made object-glasses of 170 and 210 feet focal length, and he presented one of 123 feet to the Royal Society of Lon­don. Auzout and others are said to have made telescopes of from 300 to 600 feet focus, but it does not appear that they were ever able to use them in practical observations. Bradley, on 27th December 1722, actually measured the diameter of Venus w’ith a telescope whose object-glass had a focal length of 212 ¼ feet. In these very long tele­scopes no tube was employed, and they were consequently termed *aerial telescopes.* Huygens contrived some ingenious arrangements for directing such telescopes towards any object visible in the heavens,—the focal adjustment and centring of the eye-piece being preserved by a braced rod connecting the object-glass and eye-piece. Other con­trivances for the same purpose are described by La Hire (*Mém. de l'Acad.,* 1715) and by Hartsoeker (*Miscel. Berol.,* vol. i. p. 261). Telescopes of such great length were natur­ally difficult to use, and must have taxed to the utmost the skill and patience of the observers. One cannot but pay a passing tribute of admiration to the men who, w’ith such troublesome tools, achieved such results.

Until Newton’s discovery of the different refrangibility of light of different colours, it was generally supposed that object-glasses of telescopes were subject to no other errors than those which arose from the spherical figure of their surfaces, and the efforts of opticians were chiefly directed to the construction of lenses of other forms of curvature. James Gregory, in his *Optica Promota* (1663), discusses the forms of images of objects produced by lenses and mirrors, and shows that when the surfaces of the lenses or mirrors are portions of spheres the images are curves concave towards the objective, but if the curves of the surfaces are conic sections the spherical aberration is cor­rected. He was well aware of the failures of all attempts to perfect telescopes by employing lenses of various forms of curvature, and accordingly proposed the form of reflect­ing telescope which bears his name. But Gregory, accord­ing to his own confession, had no practical skill ; he could find no optician capable of realizing his ideas, and after some fruitless attempts was obliged to abandon all hope of bringing his telescope into practical use. Newton was the first to construct a reflecting telescope. When in 1666 he made his discovery of the different refrangibility of light of different colours, he soon perceived that the faults of the refracting telescope were due much more to this cause than to the spherical figure of the lenses. He over-hastily concluded from some rough experiments (*Optics,* bk. i. pt. ii. prop. 3) “ that all refracting substances diverged the pris­matic colours in a constant proportion to their mean refrac­tion and he drew the natural conclusion “ that refraction could not be produced without colour,” and therefore “ that no improvement could be expected from the refracting tele­scope ” (*Treatise on Optics,* p. 112). But, having ascertained by experiment that for all colours of light the angle of incidence is equal to the angle of reflexion, he turned his attention to the construction of reflecting telescopes. After much experiment he selected an alloy of tin and copper as the most suitable material for his specula, and he devised means for grinding and polishing them. He did not attempt the formation of a parabolic figure on account of the probable mechanical difficulties, and he had besides satisfied himself that the chromatic and not the spherical aberration formed the chief faults of previous telescopes. Newton’s first telescope so far realized his expectations that he could see with its aid the satellites of Jupiter and the horns of Venus. Encouraged by this success, he made a second telescope of 6⅓-inches focal length, with a magni­fying power of 38 diameters, which he presented to the Royal Society of London in December 1671. A third form of reflecting telescope was devised in 1672 by Cassegrain (*Journal des Sçavans,* 1672). No further practical advance appears to have been made in the design or construction of the instrument till the year 1723, when John Hadley (best known as the inventor of the sextant) presented to the Royal Society a reflecting telescope of the Newtonian con­struction, with a metallic speculum of 6-inches aperture and 62 5/8-inches focal length, having eye-pieces magnifying up to 230 diameters. The instrument was examined by Pound and Bradley, the former of whom reported upon it in *Phil. Trans.,* 1723, No. 378, p. 382. After remarking that Newton’s telescope “had lain neglected these fifty years,” they stated that Hadley had sufficiently shown “ that this noble invention does not consist in bare theory.” They compared its performance with that of the object-glass of 123-feet focal length presented to the Royal Society by Huygens, and found that Hadley’s reflector

“will bear such a charge as to make it magnify the object as many times as the latter with its due charge, and that it represents objects as distinct, though not altogether so clear and bright. . . . Notwithstanding this difference in the brightness of the objects, we were able with this reflecting telescope to see whatever we have hitherto discovered with the Hugenian, particularly the transits of Jupiter’s satellites and their shadows over his disk, the black list in Saturn’s ring, and the edge of his shadow cast on his ring. We have also seen with it several times the five satellites of Saturn, in viewing of which this telescope had the advantage of the Hugenian at the time when we compared them ; for, being in summer, and the Hugenian telescope being managed without a tube, the twilight pre­vented us from seeing in this some of these small objects which at the same time we could discern with the reflecting telescope. ” Bradley and Molyneux, having been instructed by Hadley in his methods of polishing specula, succeeded in producing some telescopes of considerable power, one of which had a focal length of 8 feet; and, Molyneux having communicated these methods to Scarlet and Hearn, two London opticians, the manufacture of telescopes as a matter of business was commenced by them (Smith’s *Optics,* bk. iii. ch. 1). But it was reserved for James Short of Edinburgh to give practical effect to Gregory's original idea. Born at Edin­burgh in 1710 and originally educated for the church, Short attracted the attention of Maclaurin, professor of mathematics at the university, who permitted him about 1732 to make use of his rooms in the college buildings for experiments in the construction of telescopes. In Short’s first telescopes the specula were of glass, as suggested by Gregory, but he afterwards used metallic specula only, and succeeded in giving to them true parabolic and elliptic figures. Short then adopted telescope-making as his pro­fession, which he practised first in Edinburgh and after­wards in London. All Short’s telescopes were of the Gregorian form, and some of them retain even to the present day their original high polish and sharp definition. Short died in London in 1768, having realized a consider­able fortune by the exercise of his profession.

The historical sequence of events now brings us to the discovery of the achromatic telescope. The first person who succeeded in making achromatic refracting telescopes seems to have been Chester Moor Hall, a gentleman of Essex. He argued that the different humours of the human eye so refract rays of light as to produce an image on the retina which is free from colour, and he reason­ably argued that it might be possible to produce a like result by combining lenses composed of different refracting media@@1 After devoting some time to the inquiry he found that by combining lenses formed of different kinds of glass the effect of the unequal refrangibility of light was corrected, and in 1733 he succeeded in constructing telescopes which exhibited objects free from colour. One of these instruments of only 20-inches focal length had an aperture of 2½ inches. Hall was a man of independent

@@@1 The same argument was employed by Gregory more than fifty years previously, but had been followed by no practical result. The lens of the human eye is not achromatic (see Light, vol. xiv. p. 601).