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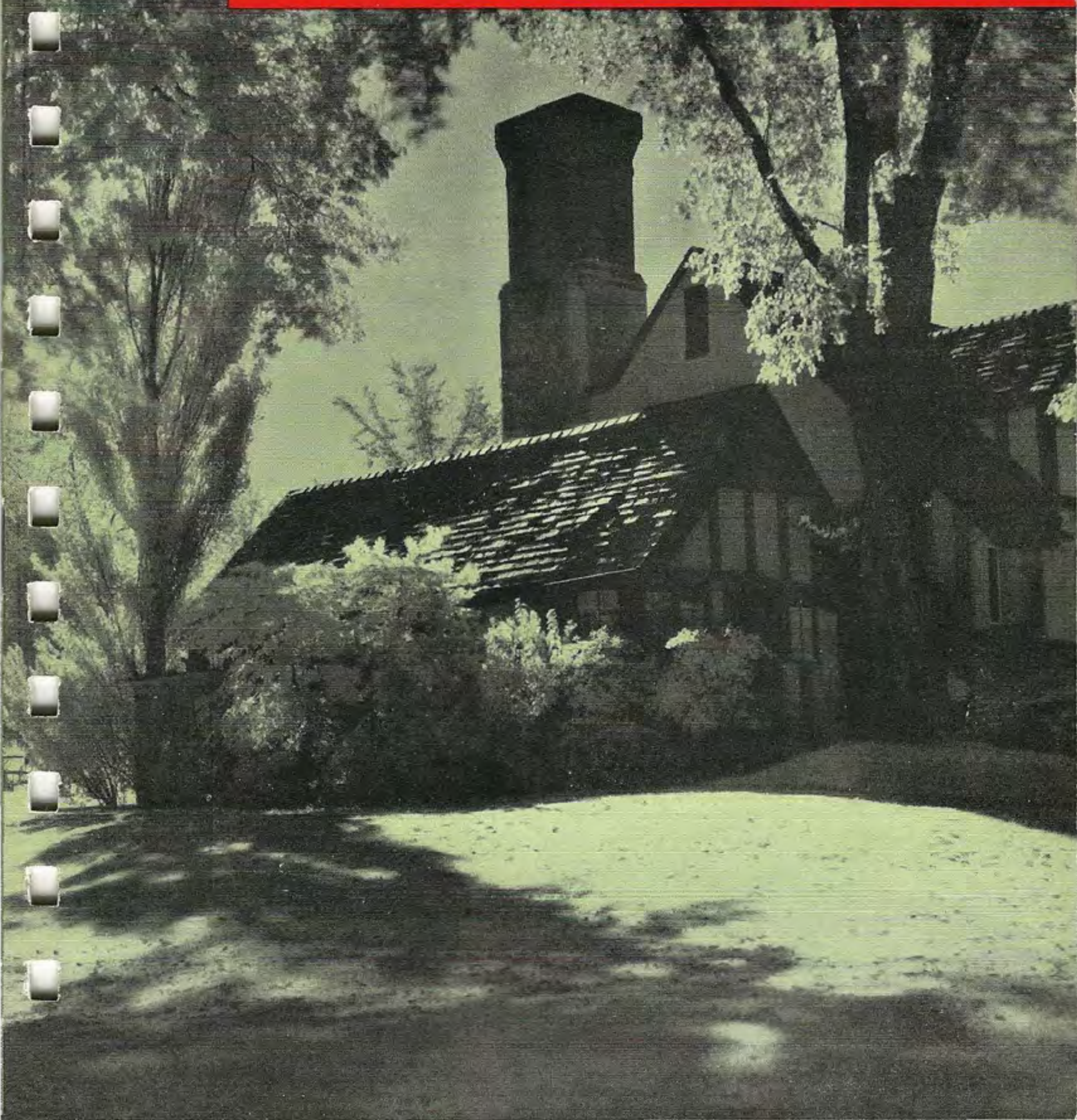
KODAK DATA BOOK ON INFRARED AND ULTRAVIOLET PHOTOGRAPHY

SECOND EDITION, PUNCHED FOR KODAK PHOTOGRAPHIC NOTEBOOK



INFRARED AND ULTRAVIOLET PHOTOGRAPHY

Inside Front Cover—*Mount Rainier, with Seattle in foreground, photographed at 10,000 feet altitude and a distance of approximately 75 miles, on Kodak Aerographic Infrared Film, with Wratten Filter No. 25. Courtesy Bradford Washburn.*

Second Edition, 1947

INFRARED
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Haze Penetration Aerial Photography
Flood and Flash Data
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Documents Medical Work
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Sheet Film
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INFRARED AND ULTRAVIOLET PHOTOGRAPHY

INFRARED PHOTOGRAPHY extends the vision of the camera beyond the limits of the human eye, affording a new photographic and pictorial dimension, as well as a medium for making record and technical photographs not otherwise possible. Infrared photography penetrates haze and renders the sky, green foliage, fabrics, etc., in a manner entirely different from ordinary photography. Kodak Infrared Films and Plates have been designed with these various applications in mind, and are as simple and dependable in practice as the more usual photographic materials.

Ultraviolet photography serves in examining subjects not responsive to ordinary photographic methods. Investigation of questioned, altered, and faded documents, restorations in works of art, the detection of invisible inks and fingerprints on a multicolored surface are frequently possible by ultraviolet.

This booklet contains information compiled to assist photographers with or without experience in these fields. Technical applications are described in some detail. Pages 3-25 give extensive data on infrared procedure; ultraviolet techniques are described on pages 26-34.

A brief bibliography on infrared and ultraviolet photography is listed on pages 35 and 36.

INFRARED RADIATION AND THE SPECTRUM

WHITE LIGHT can be spread out by a glass prism, into the "spectrum," a band of color ranging from violet through blue, blue-green, green, yellow, orange, red, and deep red. The colors of the spectrum are familiar in the rainbow, which is a result of the splitting up of white light by raindrops. The colors are separated in the spectrum because they represent light of different wave lengths,* which increase as the spectrum is traversed from blue to red. The range of wave lengths covered by the visible spectrum is from about 400 mμ at the blue end to about 700 mμ at the extreme red end (see Figure 1).

In addition to the light which we can see, there also exists invisible radiation similar to the visible radiation called "light." It manifests itself at both ends of the spectrum. Beyond the violet in the spectrum is radiation which is called the "ultraviolet," and which is of short wave length. It is invisible but has strong action on photographic materials, making it easy to detect by photographic means. At the other end of the spectrum, at wave lengths longer than the red, there also exists invisible radiation called the "infrared," meaning "below the red." The infrared region extends out indefinitely from the end of the visible region. As the wave length increases, the radiation merges into heat waves and finally into the radio waves. Even though the infrared extends far out, it is the region only quite near the visible red which is of interest photographically. It can be recorded on plates and films which have been specially prepared. The longest wave length of radiation photographically recorded is about 1,350 mμ, but in general infrared work, the region between 700 mμ and 860 mμ is used, a band almost as wide as the visible green and red regions.

*The wave lengths are denoted here in terms of the millimicron (mμ), which is one millionth of a millimeter long.

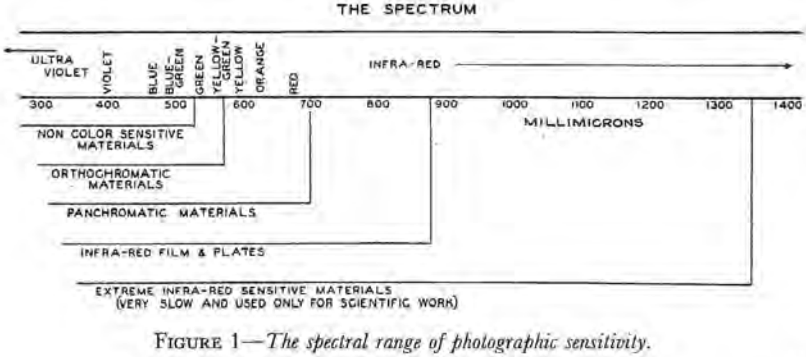


FIGURE 1—*The spectral range of photographic sensitivity.*

FIGURE 2—*Infrared-sensitive materials supplied by Eastman Kodak Company.*

INFRARED-SENSITIVE PLATES AND FILMS

USUAL photographic plates and films, even panchromatic ones, are not sensitive to infrared. Only through treatment of the emulsion with special dyes can infrared sensitivity be conferred. Some of these dyes have been known for a long time, but not until 1931 were new dyes discovered to make infrared photography as simple as photography with normal materials. The Kodak Infrared Sheet Film, Kodak Infrared-Sensitive Plates, and Kodak Infrared Film, available at the present time, may be used in almost exactly the same manner as panchromatic materials. The speed of these films and plates permits their exposure in hand-held cameras. Best quality in infrared pictures results from critically correct exposure; the latitude of these materials is less than that of usual panchromatic films.

Infrared materials can be handled in ordinary darkrooms if all white light is excluded. Safelights for panchromatic materials are unsafe; the Wratten Safelight, Series 7, is recommended for infrared film and plates. Developing and fixing are done in the usual way. The following Kodak infrared-sensitive materials, shown in Figure 2, are available:

Kodak Infrared Sheet Film is convenient for all commercial and many scientific applications. Either normal or high contrast is obtainable by varying the development technique. All common sizes are available. Full details are on the Data Sheet on page 20.

FIGURE 3—*Spectral sensitivity of Kodak infrared materials, namely Kodak Infrared Sheet Film, Kodak Infrared-Sensitive Plate, Kodak Infrared Film.*

Kodak Infrared-Sensitive Plates are available in practically all sizes up to and including 30 x 40 inches. They are made for general infrared photography when negatives of normal contrast are required. These plates are also suited to the making of "black-printer" negatives in photomechanical reproduction. Full details are on page 24.

