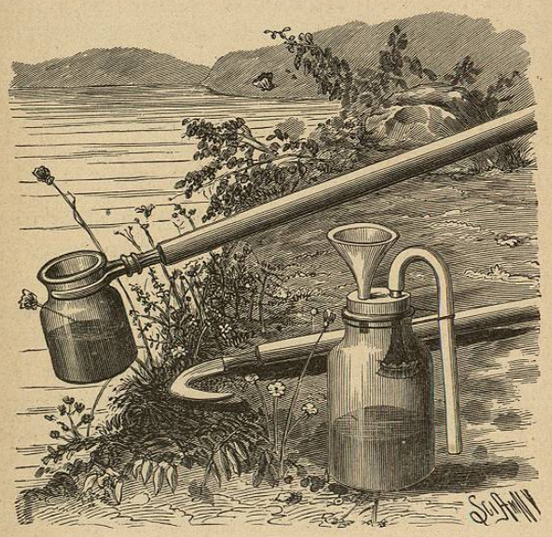
upward through the stopper, is used for concentrating the material. Over the lower end of this funnel is stretched a piece of thin muslin, and to the upper end is applied a short piece of rubber pipe, which is retained in a curved position by a thread tied around the neck of the bottle. The material gathered is poured into the funnel, the water escapes through the strainer, and the objects are retained in the bottle.* The hooked knife shown in the engraving is of great

FIG. 299.



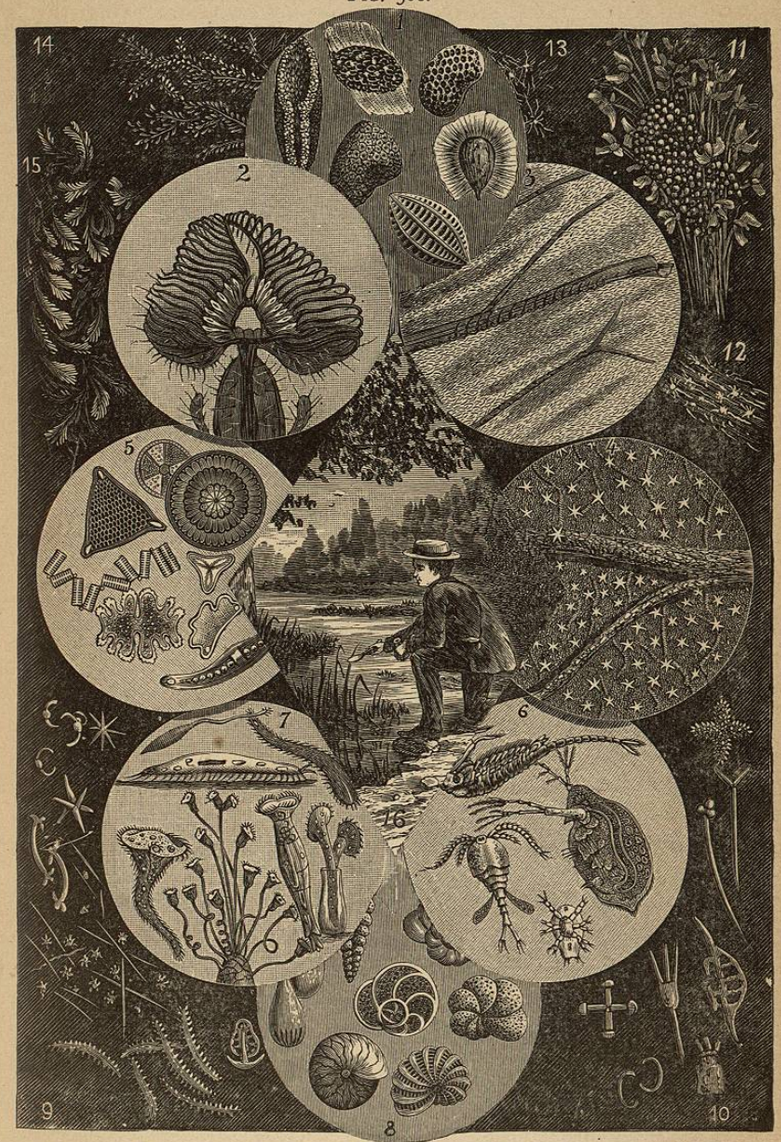
Implements for gathering Microscopic Objects.

utility in cutting and fishing out parts of aquatic plants and submerged branches and roots, which are often teeming with microscopic life.

