

CHAPTER IX

THE MOUNTAINS AND PLAINS OF THE MOON, AND THE SPECTACLES OF THE SUN

"... the Moon, whose orb
The Tuscan artist views through optic glass
At evening from the top of Fesolé,
Or in Valdarno, to descry new lands,
Rivers or mountains in her spotty globe."--PARADISE LOST.

The moon is probably the most interesting of all telescopic objects. This arises from its comparative nearness to the earth. A telescope magnifying 1,000 diameters brings the moon within an apparent distance of less than 240 miles. If telescopes are ever made with a magnifying power of 10,000 diameters, then, provided that atmospheric difficulties can be overcome, we shall see the moon as if it were only about twenty miles off, and a sensitive astronomer might be imagined to feel a little hesitation about gazing so closely at the moon--as if he were peering into a neighbor world's window.

But a great telescope and a high magnifying power are not required to interest the amateur astronomer in the study of the moon. Our three-inch telescope is amply sufficient to furnish us with entertainment for many an evening while the moon is running through its phases, and we shall

find delight in frequently changing the magnifying power as we watch the lunar landscapes, because every change will present them in a different aspect.

It should be remembered that a telescope, unless a terrestrial eyepiece or prism is employed, reverses such an object as the moon top for bottom. Accordingly, if the moon is on or near the meridian when the observations are made, we shall see the north polar region at the bottom and the south polar region at the top. In other words, the face of the moon as presented in the telescope will be upside down, north and south interchanging places as compared with their positions in a geographical map. But east and west remain unaltered in position, as compared with such a map--i. e., the eastern hemisphere of the moon is seen on the right and the western hemisphere on the left. It is the moon's western edge that catches the first sunlight when "new moon" begins, and, as the phase increases, passing into "first quarter" and from that to "full moon," the illumination sweeps across the disk from west to east.

The narrow sickle of the new moon, hanging above the sunset, is a charming telescopic sight. Use a low power, and observe the contrast between the bright, smooth round of the sunward edge, which has almost the polish of a golden rim, and the irregular and delicately shaded inner curve, where the adjacent mountains and plains picturesquely reflect or subdue the sunshine. While the crescent grows broader new objects are continually coming into view as the sun rises upon them, until at length one of the most conspicuous and remarkable of the lunar

"seas," the Mare Crisium, or Sea of Crises, lies fully displayed amid its encircling peaks, precipices, and craters. The Mare Crisium is all in the sunlight between the third and fourth day after "new moon." It is about 350 by 280 miles in extent, and if ever filled with water must have been a very deep sea, since its arid bed lies at a great but not precisely ascertained depth below the general level of the moon. There are a few small craters on the floor of the Mare Crisium, the largest bearing the name of Picard, and its borders are rugged with mountains. On the southwestern side is a lofty promontory, 11,000 feet in height, called Cape Agarum. At the middle of the eastern side a kind of bay opens deep in the mountains, whose range here becomes very narrow. Southeast of this bay lies a conspicuous bright point, the crater mountain Proclus, on which the sun has fully risen in the fourth day of the moon, and which reflects the light with extraordinary liveliness. Adjoining Proclus on the east and south is a curious, lozenge-shaped flat, broken with short, low ridges, and possessing a most peculiar light-brown tint, easily distinguished from the general color tone of the lunar landscapes. It would be interesting to know what was passing in the mind of the old astronomer who named this singular region Palus Somnii. It is not the only spot on the moon which has been called a "marsh," and to which an unexplained connection with dreams has been ascribed.

Nearly on the same meridian with Proclus, at a distance of about a hundred miles northward, lies a fine example of a ring mountain, rather more than forty miles in diameter, and with peak-tipped walls which in

some places are 13,000 feet in height, as measured from the floor within. This is Macrobius. There is an inconspicuous central mountain in the ring.

North of the Mare Crisium, and northwest of Macrobius, we find a much larger mountain ring, oblong in shape and nearly eighty miles in its greatest diameter. It is named Cleomenes. The highest point on its wall is about 10,000 feet above the interior. Near the northeast corner of the wall yawns a huge and very deep crater, Tralles, while at the northern end is another oblong crater mountain called Burckhardt.

