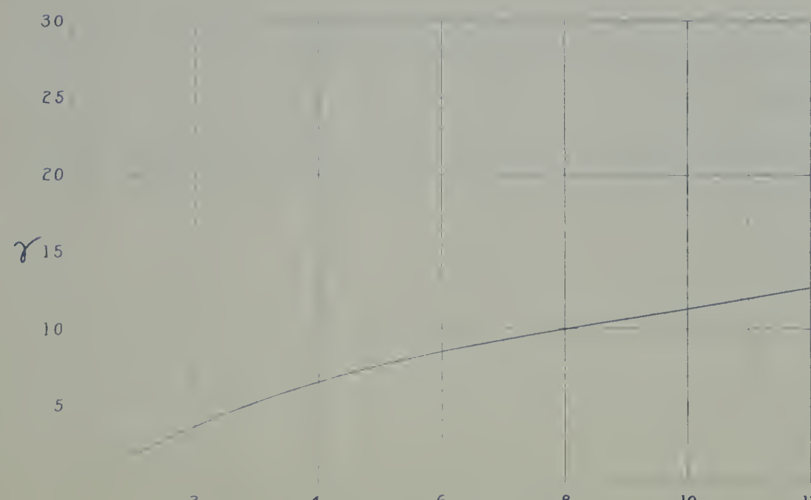


FIGURE 2

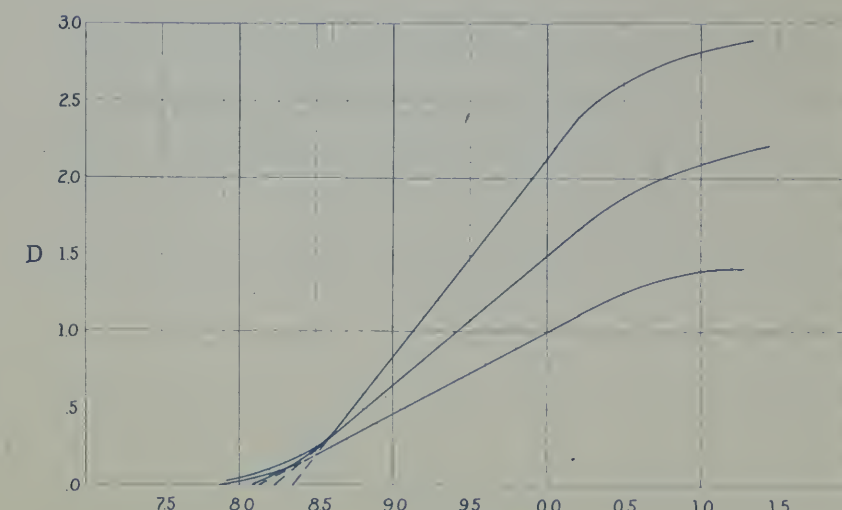


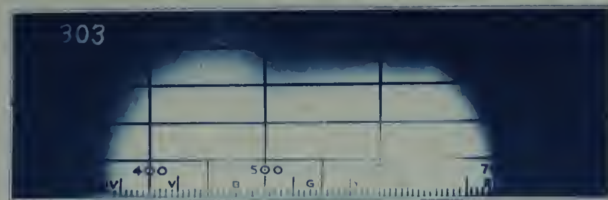
FIGURE 1

PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS

EASTMAN
WRATTEN PANCHROMATIC

EMULSION No. 2739

DEVELOPER FORMULA. X



COLOR SENSITIVITY

FIGURE 4

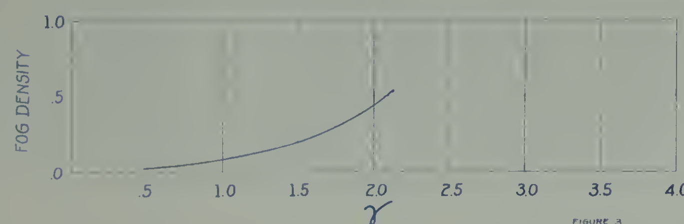


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
2.3	3.3	3.6	4.7	10.0	11.0	14.3	16.6

SPEED B.S. 160

SCALE 50

RESOLUTION NUMBER 20

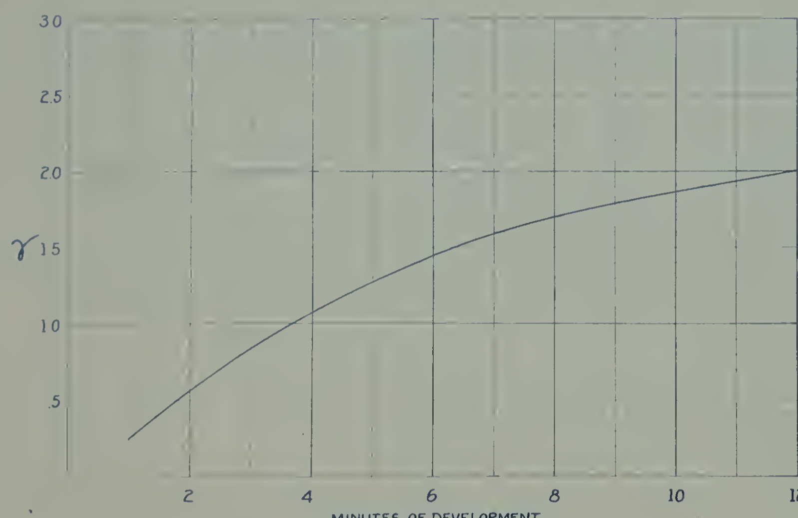


FIGURE 2

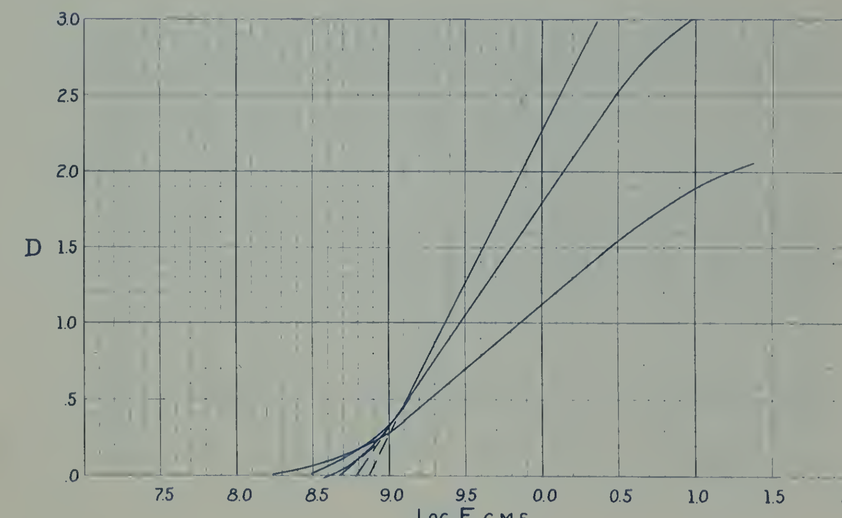
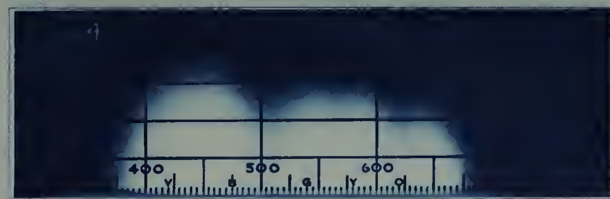


FIGURE 1.

EASTMAN
WRATTEN M

EMULSION No. 2440

DEVELOPER FORMULA. X



COLOR SENSITIVITY

FIGURE 4

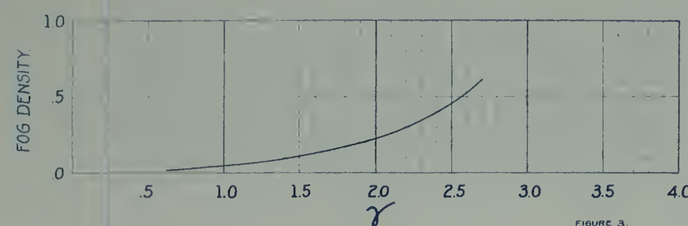


FIGURE 3.

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
2.6	3.8	4.6	5.9	15.9	12.3	15.2	22.5

SPEED B.S. 95

SCALE 25

RESOLUTION NUMBER 18

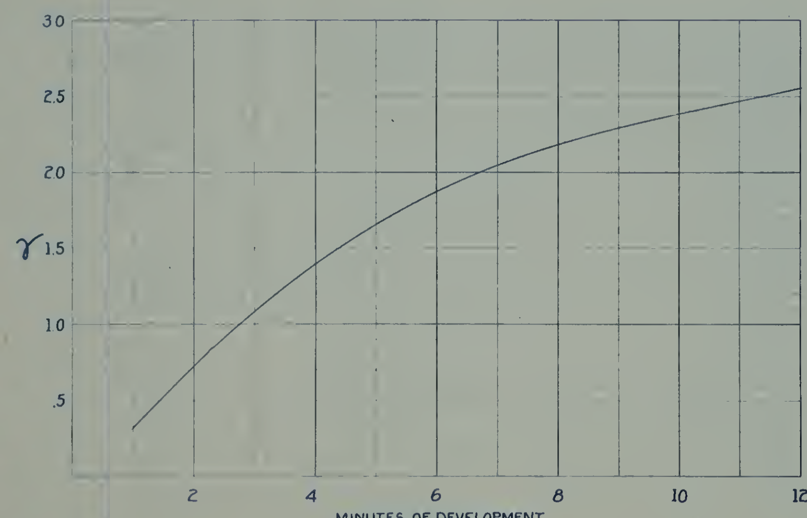


FIGURE 2.

