A PHOTOGRAPHIC LIGHT BOX FOR USE IN AGRICULTURAL RESEARCH [1]

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INTRODUCTION

The difficulty experienced in attempts to obtain a constant and always uniform source of light for photographing diseased fruits and similar specimens led the writer to devise a more satisfactory method of illumination. The result of considerable experimenting was the production of a light box which has proved to be most satisfactory for its purpose, and its use has resulted in the saving of considerable time and material, as well as in obtaining better results than had been possible before. This light box has also proved to be useful in lantern-slide production, natural-color photography, and in low-power photomicrographic work where upper-field illumination is desired.

APPARATUS

The illuminating device as designed for use with a Leitz vertical camera (pl. 1, A) consists essentially of a box, square at the top and rectangular at the base, with the lower portion of two sides extended 3½ inches at one end to make this part of the box project beyond the square upper part. The box is provided with a removable toppiece carrying a shielded aperture for the camera lens. The upper section of the box carries four 50-watt light bulbs which serve as a source of upper illumination, while two bulbs of equal size at the bottom of the box provide illumination from beneath the subject. The projecting right end of the box is hinged to provide ready access to the interior of the apparatus so that the specimen-supporting fixtures may be manipulated and the specimens arranged during the focusing process. Four grooves are cut into the inside faces of each of the two large sides of the box, and the specimen-supporting fixtures are carried in these grooves. These four grooves make it possible to adjust the distance of the subject from the lens and thus obtain a suitable magnification without moving the lens more than a slight amount, if at all. This is important, as the field becomes restricted if the lens is moved any considerable distance upward. The lights are controlled by three switches, one line switch in the cord a short distance from the box and two tumbler switches attached to the outside of the box. The upper switch controls the four bulbs on the upper circuit, and the lower switch controls the lower two bulbs. The line switch is used to control the lights while a plate is being exposed, the other two being manipulated only when the line switch is off. This precaution is necessary to prevent any vibration of the subject while it

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is being photographed. Three pieces of accessory apparatus (pl. 1, D) are used to support the objects to be photographed; two of these are used when a photograph with either a white or gray background is desired, and the third is used only when a completely black background is wanted. The first of these is a 4-sided reflector apparatus (*b*) which carries a sheet of flashed opal glass at its base and a second sheet of frosted glass over this. The flashed opal glass serves to give satisfactory diffusion of the light from below, but because of its smooth surface it must be covered with a sheet of frosted glass to eliminate objectionable glare from the lights. The second equipment is used when larger objects are to be photographed, or when lantern slides are to be made. This equipment consists of two large sheets of flashed opal and frosted glass (*b*) cut to fit directly into the grooves in the sides of the box. It is not altogether necessary to use the tray at any time, as these two large sheets of glass may be employed for the same purposes for which the tray is used. The greater convenience of the tray, together with some advantage in illuminating the sides of deep specimens, seems, however, to make its use desirable. A deep, black-velvet-lined box which fits directly into the side grooves serves as a support when a black background is desired.

