Palin

THE CALCULATING MACHINE

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PRACTICAL MECHANICS

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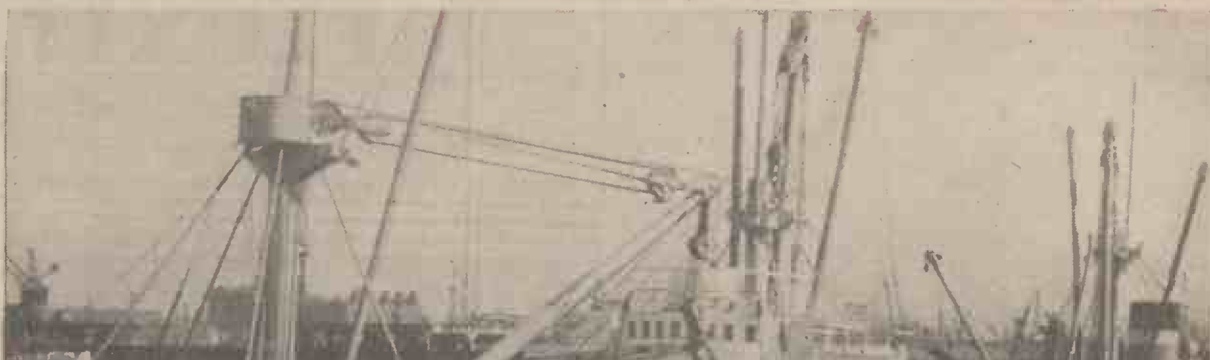
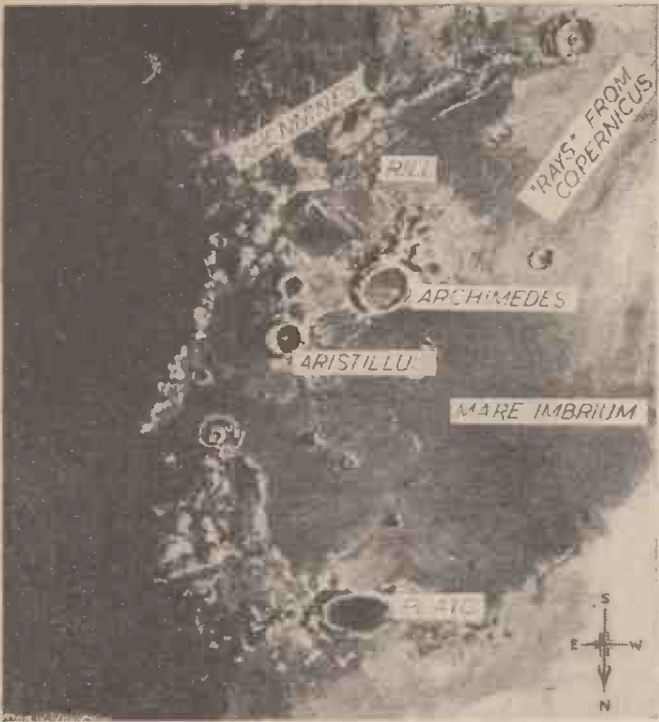


A BUSY SCENE AT LIVERPOOL DOCKS (See page 367)

The Moon's Surface



The Moon's surface in the region of Mare Imbrium.

A Short Survey of the History of Man's Progress in this Important Field of Research

By M. W. WHOLEY, G.I.Mech.E.

IT is almost certainly true that of all the objects which have excited the curiosity and sometimes worship of the human race in the past, the Moon is in the forefront. The Sun, it is true, has also had a huge share of wonder and worship, but it has forever appeared in the sky at a time when the practical considerations of everyday life excluded all thoughts and speculations as to its material nature, leaving most of the interested factions warring over its theistic aspects. Inability to stare at the Sun for long periods with the naked eye has also tended to force speculation into theistic channels by precluding any attempts at detailed observation of its surface. The Moon, on the other hand, has always been easy to look at and enough of its surface features have always been visible to the naked eye to excite speculation. Indeed, the fact that it was the most prominent object in the Heavens at night, when men's minds were relaxing, was sufficient to germinate ideas about it.

Conjectures as to its surface composition were many and fantastic. Cheese was seriously thought to be the main constituent by some people, and there was a belief that the surface of the Moon was crystalline in character, similar to glass; this mirror-like surface was thought to reflect the earth's features, a notion which received support from the fact that the Moon always keeps the same face to the earth. Colourful imaginations conjured up many celestial "pictures in the fire."

The Moon's surface became, in belief, the home of the familiar "Man in the Moon," who was replaced at various times and places by a lady, a goat, a donkey, a dog and numerous other illusions produced by mass-effect.

