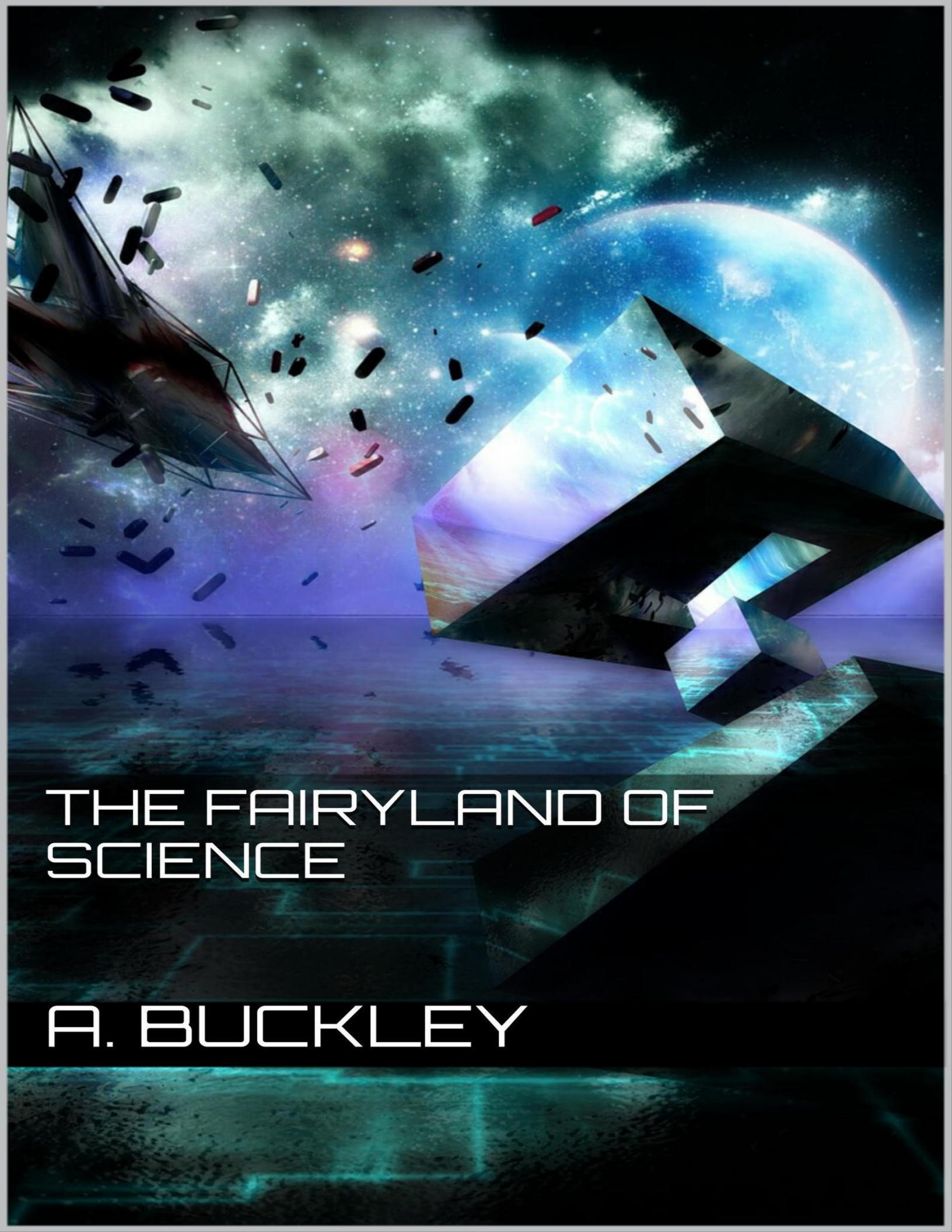
THE FAIRYLAND OF SCIENCE
A. BUCKLEY

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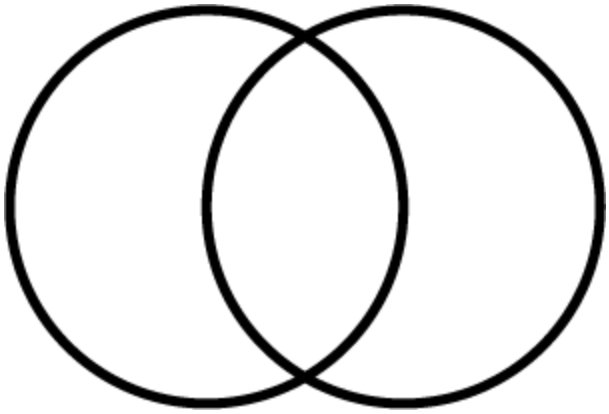
Arabella B. Buckley

PREFACE



The present volume is chiefly intended for those of my young friends who have read, and been interested in, the *Fairyland of Science* . It travels over a wide field, pointing out a few of the marvellous facts which can be studied and enjoyed by the help of optical instruments. It will be seen at a glance that any one of the subjects dealt with might be made the study of a lifetime, and that the little information given in each lecture is only enough to make the reader long for more.

In these days, when moderate-priced instruments and good books and lectures are so easily accessible, I hope some eager minds may be thus led to take up one of the branches of science opened out to us by magic glasses; while those who go no further will at least understand something of the hitherto unseen world which is now being studied by their help.

