instrument of the same type subsequently mounted at Paris, and in like instruments of intermediate size mounted at other French observatories, the object-glass is placed outside the mirror N, so that both the silvered mirrors arc protected from exposure to the outer air.

A modification of Loewy’s equatorial coudé has been suggested by Lindemann *(Astr. Nachr.,* No. 3935); it consists in placing both the mirrors of Loewy’s “ equatorial coudé ” at the top of the polar axis instead of the lower end of it. By this arrangement the long cross tube becomes unnecessary, and neither the pier nor the observatory obstruct the view of objects above the horizon near lower transit as is the case in Loewy’s form. The reflected rays pass down the tube from the direction of the elevated pole instead of upward towards that pole. The observer is, therefore, at the bottom of the tube instead of the top and looks upward instead of downward. The drawbacks to this plan are (1) the necessarily large size of the upper pivot (viz. the diameter of the tube) and of the lower pivot (which must be perforated by a hole at least equal in diameter to the photographic field of the telescope), conditions which involve very refined arrangements for relief of friction, and (2) the less comfortable attitude of looking upward instead of down­ward. The plan, however, would be a very favourable one for spectroscopic work and for the convenient installation of an under- ground room of constant temperature. The difficulties of relief friction could probably be best overcome by a large hollow cylinder concentric with the polar axis fixed near the centre of gravity of the whole instrument and floated in mercury, on the plan adopted in the Mount Wilson 60-in. reflector already described, but in this case the floating cylinder would be below and not above the upper bearing.

In 1884 Sir Howard Grubb (*Phil. Trans. R. Dub. Soc.,* vol. iii. series 2, p. 61) proposed a form of equatorial telescope of which an excellent example was erected at Cambridge (Eng). in 1898. The instrument in some respects resembles the equatorial coudé of Loewy, but instead of two mirrors there is only one. A flanged cast-iron box, strongly ribbed and open on one side, forms the centre of the polar axis. One pivot of the polar axis is attached to the lower end of this box, and a strong hollow metal cone, terminating in the other pivot, forms the upper part of the polar axis. The declination axis passes through the two opposite sides of the central box. Upon an axis concentric with the declination axis is carried a plane mirror, which is geared so as always to bisect the angle between the polar axis and the optical axis of the telescope. If then the objective tube is directed to any star, the ' convergent beam from the object-glass is received by the plane mirror from which it is reflected upwards along the polar axis and viewed through the hollow upper pivot. Thus, as in the equatorial coudé, the observer remains in a fixed position looking down the polar tube from above. He is provided with quick and slow motions in right ascension and declination, which can be operated from the eye-end, and he can work in a closed and comfortably heated room. A large slot has to be cut in the cone which forms the upper part of the polar axis, in order to allow the telescope to be pointed nearer to the pole than would otherwise be possible; even so stars within 15° of the pole cannot be observed. An illustrated preliminary description of the instrument is given by Sir Robert Ball *(Mon. Not. R.A.S.,* lix. 152). The instrument has a triple photo-visual Taylor object-glass of 12½ in. aperture and 19·3-ft. focal length.

*Type F.—*In all the previously described types of telescope mounting the axis of the instrument is either pointed directly at the object or to the pole; in the latter case the rays from the star under observation are reflected along the polar axis by a mirror or mirrors attached to or revolving with it. Equatorials of types A, B, C and D have the advantage of avoiding interposed reflecting surfaces, but they involve inconveniences from the continual motion of the eye-piece and the consequent necessity for providing elaborate observing stages or rising floors. In those of type E the eye-piece has a fixed position and the observer may even occupy a room maintained at uniform temperature, but he must submit to a certain loss of light from one or more reflecting surfaces, and from possible loss of definition from optical imperfection or flexure of the mirror or mirrors. In all these types the longer the telescope and the greater its diameter (or weight) the more massive must be the mounting and the greater the mechanical difficulties both in construction and management.

But if it be possible to mount a fixed telescope by which a solar or stellar image can be formed within a laboratory we give the following advantages:—(1) There is no mechanical limit to the length of the telescope; (2) the clockwork and other appliances to move the mirror, which reflects the starlight along the axis, are much lighter and smaller than those required to move a large telescope ; (3) the observer remains in a fixed position, and spectro­scopes of any weight can be used on piers within the laboratory; and (4) the angular value of any linear distance on a photographic plate can be determined by direct measurement of the distance of the photographic plate from the optical centre of the object-glass. The difficulty is that the automatic motion of a single mirror capable of reflecting the rays of any star continuously along the axis of a fixed horizontal telescope, requires a rather complex mechanism owing to the variation of the angle of reflexion with the diurnal motion.

