Much trouble from fogging of the negative by halation or sunshine entering the lens will be prevented by employing some kind of a lens shade to cut off all rays of light outside the view angle of the lens. This is especially important when working against the light.

APPARATUS AND METHODS FOR CLOUD PHOTOGRAPHY.

By Arthur J. Weed, Chief Instrument Maker.[1]

[Weather Bureau, Washington, July 24, 1920.]

SYNOPSIS.

The first requisite for cloud photography is a good camera with a very rigid support. To this equipment a ray filter or black mirror is a necessary adjunct in order to cut out the actinic light of the blue sky and render, in the finished print, white clouds on a dark background. Certain forms of clouds may be successfully photographed with a light bellows camera, but since many of the most interesting clouds are accompanied by high winds, a much more stable camera, such as the box type, on a permanent support is desirable. This should be so mounted as to cover the full sweep of the horizon and from the horizon to the zenith. The apparatus used at Mount Weather is fully described. Expensive apparatus is not necessary to attain excellent success in cloud photography.—*H. L.*

The first requisite in cloud photography is a good camera for that special purpose. Not necessarily an expensive apparatus, but one that is rigid and has the necessary means of attachment to a firm support.

A suitable ray filter, or black mirror, is necessary to cut out the actinic light of the blue sky and render, in the finished print, white clouds on a dark background just as we see them on a darker background of blue.

Excellent pictures may be made of certain types of clouds with a light bellows camera, when it is sheltered from the wind, but if one wishes to do really good work this will be found too light and shaky for the purpose, as some of our most interesting clouds occur only when a strong wind is blowing.

In order to get an unobstructed view, means should be provided for mounting the camera on the highest possible elevation like the top of a hill or the roof of a building.

Figure 1 (on plate facing p. 456) shows a camera built by the writer at Mount Weather Observatory. This was mounted on the roof of the Physical Laboratory.

Two permanent mountings were required for a full sweep of the horizon, each of which consisted of a piece of yellow pine timber 3 by 4 inches, the upper end turned to a diameter of about 3 inches. These turned portions of the posts were shellacked and when not in use were protected by metal covers made from pieces of tubing with a head soldered into one end.

The method of attaching the post to the metal railing is shown in figure 1.

The holder for the camera consisted of a tube to fit over the turned wood post, a frame to hold the bed of the camera, and two braces by which the vertical adjustments were made.

The tube was a piece of conduit pipe used to protect underground electric wires. To the top of the tube was secured a crosspiece of wood, and to this was hinged one end of the frame carrying the camera bed. To the other end of the frame two round metal braces were attached by hinges.

The tube was sawed open from the bottom for about one-half its length and a U-shaped strap of brass was placed around it. Through the free ends of this brass strap a bolt was inserted on which were two pairs of thick washers, each pair grooved to hold one of the metal braces of the frame. The bolt was provided with a large milled head nut. When this nut was tightened the camera was firmly secured both vertically and horizontally.

The frame was constructed so that the bed of the camera slid in between the two side rails where it was secured in position by four large-headed brass bolts provided with milled head nuts. The heads of these bolts gripped the edge of the camera bed.

This frame could be swung around on the post and had a vertical movement of 90°.

The construction of this portion of the apparatus can be seen in figure 1.

The camera consisted of a bed or frame, made from a piece of maple flooring, on which was mounted two wooden boxes painted a dead black on the inside and constructed of the proper size to telescope together readily.

The outer box was screwed to the camera bed and the front end of the inner box was secured to a maple frame having an L-shaped extension which was fitted to slide on the maple bed. This frame carried the lens board.

The arbitrary sizes to be followed in constructing such a camera are that the combined length of the two boxes plus the lap where they slide together shall equal the focal length of the lens it is desired to use. Also the outer box must conform to the size of the plate holder used so that a light trap can be arranged.

