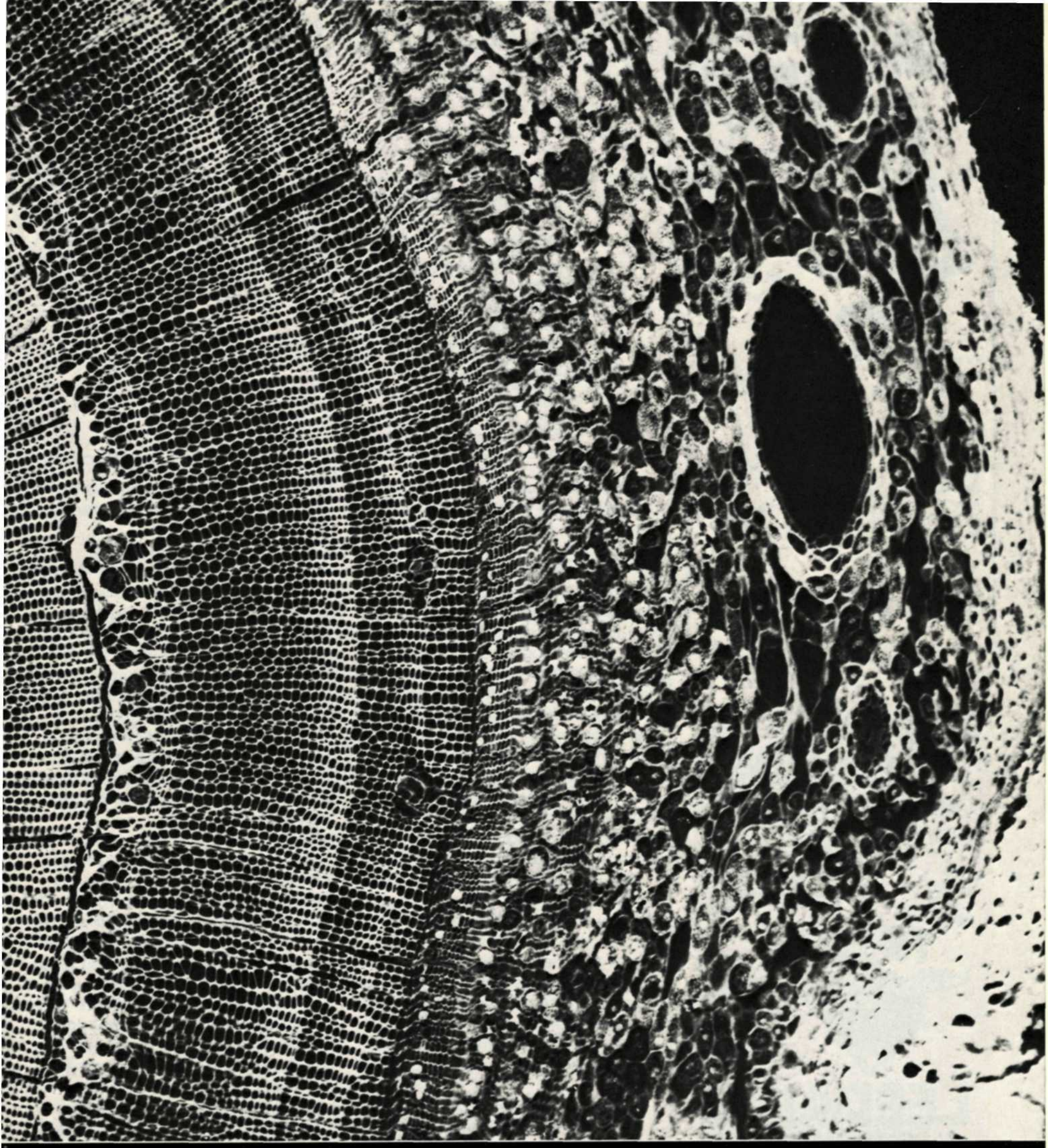
MICROCOSMIC JOURNEYS

TRANSPORT YOURSELF: BUILD YOUR OWN PHOTOGRAPHIC MICROSCOPE



BY JACK AND SUE DRAFAHL

The microscopic world intrigues people from all walks of life—from the amateur microscope sleuth to the research scientist. Photographers are especially interested, since they do more than observe—they capture this unexplored world on film.

Both images are microscopic views of an ordinary pine stem. The magnification of the pine stems is 10X with the adapted microscope, and when it is blown up to 8×10-inch prints, the magnification is 80X life-size. Photos made on Kodak Technical Pan Film.

The basic problem that photographers encounter is that taking quality photographs requires extensive equipment. Unless a photographer specializes in photomicrography, this expense seems unrealistic. But luckily, there is a solution to this problem.

MICROCOSMIC JOURNEYS

SOME CHEMICALS USED FOR MAKING CRYSTALS

CHEMICAL	MELTING PROCESS	EVAPORATION PROCESS
Ascorbic Acid (Vitamin C)		X
Benzoic Acid	X	
Bromo Seltzer		X
Citric Acid	X	
Kodak Dektol Developer		X
Dextrose (Glucose)	X	
Kodak Developer D-76		X
Epsomite (Epsom Salts)		X
Hydroquinone		X
Tartaric Acid		X
Urea	X	X
Vanillin		X

Photographers usually have a certain amount of surplus photo equipment, some of which can be modified to perform tasks other than their intended purpose. For example, look at the various types of copy equipment photographers use. One item that resembles a microscope is the vertical slide copier. Both the slide copier and the microscope can have cameras mounted at the top. The slide copier has a camera lens with a bellows or extension tubes, while the microscope has a body tube and an objective lens. The slide copier has a built-in light source and the microscope has a means of directing light onto the microscope specimen.

With only a few modifications, your vertical slide copier can double as a low-power photo microscope.

If you don't own a vertical slide copier like the Bowens Illumitran or the Sickles Chroma-Pro, you may decide to stop reading right here. But don't despair; we have an alternate system you can use that will involve jury-rigging a similar microscope setup.

Before we get into that, however, it is a good idea to look at the basics of this microscope system. First of all, you need a light source. In a vertical slide copier this is already supplied in the form of either a tungsten light source or an elecronic flash with modeling light. Since the light sources on these units are too diffuse to be of much value when photographing specimens, it is necessary to build a substage assembly which incorporates a camera lens (the normal lens, 50-55mm works well) to focus the light onto the specimen stage.

Next, you need a means to achieve the great levels of magnification necessary to analyze minute subject matter. With the vertical slide copier, you already have a bellows assembly which yields life-size and greater magnifications, but the goal of the photomicrographer is much greater magnifications. This is accomplished by either reversing a wide-angle lens and adapting it to the bellows, or by mounting a microscope objective lens onto the bellows unit.