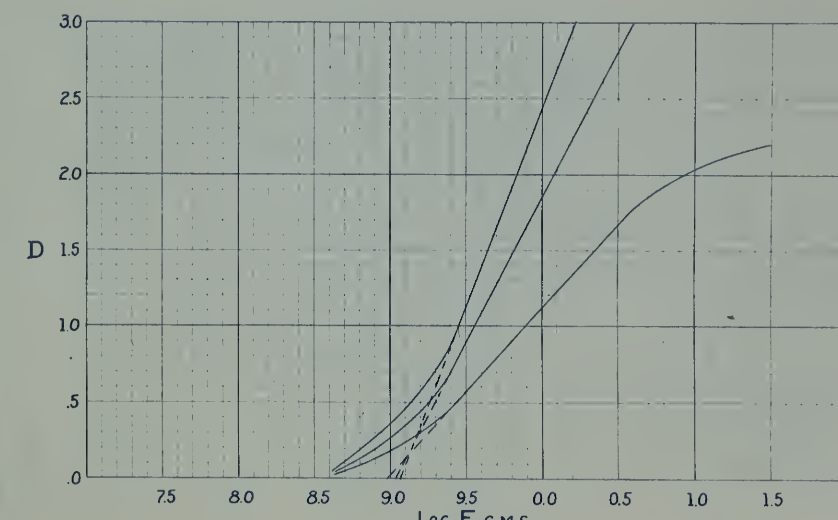
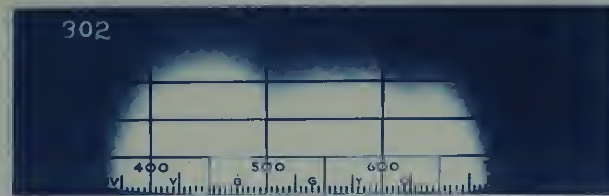


FIGURE 1

PHOTOGRAPHIC LABORATORY— BUREAU OF STANDARDS



COLOR SENSITIVITY. FIGURE 4

EASTMAN
WRATTEN PROCESS PANCHROMATIC

EMULSION No. 2754

DEVELOPER FORMULA. X

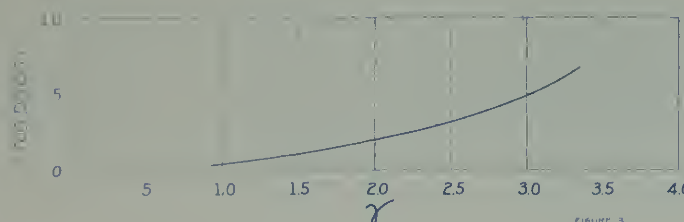


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
2.5	4.0	4.6	5.8	18.1	13.2	13.8	28.4

SPEED B.S. 95

SCALE 20

RESOLUTION NUMBER 18

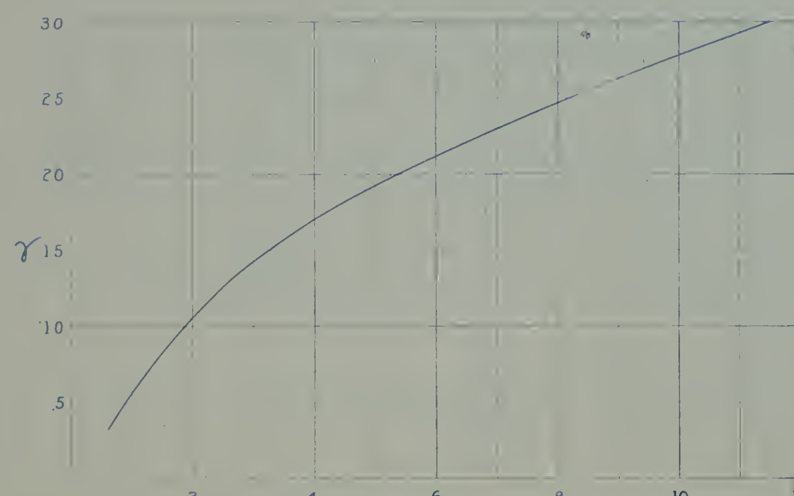


FIGURE 2

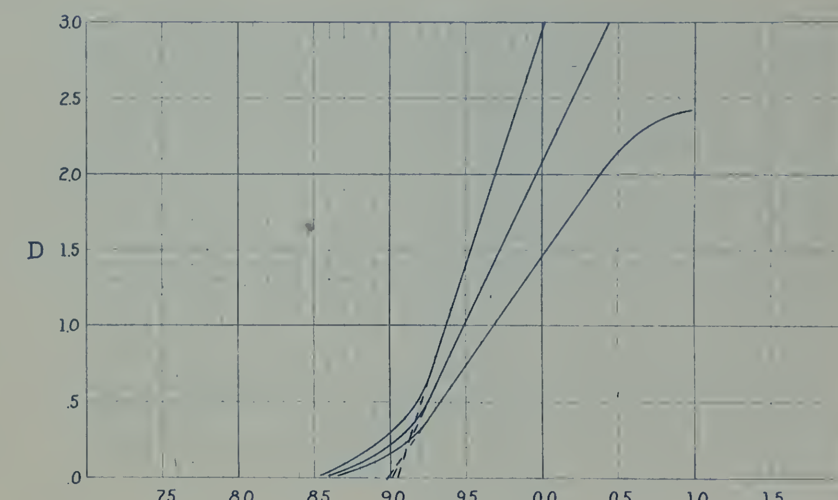


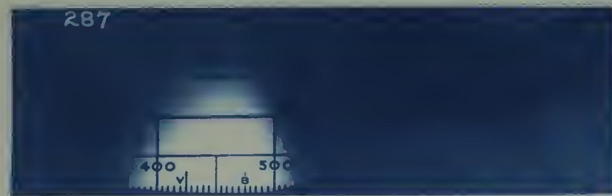
FIGURE 1

PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS.

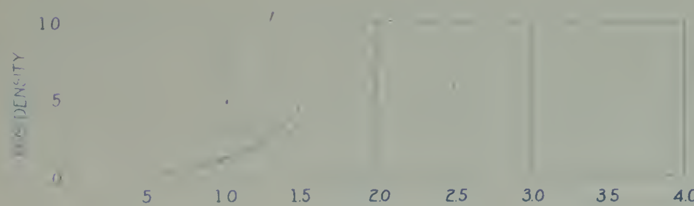
HAMMER
SPECIAL EXTRA FAST

EMULSION No. 9260

DEVELOPER FORMULA. Y



COLOR SENSITIVITY



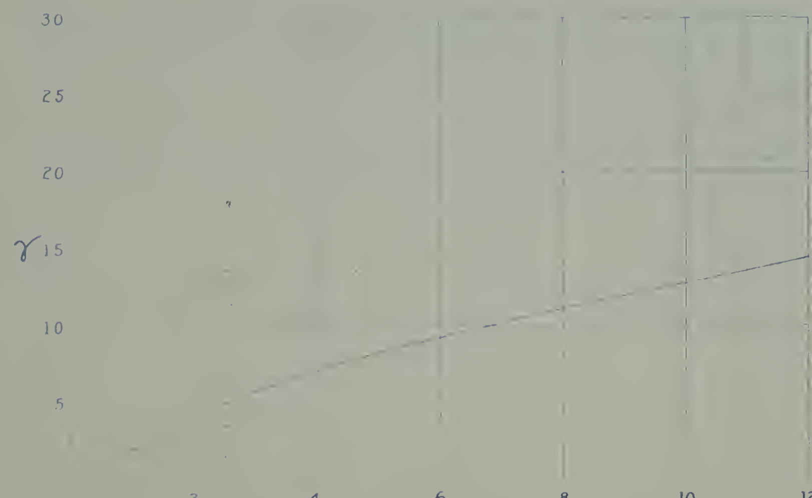
FILTER FACTORS.

