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METHODS OF USING THE

Microscope, Camera-Lucida and Solar Projector

FOR PURPOSES OF EXAMINATION AND
THE PRODUCTION OF
ILLUSTRATIONS.

BY N. A. COBB

BEING THE FIRST ANNUAL REPORT OF THE DIVISION OF PATHOLOGY
AND PHYSIOLOGY. EXPERIMENT STATION OF THE
HAWAIIAN SUGAR PLANTERS' ASSOCIATION

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METHODS OF USING THE
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*To the Experiment Station Committee,
Hawaiian Sugar Planters' Association:*

It is using a misnomer to call this an Annual Report, inasmuch as the Division of Pathology and Physiology has been in existence as a partially organized force for only about three months. Under the circumstances the energies of the Division have of course been devoted mainly to securing the proper facilities for its work in the form of laboratory equipment and land. I think I can not do better under the peculiar circumstances of the case than to describe at some little length the more original of the features embodied in the Laboratory.

The nature of this building has been mentioned in the Annual Report of the Chairman of the Committee on Experiment Stations, and the illustrations inserted there and elsewhere in this report give a good idea of its general appearance, both externally and internally. The features to which I will call particular attention are those found in the Microscope Room, Illustration Room, and Dark Room.

THE MICROSCOPE ROOM.

For many years it has been customary in the best laboratories to mount various instruments of precision upon pillars of stone or masonry deeply imbedded in wells in the ground and passing upward through the floors of the laboratory without contact. The object of this arrangement is to prevent tremors, which are of constant and inevitable occurrence in an inhabited building, from being transmitted to the instrument; the earth receives these tremors, and, within the limits of the precision of the instrument, they are nullified. Galvanometers, seismographs, balances and other instruments are mounted in this manner. It is not often that the microscope has received such special attention, but wherever high powers are used and especially when photo-micrographs are being prepared, or whenever high power camera lucida drawings are being made, the reduction of vibration is an important factor in the success of the

work. For many years the writer has had microscopes mounted in this way and hereby testifies strongly in favor of this method of using the microscope. The system is exemplified in the Laboratory of the Division of Pathology and Physiology, and as experience has added improvements to each successive plant erected, it may be worth while to describe this recent outfit.

The plan is carried out in cement and steel. See Fig. 1. Below the building is a large block of cement weighing several tons. In this block of cement three T-girders, two of which are approximately eight inches in each dimension, are imbedded vertically to the depth of about four feet. The central girder carries the microscope, together with certain accessory apparatus connected with the illumination of the object. This girder is much smaller and shorter than the other two, extending only about eighteen inches above the floor of the microscope room. The other two girders are mates and extend to within about eighteen inches of the ceiling of the room; in other words, project upward into the room about eleven feet. The building being constructed of wood, the floors were laid about the pillars after they had been set in the cement and the whole structure was then given sufficient time to settle into its permanent position. This usually occurs in the course of a few months. When everything is settled into position, an ordinary key-hole saw is run through the floor entirely around the contours of the girders, so that at the end of the sawing operation the girder entirely clears the flooring and floor covering by the width of a saw blade. See 3, 43, &c., Fig. 1.

Needless to say the object of these girders is to afford attachment for all the necessary apparatus connected with the microscope. The girders at every part clear the walls of the building by a fair margin. It is however best to place all the girders as close to the microscope window as is convenient. The reason for this will be explained on a subsequent page. In the present instance, the distance between the girders and the window casings is about one inch. The general principle on which the accessory apparatus is attached to the girders is that of sliding metal sleeves that may be clamped in any desired position. A sleeve of one-sixteenth-inch sheet metal surrounds the small central girder and projects outwards, that is toward the observer, sufficiently to form a base on which the microscope may rest. This base is from one to two times larger than the horse-shoe base of the microscope. This gives a sufficient amount of space so that the microscope can be readily arranged for different classes of work,—moved sideways in either direction, or forward, or backward. The sleeve carrying the microscope

DIVISION OF PATHOLOGY AND PHYSIOLOGY
Main Laboratory

FIG. 1.—MICROSCOPIST'S OUTFIT.

is clamped to its pillar by three set-screws, and by means of this simple arrangement the microscope can be fixed high or low to suit different operators and different classes of work. When, for instance, micro-photographs are being taken, it is most convenient to drop the sleeve to its lowest limit, so that the microscope will rest on a base about fifteen inches above the floor. For most photo-micrographic work this will enable the operator to bring the focussing plate of the camera (19 Fig. 1) low enough to render it unnecessary for the operator to have any special step-ladder to assist him in obtaining an accurate focus. On the other hand, when it is necessary to place the microscope high and the camera lucida table low, one can obtain a distance as great as two and one-half feet between the level of the eye-piece of the microscope and the drawing table. This, together with the peculiar camera lucida, which will be described later on, enables one to make his original sketches of such a size as to allow for that liberal reduction in the subsequent photographic process which gives the best results for book illustrations. The sleeve which carries the microscope also carries a wooden front as wide as the microscope window and about two feet deep, in other words about three feet by two feet. This screen, which of course slides up and down with the microscope and its sleeve, carries two apertures. One of these apertures is in front of the microscope mirror and is designed to allow the light from the special outdoor illuminating screen to strike the mirror and pass through the microscope. The second aperture is of much larger size and is glazed with ground glass and is opened or closed as desired by means of a hanging slide worked by foot-power. The object of this second opening is to secure a correct illumination on the drawing board when the camera lucida is in use. See Fig. I.