VERTICAL SLIDE COPIERS

The reason we chose the vertical slide copier for this type of work is that it has the best of all worlds. It is an in-line system, meaning that the light source is in line with the camera and bellows system. It also is rigid, and this is important because you need the camera, bellows, lens and subject to remain stationary during exposure; any movement in the system at such great magnifications will cause image blur.

If you don't own a vertical slide copier, you will have to assemble the following equipment in addition to your camera and normal lens: bellows unit or extension tubes, wide-angle lens (or microscope objective lens), light box (or other portable light source such as electronic flash), and a copy stand (or a sturdy tripod). Of these items, the copy stand and light box will most closely simulate the effectiveness of the vertical slide copier. The copy stand will hold the camera and bellows rigidly; the light box is a convenient light source on which the substage lens can be easily positioned to be directly under the camera/microscope setup.

ADAPTING A MICROSCOPE OBJECTIVE

The first thing you must do, whether you use the vertical slide copier or the copy stand with camera and bellows attached, is to adapt a lens system with microscopic powers of magnification. This can be accomplished in two different ways. A 24 or 25mm lens can be reversed by means of a reversing ring (available from your camera/lens manufacturer or from independent lens makers, like Kiron Corporation) and mounted onto the bellows backwards. This will result in a 5X microscope objective. A 5X enlargement is not that great for photomicrography applications, so if you want to increase the magnification of the image, slip a 2X or 3X tele-extender between the camera and bellows. This will give you a 10X or 15X objective depending on which you choose.

If you do not own a 24mm lens, you can also use a reversed 28mm or 35mm lens, but this will not provide nearly as much magnification. In fact, with these focal lengths you will almost surely need the tele-extender to increase image magnification. If you use a 28 or 35mm lens reversed, you must then have a substage lens of f/2 or faster. This is to ensure that the opening of the substage lens provides a wide enough coverage for a full 35mm frame. If the substage lens is slower in speed than the adapted microscope objective lens, the resulting image will be circular rather than full-frame.

The second method of adapting a microscope objective for use on your homemade microscope involves the purchase of a special macro lens mount and microscope objective. Almost all camera manufacturers carry this adapter, which is primarily designed for miniature macro lenses. The key is that this adapter has microscope-objective threads and will accept almost all microscope objectives. This adapter and a 10X objec-

tive average from $50 to $75 and complete the center section of your modified slide copier.

If you have trouble locating microscope objectives, try your local hobby shop or toy store. Even some of the large chain department stores carry them. Also, Edmund Scientific, 101 East Gloucester Pike, Barrington, New Jersey 08007, carries a wide selection of microscope objectives.

SUBSTAGE ASSEMBLY

The base of your adapted microscope must contain a special substage lens and assembly that focuses the light through a specimen slide. A slide copier has a diffused light source which causes very low-resolution pictures, so a new substage must be constructed to fit the base of your slide copier (or onto your light box if you're using an alternative method).

The substage assembly uses your camera's normal lens mounted to a Plexiglas support and on top is another support area which holds a microscope slide. If you're adapting a vertical slide copier, follow the instructions outlined here, particularly those that will allow the substage to be attached to the copier. If you are using one of the makeshift versions outlined earlier, you do not need to bother with the instructions that detail attaching the substage to the copier; the substage is manually positioned under the taking lens.

TOOLS AND MATERIALS

Here is the list of tools and supplies needed to construct the substage lens assembly:

Electric saw (radial arm or table saw preferred)
Sand paper
Electric drill and drill bits
Square foot of ⅜-inch Plexiglas
Small can of Weld-On No. 4 glue (or other acrylic or plastics glue)
Tube of Krazy Glue®
Can of lacquer spray paint
Hole-saw cutter (drill attachment used for cutting doorknob holes; they come in a variety of sizes)
Bayonet mount similar to the one on the front of your camera.

Plexiglas and Weld-On glue No. 4 (or other acrylic glue) can be found at your local plastics dealer or hobby store. If you do not own an electric saw, you can hand-cut the Plexiglas, but it will take time—it's like trying to saw the hardest of hardwoods by hand. Also, you might ask the plastics dealer who sold you the Plexiglas to cut it to your needed dimensions. It may cost you 50¢ per cut but without an electric saw it's money well spent.

Krazy Glue® can be found in most variety or hardware stores. Be very careful with this glue as it can bond your fingers together quickly if you're not careful.

The bayonet mount ring can be salvaged from a junk extension tube or purchased from your local camera repairman.

SELECTING MICROSCOPE SPECIMENS

Most microscope slides can be grouped into one of three categories: plant, animal or mineral. You can purchase these slides from larger department stores as well as toy and hobby stores or through scientific supply houses. For the avid enthusiast who wants to make his or her own microscope slides, slip covers and a gel solution to slow the creature's movement can also be purchased from the above stores. A 35mm photographic glass slide mount can also be used in place of the standard microscope glass and slip cover. A visit to your local pond with an eyedropper and specimen container should provide an ample supply of microscopic plants and animals. Collecting pollen, thin leaf sections, small insects and other specimens of nature can provide a stimulating new world of exploration.

CRYSTAL MICROSCOPE SLIDES

Some of the most beautiful photomicrographs come from very ordinary chemical crystal formations (see "How to Photograph Crystals," September, 1981 issue). The preparation of these crystals for photography is relatively easy. The easiest method is by evaporation.

Dissolve the chemical in a small vial of water and add one drop of Kodak Photo-Flo solution. Remove one drop with an eye dropper and place it on a small piece of glass that has been removed from a photographic glass slide mount. Set the glass with its drop of solution onto the burner of an electric stove and turn to the lowest power setting. The liquid will soon evaporate (after a few minutes) leaving a crystal formation.

