In the midst of the valley is the town of Vañales, red-roofed, white-pillared, and incredibly clean and prosperous. It has its church and its barren square; its wide streets cross at right angles. Beyond the town the road leads on through La Abra (the gap) a narrow gateway opening into a smaller vale similar in its characteristics, and so on to the sea, a wonderland of quaint and queer arrangement of man and nature. This valley is typical of the fair land that the United States has brought into peace, serenity, prosperity.

PHOTOGRAPHING ANIMALS UNDER WATER.*

BY PROF. JACOB REIGHARD, UNIVERSITY OF MICHIGAN.

Attempts to photograph submerged objects with a camera placed in air can result in only partial success, and this but rarely. Failure is due to the fact that the photograph is made through the surface of contact of two media, water and air, of very different refractive powers. If this surface is not perfectly smooth the light from an object beneath it is, upon emergence, refracted unequally at different parts of the surface and can not form a clear image on the ground glass. Whether the water is smooth or rough its surface reflects a part of the light which strikes it, and thus acts as a mirror. This reflected light makes it impossible, except under unusual conditions, to obtain photographs of submerged objects. To obtain such photographs the surface of the water must be smooth and light reflected from it must not enter the camera.

If the camera with which submerged objects are to be photographed is to remain above the surface of the water means must be found (1) greatly to reduce the amount of reflected light entering the camera from the surface of the water, and (2) to render the surface of the water smooth. We may consider first the case in which the surface of the water is smooth, so that it is necessary merely to minimize surface reflection.

The method to be described is best adapted to objects in water not more than two or three feet deep, and the best results are obtained when the water is less than a foot in depth and when the camera is one that can be focused. Since the objects to be photographed are usually in motion, and since the surface of the water may at any time be roughened by a puff of wind, it is best to use a lens of a speed not less than *f* 8. The operator should first select the point from which the picture is to be taken. He should, of course, have the sun at his back or to one side. If possible he should stand on the bank or on some fixed support which extends above the surface of the water.

If the operator is unable to find a fixed emergent support he may make the exposure while standing in the water. The camera may then be held in the hand or may be supported on a tripod which rests on the bottom. As the legs of the tripod are likely to sink into the bottom they should be extended to their full length. Where the bottom is firm an elevated position may be obtained for the camera by using a tripod with legs some 10 feet long, such as dealers sell for use in making pictures of large groups. In such tripods one leg forms a ladder by which the camera may be reached.†

When the operator has placed his camera and roughly adjusted it, he should set up a screen to cut off the light reflected from the surface of the water into the camera. Any piece of dark fabric, a blanket, shawl, or for small objects even a coat, may be used.

The screen is mirrored in the surface of the water. The object to be photographed should fall within the limits of this mirrored image as seen from the camera. If it does not, the screen or the camera must be shifted until it does. The operator will see also the shadow of the screen. This should *not* fall on the object to be photographed. The screen should, if possible, be adjusted by slanting it or by moving one of the poles so that the sun strikes it nearly edgewise, but yet does not strike that face of it which is toward the camera. If this adjustment is properly made the shadow of the screen is a very narrow band, which lies beneath the screen and a little nearer the camera than its lower edge. The full sunlight then falls on the object while the rays from distant objects which would otherwise be reflected into the camera from the surface of the water are cut off. If the sunlight is permitted to fall on that face of the screen which is toward the camera, it is reflected from the screen to the surface of the water and thence into the camera. A picture taken under these conditions may show, besides the object under the water, also the screen itself, although this image of the screen is usually so faint that it does not interfere with the use of the picture for scientific purposes.

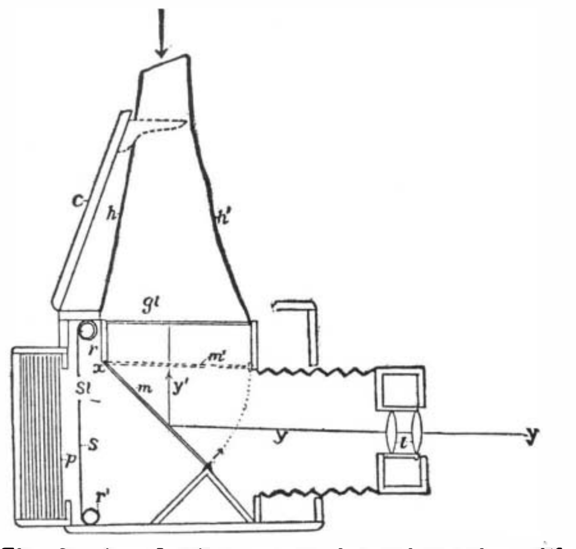

Fig. 8.—A reflecting camera shown in section with magazine plate holder attached.