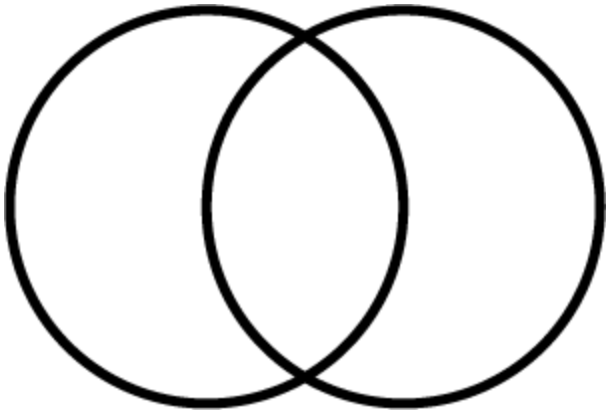
The two last lectures wander away from this path, and yet form a natural conclusion to the Magician's lectures to his young Devonshire lads. They have been published before, one in the *Youth's Companion* of Boston, U.S., and the other in *Atalanta* , in which the essay on Fungi also appeared in a shorter form. All three lectures have, however, been revised and fully illustrated, and I trust that the volume, as

a whole, may prove a pleasant Christmas companion.

For the magnificent photograph of Orion's nebula, forming the Frontispiece, I am indebted to the courtesy of Mr. Isaac Roberts, F.R.A.S., who most kindly lent me the plate for reproduction; and I have had the great good fortune to obtain permission from MM. Henri of the Paris Observatory to copy the illustration of the Lunar Apennines from a most beautiful and perfect photograph of part of the moon, taken by them only last March. My cordial thanks are also due to Mr. A. Cottam, F.R.A.S., for preparing the plate of coloured double stars, and to my friend Mr. Knobel, Hon. Sec. of the R.A.S., for much valuable assistance; to Mr. James Geikie for the loan of some illustrations from his *Geology* ; and to Messrs. Longman for permission to copy Herschel's fine drawing of Copernicus.

With the exception of these illustrations and a few others, three of which were kindly given me by Messrs. Macmillan, all the woodcuts have been drawn and executed under the superintendence of Mr. Carreras, jun., who has made my task easier by the skill and patience he has exercised under the difficulties incidental to receiving instructions from a distance.

CHAPTER I



THE MAGICIAN'S CHAMBER BY MOONLIGHT

he full moon was shining in all its splendour one lovely August night, as the magician sat in his turret chamber bathed in her pure white beams, which streamed upon him through the open shutter in the wooden dome above. It is true a faint gleam of warmer light shone from below through the open door, for this room was but an offshoot at the top of the building, and on looking down the turret stairs a lecture-room might be seen below where a bright light was burning. Very little, however, of this warm glow reached the magician, and the implements of his art around him looked like weird gaunt skeletons as they cast their long shadows across the floor in the moonlight.

The small observatory, for such it was, was a circular building with four windows in the walls, and roofed with a wooden dome, so made that it could be shifted round and round by pulling certain cords. One section of this dome was a shutter, which now stood open, and the strip, thus laid bare to the night, was so turned as to face that part of the sky along which the moon was moving. In the centre of

the room, with its long tube directed towards the opening, stood the largest magic glass, the Telescope, and in the dead stillness of the night, could be heard distinctly the tick-tick of the clockwork, which kept the instrument pointing to the face of the moon, while the room, and all in it, was being carried slowly and steadily onwards by the earth's rotation on its axis. It was only a moderate-sized instrument, about six feet long, mounted on a solid iron pillar firmly fixed to the floor and fitted with the clockwork, the sound of which we have mentioned; yet it looked like a giant as the pale moonlight threw its huge shadow on the wall behind and the roof above.

Far away from this instrument in one of the windows, all of which were now closed with shutters, another instrument was dimly visible. This was a round iron table, with clawed feet, and upon it, fastened by screws, were three tubes, so arranged that they all pointed towards the centre of the table, where six glass prisms were arranged in a semicircle, each one fixed on a small brass tripod. A strange uncanny-looking instrument this, especially as the prisms caught the edge of the glow streaming up the turret stair, and shot forth faint beams of coloured light on the table below them. Yet the magician's pupils thought it still more uncanny and mysterious when their master used it to read the alphabet of light, and to discover by vivid lines even the faintest trace of a metal otherwise invisible to mortal eye.

For this instrument was the Spectroscope, by which he could break up rays of light and make them tell him from what substances they came. Lying around it were other curious prisms mounted in metal rims and fitted with tubes and many strange devices, not to be understood by the uninitiated, but magical in their effect when fixed on to the telescope and used to break up the light of distant stars and nebulæ.

Compared with these mysterious glasses the Photographic

Camera, standing in the background, with its tall black covering cloth, like a hooded monk, looked comparatively natural and familiar, yet it, too, had puzzling plates and apparatus on the table near it, which could be fitted on to the telescope, so that by their means pictures might be taken even in the dark night, and stars, invisible with the strongest lens, might be forced to write their own story, and leave their image on the plate for after study.

