omitted, so that h reduces to the forms already given when viscosity is neglected altogether, F being again a function of a single variable, avc/κ or bvc/κ. In any case F is constant for a given fluid, provided v be taken inversely as a or b. RAYLEIGH.

PERISCOPES.

WHILE the periscope of the submarine is developing in the direction of greater optical perfection and elaboration, there has been a return to the simplest and earliest types of periscope for use in land warfare. Some of these trench periscopes recall the polemoscope, described by Helvelius in the seventeenth century for military purposes; this polemoscope in its simplest form consisted of two mirrors with their reflecting surfaces parallel to each other, and

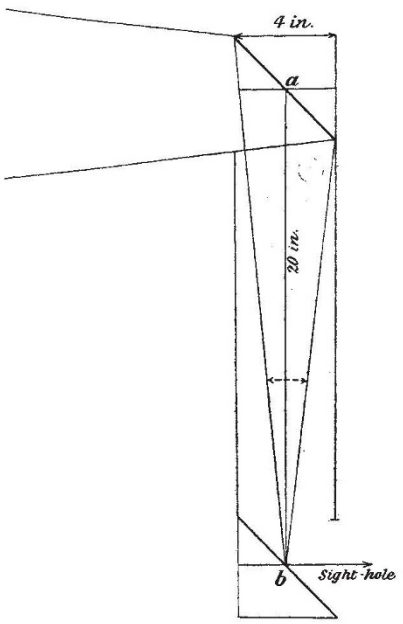

FIG. 1.

inclined at 45° to the direction of the incident light. These mirrors were mounted in a tube and separated a convenient distance (Fig. 1).

For modern trench warfare the convenient separation is about 18 to 24 in., and the mirrors are mounted in tubes, in boxes of square or oblong section, or attached to a long rod. In each case it is necessary that the mirrors should be fixed at the correct angle, and that there should be no doubling or distortion of the image.

The principal requirements of these trench periscopes are portability, lightness, small size and inconspicuous appearance, and large field of view. When there are no lenses the field of view is exactly the same as would be obtained by looking through a tube of the same length and diameter. Thus, with mirrors of 2 in. by 3 in. and a separation of about 22 in., a field of view of 5° would be obtained; and by moving the eye about, this field could be nearly doubled.

By using a box of oblong section the horizontal field of view can be increased without unduly increasing the size of the periscope. As the field of view is somewhat limited in any case, the principal objection to the use of a telescope or binocular, viz., the reduced field, no longer applies, and many periscopes are arranged to be used with a monocular or a binocular telescope.

Most periscopes can be used with a magnification of two or three, *i.e.*, with one tube of an ordinary opera glass; but when higher magnification is to be used the mirrors must be of better quality, both as regards flatness of surfaces and parallelism of the glass. When the mirrors are large enough—8 to 10 centimetres wide—both telescopes of the binocular may be used, but in this case the requirements for the mirrors are even more stringent, as the images formed by the two telescopes will not coincide unless the mirrors are plane. When suitable lenses are placed between the mirrors, the size of the mirrors can be reduced or the field of view increased; it is easy to provide a small magnification of the image or even to arrange for a variable magnification.

In such cases the lenses must be arranged to give an erect image, or mirrors or prisms employed to erect the image. An example of a periscope of this type is shown in Fig. 2, where the mirrors are replaced by reflecting prisms, and the prisms erect the image in much the same way as the prisms of a prism binocular.

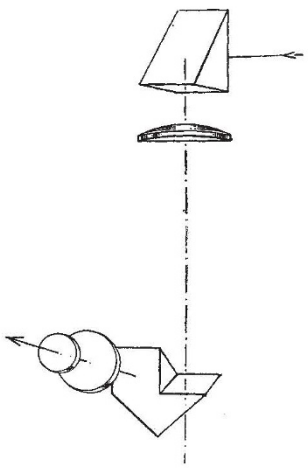

FIG. 2.

This arrangement is very suitable for a large magnification, but for larger fields the prism is unsuitable, unless it be silvered, and it is preferable to erect the image by means of lenses.

When longer tubes are used or larger fields are required, the design should approximate to that used in the submarine periscope.

This optical system has been steadily developed since its first introduction by Sir Howard Grubb in 1901.

The system consists of two telescopes, of which one is reversed, so that the image would be reduced in size, while the other magnifies this image, so that the final image is of the same size as the object, or is magnified one and a quarter or one and a half times. (As a very large angular field of view is required in these periscopes, the beam reflected into the tube must cover a large angle, and would soon fall on the sides of the tube; the reversed telescope, however, reduces the angle of the beam, and so enables it to pro-

ceed far enough down the tube to be received by the second telescope, and so transmitted to the eye.)