Kodak Infrared Film (Miniature and Roll) is regularly supplied in IR135 magazines for Kodak 35's and other 35-mm still cameras and in IR828 rolls for the Kodak Bantams.* Kodak Infrared Roll Film can also be obtained in several sizes. This material is suitable for general infrared photography outdoors and in artificial light. Full details including available sizes are on the Data Sheet on page 22.

Other Materials. In addition to the above, infrared materials are made also for aerial and 35-mm motion-picture photography, and for spectrographic and astronomical work. Particulars of these may be obtained on request.

Filters. The sensitivity of Kodak Infrared Sheet Film, Kodak Infrared-Sensitive Plates, and Kodak Infrared Film is shown in Figure 3. It should be noted that these materials are sensitive not only in the extreme red and the infrared region of the spectrum but also in the blue region. With infrared-sensitive materials, it is therefore necessary to use a filter which absorbs blue and sometimes visible red light in order to allow the picture to be made entirely by infrared radiation.

A deep orange or red filter must be used over the lens for infrared photography to absorb the blue light to which the film is sensitive. The Wratten Filter No. 25 (A) is recommended. Other Wratten Filters can also be used, such as No. 29 (F), No. 70, No. 87, No. 88, No. 88A, No. 89, and No. 89A. The Wratten Filter No. 15 (G) may also be used in artificial light.

**Kodak Bantam f/4.5 and Kodak Bantam Special are suited to hand-held infrared exposures in sunlight.*

PRACTICE OF INFRARED PHOTOGRAPHY

The value of photography by infrared lies in the fact that infrared radiation and visible light often are reflected and transmitted quite differently by common objects. For example, chlorophyll in live green foliage absorbs a large percentage of the visible light which falls upon it but does not absorb the invisible infrared radiation. This is reflected almost entirely by the leaf structure, and therefore is recorded by means of the infrared-sensitive material. Foliage thus appears white in an infrared photograph. Painted materials which match chlorophyll in color but which do not reflect strongly in the infrared will appear dark in an infrared photograph. Most photographic materials render blue sky relatively light, but, since little infrared radiation is present in the blue sky, the infrared materials render it dark. Infrared radiation is freely transmitted through atmospheric haze, so distant scenes can be recorded with greater clarity than they can be seen with the eye. Many dyes which appear brightly colored to the eye do not absorb infrared and therefore record as white. The skin is somewhat transparent to infrared radiation and therefore infrared photography is sometimes of value in medicine in diagnosing abnormal conditions immediately beneath the surface. Infrared photography has been used successfully in criminology, photomicrography, botany, paleontology, and other scientific fields.

Figure 4—*Comparison of ordinary and infrared photography to show haze penetration. Left-hand segment was taken by infrared.*

There is no fundamental difference between the practice of infrared photography and that in which visible light is used. Any photographer, equipped for work with panchromatic films and plates, can make infrared photographs without additional equipment other than a suitable filter for use on the camera lens. There are, however, a few precautions which should be observed. In some of the older cameras, bellows, shutter blades, and dark slides are not entirely opaque to infrared radiation and therefore produce fog. Most of the materials used in the more modern cameras, however, are entirely safe. The dark slides manufactured by the Eastman Kodak Company and Graflex, Inc., have five dots embossed in the tops to indicate that they are safe for infrared photography. Metal slides are safe.

Focusing for Infrared

Infrared rays, because of their longer wave length, do not focus in the same plane as visible light rays in the case of many lenses. It is, therefore, necessary to make an increase in the lens-to-film distance to correct for the focusing difference between infrared and visible light rays. The Data Sheets in the Data Book *Kodak Lenses, Range Finders and Shutters* list these corrections for various Kodak lenses. Other Kodak lenses have a special index mark (usually red) as part of the focusing scale to be used for infrared pictures. These corrections are workable averages.

While lens types vary in their infrared focusing correction, as a general rule, sharper infrared pictures are obtained if the lens is extended by about ¼ per cent of its focal length after it has been focused for visible light. Some lenses will give satisfactory focus for the near-infrared by focusing on a ground glass with a Wratten Filter No. 25 on the lens. To offset further the difference between visual and infrared focus, the diaphragm should be closed down as much as practicable under existing picture-taking conditions. Making the exposure with the camera on a tripod is therefore desirable, but not strictly necessary.

Exposure for Landscapes

The exposure required in bright sunlight for distant landscapes with Kodak Infrared Sheet Film and Kodak Infrared Film (Miniature and Roll), and with a Wratten A Filter is approximately 1/25 second at *f*/8, or its equivalent. The exposure for near-by landscapes and architecture is 1/25 second at *f*/4.5 or preferably 1 second at *f*/22.

Exposure meters sensitive only to visible light may give unreliable daylight readings for infrared, since daylight varies in its ratio of visible to infrared radiation.

Infrared landscape photographs are characterized as follows: the sky is rendered almost black; clouds and snow are white; shadows are very dense and lack detail; grass and leaves appear very light as if covered by snow; distant details are rendered with remarkable clarity. Photographs taken by infrared outdoors in sunlight and then printed slightly darker than normal strongly suggest that they were taken by moonlight. As a matter of fact, some of the "night" scenes in professional motion pictures are made in sunlight on infrared-sensitive film.

Haze Penetration

When a distant landscape is photographed on the usual photographic materials, much detail is obscured by atmospheric haze, even when a filter is used. Infrared radiation is transmitted freely through this haze, so that distant objects, sometimes invisible to the eye, may be rendered clearly and sharply on infrared-sensitive materials. Figure 4 shows the ability of infrared rays to penetrate distant haze. Infrared rays do not penetrate fog appreciably more than does ordinary light, because the particles constituting a fog are very much larger than those in haze. Claims made as to the penetration of dense fog by infrared are entirely groundless.

FIGURE 5—*Aerial photograph made on Kodak Infrared Film on a slightly hazy day. Altitude, 3,000 feet, distance recorded, about 50 miles. The dark water and light fields, contrasting with shore lines and city limits, are characteristic of infrared aerial photographs.*

Aerial Photography

While infrared aerial photography is primarily useful in obtaining extreme haze penetration and high contrast, there are other distinct advantages in such photography. For example, bodies of water are rendered very dark in sharp contrast to land, assuming the day is clear, and fields and wooded areas are rendered very light. Cities are rendered darker than fields. For this reason, in very high altitude infrared pictures, cities appear as dark patches surrounded by lighter country, Figure 5.

Extended research has resulted in a high-speed emulsion which is supplied as Kodak Aerographic Infrared Film. This negative material, sensitive to infrared radiation as well as to the blue light of the visible spectrum, has exceptional sensitivity, and is capable of giving high contrast. The actual diaphragm setting depends on prevailing light conditions, on degree of development, and to a great extent on the terrain. In this respect, experience is the best guide. Green countryside requires less exposure than an industrial area. Typical settings for terrain composed of city and surroundings on a bright day are 1/150 second at *f*/8 with the Wratten A Filter (No. 25). The Wratten Filter No. 89A is also used for aerial photography, and its use in place of the No. 25 may result in slightly greater haze penetration.

Infrared aerial photography can also be done with Kodak Infrared Sheet Film and Roll Film. The exposure required is considerably greater than for the aerial film. 1/100 second at *f*/5.6 with the Wratten Filter No. 25 is typical. It is well to check the camera focus beforehand with the lens at full aperture and focused on a very distant object.

Infrared Photography by Artificial Illumination

Fortunately, the light sources which are in common use for ordinary photography are suited ideally for infrared photography. Photoflood Lamps, regular studio lighting, or ordinary tungsten lamps may be used. The energy of the radiation from a Photoflood Lamp is greatest in approximately that region of the spectrum to which the infrared materials are sensitive. The therapeutic infrared lamps are not suited to infrared photography, because their maximum radiation is of a very much longer wave length than that to which the infrared materials are sensitive.

Close-ups of people taken by infrared are very unusual; however, this medium is not recommended for portraiture. The flesh tends to appear translucent, red lips come out light, and the eyes appear very black, as in Figure 6. A suitable arrangement of camera and lights for general infrared photography is shown in Figure 7. The Kodak Preci-

FIGURE 6—*Rendering of faces by infrared. Left picture of each pair taken by infrared, right picture on panchromatic film. Note pale lips and transparency of the skin.*

sion Enlarger, shown in Figure 10, with its camera back and copying lights, is ideal for copying and small-object photography by infrared. For infrared photography with Photoflash Lamps, the arrangement in Figure 8 is convenient. The Photoflood Lamp is used for focusing, and then, when everything is in readiness, the switch which operates the Photoflash Lamps should be turned on. The exposure required for artificial light is indicated in the following table.

Exposure Data for Photoflood and Photoflash Lamps

This table applies to Kodak Infrared Sheet Film, and Kodak Infrared Roll Film, used with the A, G, or F Filter.* For dark-colored subjects; for light-colored subjects, use one lens opening smaller.

Distance lamps to subject	Four No. 1 Photofloods** in Kodaflectors***		Two No. 22 Photoflash Lamps in Kodaflectors
	Aperture	Time	Aperture
3 ft	*f*/16	½ sec	*f*/32
	f/32	2	
5 ft	*f*/11	½ sec	*f*/22
	f/32	4	

*With Wratten Filter No. 70 use the same exposure as given above. Nos. 88 and 89 require 1.5 times, and No. 87 requires double the exposure. No. 87 Filter is to be preferred for documentary and clinical photography.

**Two No. 2 Photofloods may be used in place of four No. 1 Photofloods.

***If matte-surfaced reflectors are used, give double the exposure indicated above.

In the case of unusual subject matter or uncertain light conditions, it is advisable to make a series of exposures. First, give the exposure corresponding to the best estimate. Then, give four times (two stops) more, and last, give four times less exposure than the first. One of these usually will be satisfactory.

