

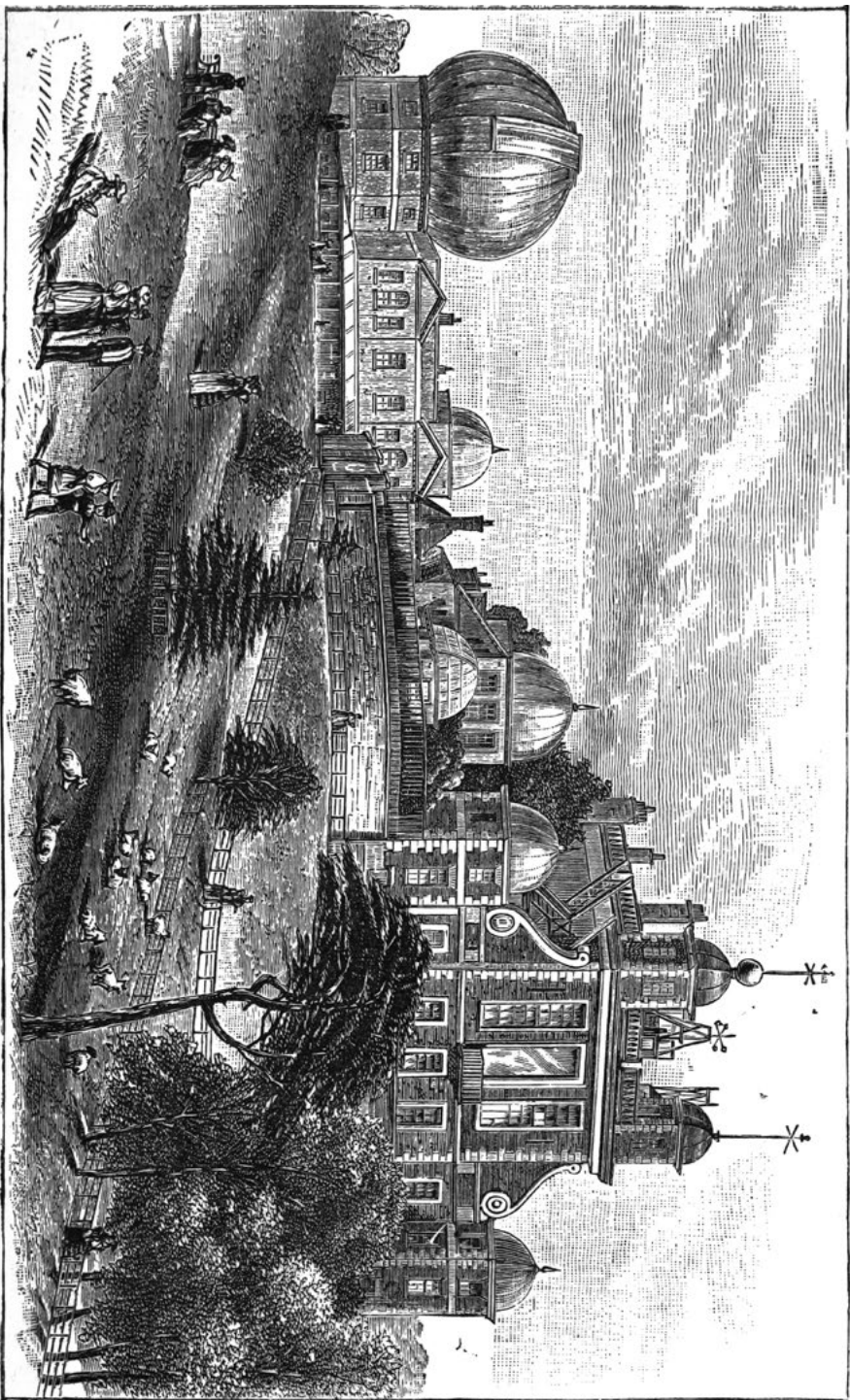


CLASSIC LIVING BOOK

THE GREAT ASTRONOMERS

Robert Ball

COMPLETE AND UNABRIDGED



THE OBSERVATORY, GREENWICH.

THE GREAT ASTRONOMERS

ROBERT S. BALL



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TYCHO BRAHE.

THE MOST picturesque figure in the history of astronomy is undoubtedly that of the famous old Danish astronomer whose name stands at the head of this chapter. Tycho Brahe was alike notable for his astronomical genius and for the extraordinary vehemence of a character which was by no means perfect. His romantic career as a philosopher, and his taste for splendour as a Danish noble, his ardent friendships and his furious quarrels, make him an ideal subject for a biographer, while the magnificent astronomical work which he accomplished, has given him imperishable fame.

The history of Tycho Brahe has been admirably told by Dr. Dreyer, the accomplished astronomer who now directs the observatory at Armagh, though himself a countryman of Tycho. Every student of the career of the great Dane must necessarily look on Dr. Dreyer's work as the chief authority on the subject. Tycho sprang from an illustrious stock. His family had flourished for centuries, both in Sweden and in Denmark, where his descendants are to be met with at the present day. The astronomer's father was a privy councillor, and having filled important positions in the Danish government, he was ultimately promoted to be governor of Helsingborg Castle, where he spent the last years of his life. His illustrious son Tycho was born in 1546, and was the second child and eldest boy in a family of ten.

