The Prismatic Astrolabe.[1]

IN the process of measuring the places of stars on the celestial sphere, or in the converse process of using these measured places to fix the position of the observer upon the earth's surface, the astronomer has at his disposal two systems of reference lines or circles upon which to base his measurements. These are respectively the vertical great circles through his zenith and the small circles parallel to his horizon, the circles of equal altitude or equal zenith distance. Using the first system, his method is to time the transit of a star across a vertical circle, almost invariably the meridian circle passing through the north and south points. If, in addition to timing the transit, he measures the altitude, he gets a complete determination of the position of the star observed, and uses both sets of reference circles, the vertical circle for fixing the time of transit, and hence the right ascension of the star, and the horizontal circle for fixing the altitude of transit, and hence the star's declination. This is the ordinary observation carried out in the observatory with the transit circle or by the surveyor in the field with the theodolite. Another method of observation which gives the same quantities, though not in the same direct form, is by the use of an instrument adapted for the recording of transits across a horizontal circle of constant altitude. An instrument of this class is the almucantar, in which horizontality is secured by the device of floating the whole in a mercury bath, it being easily seen that if either the instrument or the bath is moved round, the telescope will maintain a constant angle with the horizontal, and the line of vision will therefore always intersect an almucantar or circle of equal altitude.

Another instrument of the same fundamental type, but of an entirely different form, is the prismatic astrolabe devised about twelve years ago by MM. Claude and Driencourt. This appears to possess great merits for survey work in the field, and has earned quite enthusiastic praise from those who have used it. The one objection to its more extensive employment, the arduous labour involved in preparing observing lists of stars, has now been removed by the publication of Messrs. Ball and Knox Shaw's "Handbook" and "Diagram." We will revert to this point later, but we must first give a short description of the principles of this interesting instrument.

It consists essentially of a telescope with a 60° prism in front of the object glass, and a mercury trough placed so as to reflect the star on to the lower face of the prism.

The prism can be placed in either of the two positions shown in Fig. 1, from which it will be obvious that in both cases, on looking through the telescope at a star which is approaching and near to the altitude of 60°, two images of the star will be seen moving towards each other, and that these images will coalesce into one when the apparent altitude of the star is equal to the angle of the prism. In arrangement A the reflection is from the two outside surfaces of the prism, which must therefore be silvered; in B we get a total reflection from the two inside surfaces. It is further obvious that with outside reflection the angle of the prism can be given any value; the two star images will always coincide when the

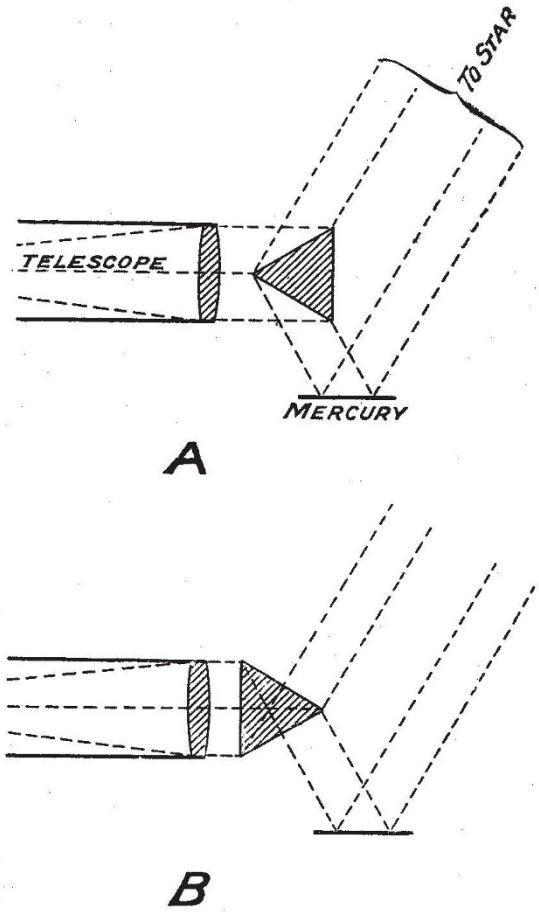

FIG. 1.—Principle of construction of the prismatic astrolabe.

altitude is equal to this angle, whereas if the rays traverse the glass they must enter and leave normal to the faces; the prism must therefore be equilateral, and stars can be observed only at the fixed altitude of 60°. The observation consists in the timing of the moment of coincidence of the two images. To allow them actually to coincide would, however, render accurate timing difficult, and far greater precision is obtained by giving the telescope a very small lateral displacement, so that the images pass close to, but not exactly over,

1 "Description et Usage de l'Astrolabe à Prisme." By Claude et Driencourt. (Paris: Gauthier-Villars, 1910.)
"Bestimmung fundamentaler Sternörter aus Höhendurchgangsbeobachtungen." By R. Trümpler. Nachrichten der K. G. der Wissenschaften. (Göttingen, 1913.)
"A Handbook of the Prismatic Astrolabe." By John Ball and H. Knox Shaw. (Cairo: Government Press, 1919.)
"Astrolabe Diagram." By John Ball. (Cairo: Government Press, 1919.)

each other; what is observed is, then, the transit of the two images over the same line of a horizontal graticule.