Foucault appears to have been the first to appreciate these advantages and to face the difficulty of designing a siderostat which, theoretically at least, fulfils the above-mentioned conditions. A large siderostat, constructed by Eichens after Foucault’s design, was completed in 1868—the year of Foucault's death. It remained at the Paris Observatory, where it was subsequently employed by Deslandres for solar photography. The largest refracting telescope yet made, viz., that constructed by Gautier for the Paris exhibition of 1900, was arranged on this plan (type F), the stars’ rays being reflected along the horizontal axis of a telescope provided with visual and with photo­graphic object-glasses of 49-in. diameter and nearly 200-ft. focal length. Up to 1908 neither the optical qualities of the images given by the object-glasses and reflecting plane nor the practical working of the instrument, have, so far as we know, been sub­mitted to any severe test. It is, however, certain that the Foucault siderostat is not capable, in practice, of maintaining the reflected image in a constant direction with perfect uniformity on account of the sliding action on the arm that regulates the motion of the mirror; such an action must, more or less, take place by jerks. There are farther inconveniences in the use of such a telescope, viz., that the image undergoes a diurnal rotation about the axis of the horizontal telescope, so that, unless the sensitive plate is also rotated by clockwork, it is impossible to obtain sharp photographs with any but instantaneous exposures. In the spectroscopic observa­tion of a single star with a slit-spectroscope, this rotation of the image presents no inconvenience, and the irregular action of a siderostat on Foucault's plan might be overcome by the following arrangement :—

A B (fig. 23) is a polar axis, like that of an equatorial telescope, rotating in twenty-four hours by clockwork. Its lower extremity terminates in a fork on which is mounted a mirror C D, capable of turning about A on an axis at right angles to A B, the plane of the mirror being parallel to this latter axis. The mirror C D is set at such an angle as to reflect rays from the star S in the direction of the polar axis to the mirror R and thence to the horizontal telescope T.

The mirrors of Lindemann’s equatorial coudé reflecting light downwards upon the mirror R would furnish an ideal siderostat for stellar spectroscopy in conjunction with a fixed horizontal telescope.

*Coelostat.—*If a mirror is mounted on a truly adjusted polar axis, the plane of the mirror being parallel to that axis, the normal to that mirror will always be directed to some point on the celestial equator through whatever angle the axis is turned. Also, if the axis is made to revolve at half the apparent diurnal motion of the stars, the image of the celestial sphere, viewed by reflection from such a moving mirror, will appear at rest at every point—hence the name *coelostat* applied to the apparatus. Thus, any fixed telescope directed towards the mirror of a properly adjusted coelo­stat in motion will show all the stars in the field of view at rest; or, by rotating the polar axis independently of the clockwork, the observer can pass in review all the stars visible above the horizon whose declinations come within the limits of his original field of view. Therefore, to observe stars of a different declination it will be necessary either to shift the direction of the fixed telescope, keeping its axis still pointed to the coelostat mirror, or to employ a second mirror to reflect the rays from the coelostat mirror along the axis of a fixed telescope. In the latter case it will be necessary to provide means to mount the coelostat on a carriage by which it can be moved east and west without changing the altitude or azimuth of its polar axis, and also to shift the second mirror so that it may receive all the light from the reflected beam. Besides these complications there is another drawback to the use of the coelostat for general astronomical work, viz., the obliquity of the angle of reflection, which can never be less than that of the declination of the star, and may be greater to any extent. For these reasons the coelostat is never likely to be largely employed in general astrono­mical work, but it is admirably adapted for spectroscopic and bolometric observations of the sun, and for use in eclipse expedi­tions. For details of the coelostat applied to the Snow telescope— the most perfect installation for spectroheliograph and bolometer work yet erected—see *The Study of Stellar Evolution* by Prof. G. E. Hale, p. 131.

*The Zenith Telescope*

The zenith telescope is an instrument generally employed to measure the difference between two nearly equal and opposite zenith distances. Its original use was the determination of geo­graphical latitudes in the field work of geodetic operations; more recently it has been extensively employed for the determination