gl, Ground glass; *h*, *h'*, hood; *l*, lens; *m*, mirror in position during focusing; *m'*, mirror, showing position during exposure; *p*, sensitive plate; *r* and *r'*, rollers of focal plane shutter; *s*, the shutter; *sl*, slot in shutter; *x*, hinge on which mirror turns; *y*, *y*, *y'*, ray of light traversing the lens and reflected from the mirror to the ground glass.

When the screen has been properly set the operator has merely to adjust the camera and make the exposure in the customary way. If the subjects are fish they will usually have been frightened away, but if the fish are engaged in nest building or in some other occupation that attracts them to a particular spot, they will, in most cases, return after a time varying from five minutes to an hour. The operator has merely to remain quiet until this happens. The photographer may focus his camera on the spot to which the fish is likely to return and then withdraw and operate the camera from a distance by pulling a string or pressing a bulb when the fish returns. The method is of most use in securing photographs of the nests and habitats of fish in shallow water, yet the writer has succeeded by means of it in making some satisfactory photographs of fish on the nest.

If the surface of the water is not smooth it may be made so by a water glass, which may be constructed as follows: A square frame is made of heavy galvanized iron, and measures 3½ inches deep and 12 inches on each side within. One of its edges (the top) is turned outward three-fourths of an inch and then downward one-half inch to form a lip. This stiffens the frame and tends to prevent water from slopping into it. The lower edge of the frame is turned outward about half an inch to form a flat surface, against which the glass, 13 inches square, is bedded in aquarium cement. After the glass is in position four trough-shaped pieces are soldered to the sides of the frame and to one another in the manner shown in the figure. The free edges of these pieces project inward beneath the lower surface of the glass and support it. Before the pieces are soldered into place cement is placed between them and the lower face of the glass. The whole border of the glass is thus bedded in cement on both surfaces and at the edge. To protect the glass when not in use a flat cover is provided, which fits against its lower face. Such a water glass may be floated over the object to be photographed and a screen set up independently of it, or the screen may be attached to the glass itself. For the latter purpose a piece of half-inch band iron may be bent to form the three sides of a rectangle, 8 by 12 inches, and this may be riveted as a bail (Fig. 7) to the inside of the frame, about 8 inches from one side. The bail should turn on the rivets so that it may be depressed into the frame when not in use. A screen may be formed by raising the bail and tying a piece of black cloth from it to the opposite side of the frame. In shallow, running water it is desirable to support the water glass from the bottom in order that it may not sink so much as to displace or distort the object to be photographed. It may be supported on four iron rods which run through metal sleeves soldered to the four corners of the frame. The rods may be fixed in any position in the sleeves by means of set screws, and may project upward far enough to support the upper edge of the screen.

The writer has used water glasses of this type varying in size from 1 to 3 feet square. The size most suitable for field photography is 2 feet square, since this may be transported by hand.

The method described is suited only to shallow water, where the camera may be supported from a firm substratum. In deeper water the unsteadiness of the boat would interfere with the manipulation of a water glass or a screen. It might be possible, however, to construct a boat of which the water glass and the screen should form constituent parts. The method described permits only of views at angles of from about 48 deg. to 90 deg. to the water's surface. Since it is not practicable to place the camera far above the water at these angles or to use screens of very large size, the pictures that may be taken are of near objects and the field covered by them is of limited extent. If a water glass is used, the camera must be near it and the field is limited by its frame. The method is, however, the only one known to the writer for certain kinds of work.