From Cleomenes northward to the pole, or to the northern extremity of the crescent, if our observations are made during new moon, the ground appears broken with an immense number of ridges, craters, and mountain rings, among which we may telescopically wander at will. One of the more remarkable of these objects, which may be identified with the aid of Lunar Chart No. 1, is the vast ringed plain near the edge of the disk, named Gauss. It is more than a hundred and ten miles in diameter. Owing to its situation, so far down the side of the lunar globe, it is foreshortened into a long ellipse, although in reality it is nearly a circle. A chain of mountains runs north and south across the interior plain. Geminus, Berzelius, and Messala are other rings well worth looking at. The remarkable pair called Atlas and Hercules demand more than passing attention. The former is fifty-five and the latter forty-six miles in diameter. Each sinks 11,000 feet below the summit of the loftiest peak on its encircling wall. Both are full of interesting

detail sufficient to occupy the careful observer for many nights. The broad ring bearing the name of Endymion is nearly eighty miles in diameter, and has one peak 15,000 feet high. The interior plain is flat and dark. Beyond Endymion on the edge of the disk is part of a gloomy plain called the Mare Humboltianum.

After glancing at the crater-shaped mountains on the western and southern border of the Mare Crisium, Alhazen, Hansen, Condorcet, Firmicus, etc., we pass southward into the area covered in Lunar Chart No. 2. The long dark plain south of the Mare Crisium is the Mare Fecunditatis, though why it should have been supposed to be particularly fecund, or fertile, is by no means clear. On the western border of this plain, about three hundred miles from the southern end of the Mare Crisium, is the mountain ring, or circumvallation, called Langrenus, about ninety miles across and in places 10,000 feet high. There is a fine central mountain with a number of peaks. Nearly a hundred miles farther south, on the same meridian, lies an equally extensive mountain ring named Vendelinus. The broken and complicated appearance of its northern walls will command the observer's attention. Another similar step southward, and still on the same meridian brings us to a yet finer mountain ring, slightly larger than the others, and still more complicated in its walls, peaks, and terraces, and in its surroundings of craters, gorges, and broken ridges. This is Petavius. West of Petavius, on the very edge of the disk, is a wonderful formation, a walled plain named Humboldt, which is looked down upon at one point near its eastern edge by a peak 16,000 feet in height. About a

hundred and forty miles south of Petavius is the fourth great mountain ring lying on the same meridian. Its name is Furnerius. Look particularly at the brilliantly shining crater on the northeast slope of the outer wall of Furnerius.

Suppose that our observations are now interrupted, to be resumed when the moon, about "seven days old," is in its first quarter. If we had time, it would be a most interesting thing to watch the advance of the lunar sunrise every night, for new beauties are displayed almost from hour to hour; but, for the purposes of our description it is necessary to curtail the observations. At first quarter one half of the lunar hemisphere which faces the earth is illuminated by the sun, and the line of sunrise runs across some of the most wonderful regions of the moon.

We begin, referring once more to Lunar Chart No. 1, in the neighborhood of the north pole of the moon. Here the line along which day and night meet is twisted and broken, owing to the roughness of the lunar surface. About fifteen degrees southwest of the pole lies a remarkable square-cornered, mountain-bordered plain, about forty miles in length, called Barrow. Very close to the pole is a ring mountain, about twenty-five miles in diameter, whose two loftiest peaks, 8,000 to 9,000 feet high, according to Neison, must, from their situation, enjoy perpetual day.

The long, narrow, dark plain, whose nearest edge is about thirty degrees south of the pole, is the Mare Frigoris, bordered on both sides by

uplands and mountains. At its southern edge we find the magnificent Aristoteles, a mountain ring, sixty miles across, whose immense wall is composed of terraces and ridges running up to lofty peaks, which rise nearly 11,000 feet above the floor of the valley. About a hundred miles south of Aristoteles is Eudoxus, another fine mountain ring, forty miles in diameter, and quite as deep as its northern neighbor. These two make a most striking spectacle.

We are now in the neighborhood of the greatest mountain chains on the moon, the lunar Alps lying to the east and the lunar Caucasus to the south of Aristoteles and Eudoxus, while still farther south, separated from the Caucasus by a strait not more than a hundred miles broad, begins the mighty range of the lunar Apennines. We first turn the telescope on the Alps. As the line of sunrise runs directly across their highest peaks, the effect is startling. The greatest elevations are about 12,000 feet. The observer's eye is instantly caught by a great valley, running like a furrow through the center of the mountain mass, and about eighty or ninety miles in length. The sealike expanse south and southeast of the Alps is the Mare Imbrium, and it is along the coast of this so-called sea that the Alps attain their greatest height. The valley, or gorge, above mentioned, appears to cut through the loftiest mountains and to reach the "coast," although it is so narrowed and broken among the greater peaks that its southern portion is almost lost before it actually reaches the Mare Imbrium. Opening wider again as it enters the Mare, it forms a deep bay among precipitous mountains.

