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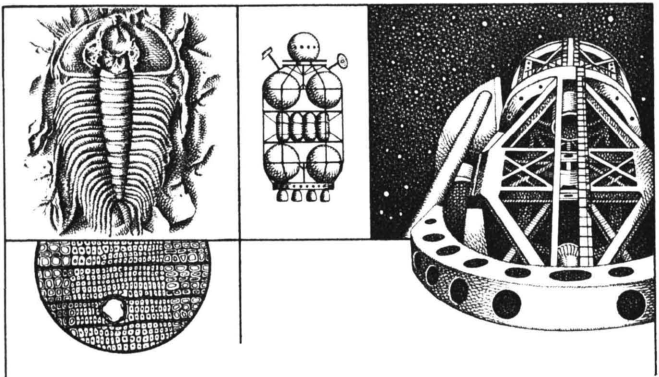
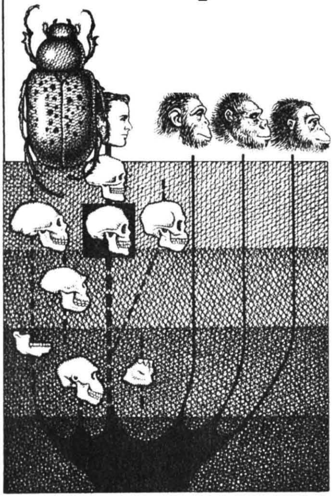
UNVEILING THE MYSTERY PLANET By WILLY LEY



for your information

By WILLY LEY



UNVEILING THE MYSTERY PLANET

NAME THE planet which most closely resembles Earth in size. The answer, of course, is Venus. From direct measurements, its diameter works out to 7700 miles, while that of Earth is 7900 miles. But note, please, that these 7700 miles include the cloud layer or layers of Venus, so the planet proper must be somewhat smaller. And don't ask by how much — it isn't very polite to ask questions to which the answer is not known.

Now name the planet that comes closest to Earth of all full-fledged planets — which means discounting a few planetoids like Hermes, Albert, Icarus, etc., and naturally our own moon, too. The answer is again Venus. When both Earth and Venus are on the same side of their orbits, the distance between them amounts to about 26 million miles, which is a good 9 million miles closer than our neighbor on the other side, Mars, can ever manage. And even this is not the best Venus can do. On December 6, 1882, during a so-called transit — the transits will be discussed later — the distance was only 24,600,000 miles.

Now name the planet with the most nearly circular orbit. Venus, of course. Now the one which is the most nearly perfect sphere. Again Venus. And now name the planet about which least is known. The answer, disappointingly, is still Venus.

THOUGH Venus can come closer than any other planet, we know as little about it as we know about Pluto, the planet which is farthest away. In fact, what we do know well (and reliably) is the same in both cases. We know their orbits.

That of Venus, as has been said, is very nearly circular. The differences in the distance of the closest approach between Venus and Earth are mostly caused by the fact that the orbit of Earth is somewhat eccentric; Earth is closest to the Sun in January. As for Venus, the average distance from the Sun is 67,200,000 miles, and the planet, moving with an average orbital velocity of 21.7 miles per second — that of Earth is 18.5 miles per second — needs 224.7 days to go around the Sun once.

If the plane of the orbit of Venus coincided with that of Earth, which is the ecliptic, we would see the planet moving across the disk of the Sun every time Venus comes closest to us, overtaking the slower Earth in the permanent race around the Sun. But the plane of the orbit of Venus does *not* coincide with the plane of the orbit of Earth. There is a considerable tilt, amounting to 3 degrees, 23 minutes and 38 seconds of arc.

This is a stronger tilt than that of any other major planet, excepting only Mercury (with 7° 0' 12") and Pluto (with 17° 8' 38"). Because of it, Venus, as a rule, does not pass between us and the Sun, but is, as seen from Earth, "above" or "below" the Sun. Only rarely does it happen that the two planets pass each other in sections of their orbit which are situated in such a manner that a line from the center of the Sun through the centers of both planets would be a straight line, or very nearly so.