It appears that Otto, the father of Tycho, had a brother named George, who was childless. George, however, desired to adopt a boy on whom he could lavish his affection and to whom he could bequeath his wealth. A somewhat singular arrangement was accordingly entered into by the brothers at the time when Otto was married. It was agreed that the first son who might be born to Otto should be forthwith handed over by the parents

to George to be reared and adopted by him. In due time little Tycho appeared, and was immediately claimed by George in pursuance of the compact. But it was not unnatural that the parental instinct, which had been dormant when the agreement was made, should here interpose. Tycho's father and mother receded from the bargain, and refused to part with their son. George thought he was badly treated. However, he took no violent steps until a year later, when a brother was born to Tycho. The uncle then felt no scruple in asserting what he believed to be his rights by the simple process of stealing the first-born nephew, which the original bargain had promised him. After a little time it would seem that the parents acquiesced in the loss, and thus it was in Uncle George's home that the future astronomer passed his childhood.

When we read that Tycho was no more than thirteen years old at the time he entered the University of Copenhagen, it might be at first supposed that even in his boyish years he must have exhibited some of those remarkable talents with which he was afterwards to astonish the world. Such an inference should not, however, be drawn. The fact is that in those days it was customary for students to enter the universities at a much earlier age than is now the case. Not, indeed, that the boys of thirteen knew more than the boys of thirteen know now. But the education imparted in the universities at that time was of a much more rudimentary kind than that which we understand by university education at present. In illustration of this Dr. Dreyer tells us how, in the University of Wittenberg, one of the professors, in his opening address, was accustomed to point out that even the processes of multiplication and division in arithmetic might be learned by any student who possessed the necessary diligence.

It was the wish and the intention of his uncle that Tycho's education should be specially directed to those branches of rhetoric and philosophy which were then supposed to be a necessary preparation for the career of a statesman. Tycho, however, speedily made it plain to his teachers that though he was an ardent student, yet the things which interested him were

the movements of the heavenly bodies and not the subtleties of metaphysics.

On the 21st October, 1560, an eclipse of the sun occurred, which was partially visible at Copenhagen. Tycho, boy though he was, took the utmost interest in this event. His ardour and astonishment in connection with the circumstance were chiefly excited by the fact that the time of the occurrence of the phenomenon could be predicted with so much accuracy. Urged by his desire to understand the matter thoroughly, Tycho sought to procure some book which might explain what he so greatly wanted to know. In those days books of any kind were but few and scarce, and scientific books were especially unattainable. It so happened, however, that a Latin version of Ptolemy's astronomical works had appeared a few years before the eclipse took place, and Tycho managed to buy a copy of this book, which was then the chief authority on celestial matters. Young as the boy astronomer was, he studied hard, although perhaps not always successfully, to understand Ptolemy, and to this day his copy of the great work, copiously annotated and marked by the schoolboy hand, is preserved as one of the chief treasures in the library of the University at Prague.

After Tycho had studied for about three years at the University of Copenhagen, his uncle thought it would be better to send him, as was usual in those days, to complete his education by a course of study in some foreign university. The uncle cherished the hope that in this way the attention of the young astronomer might be withdrawn from the study of the stars and directed in what appeared to him a more useful way. Indeed, to the wise heads of those days, the pursuit of natural science seemed so much waste of good time which might otherwise be devoted to logic or rhetoric or some other branch of study more in vogue at that time. To assist in this attempt to wean Tycho from his scientific tastes, his uncle chose as a tutor to accompany him an intelligent and upright young man named Vedel, who was four years senior to his pupil, and accordingly, in 1562, we find the pair taking up their abode at the University of Leipzig.

The tutor, however, soon found that he had undertaken a most



TYCHO BRAHE.

hopeless task. He could not succeed in imbuing Tycho with the slightest taste for the study of the law or the other branches of knowledge which were then thought so desirable. The stars, and nothing but the stars, engrossed the attention of his pupil. We are told that all the money he could obtain was spent secretly in buying astronomical books and instruments. He learned the name of the stars from a little globe, which he kept hidden from Vedel, and only ventured to use during the latter's absence. No

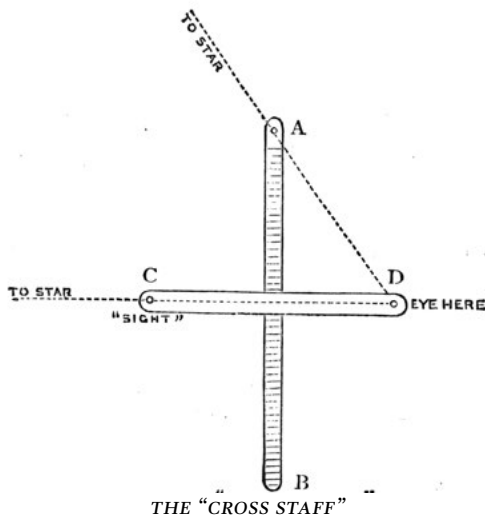
little friction was at first caused by all this, but in after years a fast and enduring friendship grew up between Tycho and his tutor, each of whom learned to respect and to love the other.