The Caucasus Mountains are not so lofty nor so precipitous as the Alps, and consequently have less attraction for the observer. They border the dark, oval plain of the Mare Serenitatis on its northeastern side. The great bay running out from the Mare toward the northwest, between the Caucasus and the huge mountain ring of Posidonius, bears the fanciful name of Lacus Somniorum. In the old days when the moon was supposed to be inhabited, those terrestrial godfathers, led by the astronomer Riccioli, who were busy bestowing names upon the "seas" and mountains of our patient satellite, may have pleased their imagination by picturing this arm of the "Serene Sea" as a peculiarly romantic sheet of water, amid whose magical influences the lunar gentlefolk, drifting softly in their silver galleons and barges, and enjoying the splendors of "full earth" poured upon their delightful little world, were accustomed to fall into charming reveries, as even we hard-headed sons of Adam occasionally do when the waters under the keel are calm and smooth and the balmy air of a moonlit night invokes the twin spirits of poetry and music.

Posidonius, the dominating feature of the shore line here, is an extraordinary example of the many formations on the moon which are so different from everything on the earth that astronomers do not find it easy to bestow upon them names that truly describe them. It may be called a ring mountain or a ringed plain, for it is both. Its diameter exceeds sixty miles, and the interior plain lies about 2,000 feet below the outer surface of the lunar ground. The mountain wall surrounding the

ring is by no means remarkable for elevation, its greatest height not exceeding 6,000 feet, but, owing to the broad sweep of the curved walls, the brightness of the plain they inclose, and the picturesque irregularity of the silhouette of shadow thrown upon the valley floor by the peaks encircling it, the effect produced upon the observer is very striking and attractive.

Having finished with Posidonius and glanced across the broken region of the Taurus Mountains toward the west, we turn next to consider the Mare Serenitatis. This broad gray plain, which, with a slight magnifying power, certainly looks enough like a sea to justify the first telescopists in thinking that it might contain water, is about 430 by 425 miles in extent, its area being 125,000 square miles. Running directly through its middle, nearly in a north and south line, is a light streak, which even a good opera glass shows. This streak is the largest and most wonderful of the many similar rays which extend on all sides from the great crater, or ring, of Tycho in the southern hemisphere. The ray in question is more than 2,000 miles long, and, like its shorter congeners, it turns aside for nothing; neither "sea," nor peak, nor mountain range, nor crater ring, nor gorge, nor cañon, is able to divert it from its course. It ascends all heights and drops into all depths with perfect indifference, but its continuity is not broken. When the sun does not illuminate it at a proper angle, however, the mysterious ray vanishes. Is it a metallic vein, or is it volcanic lava or ash? Was the globe of the moon once split open along this line?

The Mare Serenitatis is encircled by mountain ranges to a greater extent than any of the other lunar "seas." On its eastern side the Caucasus and the Apennines shut it in, except for a strait a hundred miles broad, by means of which it is connected with the Mare Imbrium. On the south the range of the Hæmus Mountains borders it, on the north and northwest the Caucasus and the Taurus Mountains confine it, while on the west, where again it connects itself by a narrow strait with another "sea," the Mare Tranquilitatis, it encounters the massive uplift of Mount Argæus. Not far from the eastern strait is found the remarkable little crater named Linné, not conspicuous on the gray floor of the Mare, yet easily enough found, and very interesting because a considerable change of form seems to have come over this crater some time near the middle of the nineteenth century. In referring to it as a crater it must not be forgotten that it does not form an opening in the top of a mountain. In fact, the so-called craters on the moon, generally speaking, are simply cavities in the lunar surface, whose bottoms lie deep below the general level, instead of being elevated on the summit of mountains, and inclosed in a conical peak. In regard to the alleged change in Linné, it has been suggested, not that a volcanic eruption brought it about, but that a downfall of steep walls, or of an unsupported rocky floor, was the cause. The possibility of such an occurrence, it must be admitted, adds to the interest of the observer who regularly studies the moon with a telescope.

