A TREATISE

ON THE

Construction, Proper Use, and Capabilities

OF

SMITH, BECK, AND BECK'S

ACHROMATIC MICROSCOPES.

BY

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LONDON:

PRINTED FOR SMITH, BECK, AND BECK, 31, CORNHILL:

PUBLISHED BY

JOHN VAN VOORST, PATERNOSTER ROW.

MDCCCLXV.

THE POPULAR MICROSCOPE.

This entirely new form of Stand has been contrived because the construction of the Educational Instrument, described at p. 89, was not suited to the addition of Wenham's Binocular Body. Whilst, therefore, the optical arrangement of the Popular Microscope remains exactly the same as that of the Educational, the stand is greatly improved, without any additional cost.

The object-glasses and eyepieces of the Popular Microscope are so similar in appearance to the best ones figured in Plate V., that any additional illustrations would only appear superfluous; but the magnifying powers and other particulars more especially relating to the object-glasses of this microscope are given in the following list.

The Popular Series of Achromatic Object-glasses.

The object-glasses in the following list are intended for all kinds of general use in which any very large aperture is not necessary.

There are many persons who would not, with ordinary objects, and using only the first and second eyepieces, see any difference between these powers and the very best, the corrections being perfect, and the workmanship really good so far as the aperture goes.

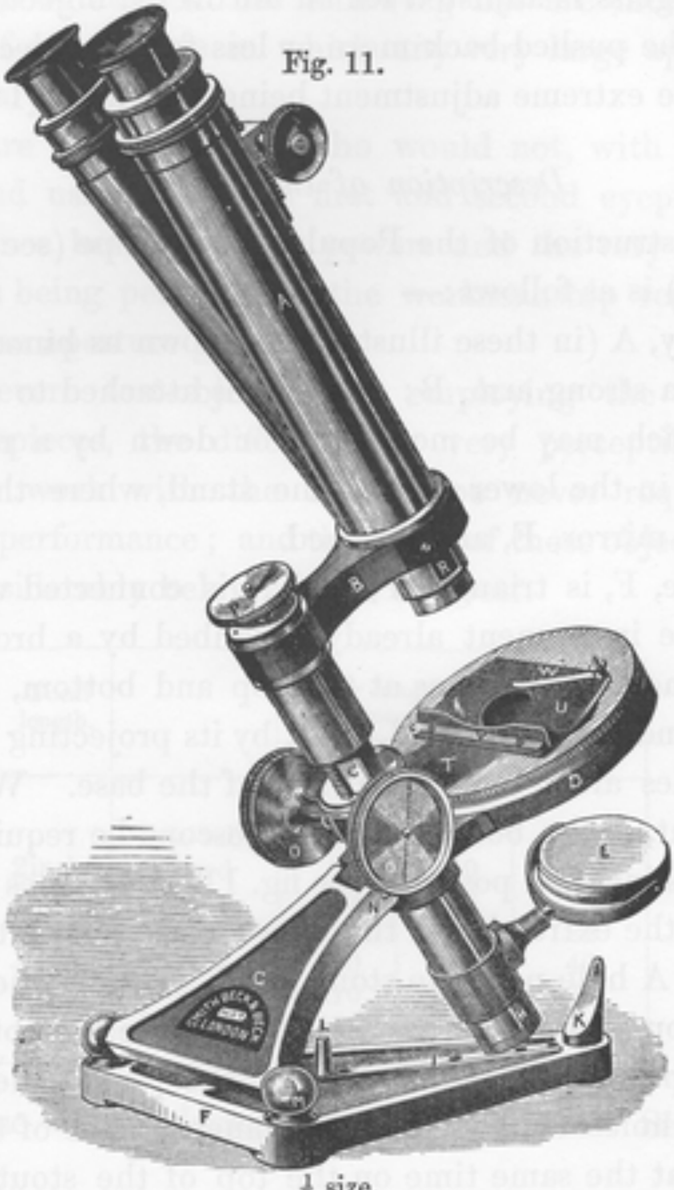
With severe test-objects, and employing the third or higher eyepieces, the difference is very perceptible; but many who work with the microscope never require this high-class performance; and the price of these object-glasses is very considerably below that of the best.