We will next pass to a description of the microscope window. This faces the sun, and preferably faces precisely south. It is so fitted with light-proof roller blinds that the light may be entirely shut off or may be allowed full access. The roller blinds slide in lateral grooves ten inches deep. The depth of these grooves must be sufficient to prevent the blinds bellying through the action of the wind. It is found when a window is tightly closed with flexible blinds as is the case in this special microscope window, that the pressure of the wind is sufficient to cause considerable inconvenience unless the edges of these roller blinds are held in deep grooves. Should it be necessary to make a further provision against the bellying of the blinds they may be stiffened from place to place with one-sixteenth-inch wooden laths; or wires may be strung across the window. The blinds may be of any opaque material, but if they are very

long, preferably of some thin material. The writer has found that ordinary green opaque window blinds can be sized black so as to become practically light-proof, and as it is advisable in constructing a light trap to have two blinds, he finds that with two such blinds the light is wholly excluded, and if necessary the room can be used as a photographic dark room. The wooden rollers used are of the ordinary pattern and present no special peculiarity. They are built in or boxed in at the top in a light-tight manner.

We turn next to the various sleeves sliding on the long upright girders. Of these one of the most important is the right-hand lower sleeve which carries a leg-of-mutton shaped table for use in connection with the production of camera lucida drawings. This sleeve as well as all the others, is balanced with a sash-weight, so that it moves with the utmost freedom either up or down through a space of about four feet. The table may therefore be placed within fifteen inches of the floor, or it may be raised to a distance of three feet. This adjustability is found to be highly convenient in the production of camera lucida drawings of definite magnification. The peculiar shape of the table has been evolved from practical experience during many years. In general, its form is such that when taken together with its mate on the other side of the microscope, it presents a semi-circular curvature which gives the investigator a free play for hands and body. This table is painted black, as are all the other accessories used in this system. See 32, 34, Fig. 1.

Turning to the left-hand side of the microscope, we find an entirely similar and symmetrical sleeve and table, which however is used for a very different purpose. This sleeve carries the mate to the camera lucida table and of course, in the case of a left-handed operator, could be used in the same way as the right-hand table would be used by a right-handed operator. The usual position for the left-hand table is about on a level with the microscope stage. This height is found to be convenient for several reasons; first, under ordinary circumstances, it is about ordinary table height and is convenient for supporting the dissecting microscope, which, as explained later on, has a special illumination of its own. Thus in the preparation and examination of objects, the dissecting stand is as close as possible to the examination stand and the objects may be transferred from one to the other with the greatest convenience; a second reason for having the left-hand table on a level with the stage of the microscope is that the preparations may be moved on and off the stage of the microscope with the least danger and with the greatest facility. A third reason is that in this position the

left forearm finds it a most convenient rest in working the fine adjustment screw. In addition to the three sleeves already described, the long girders carry two cross-pieces for the attachment of various accessories. These wooden cross-pieces slide up and down and are weighted with sash weights so that their adjustment may be quickly and easily accomplished. In order that the friction on the girders may not cause any inconvenience, arms extend upward from these cross-pieces for the purpose of carrying pulleys which are in contact with the edges of the girder and so reduce the friction. These cross-pieces are clamped in position by set-screws at the side. It will be at once evident that these cross-pieces may be used for the attachment of a variety of accessories. Among the more important of these is the microscope camera. See 19, Fig. 1. This hangs above the microscope and is ever in readiness for instant use. The camera itself presents no very peculiar features. It is of course a vertical pattern carrying the exposed photographic plate in a horizontal position. It cannot be used in a horizontal position. Experience has shown that the vertical position has very many advantages, and that if one is confined to a single outfit, the vertical outfit is the better, providing its attachment can be of the nature here described. In obtaining the focus, the cross-piece carrying the camera is loosened by unclamping the side screws and is then moved upward and downward against the sash weights which counterbalance it. A scale is marked on the girders so that the various magnifications are at once obtainable, or they may be obtained by special measurement in each case. The apparatus never needs any levelling, being, as before said, constantly ready for use. The operator loosens two hooks and the camera drops instantly into position. The whole is ready for use in a few seconds' time. If the photograph is being taken with a high power and the illumination is therefore weak, and the exposure consequently long, one leaves his instrument during the exposure with the greatest confidence that nothing can disturb it. Any tremors in the building will not be received either by the microscope or the photographic plate.

A second attachment of great importance for the production of illustrations is the

CAMERA LUCIDA.

This presents a number of peculiarities. Fig. 1, 17, 24. The history of the camera lucida is a very interesting one. It is impossible to go into its details here, but nothing is clearer than that this instrument is one of great importance to the microscopist, and its history is in accordance with this fact. The utmost in-

genuity has been exercised to produce an instrument by means of which sketches of small objects can be made with the aid of the microscope. The necessity for this class of work is very great. The photographic camera does not materially assist us with most subjects. Only in the case of exceedingly thin sections or natural objects of great thinness is a photomicrograph satisfactory. In all other cases in order to fully elucidate the structure by means of an illustration it is necessary to obtain the appearance at different depths in the preparation. This can only be done by focussing the microscope for each particular portion of the structure. This fact, thus hastily explained, is what makes it absolutely necessary to use a camera lucida for the proper representation of most microscopic objects. This fundamental necessity is what has given rise to the many patterns which the camera lucida has taken on during the course of its history. The first instrument was an extremely simple one. From time to time improvements and additions have been made until at the present time the instruments issued by the best makers are marvels of ingenuity and workmanship. In fact, in the writer's opinion they are almost too ingenious, for it appears to him that the various additions which have been made to the camera lucida during recent years, while they do accomplish the object aimed at, do so in an unsatisfactory manner.