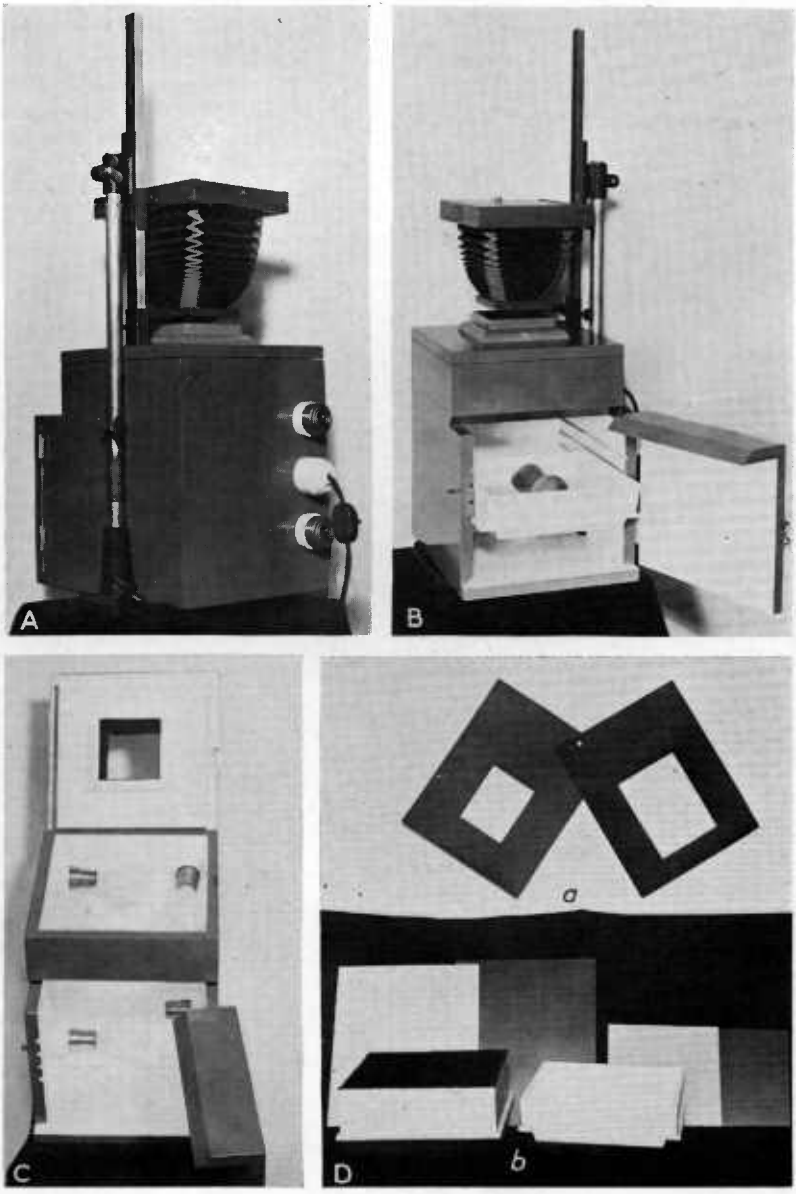
METHOD OF OPERATION

All of the more common types of photographic plates have been used with the apparatus, but the ones most generally satisfactory have been those with panchromatic emulsions. Orthochromatic plates also give good results, but require several times the exposure necessary for panchromatic plates. The process panchromatic plate is also quite useful where it is desired to accentuate the contrast. Filters have not been used as much as with daylight, but it has been found that the Wratten K 2 and K 3 filters give no appreciable correction. Difficulty was experienced in obtaining the desired contrasts with such subjects as apple and peach leaves and fruits showing spray-injured or diseased regions in which the necrotic or chlorotic areas were light brown, red, or yellow. The use of the proper filter as determined by observation of the object through a filter test chart resulted in securing satisfactory photographs. The Wratten A, B, and G filters are used where it is desired to obtain clear definition with such objects having slight contrasts between greens, reds, brown, and yellow.

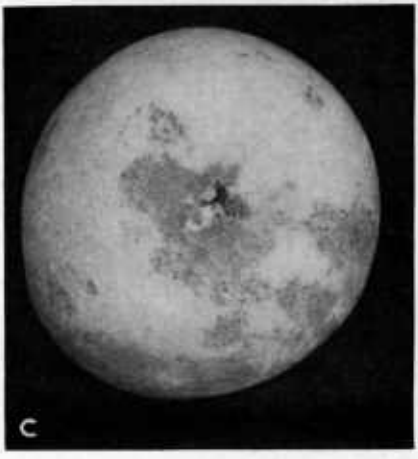
The 100-mm lens is used for practically all the work, as it will cover a 5 by 7 inch plate at the distance it must work from the objects in the box. This lens gives natural-size reproduction as well as a certain degree of enlargement or reduction. The shorter focal-length lenses will not cover as large a field in the necessary working range.

