construction of most modern reflecting telescopes. A glass prism of total reflection is sometimes substituted for the plane mirror.

The Herschelian or front view reflector is represented in fig. 9. **A** A is a concave parabolic mirror, whose axis *a c* is inclined to the axis of the tube *a b* so that the image of an object in the focus of the mirror may be viewed by an eye-piece at E, the angle *b a c* being equal to the angle c a E. This form was adopted by the elder Herschel to avoid the loss of light from reflection in the small mirror of the Newtonian telescope. The front view telescope, however, has hardly been at all employed except by the Herschels. But at the same time none but the Herschels have swept the whole sky for the discovery of faint nebulae; and

probably no other astronomers have worked for so many hours on end for so many nights as they did, and they emphasize the easy position of the observer in using this form of instrument.

*Construction of Specula.*

The composition of metallic specula in the present day differs very little from that used by Sir Isaac Newton. Many different alloys have been suggested, some including silver, nickel, zinc or arsenic; but that which has practically been found best is an alloy of four equivalents of copper to one of tin, or the following pro­portions by weight: copper 252, tin 117∙8. Such speculum metal is exceedingly hard and brittle, takes a fine white polish, and when protected from damp has little liability to tarnish. The process of casting and annealing, in the case of the specula of the great Melbourne telescope, was admirably described by Dr Robinson in *Phil. Trans.,* 1869, 159, p. 135. Shaping, polishing and figuring of specula are accomplished by methods and tools very similar to those employed in the construction of lenses. The reflecting surface is first ground to a spherical form, the parabolic figure being given in the final process by regulating the size of the pitch squares and the stroke of the polishing machine.

Soon after Liebig’s discovery of a process for depositing a film of pure metallic silver upon glass from a salt of silver in solution, Steinheil (Gaz. *Univ. d’Augsburg,* 24th March 1856), and later, in­dependently, Foucault *(Comptes Rendus,* vol. xliv., February 1857), proposed to employ glass for the specula of telescopes, the reflect­ing surface of the glass speculum to be covered with silver by Liebig’s process. Those silver-on-glass specula are now the rivals of the achromatic telescope, and it is not probable that many tele­scopes with metal specula will be made in the future. The best speculum metal and the greatest care are no guarantee of freedom from tarnish, and, if such a mirror is much exposed, as it must be in the hands of an active observer, frequent repolishing will probably be necessary. This involves refiguring, which is the most delicate and costly process of all. Every' time, therefore, that a speculum is repolished, the future quality of the instrument is at stake; its focal length will probably be altered, and thus the value of the constants of the micrometer also have to be redetermined. Partly for these reasons the reflecting telescope with metallic mirror has never been a favourite with the professional astronomer, and has found little employment out of England.@@1 In England, in the hands of the Herschels, Rosse, Lassell and De la Rue it has done

splendid service, but in all these cases the astronomer and the instrument-maker were one. The silver-on-glass mirror has the enormous advantage that it can be resilvered with little trouble, at small expense, and without danger of changing the figure. Glass is lighter, stiffer, less costly and easier to work than speculum metal. Silvered mirrors have also some advantage in light grasp over those of speculum metal, though, aperture for aperture, the former are inferior to the modern object-glass. Comparisons of light grasp derived from small, fresh, carefully silvered surfaces are sometimes given which lead to illusory results, and from such experiments Foucault claimed superiority for the silvered speculum over the object-glass. But Sir David Gill found from experience and careful comparison that a silvered mirror of 12-in. aperture, mounted as a Newtonian telescope (with a silvered plane for the small mirror), when the surfaces are in fair average condition, is equal in light grasp to a first-rate refractor of 10-in. aperture, or area for area as 2: 3. This ratio will become more equal for larger sizes on account of the additional thickness of larger object-glasses and the consequent additional absorption of light in transmission.

*Mounting of Telescopes.*

The proper mounting of a telescope is hardly of less import­ance than its optical perfection. Freedom from tremor, ease and delicacy of movement and facility of directing the instrument to any desired object in the heavens are the primary qualifica­tions. Where accurate differential observations or photographs involving other than instantaneous exposures have to be made, the additional condition is required that the optical axis of the telescope shall accurately and automatically follow the object under observation in spite of the apparent diurnal motion of the heavens, or in some cases even of the apparent motion of the object relative to neighbouring fixed stars.

Our limits forbid a historical account of the earlier endeavours to fulfil these ends by means of motions in altitude and azimuth, nor can we do more than refer to mountings such as those em­ployed by the Herschels or those designed by Lord Rosse to over­come the engineering difficulties of mounting his huge telescope of 6 ft. aperture. Both are abundantly illustrated in most popular works on astronomy, and it seems sufficient to refer the reader to the original descriptions.@@2

We pass, therefore, directly to the equatorial telescope, the instrument *par excellence* of the modern extra-meridian astronomer. The article Transit Circle describes one form of mounting in which the telescope is simply a refined sub­stitute for the sights or pinules of the old astronomers. The present article contains a description of the mounting of the various forms of the so-called zenith telescope. In its simplest form the mounting of an equatorial telescope consists of an axis parallel to the earth’s axis, called “the polar axis”; a second axis at right angles to the polar axis called “ the declination axis and the telescope tube fixed at right angles to the declination axis.

In Fig. 10 A A is the polar axis; the telescope is attached to the end of the declination axis; the latter rotates in bearings which are attached to the polar axis and concealed by the telescope itself. The telescope is counterpoised by a weight attached to the opposite end of the declination axis. The lower pivot of the polar axis rests in a cup-bearing at C, the upper bearing upon a strong metal casting Μ M attached to a stone pier S. A vertical plane passing through A A is therefore in the meri­dian, and the polar axis is inclined to the horizon at an angle equal to that of the latitude of the place of observation. Thus, when the de­clination axis is hori­zontal the telescope moves in the plane of the meridian by rota­tion on the declination axis only. Now, if a graduated circle B B is attached to the declination axis, together with the necessary verniers or microscopes V V for reading it (seeTRAN≡ιτ Circle), so arranged that when the telescope is turned on the declina­tion axis till its optical axis is parallel to A A the vernier reads 0° and when at right angles to A A 90°, then we can employ the readings of

@@@l There is a noteworthy exception in the case of the 18-in. speculum­metal mirror employed.by Sir William Huggins at Tulse Hill, with which a large part of his remarkable and important series of astro- spectroscopic results have been obtained. So far as we know, this mirror has never been repolished since its first installation in 1870, and still retains its admirable surface. One of Short’s mirrors, made about 1760 or 1770, of 6-in. aperture, now in the possession of Sir William Huggins, has surfaces which still retain their original perfection although they have never been repolished.

@@@2 Herschel, *Phil. Trans.,* 1795, 85, p. 347; Rosse, *Phil. Trans.* 1840, p. 503; 1861, p. 681.