In order to produce a good camera lucida drawing, it is necessary to have a certain degree of light passing through the microscope enabling the operator to see the object with the greatest possible clearness. It next becomes necessary to so modify the light from the drawing board as to enable him to see his drawing point with the greatest possible clearness. Now, with most objects it is not possible to secure this adjustment once for all, for all portions of the drawing. Different portions of the object emit different amounts of light, and, as the light varies, it is necessary, in order that the drawing may be made with the greatest precision and facility, that the light from the drawing board should be modified accordingly. The accomplishment of this end has been sought in a variety of ways, and this more than any other one thing has added to the complexity of the modern camera lucida. When the modern instrument is in good order, it does, as we have admitted, in a way accomplish its object. The difficulty is that it is easily thrown out of adjustment, and easily becomes soiled and dusty so as to be a hindrance rather than a help. Again, no device has yet been furnished by manufacturers which enables one to modify the light except by a series of steps. It is usual to insert or remove a certain number of tinted glasses until the right degree of light has

been secured. It often happens that the precise tint required can not be secured at all. In any case by this method there is always being inserted between the eye and the object, various pieces of apparatus which can not be regarded as other than necessary evils. It is needless to go into the particulars of instruments made by different makers. What has been said has a general application. A second defect presented by many of the camera lucidas, is the double reflection due to a silvered mirror. The thickness of this mirror has been carefully adjusted in order, as far as possible, to superimpose the various images one on the other, but it is impossible to get rid of the double reflection and while this can be tolerated for a short time, if the instrument is in use for a considerable length of time, say several hours, this double reflection of the pencil point becomes very tiresome to the eye.

Any form of camera lucida is an instrument well-calculated for the destruction of eye-sight. The writer has during many years of experience been endeavoring to reduce the injury to eye-sight in connection with the use of the camera lucida, and the following suggestions, embodied in the outfit here described, are the result of his experiences. In the first place, he has substituted for the ordinary mirror a 45° prism. Fig. 1, 24. The advantages obtained by this substitution are as follows: 1. The prism may be of any desired size so that it may be mounted at a considerable distance from the eye-piece of the microscope. This secures an increased magnification of the drawing, and the advisability of this increased magnification will be dwelt upon on a subsequent page. 2. A second advantage in the use of the prism as a reflector is the disappearance of the double reflection, and the securing of a total reflection. The light passes from the drawing-point through the lower face of the prism in a nearly perpendicular direction and with very little loss. It is then totally reflected from the oblique face and passes outward nearly at right angles to the vertical face, again with very slight diminution. The loss of light is therefore considerably less than in the case of the usual mirror, in addition to the securing of a total reflection destitute of doubles. 3. A third advantage and one of considerable importance is the stability of the apparatus here described; it rarely gets out of register.

The second modification is that which has been referred to on a previous page, as the blind worked by foot-power. Fig. 1, 32. The object of this blind is to illuminate the drawing with any degree of light at an instant's notice and to do this without in any way disturbing the adjustment of any part of the microscope or

camera lucida. This is a matter of very great importance in the rapid production of good camera lucida drawings. It often happens that the light coming through the instrument is so faint that it is only by shutting the light quite off from the drawing that the investigator can see the details of the structures to be sketched. This darkening has in the past been accomplished in various ways. It has for instance been accomplished by having a pencil on the butt end of which is a feather to be flitted in between the eye and the drawing board so as to obliterate the image of the latter. There are other methods of accomplishing the same end. With the foot-power arrangement, the light is shut off or let on without the operator's disturbing the position of his body or his drawing-point. Moreover, the light can be so modified as to instantly bring about that adjustment which is most favorable for any particular part of the sketch. To describe the whole operation briefly, we may say that the operator's left hand rests on the left-hand leg-of-mutton table on a level with the fine adjustment of the microscope. His left hand therefore is in a position to work the fine adjustment screw with the greatest ease and facility, and the most careful adjustments of focus can be easily accomplished. His right hand carrying the drawing-point rests on the drawing board and is engaged in the production of the sketch. As the light required for the various portions of the drawing varies he can by a slight movement of his right foot, which in no way disturbs either of his hands, and in no way disturbs the equilibrium of the instruments, effect the desired illumination of the drawing. It is found that the drawing surface best adapted to the production of camera lucida drawings is a dark, and, preferably, black surface. On this surface a white drawing point should be used. For most objects this is a considerable improvement over the ordinary pencil used on white paper, as will be at once admitted by any one who makes a trial. The method found most effective in this laboratory is that of using a thin black tissue-paper which is blued on the under side. A piece of enameled board of suitable size for the drawing is placed on the drawing board, i. e., the right-hand leg-of-mutton table, and it is then covered with the black tissue-paper with the blue side down. A tracing is now made with a white ivory point. This results in the production of a blue outline drawing on the enameled board. This sketch is put aside for further reference, or for the production of a finished drawing whenever necessary, or may be finished up at once. The object to be secured in this blue sketch is a sufficiently good representation of the object to be illustrated which shall have

sufficient size to admit of a liberal reduction when the drawing is photographed on metal preparatory to etching. Thus, if it is desired to publish an illustration having a magnification of 500 diameters, it is advisable to produce a blue sketch at from 1,000 to 2,000 diameters. This is easily accomplished with the apparatus that has been described. By placing the prism reflector at a considerable horizontal distance from the eye-piece of the microscope, say one foot, and lowering the right hand leg-of-mutton table sufficiently, magnifications of liberal dimensions are easily secured. Needless to say the production of a large coarse drawing is an easier matter than the production of the same drawing on a smaller scale, so that the operation is not only better, but considerably easier if carried out in the manner described. It is unnecessary to go into the details of converting the blue sketch into a pen and ink drawing. These present no peculiarities. It ought perhaps to be mentioned that the object of using the blue color is to avoid trouble through the alterations that may be necessary in finishing the drawing. Any light blue lines which are left on the enameled board need not be removed, as they do not affect the sensitive photographic film sufficiently to cause any inconvenience in the production of an etched block. The black tissue paper mentioned is produced by inking ordinary tissue. The ordinary blue carbon paper gives too dark a blue to meet the requirements. The blackened tissue is rubbed on one side with dry Prussian blue powder. This gives a light blue tracing.