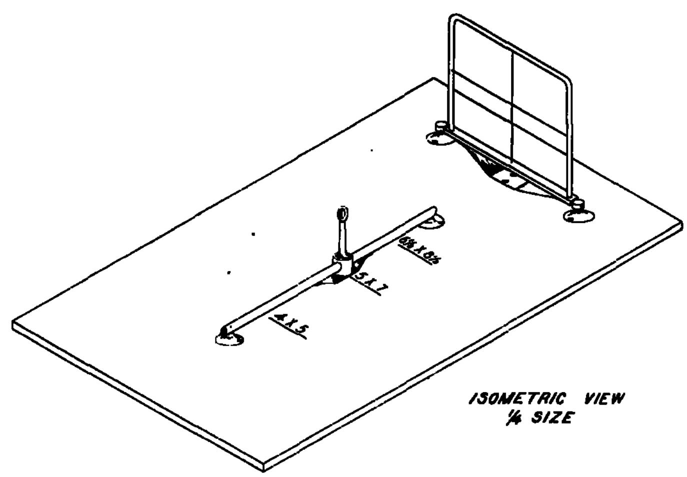

Fig. 2.—View finder for different sized pictures.

In this particular camera a groove was made at the top and bottom of the rear end of the outer box a little wider than the thickness of the plate holder, and a flat spring was fastened in the outer edge of each groove which forced the plate holder against the end of the camera box.

The ground-glass focusing screen was mounted in a frame corresponding in size to the plate holder and had to be removed before inserting the holder. In figure 1 this frame and screen are shown in position.

When only one lens is to be used with such a camera the two boxes can be adjusted to get the proper focus of a distant object on the ground glass and then firmly secured to the bed at that point.

The only use for the focusing screen thereafter is to see just how much of the view will appear in the picture.

For quick work a special view finder was made and attached to the camera. This was in two parts, as shown in figure 2.

A rectangular frame proportional to the size of the plate to be used was mounted on the top of the camera box and had both a vertical and a horizontal wire

[1] Since Sept. 1, 1920, Mechanician, Rouss Physical Laboratory, University of Virginia.

stretched across it, meeting at the center. This frame was mounted so that it could be folded down onto the top of the camera and was retained in either position by a bent flat spring, the free ends of which pressed against the bottom or side of the frame.

Behind the frame, extending lengthwise of the camera, was a round rod mounted on supports at each end and having the underside flattened. Sliding on this rod was a vertical post with a small ring at the top to sight through. The center of this ring was level with the cross wires in the frame.

A spring attached to the lower end of the post and pressing up against the flattened portion of the rod held the post vertical. When not in use this post could be turned down on either side of the rod and out of the way.

The frame was in exact proportion to a 6½ by 8½ plate, that being the size of plate holder used with this camera.

The vertical post was adjusted to such a position on the rod that when one sighted through the ring all that was visible inside the frame would also be shown on the ground glass of the camera. This position was then marked on the top of the camera.

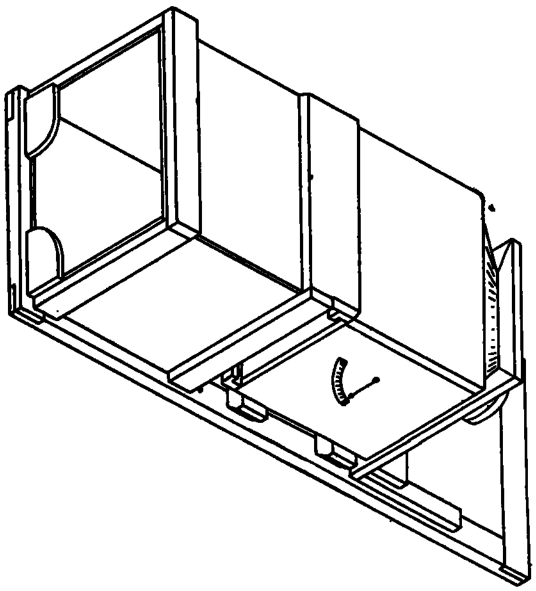

Fig. 3.—Cloud camera complete.

The dimensions of a 5 by 7 and a 4 by 5 plate were marked in pencil on the ground glass of the camera. The vertical post of the finder was then adjusted to show both these views approximately, and the corresponding positions of the post were marked on the camera.

This allowed the use of small plates in the 6½ by 8½ holders by using "kits," and the camera could be quickly sighted on a changing cloud, the finder showing just what would be included in the picture.

