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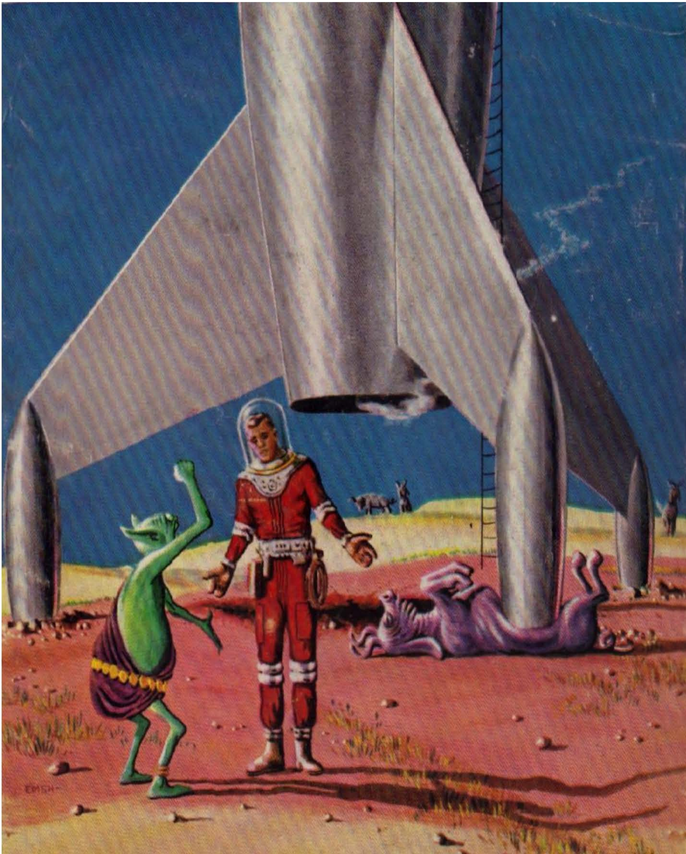
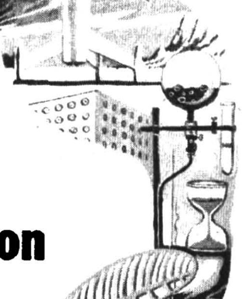


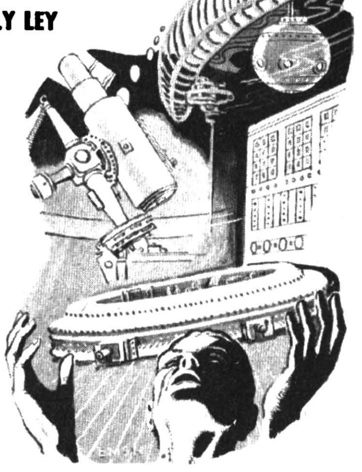
LIVING IN A SPACE STATION By WILLIE LEY





For Your Information

By WILLY LEY



SECOND TRIP TO VENUS

FOR some time now, I have been accumulating letters that could not be answered briefly, but which asked questions that I believe to be of general interest.

The first of these letters came from Donald Kingsbury of 2108 Maplewood Avenue, Montreal, Canada, who offers this problem.

Let's assume that space travel engineering has progressed to the point where we can send an expedition to Venus along the orbit of minimum fuel expenditure, a so-called Hohmann A orbit. Supposing that this is the best we can do, for we cannot yet use a more expensive orbit, the problem is this:

How soon can a second expedition follow the first?

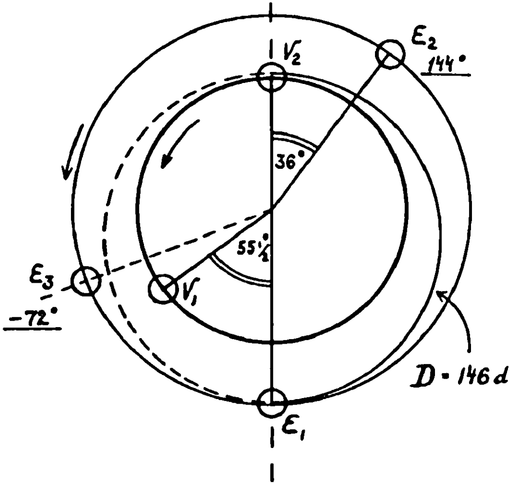
ALL right, let us see first how such a trip would be made. The Earth moves around the Sun with a velocity of 18.5 miles per second. This is exactly enough to counteract the Sun's gravitational force at the distance of 93 million miles. If a spaceship took off from the "forward" side of the Earth — which means at dawn — it would add its own velocity to that of the Earth and move "too fast" for the Sun to hold. As a result, the ship would drift outward in the Solar System, away from the Sun. But if the ship took off from the "back" of the Earth, at dusk, it would subtract its own velocity from the orbital velocity of the Earth and be "too slow" to maintain its position. It would drift inward in the Solar System.