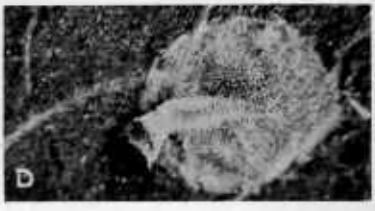
PHOTOGRAPHING WITH A WHITE BACKGROUND

The white background, as used with the apple target-spot material illustrated (pl. 2, B), is the most generally satisfactory and the most commonly used. It may be employed with any opaque or nearly opaque object, such as fruits, twigs, leaves, tubers, roots, and similar specimens, unless they are very light colored. The object to be photographed is placed directly on the frosted glass (pl. 1, B), which may



Photographic light box and accessories. A, Photographic light box in position, showing manner of fitting vertical camera support and the switch arrangement; B, interior view of box showing the manner of placing specimens for photographing; C, interior view of light box, showing the arrangement of light bulbs; D, accessories for use with light box; the masks for making lantern slides are shown in *a*, while the velvet-lined box, the reflector tray, and the pieces of flashed opal and frosted glass appear in *b*





Photographs made with the aid of the light box, illustrating the different types of background obtainable, and also showing the possibilities of the light box in photomicrography. A, *Lepiota naucina* on black background; B, target canker on apple twigs, white background; C, spray injury on apple, gray background; D, young larva of *Cydia pomonella*. D is × 25

be either the one used in the reflector tray or the large glass. The flashed opal glass must be placed beneath the frosted glass to obtain even illumination from below. The upper, or both the upper and lower, lights are switched on and the arranging of the specimens and the focusing of the camera completed. A diaphram aperture of approximately f. 48 is usually used for the exposure. The lights are switched off, the plate holder inserted, and the protecting slide withdrawn. The lower switch is set at "on," the upper one at "off," and the line switch turned on for approximately two seconds, provided a panchromatic plate without a filter is used. The line switch is then turned off, the upper switch also set at "on," and a second exposure with both sets of lights for approximately one second is given. This completes the exposure. Opaque objects, or those nearly so, may be silhouetted with the lower lights and a small lens diaphram, insuring a satisfactory white background as well as destroying any background shadows. With many objects it is not necessary to use the additional background exposure. In such cases both sets of lights are used together for the single exposure. The periods of exposure vary but little, and consequently after they have once been determined for a certain plate and developer, a high percentage of satisfactory plates may be expected.

PHOTOGRAPHING WITH A GRAY BACKGROUND

Light to medium gray backgrounds may be produced by inserting a sheet of transparent red paper between the frosted and flashed opal glasses and proceeding in about the same manner as for a white background. A medium-gray background may be obtained with the use of the upper set of lights only; the use of the lower set of lights for varying periods will produce lighter-gray backgrounds. The red paper used in wrapping film packs and other photographic materials is quite satisfactory. The dark-gray background, as used in photographing the apple injured by summer-oil spraying (pl. 2, C), was satisfactorily produced by inserting a sheet of black paper between the two sheets of glass and using only the upper set of lights. The rough surface of the glass will reflect sufficient light to give a gray background, and at the same time no photographic impression of the paper will be obtained as would be the case if the subject were placed directly upon the paper. The gray background is most useful with objects which contain considerable contrast, making either the white or black backgrounds somewhat unsatisfactory.

PHOTOGRAPHING WITH A BLACK BACKGROUND

Completely black backgrounds are desirable only when sharp contrast is desired, as was the case with the mushroom, *Lepiota naucina*. (Pl. 2, A.) Such a background is obtained by the use of the box lined with black velvet. The subject to be photographed may be placed directly upon the bottom of the box, or upon some small support which is covered by the object itself. Care must be taken to remove all lint and light-colored particles from the surface of the velvet. The upper set of lights are used alone and the usual exposure given. If these precautions are observed an even black background, free from evidences of the support, will be obtained.