Figure 1 shows the camera as at first constructed, but considerable difficulty was experienced in using a focusing cloth on windy days. Another box was therefore constructed of light material corresponding in width and height to the outer box of the camera. This was of sufficient length to occupy the rear projection of the camera bed and proved to be a valuable acquisition, as, in addition to forming a focusing hood, it also supplied a location for the plate holders. A line drawing of the completed camera is shown in figure 3.

The back of this box was left open, except for two small pieces of thin wood set across the two lower corners. These retained the plate holders when the front of the camera was elevated to sight on a high cloud.

On the side of the camera box was placed an inclinometer. This consisted of a short piece of fine brass wire having a loop bent in the upper end and a flat-pointed weight soldered to the lower end. A small brass screw was inserted through the loop and then screwed into the side of the camera box. The wire could swing free on the screw and the weight hang vertical.

The camera was then leveled and a brass sector, graduated from 0° to 90°, was placed in position, so that as the camera was tilted upward the angle from the horizon to which it was elevated would be indicated by the pointed end of the hanging weight. This should be boxed in and have a cover of glass or celluloid, otherwise it must be sheltered from the wind while the angle is being read.

In this branch of photography, as in all others, a good lens is to be desired. The lens used for most of the cloud pictures shown with this article was a Goerz 10½-inch Double Anastigmat, F.7.7, the property of Prof. A. J. Henry, who was then the Official in Charge at Mount Weather.

Occasionally a creditable cloud picture may be made with the lens alone. This applies particularly to the gray clouds. But for white clouds in a blue sky either a ray filter or black mirror must be used.

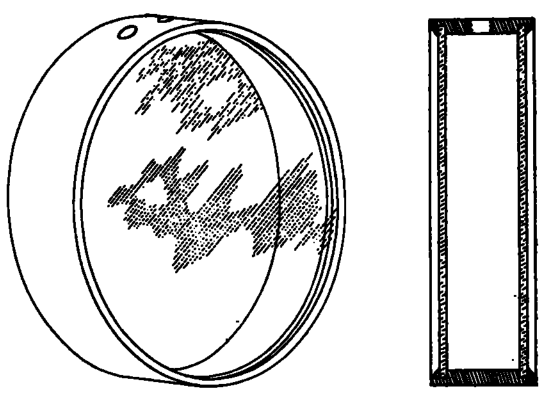

Fig. 4.—Details ray filter cell.

When the camera is pointed at the sky we see on the ground glass the white clouds on a darker background of blue sky; but when these same rays of light are allowed to fall on the ordinary sensitized plate the blue and violet rays from the sky are so much more actinic than the light rays reflected from the clouds that when the cloud has been properly exposed the sky is overexposed and, in consequence, the contrast between the blue and white is entirely lost, and the finished print shows only a bare patch of white for the sky.

If, however, a ray filter of the proper color is placed on the front of the lens, these intensely actinic rays of blue and violet are filtered out and the resulting print shows a white cloud on a dark background.

In practice the filter should be only sufficiently deep in color to give the required contract without unnecessarily increasing the length of the exposure.

The filter can be a colored liquid inclosed in a glass cell or a stained gelatine film mounted on glass or celluloid.

The first filters used on this camera were cells filled with colored liquid. These were made by using a fairly thick piece of brass tubing. A ring about ½ inch long was cut from the tube and either end bored out to form a recess for the glass plates as shown in figure 4.

Two holes were drilled in this ring and each tapped for a screw plug. These holes were for filling and cleaning the filter. A deposit will sometimes form on the inside surface of the glass plates which it is necessary to remove with a small tuft of cotton, held in a twisted loop of fine wire. If the filter is cleaned often enough a stream of water driven into one hole and escaping from the other will be sufficient to remove all deposits from the glass.

The two holes are placed as close together as possible, and in filling the cell one acts as a vent when the solution is introduced through the other.

The glass sides were made from lantern slide covers, which were selected so that there should be no spots or flaws in front of the leas. To cut the glass to the required size one was placed on a sheet of paper on which was drawn a circle the size of the recess in the brass ring. A glass cutter was used to square the lantern slide cover to the same dimensions as the diameter of the circle. Leaving the plate on the circle the corners can be cut off so that the plate is an octagon and if the cutter is in good condition the eight corners can be trimmed off leaving the glass nearly round.

The remainder of the fitting may be done with a sharp file wet with a solution of camphor dissolved in turpentine or the glass may be ground on a stone with water as a lubricant. In either case some care is required to prevent scratching the surface of the glass.