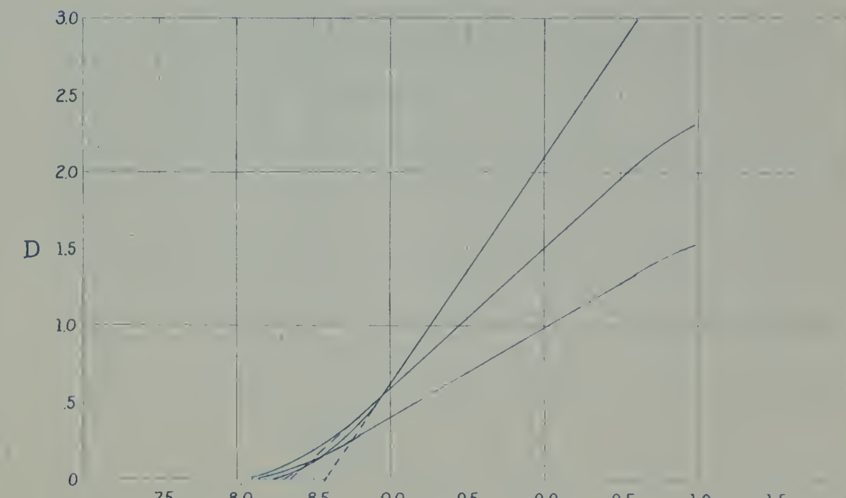
K_1	K_2	K_3	G	A	B	C	F

SPEED BS 385

SCALE 150

RESOLUTION NUMBER 26

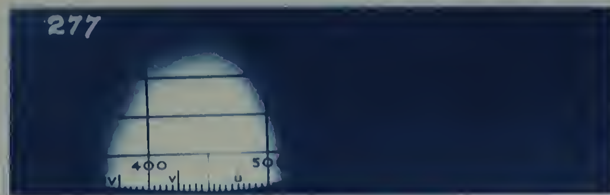




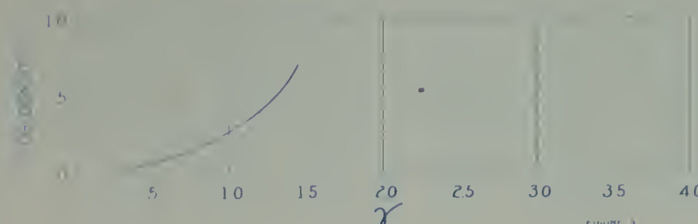
HAMMER
POSTAL

EMULSION No 9230

DEVELOPER FORMULA Y



COLOR SENSITIVITY



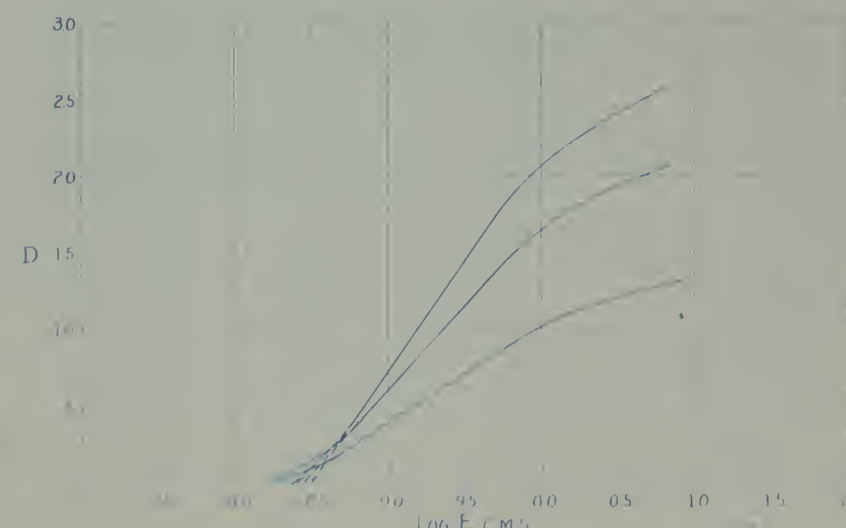
FILTER FACTORS

K1	K2	K3	G	A	B	C	F

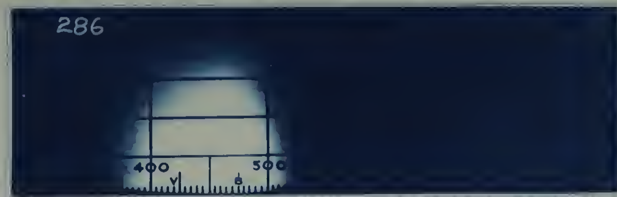
SPEED BS 360

SCALE 25

RESOLUTION NUMBER 22



HAMMER
EXTRA FAST



COLOR SENSITIVITY

FIGURE 4

EMULSION No. 9264

DEVELOPER FORMULA. Y

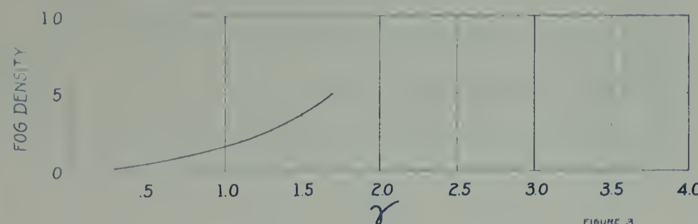


FIGURE 3

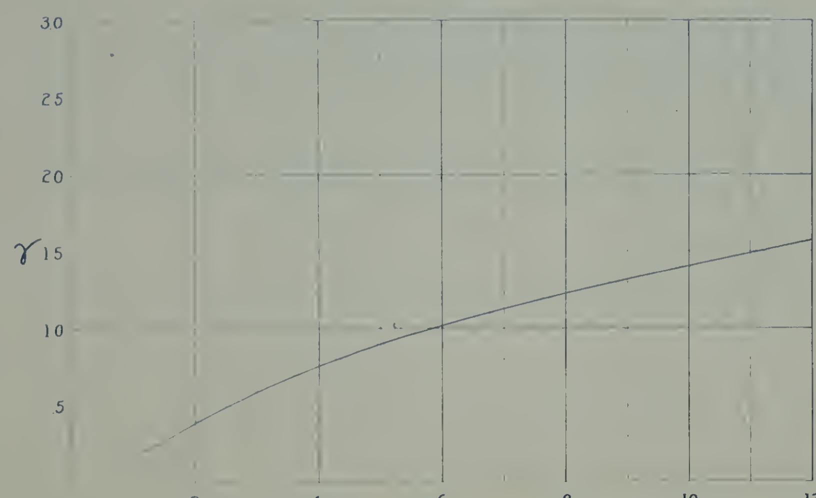
FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B.S 300

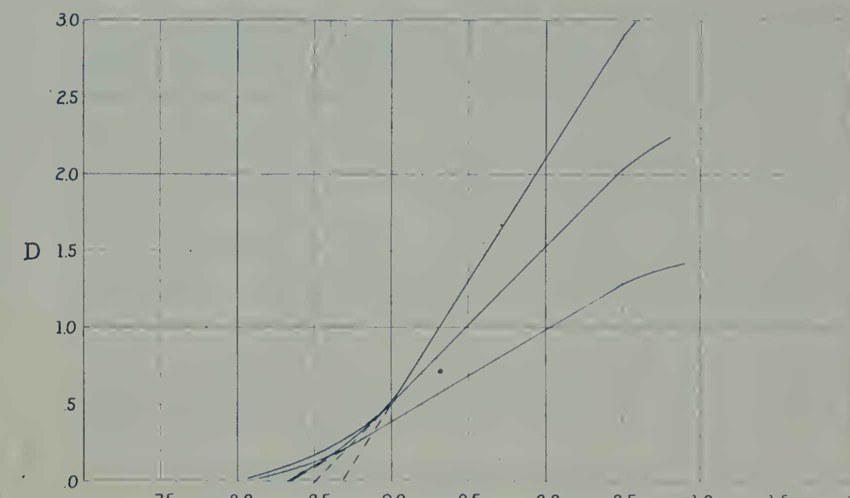
SCALE 80

RESOLUTION NUMBER 26



MINUTES OF DEVELOPMENT.

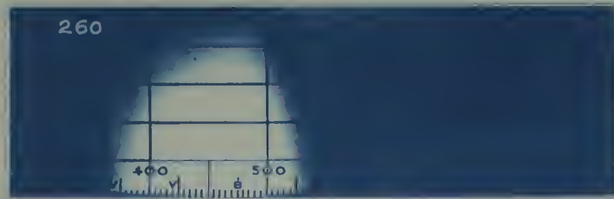
FIGURE 2



LOG. E C.M.S.

FIGURE 1

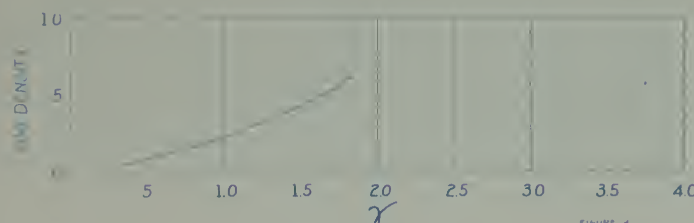
HAMMER
AURORA



COLOR SENSITIVITY

EMULSION No. 9255

DEVELOPER FORMULA. Y



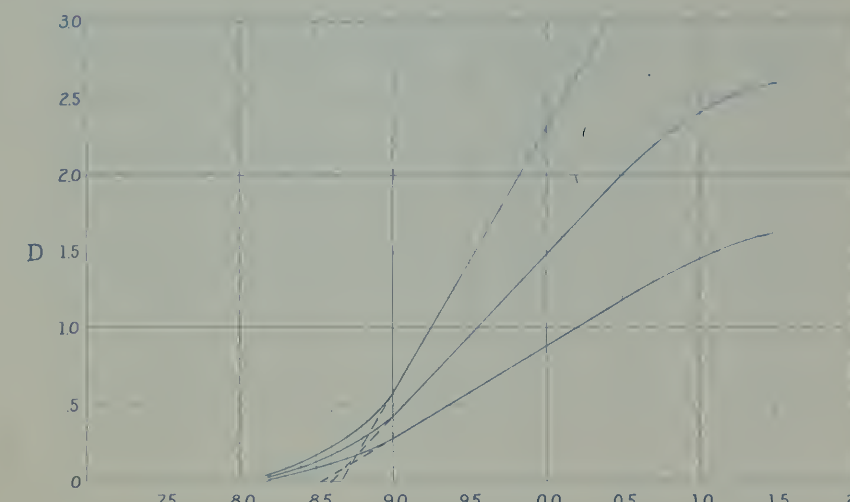
FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F

SPEED B S 245

SCALE 80

RESOLUTION NUMBER 28



HAMMER
SLOW

COLOR SENSITIVITY

EMULSION No 9247

DEVELOPER FORMULA Y

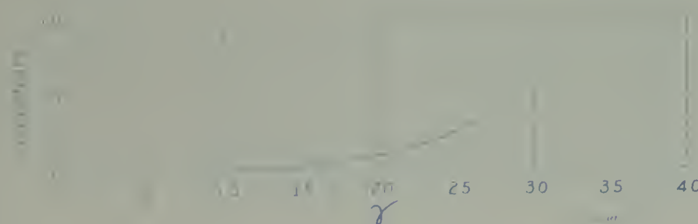
FILTER FACTORS.

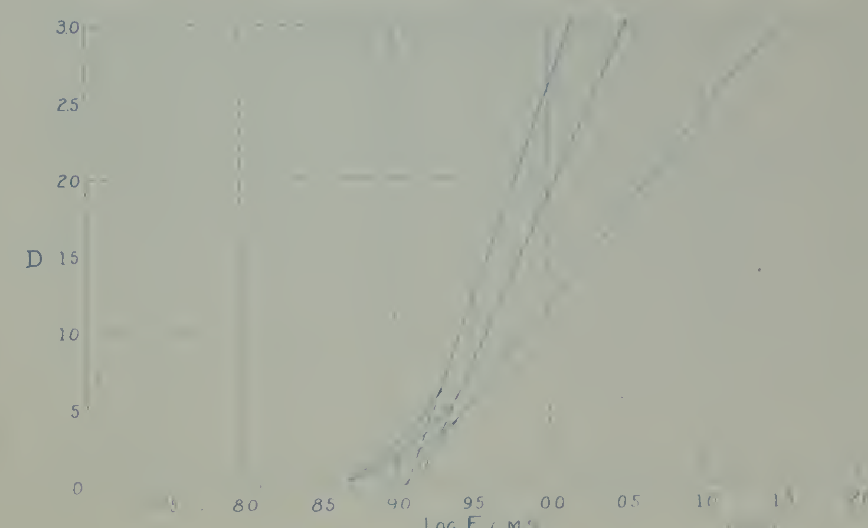
K_1	K_2	K_3	G	A	B	C	F

SPEED B S 80

SCALE 90

RESOLUTION NUMBER 18

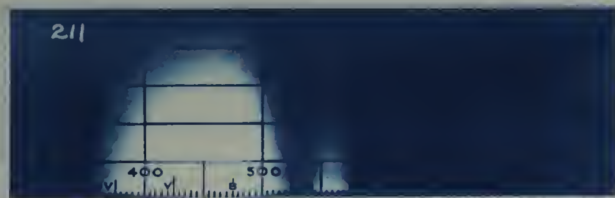




HAMMER
ORTHO N.H.