When that happens, we get a "transit." Venus, which mostly is the brightest planet in the sky, then moves across the Sun's disk as a black spot. The spacing of these transits in time is such that a man might either observe two of them within his lifetime or not live long enough to see even one. The generation born early in the present century will not live to see one, while the generation now being born will see two.

It works like this: supposing a Venus transit is due in the year X, the next transit will take place in X + 8. But the next one after that will not happen until 121½ years later. Then there is again an interval of only 8 years, but if somebody just happened to miss them, he would have to wait for 105½ years for his next opportunity. The cycle, then, runs 8, 121½, 8, 105½, 8, 121½ and so forth.

Actual years of Venus transits were 1761, 1769, 1874 and 1882, with the next two scheduled for 2004 and 2012.

BY 2004, a Venus transit will assuredly have lost most of its former importance, but in the past a transit was something that every astronomer was eager to observe — expeditions were sent halfway around the globe in order to obtain observations from as many points as possible. The main reason was what had first been pointed out by the Astronomer Royal Dr. Edmond Halley; namely, that the precise time required by Venus to cross the Sun's disk could be used to calculate the distance from the Earth to the Sun, something that was not yet established then.

In the course of these transit observations, it was found that Venus has an atmosphere. While Venus is crossing the Sun's disk, it appears simply as a round black spot, but while entering and leaving, the round dark spot is surrounded by a luminous ring, caused by the bending of the Sun's rays by the atmosphere.

It is one of the "believe-it-or-nots" of the history of science that the first two reports on this phenomenon were casually forgotten.

The first to see it and to draw the proper conclusions (and to write them up, which is important, too) was Mikhail Vasilyevitch Lomonósov, who observed it from his home in St. Petersburg, Russia, during the transit of May 26, 1761. Though his discovery was discussed with much animation at the Imperial Academy of Science, nobody outside Russia learned about this fact until another Russian scientist published a book about Lomonósov in Germany in 1910!

During the next transit of 1769, David Rittenhouse of Philadelphia made the same discovery. His report was also mislaid for more than a century and when it was again seen during the transit of 1874, it was considered a great novelty!

After the next transit, that of 1882, it was established that the same phenomenon can sometimes be observed even when Venus is not in transit. As has been said before, Venus normally is "above" or "below" the Sun when the planet passes Earth. But on these occasions, Venus may be quite "near" the Sun along the line of sight and then one can spot the planet in the daylight sky as a very thin ring of light.

Unfortunately, this phenomenon only tells us that Venus has an atmosphere. It does not tell us how deep it is. The true diameter of Venus, therefore, is still unknown. Nor do we know the mass of Venus. The books usually state that the mass of Venus is 80% of the mass of Earth and the surface gravity of the planet is also given as that of Earth minus 20 per cent. Well, it probably is near that value, but we can't be completely certain.

If Venus had a moon, the mass of the planet could be derived very readily from the time needed by that moon to swing around its primary. Since Venus is moonless, though, its mass has to be derived from its influence on the neighboring planets; you get the nice paradox that an astronomer may check on the movement of Mars with the utmost care *in order to find out how much Venus weighs!*

But since Mars is also pulled by Earth in one direction and by Jupiter in another, with Saturn exerting some influence, too, the final result has to be somewhat uncertain, although the masses of Earth, Mars, Jupiter and Saturn are well known because all of them do have moons.

THAT VENUS might have a moon was believed for quite some time and, as late as 1870, the British astronomer Richard A. Proctor (in his book *Other Worlds Than Ours*) did not yet dare to say that the older observations of a moon of Venus had been mistakes. His attitude was more or less that there was so much historical evidence for a moon of Venus that its existence had to be accepted with some reservations even though it had not been seen recently.