Focal length.		Linear magnifying power, nearly, with eyepieces		Degrees of angle of aperture.
		No. 1.	No. 2.	
2 inches	Draw-tubes closed	24	40	10
$1\frac{1}{2}$ inch	ditto	29	48	15
1 inch	ditto	55	90	22
$\frac{1}{2}$ inch	ditto	120	200	40
$\frac{1}{4}$ inch	ditto	210	350	75
$\frac{1}{8}$ inch	ditto	420	700	85

All these object-glasses have the Universal Screw (see p. 6).

With the $\frac{1}{2}$-inch and higher powers the condition of the chromatic and spherical aberrations may be considerably altered by the use of different thicknesses of thin glass, or put into, which is not unfrequently the case when the ordinary joint works loose; and in every position the heavier part of the stand is brought over the centre of the base to ensure an equality of balance.

Fig. 11.



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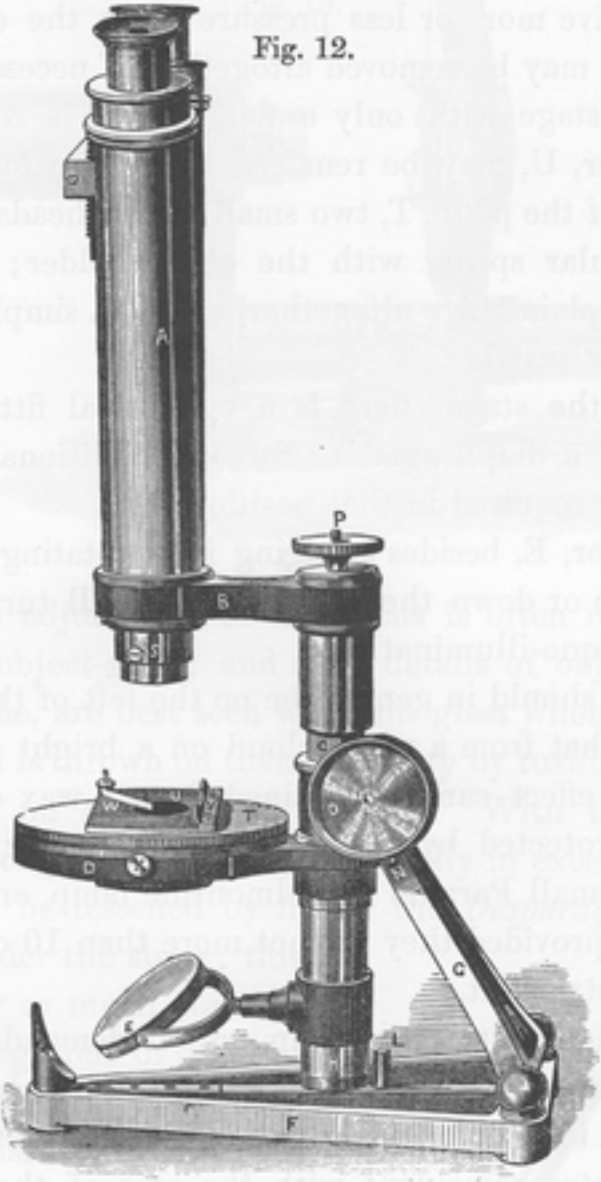
Directions for Use.

To adjust the focus of the object-glass, turn the milled head, O, for a quick movement, or the milled head, P, for a slow one.

Fig. 12.



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The stage, D, is circular; and upon it fits a plate, T; this again carries the object-holder, U, which is provided with a ledge, V, and a light spring, W; it is held on the plate T by a spring underneath, so that it can be moved about easily and smoothly by one or by both hands. The small spring, W, is fastened to the object-holder by a milled head, which will unscrew; so that the position of the spring may be altered to give more or less pressure upon the edge of the object, or it may be removed altogether, if necessary.