EMULSION No. 9069

DEVELOPER FORMULA. Y



COLOR SENSITIVITY. FIGURE 4

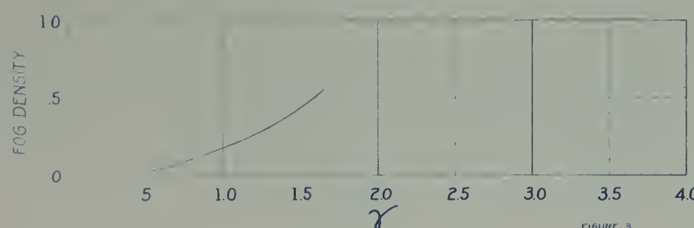


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.1	12.8	16.4	48.0				

SPEED B.S 330

SCALE 100

RESOLUTION NUMBER 20

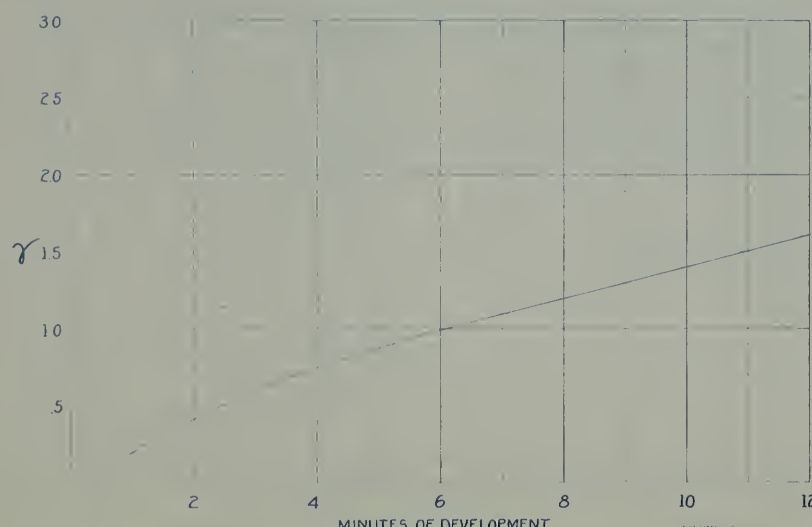


FIGURE 2

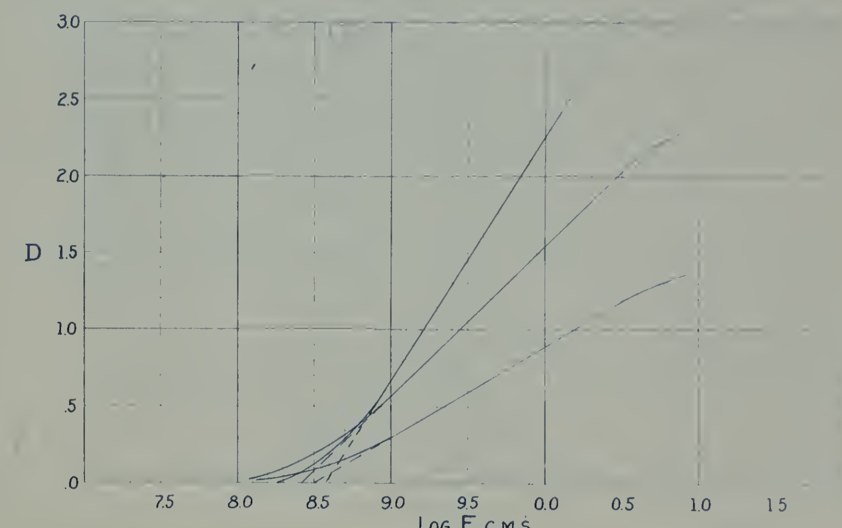
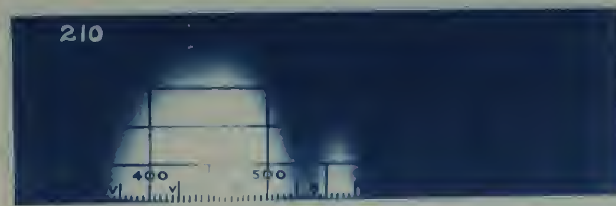


FIGURE 1

HAMMER
ORTHO EXTRA FAST

EMULSION No 9221

DEVELOPER FORMULA. Y



COLOR SENSITIVITY

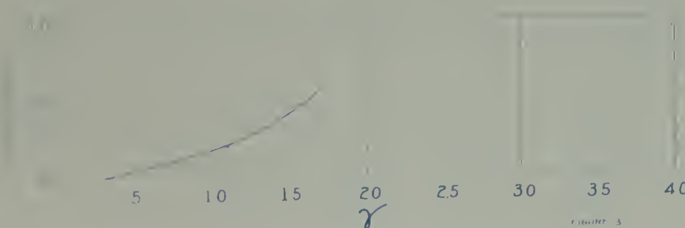
FILTER FACTORS

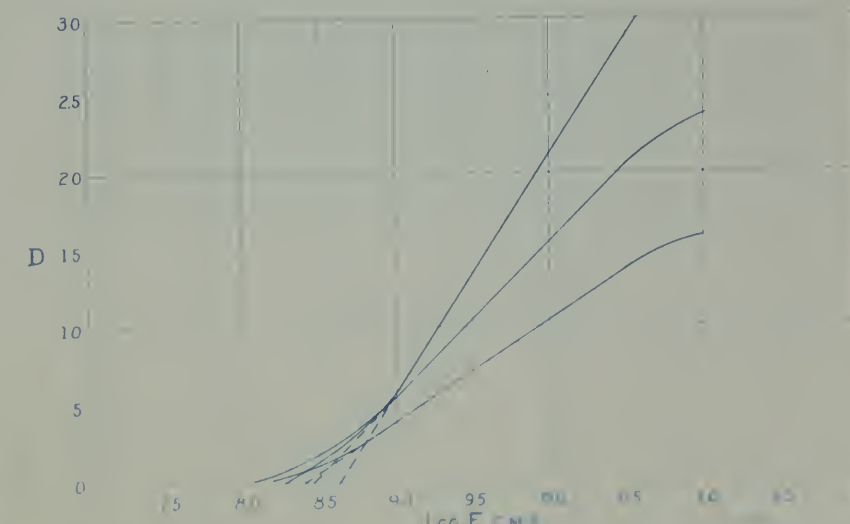
K_1	K_2	K_3	G	A	B	C	F
3.1	10.6	17.2	48.9				

SPEED BS 310

SCALE 80

RESOLUTION NUMBER 22





HAMMER
ORTHO N.H.

COLOR SENSITIVITY

FIGURE 4

EMULSION No. 9069

DEVELOPER FORMULA. Y

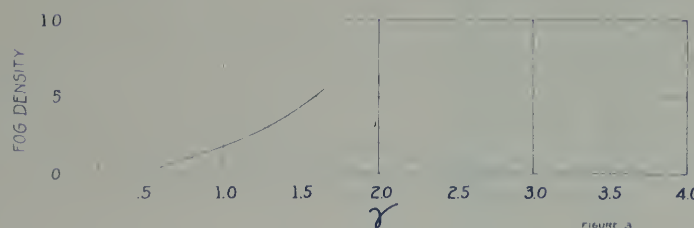


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.1	12.8	16.4	48.0				

SPEED BS 330

SCALE 100

RESOLUTION NUMBER 20

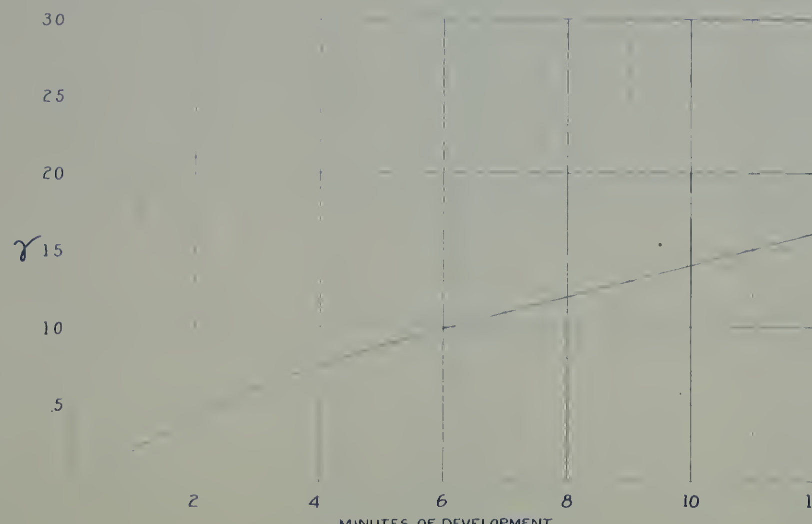


FIGURE 2

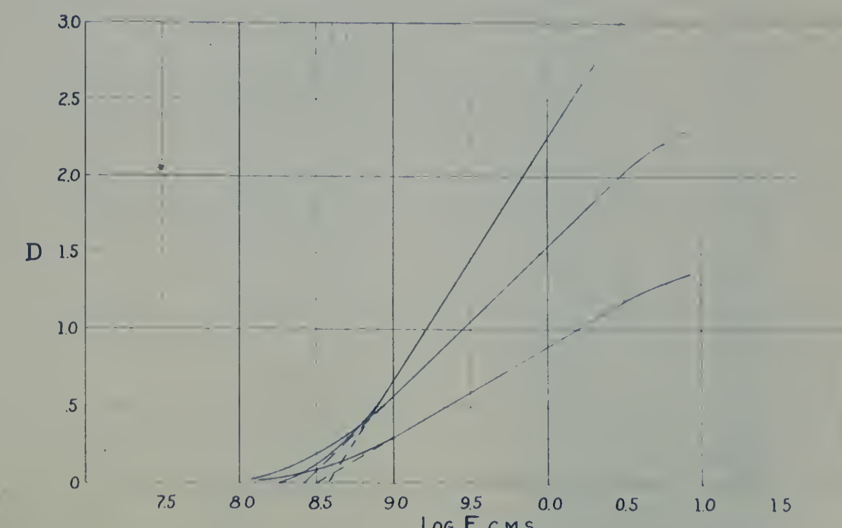
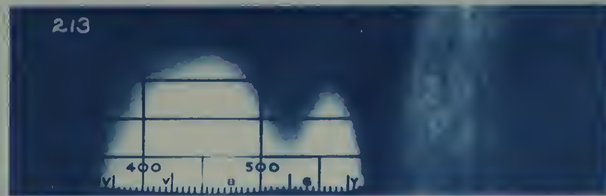