When the glasses have been fitted and cleaned they are placed in position and cemented with thick shellac. As soon as this hardens the cell is ready for use.

Potassium bichromate dissolved in water, and afterwards filtered makes an excellent solution for summer use. Distilled water should be used if possible, and the ingredients carefully measured so that in refilling the cell the same density of color will be obtained as in the original solution, and, in consequence, the same length of exposure required. The best method is to make up enough of the solution for several fillings and filter it into a bottle for future use. To prevent evaporation the cork should be dipped in melted paraffine before inserting in the bottle.

Where one wishes to obtain winter cloud pictures there is danger of this type of filter freezing. For this purpose a stained gelatine filter is best. Such a filter may be purchased from the larger supply houses or can be made up from a dry plate.

To construct a stained gelatine filter place an undeveloped dry plate, or lantern slide plate, in the hypo bath until the silver is all dissolved and the plate becomes clear. Wash out the hypo as with a regular fixed plate and it is ready for staining. If the plate is allowed to dry after washing it should be soaked up again just before staining.

For a yellow stain a few grains of picric acid dissolved in water may be used, but as this acid is rated as an explosive it is sometimes difficult to procure. Ammonium picrate may be substituted, or a good aniline dye used.

For dyeing gelatine filters the writer uses a deep but narrow tank so that the plate will stand vertically, or nearly so. The sides of the tank were made from two 4 x 5 dry plates from which the gelatine films had been removed. The two ends and bottom were made from strips of hard rubber with two grooves milled in them into which the glass plates were cemented as shown in figure 5.

The dye should be prepared and filtered to remove all particles which might settle on the soft gelatine surface and cause opaque spots.

Place the plate in the tank so that it tilts over to one side and the dye can be poured onto the glass side and not directly onto the gelatine film as it would make too deep a color at one spot. The film will take the color very quickly and should be removed from the tank immediately, rinsed and set up to dry.

In some instances it is desirable to show the landscape with the clouds. This requires a ray filter in which the color shades from a clear glass to the depth necessary for a cloud well up in the sky. This tank will be found well adapted for the making of such a filter.

Place sufficient dye in the tank to stand at a height of about ¾ inch. Lower the prepared plate into the dye and immediately run water into the tank until it overflows and the water runs away clear. On removing the plate it will be found that because of the gradual dilution of the dye in the tank the gelatine film will be shaded from a deep color at the bottom to clear glass at the top.

When the plate has been dried a section can be selected from which to cut the filter to suit the requirements.

The finished filter may be left in a square or rectangular shape or cut round in the same manner as previously described for the filter cell. Whatever the shape decided upon, a cover glass the same size and shape should be cut and the two cemented together with Canada balsam. This protects the gelatine film from injury.

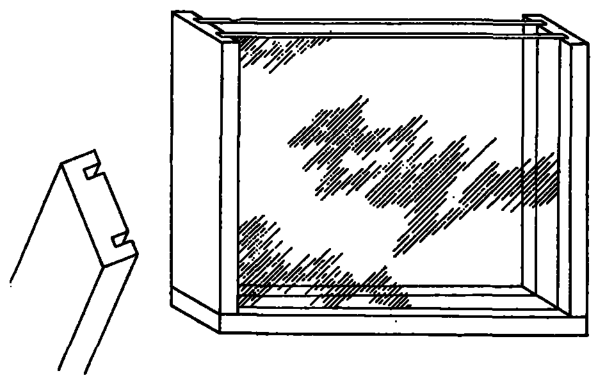

FIG. 5.—Tank for dyeing ray filters.

Provision must be made for holding the filter in front of the lens, either something to slip over the lens hood or by an independent mounting attached to the camera front. Whatever the means employed it is important that the back of the filter be shaded from the sun so that no reflected light can enter the lens.

On completion of a filter it is necessary to time it for the proper exposure, which can be accomplished by the sacrifice of one plate. From an exposure meter get the normal time of exposure required for the stop which it is desired to use, time of day, etc. Draw the plate holder slide a short distance and make an exposure corresponding to the above data. Draw the slide a little farther and make the same exposure. Continue this until the slide is entirely withdrawn.