When a stage with only a flat surface is required, the object-holder, U, may be removed by unscrewing, from the under side of the plate, T, two small milled heads which connect a circular spring with the object-holder; or, by removing the plain stage altogether, an extra simple flat plate may be substituted.

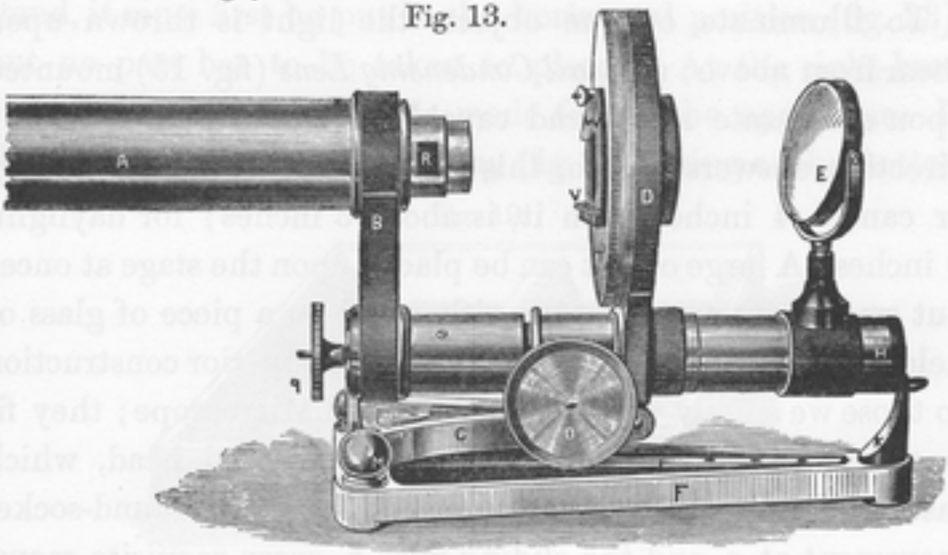
Beneath the stage there is a cylindrical fitting for the reception of a diaphragm, or for any additional apparatus that may be required in that position.

The mirror, E, besides swinging in a rotating semicircle, will slide up or down the tube, H, or it will turn on either side for oblique illumination.

The *light* should in general be on the left of the observer; the best is that from a white cloud on a bright day; but a satisfactory effect can be obtained from a wax or Palmer's candle, if protected by a glass, a Cambridge or Moderator oil-lamp, a small Paraffin or Belmontine lamp, or an Argand gas-burner, provided they are not more than 10 or 12 inches from the instrument.

The management of the illumination demands particular attention; that of a *transparent object* is produced by reflexion from the mirror below, which should most frequently have its centre coincident with the axis of the body, and should be at such a distance that the light reflected from it may nearly converge to a focus at the object: this distance will be about 2½ inches when daylight is used; but the rays from a lamp or candle 10 or 12 inches from the mirror are so divergent, that the focus for them will be lengthened to about 3 inches; and the mirror may have to be slid up or down accordingly.

Fig. 13.



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Accurate adjustment of this focus is often required with the $\frac{1}{4}$-inch object-glass; and some details of objects, such as delicate striæ, are best seen with this glass when a strong light is thrown on them *obliquely* by turning the mirror on one side of the axis. With the 1-inch object-glass the light is generally in excess, and has to be lessened by fitting the *Diaphragm* (fig. 14) under the stage; this admits only so much light as passes through one or other of the two apertures in a small revolving disk, by which contrivance, together with sliding the diaphragm up more or less under the stage, every necessary variation can be made. The diaphragm is generally left in its place when the in-

Fig. 14.

Fig. 15.