It would be futile to attempt anything more than the mere mention of a few of the interesting objects that may be seen to advantage in a small microscope. In Fig. 300 the engraver has beautifully shown some of the common objects which are easily secured, readily examined, and always interesting.

* This device is due to Mr. Stephen Helm.

FIG. 300.



1. Seeds. 2. Tongue of Fly. 3. Bee's Wing. 4. Deutzia Leaf. 5. Diatoms and Desmids. 6. Entomostraca. 7. Infusoria Rotatoria. 8. Foraminifera. 9. Spicules. 10. Spicules and Plates. 11. Pollen of Marsh Mallow. 12. Plant Hairs. 13. Shepardia Canadensis. 14. Crystals of Silver. 15. Fern Gold 16. Gathering Objects.

Various Microscopic Objects.

At 1 in this engraving are shown various seeds; the lace-covered one at the top being the seed of the *Nemesia compacta*. The seed in the center is that of heather. That on the right of the lace-covered one is the seed of the poppy. The fringed one below it is that of the climber. At the bottom of the disk the seed of sorrel is shown at the left, and portulacca at the right. The remaining seed at the left is that of eucharidium.

No. 2 represents the proboscis of the blowfly as it appears in the field of the microscope, except that the intricate structure of the pseudo-trachea is not shown in the cut as it appears in the microscope.

No. 3 shows the doubling hooks of a bee's wing, which enable the insect to connect the wings of each pair so that they may be used as a single wing.

No. 4 shows the silicious stellate hairs on the back of a deutzia leaf. The upper half of 5 shows several forms of diatoms, and the lower half is filled with desmids.

In 6 branchipus is shown at the top, cyclops at the left, a young cyclops at the bottom, and daphnia or the water flea at the right. These are common in almost every pond.

In disk 7 are shown on the left the stentor, so named on account of its trumpet-like form; in the center the beautiful and sensitive vorticella, and upon the right of the vorticella common rotifer, and upon the extreme right the sheathed trumpet animalcule. All of these have cilia around their margins, which by their peculiar vibratory motion give the bell-shaped mouths the appearance of rotation. In the common rotifer, and in the animals shown in disk 6, the internal organs may be readily seen in operation.

In the upper part of disk 7 are shown a few of the hundreds of forms of life found in water in which animal or vegetable matter has been infused.

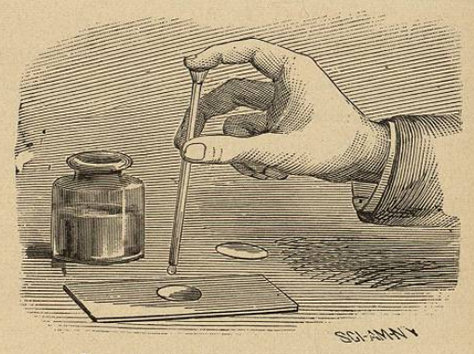
In disk 8 are represented a number of the exquisite little shells of foraminifera. At 9 are shown various spicules of sponges, sea urchins, etc. At 10 are shown sponge spicules and the anchor of *Synapia inherens;* 11 shows the pollen of marshmallow, and 12 and 13 are examples of plant hairs;

14 shows arborescent crystals of silver, and 15 the fern-like crystals of gold.*

TRANSFER OF OBJECTS TO SLIDE.

The objects are transferred from the bottle to the concavity of the slide for examination in the manner shown in

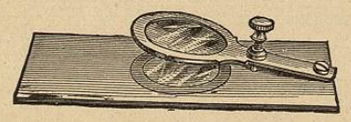
FIG 301.