FIGURE 1

HAMMER
ORTHO COMMERCIAL



COLOR SENSITIVITY

EMULSION No 9192

DEVELOPER FORMULA Y

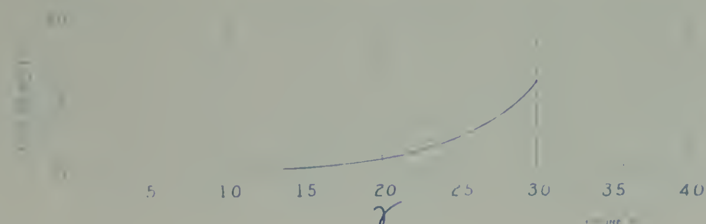
FILTER FACTORS

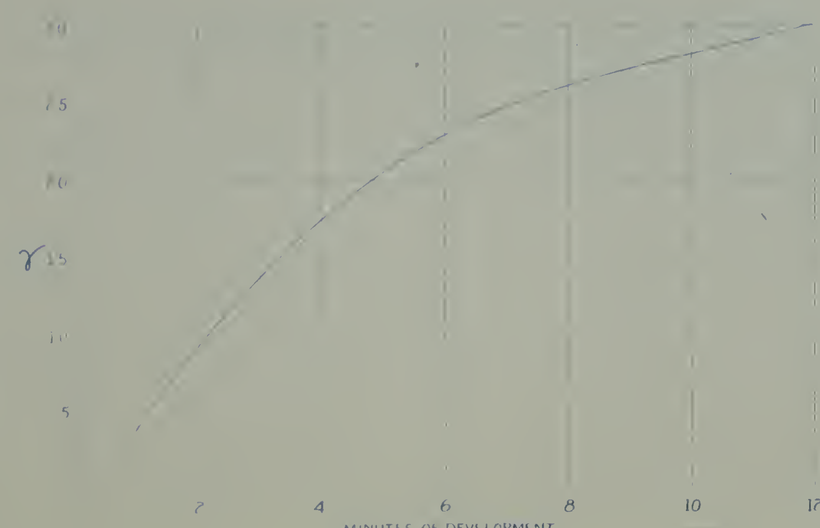
K_1	K_2	K_3	G	A	B	C	F
4.4	9.8	12.3	16.2				

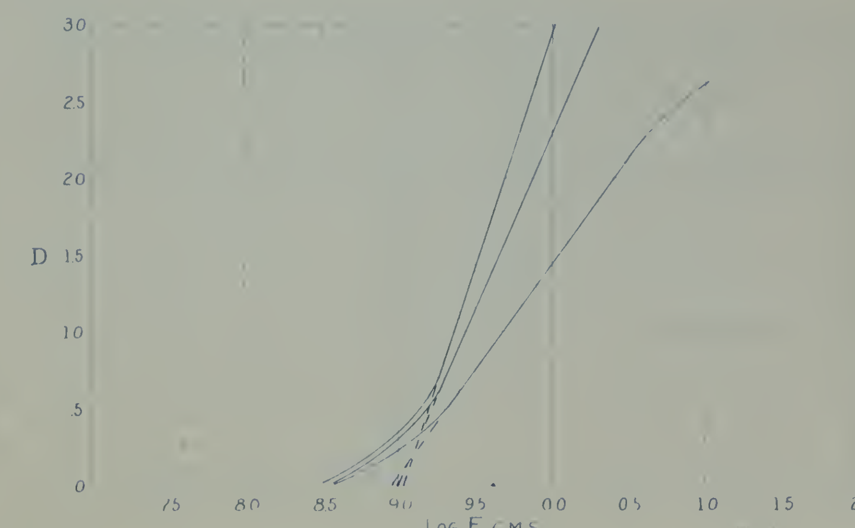
SPEED 100

SCALE 30

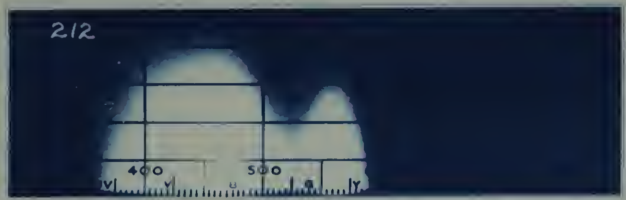
RESOLUTION NUMBER 18







HAMMER
ORTHO SLOW



COLOR SENSITIVITY

FIGURE 4

EMULSION No 9227

DEVELOPER FORMULA. Y

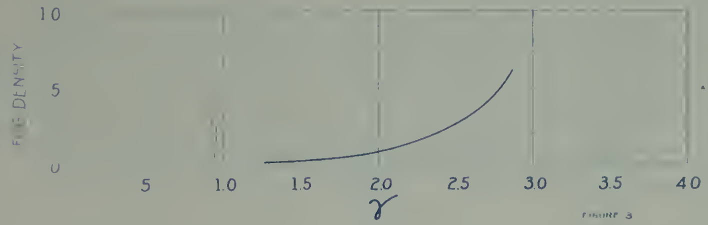


FIGURE 3

FILTER FACTORS.

K_1	K_2	K_3	G	A	B	C	F
3.0	8.9	13.2	14.7				

SPEED B.S 100

SCALE 60

RESOLUTION NUMBER 17

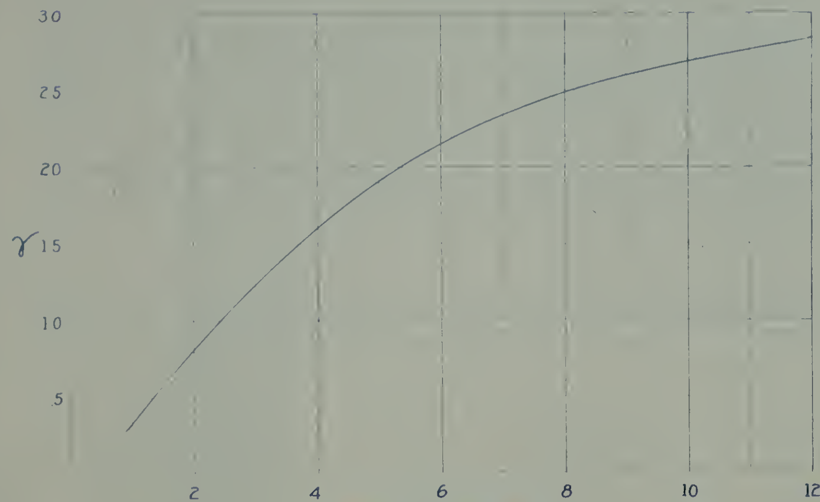


FIGURE 2

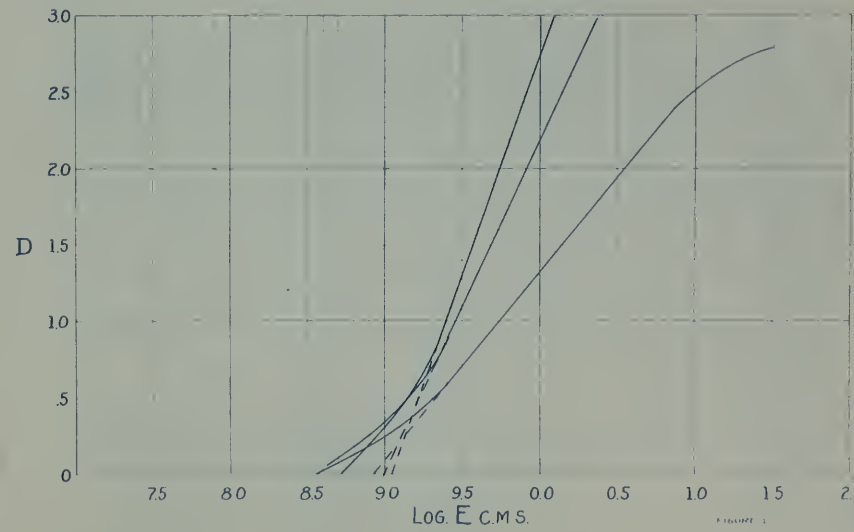


FIGURE 1

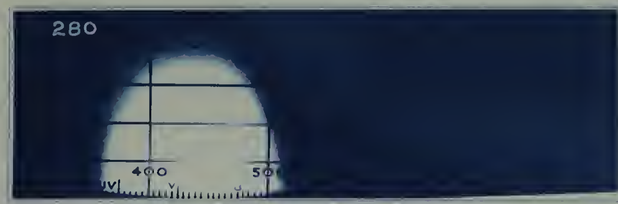
PHOTOGRAPHIC LABORATORY — BUREAU OF STANDARDS

(80)

HAMMER
LANTERN SLIDE

EMULSION No. 9265

DEVELOPER FORMULA. Y



COLOR SENSITIVITY.