At an earlier stage it has been mentioned that all the accessories in connection with the microscope are painted black. In addition to this precaution, arrangements are made such that the room itself can be darkened, in fact, converted into a photographic dark-room at will. This object is secured by having all the window blind connections light-tight. The oblong aperture, about five inches by eight inches, through which the microscope receives its light is screened by means of several thicknesses of flexible black cloth made into the form of a sleeve. This cloth sleeve attached around the perimeter of the opening, is notched above so that it surrounds the microscope just beneath the stage and buttons onto one of the screws at the back of the microscope. No light reaches the eye except that which comes through the instrument. If, now, the slide in front of the large glazed aperture be closed and the room be darkened, the operator sits in absolute darkness. Any one who has had experience with a photographic dark-room, must have observed how after a period of from five to ten minutes therein the eye becomes accustomed to the darkness of the room

and is able to distinguish objects much more readily than at first. This is a principle which can be utilized to very great advantage in connection with high-power microscope work. In fact, the writer is of the opinion that it is this contrast between the external and internal illumination which leads so many operators to use artificial light, and even in some cases to prefer working in the evening. Certain it is that if the surrounding light is dim and the eye is allowed to adjust itself to this dimness, then on looking through the microscope, details may be seen much more clearly than in any other way. It is often painful to witness the unconscious efforts of microscopists to bring about this condition as fully as possible by means of awkward attitudes and facial expression. It is not at all uncommon to see the microscope placed in a glare of light with a strong light beating on the top of the object and confusingly reflected up through the microscope, and to see the operator sitting in a cramped position, bringing his head over the top of the instrument so as to shade his eye as much as possible and then often drawing the eye-brow down to assist in the same object. I take it that all this is simply an unconscious effort to give the eye the benefit of a weak extraneous light. With the present apparatus, these difficulties disappear. The room is darkened. All light which could possibly get to the operator's eye is excluded, except that which comes through the microscope. There is no light coming upon the top of his object to cause confusing reflections in the microscope. The image is as clear as it can be made and the eye is given every facility to see this image and is distracted by no others. Needless to say the apparatus is a daylight apparatus. It hardly seems necessary to argue that as daylight is the light which has developed the human eye it is the light to which it is best adapted. Images produced by diffused daylight must be the best that can be produced on the retina of the human eye. This seems a sufficient argument for the use of daylight and a sufficient explanation of its superiority to every other light. However, when all this is said, it is not possible to always secure and control this natural light so as to get the best results. The following contrivances are such as experience has shown the writer to be very useful for this purpose, especially in sunny climates. Outside of the microscope window a universally adjustable white screen is placed in a sunny position, preferably not more than ten feet away. The surface of this screen may be of any white material. It can be made of wood, painted white, or lined with plaster of Paris, or, what to the writer seems almost equally good, a plain wooden screen covered with several thicknesses of bleached cotton cloth. It is better if this screen can

be adjusted from the interior of the microscope room, but this is not essential. If a small mirror be attached to the screen, it will indicate the position of the screen that will reflect to the microscope mirror a maximum of white light. Place the screen so that the flash of sunlight from the mirror strikes in the vicinity of the microscope. Then of course, the whole of the screen will be in a corresponding position and will be reflecting a maximum of light. It is found that if the screen be placed in this position for several hours the light from it remains practically constant, so that while an adjustment by cords from the interior is a convenience, it is not a very great necessity. If an adjustable screen is not available, it is generally best to arrange one or two fixed screens and thus accomplish the same object, one screen for morning and another for afternoon. The light from a blue sky is not a satisfactory light. A white cloud gives a very good light, but clouds are such fickle things that it is not wise to rely upon them where the microscope is in constant use. It is much preferable to construct a screen that will be available in a fixed position whenever the sun shines. When the sun does not shine the sky must serve.

It remains to say a few words in regard to the dissecting microscope. This, as before mentioned, rests on the left hand sliding table. The main microscope window is flanked by two narrower windows, (forming a "bay") each of which is fitted with opaque wooden screens sliding up and down with sash weights. Whenever necessary, these screens can be raised and the light necessary for the preparation of objects secured. The object ready for examination, the screen is dropped, the room is darkened and the examination with the compound microscope proceeds. The screens just described have a second purpose in the carriage of batteries of accessory microscopes. It is often convenient in making comparisons to have several microscopes in operation at one time, even where, on account of the cost, it is not feasible to furnish complete outfits. To meet this end, cylindrical barrels capable of carrying objectives and eye-pieces are mounted in batteries on the screens and are pointed at the sky. The outfit that is found most convenient for each unit of this battery is as follows: a rather high-power eye-piece, a barrel 160 mm. long capable of carrying the ordinary objective, and two objectives, one of which is a moderate power corresponding to a one-sixth Bausch and Lomb or a Zeiss "D," and the other a two-thirds objective or Zeiss "A." In the wooden stage, a small section of tubing of the same size, and capable of carrying an objective, is used to carry the lower power of the two objectives. It is found that by pairing these objectives with care the low

power objective furnishes a first-class achromatic condenser for the high power. It is surprising what good results may be obtained with this simple apparatus.

The other features of the outfit are sufficiently displayed in the illustrations. The rotating tables are of the usual type, though above the usual size. They carry five by eight swing drawers and hanging shelves for books and instruments.

THE DARK ROOM.

A peculiarity of the Division dark room that deserves mention is its illumination. This is carried out on a plan that has often been adopted for small dark-room lamps, but has not hitherto, so far as the writer knows, been carried out on a large scale adapted to daylight as well as artificial light.