The first to proclaim that Venus had a moon had been the Neapolitan astronomer Francesco Fontana in 1645. His report made his famous contemporary Jean Dominique Cassini watch for it. Cassini thought he saw it in 1666 and in 1672 he felt sure and published his observation.

But a long time went by until somebody else went on record as having observed the moon of the evening star. In 1740, the English astronomer Short announced his seeing it, whereupon Mayer in Greifswald in Germany started looking and succeeded in 1759. In 1761, Montaigne in Limoges, France, and Rödkier of Copenhagen corroborated the findings of Mayer and in 1764 Horrebow in Copenhagen and Montbarron in Auxerre, France, corroborated Rödkier and Montaigne.

To everybody's chagrin, that moon had failed to show up during the actual transit in 1761. Efforts to spot it were quadrupled during the transit of 1769, but except for one doubtful assertion, the evidence proved negative.

This failure had been predicted by Father Maximilian Hell, S. J., of Vienna in 1766. Father Hell — fortunately for his calling, the word *hell* merely means "bright" or "luminous" in German — had said that the moon of Venus was merely an optical illusion. The bright image of the planet is reflected back into the telescope from the cornea of the observer's eye and then "seen" as a smaller image of the same phase near the main image.

Still, people kept looking and the two transits of 1874 and 1882 were again checked for signs of a satellite of Venus. The result was negative and a Belgian astronomer, P. Stroobant, set himself the task of finding out what the various observers had seen, if they had seen anything other than Father Hell's secondary image. And he discovered that whenever the moon of Venus had been reported, the planet had been near a small fixed star, one just bright enough to be seen without a telescope as a faint star. In the telescope, it would be rather bright, though, of course, just a pinpoint of light.

The stars that had doubled for a moon of Venus were found to have been *64 Orionis, 71 Orionis* and *mu Tauri.*

WITH AN object like Venus which becomes invisible — meaning that all we can see is the night side — just when closest to us, one has to be grateful for any definite bit of information. The discovery of the atmosphere by Lomonósov, Rittenhouse and Schroeter was one of these definite bits. The final disproof of the existence of a moon by Stroobant was another one.

A third one has been added just recently, more than half a century later, by Gerard P. Kuiper of Yerkes and McDonald Observatories, who at long last succeeded in establishing the position of the axis of Venus. The inclination of the equator of Venus to the plane of its orbit turned out to be 32 degrees, with a possible error of 2 degrees either way. The axis of Venus points in the direction of the constellation of Cepheus.

The question of the position of the axis of Venus and the closely connected problem of the rotation of Venus and the length of its day both have quite a stormy history.

It must first be stated that the blinding white disk of cloud-veiled Venus is virtually featureless. The area over the poles, especially over the south pole, looks somewhat brighter on occasion, while faint and large spots seem to be located in the equatorial regions. But none is sharply defined and, in any drawing, the contrasts have to be exaggerated many times in order to be "drawable" at all. Now of course it is the surface markings of a planet from which you derive its period of rotation and the position of the equator and of the poles.

The story of the surface markings begins with Jean Dominique Cassini, who felt certain that Venus turned on its axis at very nearly the same rate as Earth. The figure he gave in 1666 was 23 hours and 15 minutes.

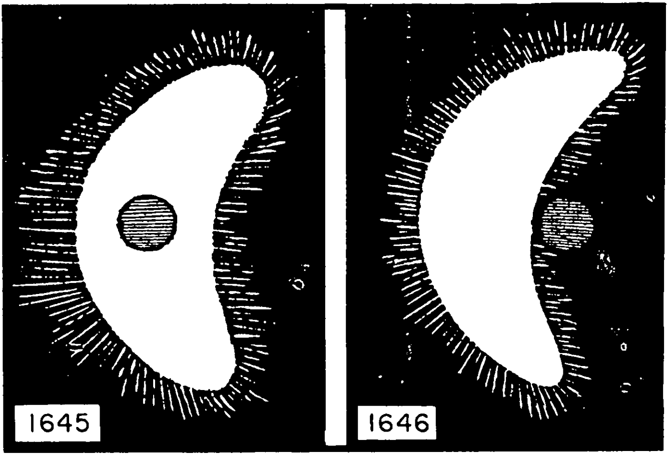
Some eighty years later, Francesco Bianchini, one of the members of Pope Clemens XI's commission for calendar reform, declared that Cassini had been mistaken. It took much longer than a day; in fact, it took 24 days and 8 hours.