There is no appreciable difference in precision between the two prism arrangements. B has the apparent disadvantage that a closer adjustment of the telescope is required, the line of collimation must be perpendicular to the prism base, and the latter must be truly vertical, whereas with A the horizontality of the telescope and the symmetrical inclination of the prism faces are immaterial. On the other hand, from the practical surveyor's point of view, the use of the easily damaged silvered faces is inexpedient, and the method of internal reflection preferable. The disadvantages attaching to the necessity of more careful adjustment of telescope and prism are, moreover, more apparent than real. It must be remembered that while the actual observation involves no reading of graduated circle or micrometer, a horizontal circle is required for the purpose of directing the line of sight, so that the desired star will cross the field. The telescope and circle must therefore be levelled and adjusted as with a theodolite, and the extra labour involved in the setting of the prism is a very small matter.

As already stated, the preparation of an observing programme involves somewhat lengthy computations. These have now been made, and are available for the use of observers within a wide range of latitude. The "Handbook of the Prismatic Astrolabe" gives a succinct description of the smaller survey form of the instrument, its construction and method of use, and contains tables of all the Nautical Almanac stars down to the fourth magnitude which cross the altitude circle at azimuths suitable for observation for each degree of latitude between 55° S. and 55° N. This list gives sufficient stars for all field work except geodetic survey of the first order, for which more and fainter stars would be wanted. For these, reference must be made to the "Astrolabe Diagram," giving, for the same limits of latitude, a series of graphs from which the azimuth and time of any star crossing the altitude circle can be plotted. A comparison of the relative accuracy of the astrolabe and other survey instruments seems to indicate that it is probably capable of somewhat greater precision than a theodolite of similar telescopic power; and there is no doubt that in it we have a valuable addition to the resources of the surveyor. It cannot, however, take the place of the theodolite, being capable of determining only latitude and time, not azimuths or angles. It has therefore been urged as an objection to its more extended use that as a survey party must in any case carry theodolites the astrolabe could be taken only when the added labour of transport is unimportant. Apart from the fact that the addition of thirty pounds to the baggage of a survey expedition would be found burdensome only in quite exceptional cases, this objection does not appear to have any validity. A theodolite is capable of conversion into an astrolabe by the addition of the prism and mercury trough, and it would be easy to design these so that they could be clamped on to the front of the telescope, and the prism levelled in a minute or two. The extra weight would then not exceed a few ounces.

An attempt has been made, not, however, yet carried very far, to develop the use of this instrument for the astronomical problem of the determination of star places of high-order precision. It is very doubtful if it presents any real advantages for this work. The difficulty of making true plane surfaces is well known, and in an instrument of large aperture and high magnification the inclusion of flat reflectors in the optical system is undesirable. Furthermore, the two star images are not symmetrical, each being formed by only half the object glass, and the results show a magnitude equation, or variation with the brightness of the stars observed. This has not been specially studied in the portable survey patterns, but would probably be found even with them. Trümpler (*loc. cit.*), using an aperture of only 4·7 cm. and a focal length of 50 cm., found it conspicuously. It would increase rapidly with increase of aperture. For the present we must regard the astrolabe as a surveyor's instrument, capable in his hands of useful service, and leave any possible application to observatory work for further investigation. E. H. H.

The Heart of a Continent.[1]

By DOUGLAS CARRUTHERS.

"CENTRAL ASIA" used to conjure up in the imagination thoughts of lonely and mysterious frontiers between three great Asiatic Empires, of strange doings in unheard-of valleys on the Pamirs, of long-dead conquerors, and of strange capitals at the back of the world. Even now, in 1920, the heart of Asia is a storm centre, for it forms the meeting-place of the civilisations of the remote past—China; of the present—Great Britain; and of the future?—Bolshevism.

Great happenings have been in middle Asia—unheard-of movements, unimagined miseries—during the past six years, when all men's thoughts have been concentrated on Europe and the Middle East. The remote highlands and deserts of Asia did not escape the turmoil. The most secluded and most apathetic native races felt the ripples of the storm in Europe. The confines of China, India, Russia, and Afghanistan have returned, by a strange coincidence, to their former place as, what may well be, the centre of a prolonged struggle, *not* between East and West, but between right and wrong.

Chinese Turkestan, or Kashgaria, is that

[1] "Through Deserts and Oases of Central Asia." By Miss Ella Sykes and Brig.-Gen. Sir Percy Sykes. Pp. xii+340. (London: Macmillan and Co., Ltd., 1920.) Price 21s. net.