The non-actinic or "safe" light for the dark room is obtained by passing daylight through suitable solutions, and the illumination is from above after the manner of numerous patterns of small dark-room lamps. The dark room window is placed somewhat higher than is usual and its upper sash is boxed in in a light-tight manner. The box is prismatic in form; one side is parallel to the side of the dark room, in fact coincides with it; another is perpendicular to the side of the dark room and forms the horizontal bottom of the box, while a third is at an angle of 45° , such that when a mirror is fastened on its inner surface it reflects the sky light, which comes through the window and throws it downward upon the dark room sink and developing board. On the bottom of this prismatic box, there rests a tray, or a number of trays nested one over another, for the reception of the various colored fluids used as light screens. One of the most useful of these fluids is a concentrated solution of bichromate of potash. It is found that ordinary daylight or sunlight on being passed through from eight to twelve inches of concentrated solution of bichromate of potash is a very sufficient and satisfactory light in the dark room, especially when it is reflected from above in the manner described.* The mirror used for reflecting the light downwards is preferably of corrugated glass, though plain glass answers the purpose. The box contains an electric or gas light so that it is available for evening work. The amount of comfort to be gained from an ample illumination in the dark room is something that should not be overlooked, as the frequent passage from the dark room to an illuminated room is a trying matter, even for the best of eye-sight. The amount of illumination which may be secured by adopting the plan here described may be readily judged when it is said that during de-

* A still better arrangement is to have a glass aquarium full of the solution placed directly in front of the window, the light passing through it being afterwards reflected downward as described.

velopment ordinary type can be read with the greatest ease, so that it is rather a misnomer to call the room a "dark" room.

THE ILLUSTRATION ROOM.

Several of the rooms of the Laboratory of the Division of Pathology and Physiology are specially fitted up for the use of solar projecting apparatus. This projecting apparatus is primarily for the purpose of projecting negatives and microscope preparations from which illustrations are to be prepared, and in some ways the apparatus thus used takes the place of the ordinary camera lucida, and for the class of objects to which it is suitable, it affords many advantages over the camera lucida. It is however limited in its application so far as the microscope is concerned as it is impossible to use the highest powers of the microscope in this manner. A second use to which the projector will be put is the projection of images of microscopic objects which are under examination and which it is desired to show to more than one person at a time to facilitate discussion and study. Needless to say the projector can be used in the same manner as an ordinary stereopticon or magic lantern, with the advantage that, as sunlight is more powerful than any artificial light, much better images may be secured. It is also needless to say that the instrument has the inevitable drawback that it can be used only when the sun shines.

When the instrument is used in the production of illustrations, it is customary to project the negative, or preparation, upon a glass screen of special character. The object of the screen is to secure to the artist that freedom of movement which comes from relieving him of the drawback which is usually presented by the shadow of his own hand and person. The projector has often been used for the production of illustrations, but the writer is not aware that the present method has been hitherto exploited, except in his own private laboratory, namely: the use of so powerful a light as to enable the operator to throw the image through ordinary cartridge paper, thus enabling him to work on what may be called the backside of the projection. This method is an expeditious one and is a very great gain indeed from an artistic point of view. It is a gain from almost any point of view, but it particularly gives a freedom of treatment that has to be experienced to be fully understood. It is found that the projector when used in this way facilitates the production of illustrations from negatives so poor that they would not make a print suitable for reproduction by the half-tone or any other process. Furthermore, it often happens that

negatives contain objectionable features that it is not desirable should appear in the illustrations. When a drawing is prepared from the projection of such a negative, the objectionable features can be omitted. Again, the desirable features of several negatives can be combined and in this way results can be procured which would be procurable in no other. As to the details of the apparatus, little need be said so far as the projector itself is concerned. It is of the ordinary pattern consisting of an adjustable mirror capable of throwing the parallel rays of sunlight through a large condensing lens. The cone of light produced in this manner is passed through the negative or preparation and the light is brought to a focus on the screen by means of an objective. This objective may be a simple cheap meniscus, or may be a photographic lens, or a microscope objective. All these forms are in use in the illustration-room. It is more necessary to give the details of the screen upon which the projection is received and upon the surface of which the artist produces his drawing. This screen is borne between two uprights about seven feet high, set on four castors placed sufficiently far apart to give the apparatus a firm support. After the apparatus has been rolled into position, four screw-legs are screwed downward and the apparatus is thus raised off its castors and placed on four legs, and is then sufficiently firm to resist all the pressure that is brought to bear upon it. The screen proper is pivoted between the two tall uprights, and by means of a series of notches is adjustable in the vertical direction. The screen consists, to all intents and purposes, of a very large glazed window sash having the glass flush with the framework. The sides of this sash or frame are sufficiently strong to give it firmness and when the necessary angle is secured, a pair of clamps secures the screen from any mal-adjustment. At each end of the screen, two long pieces are hinged in such a way as to facilitate the manipulation of the paper upon which the artist works. These long narrow pieces are four feet long and one inch square and are hinged at the top of the screen and pass downward everywhere equidistant from the side of the frame, this distance being about three-fourths of an inch. At the lower end, these pieces are constantly pulled inward or toward the glass, by spiral springs. The under surface of each of these long pieces is lined with sand-paper. If now a long soft wooden stick suitable for the attachment of drawing paper be placed across the glass face of the screen, which as before remarked is flush with the frame, and be passed under the sand-paper surfaces, these latter will grip it with great firmness, and it will be found impossible to move it

Solar camera as used to facilitate the production of illustrations from negatives and from transparent objects.