Several decades later, a team of German astronomers said that it was Bianchini who was wrong and that Cassini had been right or very nearly so. The length of the day on Venus was precisely 23 hours, 21 minutes and 8 seconds.

This was slightly revised in about 1841 by the Père de Vico, who thought he could prove a diurnal period of 23 hours, 21 minutes and 22 seconds.

OBVIOUSLY, if the period of rotation of Venus were something like 23½ hours, the position of the markings, observed on successive evenings, should be about the same, since both Earth and Venus would have completed a full rotation in the interim.

But then came Giovanni Virginio Schiaparelli, discoverer of the Martian "canals" and diligent observer of Venus, who said that you would find the markings in the same positions if the planet had not rotated at all in the



Earliest telescopic drawings of Venus, made by Francesco Fontana in 1645 and 1646

meantime. Schiaparelli felt certain that both Mercury and Venus behaved with respect to the Sun as our moon behaves with respect to Earth, that they always face the Sun with the same hemisphere — in other words, that they performed one rotation per revolution around the Sun.

As regards Mercury, Schiaparelli's opinion has been fully accepted by everybody. With respect to Venus, it had to be rejected, for the observed facts do not fit the theory and the observed fact here is one of the few things we actually and definitely do know about Venus — the existence of the atmosphere.

Let us try to imagine what would happen if Schiaparelli were right. More specifically, let us imagine what would happen if the rotation of Venus were stopped right now so that the sunlight would always fall on the same hemisphere — sunlight, incidentally, which is about twice as powerful as that received by Earth.

The heated air would rise and flow across the terminator to the dark side. There it would cool off, shed what moisture it may have contained and return to the daylight side, picking up more moisture for the return trip to the night side. After a relatively short time, as time is measured by astronomers and geologists, all the water on the planet would be deposited, frozen, on the night side, which grows colder and colder as time goes on.

Since the planet is nearly Earth size, the area of the night side would be large and, in its center, a cold pole would develop which is no longer warmed by the air coming over from the daylight side.

In time, the area of the cold pole would be cold enough so that the carbon dioxide in the atmosphere does not return to the daylight side. The atmosphere would grow thinner, too; it is heated enough for a portion to be lost into space because a number of the molecules would certainly acquire escape velocity or better.

With less air to transport heat to the night side, the night side cools off even more rapidly and grows cold enough to freeze the gases.

In the end, all the moisture and a portion of the atmosphere would be frozen on the night side, while another portion of the atmosphere would have been lost in space.

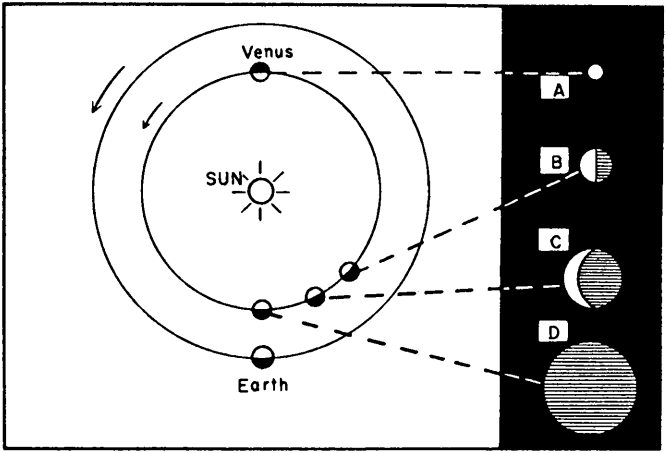
ALL THIS, of course, would have happened many million years ago, so that Venus now should be an atmosphereless planet.

