Mercury is a morning star until January 24 when he is in superior conjunction with the Sun, and becomes an evening star until March 10, when in inferior conjunction, being a morning star until May 16 in superior conjunction. An evening star from then until July 16 in inferior conjunction; then a morning star until in superior conjunction on August 30. An evening star then until November 7, when in inferior conjunction he will transit the Sun's disc. The transit commences at 9-57 A.M. and terminates at 2-9 P.M., Greenwich mean time. For the rest of the year he will be a morning star. He will be visible as an evening star during the end of February, the middle of June, and the middle of October; and as a morning star at the end of March, the beginning of August, and the middle of November.

Venus is a morning star until February 11 when she will be in superior conjunction with the Sun, and then becomes an evening star until November 27 in inferior conjunction, and a morning star for the remainder of the year. She will attain her greatest brilliancy on October 23.

Mars is a morning star until January 5 when he will be in opposition to the Sun, and will become an evening star until December 23 when he will be in conjunction with the Sun, and a morning star for the rest of the year.

Jupiter is an evening star until January 20 when he will be in conjunction with the Sun and become a morning star until in opposition on August 10, after when he will be an evening star for the rest of the year.

Saturn is an evening star until June 13 when he will be in conjunction with the Sun, and will then be a morning star until opposition occurs on December 21, and an evening star from then to the end of the year.

Uranus and *Neptune* are not visible without telescopic assistance. Their positions in the heavens can always be ascertained from the diagram.

(The dates mentioned in the notes refer to astronomical time.)

Notes on the Moon.

By Captain A. M. Urquhart, R.A.

Some six months ago I carried out experiments by firing bullets into a bath of molten lead at various stages of solidification of the surface crust, and also into a block of solid

lead. The results seemed to me to throw considerable light on what is called the bolide or meteoric theory of the cause of the craters on the Moon. For the benefit of those who may not have been present when I read my first paper on the subject last May, I shall briefly indicate the main results obtained :—

(1) When the crust is thin the bullet breaks down a very large area roughly circular in form which sinks under the liquid interior. The rampart formed by the crust is further increased and heightened by the splashes all round.

(2) As the crust thickens the area broken up decreases and the ramparts become better defined and approach a more circular formation.

(3) When the bullet is fired into solid lead a typical crater is produced, the bullet mushrooming out evenly all round and leaving its base almost intact in the centre. The outer area slopes gently away from the rampart, while the inner wall is steep. If the bullet is of soft lead it leaves no central cone.

If we imagine the surface of the Moon to have been subjected to a bombardment during the gradual cooling and solidification of its crust, it seems to me we have a simple explanation of its otherwise unexplainable "craters." I have shown in my first paper that there seems to be no valid objection to presuming the Earth to be the source of this bombardment. The effect could not be caused by bodies from outside space, as such would seldom if ever fall vertically on to the Moon. But missiles from the Earth thrown out with sufficient force to bring them within the sphere of attraction of the Moon would always fall practically normal to the surface of the latter.

An objection was raised by one member that such bodies could not fall with sufficient velocity to cause such enormous depressions as we find on the Moon. Mr. Raman has very kindly calculated for me the velocity which a body, ejected from the Earth with sufficient velocity to bring it beyond the neutral point where the gravitational force of the Moon overcomes that of the Earth, would attain by the time it reached the surface of our satellite, and his figures have been corroborated by Mr. G. E. Sutcliffe.

If we suppose the distance between the two bodies to have been as at present, *i.e.*, about 240,000 miles, then the velocity attained by a missile from the Earth would be about 7,000 feet per second by the time it reached the Moon's surface—

a velocity surely sufficient to account for the deepest crater. But we need not assume that this distance has always been the same. In fact many astronomers, *e.g.*, Prof. Darwin, think it probable that our satellite was formerly much nearer than it is now ; and if so, it may have revolved on its axis much faster. Thus it would present the whole of its surface to the Earth's bombardment, as it is not improbable that the unseen portion of the Moon's surface is also covered with craters.

But even if we bring the Moon within 1,000 miles of the Earth's surface, the velocity attained would still be over 2,000 feet per second.

The bolide theory is put forward as that which best accounts for the formations found on the Moon's surface. There are many objections to the theory that they may have been produced by volcanic action, among which the following may be stated :—

(1) The craters are utterly unlike the results produced by volcanic action as we know it. They are hollowed out like saucers while terrestrial volcanoes are mountain cones.

(2) The outer and inner slopes of the ramparts should be more or less similar if due to volcanic action, whereas we find the outer slope a gradual one of about 3°, while the inner sometimes approaches 60°.

(3) The terraces with their intervening valleys are explained neither by the volcanic theory nor by landslips.

(4) If the ramparts were due to the rain of volcanic matter, then we should expect a fairly even wall all round, but in most cases we find pointed peaks rising to as much as twice the height of the rampart. Volcanic action is very intermittent as we know it, and successive eruptions vary much in violence, yet if the circumvallations on the Moon were the result of volcanic action, it must have been wonderfully regular in each case during the time it lasted, to throw out matter in a regular rampart all round, and then suddenly to cease, and show no signs of intermediate stages between its utmost violence and its total collapse. Why should volcanic action cease suddenly at a rampart 60 miles or more in diameter, and then dwindle down to the comparatively feeble action which may have produced a central cone ? Why should there not be evidences of intervening stages in some out of the thousands of craters ?