NATURAL-COLOR PHOTOGRAPHY

The Autochrome or Agfa color plates may be used with the light box for taking photographs in natural colors. The writer has not found it necessary to use a filter, the light from the vacuum bulbs producing very satisfactory results without correction. Nitrogen-filled tungsten bulbs would no doubt be desirable if a great deal of this kind of work were to be done. The period of exposure ranges from 20 seconds to over a minute, depending upon the density of plate desired.

LANTERN-SLIDE PRODUCTION

The light box may be used in making lantern slides from plates not larger than 5 by 7 inches in size. For this purpose a sheet of black cover-stock paper is cut to the size of the large pieces of glass and a correctly centered section slightly smaller than the plate with which it is to be used is cut from the sheet. (Pl. 1, D, *a*.) The section removed must be centered beneath the camera lens. This paper mask is placed between the two large sheets of glass, the three are then slid into two of the parallel grooves which run horizontally between the upper and lower sets of light bulbs (pl. 1, B and C), and the negative placed over the aperture in the paper. The lower lights are switched on and focusing completed, after which the exposure is made in the usual manner.

PHOTOMICROGRAPHIC ILLUMINATION

The light box may be used quite successfully for upper-field illumination in low-power photomicrographic work (pl. 2, D) when other and more convenient methods are not available. To use the box for this purpose, the lower bulbs are removed and the microscope is placed on the bottom of the box and centered. The tube should be extended to the proper length and the top of the box replaced. The microscope may be too low, in which case it may be raised by placing as many sheets of cardboard beneath it as are necessary to raise it to the desired height. The camera is then fitted to the microscope as usual, the upper lights turned on, and the microscope focused. It is necessary under these circumstances to manipulate the microscope controls through the open door of the box. An exposure of approximately 30 seconds is required at a magnification of 25 diameters. The light box illuminates the field evenly and produces no shadows, shading of the field being necessary if some shadows are desired with light objects showing little contrast.

CONSTRUCTION AND FITTING OF THE BOX

The light box is not difficult to construct, and may be made by any woodworking or cabinet shop. The total cost, including labor and materials, should not exceed $20 or $25.

Three-quarter-inch white-pine lumber is used in the construction of the box. This makes a very substantial piece of equipment and allows sufficient thickness to cut the wiring and slide grooves. Detailed drawings of all the parts of the box are given in Figures 1–3. The drawings and measurements are based on butt-end construction, although mitered construction may be used if preferred. The ⅜-inch grooves at the top and bottom of the individual pieces, together with

the connecting groove in the left end, are designed to hold the wiring system, which is completely covered in the finished box. These grooves fit together to make continuous channels when the pieces are assembled. The four ¼-inch grooves in each of the two sidepieces are for holding the accessory fittings, as has been previously mentioned.

The back, front, and left sidepieces are nailed to the bottom through the sides, as the bottom fits inside the box and even with the lower