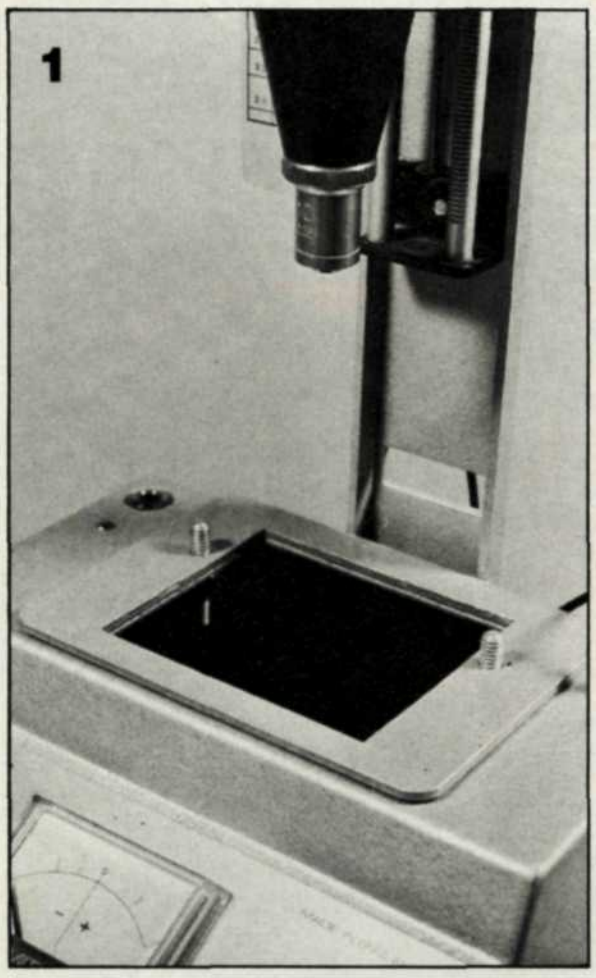
The second method of preparing crystals is called the melt process. Place a small amount of the dry chemical on a piece of glass from a glass slide mount and cover with the top piece of the glass slide mount. Press down on the top glass with a tacking iron or household iron for one to two minutes. Remove the iron and immediately set a flat, heavy object on the sandwiched glass. As the melted chemical cools, crystals will form.

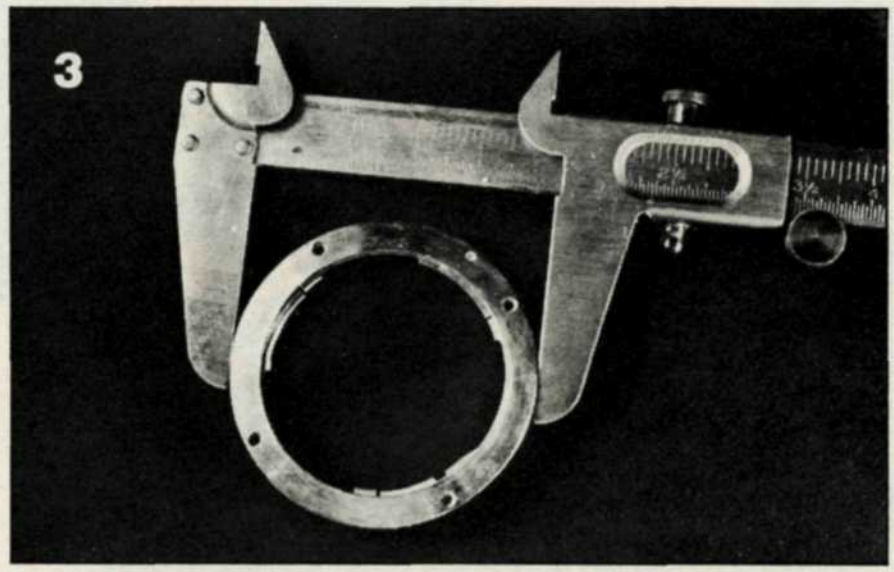
With either method, the same crystals can be remade until the desired results are formed.

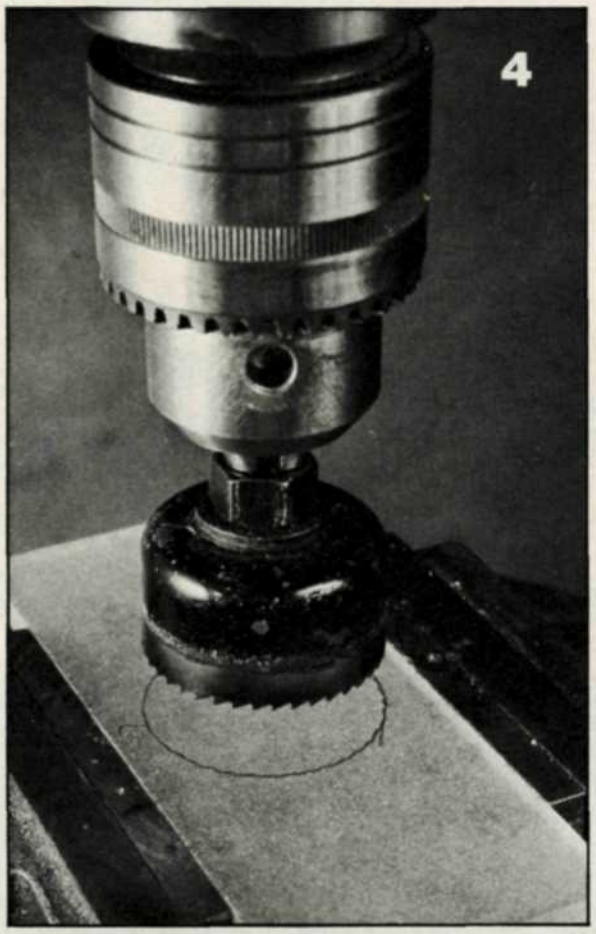
The chart on page 98 contains a list of suitable crystals that are safe and will provide interesting photographic results. These crystals can be obtained from chemical supply houses, some department stores and toy stores and even some camera

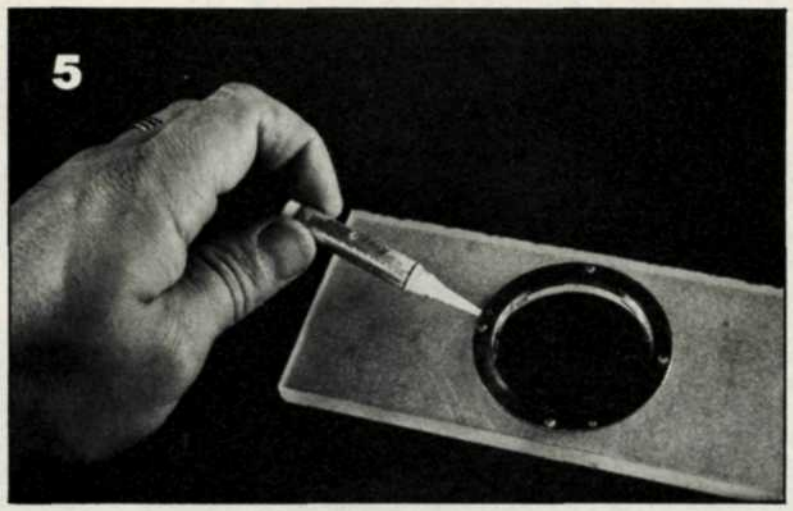
The photographs on the opposite page were all made with the homemade microscope. Our unit is an adapted Bowens Illumitran. Although we used a microscope objective mounted to the copier's bellows, you can use any of the alternate systems described in the article. All photos here are 10X magnification on the negative. Clockwise from top left: Polarized ascorbic acid crystals, Osmunda Rhizome (common fern section), polarized urea crystals, a cattle louse, minute strands of silk, polarized urea crystals in different configuration than above, amphioxus specimen, benzoic acid crystals (polarized).