"Mountain-walled Plains"

The coming of the telescope dispelled this mass-effect of the surface markings to some extent, and even Galileo with his first primitive instruments charted the Moon, but although recognising the existence of the main features, he made some unhappy attempts at naming them—hence what is now called "Crater Copernicus" he called "Mount Etna," and described the Maria as "great and ancient spots." Further advancement of the telescope revealed the Moon's features as a scene of sublime desolation, the most striking aspect of which was the vast number of craters, so varied in size that several broad classes are now enumerated. They vary from about 150 miles in diameter to sizes beyond that which can be resolved by the most powerful modern instrument. Sizes ranging from 60 to 150 miles in diameter have been given the name of "Mountain-walled Plains"—a description enhanced by the fact that a human observer deposited in the centre of one of the larger craters of this type would be unable to see the crater walls which surrounded him because of the relatively sharp curvature of the Moon's surface, and again—a good-sized telescope shows that the apparently smooth floors of these "Mountain-walled Plains" exhibit numerous tiny craters or "craterlets." Plato, for example, is known to have at least 40 of these formations on its floor. "Tiny" is, of course, a relative term; thus the Great Meteor Crater in Arizona, which is about three miles in circumference, would be classed as a rather small "craterlet" if observed on the Moon. Sizes ranging from approximately 10 to 60 miles in diameter are known as "Mountain-ringed Plains" or "Ring Mountains" and a third type known as "Crater Rings" are about three to 10 miles in diameter. Still smaller formations of this kind comprise the type previously mentioned in connection with "Mountain-walled Plains"—the "craterlets."

Keplar noted the amazing similarity of these circular formations, and regarded them as pits excavated by supposed lunar inhabitants to shelter themselves from the long and intense action of the sun. Had he known the real size of the Moon and the enormous diameters of some of the craters, he would probably have thought twice about his hypothesis. Some authorities class the largest of the "Mountain-walled Plains" as small "Maria" (sing. "Mare"), a name given to vast dark areas which, as the name implies, were once thought to be seas, and flowery names like "Mare Serenitatis" (Sea of Serenity) were given to them. Subsequent investigation proved that the Moon totally lacked atmosphere and hence could not retain surface water.

Landing Places for Space Craft

Considering the surface of the Moon as a landing place for space craft, it will be interesting to examine the various aspects which would present themselves to an astronaut during the latter portion of his orbit.

The approach to the Moon would soon enable him to distinguish the larger craters and the more rugged of the mountain ranges, until, a few thousand miles above the surface, the scene would resolve itself into masses of pockmarks vastly blotched by the apparently smooth, dark expanses of the "Maria." He would notice the haphazard confusion of craters, peaks, rills and rifts. Approaching even closer, it would become apparent that the "Maria" were not as smooth as they would at first appear; in fact, there are numberless pits, so small as to merge in with the general surface so that they become visible only when extremely close observation is possible. At a point in the orbit where landing is to take place, the full effect of the starkly naked appearance of the rugged landscape would be observed—an effect one might expect to see if all the soil, vegetable growth and snow were to be stripped from the tableland of Tibet. We will assume that the ship is that of a scientific expedition. That being the case, the point chosen for landing would most probably be one from which short journeys in various directions would bring the scientists in contact with the most varied examples of lunar topography. Such a point on the visible side of the Moon is between the craters Aristillus and Archimedes and the southern arm of the Apennines. In such a position the expedition would have two distinct types of crater in Archimedes and Aristillus, together with a portion of the "Mare" surface, and an example of the peculiarly rugged type of mountain formation characteristic of the Moon. Light also may be shed on one of its many problems by visiting the "rill" or furrow which can be seen to run almost parallel to the Apennines at that part of the range. By examining this location a fairly general picture of the surface characteristics will be obtained.

Exfoliation

Assuming that the landing has taken place during the lunar day, the first effect on climbing down to the ground would be the amazing sense of lightness, as one would only be supporting a sixth of one's terrestrial weight. Probably the next things observed would be the intense shadows, the blinding glare from the ground, the utterly black sky with its coldly brilliant stars, and the intensely bright Sun exhibiting its prominences and its corona in all their full glory. All this because of the lack of atmosphere. The horizon would appear very close at hand because of the much greater curvature of the Moon. Smooth as did the "Mare" appear from the surface, it would now seem almost impassable. Where the ground was fairly flat it would most probably be a mixture of dust and gravel composed of light materials such as porous rock. Small pits and craters from a few inches in diameter to several feet would be abundant. This is evident from the way in which the sunlight is reflected at various angles and substantiated by recent experiments on the polarisation of reflected light from the Moon. Probably, as the scientist was standing there, a small puff of dust would remind him of the continuous shower of meteorites which rain, unchecked by atmosphere, on to the ashy surface, adding continuously to the mass of small pits already there; and also perhaps of his own vulnerability, considering that an average speed of a meteorite is somewhere in the region of 30 miles per second! Due to exfoliation, the rocks and boulders of the Moon are most probably crumbly, and rock surfaces may easily flake away under the pressure of our scientist's boot.