Fig. 2. 1, steel girder to left of window affording part of the support to the ordinary camera 3; 2, cross-piece supporting camera 3; 4, support for camera lucida, same being here represented as attached to an ordinary lens carrier; 5, vertically adjustable horizontal platform; 6, drawing board; 7, horizontal ways for 6; 8, object in position to be drawn natural size; 9, mirror of ordinary camera lucida; 10, 11, camera lucida support; 12, light-tight roller-blind used, when unrolled as a diaphragm for the cone of light from the projector; 13, solar-projector set in special window casing near floor; 14, the negative being projected at 23; 15, 15, uprights carrying the adjustable sheet of glass on which the drawing 23 is being produced from the negative 14; 16, wooden frame for sheet of glass 18; 17, metal braces by which the frame 16 may be clamped at the required angle; 18, sheet of glass through which as well as through the paper 22, the image is viewed; 19, roller blinds to shut off extra light; 20, 21, sticks to which the drawing paper is attached with drawing tacks, these sticks being easily adjustable under the sand-paper-lined wooden springs-bars 24; 22, drawing paper; 23, image being drawn; 24, wooden bar lined with sandpaper and hinged at 25 and constantly pulled inward by a spiral spring at 26, so as to lightly but firmly grip the sticks 20, 21; 27, screw legs on which after the apparatus has been adjusted it can be raised so as to remain firm during the subsequent operations of focussing and drawing; 28, one of the four castors on which the whole apparatus is adjustable back and forward on the floor to vary the magnification.

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without the use of considerable force. It is to the under surface of this transverse piece thus held in position by the sand-paper surfaces at the ends of the screen, that the drawing paper is attached by means of ordinary thumb tacks. This provision is advisable, as in the use of the projector it is often necessary to bring the drawing into register, or to change the register somewhat. By slightly lifting the sand-paper surfaces, the paper is easily changed in position to accommodate any change of register. It is usual to make two punctures on the negative as register marks. As it is anticipated that this apparatus will come into much wider use, it may not be out of place to mention a number of points which experience has shown to be worthy of imitation or improvement. The light is usually a very strong one and in consequence the operator is most strongly illuminated. It is therefore desirable that he should wear dark-colored clothing, otherwise the reflections from his person will cause considerable interference. It is also desirable to have the room as dark as it can be conveniently made—the darker the better, especially when high power magnifications are in progress. When the finest detail is to be drawn, it is also advisable to arrange at the top of the screen a roller blind carrying an absolutely opaque blind with an aperture not much larger than will give freedom of movement to the hand in drawing, say from four to eight inches across. This shuts out all of the extra illumination and the eye will then accommodate itself in such a manner that any fine detail is much more readily seen. It is also desirable to have a drop blind by which the whole of the light may be instantly shut off, as well as a light at the back which can be also instantly let on so as to give the operator a very distinct notion of what he is producing. For it must be pointed out that when the drawing is being made, it is not easy for the operator to see his work, especially if he is working with a blue pencil, as is often the case if the drawing is to be afterwards finished up, photographed, and reduced for illustration purposes.

The illustration room is also furnished with an ordinary camera working on vertical uprights of the same character as those already described in connection with the microscope window. These are a second pair of steel girders imbedded in cement below the building and coming through the floor without contact. It is found that a great variety of objects are more conveniently photographed by using the camera in this manner than in any other, though of course it is necessary for many classes of objects to use it in the usual way. To facilitate the production of the necessary backgrounds, a well is provided.

This consists of an approximately cubical box, the sides of which are merely grooved framework in which run a set of opaque roller blinds. When these blinds are all drawn up, they make a box with a black interior, the roller blinds being painted black inside. The top of the well consists of a series of concentric frames capable of carrying plain and ground glass of various sizes. When it is necessary to photograph an object against a black background, it is customary to lay it upon a piece of plain glass, when the background, which consists of a black hole far beyond the focus, namely the interior of the dark-well, gives an absolutely black background which is obtainable in no other way. If it is necessary to secure grey backgrounds, a ground glass is substituted for the plain glass and one of the roller blinds is lowered and a mirror or other reflecting surface placed in the box below.

NATURAL SIZE DRAWINGS DIRECT. —

Another peculiar feature of the illustrator's room is a piece of apparatus designed for the production of natural-size or even reduced drawings with the aid of the camera lucida.

CAMERA LUCIDA FOR NATURAL SIZE OR REDUCED DRAWING.

Ever since the introduction of the camera lucida, it has been more or less used for the production of natural size and reduced drawings; in other words, it was soon seen that its application went beyond the instrument for which it was primarily designed. The writer has used the camera lucida to a greater or less extent in this manner for twenty-five years and has seen plenty of evidence that others have used it in the same way. At one time it was thought by certain manufacturers that the demand for an instrument specially designed for this class of work would justify the making and advertising of the instruments; but so far as I am aware, all this apparatus has been now withdrawn from the market. I do not know what the reason for this course may have been. It would seem that the instrument met a scientific need and that its sale should have been sufficient to keep it from oblivion. The only conclusion one can arrive at is that for some reason, the form of the instrument did not meet the need. The following notes relate to a piece of apparatus which has been gradually developed during several years, and which has as its object the application of the ordinary microscope camera lucida to the purposes we have mentioned. It is a piece of apparatus

Fig. 3. Drawing to illustrate the use of the ordinary camera riding on a vertical system. The camera lucida frame is pushed up out of the way, its details being, however, here shown in a somewhat different manner from that illustrated in Fig. 4. 1, 1, 1, 1, vertical girders imbedded in cement under the building and coming up through the floor without contact; 2,

right hand box containing a variety of roller blinds working in a horizontal direction and so tinted as to give a great variety of transmitted light; 3, similar right hand box of roller blinds; 4, 5, 6, roller blinds; 7, drawing board horizontally and vertically adjustable, and also tipping to pass platform 8; 8, vertically adjustable platform for the support of object to be drawn, in this case supported on a microscope stage; 9, 10, clamps for securing 7 and 8 in position; 11, 11, screws for clamping