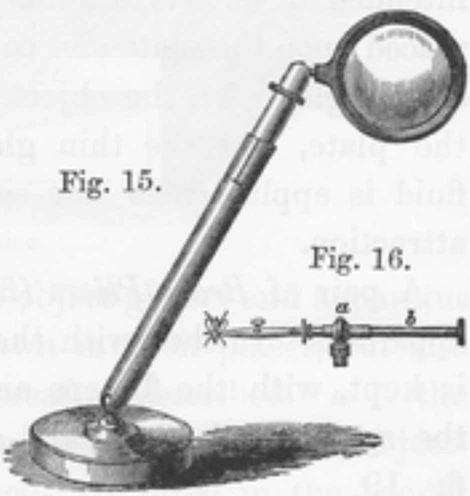

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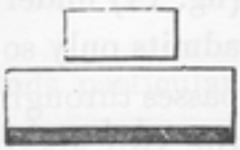
Fig. 16.

strument is packed away; or, if there be a vacant space, it may be put in the *Tray* (fig. 20).

To illuminate opaque objects the light is thrown upon them from above; a *Small Condensing Lens* (fig. 15) mounted upon a separate stand, and capable of being turned in any direction, answers well for this purpose: its focus, for a lamp or candle 4 inches from it, is about 3 inches; for daylight, 2 inches. A large object can be placed upon the stage at once; but small ones are generally either laid on a piece of glass or held in the *Forceps* (fig. 16): these are of a superior construction to those we supply with our Educational Microscope; they fit upon the pin at the top of the small milled head, which fastens the spring on the stage, and by the ball-and-socket movement at *a*, and the sliding wire *b*, every requisite movement can be obtained. In illuminating objects from above, all light that could enter the object-glass from below should be excluded; and the *Diaphragm* (fig. 14) will do this very effectually when placed under the stage, with the blank space of its revolving disk turned over the aperture.

A *Glass Plate* with a ledge, and some pieces of *Thin Glass* (fig. 17) are applicable for many purposes, but are specially intended for objects in fluid. Thus, a drop is placed upon the plate and covered by a piece of thin glass; or, the object being put upon the plate, and the thin glass over it, the fluid is applied near one side, and runs under by capillary attraction.

Fig. 17.

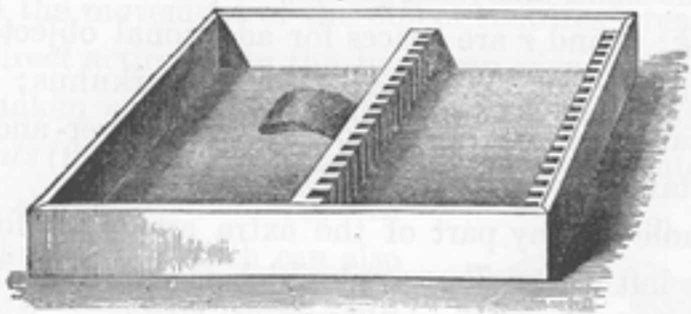


A pair of *Brass Pliers* (fig. 18) completes the necessary apparatus furnished with the microscope, and is kept, with the forceps and glass plate, in the space on the left-hand side of the *Tray*, fig. 19.

Fig. 18.

The *Case* is made of mahogany, French-polished, with brass hooks, a good lock, and a strong handle. To pack away the stand, it must first be put in the horizontal position (fig. 13); but no part has to be taken to pieces. At the right-hand end of the case, provision is made for all the apparatus. In the first place, a *Removable Tray* (fig. 19), lying at the bottom

Fig. 19.



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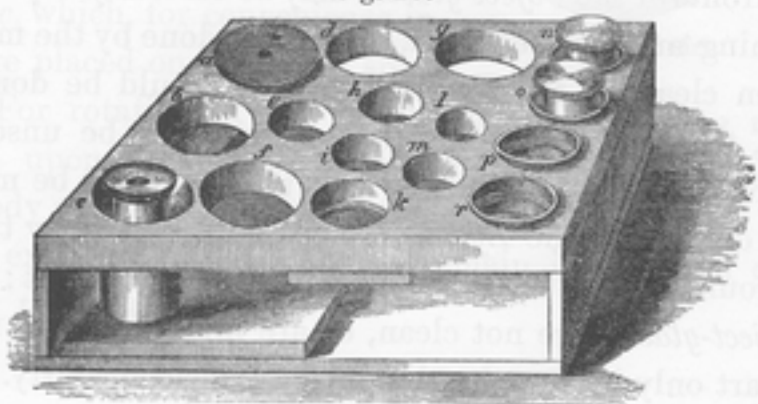
of the case, is divided into two spaces: the one is for keeping the forceps, pliers, glass plate, &c.; and the other is racked for 18 objects. Above this fits another *Tray* (fig. 20), which is