All these instruments told of the magician's power in unveiling the secrets of distant space and exploring realms unknown, but in another window, now almost hidden in the shadow, stood a fourth and highly-prized helpmate, which belonged in one sense more to our earth, since everything examined by it had to be brought near, and lie close under its magnifying-glass. Yet the Microscope too could carry its master into an unseen world, hidden to mortal eye by minuteness instead of by distance. If in the stillness of night the telescope was his most cherished servant and familiar friend, the microscope by day opened out to him the fairyland of nature.

As he sat on his high pedestal stool on this summer night with the moonlight full upon him, his whole attention was centred on the telescope, and his mind was far away from that turret-room, wandering into the distant space brought so near to him; for he was waiting to watch an event which brought some new interest every time it took place—a total eclipse of the moon. To-night he looked forward to it eagerly, for it happened that, just as the moon would pass into the shadow of our earth, it would also cross directly in front of a star, causing what is known as an "occultation" of the star, which would disappear suddenly behind the rim of the dark moon, and after a short time flash out on the other side as the satellite went on its way.

How he wished as he sat there that he could have shown this sight to all the eager lads whom he was teaching to handle and love his magic glasses. For this magician was

not only a student himself, he was a rich man and the Founder and Principal of a large public school for boys of the artisan class. He had erected a well-planned and handsome building in the midst of the open country, and received there, on terms within the means of their parents, working-lads from all parts of England, who, besides the usual book-learning, received a good technical education in all its branches. And, while he left to other masters the regular school lessons, he kept for himself the intense pleasure of opening the minds of these lads to the wonders of God's universe around them.

You had only to pass down the turret stairs, into the large science class-room below, to see at once that a loving hand and heart had furnished it. Not only was there every implement necessary for scientific work, but numerous rough diagrams covering the walls showed that labour as well as money had been spent in decorating them. It was a large oblong room, with four windows to the north, and four to the south, in each of which stood a microscope with all the tubes, needles, forceps, knives, etc., necessary for dissecting and preparing objects; and between the windows were open shelves, on which were ranged chemicals of various kinds, besides many strange-looking objects in bottles, which would have amused a trained naturalist, for the lads collected and preserved whatever took their fancy. On some of the tables were photographic plates laid ready for printing off; on others might be seen drawings of the spectrum, made from the small spectroscope fixed at one end of the room; on others lay small direct spectroscopes which the lads could use for themselves. But nowhere was a telescope to be seen. This was not because there were none, for each table had its small hand-telescope, cheap but good. The truth is that each of these instruments had been spirited away into the dormitories that night, and many heads were lying awake on their pillows, listening for

the strike of the clock to spring out and see the eclipse begin.

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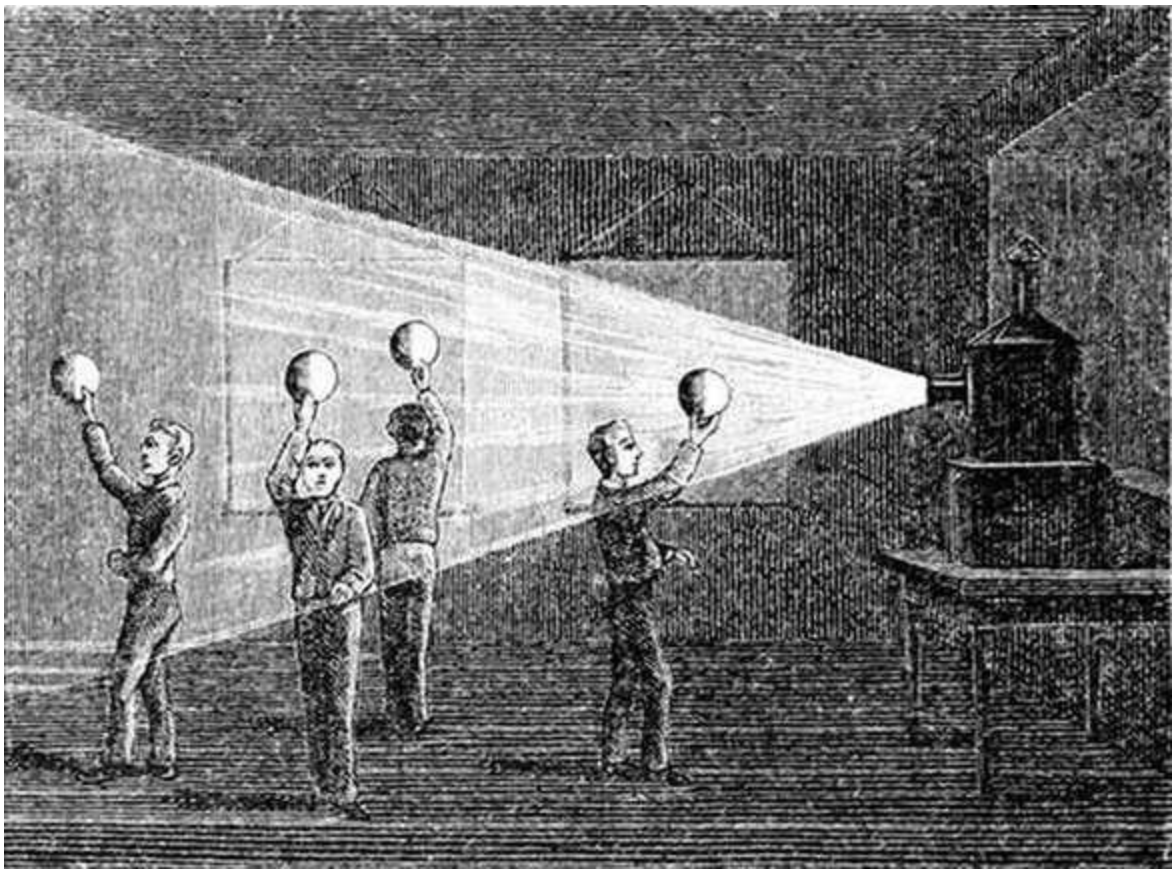

ig. 1. A boy illustrating the phases of the moon.