Before Tycho was seventeen he had commenced the difficult task of calculating the movements of the planets and the places which they occupied on the sky from time to time. He was not a little surprised to find that the actual positions of the planets differed very widely from those which were assigned to them by calculations from the best existing works of astronomers. With the insight of genius he saw that the only true method of investigating the movements of the heavenly bodies would be to carry on a protracted series of measurements of their places. This, which now seems to us so obvious, was then entirely new doctrine. Tycho at once commenced regular observations in such fashion as he could. His first instrument was, indeed, a very primitive one, consisting of a simple pair of compasses, which he used in this way. He placed his eye at the hinge, and then opened the legs of the compass so that one leg pointed to one star and the other leg to the other star. The compass was then brought down to a divided circle, by which means the number of degrees in the apparent angular distance of the two stars was determined.

His next advance in instrumental equipment was to provide himself with the contrivance known as the "cross-staff," which he used to observe the stars whenever opportunity offered. It must, of course, be remembered that in those days there were no telescopes. In the absence of optical aid, such as lenses afford the modern observers, astronomers had to rely on mechanical appliances alone to measure the places of the stars. Of such appliances, perhaps the most ingenious was one known before Tycho's time, which we have represented in the adjoining figure.

Let us suppose that it be desired to measure the angle between two stars, then if the angle be not too large it can be determined in the following manner. Let the rod AB be divided into inches and parts of an inch, and let another rod, CD , slide up and down along AB in such a way that the two always remain perpendicular to each other. "Sights," like those on a rifle, are

placed at A and C, and there is a pin at D. It will easily be seen that, by sliding the movable bar along the fixed one, it must always be possible when the stars are not too far apart to bring the sights into such positions that one star can be seen along DC and the other along DA. This having been accomplished, the length from A to the cross-bar is read off on the scale, and then, by means of a table previously prepared, the value of the required angular distance is obtained. If the angle between the two stars were greater than it would be possible to measure in the way already described, then there was a provision by which the pin at D might be moved along CD into some other position, so as to bring the angular distance of the stars within the range of the instrument.



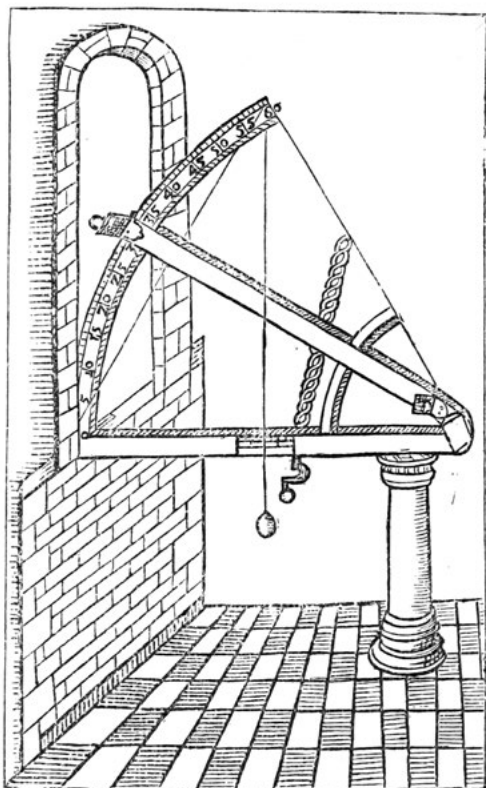
No doubt the cross-staff is a very primitive contrivance, but when handled by one so skilful as Tycho it afforded results of considerable accuracy. I would recommend any reader who may have a taste for such pursuits to construct a cross-staff for himself, and see what measurements he can accomplish with its aid.

To employ this little instrument Tycho had to evade the vigilance of his conscientious tutor, who felt it his duty to interdict all such occupations as being a frivolous waste of time. It was when Vedel was asleep that Tycho managed to escape with his

cross staff and measure the places of the heavenly bodies. Even at this early age Tycho used to conduct his observations on those thoroughly sound principles which lie at the foundation of all accurate modern astronomy. Recognising the inevitable errors of workmanship in his little instrument, he ascertained their amount and allowed for their influence on the results which he deduced. This principle, employed by the boy with his cross-staff in 1564, is employed at the present day by the Astronomer Royal at Greenwich with the most superb instruments that the skill of modern opticians has been able to construct.

After the death of his uncle, when Tycho was nineteen years of age, it appears that the young philosopher was no longer interfered with in so far as the line which his studies were to take was concerned. Always of a somewhat restless temperament, we now find that he shifted his abode to the University of Rostock, where he speedily made himself notable in connection with an eclipse of the moon on 28th October, 1566. Like every other astronomer of those days, Tycho had always associated astronomy with astrology. He considered that the phenomena of the heavenly bodies always had some significance in connection with human affairs. Tycho was also a poet, and in the united capacity of poet, astrologer, and astronomer, he posted up some verses in the college at Rostock announcing that the lunar eclipse was a prognostication of the death of the great Turkish Sultan, whose mighty deeds at that time filled men's minds. Presently news did arrive of the death of the Sultan, and Tycho was accordingly triumphant; but a little later it appeared that the decease had taken place *before* the eclipse, a circumstance which caused many a laugh at Tycho's expense.

Tycho being of a somewhat turbulent disposition, it appears that, while at the University of Rostock, he had a serious quarrel with another Danish nobleman. We are not told for certain what was the cause of the dispute. It does not, however, seem to have had any more romantic origin than a difference of opinion as to which of them knew the more mathematics. They fought, as perhaps it was becoming for two astronomers to fight, under the canopy of heaven in utter darkness at the dead of night, and



TYCHO'S "NEW STAR" SEXTANT OF 1572.
(THE ARMS, OF WALNUT WOOD, ARE ABOUT 5 1/2 FT. LONG.)

