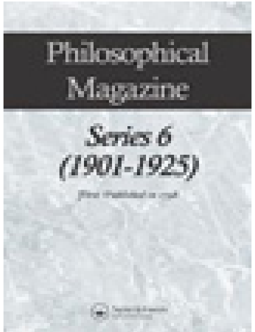


Taylor & Francis
Taylor & Francis Group

Philosophical Magazine Series 6

ISSN: 1941-5982 (Print) 1941-5990 (Online) Journal homepage: http://www.tandfonline.com/loi/tphm17

XXIII. Fish-eye views, and vision under water

R.W. Wood

To cite this article: R.W. Wood (1906) XXIII. Fish-eye views, and vision under water , Philosophical Magazine Series 6, 12:68, 159-162, DOI: 10.1080/14786440609463529

To link to this article: http://dx.doi.org/10.1080/14786440609463529

Published online: 16 Apr 2009.

XXIII. *Fish-Eye Views, and Vision under Water.* *By* R. W. Wood, *Professor of Experimental Physics, Johns Hopkins University**.

[Plate III.]

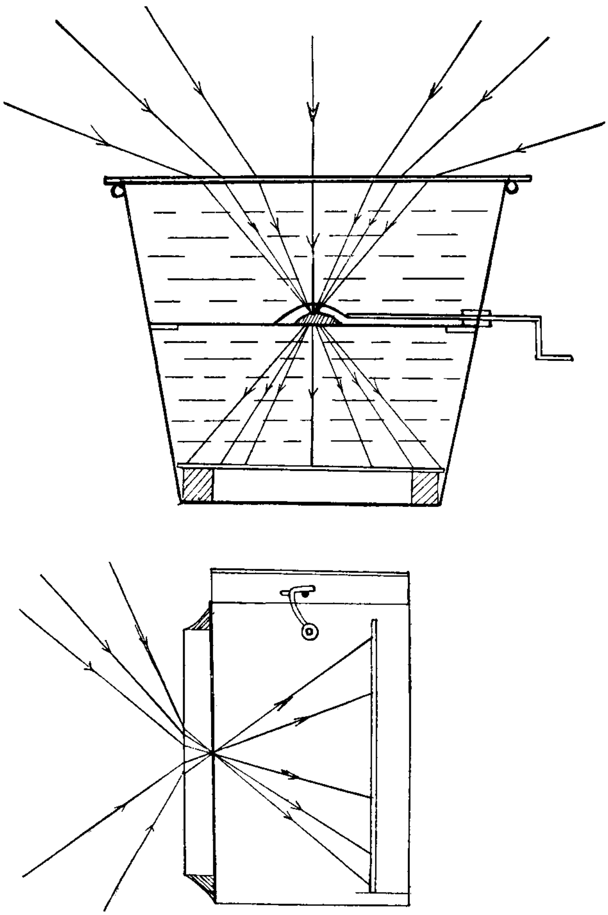
IN discussing the peculiar type of refraction which occurs when light from the sky enters the surface of still water, it seems of interest to ascertain how the external world appears to the fish. As is well known, a submerged eye directed towards the surface of still water sees the sky compressed into a comparatively small circle of light, the centre of which is always immediately above the observer, the appearance being as if the pond were covered with an opaque roof provided with a circular aperture or window. If our eyes were adapted to distinct vision under water, it is clear that the objects surrounding the pond, such as trees, horses, fishermen, &c., would appear round the edge of this circle of light. Objects not much elevated above the plane of the water would be seen somewhat compressed and distorted, but the circular picture would contain everything embraced within an angle of 180° in every direction, *i. e.* a complete hemisphere. Our eyes behave so abominably under water, however, that we can see nothing of this curious picture; the focus being so poor that it is difficult even to distinguish between a piece of blank paper and paper with black letters an inch high and a quarter of an inch wide, the letters being almost invisible. A lens of half an inch focal length, placed in front of the eye, helps matters, but even with this, vision is far from distinct. A great many years ago I attempted to get an idea of how this circular picture appeared to the fish, by constructing a diving-bell out of an old butter firkin, weighted with lead, and provided with a plate-glass window, forgetting that the refraction of the rays from water to air again would banish the illusion of the round window.

It occurred to me last autumn during a lecture, that an excellent notion of how we appear to the fishes could be obtained by immersing a camera in water, and photographing the circle of light, for it is easy enough to arrange a lens and plate so as to obtain a sharp image when both are immersed in water. The apparatus was constructed out of a lard pail, a short focus lens, provided with a very small diaphragm, being cemented over a hole perforated in a metal disk which rested on a rim soldered around the inside of the pail. The plate was placed on the bottom of the pail, and the whole filled with clean water in a dark room. The lens

* Communicated by the Author.

was covered with a metal cap operated by a handle on the outside of the pail. The apparatus was placed on the ground, and the surface of the water covered with a sheet of glass to prevent ripples, the pail being so full that the glass was in contact with the water. This arrangement obviated the necessity of immersing the affair in a pond, since the function of the latter was performed by the water in the pail above the lens. A diagram of the arrangement is shown in fig. 1,

Fig. 1.



together with the paths of the incident and refracted rays. A number of extremely interesting pictures were obtained with the device, which proved to be the equivalent of a lens having a working angle of 180°. One of these is reproduced in Pl. III. fig. 2, and represents the appearance of a circle of men standing around the edge of a small pond, to a fish stationed at the centre. The appearance of the buildings, telegraph-poles, and small trees is also shown.