Just on the southern border of the Mare, the beautiful ring Menelaus lies in the center of the chain of the Hæmus Mountains. The ring is

about twenty miles across, and its central peak is composed of some highly reflecting material, so that it shines very bright. The streak or ray from Tycho which crosses the Mare Serenitatis passes through the walls of Menelaus, and perhaps the central peak is composed of the same substance that forms the ray. Something more than a hundred miles east-southeast from Menelaus, in the midst of the dark Mare Vaporum, is another brilliant ring mountain which catches the eye, Manilius. It exceeds Menelaus in brightness as well as in size, its diameter being about twenty-five miles. There is something singular underlying the dark lunar surface here, for not only is Manilius extraordinarily brilliant in contrast with the surrounding plain, but out of that plain, about forty miles toward the east, projects a small mountain which is also remarkable for its reflecting properties, as if the gray ground were underlain by a stratum of some material that flashes back the sunlight wherever it is exposed. The crater mountain, Sulpicius Gallus, on the border of the Mare, north of Manilius and east of Menelaus, is another example of the strange shining quality of certain formations on the moon.

Follow next the Hæmus range westward until the attention falls upon the great ring mountain Plinius, more than thirty miles across, and bearing an unusual resemblance to a fortification. Mr. T. G. Elger, the celebrated English selenographer, says of Plinius that, at sunrise, "it reminds one of a great fortress or redoubt erected to command the passage between the Mare Tranquilitatis and the Mare Serenitatis." But, of course, the resemblance is purely fanciful. Men, even though

they dwelt in the moon, would not build a rampart 6,000 feet high!

Mount Argæus, at the southwest corner of the Mare Serenitatis, is a very wonderful object when the sun has just risen upon it. This occurs five days after the new moon.

Returning to the eastern extremity of the Mare, we glance, in passing, at the precipitous Mount Hadley, which rises more than 15,000 feet above the level of the Mare and forms the northern point of the Apennine range. Passing into the region of the Mare Imbrium, whose western end is divided into the Palus Putredinis on the south and the Palus Nebularum on the north, we notice three conspicuous ring mountains, Cassini near the Alps, and Aristillus and Autolycus, a beautiful pair, nearly opposite the strait connecting the two Maria. Cassini is thirty-six miles in diameter, Aristillus thirty-four, and Autolycus twenty-three. The first named is shallow, only 4,000 feet in depth from the highest point of its wall, while Aristillus carries some peaks on its girdle 11,000 feet high. Autolycus, like Cassini, is of no very great depth.

Westward from the middle of an imaginary line joining Aristillus and Cassini is the much smaller crater Theætetus. Outside the walls of this are a number of craterlets, and a French astronomer, Charbonneaux, of the Meudon Observatory, reported in December, 1900, that he had repeatedly observed white clouds appearing and disappearing over one of these small craters.

South of the Mare Vaporum are found some of the most notable of those strange lunar features that are called "clefs" or "rills." Two crater mountains, in particular, are connected with them, Ariadæus at the eastern edge of the Mare Tranquilitatis and Hyginus on the southern border of the Mare Vaporum. These clefs appear to be broad and deep chasms, like the cañons cut by terrestrial rivers, but it can not be believed that the lunar cañons are the work of rivers. They are rather cracks in the lunar crust, although their bottoms are frequently visible. The principal cleft from Ariadæus runs eastward and passes between two neighboring craters, the southern of which is named Silberschlag, and is noteworthy for its brightness. The Hyginus cleft is broader and runs directly through the crater ring of that name.

The observer will find much to interest him in the great, irregular, and much-broken mountain ring called Julius Cæsar, as well as in the ring mountains, Godin, Agrippa, and Triesnecker. The last named, besides presenting magnificent shadows when the sunlight falls aslant upon it, is the center of a complicated system of rills, some of which can be traced with our five-inch glass.

We next take up Lunar Chart No. 2, and pay a telescopic visit to the southwestern quarter of the lunar world. The Mare Tranquilitatis merges through straits into two southern extensions, the Mare Fecunditatis and the Mare Nectaris. The great ring mountains or ringed plains, Langrenus, Vendelinus, Petavius, and Furnerius, all lying

significantly along the same lunar meridian, have already been noticed. Their linear arrangement and isolated position recall the row of huge volcanic peaks that runs parallel with the shore of the Pacific Ocean in Oregon and Washington--Mount Jefferson, Mount Hood, Mount St. Helen's, Mount Tacoma--but these terrestrial volcanoes, except in elevation, are mere pins' heads in the comparison.

In the eastern part of the Mare Fecunditatis lies a pair of relatively small craters named Messier, which possess particular interest because it has been suspected, though not proved, that a change of form has occurred in one or other of the pair. Mädler, in the first half of the nineteenth century, represented the two craters as exactly alike in all respects. In 1855 Webb discovered that they are not alike in shape, and that the easternmost one is the larger, and every observer easily sees that Webb's description is correct. Messier is also remarkable for the light streak, often said to resemble a comet's tail, which extends from the larger crater eastward to the shore of the Mare Fecunditatis.