A mere glance round the room showed that the moon had been much studied lately. On the black-board was drawn a rough diagram, showing how a boy can illustrate for himself the moon's journey round the earth, by taking a ball and holding it a little above his head at arm's length, while he turns slowly round on his heel in a darkened room before a lighted lamp, or better still before the lens of a magic lantern (Fig. 1). The lamp or lens then represents the sun, the ball is the moon, the boy's head is the earth. Beginning with the ball between him and the source of light, but either a little above, or a little below the direct

line between his eye and it, he will see only the dark side of the ball, and the moon will be on the point of being "new." Then as he turns slowly, a thin crescent of light will creep over the side nearest the sun, and by degrees encroach more and more, so that when he has turned through one quarter of the round half the disc will be light. When he has turned another quarter, and has his back to the sun, a full moon will face him. Then as he turns on through the third quarter a crescent of darkness creeps slowly over the side away from the sun, and gradually the bright disc is eaten away by shadow till at the end of the third quarter half the disc again only is light; then, when he has turned through another quarter and completed the circle, he faces the light again and has a dark moon before him. But he must take care to keep the moon a little above or a little below his eye at new and full moon. If he brings it exactly on a line with himself and the light at new moon, he will shut off the light from himself and see the dark body of the ball against the light, causing an *eclipse* of the sun; while if he does the same at full moon his head will cast a shadow on the ball causing an *eclipse* of the moon.

There were other diagrams showing how and why such eclipses do really happen at different times in the moon's path round the earth; but perhaps the most interesting of all was one he had made to explain what so few people understand, namely, that though the moon describes a complete circle round our earth every month, yet she does not describe a circle in space, but a wavy line inwards and outwards across the earth's path round the sun. This is because the earth is moving on all the while, carrying the moon with it, and it is only by seeing it drawn before our eyes that we can realise how it happens.

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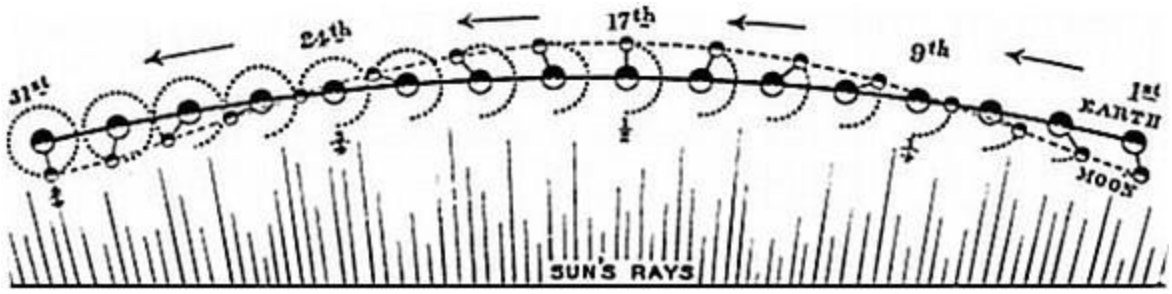

ig. 2. Diagram showing the moon's course during one month. The moon and the earth are both moving onwards in the direction of the arrows. The earth moves along the dark line, the moon along the interrupted line - - - -. The dotted curved line · · · · shows the circle gradually described by the moon round the earth as they move onwards.

Thus suppose, in order to make the dates as simple as possible, that there is a new moon on the 1st of some month. Then by the 9th (or roughly speaking in 7¾ days) the moon will have described a quarter of a circle round the earth as shown by the dotted line (Fig. 2), which marks her position night after night with regard to us. Yet because she is carried onwards all the while by the earth, she will really have passed along the interrupted line - - - - between us and the sun. During the next week her quarter of a circle will carry her round behind the earth, so that we see her on the 17th as a full moon, yet her actual movement has been onwards along the interrupted line on the farther side of the earth. During the third week she creeps round another quarter of a circle so as to be in advance of the earth on its yearly journey round the sun, and reaches the end of her third quarter on the 24th. In her last quarter she gradually passes again between the earth and the sun; and though, as regards the earth, she appears to be going back round to the same place where she was at the beginning of the month, and on the 31st is again a dark new moon, yet

she has travelled onwards exactly as much as we have, and therefore has really not described a circle in the *heavens* but a wavy line.

Near to this last diagram hung another, well loved by the lads, for it was a large map of the *face* of the moon, that is of the side which is *always* turned towards us, because the moon turns once on her axis during the month that she is travelling round the earth. On this map were marked all the different craters, mountains, plains and shining streaks which appear on the moon's face; while round the chart were pictures of some of these at sunrise and sunset on the moon, or during the long day of nearly a fortnight which each part of the face enjoys in its turn.