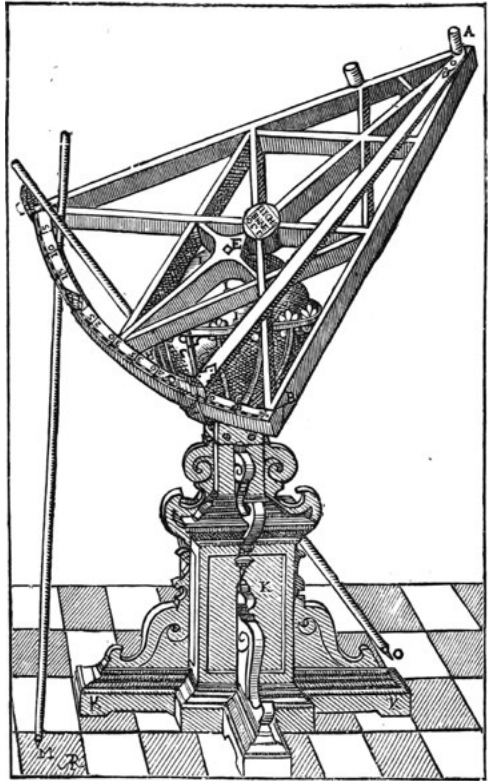
the duel was honourably terminated when a slice was taken off Tycho's nose by the insinuating sword of his antagonist. For the repair of this injury the ingenuity of the great instrument-maker was here again useful, and he made a substitute for his nose "with a composition of gold and silver." The imitation was so good that it is declared to have been quite equal to the original. Dr. Lodge, however, pointedly observes that it does not appear whether this remark was made by a friend or an enemy.

The next few years Tycho spent in various places ardently pursuing somewhat varied branches of scientific study. At one time we hear of him assisting an astronomical alderman, in the ancient city of Augsburg, to erect a tremendous wooden machine—a quadrant of 19-feet radius—to be used in observing the heavens. At another time we learn that the King of Denmark had recognised the talents of his illustrious subject, and promised to confer on him a pleasant sinecure in the shape of a canonry, which would assist him with the means for indulging his scientific pursuits. Again we are told that Tycho is pursuing experiments in chemistry with the greatest energy, nor is this so incompatible as might at first be thought with his devotion to astronomy. In those early days of knowledge the different sciences seemed bound together by mysterious bonds. Alchemists

and astrologers taught that the several planets were correlated in some mysterious manner with the several metals. It was, therefore hardly surprising that Tycho should have included a study of the properties of the metals in the programme of his astronomical work.

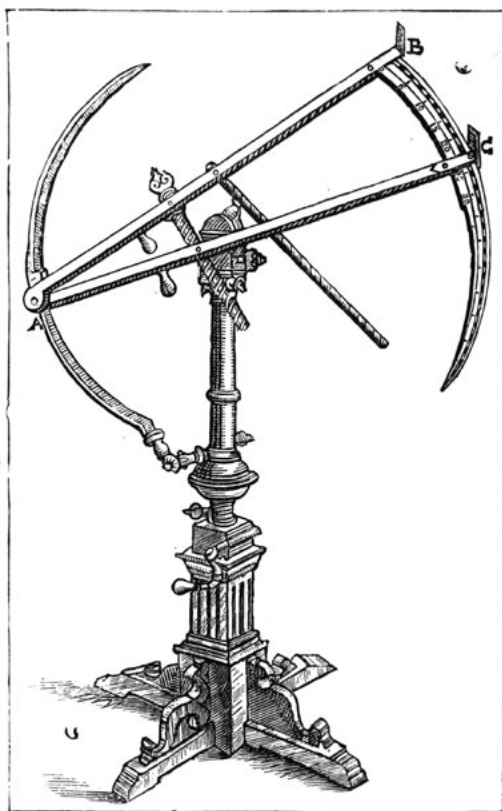
An event, however, occurred in 1572 which stimulated Tycho's astronomical labours, and started him on his life's work. On the 11th of November in that year, he was returning home to supper after a day's work in his laboratory, when he happened to lift his face to the sky,

and there he beheld a brilliant new star. It was in the constellation of Cassiopeia, and occupied a position in which there had certainly been no bright star visible when his attention had last been directed to that part of the heavens. Such a phenomenon was so startling that he found it hard to trust the evidence of his senses. He thought he must be the subject of some hallucination. He therefore called to the servants who were accompanying him, and asked them whether they, too, could see a brilliant object in the direction in which he pointed. They certainly could, and thus he became convinced that this marvellous object was no mere creation of the fancy, but a veritable celestial body—a new star of surpassing splendour which had suddenly burst forth. In these days of careful scrutiny of the heavens, we are



TYCHO'S TRIGONIC SEXTANT.

(THE ARMS, AB AND AC, ARE ABOUT 5 1/2 FT. LONG.)



TYCHO'S ASTRONOMIC SEXTANT.
(MADE OF STEEL: THE ARMS, AB, AC, MEASURE 4 FT.)