FIGURE 4

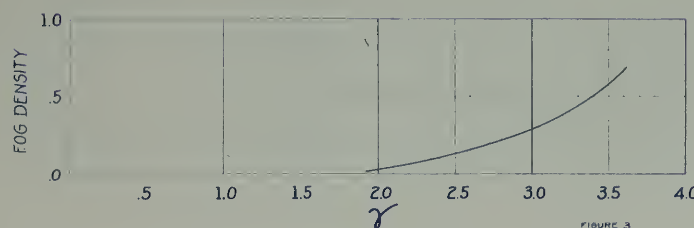


FIGURE 3

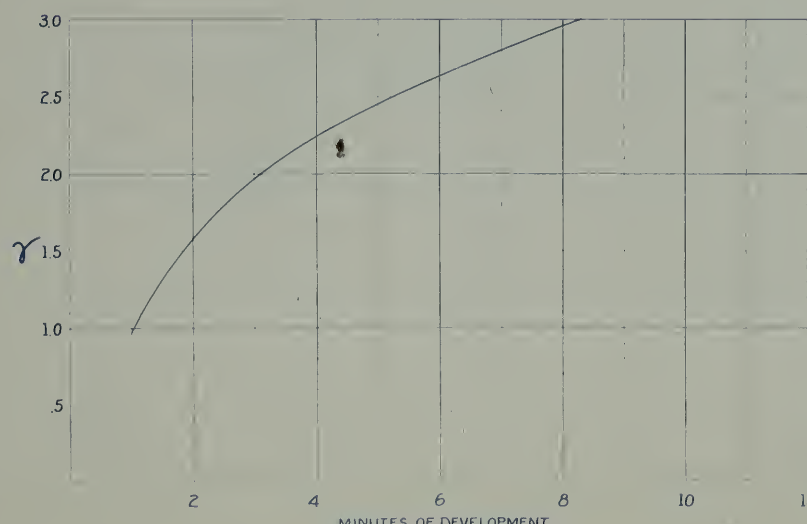
FILTER FACTORS

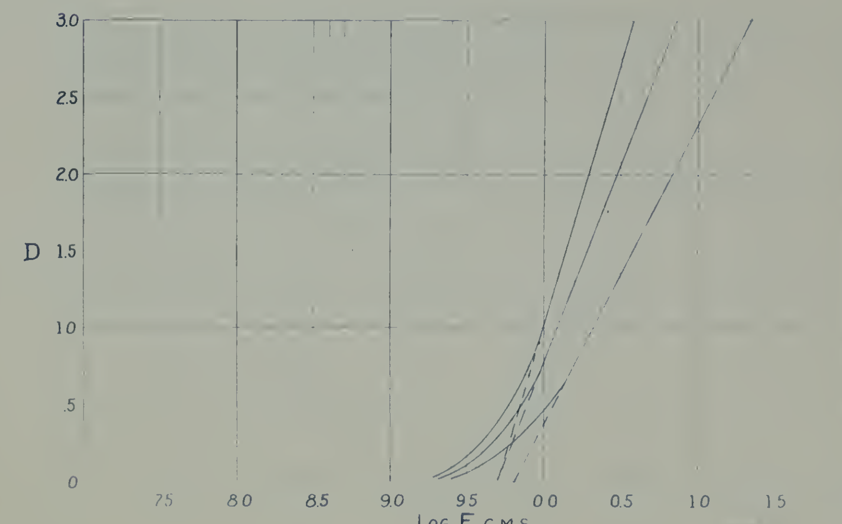
K_1	K_2	K_3	G	A	B	C	F

SPEED B 18

SCALE 25

RESOLUTION NUMBER 12

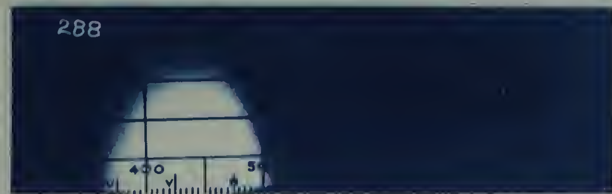




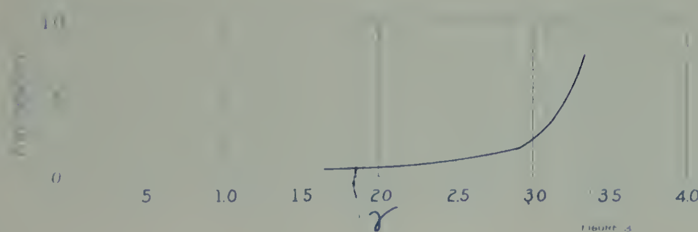
HAMMER TRANSPARENCY

EMULSION No 9228

DEVELOPER FORMULA. Y



COLOR SENSITIVITY



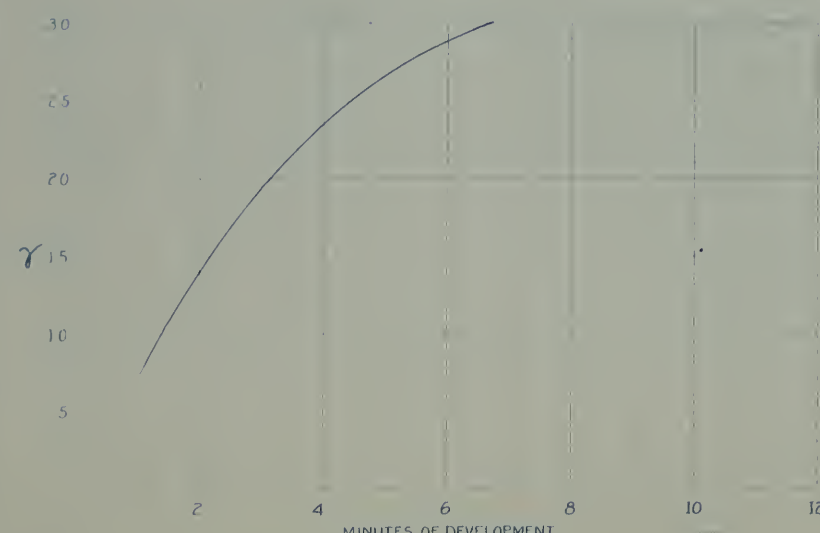
FILTER FACTORS

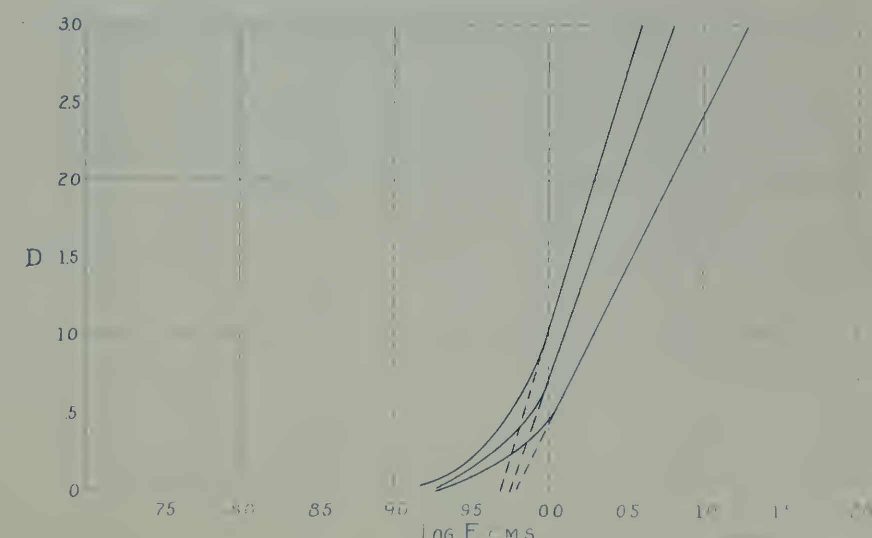
K_1	K_2	K_3	G	A	B	C	F

SPEED B S 18

SCALE 25

RESOLUTION NUMBER 12





PROGRESSIVE STUDIO No. 1.

EMULSION No. 23

DEVELOPER FORMULA. X

COLOR SENSITIVITY

FIGURE 4

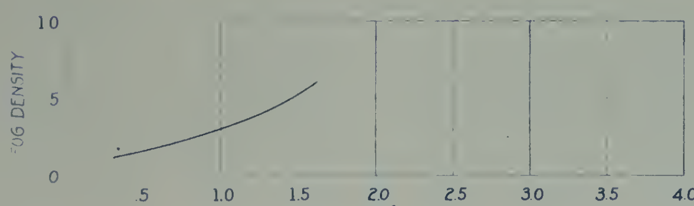


FIGURE 3

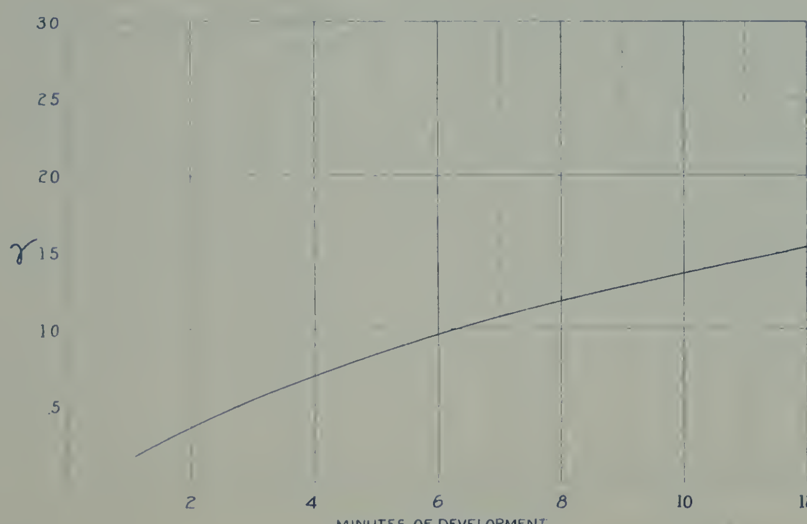
FILTER FACTORS

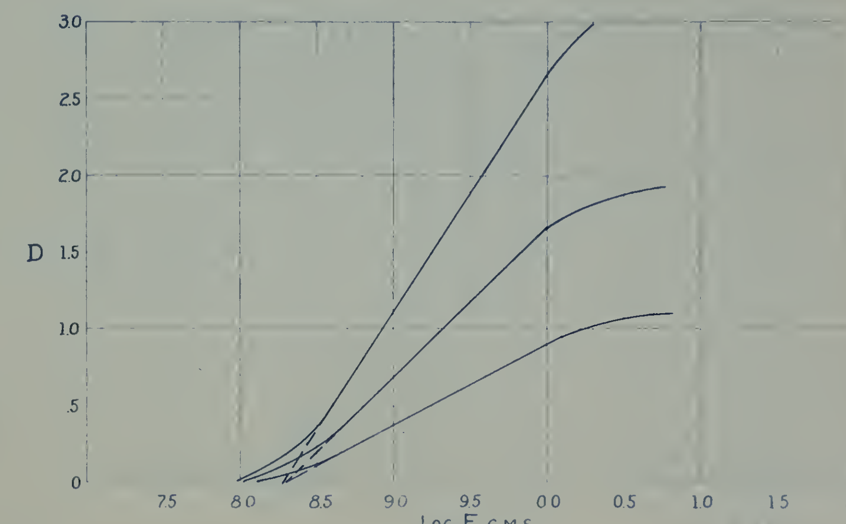
K_1	K_2	K_3	G	A	B	C	F

SPEED B.S. 520

SCALE 40

RESOLUTION NUMBER 22





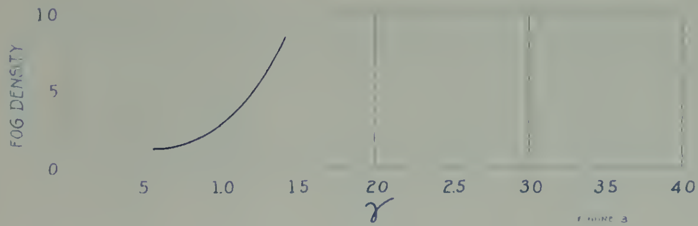
PHOTOGRAPHIC LABORATORY - BUREAU OF STANDARDS

PROGRESSIVE
ORTHO No. 1.