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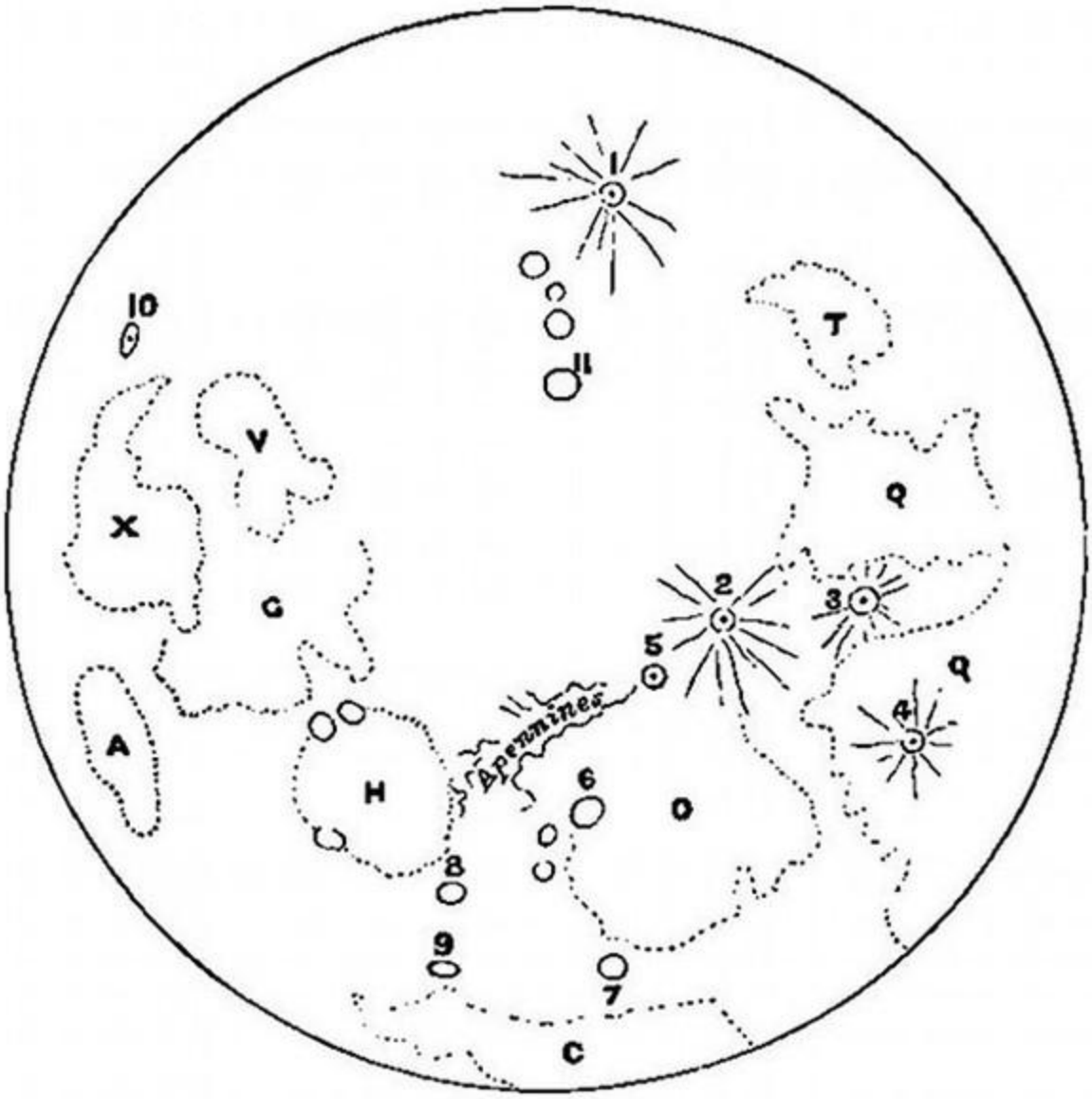

ig. 3. Chart of the moon.
Craters—

1 Tycho.	2 Copernicus.	3 Kepler.	4 Aristarchus.
5 Eratosthenes.	6 Archimedes.	7 Plato.	8 Eudoxus.
9 Aristotle.	10 Petavius.	11 Ptolemy.	

Grey plains formerly believed to be seas—

A Mare Crisium.	O Mare Imbrium.
C —— Frigoris.	Q Oceanus Procellarum.
G —— Tranquillitatis.	X Mare Fœcunditatis.
H —— Serenitatis.	T —— Humorum.