MICROCOSMIC JOURNEYS







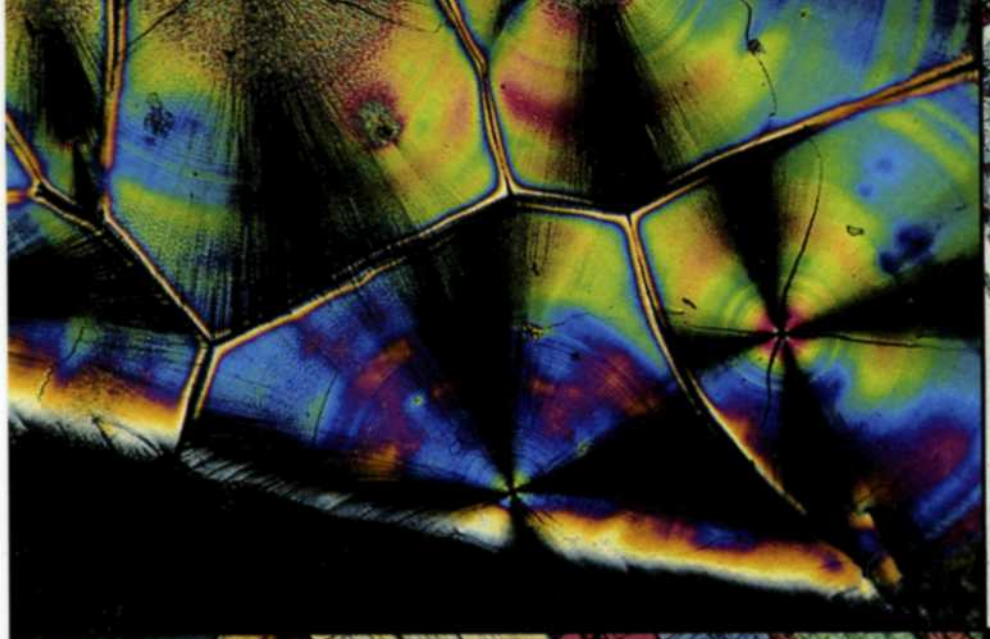


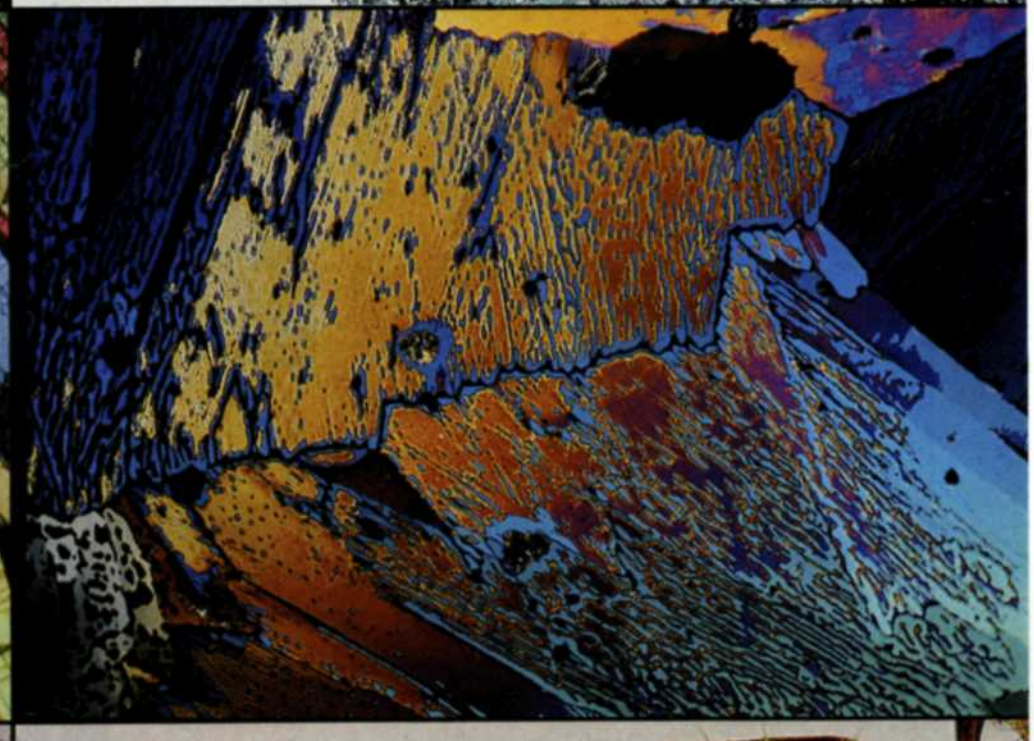
CONSTRUCTING THE SUBSTAGE

You begin the construction of the substage by taking the measurement of the base of the slide copier (photo No. 1). When measuring, allow ½ inch beyond the light box area and include the stud or bolt holes that secure the slide holder. These measurements will be used for the baseplate of the substage assembly. Note: If not using a vertical slide copier, omit assembly calling for attachment of the substage to the copier. When cutting the first piece of Plexiglas, remember to use a fine-tooth saw and safety goggles for protection (photo No. 2). Note: If you have the Plexiglas cut by your plastics dealer, be sure all measurements are taken beforehand.

Next, measure the diameter of the bayonet mount that will hold the lens in the substage assembly (photo No. 3). Subtract about ¼ inch from this measurement and select the correct hole-saw cutter. Find the center of the baseplate and cut a hole through it using the electric drill with the hole-saw cutter attached (photo No. 4).

Position and glue (with Krazy Glue®) the bayonet mount to this hole so that the lens will face forward (photo No. 5).