Aperture Compensation for Close-Up Work

In photographing small specimens, where the camera bellows must be extended considerably, the effective aperture is considerably less than that marked on the lens. At unit magnification the lens-to-film distance is twice the focal length, and therefore the effective *f*-value is numerically twice the rated value. For example, if the diaphragm is stopped down to *f*/8, the actual working aperture is really *f*/16. For

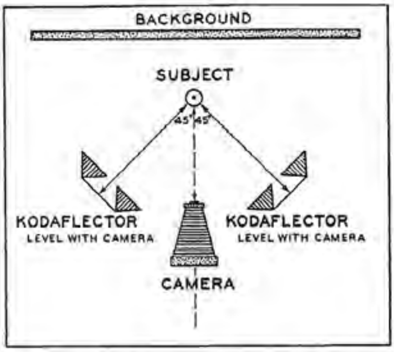


FIGURE 7—*Diagram showing setup for infrared photography with Photoflood Lamps.*

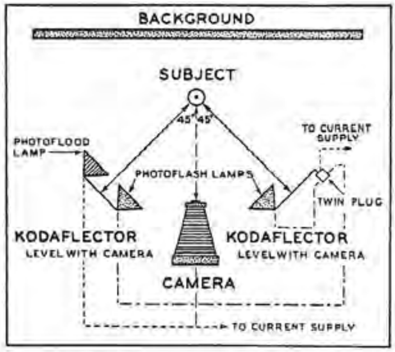


FIGURE 8—*Setup for infrared photography with 2 Photoflash Lamps; Photoflood Lamp is used for focusing.*

this reason, it is necessary to give four times the exposure which would be given if the lens were really working at *f*/8. When the total bellows extension is about one and one-half times the focal length, the exposure should be about doubled. For objects no nearer than 3 or 4 feet, no allowance need be made. The effective *f*-value for all close-up work can be computed from the formula:

$$\text{Effective } f\text{-value} = \frac{\text{Indicated } f\text{-value} \times \text{lens-to-film distance}}{\text{focal length}}$$

The lens-to-film distance is the focal length plus the lens extension from its position for infinity focus. This aperture compensation can be readily computed with the Kodak Lens Guide.

The Kodak 35's and Kodak Bantam Special can be used conveniently for photographing small specimens if the various close-up attachments and supplementary lenses are used.

When supplementary lenses are used with these cameras, it is not necessary to make any compensation in the exposure for close-up work, since the effective *f*-value remains unchanged. However, for best definition, the lens should be stopped down to *f*/11 or *f*/16.

FIGURE 9—*Such an extreme close-up as this requires allowance for change in effective f-number. Same-size documentary photography requires a fourfold increase in exposure time, since the effective f-number is doubled. Left—visual appearance. Right—penetration by infrared of a dye-type ink to show an obliterated address in pigment-type ink.*

SPECIAL USES

Photographs in Darkness

Inasmuch as infrared radiation is invisible, infrared photographs can be made in total darkness. However, this does not imply a total absence of radiation. Since there is never sufficient infrared radiation from natural sources for such photography, it must be supplied. Enough infrared radiation can be supplied by blackout flash bulbs or by Photoflood bulbs with proper infrared transmitting filters.

Blackout Flash Pictures. This technique permits flash photography in almost complete darkness and without the usual flash of light associated with ordinary flash bulbs. Only a dull red glow from the lamp is visible. It is necessary, however, for the photographer to know where his subject is; this makes it difficult to shoot a subject in motion or in an unknown position or at a distance in total darkness.

The principle of blackout flash photography is that the scene is illuminated only by infrared radiation and photographed on infrared film. The radiation comes from an otherwise ordinary flash bulb which the manufacturer has coated with an infrared transmitting lacquer much like the No. 89A Filter. No visible light reaches the scene; in fact, the only thing visible is a slight red glow from the lamp. While the subject illuminated appears perfectly dark to the eye, it is brilliantly illuminated to infrared film. No filter is needed over the camera lens since the lacquer on the flash bulb fulfills this function.

The maximum working distance for a No. 22R lamp and *f*/3.5 lens is 20 feet. A decision must be made beforehand as to the approximate distance intended and the focusing scale set accordingly. The lens diaphragm must also be set according to a guide number calculation involving this distance. Approximate guide numbers are as follows, and apply to Kodak Infrared Sheet Film and Roll Film, shutter speed 1/50 second or slower.

Lamp	7-inch Reflector	5-inch Reflector
Mazda Synchro-Press No. 22R	75	60
Mazda Synchro-Press No. 5R		55

Divide these guide numbers by the lamp-to-subject distance in feet to find *f*-number of lens opening.

The above blackout flash bulbs are made by the General Electric Company and are supplied on special order only.

Floodlamp Pictures. Regular tungsten or Photoflood Lamps can be used for pictures in total darkness, provided they are screened with a filter absorbing all visible light, yet transmitting freely the infrared region of the spectrum to which the photographic material is sensitive. A convenient arrangement is to use two Eastman Indirect Light Boxes placed on end and each fitted with one No. 1 Photoflood and a window consisting of a double thickness of Wratten Filter No. 87. To increase the efficiency, the inside of the boxes can be lined with tinfoil. With these units three feet from the subject, an exposure of about 1 second at *f*/4.5 is required. Since no provision is made for ventilation, the lamps should be left on only for the duration of the exposure.

Photographs of Hot Objects. Infrared-sensitive materials are valuable for studying the temperature distribution of hot bodies which are just below red heat, such as cooling ingots and castings, stoves, engine parts, high-pressure boilers, flatirons, and other subjects similar in temperature. A hot electric flatiron can be photographed in this way in about one to five minutes at *f*/4.5. At temperatures below 400°C, the exposures are very long, about 6 hours at *f*/5.6 being required at 330°C. If the plates are hypersensitized the exposure is reduced to one-half or one-third. Photography of hot objects must be done in a completely darkened room; otherwise a photograph is obtained by reflected, not emitted infrared. If a small amount of stray light is unavoidable, a satisfactory record may be obtained if a Wratten Filter No. 25 or No. 87 is used at the lens to avoid exposure by the blue component of the stray light. No filter is needed if total darkness is possible. Proper precautions should be taken to prevent the surroundings from burning if the object is to be heated for a long exposure.

Criminology

In the field of criminology, infrared photography has found many applications which include the following: detection and deciphering of erasures and forgeries; deciphering of charred documents, or those which have become illegible as the result of age or abuse; differentiation between inks, dyes, and pigments

FIGURE 10—*Kodak Precision Enlarger with Camera Back Adapter and copying lights is well suited to documentary and small-object photography. Plates, sheet film, or 828 and 135 film can be used with the appropriate accessory. Negatives may be subsequently enlarged in the same instrument. Interchangeable lenses and other features render this a versatile instrument.*

which are visually identical but dyed with different dyes; detection of stains and irregularities in cloth; examination of cloth, fibers, and hair which are dyed too dark to be easy to study by visible light; study of fingerprints; examination of the contents of sealed envelopes; detection of certain kinds of secret writing; detection and demonstration of blood stains on cloth; determination of carbon monoxide impregnation of victims of gas poisoning; photography in the dark. All of these applications rely on the fact that the reflection and transmission of infrared by materials is frequently very different from their behavior to visible light.

Documentary Photography

Infrared photography is useful in making discriminating examinations of documents. The most important applications are the deciphering of writing made illegible by charring, deterioration as a result of age or the accumulation of dirt, obliteration by application of ink by a censor or forger, invisible inks, deliberate chemical bleaching, or mechanical erasure and subsequent overwriting. In these fields, the infrared method forms a valuable adjunct to ultraviolet photography. Inks, pigments, and other materials which may appear identical to the eye are frequently rendered quite differently in an infrared photograph. If an ink transparent to the infrared is applied over one opaque to it, the underlying ink will show up in an infrared photograph. The original writing on charred documents may be revealed, although success will depend on the degree of charring of the paper. Figure 11. Writing which has been mechanically erased may be revealed by virtue of traces of carbon or other pigment left embedded in the paper fibers. Chemically bleached writing often is deciphered if the product resulting from the reaction of the bleach with the ink absorbs more infrared radiation than the surrounding paper. Dyes and pigments which are identical by visual inspection can be distinguished if they differ in their transparency to the infrared.

FIGURE 11—*Left, visual appearance shown by ordinary film. Right, infrared photograph. Note the three fingerprints, shown by arrows.*

FIGURE 12—*The location and extent of varicose veins are recorded in the infrared photograph (right); in the ordinary photograph (left) they are scarcely noticeable.*

Medical Infrared Photography

Complete treatment of this field being beyond the scope of this book,* an outline of applications and technique is given here.

The main use of infrared photography in medicine is obtaining an emphasized record of the pattern, number, and engorgement of superficial veins, as in Figure 12. This is possible because nonoxygenated blood is rendered dark in infrared photographs, whereas oxygenated arterial blood is not recorded. Therefore, as the medical literature indicates, pathologic conditions involving changes in the superficial veins or certain circulatory disturbances often can be studied to advantage through infrared photography. In that way a diagnostic aid is provided. The technique has been utilized to make a distinction between portal cirrhosis of the liver and other hepatic diseases. Significant changes from the normal venous pattern have been recorded in connection with axillary thrombosis and carcinosis involving regions near the surface of the body. The presence or absence of venous blood can often be determined in cases of suspected vascular tumors. The progress of treatment for varicose veins has been followed. Applications in dermatology have been found in connection with eczema and lupus. In addi-

*Full information and a bibliography of applications can be obtained by writing to the Medical Division, Eastman Kodak Company, Rochester 4, N. Y.

tion to the diagnostic aspects published, the technique has value in teaching by demonstrating venous patterns in healthy persons, in pathologic changes, and in natural changes such as pregnancy.

Other valuable uses of infrared photography have been described in ophthalmologic journals. In this field, the details are revealed mainly through the ability of infrared radiation to penetrate turbid media. Infrared photography has also been utilized in the examination of gross and microscopic specimens.