By studying this map, and the pictures, they were able, even in their small telescopes, to recognise Tycho and Copernicus, and the mountains of the moon, after they had once grown accustomed to the strange changes in their appearance which take place as daylight or darkness creeps over them. They could not however pick out more than some of the chief points. Only the magician himself knew every crater and ridge under all its varying lights, and now, as he waited for the eclipse to begin, he turned to a lad who stood behind him, almost hidden in the dark shadow—the one fortunate boy who had earned the right to share this night's work.
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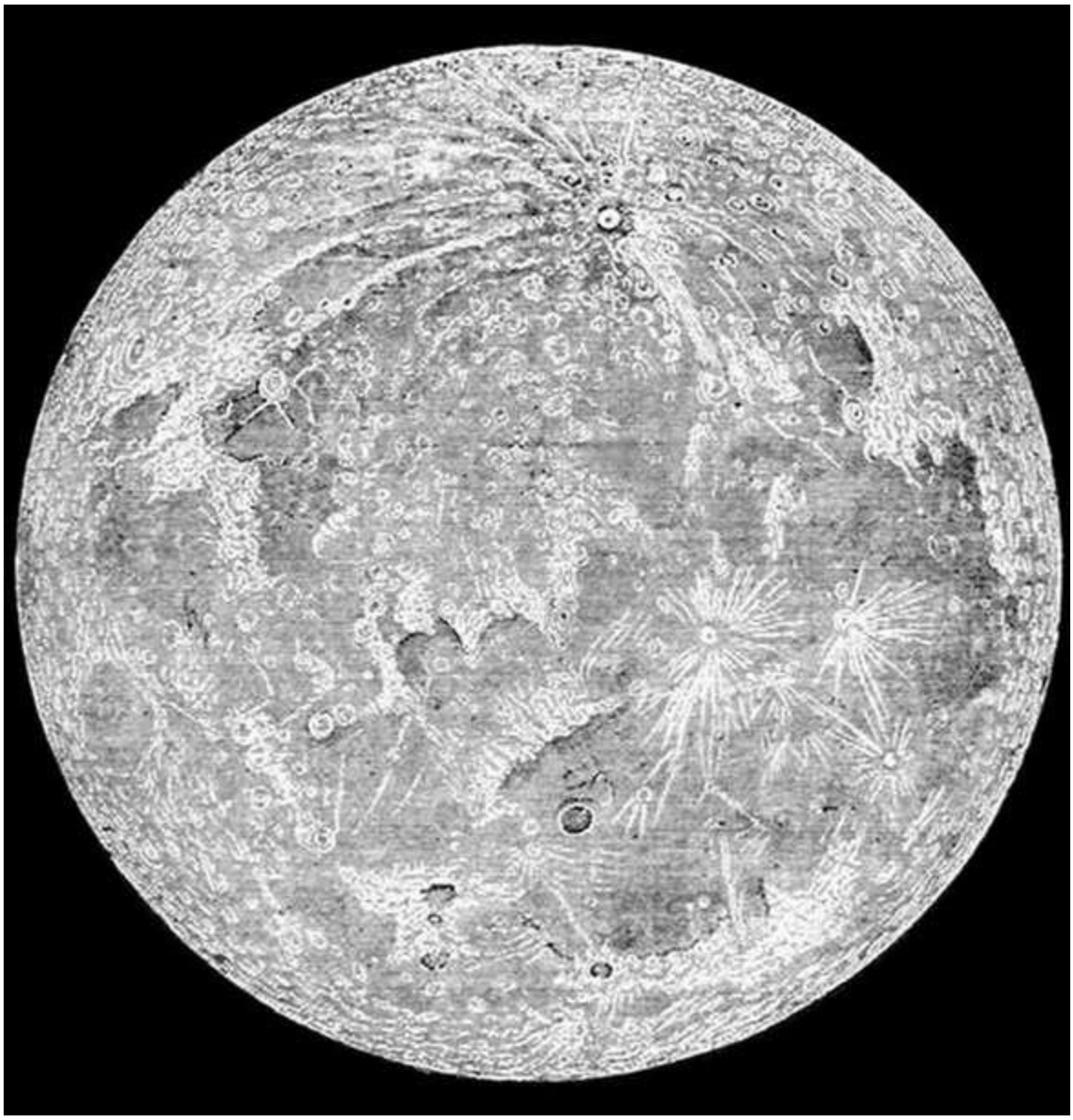

ig. 3
a. The full moon. (From Ball's*Starland*.)

"We have still half an hour, Alwyn," said he, "before the eclipse will begin, and I can show you the moon's face well to-night. Take my place here and look at her while I point out the chief features. See first, there are the grey plains (A, C, G, etc.) lying chiefly in the lower half of the moon. You can often see these on a clear night with the naked eye,

but you must remember that then they appear more in the upper part, because in the telescope we see the moon's face inverted or upside down.

"These plains were once thought to be oceans, but are now proved to be dry flat regions situated at different levels on the moon, and much like what deserts and prairies would appear on our earth if seen from the same distance. Looking through the telescope, is it not difficult to imagine how people could ever have pictured them as a man's face? But not so difficult to understand how some ancient nations thought the moon was a kind of mirror, in which our earth was reflected as in a looking-glass, with its seas and rivers, mountains and valleys; for it does look something like a distant earth, and as the light upon it is really reflected from the sun it was very natural to compare it to a looking-glass.

"Next cast your eye over the hundreds of craters, some large, others quite small, which cover the moon's face with pitted marks, like a man with small-pox; while a few of the larger rings look like holes made in a window-pane, where a stone has passed through, for brilliant shining streaks radiate from them on all sides like the rays of a star, covering a large part of the moon. Brightest of all these starred craters is Tycho, which you will easily find near the top of the moon (I, Fig. 3), for you have often seen it in the small telescope. How grand it looks to-night in the full moon (Fig. 3 *a*)! It is true you see all the craters better when the moon is in her quarters, because the light falls sideways upon them and the shadows are more sharply defined; yet even at the full the bright ray of light on Tycho's rim marks out the huge cavity, and you can even see faintly the magnificent terraces which run round the cup within, one below the other."