There is much evidence that these "plains" were once in the plastic state, and if the scientist were to strike away from the ship towards the foot of the Apennines, he is almost certain to come across numerous clefts along the margin of the "Mare," apparently caused by the shrinking of the surface crust as it cooled. The huge "rill," one of the several hundred to be found in various parts of the Moon, which is parallel to the Apeninnes, S.E. of the craters and the supposed expedition, is most probably formed in this way, helped, perhaps, by the raising of the adjacent mountains at the same geological age. This crack will now almost certainly be filled or partly filled by solidified lava. In places the lava "plug" may have been forced up above the surface during subsequent moon-quakes much as a plug of lava is sometimes forced from an old volcano —as happened in the early stages of the Krakatoa eruption. If this is the case, the ridge, which can be seen to follow the "rill" southward on its path alongside the Apennines, may indicate a continuation of the "rill" in the form of a sawback of lava. The appearance, then, of this ridge to our scientist would be the brown-black of a rock of the igneous type, probably a basalt.

Exfoliation by expansion and contraction due to changes in temperature from day to night conditions is likely to be small, because although the temperature change is extreme—from about 214 deg. F. at noon to −243 deg. F. at midnight—it takes place very slowly.

However, coupled with the flaking caused by the quick changes of temperature during eclipses of the Moon—on one observed occasion it fell from 160 deg. F. to −110 deg. F. in about an hour—an extensive system of talus slopes or rock slides is almost sure to be present on the flanks of the ridge and adjacent slopes of the Apennines. In fact, owing to the absence of all other types of erosion, the meteoric dust and flaky gravel will lie thickly wherever gravity allows. With not even sound waves to stir the deposits, the only disturbance other than exfoliation will be the occasional tiny tremor of an impinging meteor or meteorite. Meteor scars will be numerous even on the vertical sides of the rocks as dark burn marks where the flying fragments have liquifted under terrific generation of heat, or possibly as long scars of lighter colour than the parent rock.

Travelling Problems

Travelling on foot even with less gravity would be extremely difficult and, owing to the danger of becoming buried by the lightly balanced slopes of talus, impossible in some places. In fact, some form of light frame, akin to a snow shoe, would probably be needed to skirt such patches.

It is interesting to note that, if it is established that ecliptic changes of temperature are the chief cause of erosion on the Moon, then it follows that the visible side will be more rugged and dusty than the hemisphere which is away from us, because it is only the near side which is subjected to eclipse by the Earth, and thus the unseen side would be inflicted only by the day and night temperature changes.

On the rocky heights of the Apennines only the varying types of rocks will change the colour of the landscape. No soil formations of any type will be present, as soil depends on fluid erosion for its formation, and hence the passage of a climber would be characterised only by clouds of dust and slow falls of shale and rock slivers, which to an outside observer would appear to drop and settle with curious slowness. If the protective suit of the climber conducts, very slightly, big changes in temperature, such changes would be noted with surprising abruptness when passing from the sunlight into the shadow cast by a rock. This phenomenon has been measured by a vacuum thermocouple with subsidiary instruments, using the principle that the maximum energy of sunlight is in the visible spectrum and hence any infra-red emanation observed is an indication and measure of the surface temperature of the body in question. This proves that the surface of the Moon is extensively covered by an extremely non-conductive material, and laboratory tests suggest that the most likely material which obeys the observed thermo-dynamic and optical evidence collected is a mixture of porous rocks resembling pumice and pulverised rock. The low albedo or reflecting power of the Moon—about 7 per cent.—coupled with the evidence that its reflected light is yellowish and reddish compared with direct sunlight, generally suggests that dark brown rocks are most abundant in the crater formations and mountains. It follows that the dust must be of coarse structure because fine dust has a high albedo.

Meteor Crater, Arizona, U.S.A. Nearly a mile wide, this enormous crater was caused by the impact of a huge meteorite in prehistoric times.