(5) If the ramparts were produced as suggested we should expect a more perfect circular formation.

The impact theory, however, covers all these objections and we can follow the various formations in sequence according to their character and appearance as the surface gradually cooled, on the analogy of the bullet experiments.

First we have the large walled plains and smaller formations of a like nature with an irregular and sometimes not very clearly defined rampart, larger examples of which are Ptolemacus, Clavius, Grimaldi, etc. As the crust hardened the walls became sharper and better defined, *e.g.*, Plato.

Then we arrive at a stage when the crust could not be pierced or broken through, and we have a distinct change in the effect produced. We get formations which are usually classed under ring plains and craters proper. The more prominent features of these are :—

(*a*) A nearer approach to a circular formation.

(*b*) A gentle rise of the surrounding area towards the rampart with a steep declivity inside.

(*c*) Terraces and intervening valleys.

(*d*) Central cones in most cases.

(*e*) A floor greatly depressed below the outside surface.

These correspond exactly with the effect produced by firing a bullet into solid lead. The area surrounding the rim of the "crater" is raised gently, a deep saucer-shaped cavity is formed round which the bullet mushrooms out forming a terrace, while the base is left in the centre, forming the central cone. The formation of these terraces has not been explained by any other theory, and the fact that they are sometimes nearly as high as the original rampart does away with the idea that they are due to landslips.

The sudden impact of bodies travelling at such tremendous speeds as five or six thousand feet per second would cause solid matter to spread out like a fluid until it came to rest in the form of their terraces and central cones. The cases where there are no central cones correspond to that of the soft lead bullet which spreads out evenly over the cavity, leaving no trace of itself in the centre. In such cases we may presume the matter of the missile to have been less coherent. Another thing you will notice from the photographs is, that, as the surface of the Moon gradually hardened, the rims of the craters become sharper and better defined and more regular. In such a case as Clavius you will see the later formation superimposed on the earlier.

The question has been raised: "Why do not the maria or seas show as many traces of bombardment as the rest of the surface?" The most probable explanation is that the areas covered by the maria sinking at a comparatively late stage, were covered over by the liquid interior which obliterated most traces of the previous markings. This is plainly shown by the numerous rims of mountain rings and other formations which are scattered over the surface of the seas, and the ruins of formations round the edges, *e.g.*, Fracastorius. After the maria had cooled down, which would have taken place in a very short time owing to their shallowness, we get many traces of continued bombardment on them.

There are many interesting points which might be investigated in the light of this theory such as:—

(1) The numerous crater pits which are found in the neighbourhood of the larger formations, *vide* Copernicus. Is it probable that these may have been formed by a swarm of smaller missiles which accompanied the larger one?

(2) The nimbus or halo which surrounds all the craters which are presumably of later formation and the development of these into the great Ray systems. The fact that we find these rays in connection with craters of later formation only, suggests at once some connection between them and the hardening of the crust, and the familiar effect of the impact of a heavy body on smooth hard ice or the cracking of glass occurs to one's mind. Is the resultant whiteness due to some change in the albedo of the matter due to its brittleness and the vibration of the impact, or is it due to some salt which thus finds an easier outlet to the surface?

Does the greater whiteness of the rays from Tycho, for instance, indicate a later formation than Copernicus? Is Aristarchus later than Kepler and is the evidence of their brightness corroborated by the appearance of their ramparts?

(3) It is a well known fact that the maria are not all on the same level, *i.e.*, they do not all form part of the same sphere. Is the difference of level any indication of their age? If so, the deepest may be the more recent. The Mare Crisium is considered by Neisson to be the deepest of all.

These and similar questions require careful and painstaking observation and the best available instrumental equipment, but much may be learnt from the observations of others, and the excellent photographs of the Moon's surface which are now available.

"Selenology," says M. Fauth, "will have to include all the ring formations, even the largest, in one general explanation," and this the bombardment theory does.

The best test of any theory is whether it covers the observed facts, and from this point of view I think the bombardment theory is easily first.

It does not necessarily follow that all the formations were due to impact. It is only reasonable to suppose that volcanic action may have played its part, and we have evidence of this in the fact that some observers have seen volcanic cones with craters on their tops similar to what we find on the Earth. But these are so small as to be beyond the range of any but very powerful instruments. But the fact that we have evidence of volcanic action similar to what we find on the Earth is added evidence in favour of the bombardment theory, for it shows that the smaller gravitational force of the Moon does not (as has sometimes been maintained by upholders of the volcanic theory) cause volcanic action to produce results different from what we should expect.

I am much indebted to Mr. Tomkins for lending me the slides of the Moon which are now to be shown.

Extracts from Publications.

A Simple Method of Measuring the Heights of Solar Prominences.

BY THE REVD. A. L. CORTIE, S.J., F.R.A.S.

A very convenient, simple, and quite accurate method of measuring the heights of solar prominences is by means of a photographed scale on glass, which can be fitted in the shoulder of the draw tube containing the positive eye-pieces of the viewing telescope of a spectroscope. If an accurate scale be drawn to any convenient size it can be reduced by photography, and, from the negative, glass positives can easily be obtained on very thin glass, like microscopic cover glasses. For instance, in the case of such a scale fitted to one of the eye-pieces of the Browning 12-prism automatic spectroscope at Stonyhurst, the diameter of the thin circular glass containing the scale is 20 mm. on which the scale of 100 divisions centrally placed covers 9·1 mm. The thickness of the glass is only 0·2 mm.