Regarding technique, the most important special factor in medical infrared photography is to provide suitable illumination for the photography of patients. The lighting must be flatly and evenly distributed by placing an equal amount of illumination on both sides of the camera-subject axis and aiming the lights to cover the area of interest uniformly. Suitable lighting angles must be employed. Figures 7 and 8 show a 45° horizontal angle, which is the basic setup and is suited to flat areas. Angles of 55° are required for convex surfaces, and 40° for concave surfaces. It is preferable to use two lights on each side, one above the other and spaced equally above and below the camera level to provide vertical lighting angles of about 30°.

A few other factors are important for good clinical records. The background should be one that photographs dark gray. The negatives should be given full development and should appear somewhat like overexposed, but flat, ordinary negatives. Prints should be made contrasty enough to show the veins as clearly as possible and the inherent "unnaturalness" of the flesh tones ignored.

Following are development recommendations: Infrared Sheet Film—Kodak DK-50, 9 min. tray, 11 min. tank. Infrared Roll Film—Kodak D-76, 16 min. tank.

Scientific and Technical Application

Infrared photography has proved of importance in many fields of investigation, and its value is increasing with further applications. It is not possible to mention more than a few of the more special uses, but the imaginative photographer should have no difficulty in widening its field. Useful references are available from the Eastman Kodak Company. In *plant pathology*, infrared has provided a valuable means of studying and diagnosing plant diseases in which there is change in the pigment or cellular material. Different kinds of wood show marked variation in their transparency to the infrared, and photographs have shown that the infrared may be of much value in coal petrology and other fields of *paleobotany*. In the *textile* industry, infrared photography has been successfully applied to the detection of irregularities in the dyeing and weaving of cloth, and damage to the fibers, particularly where the material is dyed in such a manner as to render visual observation difficult. The *graphic arts* industry has used infrared-sensitive plates to differentiate between light and dark blues in multicolor printing, and in preparing the negative of the black printing plate from originals prepared in specially selected colors. In the field of *technology*, other applications are the study of the interiors of furnaces while they are operating, the detection of carbonaceous matter in the lubricating oils which have been used in internal combustion engines, and the study of the porosity of tin plate. Infrared photography has proved of enormous value in *astronomy* and *spectrography*. Hundreds of new lines have been recorded in the spectra of the elements, and much has been learned of the composition of the stars and of the atmospheres of the planets. Photographs, which have been made through the haze of nebulae, show stars normally invisible behind them; large numbers of new stars have been discovered by the infrared radiation which they emit. It has been found that the night sky is relatively much stronger in radiation of wave length 8,500Å than in the violet and blue parts of the spectrum. In *photomicrography*, much use has been made of the infrared in the fields of entomology, cytology, histology, embryology, and botany. In general, photomicrographs of deeply pigmented tissues and the thicker microscopic sections and specimens show details of internal structure which are not visible in ordinary photomicrographs.

Works of Art

Infrared photography has taken its place with chemical study and x-ray and ultraviolet photography, as an important means of determining the authenticity of paintings. Pigments vary in the way in which they transmit and reflect the infrared, even though they appear identical in color. Infrared photography, therefore, sometimes can be of use in detecting the presence of overpainting and other alterations, and in distinguishing between an original and a later copy. Important factors are the varnish and medium, which differ in their infrared transparency according to their nature and age. Paintings which have so deteriorated, due to darkening of the varnish, that detail can scarcely be seen, may be revealed by infrared photography. Similarly, photographs, daguerreotypes, engravings, drawings, maps, and other such documents which have become badly discolored or faded by age or misuse have been successfully photographed by infrared.

HANDLING AND PROCESSING INFRARED MATERIALS

Storage of Unexposed Material. Kodak Infrared Sheet Film, Kodak Infrared-Sensitive Plates, and Kodak Infrared Films will keep for many months under normal conditions of storage, although like all photographic materials they keep best if cold and at a relative humidity below 60%. If they are kept in an icebox or refrigerator, they should be removed several hours before they are used, and allowed to warm up to the temperature of the room before being removed from the box. Otherwise, dew may form on them and give rise to markings.

Hypersensitizing. The speed of Kodak Infrared Roll Films, Sheet Films, and Plates can be approximately doubled by hypersensitizing immediately before use. The plates or films should be bathed in a 4 per cent solution of ammonia made by diluting 4 parts of 28 per cent ammonia (the strongest available commercially) to 100 parts with water. This solution should be used at a temperature not exceeding 50° F, and bathing should be for about 3 minutes. The material should be dried as rapidly as possible, preferably with an electric fan. The operations should, of course, be carried out in total darkness. As an alternative to ammonia, a 1 per cent solution of triethanolamine* in water may be used for hypersensitizing.

Care must be exercised in hypersensitizing, or streaks may result. In drying, particular care must be taken to prevent dust blowing on the emulsion surface; otherwise spots will occur.

Safelights. Infrared materials must be handled and developed in *total darkness* or with the aid of a Wratten Safelight, Series 7 (Infrared), used in a suitable safelight lamp, at a distance of not less than 3 feet from the film or plate. Other Wratten Safelights *cannot* be used with infrared-sensitive materials because they transmit infrared radiation which rapidly fogs the film or plate. The Wratten Safelight, Series 7, is *not safe* for use with orthochromatic or panchromatic materials.

Development. Infrared-sensitive materials are developed and fixed in exactly the same manner as other films and plates except that the antihalation backing on the *plates* must be rubbed off during development. Detailed development recommendations will be found in the Data Sheets for each film or plate. The contrast can be varied by developing for longer or shorter times than those specified. Some of the developers mentioned are available in several sizes as packaged chemicals, which many workers prefer because of their convenience.

*The practical grade is usually satisfactory.

RECOMMENDED FORMULAS
FOR INFRARED PHOTOGRAPHY WITH KODAK MATERIALS

Dissolve the Chemicals in the Order Given in Each Formula

KODAK DEVELOPER D-11

	Avoirdupois U. S. Liquid	Metric
Water (about 125° F.) (50° C.)	16 ounces	500.0 cc.
Elon	15 grains	1.0 gram
Kodak Sodium Sulfite, desiccated	2½ ounces	75.0 grams
Kodak Hydroquinone	130 grains	9.0 grams
Kodak Sodium Carbonate, desiccated	365 grains	25.0 grams
Kodak Potassium Bromide	73 grains	5.0 grams
Cold water to make	32 ounces	1.0 liter

KODAK DEVELOPER D-19

Water (about 125° F.) (50° C.)	16 ounces	500.0 cc.
Elon	32 grains	2.2 grams
Kodak Sodium Sulfite, desiccated	3 oz. 90 grains	96.0 grams
Kodak Hydroquinone	128 grains	8.8 grams
Kodak Sodium Carbonate, desiccated	1 oz. 265 grains	48.0 grams
Kodak Potassium Bromide	73 grains	5.0 grams
Cold water to make	32 ounces	1.0 liter

KODAK FINE GRAIN DEVELOPER DK-20

Water (about 125° F.) (50° C.)	96 ounces	750.0 cc.
Elon	290 grains	5.0 grams
Kodak Sodium Sulfite, desiccated	13¼ ounces	100.0 grams
Kodalk	116 grains	2.0 grams
Kodak Sodium Thiocyanate (Sulfocyanate)	58 grains	1.0 gram
Kodak Potassium Bromide	29 grains	0.5 gram
Cold water to make	1 gallon	1.0 liter

KODAK DEVELOPER DK-50

Water (about 125° F.) (50° C.)	64 ounces	500.0 cc.
Elon	145 grains	2.5 grams
Kodak Sodium Sulfite, desiccated	4 ounces	30.0 grams
Kodak Hydroquinone	145 grains	2.5 grams
Kodalk	1 oz. 145 grains	10.0 grams
Kodak Potassium Bromide	29 grains	0.5 gram
Cold water to make	1 gallon	1.0 liter

KODAK DEVELOPER D-76

Water (about 125° F.) (50° C.)	24 ounces	750.0 cc.
Elon	29 grains	2.0 grams
Kodak Sodium Sulfite, desiccated	3 oz. 145 grains	100.0 grams
Kodak Hydroquinone	73 grains	5.0 grams
Kodak Borax, granular	29 grains	2 0 grams
Cold water to make	32 ounces	1.0 liter

KODAK FIXING BATH F-5

Water (about 125° F.) (50° C.)	20 ounces	600.0 cc.
Kodak Sodium Thiosulfate (Hypo)	8 ounces	240.0 grams
Kodak Sodium Sulfite, desiccated	½ ounce	15.0 grams
*Kodak Acetic Acid 28%	1½ ounces	48.0 cc.
**Kodak Boric Acid, crystals	¼ ounce	7.5 grams
Kodak Potassium Alum	½ ounce	15.0 grams
Cold water to make	32 ounces	1.0 liter

*To make approximately 28% acetic acid from glacial acetic acid, dilute 3 parts of glacial acid with 8 parts of water.

**Crystalline boric acid should be used as specified; the powdered variety is difficult to dissolve and its use should be avoided.

KODAK INFRARED SHEET FILM

Code Notch

A moderately high-contrast, infrared, antihalation film for distant haze penetration and for special effects in commercial, architectural, and landscape photography. With variations in development it is useful in certain types of scientific, medical, and documentary photography and photomicrography.

Safelight: Use a Wratten Safelight, Series 7 (green), in a suitable safelight lamp with a recommended bulb at not less than 3 feet. The Series 7 is for infrared-sensitive materials *only*.

Exposure

Exposure Index: *Tungsten*—**8**

This index is intended for meters using ASA exposure indexes and for all Weston, G.E., and similar meters. The index applies when the film is exposed through the Wratten A Filter (No. 25) and developed as recommended.