When this plate is developed its density will be divided into strips, or sections, corresponding to the withdrawals of the plate holder slide. The last section exposed will have had *one* normal exposure and will be underexposed, for the filter will have cut down the amount of light which entered the lens. The previous section will have had *two* normal exposures and, in consequence, will show increased density and strength. The next section will give the result of *three* normal exposures, the next one *four*, etc.

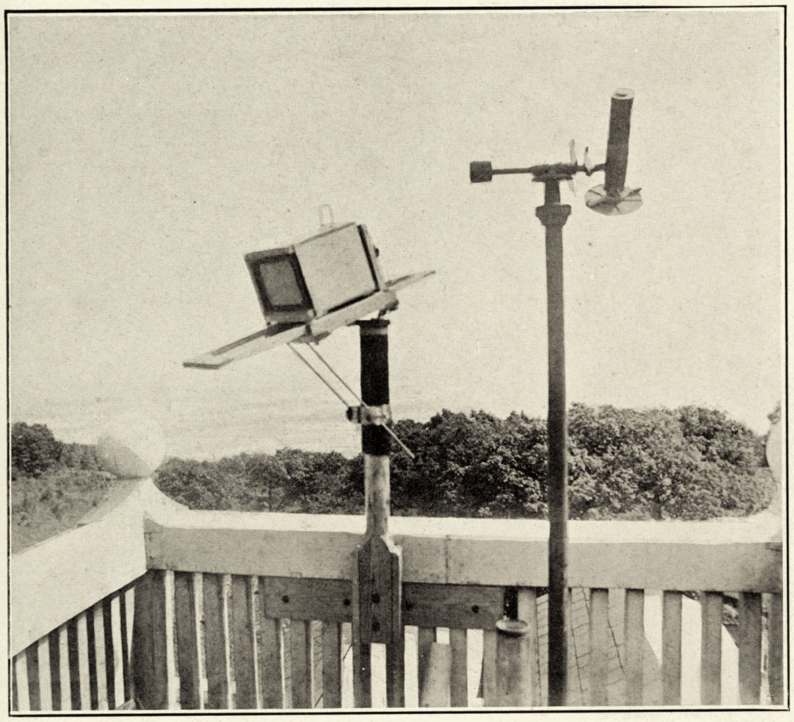

FIG. 1.—Cloud camera (on right) used at Mount Weather and Pickering polarimeter (on left).

FIG. 7.—Distant lightning on "Polychrome" plate.