See also
Fig. 2
and 4
on the
preceding
pages.

all the previously described apparatus to the steel girders 1, 1, 1, 1,; 12, roller blind used as a diaphragm as described in the description of Fig. 2; 13, diaphragm aperture in the roller blind 12; 14, lower portion of the framework of the apparatus supporting 2-13; 15, 15, cross-piece carrying the ordinary camera 17; 16, 16, screw clamps for securing the camera after adjustment; 17, ordinary camera; 18, dark-well for securing black or other background for objects; 19, one of the various adapters for varying the aperture in the top of the dark well; 20, inner roller blind being used to secure a light background for the object being photographed; 21, one of the four roller blinds blackened inside and forming, when pulled up, the black inside surface of the dark well; 22, 22, vertical slots in which the roller blinds 21, 24, &c., slide in a light-tight manner; 23, anti-friction bearings of the framework of the cross-piece 15; 24, one of the four blinds forming the sides of the dark well.

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which in use is placed in front of a window, in fact is usually attached either to the window, the window casing, or to special uprights near by. As exemplified in this laboratory, the apparatus is attached to two upright girders, the same two that carry the ordinary photographic camera. Both these attachments are slung on sash weights and can be moved up and down, so that either may be brought into play while the other is raised out of the way. The camera lucida attachment consists of two distinct frames which are separated near the middle of the window by a distance of eight to ten inches. The left hand frame is designed mainly to support the camera lucida, the right hand frame to support the drawing board. Both frames carry adjustable brackets and each bracket carries a horizontal shelf. The left hand frame therefore has a horizontal shelf carrying the microscope and this shelf is adjustable in the vertical direction, and can be clamped in any desired position. In a similar manner, the right hand frame carries a horizontal shelf, or drawing board, also adjustable in the vertical direction. The drawing board presents the peculiarity of being also adjustable in the horizontal direction, and of rotating about a horizontal axis so as to pass the opposite shelf,—it is required sometimes above that shelf and sometimes below it. The size of the apparatus is determined by that of the human body. The greatest distance that can be comfortably reached by an ordinary artist for drawing purposes is about thirty inches, i. e., when gazing through the camera lucida he can not comfortably produce a drawing at a distance of more than thirty inches from his eye as the light travels. An examination of the adjacent illustration will make this matter somewhat clearer. The camera lucida is usually carried on a piece of tubing clamped to an ordinary lens holder or empty microscope barrel. The object to be drawn is placed below, without a lens, or with a reducing lens, or in some cases with a lens which slightly enlarges the object. The drawing board is then lowered or raised until the drawing to be made will have the necessary size. It will be observed therefore that the whole arrangement is a three-fold one. There is a support for the object, a support for the camera, and a support for the drawing board, and these must be adjustable within the limits of the artist's reach. It will be seen however that if two of these are adjustable, the whole system is, for all practical purposes, the same as if all three were adjustable. We now come to the most important matter in connection with the use of this apparatus, namely: the illumination of the object and the illumination of the drawing board. It is possible that it is in this respect that the apparatus hitherto put on the market fails

to meet the requirements of the case. It is very desirable to fully control the illumination. Sometimes the object has to be strongly illuminated, and the drawing board weakly illuminated; sometimes the reverse is the case, the object has to be weakly illuminated while the drawing board has to be very strongly illuminated, and the variation in illumination should be as great as possible,—from strong sunlight to absolute darkness, if possible. This is the main point in the successful use of the camera lucida for this class of work. This object is attained in the present piece of apparatus by placing the whole at a sunny window and modifying the light by a series of seven roller blinds. One of these, and one of the most important, is the blind attached to the window itself. This does not differ from those elsewhere described in this report. The other blinds for this piece of apparatus have the peculiarity of working in the horizontal direction, the rollers being placed vertically side by side and enclosed in a light-tight box at the side of the window. The box on the right carries three of these rollers and that on the left carries a corresponding set of three. These blinds are of varying nature. One of each set is white, another is nearly translucent and a third is somewhat opaque. By placing these blinds one over the other, that is by adjusting them properly in the horizontal direction, the light may be varied to any extent required. No way has yet been found by which the light both upon the object and upon the drawing board can be fully controlled by foot-power, as in the case of the microscope window previously described; but it is believed that if sufficient thought were given to the subject, such a device might be evolved. In the meantime, the present arrangement works fairly satisfactorily and avoids the use of complicated apparatus between the eye and what it is looking at, in the same way as does the apparatus previously described in connection with the microscope window.

A LIBERAL REDUCTION OF ORIGINAL DRAWINGS.

A study of the published work of the best modern artists gives ample proof that their originals are considerably reduced for purposes of publication. From the examination of the published illustrations it is difficult to give an estimate of the amount of reduction that takes place in the process of photographing the original, but a somewhat extensive and careful study of the best modern magazine illustrations leads to the conclusion that in many cases the reduction is a liberal one. Judging from the texture of the drawing as shown in enlarged projections, it is probably not far from correct to say that the reduction varies