A camera for submerged use made after the ordinary type must be securely closed before submerging it in order to protect the lens and the plates from the action of the water. While the camera is under water it is not possible to remove the plates or plate holder in order to substitute a ground glass for them. In subaquatic photography the objects to be photographed are all near, and if instantaneous work is to be done the lens must be very rapid. It is therefore important to be able to focus accurately on the ground glass under water, and this might be accomplished by using two identical cameras (twin camera) united so as to form one instrument. One of these contains the plates and has a lens provided with a shutter. The other camera carries the ground glass. The same focusing mechanism operates both cameras, so that when a sharp image is formed on the ground glass of the one an identical image strikes the sensitive plate in the other when the shutter is operated. One of the cameras serves merely as a focusing finder of full size. A camera of this type properly constructed of metal could undoubtedly be used successfully under water, though it has the disadvantage of being unnecessarily cumbersome and expensive.

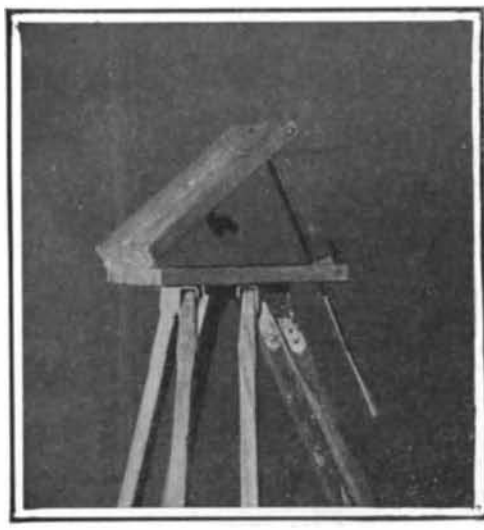

Fig. 5.—Tripod top by means of which the camera can be inclined at any angle.

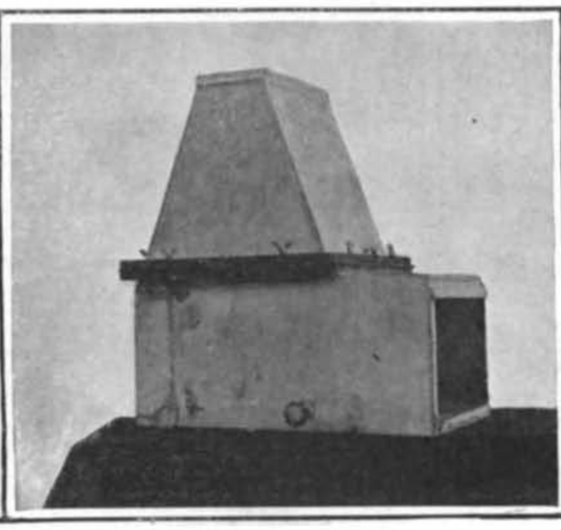

Fig. 6.—Watertight box to contain submerged camera.

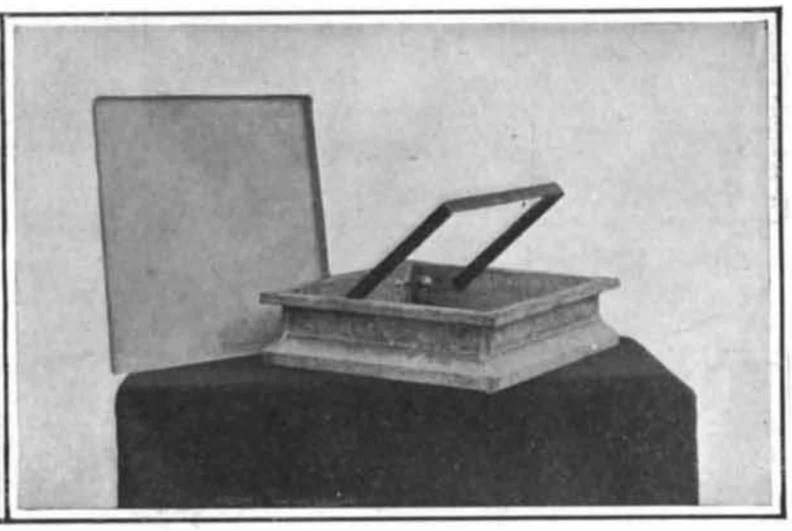

Fig. 7.—Reighard water glass for observation or photography of objects under water.

PHOTOGRAPHING ANIMALS UNDER WATER.

* Abstracted from "The Photography of Aquatic Animals in Their Natural Environment," a bulletin published by the Bureau of Fisheries. The complete bulletin will appear shortly in the SCIENTIFIC AMERICAN SUPPLEMENT.

† A detailed description of the construction of the tripod top will be found in the original.