COLOR SENSITIVITY

EMULSION No **30**

DEVELOPER FORMULA. **X**



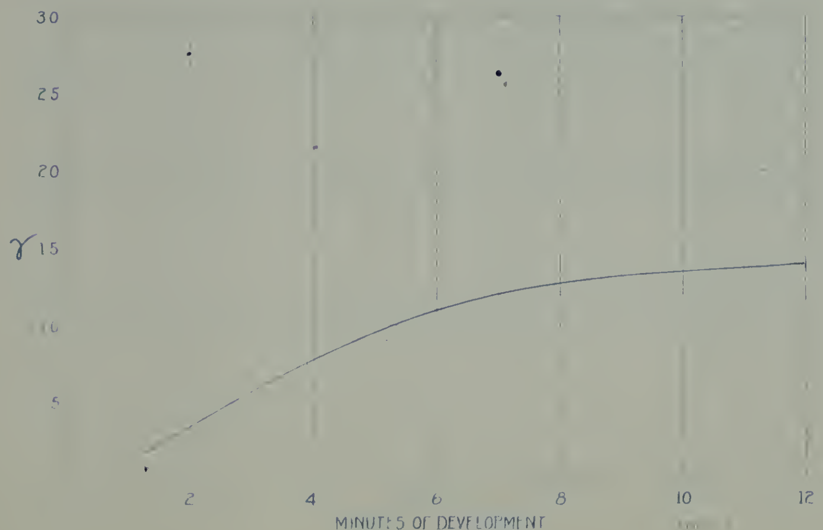
FILTER FACTORS

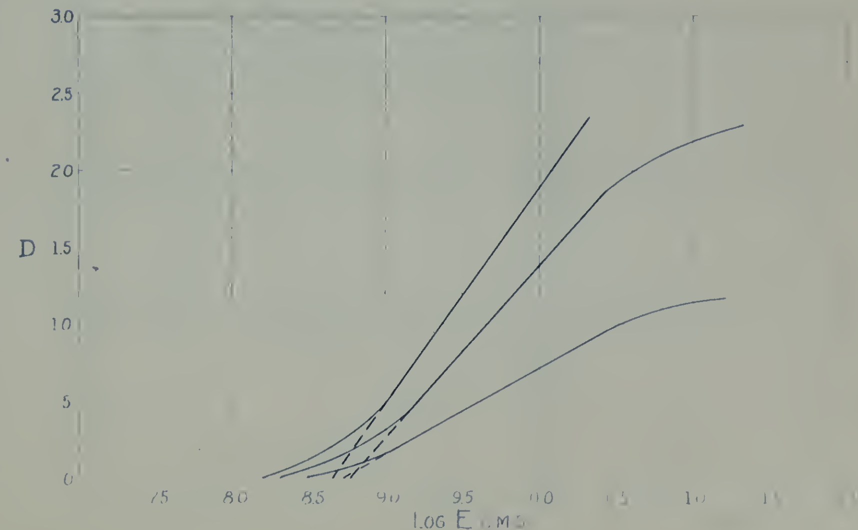
K_1	K_2	K_3	G	A	B	C	F
3.6	11.0	15.6	22.1				

SPEED B S **200**

SCALE **40**

RESOLUTION NUMBER **22**



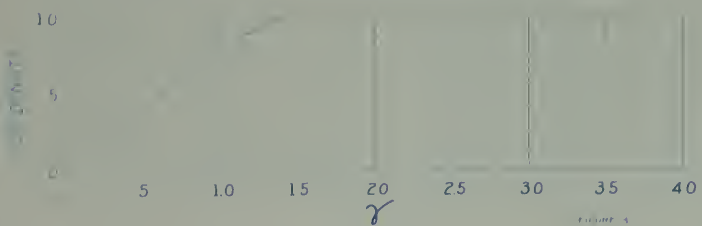


PROGRESSIVE
ORTHO No.2.

COLOR SENSITIVITY

EMULSION No. 27

DEVELOPER FORMULA X



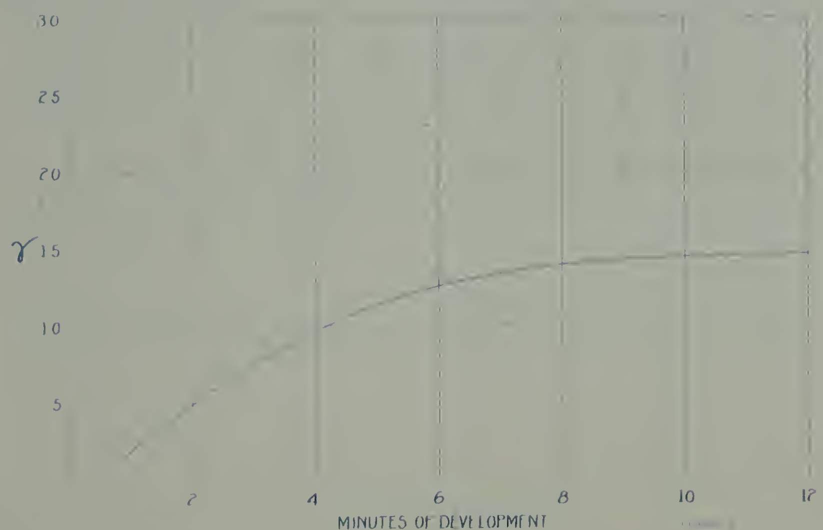
FILTER FACTORS

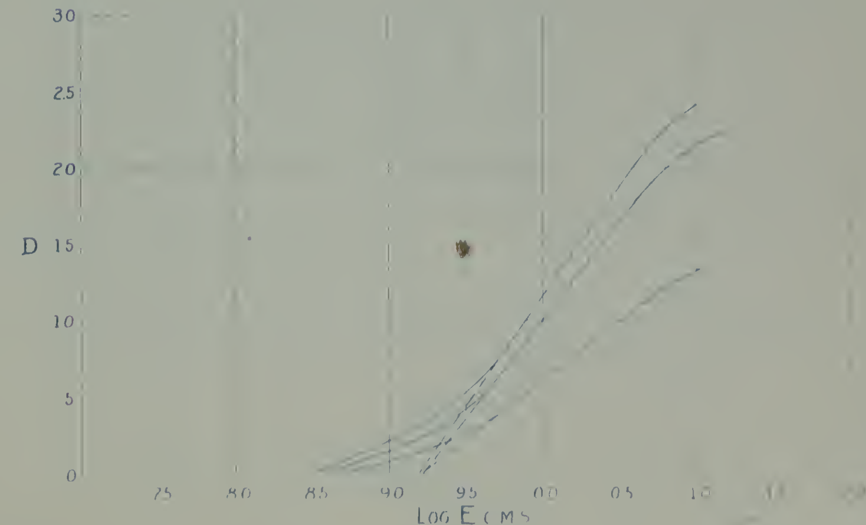
K_1	K_2	K_3	G	A	B	C	F
3.6	12.3	16.6	25.5				

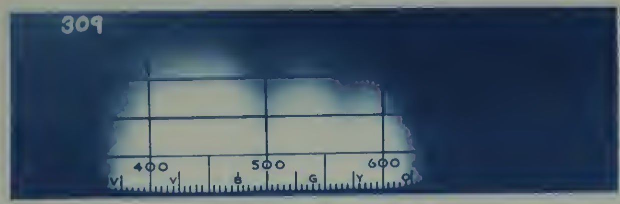
SPEED B.S. 62

SCALE 20

RESOLUTION NUMBER 26







COLOR SENSITIVITY

PROGRESSIVE
PANCHROMATIC No.1. YELLOW EM.

EMULSION No. 28

DEVELOPER FORMULA X

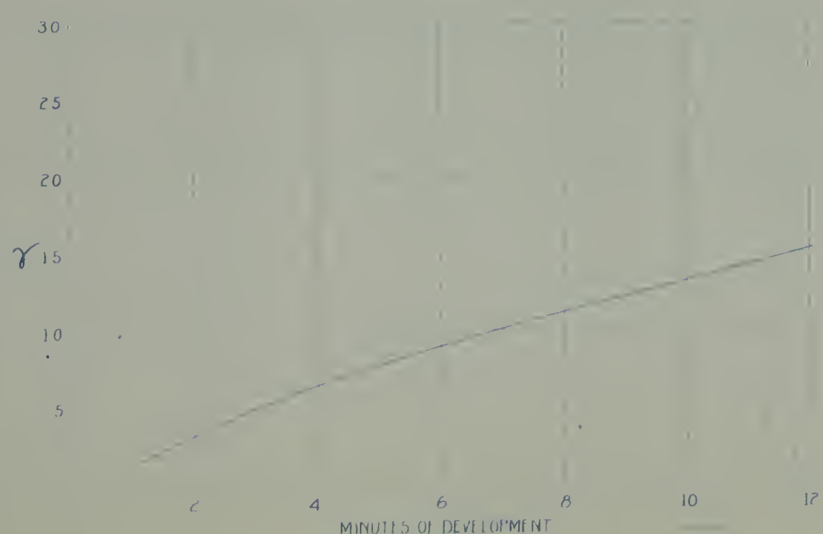
FILTER FACTORS

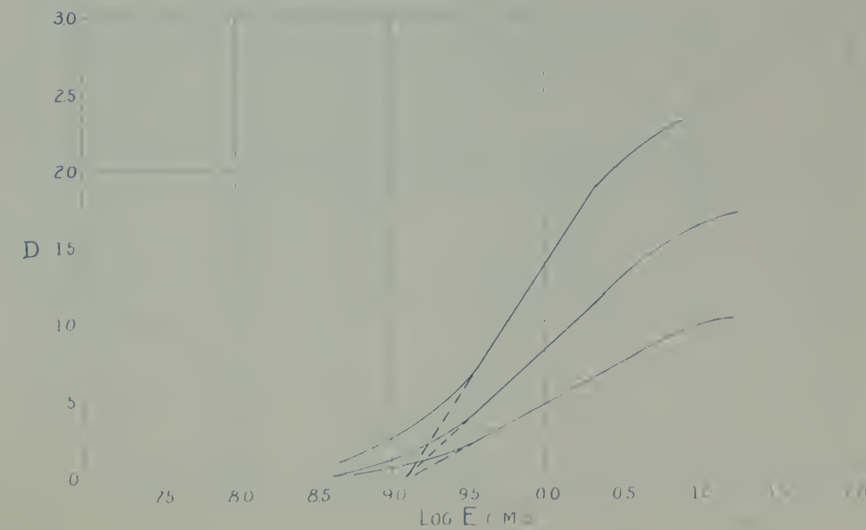
K_1	K_2	K_3	G	A	B	C	F
2.7	4.8	6.8	8.5	36.0	10.2	11.9	63.0

SPEED B.S. 80

SCALE 25

RESOLUTION NUMBER 23

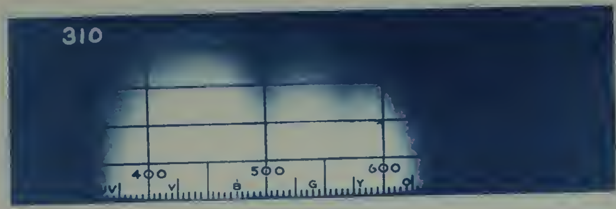




PROGRESSIVE
PANCHROMATIC No. 2. RED EM.

