[The Editor of the Home Laboratory will be glad to receive any suggestions for this department and will pay for them, promptly, if available.]

A Twenty-five-cent Photographic Objective By Gustave Michaud, Costa Rica State College

SOME amateur photographers take nothing but snapshots, while others, because they aim, above all, at technical perfection and have no use for underexposed negatives, take nothing but time exposures. Amateurs of the first category need not read the following lines, as the objective described here would be, in most cases, too slow for them. It requires 1 second to perform work which would be done in 1/15 of a second by an anastigmat used at full aperture. As a compensation, when made to cover the whole plate as sharply as the anastigmat does, it has over the costly objective the following points of superiority:

- 1st. A better rendering of color. The blue sky is not made just as luminous as the white clouds. Red cheeks are not made to appear as black depressions.
- 2nd. A greater depth of focus. The small aperture gives a better definition of any object out of focus.
- 3rd. A more uniform illumination of the field. The margin of the plate is not darker than the center. This again is a result of the smaller aperture.

Fig. 1.—Longitudinal section of objective tube.

4th. A lower price. Twenty-five cents and some easy work is about the price paid for the home-made objective. Twenty-five dollars is about the price of an anastigmat covering a 5x7 plate or of a good rectilinear combination covering an 8x10 plate.

The home-made objective is composed of two parts: the refracting combination contained in a wooden tube placed, as usual, in front of the camera; and the screen, placed behind the lenses and close to the sensitized plate.

The refracting combination is made of two circular, periscopic, spectacle lenses, separated by a diaphragm. Such a combination, has over a single lens, the advantage of a complete elimination of the distortion, together with a considerable reduction of the spherical aberration and of the curvature of the focal surface.

The screen confers to the objective the qualities of being, to some extent, achromatic and orthochromatic, qualities which are incompatible from the etymological, not from the optical point of view. The screen is dyed with ammonium picrate, a yellow substance which effectively stops most of the ultra-violet and violet rays, and so weakens the blue that this color has not much more action on the plate than the less actinic green and yellow rays.

The needed material for the making of an objective which will sharply cover the 5x7 plate consists of two periscopic convex, two diopter, spectacle lenses, X or test lens shape (price, 15 cents the pair, sold by all manufacturing opticians), and a parallelopiped of seasoned hard wood, 2 3/4 x 2 3/4 x 2 3/4 inches. A hole same diameter as lens, that is about 1 1/2 inches, and about 1/4 inch deep, is drilled in each square end of the parallelopiped. Then a 1 3/4-inch auger bit is substituted for the 1 1/2-inch bit and the hole is drilled throughout the block, the longitudinal section of which will then be as shown in Fig. 1. While drilling the counterbore as well as the main bore, the utmost care should be taken to keep the auger bit at right

angles with the surface. The block is then sawed transversely through its central part until the saw has passed clear through the hole, but not much farther. Two wooden strips are screwed on the sides of the block. They close laterally the cleft made by the saw and leave it open only on the top of the parallelopiped. Through this upper opening the diaphragms are introduced and removed. There should be at least three of them, with openings 1/2, 5/16, 3/16

Fig. 2.—Sectional view of the completed objective.

of an inch in diameter, approximately corresponding to 1/20, 1/32, and 1/64 of the focal distance. They can be made of black pasteboard or of metal. No diaphragm should be used while focusing.

After the inside of the objective tube has been blackened with drawing ink the two lenses are placed as shown on Fig. 2, with their concavity facing the diaphragm. A ring of pasteboard or of wire keeps them in place and allows of easily removing them when they must be cleaned. The shutter is a cover made of black pasteboard. A hole 1 3/4 inches in diameter is drilled into the center of a board about 4x4 inches, which is afterward fastened upon the objective tube in the manner shown on Fig. 3. Four screw holes are drilled on the four corners of this board. The objective can now be screwed in two minutes upon any 5x7 camera.

To make the screen, two of the 5x7 sensitized plates are immersed into the ordinary fixing bath of hypo until the white bromide of silver has entirely disappeared. This operation is made in the darkroom, far away from the ruby light. A thorough washing (fifteen minutes at least) in running water follows. The two plates are then left, film upward, for about five minutes in the following solution: Water, 250 cubic centimeters; picric acid, 2 grammes; ammonia, 10 cubic centimeters.