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Fig. 1.—Photograph of subaqueous life taken with submerged camera.

Fig. 2.—Using the camera when inclosed in the watertight box.

Fig. 3.—Two-foot water glass for studying lampreys.

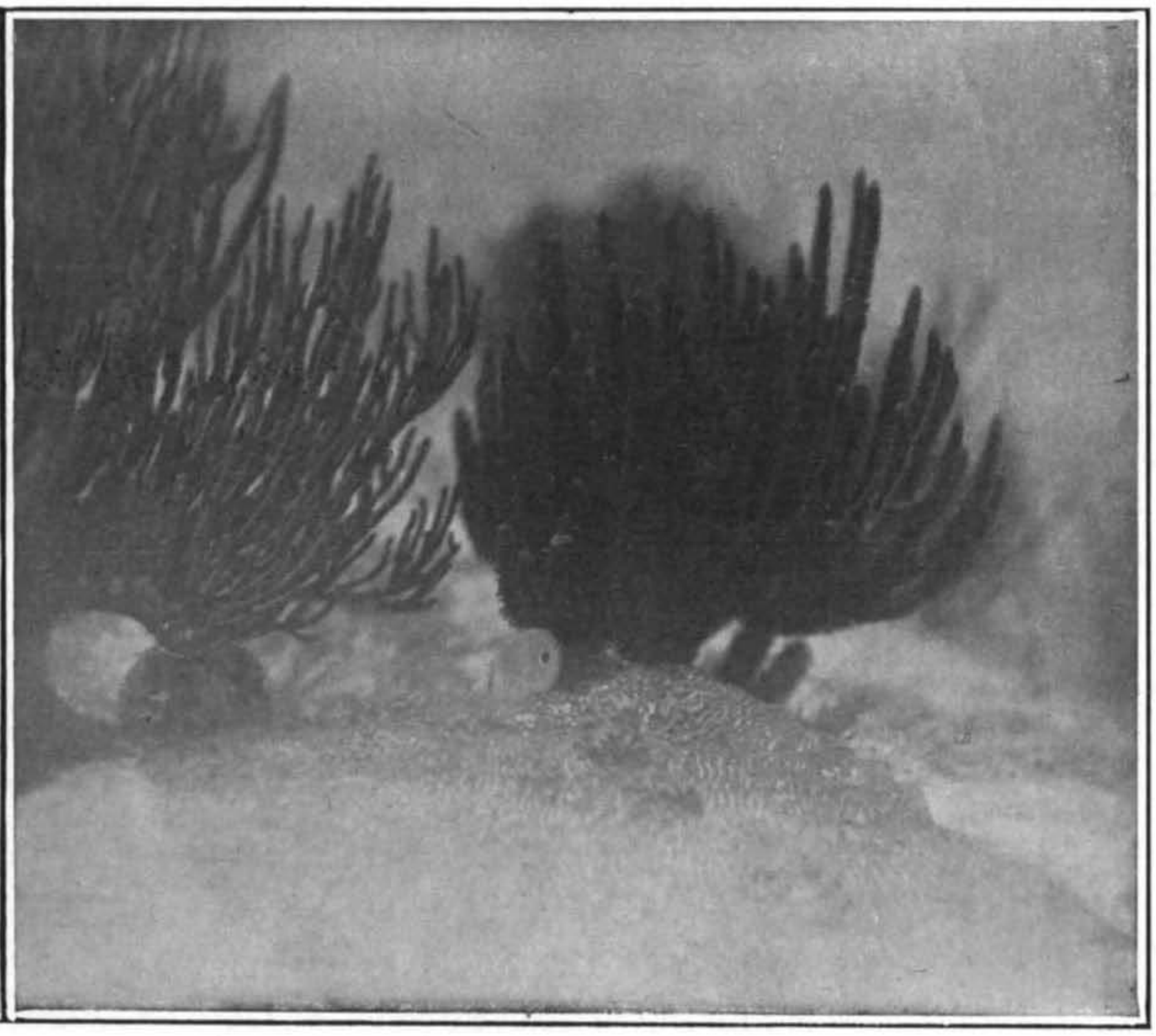


Fig. 4.—Photograph of sea bottom made with a submerged reflecting camera.

PHOTOGRAPHING ANIMALS UNDER WATER.—[See page 138.]