I might add that conditions on Mercury do not have to be precisely the same as just described for a hypothetical Venus. Mercury is much smaller than Venus, which means that its escape velocity is less and, being closer to the Sun, it is heated up more. Any atmosphere which Mercury might have had was probably lost in space, and what moisture there was might well be frozen on the night side.

In the case of Mercury, this might have taken much longer because it has a rather wide "twilight belt" because of its very eccentric orbit. Venus, running along a nearly circular orbit, cannot have a twilight belt of any width.

So we are sure that Schiaparelli was wrong with respect to Venus. The planet must have a diurnal rotation but the question of what it is is still unsolved.

If, for example, Cassini had been right, we could now detect this rotation by the Doppler effect. But the Doppler effect does not give any reading, which means that the rotation must be slower than that of Earth, longer, say, than 100 hours. On the other hand, it cannot be very much



Orbits of Venus and Earth and Venus' appearance in various positions. When showing phase C, Venus has maximum brightness

more than 100 hours because, if it were, the temperature of the upper layers of the atmosphere should be quite different on the daylight and on the night side.

But what differences have been measured are not very large — and somewhat uncertain, too. From what we now know, which is admittedly not enough, the period of rotation of Venus seems to be in the vicinity of 20 days.

Now for the markings.

They are, as has been mentioned, quite faint and indistinct and consist mainly in the fact that the polar regions look somewhat brighter than the equatorial areas. Bianchini, after many observations, came to the conclusion that there were a number of interconnected equatorial seas which he named *Mare Galilei, Mare Columbi, Mare Vespucci* and so forth.

The German Schroeter centered his attention on the polar areas and announced that he had caught glimpses of an enormous mountain near the south pole, a mountain that had to be about

45 miles high. Since no mountain of such a height is possible — its own weight would cause it to "settle" — Schroeter was probably deceived by an isolated high cloud.

IN 1891, just after Schiaparelli had published his conclusions about the rotation of Venus, the astronomer Niesten, who did not agree with him at all, published a map of Venus (Fig. 3) which has remained the only one of its kind after Bianchini's.

Some seven or eight years later, W. Villiger, an astronomer in Munich, took a few rubber balls, dipped them in flat white paint and made a few spheres of plaster of Paris. Then he placed them at such a distance that, when observed through a small telescope, they would show the same angular diameter as Venus does in a larger telescope. And he illuminated them in the manner in which Venus is illuminated by the Sun. After that, he had some graduate students make drawings of them and also produced a few of his own. The featureless white spheres looked much brighter around their "poles" and acquired some vaguely elliptical grayish areas near their middle.

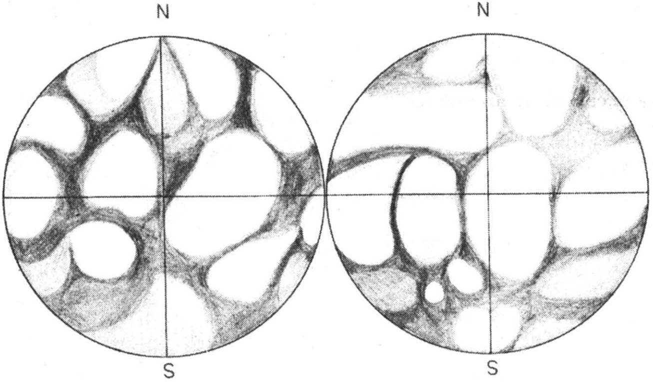
It was quite evident then that no astronomer had ever succeeded in seeing the surface of Venus. Even though definite indentations in the terminator have been seen, such irregularities in the cloud layer did not open a vista of the surface.