Filters: A filter must be used over the lens (or light source) to absorb the blue light to which the film is sensitive. For general photography, a Wratten A Filter (No. 25) is recommended; Nos. 29 and 70 require the same exposure. Nos. 88, 89, and 89A require 1.5 times, and Nos. 87 and 88A require double the exposure.

Daylight Exposures: Subjects in Bright Sunlight.

Exposed Through Wratten A Filter		No Filter, for "Ordinary" Rendering
Distant Scenes	Nearby Scenes	Distant Scenes
1/25 sec at *f*/8	1 sec at *f*/22 or 1/10 at *f*/6.3	1/50 sec at *f*/16

Photoflood and Photoflash Exposures: With Wratten A, G, or F Filter.

Distance, Lamps-to-Subject	Four No. 1 Photofloods in Kodaflectors*		Two No. 22 Photoflash Lamps in Kodaflectors*
	Aperture	*Time*	*Aperture—Open Flash*
3 feet	*f*/16	½ second	*f*/32
5 feet	*f*/16	1 second	*f*/22

*If matte-surfaced reflectors are used, give double the exposure indicated above.
For dark-colored subjects; for light-colored subjects, use one lens opening smaller.

Caution: The use of a suitable screen over the reflector when making pictures of people is recommended, as flashlamps may shatter. Do not flash in an explosive atmosphere.

Blackout Flash: Photoflash Lamps Nos. 5R and 22R require no filter at the lens. Use exposure guide number 55 for No. 5R Lamp in 5-inch reflector; for No. 22R Lamp use 60 for 5-inch reflector, and 75 for 7-inch reflector. To obtain *f*-number, divide exposure guide number by distance in feet from lamp to subject. These lamps are obtainable from G.E. on special order only.

For unusual subjects or uncertain light, make a series of different exposures.

Processing

Develop at 68° F (20° C) for approximate times given below.

Kodak Developer	Continuous Agitation (Tray)	Intermittent Agitation** (Tank)
D-76* (General Use)	6 minutes	8 minutes
Microdol* or DK-20 (Fine Grain)	7 minutes	9 minutes
DK-50* (High Contrast)	7 minutes	9 minutes
D-19* (Maximum Contrast)	7 minutes	9 minutes
DK-50* (Medical Use)	9 minutes	11 minutes

*These developers are available in prepared powder form in several package sizes.
**Agitation at one-minute intervals during development.

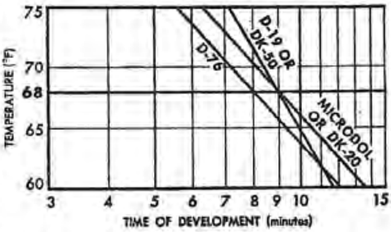
Rinse in water or in Kodak Stop Bath SB-1a for about 10 seconds.

Fix 10 to 20 minutes at about 68° F (20° C) in a solution prepared from Kodak Acid Fixing Powder with Hardener or in Kodak Fixing Bath F-5. *Agitate films frequently during fixing.*

Wash 20 to 30 minutes in an adequate supply of running water. Drying-mark tendency can be reduced by bathing in Kodak Photo-Flo after washing.

Dry in a dust-free place, after wiping surfaces carefully with a Kodak Photo Chamois or a soft sponge.

Time-Temperature Development Chart: Showing development times (tank) at various temperatures corresponding to recommended times at 68° F. For lower or higher contrast, draw a parallel line to left or right of existing diagonal line (through time at 68° F which produces contrast desired, if this time is known). *Best results are obtained at 65° to 70° F.*



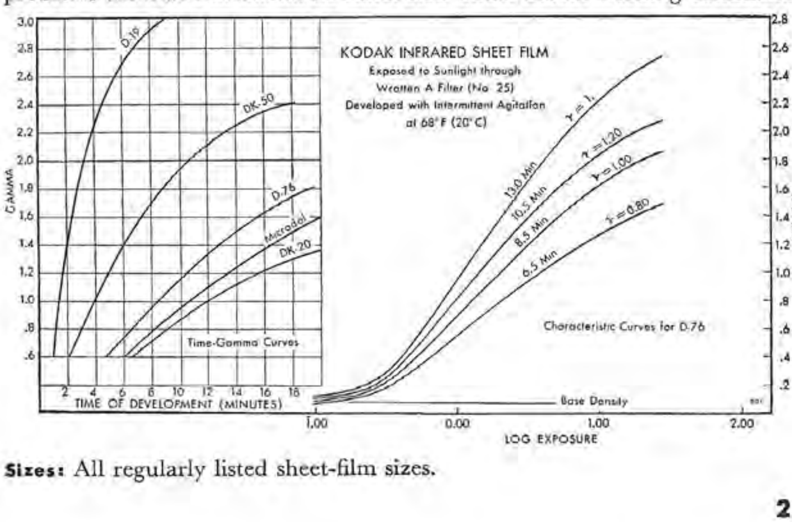
Sensitometric Data

Color Sensitivity: Blue-violet and infrared.

Spectrogram to Tungsten Light

Contrast: Recommended development in Kodak D-76 gives gamma of approximately 0.9; maximum practical gamma in Kodak D-19, approximately 3.0.

Sensitometric Curves: These data apply to average product and processing and are sufficiently accurate for all ordinary photographic work. For special problems the material should be calibrated under actual working conditions.



Sizes: All regularly listed sheet-film sizes.

KODAK INFRARED FILM (Miniature and Roll)

A moderately high-contrast, infrared film. With an orange or red filter it gives striking and unusual effects. Most commonly used for distant landscape photography, to produce detail ordinarily obscured by atmospheric haze. Also useful in medical, scientific, and documentary photography and photomicrography.

Safelight: Use a Wratten Safelight, Series 7 (green), in a suitable safelight lamp with a recommended bulb at not less than 3 feet. The Series 7 is for infrared-sensitive materials *only*.

Exposure

Exposure Index: *Tungsten*—**8**

This index is intended for meters using ASA exposure indexes and for all Weston, G.E., and similar meters. The index applies when the film is exposed through the Wratten A Filter (No. 25) and developed as recommended.

Filters: A filter must be used over the lens (or light source) to absorb the blue light to which the film is sensitive. For general photography, a Wratten A Filter (No. 25) is recommended; Nos. 29 and 70 require the same exposure. Nos. 88, 89, and 89A require 1.5 times, and Nos. 87 and 88A require double the exposure.

Daylight Exposures: Subjects in Bright Sunlight.

Exposed Through Wratten A Filter		No Filter, for "Ordinary" Rendering
Distant Scenes	Nearby Scenes	Distant Scenes
1/25 sec at *f*/8	1 sec at *f*/22 or 1/10 at *f*/6.3	1/50 sec at *f*/16

Photoflood and Photoflash Exposures: With Wratten A, G, or F Filter.

Distance, Lamps-to-Subject	Two No. 1 Photofloods in Kodaflectors*		One No. 22 Photoflash Lamp in a Kodaflector*
	Aperture	*Time*	*Aperture—Open Flash*
3 feet	*f*/11	½ second	*f*/22
5 feet	*f*/8	½ second	*f*/16

*If matte-surfaced reflectors are used, give double the exposure indicated above.
For dark-colored subjects; for light-colored subjects, use one lens opening smaller.

Caution: The use of a suitable screen over the reflector when making pictures of people is recommended, as flashlamps may shatter. Do not flash in an explosive atmosphere.

Blackout Flash: Photoflash Lamps Nos. 5R and 22R require no filter at the lens. Use exposure guide number 55 for No. 5R Lamp in 5-inch reflector; for No. 22R Lamp use 60 for 5-inch reflector, and 75 for 7-inch reflector. To obtain *f*-number, divide exposure guide number by distance in feet from lamp to subject. These lamps are obtainable from G.E. on special order only.

For unusual subjects or uncertain light, make a series of different exposures.

Processing

Develop at 68° F (20° C) for approximate times given below.

Kodak Developer	Continuous Agitation (Tray)	Intermittent Agitation** (Tank)
D-76* (General Use)	7 minutes	9 minutes
Microdol* or DK-20 (Fine Grain)	8 minutes	10 minutes

*These developers are available in prepared powder form in several package sizes.
**Agitation at one-minute intervals during development.

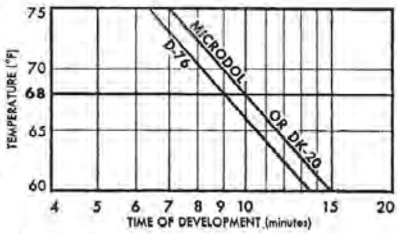
Rinse in water for about 10 seconds after development.

Fix 10 to 20 minutes at about 68° F (20° C) in a solution prepared from Kodak Acid Fixing Powder with Hardener or in Kodak Fixing Bath F-5. *Agitate films frequently during fixing.*

Wash 20 to 30 minutes in an adequate supply of running water. Drying-mark tendency can be reduced by bathing in Kodak Photo-Flo after washing.

Dry in a dust-free place, after wiping surfaces carefully with a Kodak Photo Chamois or a soft sponge.

Time-Temperature Development Chart: Showing development times (tank) at various temperatures corresponding to recommended times at 68° F. For lower or higher contrast, draw a parallel line to left or right of existing diagonal line (through time at 68° F which produces contrast desired, if this time is known). *Best results are obtained at 65° to 70° F.*



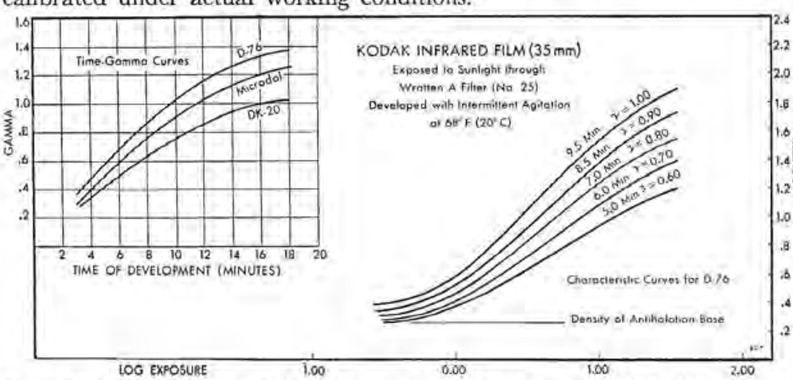
Sensitometric Data

Color Sensitivity: Blue-violet and infrared.