Fig. 4. Sketch of the arrangement of a camera lucida for the production of drawings of objects at nearly the natural size. The apparatus is attached to upright steel girders, one at each side of a window. The artist faces the light. 1, 2, the two steel girders which are imbedded in several tons of cement beneath the building and

pass through the floor without contact; 3, cross-piece to carry an ordinary camera (4), this cross-piece being hung on sash weights and sliding in the vertical direction and readily clamped by the side screws shown; 4, ordinary camera pushed up out of the way but easily brought into use as shown in Fig. 4; 5, anti-friction arms of the cross-piece (3) which roll against the edges of the girders 1, 2; 6, left hand box of roller blinds; 7, right hand box of roller blinds; 8, light-tight vertically acting rollerblind of the window; 9, 10, horizontally acting roller blinds from the boxes 6, 7; 11, object to be drawn, held in stage forceps; 12, mirror of ordinary camera lucida; 13, horizontal stage, adjustable in the vertical direction, designed to support the object 11, which in this case is supported on the stage of a microscope carrying no objective or eyepiece; 14, horizontal stage, adjustable in the vertical direction, designed to support the drawing board, which tips out to pass 13, and is also adjustable in the horizontal direction. 15, 16, framework supporting all the apparatus 6-14 and slung on sash weights so as to be easily pushed up out of the way when the window is used for other purposes; 17, screw clamp to stage 14; 18, roller blind acting as a light trap and diaphragm when the window is used with the solar projector as shown in Fig. 2.

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from one-half to two to three times, i. e., the areas of the published illustrations are from one-fourth to one-ninth that of the original drawings.

It seems doubtful whether artists have yet fully appreciated the advance that has been made in the art of etching on metal, and also doubtful whether we are not laboring too much under the influence of the former styles of reproduction. Without intending any disparagement to the high class illustration work of the past, I venture to call attention to the probable gain to be obtained by taking greater advantage of the perfection of modern etching processes. The best etchers, supplemented by the best printers, are now able to produce on good book paper well-defined lines as narrow as one four-hundredth of an inch. This is far beyond the power of any artist's pen if the work he does is to come within commercial limits. While what is here said refers more particularly to scientific illustrations, it is believed it is not without its application throughout the range of black and white line work subject to reproduction by means of photography and etching. Speaking from the scientific point of view, many of the illustrations required are of objects far beyond the reach of unaided vision, to say nothing of the capacity of the artist, and we always resort to magnification in order to avoid this difficulty. Natural size illustrations are the best; reductions and enlargements are resorted to as a compromise with our methods of reproduction and publication. Any hint that will lead us to bring our illustrations nearer the truth and more nearly to the natural size should, therefore, be of value. Now, it is found that if original drawings are made on a large scale by means of various mechanical methods, some of which are described in the course of these pages, justness of proportion and accuracy in the formation of the lines are much increased. By taking advantage of high class modern etching it is possible to reduce these large original drawings and retain in the resulting comparatively small and therefore also comparatively inexpensive illustrations, all that justness of proportion and accuracy of line that is displayed in the large original. So far as the writer has exploited the matter, he believes that reductions to one-tenth and even one-twentieth linear are feasible, i. e., the blocks for publication will have only 1-100th to 1-400th the area of the original drawing.

What has hitherto been said introduces no practical difficulty. The modern mechanical processes will meet all the requirements that have been mentioned. There is however a rather serious difficulty connected with producing the original drawings. It is very difficult for an artist who has formed a style that meets the needs of former requirements to so alter it as to meet the exi-

gencies of the liberal reductions that have just been mentioned. I find that the tendency of all artists who have been engaged upon my work is to do more work on these coarse originals, if I may so style them, than is necessary. The tendency is to make the work too fine, to do too much, the result being that the limits of the etcher are passed in certain respects, particularly in the narrowness of the white lines, so that the problem confronting the artist who attempts to work in the manner indicated is to learn a coarser style of work and to learn how much he can leave out. Once this art has been acquired, the rest is clear sailing and the gain in the published illustration may be briefly summarized by saying that it is nearer the natural size, i. e., the ideal size; second, its lines are brought nearer the limit of modern processes, in other words, are finer where it is necessary that they should be finer; of course nothing is here for a moment urged against the use of coarse lines wherever they are appropriate; thirdly, the drawing gains in the important point of scientific accuracy; fourthly, there is a greater range in width of line; fifthly, the great reduction gives the photographer less trouble and at the same time lines accidentally gray are better rendered.

EXPERIMENT FIELD.

At the Experiment Field a number of experiments have been started, having for their primary object a physiological and pathological study of the cuttings of cane and their germination.

These experiments are of a preliminary nature, and it is not expected that many of them will do more than point out the best method of procedure for next year. The plantings were unavoidably late, and many of the conditions surrounding the experiments were such as to preclude anything more than making a beginning this present year; but it may be well to outline some of the objects of the different experiments.

The extent to which cane cuttings may be injured by lengthy soaking in Bordeaux mixture, has been tested in a preliminary way. The strength of Bordeaux that cane cuttings will bear has been the subject of another small experiment. The relative germination of cuttings showing a definite number of diseased fibres has been tested in another small experiment. Cuttings have been prepared in different ways with the object of ascertaining whence the bud derives the greater portion of what may be called its internal nourishment. The effect of lime on cane cuttings has also been the subject of experiment. A number of other experiments are in progress, and a plan of work for next season is being most carefully elaborated. It is thought that a careful study of the whole subject of the early history of the planted cuttings will yield results that may prove of considerable importance.

Plan of the Experiment Field of the Division of Pathology and Physiology, drawn to scale. The trees have been drawn to scale to show the original condition of the field as nearly as possible. The right hand half of the field carried a heavier growth of trees than the other half, and moreover horses were formerly in the habit of camping under the trees of this part of the original field, as the trees there afforded better shade in the daytime. These facts rendered

this part of the field less suitable for experiments. Accordingly the first year's planting has been confined to the other and less objectionable portion. This course leaves the experiments as little as possible under the uneven influence of these former factors, and gives the best conditions possible under the circumstances. Land newly cleared and newly cultivated nearly always presents these unevennesses, and on that account, unless fallowed for a sufficient length of time, is more unsuited for many classes of experiment work.

The plan is lettered and fully explains itself.