the first, he took it to Venice, where he communicated the details of his invention to the public, and presented the instrument itself to the doge Leonardo Donato, sitting in full council. The senate, in return, settled him for life in his lectureship at Padua and doubled his salary, which was previously 500 florins and which then became treble that which any of his predecessors had enjoyed. Galileo may thus claim to have invented the telescope independently, but not till he had heard that others had done so. In fact the time was ripe; and, as often happens in similar circumstances, only a hint was necessary to complete the latent chain of thought. Galileo devoted all his time to improving and perfecting the telescope. Knowing the theory of his instrument, and possessed of much practical skill, coupled with unwearied patience, he conquered the difficulties of grind­ing and polishing the lenses, and soon succeeded in producing telescopes of greatly increased power. His first telescope magnified three diameters; but he soon made instruments which magnified eight diameters, and finally one that magnified thirty-three diameters.@@1 With this last instrument he dis­covered in 1610 the satellites of Jupiter, and soon afterwards the spots on the sun, the phases of Venus, and the hills and valleys on the moon. He demonstrated the rotation of the satellites of Jupiter round the planet, and gave rough predictions of their configurations, proved the rotation of the sun on its axis, established the general truth of the Copernican system as compared with that of Ptolemy, and fairly routed the fanciful dogmas of the philosophers. These brilliant achievements, together with the immense improvement of the instrument under the hands of Galileo, overshadowed in a great degree the credit due to the original discoverer, and led to the universal adoption of the name of the Galilean telescope for the form of the instrument invented by Lippershey.

Kepler first explained the theory and some of the practical advantages of a telescope constructed of two convex lenses in his *Catoptrics* (1611). The first person who actually constructed a telescope of this form was the Jesuit Christoph Scheiner, who gives a description of it in his *Rosa Ursina* (1630). William Gascoigne was the first who practically appreciated the chief advantages of the form of telescope suggested by Kepler, viz., the visibility of the image of a distant object simultaneously with that of a small material object placed in the common focus of the two lenses. This led to his invention of the micrometer and his application of telescopic sights to astronomical instru­ments of precision (see Micrometer). But it was not till about the middle of the 17th century that Kepler’s telescope came into general use, and then, not so much because of the advantages pointed out by Gascoigne, but because its field of view was much larger than in the Galilean telescope. The first powerful tele­scopes of this construction were made by Huygens, after much labour, in which he was assisted by his brother. With one of these, of 12-ft. focal length, he discovered the brightest of Saturn’s satellites (Titan) in 1655, and in 1659 he published his *Systema Saturnium,* in which was given for the first time a true explanation of Saturn’s ring, founded on observations made with the same instrument. The sharpness of image in Kepler’s telescope is very inferior to that of the Galilean instrument, so that when a high magnifying power is required it becomes essential to increase the focal length. G. D. Cassini discovered Saturn’s fifth satellite (Rhea) in 1672 with a telescope of 35 ft., and the third and fourth satellites in 1684 with telescopes made by Campani of 100- and 136-ft. focal length. Huygens states that he and his brother made object-glasses of 170 and 210 ft. focal length, and he presented one of 123 ft. to the Royal Society of London. Adrien Auzout (d. 1691) and others are said to have made telescopes of from 300 to 600 ft. focus, but it does not appear that they were ever able to use them in practical observations. James Bradley, on 27th December 1722, actually measured the diameter of Venus with a telescope whose object­glass had a focal length of 212¼∙ ft. 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 eye­piece being preserved by a braced rod connecting the object­glass and eye-piece. Other contrivances for the same purpose are described by Philippe de la Hire *(Mém. de l'Acad.,* 1715) and by Nicolaus Hartsoeker *(Miscel. Berol.,* 1710, 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, with such troublesome tools, achieved such results.

*Reflecting Telescopes.—*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 and 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 gτinding 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-in. focal length, with a magnifying power of 38 diameters, which he presented to the Royal Society of Loudon 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 r723, 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-in. aperture and 62⅝-in. 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

@@@1 This last power could not be exceeded with advantage in this form of telescope till after the invention of the achromatic object­glass.