Spectrogram to Tungsten Light

Contrast: Recommended development in Kodak D-76 or Microdol gives a gamma of approximately 0.9.

Sensitometric Curves: The base density for IR828 film and for larger roll films is 0.05, rather than 0.24 as shown for the IR135 film. All points on all the characteristic curves for the former, therefore, are 0.19 lower in density than the curves shown. Time-gamma curves are not affected. These data apply to average product and processing and are sufficiently accurate for all ordinary photographic work. For special problems the material should be calibrated under actual working conditions.



Sizes Available: *Bantam*—IR828 (8-exposure roll). *35 mm*—IR135 (36-exposure magazine); IR401 (50-ft roll). *Roll Films*—IR116, IR616, IR120, IR620, IR127 (6 exposures each).

KODAK INFRARED-SENSITIVE PLATE

A moderately high-contrast, infrared-sensitive, antihalation plate recommended especially for making the continuous-tone "black-printer" in photomechanical color reproduction. It is also useful for distant haze penetration and for special effects in commercial, architectural, and landscape photography and for many types of scientific, medical, and documentary work.

Safelight: A Wratten Safelight, Series 7 (green), in a suitable safelight lamp with a recommended bulb at not less than 3 feet. The Series 7 is for infrared-sensitive materials *only*.

Exposure

"White Card" Meter Settings for Copying Continuous-Tone Originals:

White Flame Arc—**0.02** *Tungsten*—**0.1**

These meter settings are intended for meters using ASA exposure indexes and for all Weston, G.E., and similar meters. Since these settings are too low to appear on the meter calculator scale, multiply them by 100, and give 100 times the calculated exposure time. The meter reading should be made from a white surface in the copying position and the calculator set in the normal manner. The lens settings indicated should be used only for a trial exposure. The settings apply when the plate is exposed through the Wratten Filter No. 88A.

Filters: A filter is used to absorb the blue light to which the plate is sensitive.

For indirect process photography, the Wratten Filter No. 88A is recommended. When the No. 88A filter does not produce a negative which will print enough black for a given purpose, a Wratten Filter No. 25, No. 29, or No. 70 is sometimes used. The use of one of the latter filters augments the black with a portion of the blue or cyan printing record.

For general photography, the Wratten A Filter (No. 25) is recommended.

White Flame Arc Exposures: The correct exposure will have to be determined in each case. For example, the exposure through the Wratten Filter No. 88A with two 35-ampere arcs at 4 ft from the copy will be about 1½ min at *f*/22.

"Black-Printer": Suggestions for "black-printer" use are given in the instruction sheet packed with the plates.

Daylight Exposures: The average exposure in bright sunlight through the Wratten A Filter (No. 25) is 1/25 second at *f*/4.5 for distant scenes or 1 second at *f*/11 for nearby scenes.

For unusual subjects or uncertain light, make a series of different exposures.

Processing

Develop at 68° F (20° C) for approximate times given below.

Kodak Developer*	Continuous Agitation (Tray)	Intermittent Agitation** (Tank)
D-11 (Photomechanical work)	(1:1) 4 minutes	(1:1) 5 minutes
D-19 (General)	(1:4) 3 minutes	(1:4) 4 minutes

*These developers are available in prepared powder form in several package sizes.
**Agitation at one-minute intervals during development.

The antihalation backing is merely softened by the developer and requires light rubbing with a wad of cotton to be removed. If it is not removed before the plate is placed in an acid stop bath or acid fixing bath, the backing is rehardened and then requires swabbing with a wad of cotton soaked in a developer or other alkaline solution.

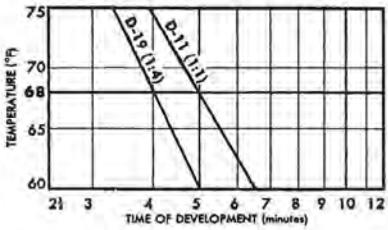
Rinse in water or in Kodak Stop Bath SB-1a for about 10 seconds.

Fix 10 to 20 minutes at about 68° F (20° C) in a solution prepared from Kodak Acid Fixing Powder with Hardener or in Kodak Fixing Bath F-5. *Agitate plates frequently during fixing.*

Wash 20 to 30 minutes in an adequate supply of running water. Drying-mark tendency can be reduced by bathing in Kodak Photo-Flo after washing.

Dry in a dust-free place, after wiping the surfaces carefully with a Kodak Photo Chamois or a soft sponge.

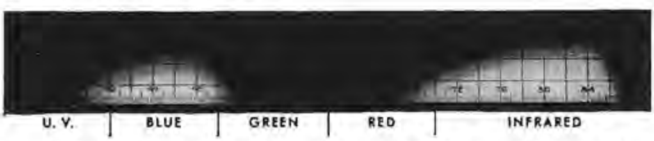
Time-Temperature Development Chart: Showing developing times (tank) at various temperatures corresponding to recommended times at 68° F. For lower or higher contrast, draw a parallel line to left or right of existing diagonal line (through time at 68° F which produces contrast desired, if this time is known). *Best results are obtained at 65° to 70° F.*



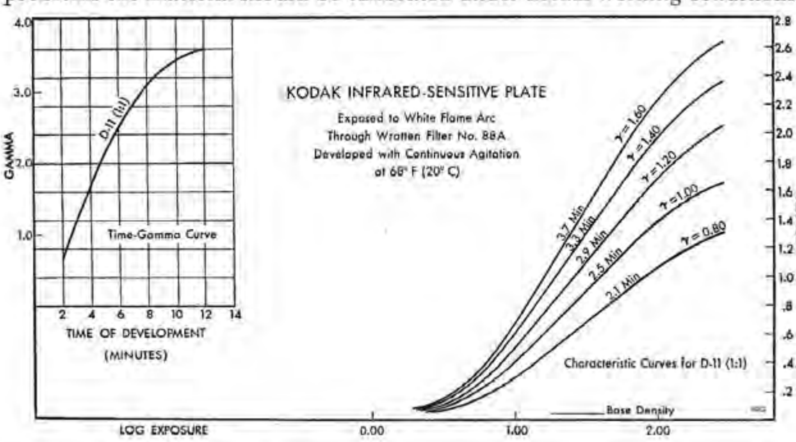
Sensitometric Data

Color Sensitivity: Blue-violet and infrared.

Spectrogram to Tungsten Light



Sensitometric Curves: These data apply to average product and processing and are sufficiently accurate for all ordinary photographic work. For special problems the material should be calibrated under actual working conditions.



Sizes: All regularly listed plate sizes.

ULTRAVIOLET PHOTOGRAPHY

Principles of Ultraviolet Photography

PERHAPS the most frequent uses of ultraviolet photography are the examination of altered documents, engravings, tapestries and other textiles, paintings, sculptures, and porcelain. Invisible inks and fingerprints on a multicolored surface can be detected, and other such subjects which cannot be examined with success by the ordinary methods of photography. The diversity of application of ultraviolet is evident from the fields in which it is already an important tool of investigation, for example, in the hands of police departments, museums, banks, analytical laboratories, examiners of questioned documents, food manufacturers, mineralogists, and many others. In ultraviolet photography, like infrared, unusual rendition of tones is possible and likely.

Ultraviolet photography is also being used in a lithographic reproduction process in the interests of securing highly color-corrected reproductions. Specifically, the Kodak Fluorescence Process is concerned with greatly improved methods for the preparation and reproduction of water-color originals. The originals are painted with Kodak Fluorescent Water Colors, which make it possible to employ photographic color correction and thus reduce handwork to a minimum. Additional details on the fluorescence process are available on request from the Eastman Kodak Company, Rochester 4, New York.

Ultraviolet photography uses the same equipment as ordinary photography. Special lamps, however, are required and certain filters are needed. Special films and processing are not required, but a film of considerable speed is preferable unless very high contrast is needed. All films respond to ultraviolet without being specially sensitized to it—so differing from infrared which requires special materials. Every photographic material, film, plate, or printing paper will react to ultraviolet. However, some particularly attractive aspects of ultraviolet photography are concerned with color effects, so it is well to use the common panchromatic films for all purposes. Color films can be used for ultimate effectiveness in some of these cases.

There are two distinctly different methods of using ultraviolet radiation for taking photographs. The first of these, the "reflected ultraviolet method," is strictly analogous to ordinary photographic methods whereby the photograph is made by the light reflected from the object. In the case of ultraviolet photography, however, the source of radiation or the camera lens is covered with filters which transmit the invisible ultraviolet and allow no visible light to act on the photographic film.

The second method is known as the "fluorescent light method." This depends on the "fluorescence" of certain objects which, when subjected to invisible ultraviolet in a darkened room, will give off a new radiation visible because it is longer in wave length than the ultraviolet. This light is usually blue or greenish-yellow, although the color may range from violet to red, depending upon the nature of the material. In addition, the object reflects considerable ultraviolet which is stronger photographically than the fluoresced light. Therefore, since it is desired to photograph only the fluorescence when this method is used, it is necessary to place a filter over the camera lens to absorb the reflected ultraviolet and transmit only the visible fluorescence.

It is doubtful whether ultraviolet photography is of much interest for taking photographs in the dark in the way that infrared photography has been used. Many materials fluoresce quite strongly under ultraviolet, particularly such objects as the skin, teeth, eyes, and fingernails; therefore, if such objects were "illuminated," as it were, with invisible ultraviolet rays, they would be quite visible by virtue of the fluorescence induced by the ultraviolet and transmit only the visible fluorescence. If such a filter is not used, the photograph will be taken by the reflected ultraviolet rather than the fluorescence, and the rendering probably will not show the effects visible by fluorescent light.