EMULSION No 28

X



COLOR SENSITIVITY

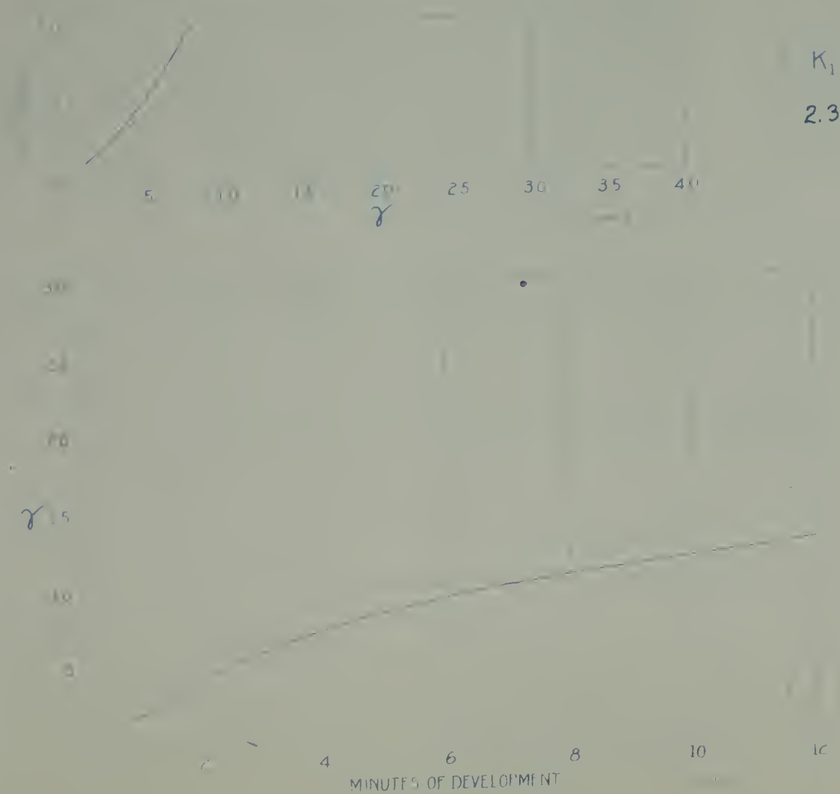
FILTER FACTORS

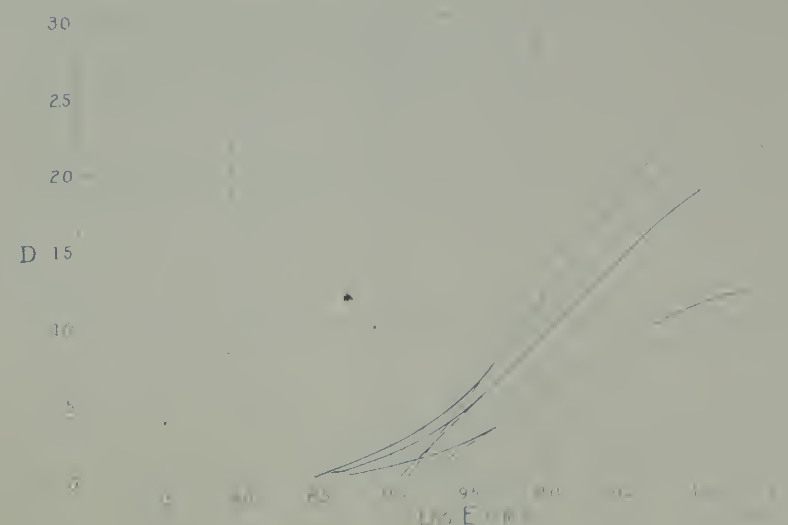
K_1	K_2	K_3	G	A	B	C	F
2.3	4.2	6.6	7.6	55.0	12.4	16.0	133.0

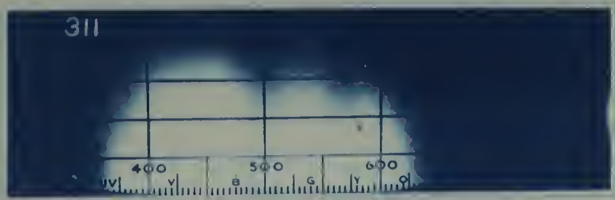
75

30

23





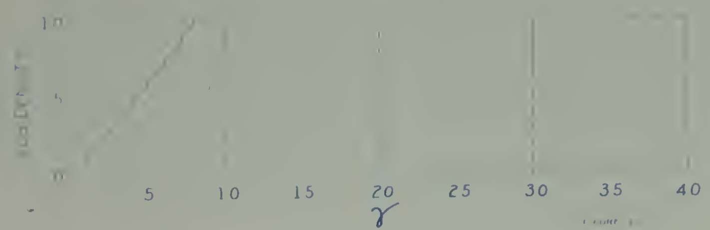


COLOR SENSITIVITY

PROGRESSIVE
PANCHROMATIC No.3. BLUE EM.

EMULSION No 28

DEVELOPER FORMULA X



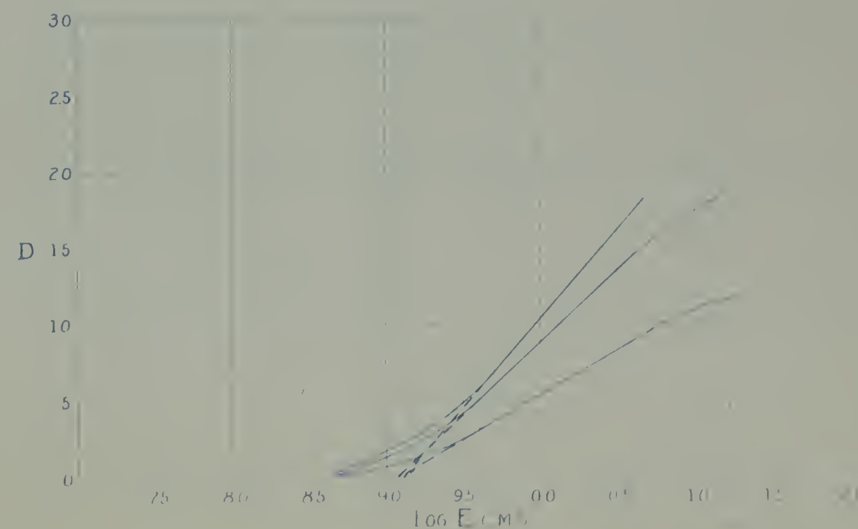
FILTER FACTORS

K_1	K_2	K_3	G	A	B	C	F
2.7	4.8	6.7	9.0	48.0	11.0	11.8	150.0

SPEED B S 85

35

NUMBER 23



SPEED OF PLATES WHEN USED WITH FILTERS

Plate	No Filter	K_1	K_2	K_3	G	A	B	C	F
Pan Ortho	80	33	22	18	14	7	6	5	4
Pan Ortho D. C.	75	34	21	18	16	7	6	6	5
Spectrum	180	82	46	40	32	9	15	14	6
Spectrum Process	110	41	23	20	12	6	8	8	3 1/2
Seed's Pan	110	33	12	9	4	3	4	10	1
Wratten "M"	95	48	24	21	17	5	7	8	4
Wratten Pan.	160	70	48	44	34	16	15	11	10
Wratten Pan Process	100	40	25	22	17	6	8	7	3 1/3
Progressive Pan No.1 Yellow	80	30	17	12	9	2	8	7	1 1/4
Progressive Pan No.2 Red	75	32	18	11	10	1 1/3	6	5	1/2
Progressive Pan No.3 Blue	85	31	18	13	9	2	8	7	1/2
Hammer Ortho Commercial	98	22	10	8	6				
Hammer Ortho Ex Fast	310	100	29	18	6				
Hammer Ortho N.H.	330	110	37	28	22				
Hammer Ortho Slow	100	32	8	6	2				
Hammer Ortho Sp. N.H.	300	104	32	23	11				
Progressive Ortho No.1	200	55	18	12	9				
Progressive Ortho No.2	62	17	5	4	2				
Colornon	215	86	34	23	14				
Special XX	210	70	23	16	7				
Iso Inst.	450	225	140	102	96				
Iso Inst. D. C.	650	232	137	114	102				
Iso Med.	330	127	72	62	57				
Iso Med. D. C.	380	141	86	83	65				
Iso Process	320	132	87	68	60				
Iso Slow	78	41	34	33	30				
Iso Slow D. C.	120	63	50	44	39				
Isonon Commercial	330	122	79	63	59				
Isonon Portrait	560	233	144	132	119				
Speed-O-Chrome	600	193	85	66	30				
Trichromatic	260	84	51	48	43				
Aero Film	210	70	21	14	10				
Autograph Film	380	115	32	18	8				
Commercial Ortho Film	250	83	33	22	10				
Portrait Film	355	131	41	24	9				
M.P.Neg. Film	400	125	35	21	--				
Premo Film	380	131	38	20	--				
L-Ortho	460	170	60	47	35				
L-Ortho N.H.	400	148	75	49	34				
Orthonon	460	191	72	54	33				
Polychrome	600	133	76	53	28				
Stanley Commercial	240	109	39	32	23				
Rexo Film	240	65	18	11	--				

DEPARTMENT OF COMMERCE

Bureau of Standards

S. W. Stratton, Director

A PROPOSED ATLAS

OF

PHOTOGRAPHIC NEGATIVE EMULSIONS

(For the confidential and exclusive use of the United States Government, and later to be revised and issued as a Scientific Paper of the Bureau of Standards,

by

Raymond Davis, Photographic Technologist

and

F. M. Walters, Jr., Associate Physicist

Bureau of Standards.)

(Issued Sept.23,1920)