Much of the porosity of the surface materials is probably due to small bubbles of subsurface gases which forced the molten materials upwards to form the extensive "Maria." Evidence that these were formed after most of the craters had come into existence is to be seen in the type of crater characterised by Archimedes. This crater formation is found on the outer limits of most of the "Maria" and by comparison with formations such as Aristillus, it intimates that they, too, were once normal but were subsequently filled by molten material up to the level of the surrounding "Maria" whose comparatively smooth and uninterrupted surfaces complete the evidence that most of the crater-creating phase was over at the time of the volcanic flooding.

Crevices, Crags and Shattered Rock

Following our scientist away from the rugged desolation of the Apennines, northward to the crater of Aristillus, we would find its approaches extremely difficult to surmount, being a hodge-podge of crevices, crags and shattered rock, much of it showing signs of subjection to great heat. Being of the school of meteoric origin of the craters, it is the writer's opinion that the evidence of lava *only in the crater rims* of most of the craters is direct evidence of such an origin, and that the "lava" is, in fact, not lava in a volcanic sense, but surface rocks liquified by the heat generated in meteoric impact.

Climbing the riven walls of the crater, it would be found that the slope of the wall was much steeper on the inside of the crater than the outside, and a comparison between the floor of the crater and the surface outside would show that the floor was much the lower. Furthermore, far out in the centre of the floor a group of sharp peaks, not quite so high as the walls, project themselves. Such are the characteristics of the majority of the craters. Such types as the "level floored craters," craters with no centre peaks, and a few others can be regarded as exceptions to the general rule. The number of the exceptions, it is true, is large, but then there are so many ways in which modifications to structure could have occurred *after* their formation in the early stages of the moulding of the lunar topography, that this objection is, in the main, neutralised.

The characteristic crater shape outlined above can be reproduced perfectly by firing a rifle *at any angle* into fairly soft mud, or by firing a shotgun at close range in the same way, so that the shots remain bunched together.

The crater floor would be found to be covered with shattered rock, some of it from fairly deep strata, and huge quantities of "rock flour" which is the probable cause of the local increase of albedo noted in some craters, and may be the key to the solution of the problem of the peculiar "rays" which emanate from some of the larger craters, Tycho in particular. It is observed that these "rays" cast no shadow, whatever the direction of the Sun's rays, and are unimpeded by crater or mountain in their radial path from their parent crater. From evidence at hand, the simplest explanation is that the "rays" are composed of "rock flour" mixed with somewhat coarser material, the mixture having been flung out of the impact centre in the same way a pile of flour is scattered when a marble is dropped upon it. The terrific impact and the low gravity explain the immense distances covered by these "rays." The rim of the crater Archimedes would have all the characteristics found in that of Aristillus, but its floor would have the appearance of a small "Mare."

Temperature Gradient

A survey of the lunar surface conditions would not be complete if mention were not made of the temperature gradient on the crust. It ranges from 214 deg. F. at the Moon zenith, nearest the Sun, to under −58 deg. F. at the terminator. A fairly constant temperature of −243 deg. F. is recorded on the night side. To obtain a more complete record of the temperature gradient on the sunlit side, imagine the Moon in its first or last quarter, when half the visible side of the Moon is sunlit, then divide the bright portion into six longitudinal sections of approximately the same width except for the first, which just slices off the Moon's bright zenith. Then the approximate temperatures on the surface of each of these sections thus formed, starting with the bright zenith and ending with that bounded by the terminator, are: 214 deg. F., 194 deg. F., 140 deg. F., 86 deg. F., 32 deg. F., and minus 58 deg. F.

So multitudinous and varied are the individual features of the Moon's surface that a full description of them could fill many volumes, and such a task is obviously not within the scope of this short survey, but in conclusion it may be of interest to mention a few of the more outstanding individual peculiarities. One interesting lunar formation is the "Straight Wall," some 70 miles in length, in the S.E. corner of Mare Nubium, north of Tycho. It is shown to be a cliff or wall 1,000 to 2,000 feet in height, its sheer face clearly due to its origin as a rock fault, where one edge has risen above the other. Similar faults on a much smaller scale are found, on Earth, to be the foci of earthquakes. Another phenomenon is the "crater pit," which differs from the "craterlet" by its lack of an elevated rim to the crater. It is very small compared with most formations, but is quite common on the Moon's surface. A system of these can be seen west of Crater Copernicus.

Peculiar Formations

We have already mentioned the queer "rays" which flare from many of the large craters, but it is interesting to consider an additional point. The presence of the "rays" attached to some craters and not to others, even though the structure of the crater may be the same but for that, can perhaps be explained by one Selenologist who has a theory that such craters can only be formed by *metallic* meteorites, and suggests that the bright "rays" are areas covered by tiny spheres of shining metal—metal that has been vaporised by the impact and condensed into millions of tiny spheres. A geologist has recently substantiated this theory by discovering millions of tiny iron pellets in the soil about a meteoric crater near Haviland, Kiowa, County Kansas, U.S.A. Analytical tests prove the pellets are composed of meteoric iron alloyed with nickel.