Fig. 20.



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contrived to receive not only the object-glasses and apparatus already alluded to, and here shown in their places, but also the whole of the apparatus hereafter described. *a* is the diaphragm; *c*, the 2nd eyepiece; and *n* and *o*, the object-glasses, for which some brass cells are fitted in the board;

and when the object-glasses are put away, the engraved brass caps should always be screwed on, to prevent any dust settling on the inner glasses, which cannot be easily wiped.

The other spaces in the tray are arranged as follows:—in the holes, *a*, *b*, *d*, *g*, the achromatic condenser, the parabolic reflector, the dark-well holder, or the large polarizing prism will fit; the small analyzing prism will pack in *c*; the camera lucida in *k*; *p* and *r* are spaces for additional object-glasses; *l* and *m* will receive the 1-in. and ½-in. Lieberkuhns; an extra eyepiece can be packed at *f*; and *h* and *i* are finger- and thumb-holes for taking hold of the tray.

The whole or any part of the extra apparatus for which spaces are left in the *Tray*, and which is described in pages 83 to 88, may be added to the instrument at any time, without its being sent back to the makers.

Glass of any kind requires occasional cleaning; a piece of soft wash-leather is the best for the purpose.

The fronts of the *Object-glasses* may be carefully wiped; but if anything more be required, it must be done by the makers.

When cleaning the *Eyepieces*, which should be done *frequently*, the cells containing the glasses must be unscrewed and replaced one at a time, so that they may not be mixed.

Any dirt upon the *Eyepieces* may be detected by turning them round whilst looking through the instrument; but if the *Object-glasses* are not clean, or are injured, it will for the most part only be seen by the object appearing misty.

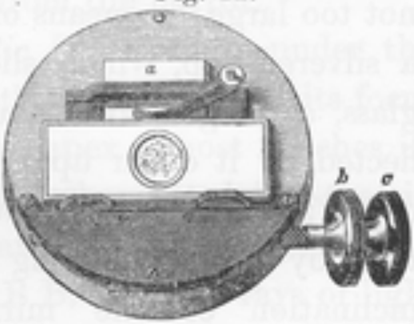
Wenham's Binocular Body.

Thus far in this description the Popular Microscope has been considered as having a single body only; the addition, therefore, of the Binocular Body, as shown in the illustrations, requires a few explanations and directions for use, which will be found in pp. 48 to 55, where there is a full description of the contrivance, in every way applicable to this instrument, excepting a slight difference in the fitting of the prism, which in the Popular Microscope can only be removed after a smaller milled head (fig. 12, S) has been unscrewed.

Mechanical Stage.

When the movement of the object requires greater nicety than a direct action from the hand can give, the plain stage may be taken off and replaced by *a Stage with Mechanical Movements* (fig. 21). By this arrangement the plate (*a*) with a fitting, sliding up or down, will receive the object, which can also be moved sideways, these two movements forming a quick adjustment; the slower movements in rectangular directions being given by turning the milled heads *b* and *c*, which, for convenience in use, are placed on the same spindle. For rotation of the object, the whole stage may be turned upon the bottom stage-plate, which is central with the body; and consequently the part of the object that is under examination will always remain in the field of view during the rotation.

Fig. 21.



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Additional Apparatus.