Transferring Objects to the Slide.

Fig. 301. The drop tube, which has a funnel-shaped top, is stopped by the finger at the upper end, while its lower end is inserted in the water in the bottle above the matter to be removed. The finger is then removed and some of the

FIG. 302



Compressor.

water, together with the objects carried by it, rushes upward into the tube. While the lower end is still in the water, the finger is again placed on the tube and this is withdrawn from the bottle and held over the cavity of the

* The following books are recommended to the beginner in microscopy: Wood's "Common Objects for the Microscope;" "One Thousand Objects for the Microscope," by M. C. Cooke; "Evenings at the Microscope," by Gosse; and "Practical Microscopy," by George E. Davis.

slide, as shown in the engraving, when a drop or so of the water is forced out by pressing down the end of the finger on the top of the tube; the soft end of the finger acting as a sort of diaphragm in forcing out the required amount of water. Care must be taken to avoid getting solid matter upon the slide around the edge of the cavity, as it will prevent the cover glass from seating itself properly. The cover glass is placed over the cavity and pressed down lightly to squeeze out the surplus water, when the slide may be inserted under the clips of the stage and examined.

A more convenient device for holding animalcules is represented in Fig. 302. It is known as the compressor, and serves to lightly hold any object placed between the glass in the oblong plate and the glass in the adjustable arm. In any position it retains a drop of water.

To confine living objects to the field of vision, it is common to place between the glasses of the compressor a few fibers of cotton or a piece of fine lace.

MICROSCOPIC EXAMINATION OF CILIATED ORGANISMS BY INTERMITTENT LIGHT.

Every observing person has noticed that moving objects appear stationary when viewed by a flash of light; examples of this are seen during every thunder storm occurring in the night. The wheels of a carriage, a moving animal, or any moving thing, seen by the light of the lightning, appears perfectly stationary, the duration of the light being so brief as to admit of only an inappreciable movement of the body while illumination lasts.

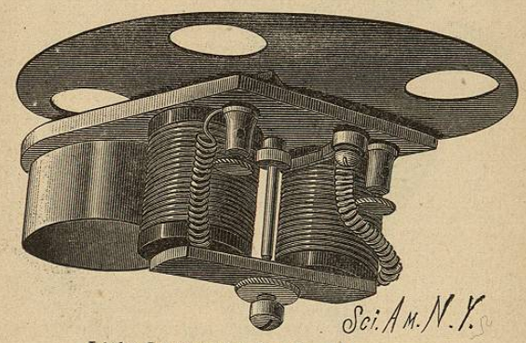
If by any means a regular succession of light flashes be produced, the moving body will be seen in as many different positions as there are flashes of light. If a body rotating rapidly on a fixed axis be viewed by light flashes occurring once during each revolution of the body, only one image will be observed, and this will result from a succession of impressions upon the retina, which by the persistence of vision become blended into one continuous image. In this case no movement of the body will be apparent, but if the

flashes of light succeed each other ever so little slower than the rotary period of the revolving body, the body will appear to move slowly forward, while in reality it is moving rapidly; and should the light flashes succeed each other more rapidly than the revolutions of the revolving body, the body will appear to move slowly backward, or in a direction opposite to that in which it is really turning.

These curious effects are also produced when the number of the light flashes is a multiple of the number of revolutions, or *vice versa*.

The combined effect of interrupted illumination and persistence of vision may be practically utilized for examining objects under motion which could not otherwise be satisfactorily studied. To apply intermittent light to the microscopical examination of ciliated organisms, the writer has devised the electrically rotated apertured disk shown in Fig. 303, which is arranged to interrupt the beam of light employed in illuminating the object to be examined.