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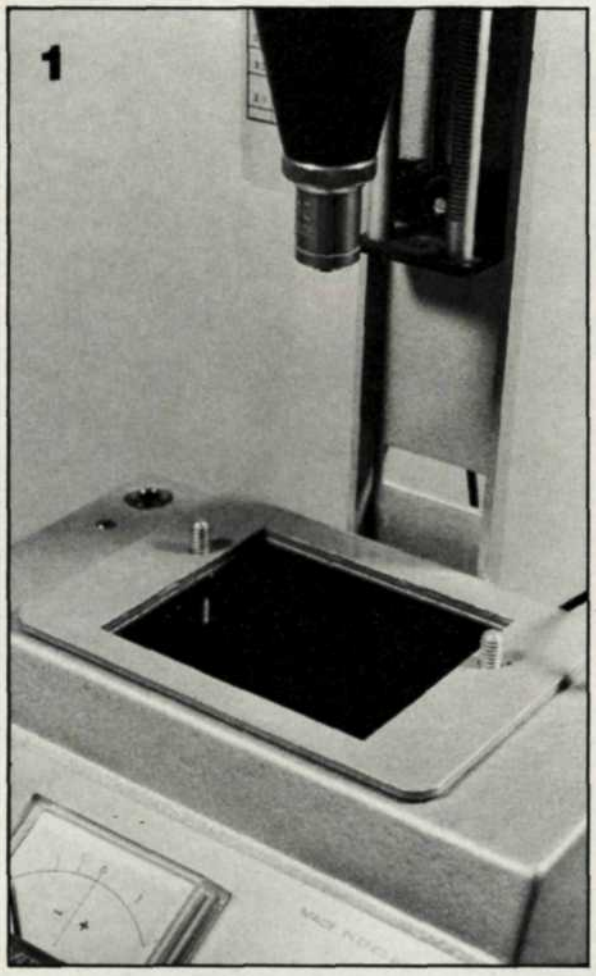