The water camera was then modified so that it could be pointed in a horizontal direction. The lens was dispensed with and a pin-hole substituted, since it was found that as good, if not better, definition could be obtained in this way. The hole was made in the opaque film on the back of a piece of modern mirror-glass, which was cemented, glass side out, over a hole in the end of a water-tight box (fig. 1, lower diagram). The plate was inserted in a dark room, and the whole filled full of water, after which the cover was closed, and a little additional water added through a small hole to displace the enclosed air. The hole was then closed with a stopper and the exposure made as desired. It will be seen that the views obtained with the apparatus in the horizontal position, represent things as seen by a fish looking out through the glass sides of an aquarium. The cone of light entering the fish's eye has an aperture of about 96°, but the rays within it came originally from a cone of 180°. Very curious pictures were obtained with this apparatus. It will photograph all three sides and the complete ceiling and floor of a room, or when placed at a point where two streets cross at a right angle, will give a view looking down any three streets, the view including the ground quite up to the base of the tripod, and the sky from the horizon to the zenith. Suspended from a balloon it would photograph the entire surface of the earth out to the horizon in all directions.

Some very curious pictures were obtained with the apparatus in this form. A straight row of nine men, standing side by side in a garden path, was photographed with the camera standing not more than 18 inches in front of the central figure. The straight path appears as if bent into a semicircle, and the end figures appear distorted, as if seen by reflexion in a cylindrical mirror. This view (fig. 3, Pl. III.) gives us a good idea of how the visitors at an aquarium appear to the fishes. Fig. 4 is a view taken at the intersection of two narrow streets, and shows Monument Street, looking west, with the dome of the physical laboratory, and Eutaw Street looking north and south; the foreground is recorded up to the base of the camera's tripod, and the sky to the zenith, while an overhead wire appears bent into an arc.

A kite or balloon picture being out of the question, on account of the long exposure required, the camera was carried to the top of the monument located at the centre of Mount Vernon Place, lashed to the underside of a twelve-foot piece of timber, and run out over the edge of the parapet, which surrounds the top of the cylindrical shaft. The view obtained in this way is shown in fig. 5, a portion of the city being of course hidden by the monument.

An improved form of fish-eye camera was subsequently constructed. The box was made of sheet-brass, and measured $4 \times 5 \times 2$ inches (inside measurement). The plate was inserted through a slot provided with a hinged metal cover and rubber washer, and the optical part made by cementing a piece of tinfoil, perforated with a needle-hole, between two pieces of plate-glass, with Canada balsam. The plates were then cemented over a circular hole 2 inches in diameter, cut in the top of the metal box. This arrangement was so compact that it could be carried in the coat-pocket, and was absolutely water-tight. It seems quite possible that the peculiar type of refraction described in the present paper, which makes a working angle of 180° possible, may be made use of in certain cases. Since the device will photograph the entire sky, a sunshine recorder could be made on this principle, which would require no adjustment for latitude or month. While the views used for the illustration of this paper savour somewhat of the "freak" pictures of the magazines, it is believed that the fact that they illustrate how one half of the world appears to "the other half" is sufficient excuse for their publication.

Baltimore, June 1906.

XXIV. *Notices respecting New Books.*

Physical Optics. *By* Robert W. Wood, Professor of Experimental Physics in the Johns Hopkins University. New York: The Macmillan Co. 1905.

IF we have not been so forward with the review of this book as we might have been, it is in part to be ascribed to the merits of the book itself. We have had, midst the pressure of other work, to read a great deal more than the reviewer is wont to read before committing his opinions to paper.

Professor Wood's 'Physical Optics' is at once a teaching book of value, a compendium of practical details for laboratory work, and a brilliant exposition of recent problems of Physical Optics. We

Fig. 2.

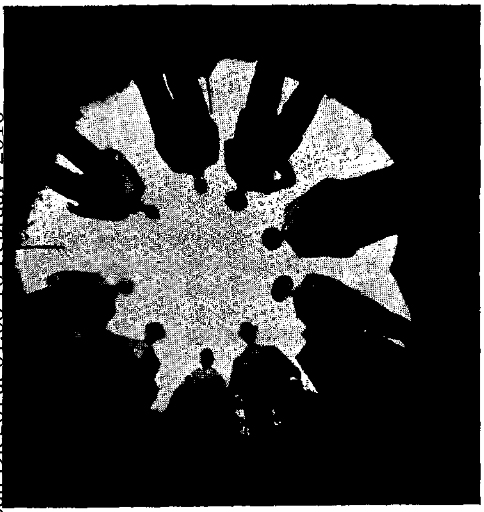


Fig. 3.

Fig. 4.

Fig. 5.