Goclenius and Guttemberg, on the highland between the Mare Fecunditatis and the Mare Nectaris, are intersected and surrounded by clefts, besides being remarkable for their broken and irregular though lofty walls. Guttemberg is forty-five miles and Goclenius twenty-eight miles in diameter. The short mountain range just east of Guttemberg, and bordering a part of the Mare Nectaris on the west, is called the Pyrenees.

The Mare Nectaris, though offering in its appearance no explanation of its toothsome name--perhaps it was regarded as the drinking cup of the Olympian gods--is one of the most singular of the dark lunar plains in its outlines. At the south it ends in a vast semicircular bay, sixty miles across, which is evidently a half-submerged mountain ring. But submerged by what? Not water, but perhaps a sea of lava which has now solidified and forms the floor of the Mare Nectaris. The name of this singular formation is Fracastorius. Elger has an interesting remark about it.

"On the higher portion of the interior, near the center," he says, "is a curious object consisting apparently of four light spots, arranged in a square, with a craterlet in the middle, all of which undergo notable changes of aspect under different phases."

Other writers also call attention to the fine markings, minute craterlets, and apparently changeable spots on the floor of Fracastorius.

We go now to the eastern side of the Mare Nectaris, where we find one of the most stupendous formations in the lunar world, the great mountain ring of Theophilus, noticeably regular in outline and perfect in the completeness of its lofty wall. The circular interior, which contains in the center a group of mountains, one of whose peaks is 6,000 feet high, sinks 10,000 feet below the general level of the moon outside the wall! One of the peaks on the western edge towers more than 18,000 feet above

the floor within, while several other peaks attain elevations of 15,000 to 16,000 feet. The diameter of the immense ring, from crest to crest of the wall, is sixty-four miles. Theophilus is especially wonderful on the fifth and sixth days of the moon, when the sun climbs its shining pinnacles and slowly discloses the tremendous chasm that lies within its circles of terrible precipices.

On the southeast Theophilus is connected by extensions of its walls with a shattered ring of vast extent called Cyrillus; and south from Cyrillus, and connected with the same system of broken walls, lies the still larger ring named Catharina, whose half-ruined walls and numerous crater pits present a fascinating spectacle as the shadows retreat before the sunrise advancing across them. These three--Theophilus, Cyrillus, and Catharina--constitute a scene of surpassing magnificence, a glimpse of wonders in another world sufficient to satisfy the most riotous imagination.

South of the Mare Nectaris the huge ring mountain of Piccolomini attracts attention, its massive walls surrounding a floor nearly sixty miles across, and rising in some places to an altitude of nearly 15,000 feet. It should be understood that wherever the height of the mountain wall of such a ring is mentioned, the reference level is that of the interior plain or floor. The elevation, reckoned from the outer side, is always very much less.

The entire region south and east of Theophilus and its great neighbors

is marvelously rough and broken. Approaching the center of the moon, we find a system of ringed plains even greater in area than any of those we have yet seen. Hipparchus is nearly a hundred miles long from north to south, and nearly ninety miles broad from east to west. But its walls have been destroyed to such an extent that, after all, it yields in grandeur to a formation like Theophilus.

Albategnius is sixty-five miles across, with peaks from 10,000 to 15,000 feet in height. Sacrobosco is a confused mass of broken and distorted walls. Aliacensis is remarkable for having a peak on the eastern side of its wall which is more than 16,000 feet high. Werner, forty-five miles in diameter, is interesting because under its northeastern wall Mädler, some seventy years ago, saw a light spot of astonishing brightness, unmatched in that respect by anything on the moon except the peak of Aristarchus, which we shall see later. This spot seems afterward to have lost brilliance, and the startling suggestion has been made that its original brightness might have been due to its then recent deposit from a little crater that lies in the midst of it. Walter is of gigantic dimensions, about one hundred miles in diameter. Unlike the majority of the ringed plains, it departs widely from a circle. Stöfler is yet larger than Walter; but most interesting of all these gigantic formations is Maurolycus, whose diameter exceeds one hundred and fifty miles, and which has walls 13,000 or 14,000 feet high. Yet, astonishing though it may seem, this vast and complicated mass of mountain walls, craters, and peaks, is virtually unseen at full moon, owing to the perpendicularity of the sunlight, which prevents the casting of shadows.

