of the clock, and in the Pulkowa 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 deficiency of the slow motions (see Micro­meter, vol. xvi. p. 245). 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, whilst its position at the lower end of a too weak polar axis tends to create instability in right ascension from torsion of that axis. Strange to say, the wooden tube has till very recently retained its place in German mountings.

About 1840 a great advance was made in the right direction 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 axis and the declination axis were made much stronger in propor­tion to the mass of the instrument they were destined to carry. (A figure of this instrument is given in the Oxford *Observations* for 1850.) About 1850 Thomas Cooke of York began his career as a maker of equa­torial telescopes, and gave a new character to the German mounting. Fig. 21 represents a typical equatorial of his design. A strong cast-iron pillar is substituted for Fraunhofer’s stand. On the semi-cylindrical top of the pillar rests the cast-iron box AA, which contains at its upper and lower extremities the bearings of the polar axis. Its mode of connexion with the pillar permits the inclination of the box to be changed for adjustment of the inclination of the polar axis. The strong cross-head C, sup­porting the bearings of the declination axis, is of cast iron, bolted to a flange on the upper pivot of the polar axis. Fraun­hofer’s cradle and wooden tube are abolished, and in their place is a cast-iron cylindri­cal tube D, flanged at both ends aud also at the point where it is bolted to a corresponding flange on the end of the declination axis, all three flanges being cast in one piece with the central tube ; the rest of the tube consists of two slightly tapered brass cylinders bolted by strong flanges to the central tube D. The handle F clamps the arm H to the cross-head C at pleasure, and slow mo­tion in declination is communicated by the handles at E and G.

Two circles at K and M are attached to the upper part of the polar axis. To one of these motion is communicated by the tangent screw at M (turned by the clock N) acting on teeth cut at the edge of the circle. The other is a graduated hour circle read by two opposite microscopes, one of which is seen at P. The endless cord hanging down and holding a sliding ring at Q is em­ployed to give slow motion in right ascension, in some instruments by moving the frame of the driving screw in the direction of the axis of the screw, in others by moving differential wheels which accelerate or retard the velocity of rotation of the driving screw without affecting the rate of the clock. The declination circle RR is attached to the farther end of the declination axis and is inconvenient of access. Cooke’s stand is admirable for its symmetry and simplicity of design, its just apportioning of strength, and a general rigidity with suitability of means to ends.

It is not a little curious that the obvious improvement of trans­ferring the declination circle as well as the declination clamp to the telescope end of the declination axis was so long delayed ; we can ascribe the delay only to a desire to retain the declination circle as part of the counterpoise. We believe that the first important equatorials in which the declination axis was read from the eye end were the 15-inch by Grubb and the 6-inch by Cooke, made for the observatory of Lord Crawford (then Lord Lindsay) at Dun Echt (Aberdeenshire) about 1873. The plan is now almost 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 eye end. This was first accomplished by Grubb in the great refractor of 27-inches aperture which he constructed for the Vienna observatory, represented in section in fig. 22. The observer’s eye is applied to the small telescope E, which (by means of prisms numbered 1, 2, 3, 4) views 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 cross­head and therefore preserve their relative positions to each other. Through the eye-piece 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 H 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 further description into critical remarks on a few typical modern instruments.

(1) *Telescopes of Moderate Size for Micrometric Research only.—*

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