In modern submarines the tube has a length of from 16 to 24 ft., the diameter is from 6 to 9 in., while the field of view is about 65°. In order that objects shall look their real size, it is necessary to give a magnification of one and a quarter to one and a half.

Fig. 3 gives an illustration of a periscope in which three telescope systems are employed. The drawing is made from information published by Messrs. Goerz[1] of Berlin, and relates to periscopes made by them. It is, of course, undesirable to give any details of English periscopes at the present time.

An outer tube has a spherical glass cover. In the inner tube is the optical system, which can be rotated to face in any required direction; the eye piece, however, remains fixed.

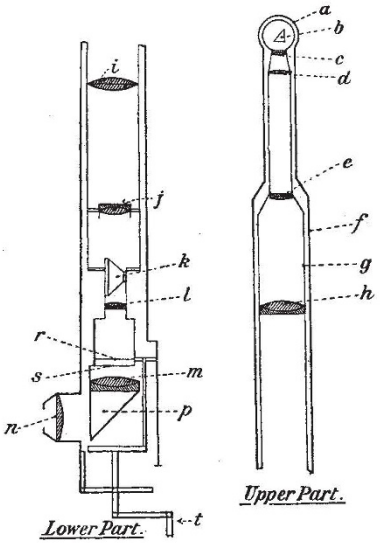

FIG. 3.—*a*, Glass cover; *b*, prism; *c*, *d*, and *e*, lenses of reversed telescope; *f*, outer tube; *g*, inner tube; *h*, *i*, and *j*, lenses of second telescope; *k*, reversing prism; *l*, *m*, and *n*, lenses of third telescope; *p*, prism; *r* and *s*, pointer and scale; *t*, rotating mechanism.

The optical system, which follows in its general principles Sir Howard Grubb's original design, consists of:—

(1) A reversed telescope, giving a reduction of about one quarter;

(2) A telescope, giving a magnification of about two;

(3) An erecting prism which can be rotated so that the image given by the system is correctly oriented;

(4) A telescope giving a magnification of about three.

This telescope includes a fixed eye piece and prism, so arranged that the observer looks horizontally at the object. At the focus of the eye piece are placed a scale and pointer to show the bearing of the object sighted, and a ruling to allow the distance to be estimated when the size of the object is known.

By the aid of a subsidiary system, special parts of the field can be further magnified to allow of objects being examined in more detail.

The continued use of the periscope is very trying to the eye, so that devices have been used to throw the image on to a ground glass screen. The ordinary eye piece and ground glass systems are made interchangeable, so that the observer can readily pass from one to the other; he may observe with the ground glass in the ordinary way, but examine special objects with the ordinary eye piece.

The field of view of the periscope is still limited, and various attempts to overcome this difficulty have been made. More than one periscope can be used and the images combined to form a complete image. A recent improvement consists in the use of a ring reflector which enables a view of the whole horizon to be obtained at once. The image formed by the ring system is much distorted, but when any object is picked up it can be examined by means of the ordinary system. These two optical systems are combined in one instrument, so that the two images are seen in the one field, the image formed by the ring system surrounding the other.

But these ring periscopes are still far from perfect, their distortion making it very difficult to identify objects; and this difficulty, though not so pronounced, occurs with the ordinary periscope. The point of view from which the surface of the sea and surrounding objects are seen is one to which the eye is not generally accustomed. The conditions of lighting, too, render it difficult to distinguish objects, especially when there is mist or spray, so that the effective use of a periscope requires considerable skill and training.

Trench periscopes may be obtained from most opticians, and the following are a few typical forms:—

The Hampson, wooden stake carrying two mirrors; price 7*s*. 6*d*.

The Adams, jointed rod; price 10*s*. 6*d*.

The Stanley; the support is in the form of lazy tongs, and is of a light alloy; price 25*s*.

These open-mirror types are light, portable, with good field, but the mirrors are not protected from rain, and the useful field is surrounded by bright sky.

Tube types are made by Messrs. Negretti and Zambra, Dixey, The Periscope Co., and many others; prices from 8*s*. 6*d*. to 15*s*., depending on the metal tube used. In these types the field is rather limited.

Messrs. Chas. Baker and Co. supply a type with large mirrors, which can be satisfactorily used with both barrels of a binocular. In spite of the large mirrors, the type is very portable; price 30*s*.

Many makers supply types in which the optical system is incorporated with the periscope, and the prices of these range from 28*s*. to 6*l*. 10*s*., according to the type of optical system used.

S. D. CHALMERS.

[1] Dr. Weichert, Jahrbuch der Schiffsbautechnischen Gesellschaft, 1914.

OIL OF VITRIOL AS AN AGENT OF "CULTURE."

IN a former article under this heading (NATURE, December 31, 1914, vol. xciv., p. 472) we pointed out that Germany's ability to continue the war depended largely upon her power to maintain her supply of oil of vitriol, this product being absolutely indispensable in the manufacture of