We shall next suppose that another period of about seven days has elapsed, the moon in the meantime reaching its full phase. We refer for guidance to Lunar Chart No. 3. The peculiarity of the northeastern quadrant which immediately strikes the eye is the prevalence of the broad plains called Maria, or "seas." The northern and central parts are occupied by the Mare Imbrium, the "Sea of Showers" or of "Rains," with its dark bay the Sinus Æstuum, while the eastern half is covered by the vast Oceanus Procellarum, the "Ocean of Storms" or of "Tempests."

Toward the north a conspicuous oval, remarkably dark in hue, immediately attracts our attention. It is the celebrated ringed plain of Plato, about sixty miles in diameter and surrounded by a saw-edged rampart, some of whose pinnacles are 6,000 or 7,000 feet high. Plato is a favorite subject for study by selenographers because of the changes of color which its broad, flat floor undergoes as the sun rises upon it, and also because of the existence of enigmatical spots and streaks whose visibility changes. South of Plato, in the Mare Imbrium, rises a precipitous, isolated peak called Pico, 8,000 feet in height. Its resemblance in situation to the conical mountain Pico in the Azores strikes the observer.

Eastward of Plato a line of highlands, separating the Mare Imbrium from the Mare Frigoris, carries the eye to the beautiful semicircular Sinus Iridum, or "Bay of Rainbows." The northwestern extremity of

this remarkable bay is guarded by a steep and lofty promontory called Cape Laplace, while the southeastern extremity also has its towering guardian, Cape Heraclides. The latter is interesting for showing, between nine and ten days after full moon, a singularly perfect profile of a woman's face looking out across the Mare Imbrium. The winding lines, like submerged ridges, delicately marking the floor of the Sinus Iridum and that of the Mare beyond, are beautiful telescopic objects. The "bay" is about one hundred and thirty-five miles long by eighty-four broad.

The Mare Imbrium, covering 340,000 square miles, is sparingly dotted over with craters. All of the more conspicuous of them are indicated in the chart. The smaller ones, like Caroline Herschel, Helicon, Leverrier, Déglise, etc., vary from eight to twelve miles in diameter. Lambert is seventeen miles in diameter, and Euler nineteen, while Timocharis is twenty-three miles broad and 7,000 feet deep below its walls, which rise only 3,000 feet above the surface of the Mare.

Toward the eastern border of the sea, south of the Harbinger Mountains, we find a most remarkable object, the mountain ring, or crater plain, called Aristarchus. This ring is not quite thirty miles in diameter, but there is nothing on the moon that can compare with it in dazzling brilliance. The central peak, 1,200 or 1,300 feet high, gleams like a mountain of crusted snow, or as if it were composed of a mass of fresh-broken white metal, or of compacted crystals. Part of the inner slope of the east wall is equally brilliant. In fact, so much light is

poured out of the circumvallation that the eye is partially blinded, and unable distinctly to see the details of the interior. No satisfactory explanation of the extraordinary reflecting power of Aristarchus has ever been offered. Its neighbor toward the east, Herodotus, is somewhat smaller and not remarkably bright, but it derives great interest from the fact that out of a breach in its northern wall issues a vast cleft, or chasm, which winds away for nearly a hundred miles across the floor of the Mare, making an abrupt turn when it reaches the foot of the Harbinger Mountains.

The comparatively small crater, Lichtenberg, near the northeastern limb of the moon, is interesting because Mädler used to see in its neighborhood a pale-red tint which has not been noticed since his day.

Returning to the western side of the quadrant represented in Lunar Chart No. 3, we see the broad and beautifully regular ringed plain of Archimedes, fifty miles in diameter and 4,000 feet deep.

A number of clefts extend between the mountainous neighborhood of Archimedes and the feet of the gigantic Apennine Mountains on the southwest. The little double crater, Beer, between Archimedes and Timocharis, is very bright.

The Apennines extend about four hundred and eighty miles in a northwesterly and southeasterly direction. One of their peaks near the southern end of the range, Mount Huygens, is at least 18,000 feet high,

and the black silhouettes of their sharp-pointed shadows thrown upon the smooth floor of the Mare Imbrium about the time of first quarter present a spectacle as beautiful as it is unique. The Apennines end at the southeast in the ring mountain, Eratosthenes, thirty-eight miles across and very deep, one of its encircling chain of peaks rising 16,000 feet above the floor, and about half that height above the level of the Mare Imbrium. The shadows cast by Eratosthenes at sunrise are magnificent.