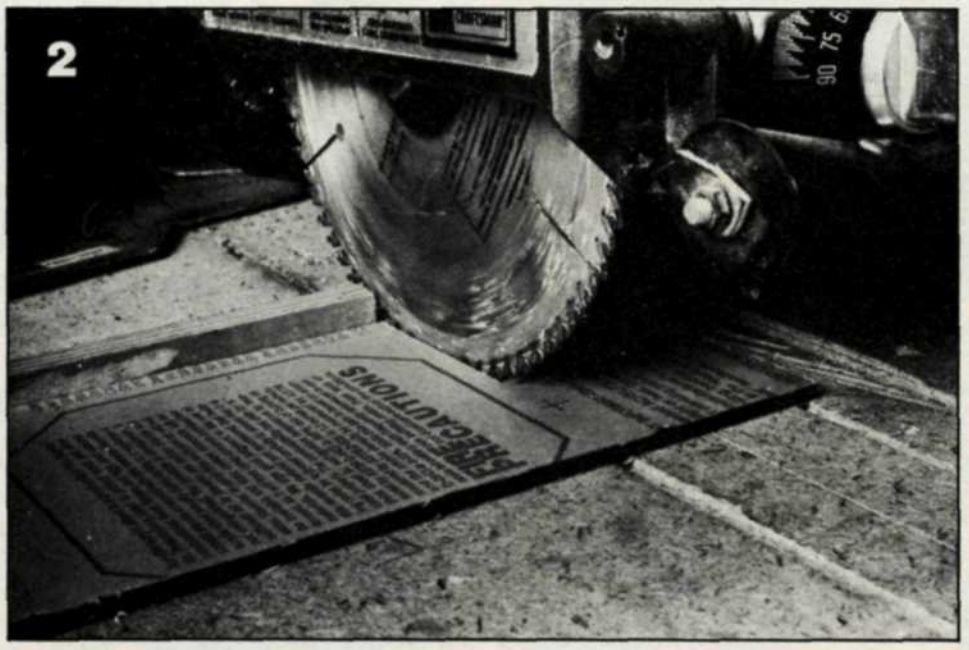

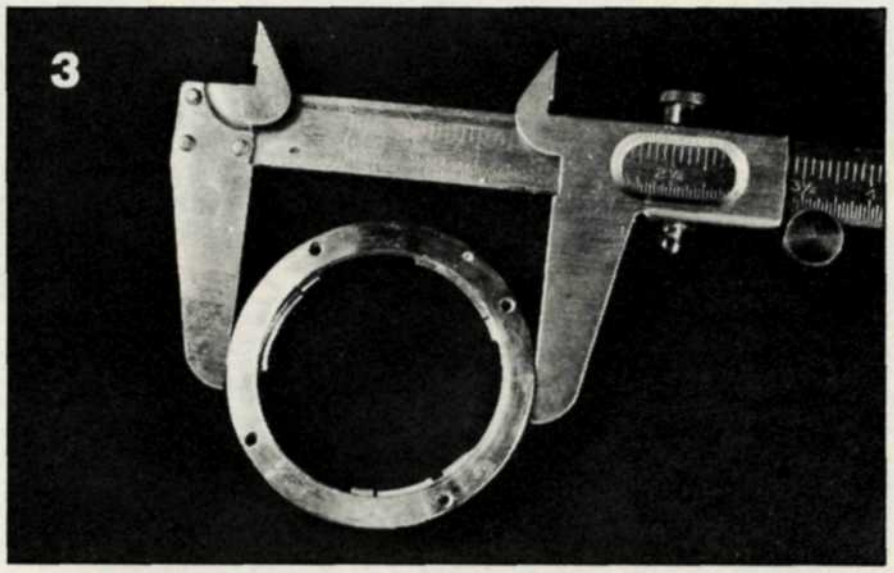

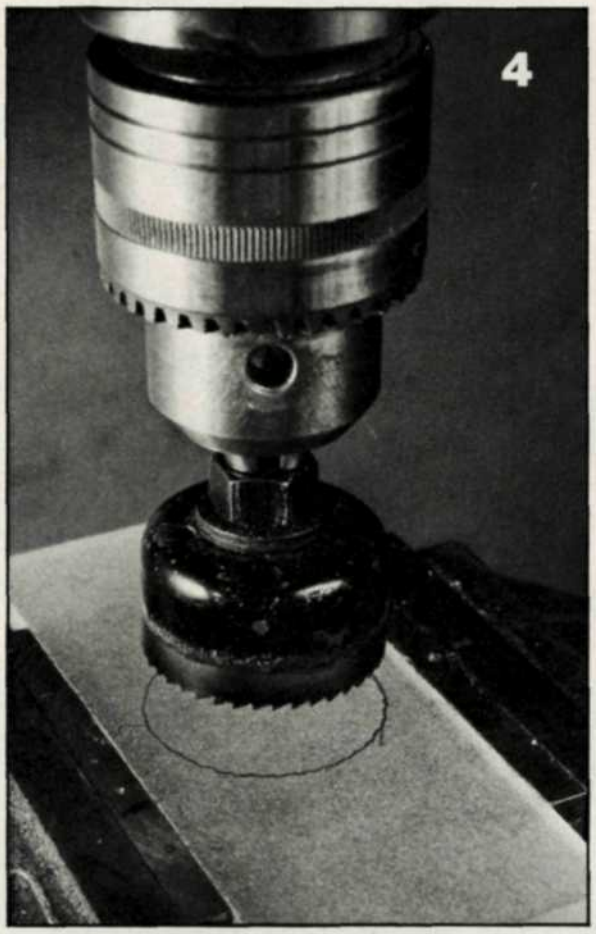

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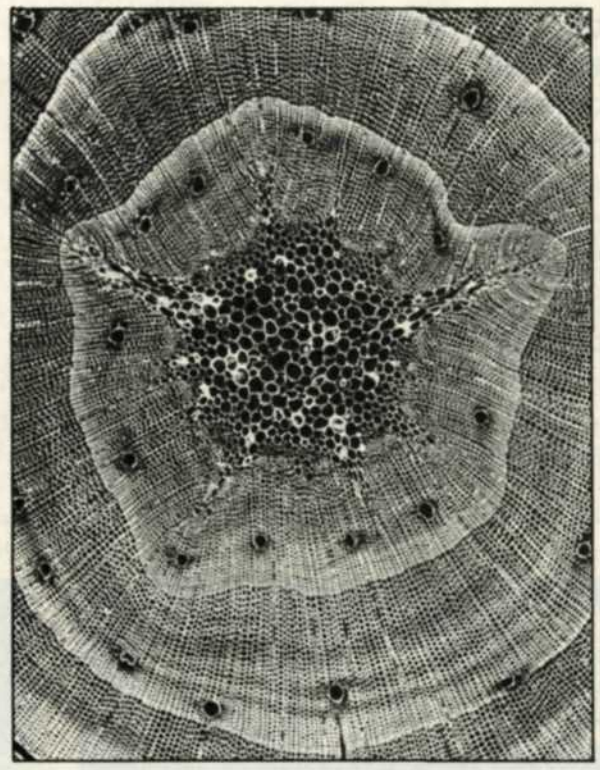
shops. For more detailed information on crystal preparation, see Kodak publications, *The 10th Here's How, AE-110,* or *Biomedical Photography, N-19.* Both are available from your camera dealer or directly from Eastman Kodak.

FILM CHOICES

There are a few basic film types available to the photomicrographer for working with this new type of microscope. Kodak Technical Pan Film, rated at E.I. 50 and developed in Kodak HC-110 Developer (Dilution F) for eight minutes at 68° F., gives outstanding high-resolution black-and-white results. For color slides, we recommend Kodak Ektachrome 50 (Tungsten—for copiers with tungsten light sources), and Ektachrome 64 (Daylight—for systems using electronic flash) Film. Both, in fact, work extremely well.



Pine stem

SETTING UP THE MICROSCOPE

To set up the microscope, first load the film and mount your camera onto the slide copier (or copy stand or sturdy tripod if you have used alternate methods). Set the camera on B (bulb) and attach a cable release. Do not connect the flash cord if your unit has one. Mount the microscope objective (or inverted wide-angle lens) onto the special mount and attach to the bellows or extension tube, whichever your "microscope" uses. Insert the 50-100mm camera lens into the bayonet mount of your substage assembly and center the substage on the baseplate of the slide copier (or directly under the microscope objective or inverted lens if you have used alternate methods). Position a microscopic specimen under the objective and focus.

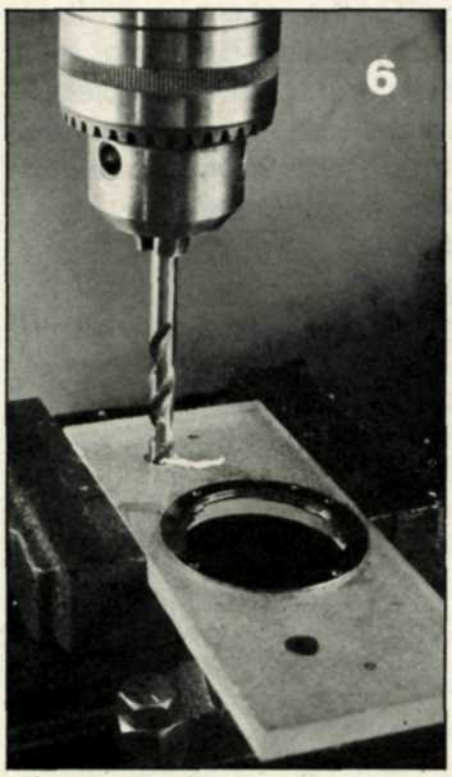
EXPOSURE

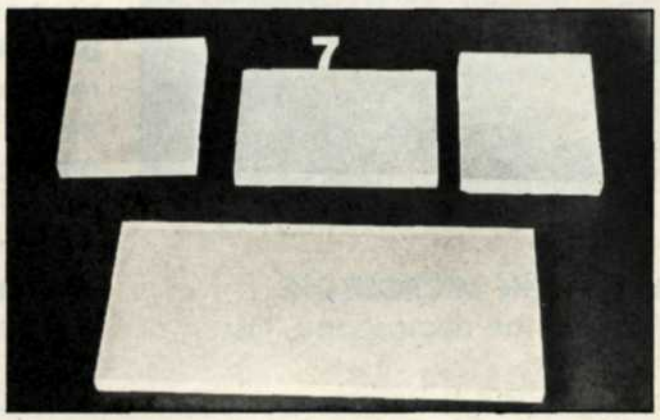
Exposure is controlled by the aper-

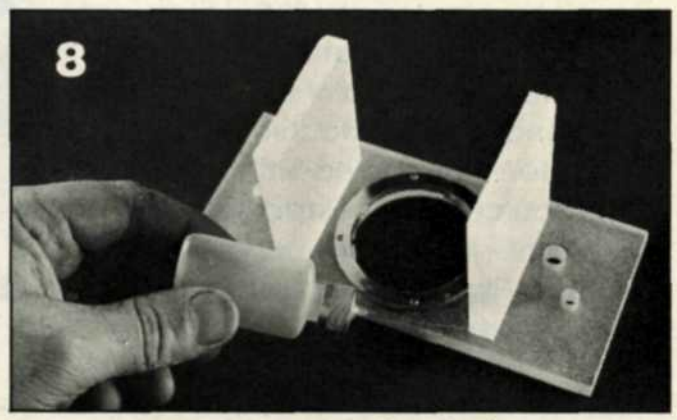
ture on the lens in the substage. If tungsten light is normally used to make exposures with your setup, then use similar exposure times for your first exposure test.

It is important to separate the shutter movement from the actual exposure. This can be accomplished by turning the exposure light out, opening the shutter on B, waiting one second, then turning the exposure light on and closing the shutter after the desired exposure time has elapsed. This will provide a considerable increase in sharpness over the normal method of exposure because it eliminates any minute vibrations in the system. You are exposing the film by turning the light source off and on—and this, in effect, becomes your shutter.