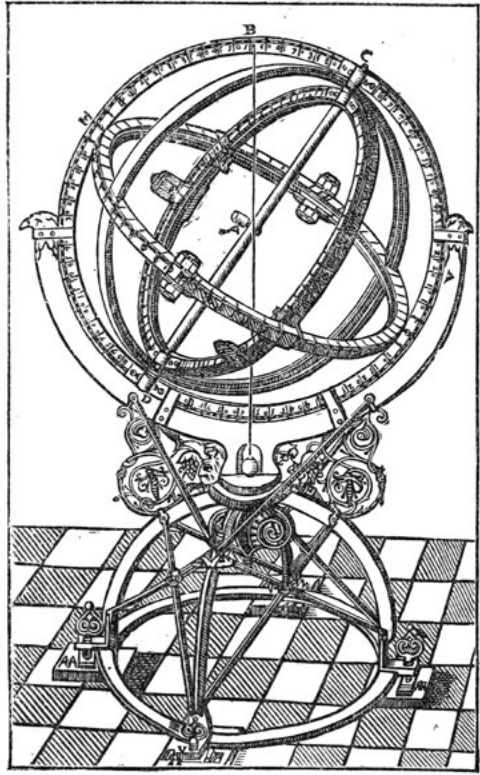
accustomed to the occasional outbreak of new stars. It is not, however, believed that any new star which has ever appeared has displayed the same phenomenal brilliance as was exhibited by the star of 1572.

This object has a value in astronomy far greater than it might at first appear. It is true, in one sense, that Tycho discovered the new star, but it is equally true, in a different sense, that it was the new star which discovered Tycho. Had it not been for this opportune apparition, it is quite possible that Tycho might have found a career in some direction less beneficial to

science than that which he ultimately pursued.

When he reached his home on this memorable evening, Tycho immediately applied his great quadrant to the measurement of the place of the new star. His observations were specially directed to the determination of the distance of the object. He rightly conjectured that if it were very much nearer to us than the stars in its vicinity, the distance of the brilliant body might be determined in a short time by the apparent changes in its distance from the surrounding points. It was speedily demonstrated that the new star could not be as near as the moon, by the simple fact that its apparent place, as compared with the stars in its neighbourhood, was not appreciably altered when it was observed be-

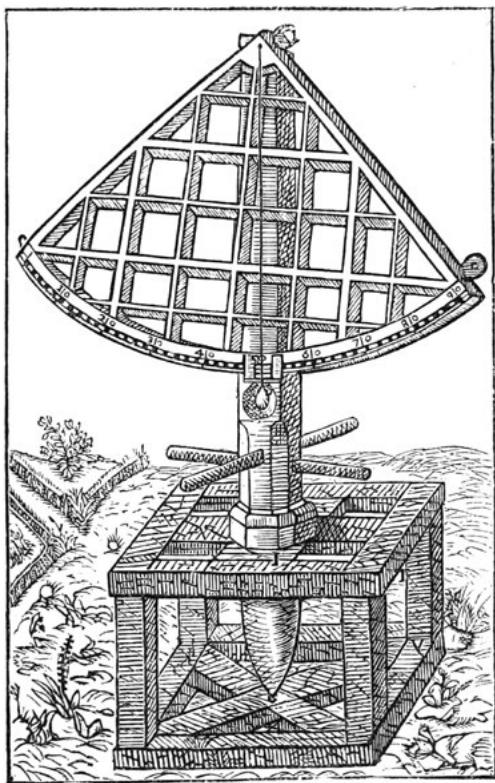
low the pole, and again above the pole at an interval of twelve hours. Such observations were possible, inasmuch as the star was bright enough to be seen in full daylight. Tycho thus showed conclusively that the body was so remote that the diameter of the earth bore an insignificant ratio to the star's distance. His success in this respect is the more noteworthy when we find that many other observers, who studied the same object, came to the erroneous conclusion that the new star was quite as near as the moon, or even much nearer. In fact, it



TYCHO'S EQUATORIAL ARMILLARY.
(THE MERIDIAN CIRCLE, E B C A D, MADE OF SOLID STEEL, IS
NEARLY 6 FT. IN DIAMETER.)

may be said, that with regard to this object Tycho discovered everything which could possibly have been discovered in the days before telescopes were invented. He not only proved that the star's distance was too great for measurement, but he showed that it had no proper motion on the heavens. He recorded the successive changes in its brightness from week to week, as well as the fluctuations in hue with which the alterations in lustre were accompanied.

It seems, nowadays, strange to find that such thoroughly scientific observations of the new star as those which Tycho made, possessed, even in the eyes of the great astronomer himself, a profound astrological significance. We learn from Dr. Dreyer that, in Tycho's opinion, "the star was at first like Venus and Jupiter, and