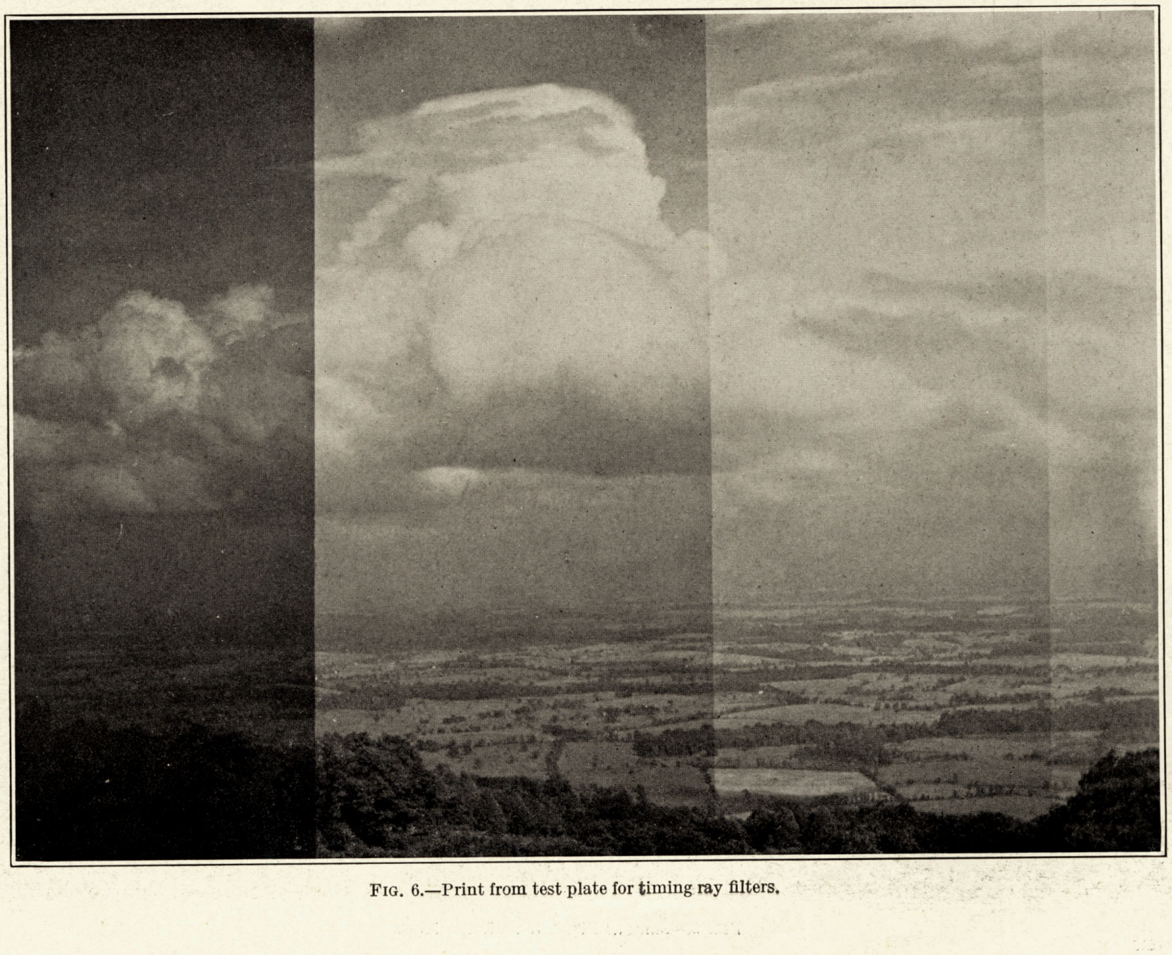

FIG. 6.—Print from test plate for timing ray filters.

Fig. 8.—Thunderstorm in Shenandoah Valley, distant 25 miles.

Fig. 9.—Same as Fig. 8, ten minutes later.

Suppose the third section of the negative is found to have the required printing qualities—the filter should be marked "3T," meaning "3 times," and whenever this particular filter is used it is only necessary to multiply the normal exposure given by the exposure meter three times to give the time of exposure necessary to produce the desired density of negative. Figure 6 shows a print from such a test negative.

For photographing the minute details of high cirrus clouds a black mirror is superior to a ray filter. The mirror must be mounted in such a manner that its reflecting surface stands at an angle of 33° with the axis of the lens. In this position the rays of light which come from the blue of the sky are partially polarized and are not reflected by the mirror, while the white light from the clouds is reflected very clearly.

The mirror must be a black, or very dark, glass, as an ordinary piece of clear glass blackened on the back with pigments while seeming perfect to the eye will, in nearly all cases, give a double image through the lens. One reflection from the front surface of the glass and a second reflection from the back take place. This gives the cloud a blurred outline on the negative.

In a recent publication, the name of which the writer can not recall, it was stated that if the back surface of a piece of clear glass were roughened or ground coarse before painting it black, this double reflection would be eliminated. This is passed along as an experiment worth trying, for a good black mirror is expensive.

One objection to the use of a mirror in cloud photography is that the reflection reverses the sky in the finished print. At Mount Weather another camera was constructed on a more elaborate scale for cloud work than the one here described. This was fitted with a real black-glass mirror and means were devised for obviating the reversal of the sky, but there was no opportunity to try it out before the closing of that Observatory.

The plates used for most of the pictures made at Mount Weather were "Standard Orthonon." These were found to give excellent results on white clouds but for clouds lighted up in color at sunrise and sunset "Standard Polychrome" plates were to be preferred. This latter plate was found to be well adapted for lightning pictures, being sensitive to red and yellow.

One night two "Orthonon" plates were exposed in succession on a receding storm. The third and last plate exposed was a "Polychrome," and as the storm was at that time several miles distant the lens was allowed to remain open until the lightning ceased. When developed the two "Orthonon" plates showed nothing, while on the "Polychrome" every flash was seen. This picture is reproduced in figure 7. In the original the contour of Bull Run Mountains can be seen, behind which the lightning was descending. This range of mountains is 20 miles distant from Mount Weather.