Documentary Applications

The possibility of deciphering altered documents and examining paintings, etc., by the ultraviolet depends upon the relative reflecting power of the papers, inks, and erased inks in the case of documents or of the various pigments in the case of paintings, or else on different extents to which these materials fluoresce. For example, paper is composed mainly of cellulose, which fluoresces strongly in the ultraviolet. If paper is inscribed with ink and the ink is subsequently erased or bleached, it usually happens that the parts of the paper where the ink has been removed have a lower fluorescing power than the rest of the paper. In this way a photograph taken by fluorescent light may show up the original writing even though it is quite invisible to the eye and cannot be photographed by usual photographic methods.

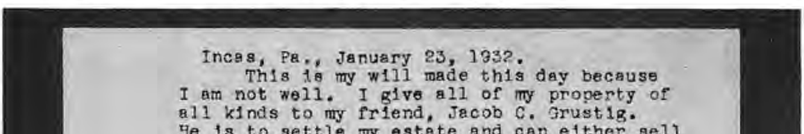
There is no general rule determining the choice between the two methods of ultraviolet photography. If the detail to be shown can be seen by fluorescent light, it can be photographed by fluorescent light. If the detail does not appear thus, it may or may not be possible to photograph it by reflected ultraviolet, and only experiment will tell. The method using reflected ultraviolet is quicker, and if convenient, should be tried first.

Light Sources

There are many sources of ultraviolet light, but not all of them are suitable for ultraviolet photography. Sunlight contains only a small amount of ultraviolet as compared with the amount of visible light and is not generally usable. Ordinary electric lamps radiate so little ultraviolet that they need not be considered. Carbon arc lamps are suitable sources of ultraviolet provided conditions do not require their enclosure in a lighttight box, and also provided the carbons will burn steadily without attention during the exposure.

A suitable source of ultraviolet is the mercury vapor arc lamp, available in many forms for a variety of purposes, such as photographic studio use, industrial installations, photographic copying and printing, and scientific and medical purposes. They are available either as quartz lamps or as glass lamps from several manufacturers, among whom are the Hanovia Chemical and Manufacturing Company, Newark, N. J., and the General Electric Vapor Lamp Company, Hoboken, N. J.

FIGURE 13—*Forged will disclosed by ultraviolet photography using the fluorescent method. A letter above the signature had been erased chemically and a typewritten will substituted. Above, ordinary appearance. Below, photography by ultraviolet fluorescence.*



Incas, Pa., January 23, 1932.
This is my will made this day because
I am not well. I give all of my property of
all kinds to my friend, Jacob C. Grustig.
He is to settle my estate and can either sell
the house or keep it as it is. I do this for
Jake because he is my best friend and has done
so much for me.

Signed. L. H. Sarnoff Seal.

Incas, Pa., January 23, 1932.
This is my will made this day because
I am not well. I give all of my property of
all kinds to my friend, Jacob C. Grustig.
He is to settle my estate and can either sell
the house or keep it as it is. I do this for
Jake because he is my best friend and has done
so much for me.

Signed. L. H. Sarnoff Seal.

If the mercury vapor lamp is of clear glass or quartz, it must be used in conjunction with an ultraviolet transmitting filter such as the Corning Violet Ultra Glass No. 5860, molded, 6½ inches square. The lamp should be mounted in a lighttight, ventilated metal box with the filter mounted at one side. The ultraviolet radiation supplied by this arrangement is the 365 mμ mercury line.

The capillary type of high-pressure mercury lamp was recently introduced, and it is available in rather inexpensive forms of high efficiency. A convenient type for photography is the General Electric B-H4 lamp, which is a capillary mercury lamp enclosed in a jacket of ultraviolet-transmitting glass resembling the Corning No. 5860. The complete lamp outfit includes an autotransformer in addition to the lamp. Such lamps require no additional light source filter.

Other lamps are also available in which the glass of the tube itself is an ultraviolet transmitting filter which absorbs visible light, and, in this case, an additional light source filter need not be used. The Cooper Hewitt lights can be obtained with so-called Nico tubes instead of clear glass. The Nico tube is a glass ultraviolet filter. The mercury vapor tubes have been made in a variety of shapes other than the common straight tubes, for instance, U-shaped, M-shaped, square, circular, and concentric spiral.

Many filter-enclosed ultraviolet lamps transmit some visible light and thus are unsatisfactory for photographing faintly fluorescing objects. Nevertheless, they are quite suitable for detecting and photographing some chemical erasures, invisible inks, certain minerals and pigments, anthracene fingerprint dusting powders, and other brightly fluorescing materials.

Most ultraviolet light sources require a "warming up" period before they attain their maximum output. Information concerning this usually can be obtained from the lamp manufacturers. For reproducibility of results, it is important not to start a photographic exposure until the lamp supplies its full output.

Ordinary Photoflood lamps radiate a small amount of ultraviolet. They can readily be applied to the reflected ultraviolet method by simply putting an ultraviolet transmitting filter, such as the Wratten No. 18A, on the camera lens. The No. 1 Photoflood lamps can also be used in improvised lamphouses for the fluorescent light method, provided that the fluorescence is so bright that the exposure time does not exceed one minute. The lamphouse can consist of a safelight with the safelight filter replaced by a metal or wooden mask carrying a Corning Glass Filter Violet Ultra No. 5860 or preferably a Heat Resisting Red

Purple Ultra No. 5874 taped over a central hole. The chief trouble with this lamp is that it gets very hot, and since the lamphouse must be lighttight, the heat is not readily dissipated. The lamp should only be turned on for a short time, not over a minute.

Because of the great quantity of heat dissipated by these lamps and because of danger of breakage of the filter, this source is not recommended except in the case of occasional investigations in the absence of more appropriate light sources.

WARNING: Short wave-length ultraviolet has a very painful effect on the eyes, and whenever quartz mercury tubes or others which give such radiation in high intensity are used in the open, all people who can see them or the subject they illuminate should wear goggles of ultraviolet-absorbing glass.

Filters

The more common technique in ultraviolet photography is the fluorescent method, although it is quite usual for the worker in this field to use the reflected light method as well. With this in mind, it is well to obtain the filters for the fluorescent technique, even though the filter requirements for the reflection technique are simpler. Probably the most suitable filter for use at the light source is the Corning Violet Ultra Glass No. 5860. This filter, since it transmits no visible light, is appropriate for faintly fluorescing subjects such as documents. This filter is quite dense and exposure times will therefore be rather long. Other light source filters are the Corning Glass Heat Resisting Red Purple Ultra No. 5874 and Red Purple Ultra No. 5970. These transmit ultraviolet more freely than the No. 5860 and are most commonly used in filtering illumination under which materials coated or impregnated with fluorescent paints and dyes are to be observed. No. 5970 transmits more ultraviolet and more visible light than No. 5874; however, No. 5874 is a heat-resisting glass and permits the use of a much more intense light source without serious danger of thermal breakage. Red Ultra No. 5840 is another Corning Glass which transmits ultraviolet freely, but little or no visible light. The use of these filters which transmit much ultraviolet is usually practical with mercury vapor arcs, but not with carbon arcs and faintly fluorescing subjects. Since these filters are used at the light source, polished filters are unnecessary and the standard 6½-inch molded squares are entirely suitable. Corning filters are available from the Corning Glass Works, Corning, N. Y.

Since the fluorescent technique demands an ultraviolet-absorbing filter at the lens, the Wratten Filter No. 2A is recommended for this purpose. This can be secured as gelatin filter film and as such is suited to experimental work. For a more permanent installation, this filter cemented in B glass is preferable and is supplied to fit Kodak Combination Lens Attachments. The Wratten Filter No. 2A absorbs all radiation below 400 mμ and does not fluoresce when exposed to ultraviolet rays. The Wratten K2 Filter can also be used, but it absorbs some blue fluoresced light, if present. The Wratten K2 Filter is preferable, however, if the light source filter transmits much visible violet light.

Assuming that the light source is already equipped with one of the ultraviolet-transmitting filters mentioned above, no additional filters are needed for the reflection technique. The Wratten Filter No. 2A is merely removed from the lens. In the unusual case where all work is to be done by the reflection technique, it is simpler to apply the ultraviolet transmitting filter to the lens rather than to the light source. In this case, the Wratten Filter No. 18A is recommended. This filter is a polished glass filter and therefore is not available as gelatin filter film. It is supplied in sizes to fit the Kodak Combination Lens Attachments.

Cameras and Lenses

Any camera used for normal photography is satisfactory for use with either method. Also, the regular camera lens can be used for both methods, provided that, in the case of reflected ultraviolet, it transmits the wave lengths desired. Even though the glass of an ordinary lens is not transparent to far ultraviolet radiation, the transmission at 365 mμ is sufficient so that an exposure can be made in a comparatively short time. Since this wave length is concerned in nearly all practical work, any camera lens which does not appear yellowish when placed on white paper will serve. For special problems requiring wave lengths shorter than about 350 mμ, a quartz lens is necessary because of both the strong absorption of glass and the possibility of fluorescence of cemented lenses. The focus of the lens is not quite the same in the ultraviolet as in the visible region, and therefore a small lens aperture should be used for the reflected ultraviolet method to avoid any difficulty.

Details of the Reflected Ultraviolet Method

In photographing objects by reflected ultraviolet, no visible light must be permitted to reach the photographic film or plate, and therefore a filter is required at either the light source or lens. A suitable arrangement for filtering the light source has been described above. When this, or a mercury vapor lamp with ultraviolet-transmitting glass, is used, the operation must take place in total darkness. If the Wratten Filter No. 18A is placed over the camera lens, the subject can be photographed in normal room light. The former method is usually desirable since it can be employed also for fluorescence.