And now we come to one of the supreme spectacles of the moon, the immense ring or crater mountain Copernicus. This is generally regarded as the grandest object that the telescope reveals on the earth's satellite. It is about fifty-six miles across, and its interior falls to a depth of 8,000 feet below the Mare Imbrium. Its broad wall, composed of circle within circle of ridges, terraces, and precipices, rises on the east about 12,000 feet above the floor. On the inner side the slopes are very steep, cliff falling below cliff, until the bottom of the fearful abyss is attained. To descend those precipices and reach the depressed floor of Copernicus would be a memorable feat for a mountaineer. In the center of the floor rises a complicated mountain mass about 2,400 feet high. All around Copernicus the surface of the moon is dotted with countless little crater pits, and splashed with whitish streaks. Northward lie the Carpathian Mountains, terminating on the east in Tobias Mayer, a ring mountain more than twenty miles across. The mountain ring Kepler, which is also the center of a great system of whitish streaks and splashes, is twenty-two miles in diameter, and

notably brilliant.

Finally, we turn to the southeastern quadrant of the moon, represented in Lunar Chart No. 4. The broad, dark expanse extending from the north is the Mare Nubium on the west and the Oceanus Procellarum on the east. Toward the southeast appears the notably dark, rounded area of the Mare Humorum inclosed by highlands and rings. We begin with the range of vast inclosures running southward near the central meridian, and starting with Ptolemæus, a walled plain one hundred and fifteen miles in its greatest diameter and covering an area considerably exceeding that of the State of Massachusetts. Its neighbor toward the south, Alphonsus, is eighty-three miles across. Next comes Arzachel, more than sixty-five miles in diameter. Thebit, more than thirty miles across, is very deep. East of Thebit lies the celebrated "lunar railroad," a straight, isolated wall about five hundred feet high and sixty-five miles long, dividing at its southern end into a number of curious branches, forming the buttresses of a low mountain. Purbach is sixty miles broad, and south of that comes a wonderful region where the ring mountains Hell, Ball, Lexell, and others, more or less connected with walls, inclose an area even larger than Ptolemæus, but which, not being so distinctly bordered as some of the other inclosed plains, bears no distinctive name.

The next conspicuous object toward the south ranks with Copernicus among the grandest of all lunar phenomena--the ring, or crater, Tycho. It is about fifty-four miles in diameter and some points on its wall rise

17,000 feet above the interior. In the center is a bright mountain peak 5,000 feet high. But wonderful as are the details of its mountain ring, the chief attraction of Tycho is its manifest relation to the mysterious bright rays heretofore referred to, which extend far across the surface of the moon in all directions, and of which it is the center. The streaks about Copernicus are short and confused, constituting rather a splash than a regular system of rays; but those emanating from Tycho are very long, regular, comparatively narrow, and form arcs of great circles which stretch away for hundreds of miles, allowing no obstacle to interrupt their course.

Southwest of Tycho lies the vast ringed plain of Maginus, a hundred miles broad and very wonderful to look upon, with its labyrinth of formations, when the sun slopes across it, and yet, like Maurolycus, invisible under a vertical illumination. "The full moon," to use Mädler's picturesque expression, "knows no Maginus." Still larger and yet more splendid is Clavius, which exceeds one hundred and forty miles in diameter and covers 16,000 square miles of ground within its fringing walls, which carry some of the loftiest peaks on the moon, several attaining 17,000 feet. The floor is deeply depressed, so that an inhabitant of this singular inclosure, larger than Massachusetts, Connecticut, and Rhode Island combined, would dwell in land sunk two miles below the general level of the world about him.

In the neighborhood of the south pole lies the large walled plain of Newton, whose interior is the deepest known depression on the moon. It

is so deep that the sunshine never touches the larger part of the floor of the inner abyss, and a peak on its eastern wall rises 24,000 feet sheer above the tremendous pit. Other enormous walled plains are Longomontanus, Wilhelm I, Schiller, Bailly, and Schickard. The latter is one hundred and thirty-four miles long and bordered by a ring varying from 4,000 to 9,000 feet in height. Wargentín, the oval close to the moon's southeast limb, beyond Schickard, is a unique formation in that, instead of its interior being sunk below the general level, it is elevated above it. It has been suggested that this peculiarity is due to the fact that the floor of Wargentín was formed by inflation from below, and that it has cooled and solidified in the shape of a gigantic dome arched over an immense cavity beneath. A dome of such dimensions, however, could not retain its form unless partly supported from beneath.