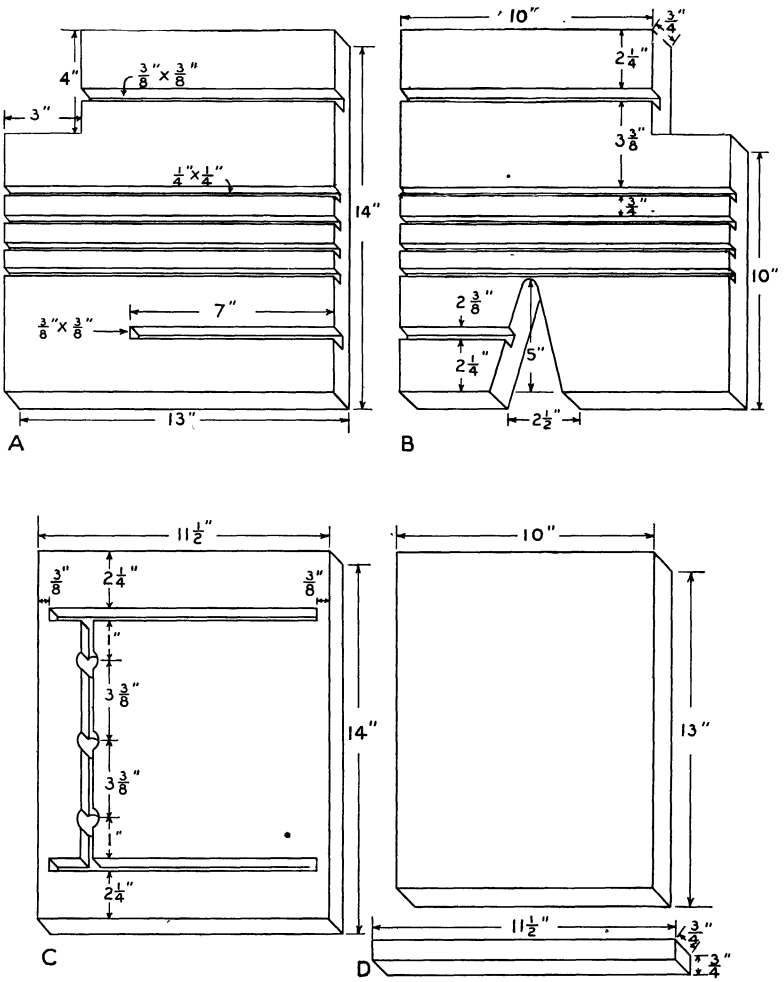


FIGURE 1.—Detailed drawings showing the dimensions and construction of certain parts of the photographic light box: A, Front; B, back; C, left side; D, bottom

edges of the side and end pieces. The upper piece of the right-end assembly is nailed across the upper inset of the two sidepieces. The other two right sidepieces are nailed together as illustrated in Figure 2, B, to form the door of the box. This door is hinged to the side away from the operator, or to the sidepiece designed to fit up against the upright support of the camera. It should be mentioned here that it will be necessary to cut a groove in the outside face of the sidepiece

fitting against the camera support in order to center the camera properly. This groove extends upward from the apex of the triangular cut in the bottom of the sidepiece, but this groove has not been illustrated as the fitting will have to be made to the individual camera. (Pl. 1, A.) The small ¾ by ¾ by 11½ inch piece is nailed across the right end to the bottom piece and extends the bottom out even with the outer edge of the door. When assembled, the inside dimensions