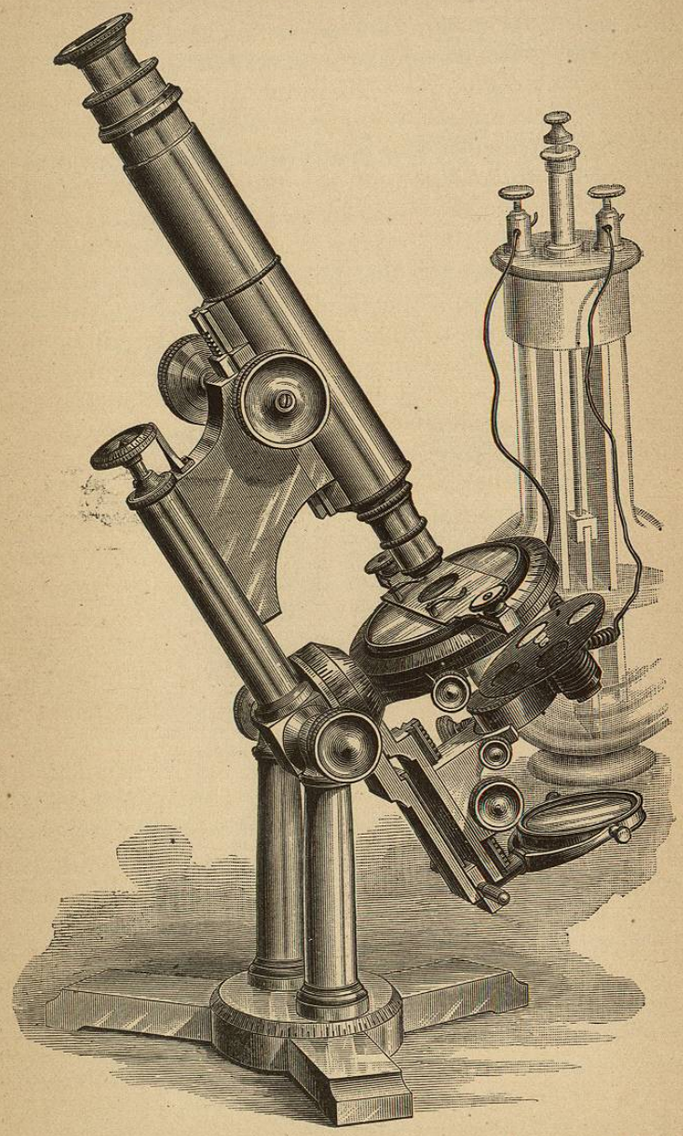
FIG. 303.



Light Interrupter for the Microscope.

The instrument consists of an electric motor of the simplest kind mounted on a plate having a collar fitted to the sub-stage of the microscope, as shown in Fig. 304. The shaft, which carries a simple bar armature before the poles of the magnet, also carries upon its upper extremity a disk having two or four apertures, which coincide with the apertures of the stage and sub-stage two or four times during the rev-

FIG. 304.



Microscopic Examination of Ciliated Organisms by Intermittent Light.

olutions of the disk. The shaft carries a commutator, and the course of the current from the battery through the instrument is through the spring touching the commutator, through the shaft and frame of the instrument to the magnet, thence out and back to the battery. There are two methods by which the speed of rotation of the apertured disk may be varied; one is by plunging the elements of the battery more or less, and the other is by applying the finger to the shaft of the motor as a brake, the motor in the latter case being started at its maximum speed, and then slowed down to the required degree by the friction of the finger.

Experiment shows that the period of darkness should be to the period of illumination about as three to one for the best effects. Closing two diametrically opposite holes in the disk represented in the cut secures about the correct proportion.

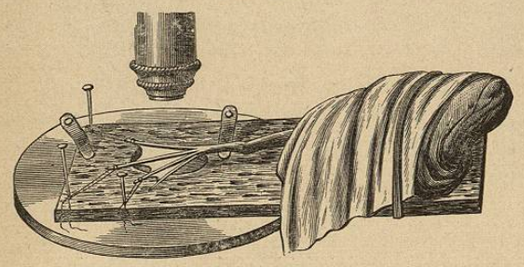
Various rotifers examined by intermittent light showed the cilia perfectly stationary. The ciliary filaments of some of the infusoria, vorticella, and the stentor, for example, when viewed by intermittent light, appeared to stand still, and their length seemed much greater than when examined by continuous light. The interrupted light brings out not only the cilia around the oral aperture, but shows to good advantage the cilia disposed along the margin of the body.