When the light from the concave mirror proves insufficient for any object requiring an intense transmitted light, the *Achromatic Condenser* (fig. 22) may be employed with advantage: this slides, by its tube, into the fitting under the stage of the instrument, in which it has to be moved up or down until the focus of its lenses falls upon the object, the light having been previously reflected in the proper direction by the flat mirror.

Fig. 22.

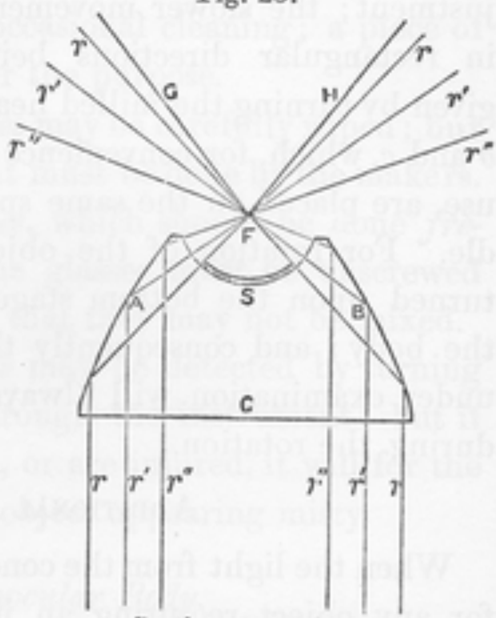
Fig. 23.

$\frac{1}{3}$rd size.

Fig. 24.

The *Illumination of Opaque Objects*, already described, must be more or less one-sided; and in most cases it is desirable that it should be so. An illumination on any or every side is, however, easily obtained, provided the object is not too large, by means of the *Lieberkuhn* (fig. 23). This is a silvered cup, which slides upon the front of the object-glass, and light thrown upwards by the mirror will be reflected by it down upon the object; it will then be found that, by slightly varying the inclination of the mirror, every necessary alteration in the direction of the illumination can be obtained. The *Lieberkuhn* here shown is intended for the 1-inch object-glass.

Fig. 25.



Section, true size.

It is in most cases necessary, when using the Lieberkuhn, to slide a *Dark Well* (fig. 24) under the stage, to prevent any light entering the object-glass direct from the mirror.

Dark-Field Illumination is, to appearance, a means of seeing a transparent object as an opaque one. The principle, however, is that all the light shall be thrown under the object, but so obliquely that it cannot enter the object-glass unless interrupted by the object: this is best accomplished by *Wenham's Parabolic Reflector* (fig. 26). It may be easily understood by reference to fig. 25, which represents it in section A B C, and shows that the rays of light, $r\ r'\ r''$, entering perpendicularly at its surface C, and then reflected by its parabolic surface A B to a focus at F, can form no part of the largest pencil of light admitted by the object-glasses and represented by G F H; but an object placed at F will interrupt the rays and be strongly illuminated. A stop at S prevents any light from passing through direct from the mirror.

Fig. 26.

⅓rd size.

In this microscope, the *Parabolic Reflector* fits under the stage by the tube A (fig. 26), and the adjustment of its focus upon the object (which is when its apex almost touches it) is made by giving it a spiral motion when fitted in—that is, carefully pushing it up or down at the same time that it is turned round by the milled edge, B B. As the rays of light must be parallel when they enter it, a *Flat Mirror*, which in this case should be added to the instrument, is generally used; daylight will then require only direct reflexion, but the rays from an artificial source will have to be made parallel by putting the condenser (fig. 15) between the light and the mirror, about 1¾ inch from the former and 4½ inches from the latter. Nearly the whole surface of the mirror should be equally illuminated, which may be tested by temporarily placing upon it a card or piece of white paper. Parallel rays can also be obtained from the *Concave Mirror*, if the light is put about 2½ inches from it.

