Chapter One

WHEN THE WORLD WAS YOUNG.

THREE thousand years ago men believed the earth was supported on gigantic pillars. The sun rose in the east every morning, passed overhead, and sank in the west every evening; then it was supposed to pass between the pillars under the earth during the night, to re-appear in the east again next morning.

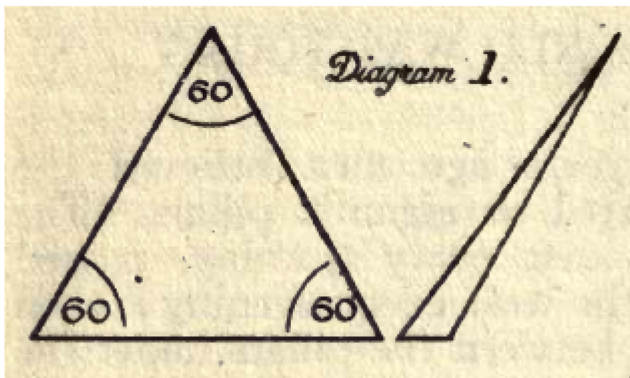
This idea of the universe was upset by Pythagoras some five hundred years before the birth of Christ, when he began to teach that the earth was round like a ball, with the sun going round it daily from east to west; and this theory was already about four hundred years old when Hipparchus, the great Greek scientist, took it up and developed it in the second century, B.C.

Hipparchus may be ranked among the score or so of the greatest scientists who have ever lived. He was the inventor of the system of measuring the distance to far off objects by triangulation, or trigonometry, which is used by our surveyors at the present day, and which is the basis of all the methods of measuring distance which are used in modern astronomy. Using this method of his own invention, he measured from point to point on the surface of the earth, and so laid the foundation of our present systems of geography, scientific map-making and navigation.

It would be well for those who are disposed to underestimate the value of new ideas to consider how much the world owes to the genius of Hipparchus, and to try to conceive how we could have made progress as we know it—without him.

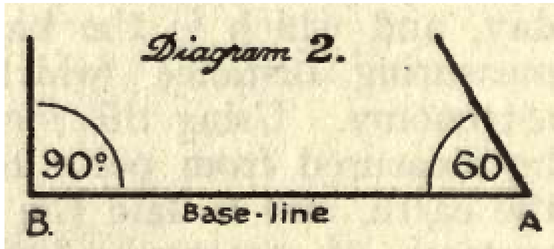
TRIANGULATION.

The principles of triangulation are very simple, but because it will be necessary—as I proceed—to show how modern astronomers have departed from them, I will explain them in detail.



Every figure made up of three connected lines is a tri— or three-angle, quite regardless of the length of any of its sides. The triangle differs from all other shapes or figures in this:—that the value of its three angles, when added together, admits of absolutely no variation; they always equal 180 degrees; while —on the other hand—all other figures contain angles of 360 degrees or more. The triangle alone contains 180 degrees, and no other figure can be used for measuring distance. There is no alternative whatever, and therein lies its value.

It follows, then, that if we know the value of any two of the angles in a triangle we can readily find the value of the third, by simply adding together the two known angles and subtracting the result from 180. The value of the third angle is necessarily the remainder. Thus in our example (diagram 2) an angle of 90 degrees plus an angle of 60 equals 150, which shows that the angle at the distant object—or apex of the triangle— must be 30.



Now if we know the length of the base-line A—B, in feet, yards, kilometres or miles, (to be ascertained by actual measurement), and also know the value of the two angles which indicate the direction of a distant object as seen from A. and B., we can readily complete the triangle and so find the length of its sides. In this way, we can measure the height of a tree or church steeple from the ground level, or find the distance to a ship or lighthouse from the shore.

The reader will perceive that to obtain any measurement by triangulation it is absolutely necessary to have a base-line, and to know its length exactly. It is evident, also, that the length of the base-line must bear a reasonable proportion to the dimensions of the triangle intended; that is to say,—that the greater the distance of the object under observation the longer the base-line should be in order to secure an accurate measurement.

A little reflection will now enable the reader to realize the difficulties which confronted Hipparchus when he attempted to measure the distance to the stars.

It was before the Roman Conquest, when the geography of the earth was but little known, and there were none of the rapid means of travelling and communication which are at our disposal to-day. Moreover, it was in the very early days of astronomy, when there were few—if any—who could have helped Hipparchus in his work, while if he was to make a successful triangulation to any of the stars it was essential that he should have a base-line thousands of miles in length, with an observer at each end; both taking observations to the same star at precisely the same second of time.