All of the advantages of the twin camera are to be had by using a reflecting camera, which is at the same time both lighter and less expensive. The principle of the reflecting camera is shown in the diagram (Fig. 8), which represents diagrammatically such a camera in longitudinal section. The operator, holding the camera in front of him, looks in the direction indicated by the upper arrow, at the ground glass through the hood, which takes the place of a focusing cloth. The interior of the camera contains a mirror (*m*), which extends from beneath the back edge of the ground glass downward and forward at an angle of 45 deg. The mirror is hinged at *x* to the top of the camera. When it is in the position shown at *m* in the figure the space between the back of the mirror and the back of the camera is quite dark. Light entering through the lens is reflected by the mirror and strikes the ground glass, as shown by the line *y y y'*. The image as seen on the ground glass by the operator looking down through the hood is, on account of the action of the mirror, an erect image, not an inverted image such as one sees on the ground glass in the back of an ordinary camera. It is also an image of the full size permitted by the plate and the lens, not a reduced image such as one sees in a finder. The shutter (*s*) is a focal plane shutter situated at the back of the camera just in front of the plate (*p*). Such a shutter is essentially a roller curtain of black cloth with a slot (*sl*) across it at one point. The width of the slot may be regulated. The shutter is wound upon an upper roller (*r*) until the slot is upon the roller. The exposure is made by causing the curtain to unwind from the upper roller (*r*) and wind upon the lower roller (*r'*) so that the slot passes with great rapidity across the face of the plate.

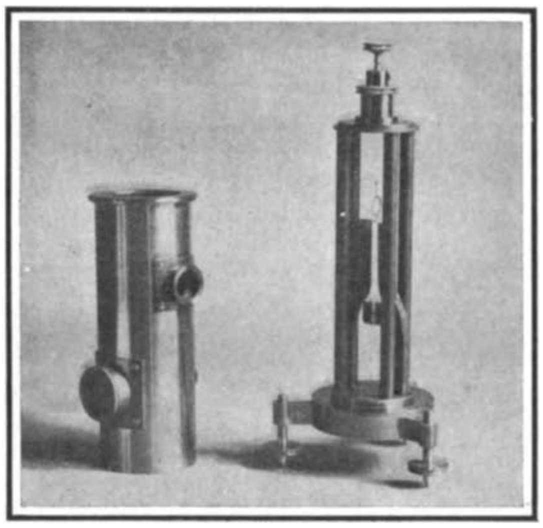
The length of the exposure depends on the width of the slot and the rate at which it moves. The rate may be varied by changing the tension of the spring which actuates the lower roller. The operator holds the camera in front of him with both hands while he looks down at the ground glass through the opening in the hood. With one hand he focuses. When the object appears in sharp focus and in the desired position on the ground glass, he presses a button with the other hand. This causes the mirror to swing on its hinge to the position shown by the dotted outline *m'* beneath the ground glass. In this position the mirror excludes light which might otherwise enter the camera through the ground glass. At the same time the change in position of the mirror permits the light, which was before reflected to the ground glass, to fall upon the plate. The adjustment is such that an image which is in sharp focus on the ground glass will be in sharp focus on the plate when the mirror changes position. The image does not actually strike the plate so long as the shutter is wound upon either roller. Before the instrument is to be used the shutter is wound on the upper roller. When the mirror in swinging upward reaches the position *m'* the shutter is released from the upper roller and taken up on the lower roller. As the slot of the shutter curtain passes across the plate from above downward, the image falls through the slot onto the plate in successive strips corresponding to the width of the slot.

A 5x7 camera of the type just described, with a magazine holder for twelve plates, was used by the writer to obtain submarine photographs at Tortugas, Fla., during the season of 1907.