A rubber stamp was used for imprinting data slips similar to the following:

	Name	
No.		
Date	Time	
Direction	Angle	Filter
Lens	Stop	Exp.
Plate	Dev.	Formula
Print	Time	Dist.

As the plate holders were loaded in the dark room one of these slips of paper was marked with the number corresponding to that on the plate holder and the name of the plate therein. One slip was used for each plate.

When the loaded plate holders were placed in the receptacle at the back of the camera these slips were inserted under a spring clip just above them.

After exposing a plate in the camera its slip was filled out with the name of the cloud, date, time of day, direction by compass, angle in degrees from the horizon, as shown by the inclinometer, ray filter used, lens, stop and length of exposure.

These data slips were taken to the dark room with the plate holders, and after development the plates were filed away in negative envelopes as preservers, imprinted by the same rubber stamp with the above data filled in, together with the name of the developer and its formula number.

The envelope was marked with the serial number of the negative, which number was also scratched in the upper corner of the film to prevent its being misplaced in printing.

When prints were made, the paper used, time of printing, and distance from the light were added under their proper heading. This data adds very materially to the value of one's negatives.

As to a developer, every one has his favorite formula. some workers claim that the long feathery lines of the cirrus are only properly brought out with hydrochinone, but if the exposure is correct there is little choice in developing agents.

Giving the right exposure means having a fast lens, and a filter only sufficiently colored to cut out the blue and adding as little as possible to the time. This is particularly necessary on a fast-moving cloud having fine detail on its edges.

Since this cloud work was done at Mount Weather the Bureau of Standards has conducted a series of experiments on plates and filters for this class of work. They state that the best plate for sensitivity in red is the "Ilford Panchromatic" and a good plate for the same is the "Cramer Spectrum Process."

For a commercial ray filter they recommend "Wratten's Minus Blue," or "Kramer Isochromatic, medium-rapid, double.coated minus blue."

In preparing this article it has been the aim to deal more with the how and why of cloud photography than the treatment of the subject from a meteorological standpoint.

The apparatus described was made up of cheap material which could be acquired in an isolated location, yet it worked very successfully. It is not expected that the directions and suggestions here given will be followed implicitly, but that each worker will, as in this case, adapt means to ends.

In this work there is a psychological moment in which to "get your cloud" (compare figs. 8 and 9), but, unfortunately, the game has to be played under the rules of "catch-as-catch-can." It therefore behooves the worker to be always ready. The cloud camera at Mount Weather was located just under the rafters beside the stairway to the roof, with plate holders loaded, yet many a hurried trip was made from the main floor to the roof only to find that the opportunity for a successful picture had passed.

Aside from its meteorological value the work has all the fascination of hunting big game without its attendant danger, and there is no "closed season." You will learn what to hunt for in April; what in October.

A cumulus cloud is easy to get, but how many really good photos have you seen of change cirrus, mammato-cumulus, or scarf cloud? These are a few samples of the big game which it pays to go after, and to be able to exhibit a good specimen picture of such a cloud will be found as satisfactory as the showing of a pair of antlers.

PHOTOGRAPHY OF CLOUDS.

By C. J. P. CAVE.

[Excerpt from "The forms of clouds," Quart. Jour. Roy. Meteorological Soc., 1917, 43: 61-82. (From pp. 80-81.)]

The photography of clouds affords a subject of much interest. There is some difficulty in getting the exposure right until the photographer is somewhat experienced. As a general rule very short exposures are necessary. Clayden says that he has found very slow plates the best for the purpose, with no color screen. My own experience is that panchromatic plates and color screens give the most satisfactory results. I use a moderately deep yellow screen for all clouds except cirrus, but for cirrus I think a red screen is the best. When using color screens the exposure must be lengthened more in proportion than if one were taking ordinary subjects such as landscapes.