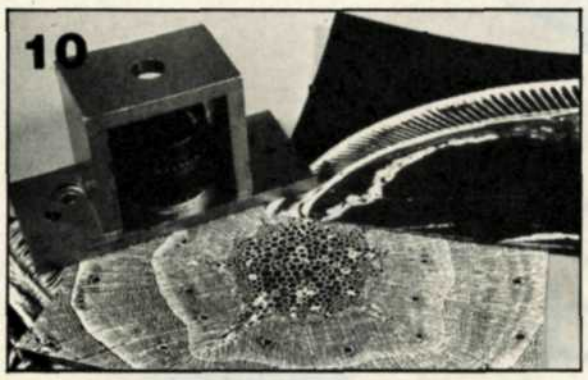
For slide copiers that use electronic flash for exposure, first turn off the focusing light, open the shutter on B, trip the flash with the "open-flash" button and then close the shutter. Some copiers may not have an open-flash button. In this case, a small switch will have to be connected to the sync cord so that the flash may be fired manually. Even though the flash has a very short duration, the image can still be blurred by mirror slap. One alternative to building a separate switch into the sync cord is to lock the mirror in the







CONSTRUCTING THE SUBSTAGE



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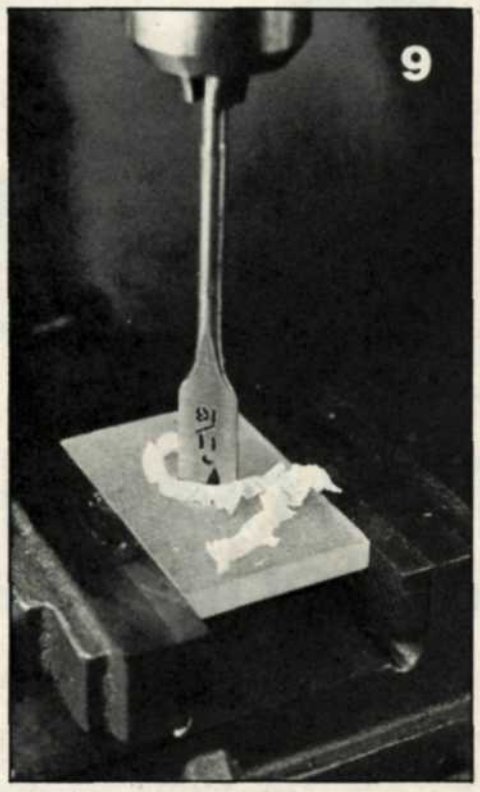

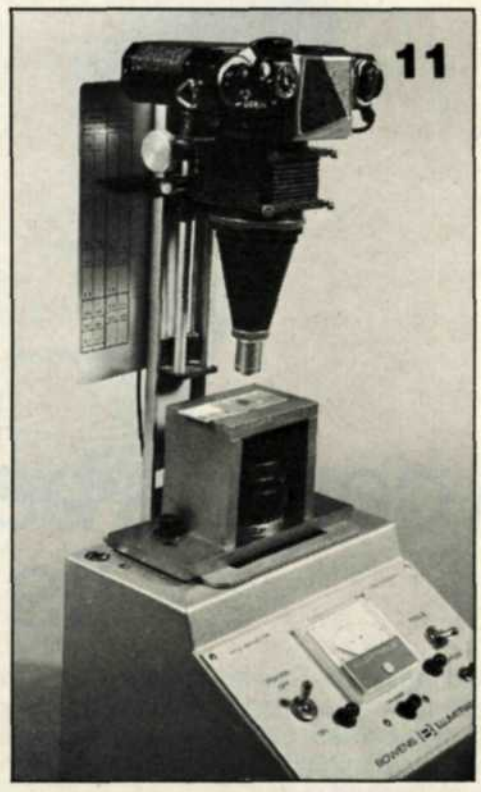

Next, position the baseplate on the slide copier and mark the position of the attachment holes or studs. Drill the holes with an electric drill bit slightly larger than necessary (photo No. 6). The measurement of the length and diameter of the substage lens (50-100mm camera lens) will determine the height of the uprights and just how far apart they will be glued. These uprights must be exactly the same size so the plane of focus will remain level (photo No. 7). Glue these uprights into place with Weld-On No. 4 Glue (or other acrylic glue) using the applicator supplied with the glue (photo No. 8). Before the uprights dry, measure the width and length of a piece of Plexiglas that will fit on top of the uprights. Cut this piece, find the center and drill an 11/16-inch hole that will eventually allow the light to pass through the substage lens to the microscope specimen slide (photo No. 9). Sand all sharp edges with sandpaper and paint with a dark-colored spray paint. When all is dry, mount the lens to the substage bayonet mount.

The finished substage (photo No. 10) can now be mounted onto the base of the slide copier, thus completing your new low-power microscope (photo No. 11).

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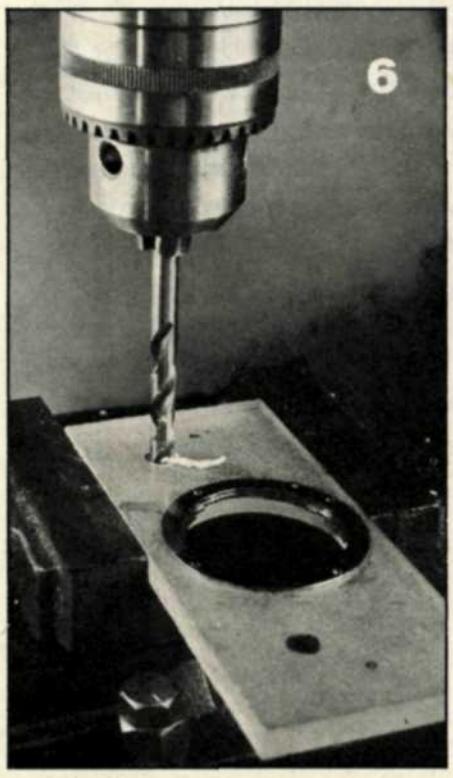
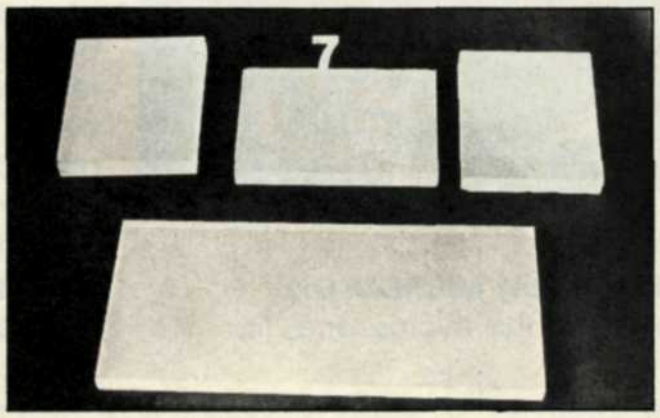
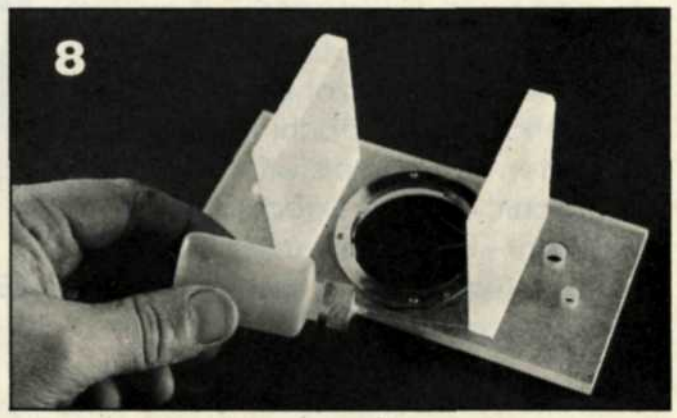
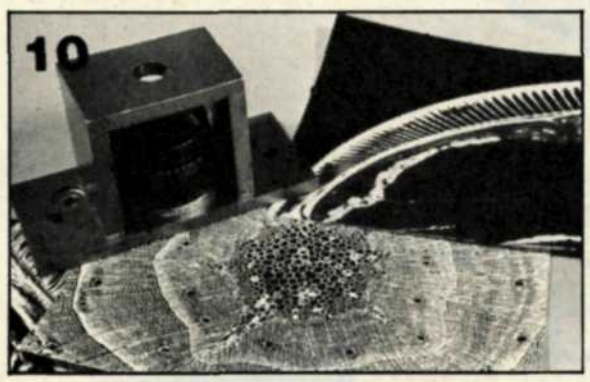