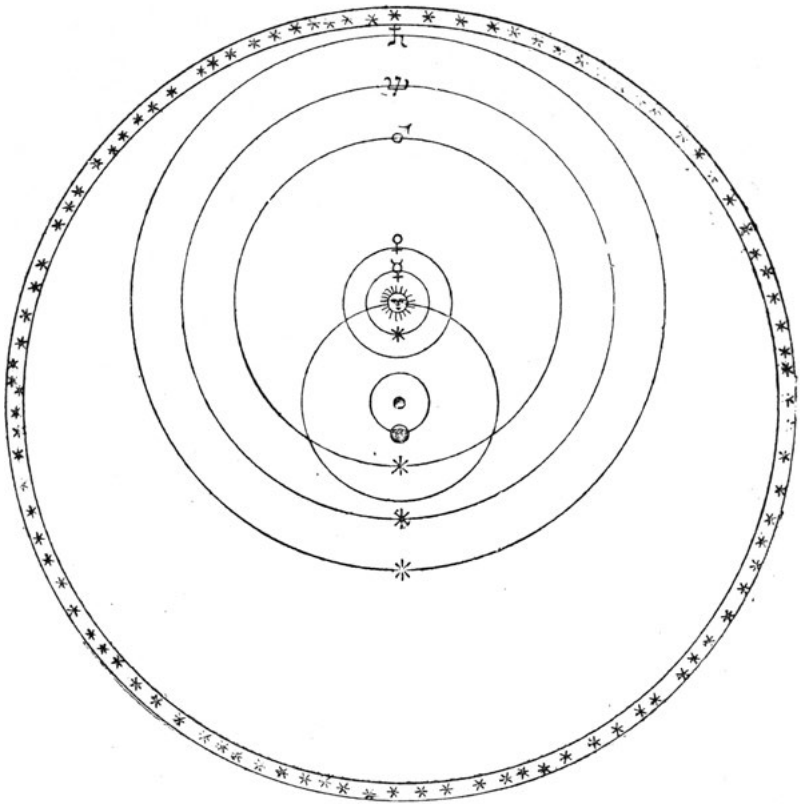
THE GREAT AUGSBURG QUADRANT.
(BUILT OF HEART OF OAK; THE RADII ABOUT 19 FT.)

its effects will therefore, first, be pleasant; but as it then became like Mars, there will next come a period of wars, seditions, captivity, and death of princes, and destruction of cities, together with dryness and fiery meteors in the air, pestilence, and venomous snakes. Lastly, the star became like Saturn, and thus will finally come a time of want, death, imprisonment, and all kinds of sad things!" Ideas of this kind were, however, universally entertained. It seemed, indeed, obvious to learned men of that period that such an apparition must forebode startling events. One of

the chief theories then held was, that just as the Star of Bethlehem announced the first coming of Christ, so the second coming, and the end of the world, was heralded by the new star of 1572.

The researches of Tycho on this object were the occasion of his first appearance as an author. The publication of his book was however, for some time delayed by the urgent remonstrances of his friends, who thought it was beneath the dignity of a nobleman to condescend to write a book. Happily, Tycho determined to brave the opinion of his order; the book appeared, and was the first of a series of great astronomical productions from the same pen.

The fame of the noble Dane being now widespread, the King of Denmark entreated him to return to his native country, and

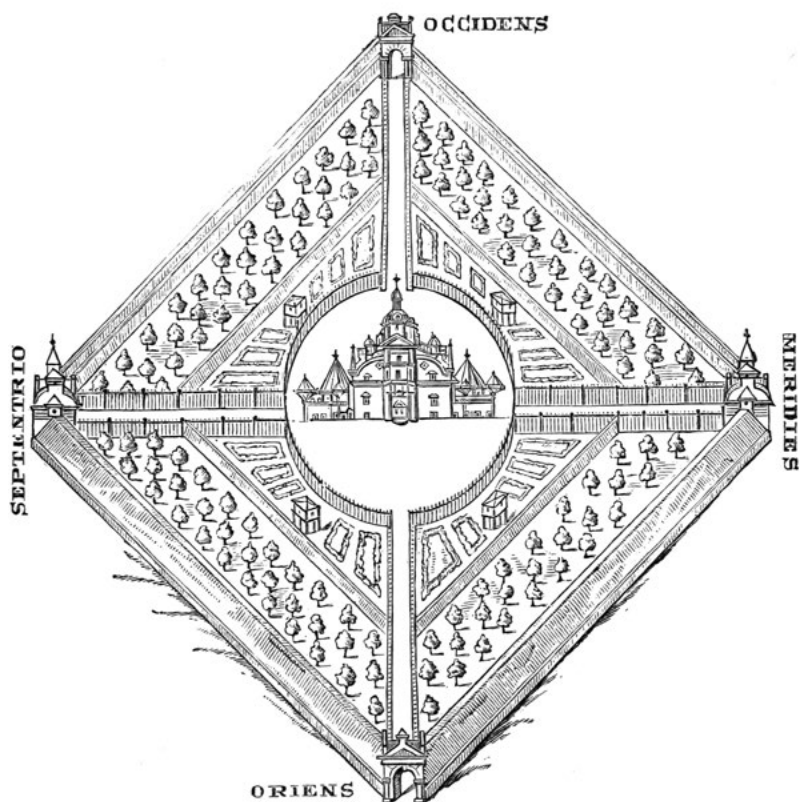


TYCHO'S "NEW SCHEME OF THE TERRESTRIAL SYSTEM," 1577.