Kodak Super Panchro-Press, Type B, Film is suitable for this type of photography, although greater contrast with less sensitivity can be obtained with Kodak Contrast Process Ortho Film. Panchromatic film is not necessary, and any of the non-color-sensitive or orthochromatic films can be used. It is usually most convenient, however, to use one film, or two films differing in contrast, for all work.

The ultraviolet light source or sources should be placed at sufficient distance to give even illumination over the subject, for example, at 24 inches for a subject area 9 x 11 inches. Two General Electric B-H4 lamps at this distance may require an exposure time of about a minute at *f*/11 on Kodak Super Panchro-Press, Type B, Film. Trial exposure times of 15 seconds, one minute, and four minutes should be tried, and future exposure times determined from the results. The improvised units using Photoflood lamps should be subjected to the same trial exposures at the same distance.

Details of the Fluorescent Light Method

In photographing objects by ultraviolet with the fluorescent light method, the light source must be screened with an ultraviolet transmitting filter and exposures must be made in a totally darkened room. In this case, however, it is also necessary to use over the camera lens some filter, such as the Wratten Filter No. 2A, which does not transmit any ultraviolet rays but which freely transmits all of the fluorescent light from the subject.

FIGURE 14—*On the left is a normal photograph of a French hotel advertisement. On the right is a fluorescence photograph of the same card revealing a message which had been written on it in invisible fluorescent ink.*

For fluorescent light photography, a panchromatic material is generally preferable to record fluorescence over the entire spectrum. Kodak Super Panchro-Press, Type B, Film is suitable. For greater contrast, Kodak Contrast Process Panchromatic Film, Kodak Process Panchromatic Plates, or Kodak M Plates are recommended.

Exposures for fluorescence may range from 30 seconds to one hour at *f*/4.5, depending upon the nature of the material. With two lamps, such as the Hanovia or General Electric B-H4 with natural Red Purple Bulb at 20 inches from the subject, and with the Wratten Filter No. 2A, an exposure of about 2 minutes at *f*/4.5 is suggested. However, this should be considered only a basis for a series of trial exposures.

The fluorescence of anthracene-dusted fingerprints against a multicolored background can be photographed with these lamps quite satisfactorily. It may be desirable in some cases to use a Wratten K2 or B Filter to provide greater contrast between the fluorescing impressions and the background. With either of these filters and using the lamps mentioned above, the approximate exposure on Kodak Contrast Process Ortho Film is 2 minutes at *f*/16.

PRECAUTION: Many materials lose their fluorescence if frequently exposed to ultraviolet rays. It is, therefore, important that this method should not be used too often on any rare object.

Development of Films and Plates

Development details are given in instruction sheets packed with the films and plates mentioned above. In some cases there are several recommended developments. Therefore, the development best suited to materials used for ultraviolet photography are summarized here.

Kodak Films and Plates	*Recommended Kodak Developer*	*Time of Development at 68°F (20°C)*	
		Tray	*Tank*
Super Panchro-Press, Type B, Film	DK-50	5½ min	7 min
Contrast Process Pan Film	D-11	4 min	5 min
Contrast Process Ortho Film	D-11	4 min	5 min
Process Pan Plates	D-11	4 min	5 min
M Plates	D-19	4 min	5 min

It should be noted that the process materials in the preceding table, when developed as recommended, yield a very high contrast suited to document examination where the subject contrast may be quite low.

Less contrast can be obtained by using Kodak Super Panchro-Press, Type B, Film.

Rinse the developed films thoroughly in water or in Kodak Stop Bath SB-1a; then place them in a suitable acid hardening fixing bath such as the solution prepared from Kodak Acid Hardening Fixing Powder or from the formula for Kodak Fixing Bath F-5. Fix the films or plates 10 to 20 minutes at 68°F (20°C), agitating them frequently while they are in the bath. Wash the films about 30 minutes in an adequate supply of running water. Wipe the surfaces carefully with a damp Kodak Photo Chamois or soft sponge before drying.

Kodachrome Photography by the Fluorescent Light Method

Fluorescence can be photographed in color on sheet or miniature roll film using either Kodachrome Film, Daylight Type, or the films intended for tungsten light, Type B and A. If daylight film is used, yellows and reds will be more brilliant; tungsten-light film will accentuate the blues. Although the difference is small, the choice of film should be based on the fluorescing color which it is desired to emphasize.

The light source used for Kodachrome photography should be as strong as possible. A high-intensity, capillary mercury vapor lamp having an ultraviolet-transmitting envelope is ideal for small specimens. For larger displays, mercury vapor lamps made of ultraviolet transmitting glass are excellent. Mercury vapor lamps with clear glass should be screened by one of the Corning ultraviolet-transmitting filters described earlier, to cut off all extraneous white light. The Wratten Filter No. 2A is needed at the camera lens.

The strength of the fluorescence of different materials varies widely, and it is inadvisable to try to photograph more than one specimen at a time. The brightness range that exists in a display of a number of materials is usually far beyond that capable of being photographed on color films. For most effective results, single specimens or groups of specimens having nearly uniform fluorescence should be photographed.

These widely varying conditions make impossible specific exposure recommendations. It is suggested that a series of test exposures of ½, 2, 8, and 32 minutes at *f*/4.5 be made, and the results applied to future work under similar conditions.

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KODAK CHEMICAL PREPARATIONS

For the convenience of the photographer, the Eastman Kodak Company makes available a variety of chemical preparations. For efficient, standard solutions, the photographer need only dissolve the powders in the proper volume of water according to directions printed on the package. The use of prepared developers and other processing solutions is a quick, convenient, and safe method of working which assures the user of purity, uniformity, and economy. Preparations of particular interest for use with Kodak Infrared-Sensitive Materials are shown in the following table.

DEVELOPERS AND REPLENISHERS

Name	Sizes Available	Use
Kodak Microdol	1 qt, 1 and 5 gal	For microscopically fine-grain development of films and plates
Kodak Microdol Replenisher	1 and 5 gal	To replenish Kodak Microdol Developer
Kodak Versatol	8 and 16 oz, 1 gal Stock solution	For development of films, plates, and papers; in concentrated liquid form
Kodak D-11	1 and 5 gal	For high-contrast development of films and plates
Kodak D-19	1 and 3½ gal	For rapid, high-contrast development of films and plates
Kodak DK-50	1 and 3½ gal	Primarily for development of professional films and plates
Kodak DK-50R	1 gal	To replenish Kodak Developer DK-50
Kodak D-76	1 qt, ½ and 1 gal	For maximum shadow detail with normal contrast on films and plates
Kodak D-76R	1 and 5 gal	To replenish Kodak Developer D-76

OTHER PREPARATIONS

Name	Sizes Available	Use
Kodak Liquid Hardener	8 oz and 1 gal	To make an acid stop bath; to add to hypo for making a fixing-hardening bath
Kodak Tropical Hardener	1 gal	For making a hardening rinse for high-temperature processing of films and plates
Kodak Acid Fixing Powder with Hardener	1 qt, ½ and 1 gal	For fixing films, plates, and papers; a single-powder preparation
Kodak Rapid Liquid Fixer (with Hardener)	1 and 5 gal	Primarily for fixing films and plates; can be used with papers
Kodak Testing Outfit for Stop Baths and Fixing Baths	1 oz of each test solution, 8-oz bottles	For determining when stop baths and fixing baths are exhausted
Kodak Farmer's Reducer	1 qt	For reducing overexposed negatives
Kodak Reducer and Stain Remover	16 oz each of two solutions	For reducing negatives and removing developer stains from negatives
Kodak Chromium Intensifier	16 oz	For intensifying weak negatives
Kodak Anti-Calcium	4 oz and 1 lb	For addition to developers for prevention of calcium scums, sludges, and incrustations
Kodak Photo-Flo	5 gal	To minimize formation of water marks during the drying of films and plates

◆ This punching provides convenient means of insertion in the *Kodak Photographic Notebook*. See your dealer.

SELECTED KODAK PUBLICATIONS

On Sale at Kodak Dealers

Kodak Reference Handbook. A convenient binder containing separators and seven Kodak Data Book sections (Data Books without covers). It can be kept up to date by replacing out-dated sections with new editions of the following seven Data Books:

Kodak Lenses, Range Finders and Shutters. A Data Book on the characteristics of these vital camera parts and their use, with specifications, depth of field and field-size tables, and useful optical formulas.

Filters and Pola-Screens. A Data Book which discusses the theory and use of filters and Pola-Screens, with Data Sheets for the more popular Wratten Filters. Illustrated in color.

Kodak Films. A Data Book treating the physical and photographic properties of black-and-white films, and including Data Sheets for Kodak roll films, film packs, and sheet films.

Kodak Papers. A Data Book on the characteristics of contact and enlarging papers, and methods of selection and use of papers for prints of high quality. Data Sheets and formulas included.

Formulas and Processing. A Data Book presenting a comprehensive list of Kodak formulas. It discusses principles and procedures for processing films, plates, and papers.

Kodachrome and Kodacolor Film. A Data Book on still photography and home movies in color. Discusses lighting, exposure, and many special subjects. Illustrated in color.

Copying. A Data Book dealing with the copying of all types of originals. Data Sheets and formulas included.

Kodak Photographic Notebook. A loose-leaf, metal-ring binder containing five separators, a quantity of notebook paper, and a list of special photographic articles available without charge. Designed to serve as a supplement to the *Kodak Reference Handbook.*

Kodak Data Books not included in the *Kodak Reference Handbook* but punched for insertion in the *Kodak Photographic Notebook* are:

Photography with Kodachrome Professional Film. A Data Book on Kodachrome sheet film, with particular attention to make-up, portrait lighting, and other special problems. Illustrated in color.

Slides. A Data Book on the making and showing of slides and transparencies in black and white and color.

Infrared and Ultraviolet Photography. A Data Book describing both the principles and practice in two specialized fields of photography.

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