What interrupted light may reveal in the examination of flagellate or ciliated plants the writer is unable to say, as no objects of this character have been available. It is presumable, however, that something interesting will result from the examination of volvox and other motiie plants, by means of this kind of illumination. Although it is necessary to interrupt the beam of light regularly, for continuous observation, the effect of intermittent light may be exhibited to some extent by an apertured disk, like that above described, twirled by the thumb and finger or revolved like a top by means of a string; or by using a larger apertured disk fitted to a rotator, and placed between the source of light and the mirror of the microscope.

CIRCULATION IN ANIMAL AND VEGETABLE TISSUES.

Among vegetable organisms in which the circulation of the sap is visible, the nitella is prominent. So, also, is the beautiful desmid colosterium.

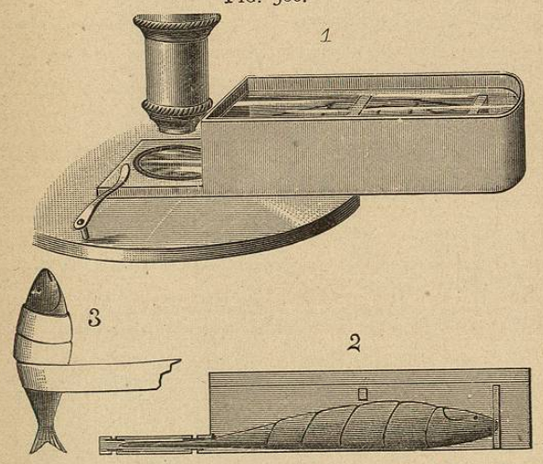
FIG. 305.



Simple Frog Plate.

Among animal organisms, the daphnia, or water flea, is extremely interesting, the minute heart being made clearly visible by the transparency of the shell of this little creature.

FIG. 306.



Kent's Trough for showing the Circulation of Blood in a Fish's Tail.

The circulation of blood in a frog's foot may be shown by stretching the foot so as to distend the web, as shown in Fig. 305. One form of apparatus consists of a thin, aper-

tured piece of wood, provided with a glass slide upon which to rest the frog's foot. A piece of cork has been used for this purpose without the glass slide.

The slice of cork has a hole near one end corresponding with the hole in the stage of the microscope. The frog is wrapped in a wet cloth and held in place upon the cork by means of a small rubber band (Fig. 305). One of the frog's legs is extended. To two or three of the toes are attached threads which are held under tension by ordinary pins stuck into the cork. The foot is moistened to render the web more transparent, and the circulation is observed with a three-fourth or one inch objective.

The circulation of blood in the tail of a gold fish requires more complicated apparatus. It consists of a metallic tank provided with a thin extension, having in its upper and lower sides glass windows, formed of cover glasses set in recesses and secured by marine glue. The fish is wrapped in a strip of thin muslin, as shown at 3, to deprive it of the use of its fins, and laid upon its side in the tank, as shown at 2, in Fig. 306, with its tail between two windows, allowing the light to pass upward through the tissues from the mirror of the instrument. The tank is filled with water, and to prevent the fish from jumping, small wooden cross bars are placed in different positions in the tank. Arranged in this way, the fish may be observed for about twenty minutes. The blood is seen flowing in crimson streams in various directions through the tissues of the tail, the corpuscles being distinctly visible. A one-inch or three-quarter inch objective is ample for this purpose.

The blood of the frog is white, and the corpuscles are larger than those of the fish. As compared with the corpuscles of human blood, those of the fish are larger.

QUICK METHODS OF MOUNTING DRY OBJECTS.

There is a certain class of microscopic objects that need little or no preparation for mounting, and require no protection beyond a well secured glass cover. Many of these objects are interesting and in some degree valuable; but the microscopist considers them hardly worth the trouble of