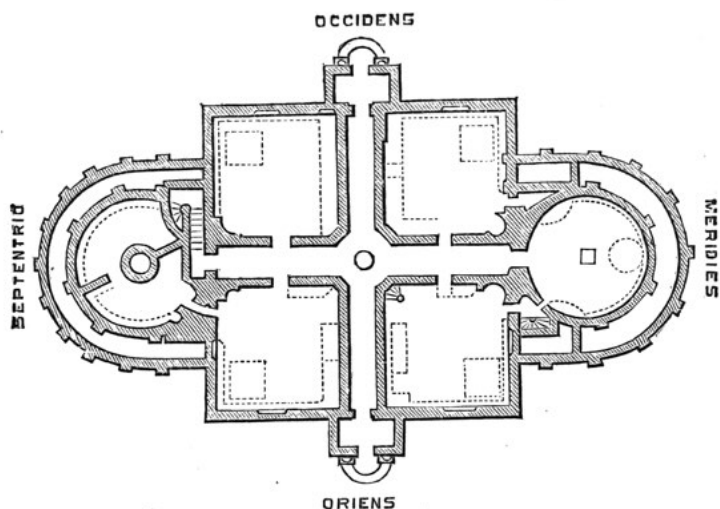
to deliver a course of lectures on astronomy in the University of Copenhagen. With some reluctance he consented, and his introductory oration has been preserved. He dwells, in fervent language, upon the beauty and the interest of the celestial phenomena. He points out the imperative necessity of continuous and systematic observation of the heavenly bodies in order to extend our knowledge. He appeals to the practical utility of the science, for what civilised nation could exist without having the means of measuring time? He sets forth how the study of these beautiful objects "exalts the mind from earthly and trivial things to heavenly ones;" and then he winds up by assuring them that "a special use of astronomy is that it enables us to draw conclusions from the movements in the celestial regions as to human fate."

An interesting event, which occurred in 1572, distracted Tycho's attention from astronomical matters. He fell in love. The young girl on whom his affections were set appears to have sprung from humble origin. Here again his august family friends sought to dissuade him from a match they thought unsuitable for a nobleman. But Tycho never gave way in anything. It is suggested that he did not seek a wife among the highborn dames of his own rank from the dread that the demands of a fashionable lady would make too great an inroad on the time that he wished to devote to science. At all events, Tycho's union seems to have been a happy one, and he had a large family of children; none of whom, however, inherited their father's talents.

Tycho had many scientific friends in Germany, among whom his work was held in high esteem. The treatment that he there met



URANIBORG AND ITS GROUNDS.



GROUND-PLAN OF THE OBSERVATORY.

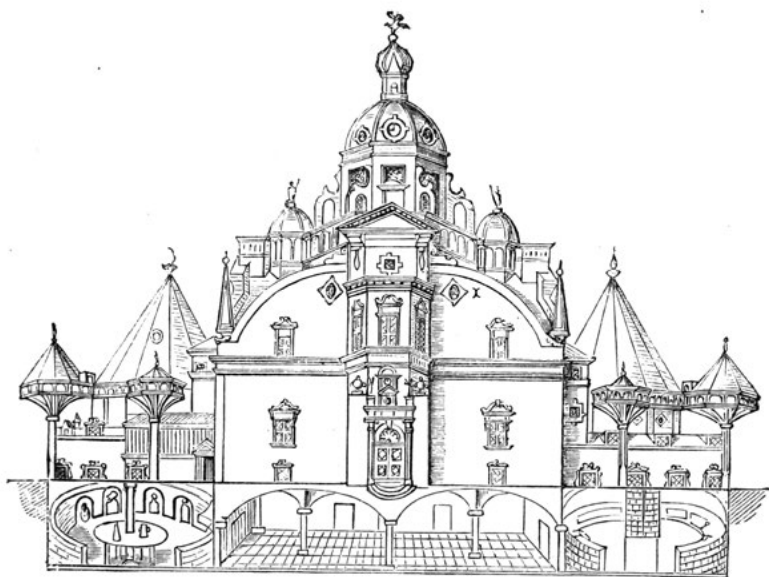
with seemed to him so much more encouraging than that which he received in Denmark that he formed the notion of emigrating to Basle and making it his permanent abode. A whisper of this intention was conveyed to the large-hearted King of Denmark, Frederick II. He wisely realised how great would be the fame which would accrue to his realm if he could induce Tycho to remain within Danish territory and carry on there the great work of his life. A resolution to make a splendid proposal to Tycho was immediately formed. A noble youth was forthwith despatched as a messenger, and ordered to travel day and night until he reached Tycho, whom he was to summon to the king. The astronomer was in bed on the morning of 11th February, 1576, when the message was delivered. Tycho, of course, set