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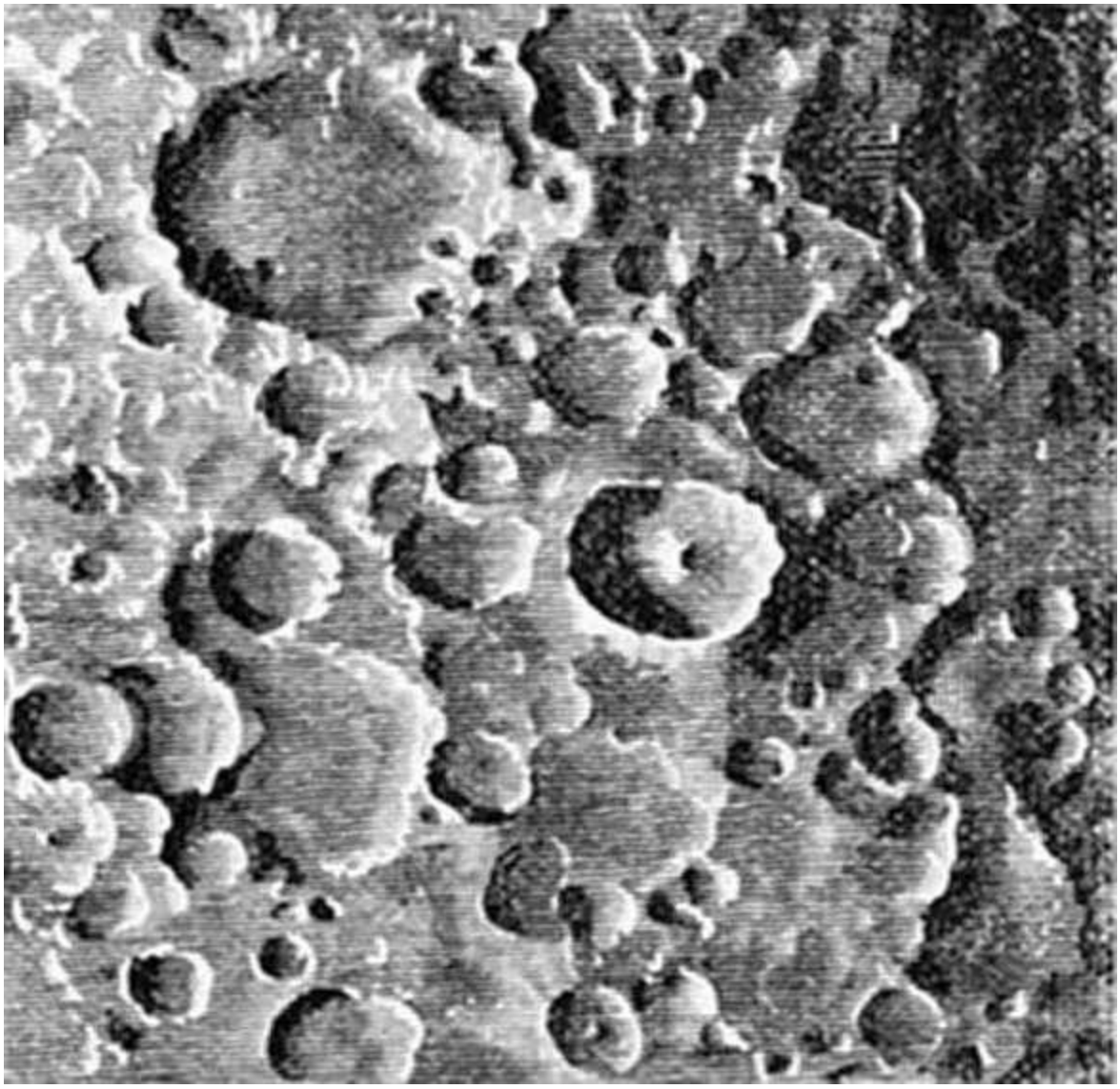

ig. 4. Tycho and his surroundings.
(From a photograph of the moon taken by Mr. De la Rue, 1863.)

"This cavity measures fifty-four miles across, so that if it could be moved down to our earth it would cover by far the largest part of Devonshire, or that portion from Bideford on the north, to the sea on the south, and from the borders of Cornwall on the east, to Exeter on the west, and it is 17,000 feet or nearly three miles in depth. Even in the

brilliant light of the full moon this enormous cup is dark compared to the bright rim, but it is much better seen in about the middle of the second quarter, when the rising sun begins to light up one side while the other is in black night. The drawing on the wall (Fig. 4), which is taken from an actual photograph of the moon's face, shows Tycho at this time surrounded by the numerous other craters which cover this part of the moon. You may recognise him by the gleaming peak in the centre of the cup, and by his bright rim which is so much more perfect than those of his companions. The gleaming peak is the top of a steep cone or hill rising up 6000 feet, or more than a mile from the base of the crater, so that even the summit is about two miles below the rim.