The apparatus was carried to a boat or, if it was to be operated near shore, to the shore. In working with the help of a boat the operator wades on or near the coral reef with his head and shoulders above the water. The boat, with an attendant on board, is anchored near. The operator, with the help of a water glass, now seeks a favorable place for operations. As he moves about the reef, the fish at first seek shelter in the dark recesses of the coral rock, but if he selects a favorable place and remains quiet they soon reappear. They are at first wary, but soon grow bolder and after half an hour or so pay but little attention to him. There is a great difference in wariness among different species of fish. At first only one or two species appear, demoiselles and slippery-dicks usually, then the number of species gradually increases until the shyest butterfly-fish and parrots come within 6 or 8 feet of the operator. He then has the camera passed to him from the boat. It floats with the upper part of the hood protruding and may be easily turned toward any point on the horizon or even tilted so as to be pointed at a considerable angle upward or downward. The operator has now merely to direct the camera at the fish, while he focuses with his right hand. He must often wait some time before the fish come to the point selected or assume the desired attitude. Often they may be enticed by throwing in a bait of crushed sea urchins or pieces of crawfish. They are in constant motion, so that he must as constantly focus. He often misses a long-awaited opportunity because the fish moves on or takes a wrong attitude before he has had time to focus sharply; but when the favorable time comes he presses the release stem and the exposure is made.

A NEW DIRECT-READING PHOTOMETER.

Lamps of all kinds transform heat into light, the apparent intensity of which varies with the character of the incandescent body which emits it, and is also a yet unknown function of the photo-chemical transformations which are produced in the retina. In our ignorance of these transformations we can only measure the luminous power of a lamp in terms of standard candles or other arbitrary units. Numerous attempts have been made to effect these photometric comparisons without the aid of the eye, but it has hitherto been found impossible to construct an apparatus having the same comparative sensitiveness to the various regions of the spectrum that is possessed by the retina. This fact explains the failure of methods based, for example, on photography and on the effect of light on the electrical resistance of selenium.

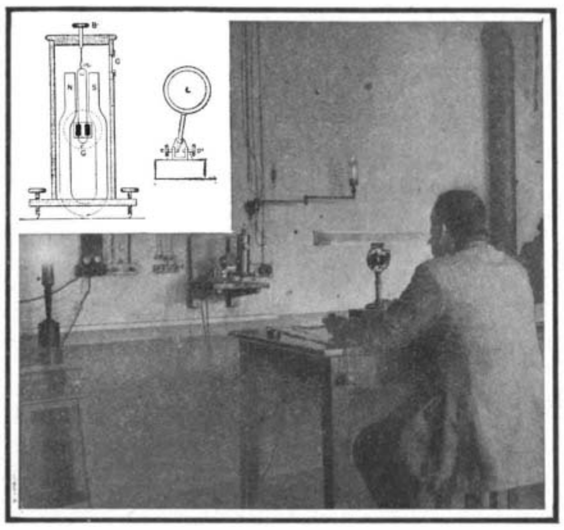


Féry photometer, with copper cylinder removed.

No better result has been obtained by measuring the total energy of the radiation emitted by sources of light, for the maximum of this energy usually falls in a part of the spectrum to which the eye is absolutely insensitive. Prof. Charles Féry, of the Paris School of Applied Physics and Chemistry, has demonstrated that, in order to obtain correct results by this method, the measurement should be made on light which contains the various elementary radiations in quantities proportional to their effects on the retina.

Upon this principle Féry, after overcoming many difficulties, has constructed a novel direct-reading photometer. The selection of the radiations, in the proper proportion, can be effected by various means. For example, the height or width of the spectrum of the light under examination might be limited by the interposition of a screen with its upper or lower edge, or both, in the form of the curve of retinal sensitiveness, as a function of wave-length. It appears simpler, however, to employ an absorbing cell. After trying various substances, Féry chose a solution of copper sulphate as the absorbent liquid and, by modifying the radiomicrometer of C. V. Boys, he obtained an instrument with which exceedingly small quantities of heat can be measured.

The essential part of the new Féry photometer is a combined galvanometer coil and thermo-electric couple, composed of a coil of copper wire with its ends connected, by means of silver plates, with the ends of a loop of phosphor bronze. The compound coil is suspended between the poles of a magnet by a quartz filament attached to the strip of bronze. The silver plates, which are ⅛ inch thick, are brought close together and inclosed in a short thick-walled copper tube, to insure equality of temperature. The plates are polished on one side and coated with platinum black on the other. The beam of light is received on the blackened surface, the adjustment being facilitated by a fringe of paper surrounding the plate. A small concave mirror carried by the bipolar suspension throws a spot of light on a scale at a distance of 2 meters (6½ feet). A deviation of 50 centimeters (20 inches) is produced by the radiation of a candle distant 1 meter (39 inches) from the blackened silver plates, the radiation being allowed to fall on only one of the plates. As this sensitiveness is greatly diminished by the interposition of the absorbing lens, the image of the source of light is projected on the plate by a convex lens, which can very conveniently be moved aside, and brought to cover each plate in succession by compressing two India rubber bulbs, the movement being limited by adjustable stops. By repeating this series of operations at regular intervals, errors due to the gradual displacement of the zero point are eliminated. With the lens and the absorbing cell, a Carcel lamp at a distance of 1 meter (39 inches) produces a deviation of 60 millimeters (2.4 inches). In measuring very powerful sources of light, the sensitiveness must be diminished by interposing diaphragms of known area.