Next, they are immersed for not more than two seconds in water and are allowed to dry away from dust. When perfectly dry, they are bound together, film against film, with simple syrupy shellac varnish. The liquid is rapidly poured over both films; the plates are then firmly pressed against each other to drive away air bubbles. A few days later the glass is cleansed and the edges are finished with black *passe partout* binding.

In most cameras the screen can be effectively and permanently kept in place by means of four thumbtacks nailed on the inside part of the frame which carries the ground glass and its spring. The screen will then be almost in contact with the sensitized plates.

If the home-made objective is intended to cover the 8x10 plate, the following alterations must be made in the figures given for the 5x7 plate: The objective

Fig. 3.—General view of the 25-cent objective.

tube should be long enough to allow of a distance of 4 inches between the two lenses. These should be 1.25 diopter lenses. Finally, the diaphragm apertures should be 3/4, 1/2 and 1/4 of an inch, to correspond to 1/20, 1/32 and 1/64 of the focal distance.

An Experimental Proof of Inverted Retinal Images

By A. H. Patterson

IT is usually somewhat mystifying to be told that all upright objects, such as trees, men walking, etc., form inverted or upside-down images on the retina of the eye. However, it is easy to construct a simple bit of apparatus which will prove the point in question. But first we must understand clearly one or two principles of the action of light rays.

Take a sheet of cardboard *S* and pierce in it a small hole about one-tenth of an inch in diameter. In front of it place a lighted candle, and behind it a cardboard screen *S'*. On this latter screen will be seen an inverted image of the candle—a so-called "pin-hole image." Now place the candle quite close to the screen *S* and let its light shine through the small hole upon the screen *S'*. Then take a third cardboard screen *S''*, from the middle of which is cut a hole 1 inch in diameter, and place it between the two screens *S* and *S'*. The divergent pencil of rays coming through the hole in *S* and the inch hole in *S''* will illuminate a circular area on screen *S'* slightly more than an inch in diameter. Take some object, say a small cross, and hold it upright before the hole in *S''*. It will cast a shadow in the circular lighted area on screen *S'*, and this shadow will be upright. There is no reason why it should be otherwise. If, now, a double convex lens is held behind the hole in screen *S''*, the size

Experimental proof of inverted retinal images.

of the lighted area and the cruciform shadow on *S'* will be altered, but the shadow will still be upright.

Now for our experiment. Construct of thin pieces of wood a frame like that shown in the drawing. The distance *AB* is about 7 inches; the hole *C* is about one-tenth of an inch in diameter, and *DE* is a piece of white letter paper about 4 inches square, pasted over the wooden upright at the left. At *F* a tiny hole is pierced through the paper with an ordinary pin. Now stick a pin upright in the block *G* and adjust the position of the block so that the head of the pin is exactly in line between the holes *C* and *F*, and three-fourths of an inch from the hole *C*. Fix the block *G* in this position. This completes our apparatus. Placing the eye close to the hole *C* and looking through hole *F* at the sky, we see a lighted circular area with the shadow of the pinhead in its center, but *this shadow is inverted*. We are ready to declare that the pin is upside down, for it certainly looks so. When we reflect a moment, however, we see that we have now exactly the same arrangement as in the middle diagram. The hole *F* represents the hole in the screen *S*, the pinhead represents the cross, the pupil of the eye represents the hole in screen *S''*, and the retina of the eye takes the place of screen *S'* and receives the upright shadow of the pin head upon it. The crystalline lens of the eye acts precisely like the lens in Fig. 2, altering the size of the retinal shadow, but not its upright position. This upright shadow on the retina, however, makes us think that the object throwing it is inverted, for the shadow certainly "looks" inverted to us. But we know that the object throwing the shadow is upright, and it follows in consequence that the retinal images of upright objects are inverted. In using this apparatus the eye must not be focussed on the pin, or the hole *F*, but on something distant, like the clouds or the twigs of trees between the observer and the sky.