*Fraunhofer,* Dorpat, 1825), and was an enormous advance upon all previous telescopes for micrometric research. In the hands of Struve results were obtained by it which in combined quality and quantity had never before been reached. Its success was such that the type of Fraunhofer's telescope became stereotyped for many years not only by Fraunhofer's successors but throughout Germany. When, twelve years afterwards, Struve ordered the 15-in. refractor for the new observatory at Pulkovo, the only important change made by Fraunhofer's successors was, at Struve's suggestion, the substitution of a stone pier for the wooden stand in the original instru­ment.

Both the Dorpat and the Pulkovo refractors are defective in rigidity, especially in right ascension. The declination circle is most incon­venient of access, and slow motion in declination can only be effected when the instru­ment is clamped by a long and inconvenient handle; so that, practically, clamping in declination was not employed. The slow motion in right ascension is defec­tive, being accom­plished in the Dorpat refractor by changing the rate of the clock, and in the Pulkovo refractor by a handle which, when used, affects very injuriously the rate of the clock for the time being. Struve’s skill as an observer was such that he used to complete the bisection on the fixed wire of the micrometer by a pressure of the finger on the side of the tube—a method of proved efficiency in such hands, but plainly indicative of the want of rigidity in the instrument and of the imperfection of the slow motions (see Micrometer).

The driving circle is also much too small, so that a very slight mechanical freedom of the screw in the teeth involves a large angular freedom of the telescope in right ascension, while its position at the lower end of a too weak polar axis tends to create instability from torsion of that axis. Strange to say, the wooden tube long retained its place in German telescope-mountings.

About 1840 a great advance was made by the Repsolds of Hamburg in the equatorial mounting of the Oxford heliometer. The driving circle was greatly increased in diameter and placed at the upper end of the polar axis, and both the polar and declination axes were made much stronger in proportion to the mass of the instrument they were designed to carry. (A figure of the instrument is given in the Oxford *Observations* for 1850.) About 1850 Thomas Cooke of York began his career as a maker of equatorial telescopes. The largest example of his work is the refractor of 24-in. aperture, originally made for the private observatory of Robert Stirling Newall at Gateshead, Northumberland, and afterwards presented by him to the University Observatory, Cambridge. Cooke's mount­ing is admirable for its symmetry and simplicity of design, its just apportioning of strength, and a general suitability of means to ends.

It is not a little curious that the obvious improvement of trans­ferring the declination axis as well as the declination-clamp to the telescope end of the declination axis was so long delayed; we can explain the delay only by the desire to retain the declination circle as a part of the counterpoise. We believe the first important equatorials in which the declination was read from the eye-end were the 15-in. by Grubb and the 6-in. by Cooke, made for the observatory of Lord Crawford (Lord Lindsay) at Dun Echt, Aberdeenshire, about 1873. The plan is now universally adopted. Telescopes of such dimensions can be conveniently directed to any object by the circles without the observer being under the necessity to climb a special ladder. But when much larger instruments are required the hour circle becomes inaccessible from the floor, and means have to be devised for reading both circles from the eye­end. This was first accomplished by Grubb in the great refractor of 27-in. aperture which he con­structed for the Vienna observatory, represented in section in fig. 14. The observer's eye is applied to the small telescope E, which (by means of prisms numbered 1, 2. 3, 4) view’s the vernier attached to the cross-head simultaneously with the hour circle at­tached to the upper end of the polar axis. Light to illuminate the vernier and circle is thrown from the lamp L upon prism 4 by the prisms 6 and 5. Prism 1 is in the axis of the declination circle and always reflects rays along that axis, whatever the position of the telescope may be, whilst the prisms 2, 3, 4, 5 and 6 are attached to the cross-head and therefore

preserve their relative positions to each other. Through the eye­piece of the bent@@1 telescope E, another hour circle attached to the lower end of the polar axis can be seen; thus an assistant is able to direct the telescope by a handle at II to any desired hour angle. A slight rotatory motion of the tele­scope E on its axis enables the vernier of the declination circle to be read through prism 1. The leading features of this fine instrument represent those of all Grubb's large telescopes. The mode of relieving the friction of the declination axis is similar to that employed in the Melbourne telescope and in the account of the Vienna telescope published by Grubb. The end friction of the polar axis is relieved by a ring of conical rollers shown in section beside the principal figure.

From this point we must condense farther description into critical remarks on a few typical modern instruments.

(1) *Telescopes of Moderate Size for Micrometric Research Only.—* Fig. 15 shows the mounting of the 8-in. refractor, of. 9-ft. focal length, at the private observatory of Dr Engelmann, Leipzig. The object-glass is by Messrs Clark of Cambridge, Mass., the mounting by the Repsolds of Hamburg. The declination circle reads from the eye-end, and four handles for clamping and slow’ motion in right ascension and declination are situated near the observer’s hands. The tube is of sheet steel, light, stiff, and free from tremor. . The eye-end carries the micrometer with an illuminating apparatus similar to that described under Micrometer. The lamp near the eye-end illuminates the field or the wires at pleasure, as well as the position circle of the micrometer and the declination circle; .a separate lamp illuminates the hour circle. An excellent feature is the short distance between the eye-piece and the declination axis, so that

@@@1 In the bent telescope refracting prisms are employed at the corners to change the direction of the rays.