I said on one occasion in the past that Venus seems to be at least triple-veiled, for every overcast develops a hole once in a while, and even in a double overcast the holes should occasionally match. With a triple layer of clouds, the probability of the matching of holes — which are evidently rare events to begin with — becomes invisibly small. In short, the clouds of Venus are, as one writer phrased it, as opaque as marshmallows.

But what are they? For many years, they were taken to be water vapor without question and, at the beginning of this century, the surface of Venus was universally considered "dripping wet." If there was a difference in opinion, it was merely about the degree of wetness. When asked, most astronomers would haul a book on geology off the shelf, point at a picture depicting a carboniferous forest and say, "This is how it must look."

Only a few considered the possibility that Venus was a *panthalassa,* meaning that it was covered by a shoreless ocean without any considerable land masses at all, or possibly just a few islands.

The view of a dripping wet



Map of Venus, drawn in 1891 by Niesten

Venus was still held by as important a scientist as Svante Arrhenius in 1918.

JUST one decade later, opinion had completely reversed itself, largely as the result of a long series of pictures taken by F. E. Ross at Mt. Wilson Observatory in 1927. The new view was that Venus was completely dry, that violent storms picked up dust from the endless desert, forming a dust-cloud layer beneath the other cloud layers.

One of the results of this work was that, while the markings seen with the telescope might be optical illusions, there were markings that could be photographed, provided you photographed them in violet and ultra-violet, for they do not show up in light of the wave-lengths the eye can see best. (Dr. Kuiper's determination of the position of Venus' axis is also based on such photographs.) The reason for postulating absolute dryness was that neither water nor oxygen could be detected spectroscopically, but that another set of lines showed up well which was then identified as belonging to carbon dioxide.

But negative evidence is often insufficient grounds for building conclusions. The statement that neither water nor oxygen has been found in the atmosphere of Venus should really read that neither water nor oxygen *has been found above the clouds.* And one can easily explain why there couldn't be any above the clouds.

The spectroscope can only detect water vapor, not water, and the highest clouds of Venus must be quite high up. If, for the sake of discussion, we compare the atmosphere of Venus with that of Earth, the clouds might be 10 miles from the surface, but in the terrestrial atmosphere, the temperature ten miles up is *minus* 67° Fahrenheit. Any water at ten miles would be in the form of ice crystals, so the clouds themselves would be ice crystals. And ice crystals do not show up in the spectroscope.

Likewise, any oxygen present would be past the stage of oxygen molecules, but would be single oxygen atoms because of the powerful solar radiation. I don't know where the bands caused by oxygen atoms would be in a spectrogram, but certainly not in or near the place where one looks for the bands of oxygen — that is to say, oxygen molecules.

SO, WHILE the picture of the bone-dry planet fits what observations there are, it is not necessarily the truth. In fact, Donald H. Menzel and Fred L. Whipple of Harvard Observatory have shown recently that the existing observations would also fit a *panthalassa,* incidentally one where the oceans consist of carbonated water — seltzer!

In short, Venus is either completely dry or completely wet. But can we ever find out which it is? Probably not until a new factor enters into the picture — space travel.

Just to observe from outside our own atmosphere would be an incredible boon to astronomers; the constitution of the atmosphere of Venus above its highest cloud layer could indubitably be established from the space station. The precise mass of Venus could be established by means of a slightly more elaborate experiment. One could fire a missile from the space station in such a manner that its path would be bent by the gravitational field of Venus. Careful observation of the path of this missile would settle the problem once and for all.

But to learn what is below the cloud layer, we would have to go a bit closer. A method that comes to mind without much deliberation is to fire sampling missiles into the atmosphere of Venus from a nearby ship. In the end, it might be possible to lower a reporting missile all the way to the ground.

And then we'll *know.*

— WILLY LEY