Measuring the candle-power of a lamp with the Féry photometer.

NEW DIRECT-READING PHOTOMETER.

With this apparatus, which is very easily managed, Prof. Féry has already obtained interesting results, some of which confirm the measurements made by the usual methods of photometry. He finds that the optical efficiency of the Bengel burner is only 0.091, while that of the Auer burner is 0.401. He intends to extend his researches to arc and mercury vapor lamps.

The Current Supplement.

The new system of reinforced concrete is described and illustrated in the opening article of the current SUPPLEMENT, No. 1728. The theory that electricity or electrical charge is a kind of matter composed of discrete particles or electrons has steadily gained ground during the last decade. A lucid and popular explanation of the theory is given by Prof. L. Graetz. The possibility of a future fuel supply in the growth of vegetation from the soil is set forth in an article entitled "Alcohol as a Fuel." The recent collision of the "Republic" and "Florida" lends timely interest to the splendid article by Gen. E. E. Goulaeff on unsinkable and uncapsizable ships. About twelve miles from Paris, the French Institute for the Encouragement of Aviation has established a trial ground and race course for aeroplanes and other airships. This is admirably pictured in the current SUPPLEMENT. A new development in the art of indirect color photography is described by Frederick Limmer, and sets forth the details of the Szczepanik process. The strength of wooden poles for overhead power transmission is discussed by our London correspondent. Paraphrasing the remark that has been made about books, it may be said that of the making of many alloys there is no end. Some of our legion alloys are described by Dr. John A. Mathews. The coming return of Halley's comet lends peculiar interest to Irene E. Toye Warner's article "Ancient and Popular Ideas of Comets." The usual electrical, engineering, and trade notes will be found in their accustomed places in the SUPPLEMENT.

Official Meteorological Summary, New York, N. Y., January, 1909.

Atmospheric pressure: Highest, 30.66; lowest, 29.17; mean, 30.14. Temperature: Highest, 57; date, 5th; lowest, 7; date, 19th; mean of warmest day, 50; date, 5th; coolest day, 17; date, 19th; mean of maximum for the month, 39.7; mean of minimum, 26.7; absolute mean, 33.2; normal, 30.6; excess compared with mean of 39 years, 2.6. Warmest mean temperature of January, 40, in 1880, 1890. Coldest mean, 23, in 1893. Absolute maximum and minimum for this month for 39 years, 67 and —6. Precipitation: 3.33; greatest in 24 hours, 1.23; date, 5th; averages of this month for 39 years, 3.76. Deficiency, 0.43. Greatest January precipitation, 6.15, in 1882; least, 1.15, in 1871. Wind: Prevailing direction, northwest; total movement, 10,241 miles; average hourly velocity, 13.8 miles; maximum velocity, 57 miles per hour. Weather: Clear days, 6; partly cloudy, 10; cloudy, 15; on which 0.01 inch or more of precipitation occurred, 11. Snowfall, 9.5. Sleet, 14th, 17th. Fog (dense), 5th, 6th, 22d, 23d, 24th, 25th.

A $10,000 Aeronautic Prize.

The Aero Club of America has just announced the offering of a cash prize of $10,000 by the New York World for a flight by an aeroplane or airship up the Hudson River from New York to Albany. This flight will be made next October at the time of the Hudson-Fulton centennial celebration. The distance is about 140 miles, and when the historic "Clermont" made the journey one hundred years ago, it took 35 hours to accomplish it. A modern aeroplane or airship should do it in about one-tenth of this time.

The exact conditions of the flight and the rules under which it is to be conducted will be announced in the near future. The contest will be in the form of a race, and it is probable that a number of stops will be allowed *en route* for fuel replenishment.