"There is one very interesting point in Tycho, however, which is seen at its very best at full moon. Look outside the bright rim and you will see that from the shadow which surrounds it there spring on all sides those strange brilliant streaks (see Fig. 3 *a*) which I spoke of just now. There are others quite as bright, or even brighter, round other craters, Copernicus (Fig. 6), Kepler, and Aristarchus, lower down on the right-hand side of the moon; but these of Tycho are far the most widely spread, covering almost all the top of the face.

"What are these streaks? We do not know. During the second quarter of the moon, when the sun is rising slowly upon Tycho, lighting up his peak and showing the crater beautifully divided into a bright cup in the curve to the right, while a dense shadow lies in the left hollow, these streaks are only faint, and among the many craters around (see Fig. 4) you might even have some difficulty at first in finding the well-known giant. But as the sun rises higher and higher they begin to appear, and go on increasing in brightness till they shine with that wonderfully silvery light you see now in the full moon."

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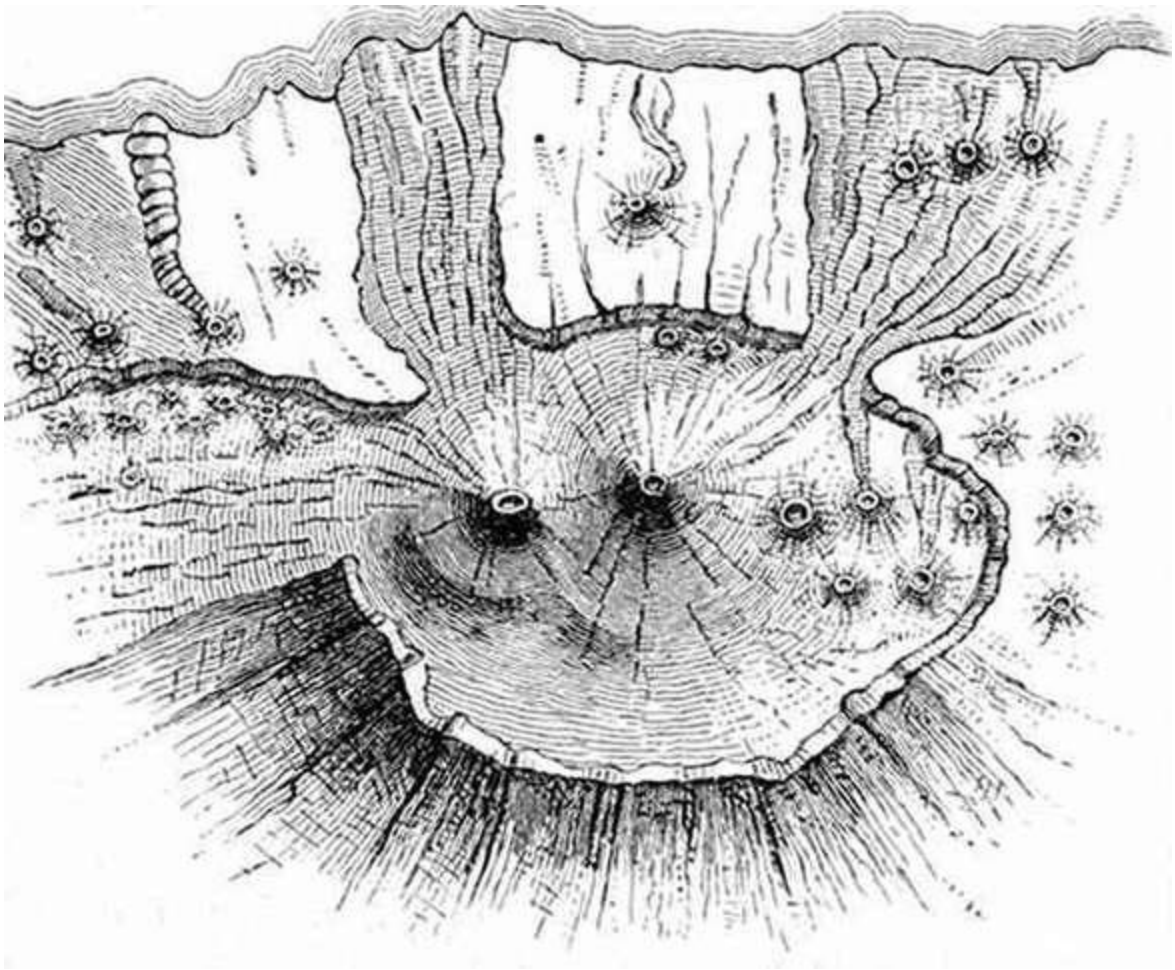

ig. 5. Plan of the Peak of Teneriffe, showing how it resembles a lunar crater. (A. Geikie.)

"Here is a problem for you young astronomers to solve, as we learn more and more how to use the telescope with all its new appliances."

The crater itself is not so difficult to explain, for we have many like it on our earth, only not nearly so large. In fact, we might almost say that our earthly volcanoes differ from those in the moon only by their smaller size and by forming *mountains* with the crater or cup on the top; while the lunar craters lie flat on the surface of the moon, the hollow of the cup forming a depression below it. The peak of Teneriffe (Fig. 5), which is a dormant volcano, is a good