CONSTRUCTING THE SUBSTAGE



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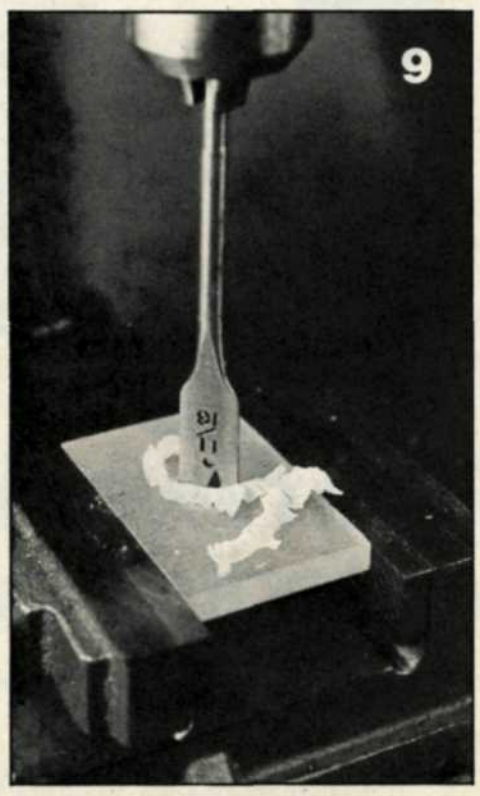

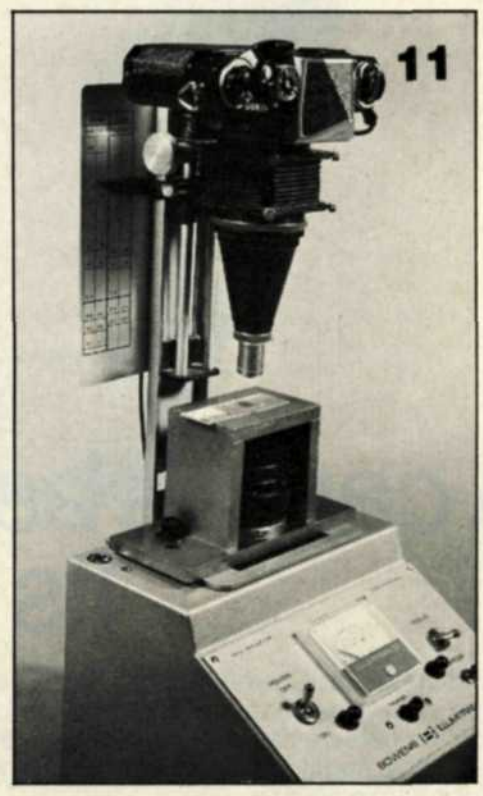

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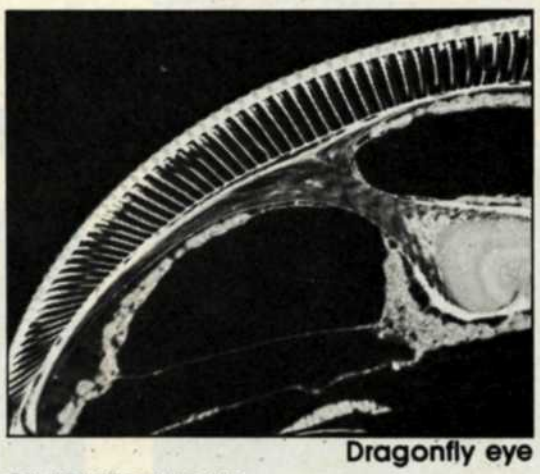
up position if your camera has such a feature.

One final word about exposure—keep detailed records of your tests and determine what the optimum aperture of your substage lens is for flash or tungsten light sources. Then use this exposure as a starting point for future exposures. Be sure to bracket in ⅓ to full f-stops around the indicated exposure.

A WORD ABOUT SHOOTING APERTURES

If you use an inverted wide-angle lens as your microscope objective, always leave this lens wide open. The substage lens can be used at any aperture without affecting the diameter of the light transmitted to the microscope specimen. In fact, the smaller the aperture used, the sharper the light source becomes and consequently, the sharper the image you will record.



Dragonfly eye

POLARIZED LIGHT

When photographing crystals, you can give the clear crystals a prismatic effect by polarizing the light source. To get this effect, you need two polarizing filters. The first polarizer is attached directly to the substage lens and the second polarizer is used directly over the crystal specimen directly below the microscope objective. By turning either polarizer to the right or left, a change in the refractive index through the crystals can be observed. Turn the filters until you achieve the desired prismlike effect and then make your exposure. Considerably more exposure will be needed for the polarized microscope setup. Keep in mind that this setup is not totally restricted to just crystals. Some plants and animals also contain matter that will undergo changes in its refractive index. These, too, will transmit a prismatic effect.

Don't be afraid to experiment with other filters, specimens, lenses and films. This article only scratches the surface of a whole new world of photography. Besides, if you ever get tired of taking photomicrographs, you can always dismantle your microscope and use the slide copier to just copy slides . . . especially some of those you made with your new microscope. □