The times in which he lived did not provide the conveniences which were necessary for his undertaking, the conditions were altogether impossible, and so it is not at all surprising that he failed to get any triangulation to the stars. As a result, he came to the conclusion that they must be too far off to be measured, and said "the heavenly bodies are infinitely distant."

Such was the extraordinary conclusion arrived at by Hipparchus, and that statement of his lies at the root of astronomy, and has led its advocates into an amazing series of blunders from that day to this. The whole future of the science of astronomy was affected by Hipparchus when he said "the heavenly bodies are infinitely distant," and now, when I say that it is not so, the fate of astronomy again hangs in the balance. It is a momentous issue which will be decided in due course within these pages.

The next astronomer of special note is Sosigenes, who designed the Julian Calendar in the reign of Caesar. He saw no fault in the theories of Hipparchus, but handed them on to Ptolemy, an Egyptian astronomer of very exceptional ability, who lived in the second century A.D.

Taking up the theories of his great Greek predecessor after three hundred years, Ptolemy accepted them without question as the work of a master; and developed them. Singularly gifted as he was to carry on the work of Hipparchus, his genius was of a different order, for while the Greek was the more original thinker and inventor the Egyptian was the more accomplished artist in detail; and the more skillful in the art of teaching. Undoubtedly, he was eminently fitted to be the disciple of Hipparchus, and yet for that very reason he was the less likely to suspect, or to discover, any error in the master's work.

In the most literal sense he carried on that work, built upon it, elaborated it, and established the Ptolemaic System of astronomy so ably that it stood unchallenged and undisputed for fourteen hundred years; and during all those centuries the accepted theory of the universe was that the earth was stationary, while the sun, moon, stars and planets revolved around it daily.

Having accepted the theories of Hipparchus in the bulk, it was but natural that Ptolemy should fail to discover the error I have pointed out, though even had it been otherwise it would have been as difficult for him to make a triangulation to the stars in the second century A.D., as it had been for the inventor of triangulation himself three hundred years earlier. However, it is a fact that he allowed the theory that "the heavenly bodies are infinitely distant" to remain unquestioned; and that was an error of omission which was ultimately to bring about the downfall of his own Ptolemaic system of astronomy.

Ptolemaic System of Astronomy

Chapter Two
COPERNICUS AND GALILEO.

PTOLEMY'S was still the astronomy of the world when Columbus discovered America, 1492, but there was living at that time—in the little town of Franenburg, in Prussia—a youth of 18, who was destined in later years to overthrow the astronomy of Hipparchus and Ptolemy, and to become himself the founder of a new theory which has since been universally accepted in its stead; Nicholas Copernicus.

It is to be remembered that at that time the earth was believed to stand still, while the sun, moon, planets and stars moved round it daily from east to west, as stated by Ptolemy; but this did not seem reasonable to Copernicus. He was a daring and original thinker, willing to challenge any theory—be it ever so long established—if it did not appear logical to him, and he contended that it was unreasonable to suppose that all the vast firmament of heavenly bodies revolved around this relatively little earth, but, on the contrary, it was more reasonable to believe that the earth itself rotated and revolved around an enormous sun, moving within a firmament of stars that were fixed in infinite space; for in either case the appearance of the heavens would be the same to an observer on the surface of the earth.

This was the idea that inspired Nicholas Copernicus to labour for twenty-seven years developing the Heliocentric Theory of the universe, and in compiling the book that made him famous:— "De Revolutionibus Orbium Coelestium," which was published in the last year of his life: 1543.

And now it is for us to very carefully study this fundamental idea of the Heliocentric theory, for there is an error in it.

Ptolemy had made it appear that the sun and stars revolved around a stationary earth, but Copernicus advanced the theory that it was the earth which revolved around a stationary sun, while the stars were fixed; and either of these entirely opposite theories gives an equally satisfactory explanation of the appearance of the sun by day and the stars by night. *Copernicus did not produce any newly-discovered fact to prove that Ptolemy was wrong, neither did he offer any proof that he himself was right*, but worked out his system to show that he could account for all the appearances of the heavens quite as well as the Egyptian had done, though working on an entirely different hypothesis; and offered his new Heliocentric Theory as an alternative.

He argued that it was more reasonable to conceive the earth to be revolving round the sun than it was to think of the sun revolving round the earth, because it was more reasonable that the smaller body should move round the greater. And that is good logic.

We see that Copernicus recognised the physical law that the lesser shall be governed by the greater, and that is the pivot upon which the whole of his astronomy turns; but it is perfectly clear that in building up his theories he assumed the earth to be much smaller than the sun, and also smaller than the stars; and that was pure assumption unsupported by any kind of fact. In the absence of any proof as to whether the earth or the sun was the greater of the two, and having only the evidence of the senses to guide him, it would have been more reasonable had he left astronomy as it was,