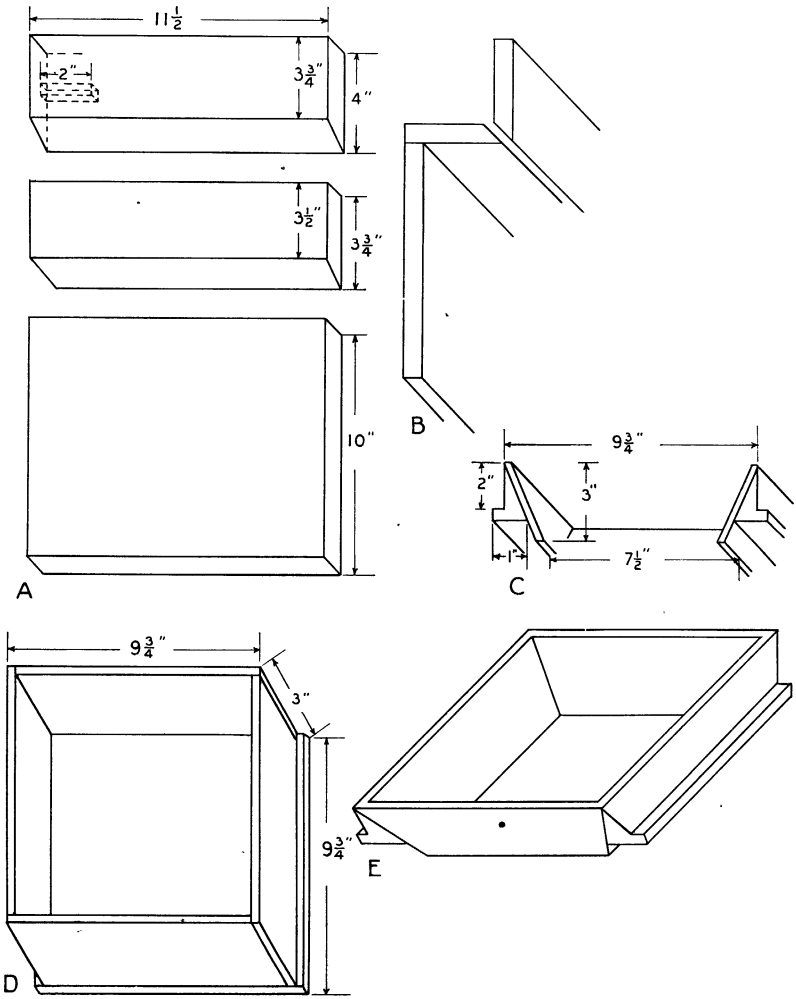


FIGURE 2.—Detailed drawings showing the dimensions and construction of certain parts of the photographic light box: A, Right side; B, detail of right-side construction; C, cross section of the reflector; D, black-background box; E, reflector tray

of the box are 10 by 10 inches at the top and 10 by 13 inches at the bottom. The outside dimensions are 11½ by 14½ inches. The top-piece is 11½ inches square, having a section 4½ by 4½ inches cut from the center. A square tube constructed of ¼-inch plywood is fitted in the hole in the top so that it projects 2¾ inches below the lower surface

and 1 inch above the upper surface of the toppiece. Three-quarter-inch quarter-round molding is fitted around the top of the tube to brace it and give the top a finished appearance. The lower side of the toppiece is fitted with a flange made of triangular stock 1½ inches on each of two sides. (Pl. 1, C, and fig. 3, B.) This piece holds the top