Polarized Light, invaluable to some microscopists, and to others a beautiful appliance by which many objects otherwise almost invisible are shown in every imaginable colour, can here only be treated of by describing the way in which it is applied to this microscope by the following apparatus:—

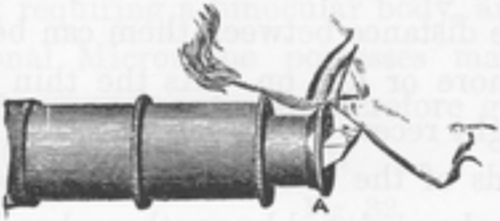
Fig. 27.

$\frac{1}{3}$rd size.

A Nicol's prism as a Polarizer (A, fig. 27) fits, and can be turned round, under the stage; another prism, B, slides in the place of the cap of either eyepiece, and also revolves; or by unscrewing its outer tube, *c*, and its cap, *d*, it screws, as *e*, in the place of the back-stop, *f*, of either object-glass, and then the object-glass together with the prism are attached to the nosepiece of the microscope by the adapter (H), which has a revolving fitting at *k*. When the prism B is over the No. 2 eyepiece, the field of view is considerably cut off; and although it is not so when the prism is screwed above the object-glass, yet the definition is then somewhat impaired: its position therefore must be regulated by the character of the object. When only alternate black and white images are given by the prisms alone, a plate of selenite, G, will produce coloured ones.

To draw an object, the *Camera Lucida* (fig. 28) is used. It slides on in the place of the cap of either eyepiece, with its flat side uppermost, as shown. The body of the microscope must be in a horizontal position, and the whole instrument has to be raised until the edge of the prism is exactly 10 inches from a piece of paper placed upon the table. If the side of the case be used for this purpose, the proper distance is exceeded by $\frac{3}{4}$ of an inch; but the paper may easily be raised this amount by some pad. The light must be so regulated that no more than is really necessary is upon the object, whilst a full light should be thrown upon the paper. Only one eye is to be used; and if one half of the pupil be directed over the edge of the prism, the object will appear upon the paper, and can be traced on it by a pencil, the point of which will also be seen. Should any blueness be visible in the field, the prism is pushed too far on, and should be drawn back till the colour disappears.

Fig. 28.



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Substituting in the place of the object a piece of glass ruled into 1-100ths and 1-1000ths of an inch, termed a *Micrometer* (fig. 29), its divisions can be marked on the same or another piece of paper, and, by comparing them with the sketch, the object can be most accurately measured. These divisions also, if compared with a rule divided into inches and tenths, will give the magnifying power: thus, supposing 1-100th of an inch when marked on the paper measured 1 inch and $\frac{3}{10}$ths, the magnifying power would be 130.

The *Live-box* (fig. 30) hardly needs description: the object is confined between the glass, *a*, of the lower part, B, and that of the cap, C; the distance between them can be varied by sliding the latter more or less on. As the thin glass is only dropped into a slight recess in the top of the cap, and is held there by the heads of the two screws, it can be easily taken out for wiping, or be replaced by another when broken.

The *Glass Trough* (fig. 31), for larger objects in water, must be used with its thinner plate of glass, *b*, in front. The modes of confining such objects, and keeping them near

Fig. 29.

Fig. 30.

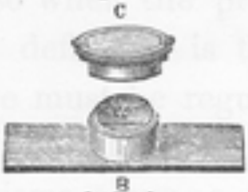

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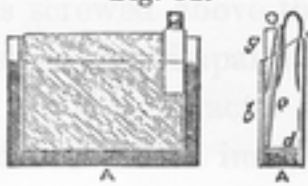
Fig. 31.



the front surface, must vary according to the occasion. For many it is a good plan to place a piece of glass, *e*, diagonally in the trough, its lower edge being kept in its place by a strip (*d*) at the bottom; then if the object introduced is heavier than water, it will sink till stopped by the sloping plate. Sometimes a very slight spring (*f*) may be applied behind this plate to advantage, with a wedge (*g*) in front to regulate the depth.

Arrangements are made for all those parts which may require cleaning. Thus, the Parabolic Reflector unscrews from the tube; the Nicol's Prisms will push out of their fittings; and the Camera-lucida Prism can be taken out by turning aside the plate that covers it.