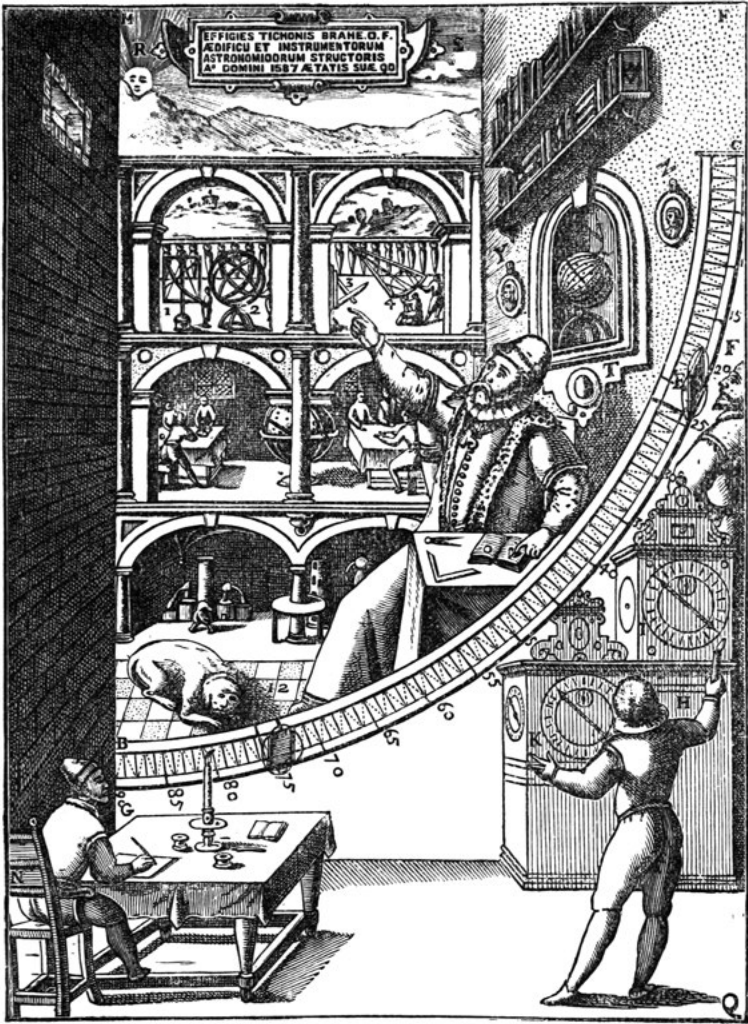
EFFIGY ON TYCHO'S TOMB AT PRAGUE.

off at once and had an audience of the king at Copenhagen. The astronomer explained that what he wanted was the means to pursue his studies unmolested, whereupon the king offered him the Island of Hven, in the Sound near Elsinore. There he would enjoy all the seclusion that he could desire. The king further promised that he would provide the funds necessary for building a house and for founding the greatest observatory that had ever yet been reared for the study of the heavens. After due deliberation and consultation with his friends, Tycho accepted the king's offer. He was forthwith granted a pension, and a deed was drawn up formally assigning the Island of Hven to his use all the days of his life.

The foundation of the famous castle of Uraniborg was laid on 30th August, 1576. The ceremony was a formal and imposing one, in accordance with Tycho's ideas of splendour. A party of scientific friends had assembled, and the time had been chosen so that the heavenly bodies were auspiciously placed. Libations of costly wines were poured forth, and the stone was placed with due solemnity. The picturesque character of this wonderful temple for the study of the stars may be seen in the figures



THE OBSERVATORY OF URANIBORG, ISLAND OF HVEN.



TYCHO'S MURAL QUADRANT PICTURE, URANIBORG.

with which this chapter is illustrated.

One of the most remarkable instruments that has ever been employed in studying the heavens was the mural quadrant which Tycho erected in one of the apartments of Uraniborg. By its means the altitudes of the celestial bodies could be observed with much greater accuracy than had been previously attainable. This wonderful contrivance is represented on the preceding

page. It will be observed that the walls of the room are adorned by pictures with a lavishness of decoration not usually to be found in scientific establishments.

A few years later, when the fame of the observatory at Hven became more widely spread, a number of young men flocked to Tycho to study under his direction. He therefore built another observatory for their use in which the instruments were placed in subterranean rooms of which only the roofs appeared above the ground. There was a wonderful poetical inscription over the entrance to this underground observatory, expressing the astonishment of Urania at finding, even in the interior of the earth, a cavern devoted to the study of the heavens. Tycho was indeed always fond of versifying, and he lost no opportunity of indulging this taste whenever an occasion presented itself.

Around the walls of the subterranean observatory were the pictures of eight astronomers, each with a suitable inscription—one of these of course represented Tycho himself, and beneath were written words to the effect that posterity should judge of his work. The eighth picture depicted an astronomer who has not yet come into existence. Tychonides was his name, and the inscription presses the modest hope that when he does appear he will be worthy of his great predecessor. The vast expenses incurred in the erection and the maintenance of this strange establishment were defrayed by a succession of grants from the royal purse.

For twenty years Tycho laboured hard at Uraniborg in the pursuit of science. His work mainly consisted in the determination of the places of the moon, the planets, and the stars on the celestial sphere. The extraordinary pains taken by Tycho to have his observations as accurate as his instruments would permit, have justly entitled him to the admiration of all succeeding astronomers. His island home provided the means of recreation as well as a place for work. He was surrounded by his family, troops of friends were not wanting, and a pet dwarf seems to have been an inmate of his curious residence. By way of change from his astronomical labours he used frequently to work with his students in his chemical laboratory. It is not

indeed known what particular problems in chemistry occupied his attention. We are told, however, that he engaged largely in the production of medicines, and as these appear to have been dispensed gratuitously there was no lack of patients.

Tycho's imperious and grasping character frequently brought him into difficulties, which seem to have increased with his advancing years. He had ill-treated one of his tenants on Hven, and an adverse decision by the courts seems to have greatly exasperated the astronomer. Serious changes also took place in his relations to the court at Copenhagen. When the young king was crowned in 1596, he reversed the policy of his predecessor with reference to Hven. The liberal allowances to Tycho were one after another withdrawn, and finally even his pension was stopped. Tycho accordingly abandoned Hven in a tumult of rage and mortification. A few years later we find him in Bohemia a prematurely aged man, and he died on the 24th October, 1601.