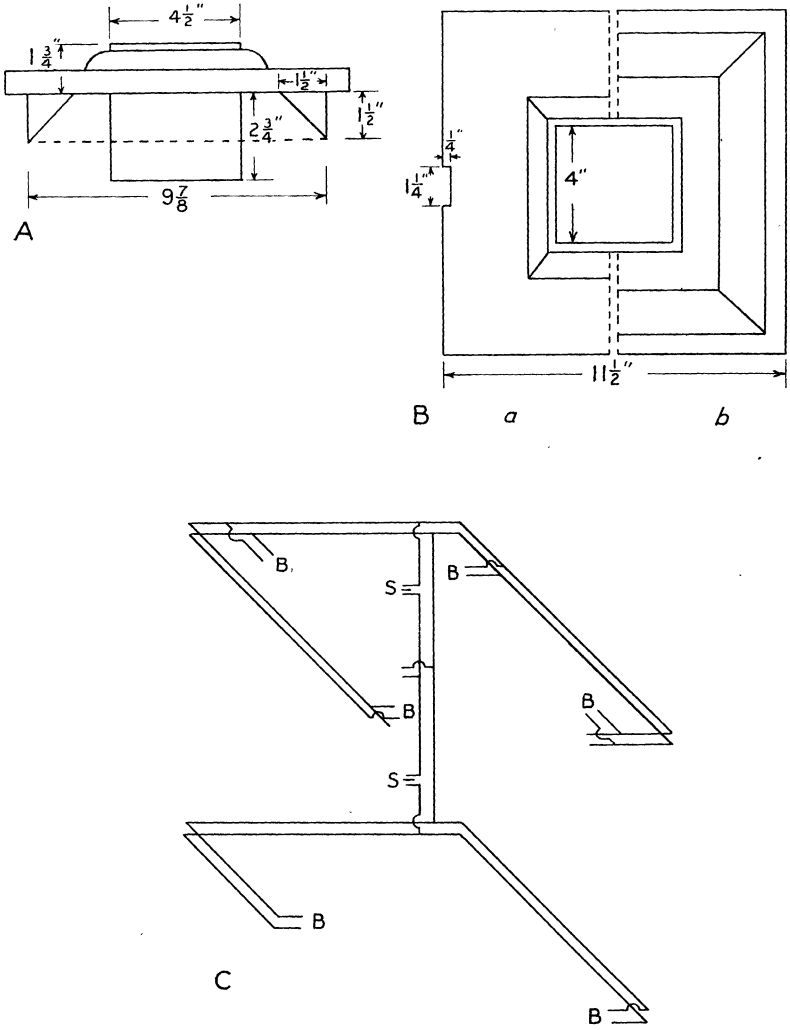


FIGURE 3.—Detailed drawings showing the dimensions and construction of certain parts of the photographic light box, and the arrangement of the light bulbs: A, Cross-sectional view of the top; B, toppiece with upper side shown at *a* and lower side at *b*; C, diagram of wiring in which B stands for bulb and S for switch

in position and also serves as a reflector above and back of the bulbs. The toppiece should not fit too tightly or it may bind after painting.

The box is wired with double-strand insulated wire, which is placed around in the wiring grooves in the box and secured with insulated staples. A loop of wire should be left about 1 inch from each corner

and at the ends of the two lower grooves for later attachment to the light sockets. A single loop is pulled through the upper and lower holes in the left end piece for attachment to the two circuit switches. A double loop is pulled through the center hole to be attached to the rosette to which the lead-in wire is attached. After the wiring has been completed, but before any fixtures have been attached, the wiring grooves are filled with plastic wood material and this allowed to dry thoroughly and harden. The small irregularities remaining are then smoothed over with a thin paste of plaster of Paris and after this has dried and again been smoothed down, the box is ready to be painted. After painting, open-bottom receptacles are fitted at the bulb locations and the wiring brought up through them and attached to the keyless sockets. This assembly of bottom-wired receptacles and keyless sockets places the filaments of the bulbs at approximately the centers of the sides. The switches, rosette, and hinges are also attached after painting has been completed. The arrangement of the bulbs and switches is shown in Plate 1, A and C. The wiring diagram is given in Figure 3, C.

The interior of the box is painted white, as is the reflector tray. Lacquer has proved to be better than enamel for this purpose. The interior of the square lens-receiving tube or aperture is lined with black velvet, although dull black paint should be satisfactory.

The reflector tray is made of ¼-inch plywood, as is the black background box. The reflector tray is constructed with sloping sides, the dimensions at the top being 9¾ by 9¾ inches and 7½ by 7½ inches at the bottom. The tray has no other bottom than the two pieces of glass which serve as a transparent base. The two pieces of glass are cut 8 inches square, thus fitting near the bottom of the tray. The tray is fitted with projecting tongues on two sides (fig. 2, C and E) to fit into the side grooves. The black background box is a plain open-top box 9¾ inches square and 3 inches deep (fig. 2, D) with the bottom edge projecting a short distance on each of two sides in order to engage in the grooves in the box. The interior of the box is lined with a good grade of black velvet. This box may also be used quite satisfactorily outside the box. The two large pieces of frosted and flashed opal glass are each cut 10$\frac{5}{16}$ by 13 inches in size.

The light box as described is designed to operate with the Leitz vertical camera, although the design may be readily adapted to other cameras. The principal precautions to observe are to see that the over-all height of the box is not greater than the height to which the lower end of the camera rail can be raised, and to determine the largest size box that can be centered beneath the camera.

SUMMARY

The light box described in this paper has proved very satisfactory as a source of illumination for photographing diseased fruits and similar specimens. It provides a simple and inexpensive means by which shadows, high lights, and cross lights can be eliminated and at the same time enables the operator to secure the color of background that is best suited for the object to be photographed.

Since the illumination comes entirely from artificial sources, daylight being excluded, the light is always uniform. This makes it possible for one to do photographic work at any time of day or at

night, and so long as other factors are kept the same the period of exposure for best results will not vary appreciably. This results in a great saving in time and photographic supplies.

In addition to being of use in ordinary indoor photography, the box may be used for making lantern slides and in low-power photomicrographic work. The construction of the box, together with its method of operation, is described in detail.

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