A final peculiar formation is found in the discovery of a dark spot near the Crater Aristachus while photographing with ultra violet light-sensitive plates. It was found that the patch did not appear on plates sensitive to orange light, and subsequent experiments led to a conclusion that this large dark spot was an extensive deposit of sulphur.

A short survey of the surface conditions of the Moon, such as this, can touch only on the main points of the subject, and many tomes would be needed to hold all the evidence and experimental results which have led to the numberless theories of the Moon's composition. It is true to say that confirmation of any one theory with scientific certainty will only be possible when the first expedition steps from its vessel on that enigmatical crust, and that time is not far distant!

The Helicopter—2

The Focke-Wulf FW.61 Machine

By L. H. HAYWARD

(Continued from page 309, June issue)

A model of a 14-passenger helicopter air bus intended to be used on local air services in the United States. The aircraft was designed by Raymond Loewy, in collaboration with Igor Sikorsky.

FIVE years of hard work, intensive research and the carrying out of countless experiments, coupled with thousands of mathematical calculations and the expenditure of large sums of money, brought due reward to the German, Professor Henrich Focke, when the helicopter that he designed captured all the world records for this type of aircraft in 1937.

Believing that the conventional type of aircraft suffered from the limitations that a large flat space was necessary for take-off and landing, and that it was unable to hover or fly very slowly—two requirements that have very considerable advantages in certain conditions of flight—Professor Focke interested himself in the direct lift, rotary wing type of aircraft. He aimed at providing a machine capable of taking off and landing vertically, hovering as required, flying in any direction, giving the maximum service for the minimum amount of attention, combining rigidity with lightness, being perfectly stable under all conditions of flight, and last, but not by any means least, the provision of such a machine that would be simple and easy to fly.

During 1932 Focke designed and built a model helicopter that was powered by a 0.7 horse power petrol engine installed in the nose of an orthodox type of aircraft fuselage. A structure extended outwards and upwards from each side of the fuselage and carried a three-bladed rotor assembly. The two rotors revolved in opposite directions to each other and thereby cancelled out the torque on the machine. The model was extensively used for experimental purposes, and although it usually turns out that a model and a full-size machine behave in rather different ways, it did prove that Focke's theory was sound.

The Focke-Wulf Company built a full-size machine that was ready for initial testing during the early part of 1936. To minimise the risk of damaging the machine through mechanical failures, and to obtain experimental data, a large number of "flights" were made while it was securely tethered to the ground. The first free flight was made on June 26th, 1936, by Herr Ewald Rohlfs, a Focke-Wulf test-pilot. In addition to covering the fuselage, many refinements and detail modifications were made to the machine during the next twelve months, and on June 25th-26th, 1937, this machine, flown by the same pilot, put up a performance that captured all the international helicopter records for Germany. A speed of 76 miles per hour was averaged over a distance of 12½ miles, the machine making a duration flight of 1 hour 20 minutes, and rising to a height of nearly 8,000ft. Exactly a year later, on June 20th, 1938, a distance of 143 miles was flown on a dead-straight course.

Fig. 4.—Focke's proposed passenger helicopter.

Indoor Flight

In 1938, Fraulein Hanna Reitsch, who was famous in Germany for her sailplane and glider flights, flew the Focke helicopter, now known as the FW.61, a distance of nearly 70 miles from Stendal to Berlin to demonstrate the machine in the Deutschlandhalle. A number of diehard technicians and government officials had expressed the opinion that the FW.61 could only hover when flying into a strong wind, so the Focke-Wulf company arranged that the machine should be flown indoors, where any assistance from the wind was an absolute impossibility. Although this is believed to be the first time a helicopter was successfully flown indoors under perfect control, the Royal Aeronautical Establishment at Farnborough had previously been experimenting with machines in the old balloon shed, and the Brennan and Isacco machines are reported to have made a number of indoor "hops," but, unfortunately, the greatest feature of these machines was their apparent lack of control.

Construction

A normal aeroplane fuselage of fabric covered welded steel tubes, with rigid bracing and carrying a fin and rudder at the tail, is used. A seven-cylinder, air-cooled, radial, Siemens' Bramo Sh.14A engine (without supercharging), and with a direct drive to the engine-cooling fan, is installed in the nose of the fuselage. The engine weighs approximately 300 lbs., has one inlet and one exhaust valve per cylinder, operates on the dry sump principle, and develops a maximum of 160 h.p. at 2,200 revolutions per minute.