Hainzel is interesting from its curious outline; Cichus for the huge yawning crater on its eastern wall; Capuanus for a brilliant shining crater also on its eastern wall; and Mercator for possessing bright craters on both its east and its west walls. Vitello has a bright central mountain and gains conspicuousness from its position at the edge of the dark Mare Humorum. Agatharchides is the broken remnant of a great ring mountain. Gassendi, an extremely beautiful object, is about fifty-five miles across. It is encircled with broken walls, craters and bright points, and altogether presents a very splendid appearance about the eleventh day of the moon's age.

Letronne is a half-submerged ring, at the southern end of the Oceanus

Procellarum, which recalls Fracastorius in the western lunar hemisphere. It lies, however, ten degrees nearer the equator than Fracastorius. Billy is a mountain ring whose interior seems to have been submerged by the dark substance of the Oceanus Procellarum, although its walls have remained intact. Mersenius is a very conspicuous ring, forty miles in diameter, east of the Mare Humorum. Vieta, fifty miles across, is also a fine object. Grimaldi, a huge dusky oval, is nearly one hundred and fifty miles in its greatest length. The ring mountain Landsberg, on the equator, and near the center of the visible eastern hemisphere, is worth watching because Elger noticed changes of color in its interior in 1888.

Bullialdus, in the midst of the Mare Nubium, is a very conspicuous and beautiful ring mountain about thirty-eight miles in diameter, with walls 8,000 feet high above the interior.

Those who wish to see the lunar mountains in all their varying aspects will not content themselves with views obtained during the advance of the sunlight from west to east, between "new moon" and "full moon," but will continue their observations during the retreat of the sunlight from east to west, after the full phase is passed.

It is evident that the hemisphere of the moon which is forever turned away from the earth is quite as marvelous in its features as the part that we see. It will be noticed that the entire circle of the moon's limb, with insignificant interruptions, is mountainous. Possibly the

invisible side of our satellite contains yet grander peaks and crater mountains than any that our telescopes can reach. This probability is increased by the fact that the loftiest known mountain on the moon is never seen except in silhouette. It is a member of a great chain that breaks the lunar limb west of the south pole, and that is called the Leibnitz Mountains. The particular peak referred to is said by some authorities to exceed 30,000 feet in height. Other great ranges seen only in profile are the Dörfel Mountains on the limb behind the ring plain Bailly, the Cordilleras, east of Eichstadt, and the D'Alembert Mountains beyond Grimaldi. The profile of these great mountains is particularly fine when they are seen during an eclipse of the sun. Then, with the disk of the sun for a background, they stand out with startling distinctness.

THE SUN

When the sun is covered with spots it becomes a most interesting object for telescopic study. Every amateur's telescope should be provided with apparatus for viewing the sun. A dark shade glass is not sufficient and not safe. What is known as a solar prism, consisting of two solid prisms of glass, cemented together in a brass box which carries a short tube for the eyepiece, and reflecting an image of the sun from their plane of junction--while the major remnant of light and heat passes directly through them and escapes from an opening provided for the purpose--serves very well. Better and more costly is an apparatus called

a helioscope, constructed on the principle of polarization and provided with prisms and reflectors which enable the observer, by proper adjustment, to govern very exactly and delicately the amount of light that passes into the eyepiece.

Furnished with an apparatus of this description we can employ either a three-, four-, or five-inch glass upon the sun with much satisfaction.

For the amateur's purposes the sun is only specially interesting when it is spotted. The first years of the twentieth century will behold a gradual growth in the number and size of the solar spots as those years happen to coincide with the increasing phase of the sun-spot period.

Large sun spots and groups of spots often present an immense amount of detail which tasks the skill of the draughtsman to represent it. But a little practice will enable one to produce very good representations of sun spots, as well as of the whitish patches called *faculæ* by which they are frequently surrounded.

For the simple purpose of exhibiting the spotted face of the sun without much magnifying power, a telescope may be used to project the solar image on a white sheet or screen. If the experiment is tried in a room, a little ingenuity will enable the observer to arrange a curtain covering the window used, in such a way as to exclude all the light except that which comes through the telescope. Then, by placing a sheet of paper or a drawing board before the eyepiece and focusing the image of the sun upon it, very good results may be obtained.

If one has a permanent mounting and a driving clock, a small spectroscope may be attached, for solar observations, even to a telescope of only four or five inches aperture, and with its aid most interesting views may be obtained of the wonderful red hydrogen flames that frequently appear at the edge of the solar disk.