Stereoscopic photographs of clouds may be taken by having two cameras at some distance apart and taking two photographs simultaneously; the two cameras must be a quarter of a mile or so apart, except for clouds that are very near the observer. There is another way in which such photographs may be taken which I have not seen described before. If a cloud is moving, two photographs may be taken in succession from the same place, the resulting photographs showing a stereoscopic effect. Unless the clouds are moving very slowly it is advisable to take the two photographs as quickly as possible. Those shown (fig. 27 [not reproduced here]) were taken with an interval of abour 20 seconds. The clouds must be taken when they are moving in a direction at right angles to the line from the cloud to the observer. Of course different parts of the cloud may be moving with different velocities, and in this case the stereoscopic effect will not be true. In figure 27 [not reproduced here] it will be seen that there are about six different distances to be seen at the left-hand top corner of the picture. In the case of cloud sheets which are moving fast I have generally found that the stereoscopic effect is exaggerated and the sheet looks as though it were very low down. The chief difficulty in this way of taking stereographic photographs of clouds is that the form of the clouds changes even in the short interval between the two exposures.

CLOUD PHOTOGRAPHY.

[Reprinted from Scientific American Supplement, New York, Mar. 3, 1918, 163.]

A method recommended for cloud photography consists in the use of a device made up of a mirror of black glass mounted in a special frame and placed in front of the camera lens, so that the photograph will be taken from the mirror and the brilliant light of the clouds will be thus diminished. However, it is difficult to procure such black glass mirrors in ordinary trade, but it is comparatively easy to make a suitable mirror. This is done by taking a piece of clear glass such as is used for making mirrors and roughening one side after the manner of ground glass. On this latter side is applied a coating of black varnish made of Judaea bitumen. This avoids the double reflection which would be produced by using ordinary glass and simply putting on a coat of varnish. The time of exposure is, of course, much longer than in the usual way and may be from one-fifth to one twenty-fifth second when well stopped down. It is claimed that this arrangement allows of obtaining details of clouds which can not be had otherwise by the most improved plates and screens.

CUMULUS CLOUD OVER FIRE.

By OTTO NEUMER.

On September 13, about 4.30 p. m. (seventy-fifth meridian time) I was approaching New York City on a train, and, when between Rahway and Elizabeth, N. J., I observed a heavy black cloud in the direction of New York City. The cloud, I discovered later, was a smoke cloud and was hanging over New York Bay. The fire, which caused the great volume of smoke was in the Borough of Queens, just across the East River from Manhattan. The smoke rose almost vertically until it reached a height of about 1,500 meters, then passed off apparently horizontally to the southeast or south under the influence of a moderate or strong wind at that altitude. This wall of dense smoke extended from its origin in Queens as far as one could see toward the south. Directly in line with what seemed to be New York Bay, the smoke cloud was capped by a small puff of white—a small cumulus cloud. The formation seemed to be 400 or 500 meters long and very shallow. I do not think it lasted long, although I was unable to observe it longer than 10 minutes. There were no other clouds visible at the time.

NOTE.—The surface meteorological conditions at the New York Weather Bureau, at 4.30 were as follows: Temperature 21.7° C.; wind NW., 8.9 meters per second; dewpoint (noon) 7.8° C. Substituting these values in the equation for the height of the base of the cloud,[1] we obtain 1,800 meters, which is quite in accord with non-instrumental observations of Mr. Neumer.—*C. L. M.*

METEOROLOGICAL ASPECTS OF A MUNITION-DUMP EXPLOSION AT KIEV, JUNE 6, 1918.

By Dr. FRIEDRICH NOWOTNY.

[Abstracted from *Meteorologische Zeitschrift*, Mar.-Apr., 1920, pp. 67-73.]

At 10 a. m., June 6, 1918, about 11,000 tons of explosives stored at the munition depot of Zwierniec, a suburb of Kiev, were exploded from a fire which started in a bomb factory. The magnitude of the disaster may be surmised from the fact that at least 200 were killed and over 1,000 injured. The town of Zwierniec was almost completely destroyed through the agency of fire and air pressure. Other towns 6 and 8 kilometers distant were badly shaken and much property was destroyed. The meteorological conditions on the day in question were carefully observed both at the Austro-Hungarian meteorological station in that vicinity and by the author.

At the time of the catastrophe the sky was about seven-tenths covered with cumuli, whose bases were at about 1,300 meters elevation. The explosions sent dense masses of black smoke into the air, probably reaching an elevation of 3,600 meters, although the great mass of smoke reached the height of 3,200 meters. The clouds

[1] See "Heights of cumulus clouds forming over fires." MONTHLY WEATHER REVIEW, March, 1919, 147-149.