Don't be confused by the idea of taking off in the opposite direction of Earth's orbital movement. The ship would still move around the Sun in the same direction, because the ship's velocity would be on the order of 8 or 9 miles per second, so it would still move in the same direction as the Earth, only more slowly. Seen from the Sun, it would make about 10 miles per second instead of 18.5.

Drifting inward in the Solar System, the ship would approach the orbit of Venus. Now it can be shown conclusively that the minimum of fuel would be required if the ship's orbit just touched that of Venus. If you spent more fuel, it would cross the orbit and then you'd need more fuel to correct this. If you wanted to spend still less, the ship would not quite reach its destination.

To travel from Earth to Venus along this most economical orbit would take 146 days. (See Diagram). In the course of these 146 days, the ship would traverse an angle of 180° as seen from the Sun. In other words, Earth at the moment of departure, the Sun, and Venus at the moment of arrival, must form a straight line.

BUT where must Venus be at departure time so that it will be in that straight-line position 146 days later? Venus, moving with an orbital velocity of 21.7 miles per second, needs 224 days



to go around the Sun once. This means that Venus moves 360°/224 d = 1.607 degrees per day. Earth moves 360°/365 d = 0.987 degrees per day. So while the ship describes an arc of 180° during the 146 days of the trip's duration, Earth describes an arc of 146 times 0.987° = 144° and Venus 146 times 1.607° = 234.5°. Venus, during that time interval, moves 234.5 - 180 = 55.5° *more* than the ship. Therefore the planet could be reached only if at the instant of departure Venus (V_1) is 55½ degrees behind Earth (E_1). At the instant of arrival when Venus (V_2) is in the right position, the more sedately moving Earth (E_2) is 36° behind Venus.

Supposing the ship somehow missed Venus, it would then drift back (dotted line in diagram) to the orbit of Earth, needing another 146 days for the trip back. It would arrive, after 292 days, where the Earth was 292 days ago — but unfortunately Earth needs 365 days (let's forget about those extra six hours) to get to the same spot so that it would still be 72° away (E_3). To arrive at Earth from Venus, Earth should not be 36° behind Venus, but 36° ahead of Venus.

Since Venus is faster than

Earth, the only thing one can do is to wait until Venus has caught up from behind. Venus is 36° ahead at arrival, but we want Venus to catch up so that it is 36° behind Earth. In other words, we want Venus to gain $360° - 72° = 288°$. Per day, Venus gains $1.607° - 0.987° = 0.62°$ or a little better than half a degree. To gain 288° consequently takes $288/0.62 = 464$ days, which is the waiting period until the expedition can return, reaching Earth after $146 + 464 + 146$ days.

The figures for a trip to Mars work out as $258 + 455 + 258$ days. Although the trip to Mars would take longer in itself, the waiting period happens to be a little shorter.

But how soon could a second expedition follow the first?

Well, obviously, the next time Venus is behind Earth by 55.5°, which simply means that, from one takeoff position to the next, we want Venus to gain a full circle or 360°. Which is $360/0.62 = 581$ days or a year and seven months.

The second expedition, then, would reach its goal almost precisely two years after the departure of the first.

LIKE everything unknown or supposed to be unknown, cosmic rays continue to excite the imagination, and in my mail they run a close second to "flying saucers." Indeed, sometimes they seem to catch up with the saucers, which, considering the reported velocities involved, would be only natural. The letter that prompts me to write about cosmic rays at this time came from a lady (Joan Ellen Coan, 30 East 30th Street, N. Y. C.), who had been informed by somebody she politely fails to identify that "a person living near the equator is safer from the mysterious cosmic rays than a person in the arctic because he has more air over his head to protect him." The informant also added — I knew this was coming — that it would be impossible to protect a space crew against cosmic rays.

This takes some careful dissecting to straighten out, because the statement as quoted is a fine mixture of fancy with some fact hidden inside.

To begin with, there is little mystery about the nature of the cosmic rays. They are simply atomic nuclei traveling at high velocities. Most of them are the nuclei of light atoms, but there are occasional heavies.

What is "mysterious" is the source.

The very best available evidence indicates that the cosmic ray intensity does not vary with either the time of the day or with the season. Day in and day out, all year round, you get very closely the same number. It *does* vary with the latitude because of the Earth's magnetic field. At the magnetic equator, the number is smallest; at the magnetic poles, it is highest, about ten times as large near the magnetic poles as near the magnetic equator.

What happens is that the magnetic lines of force deflect the incoming particles. It is just because of this deflection that we don't know where they originate, for the direction of travel near the ground where we catch them has absolutely nothing to do with the direction of their travel in space before they approached the Earth. Although we don't have enough material as yet to be sure, this deflection seems to take place at such heights that the 100-mile altitude of research rockets makes no difference.

The same force that obscures the origin of the cosmic rays is also responsible for their distribution. Over the magnetic poles, an incoming cosmic ray is virtually unopposed; over the magnetic equator, there is maximum deflection. You might say that the rays are admitted at the magnetic poles while those which appear elsewhere managed to climb the fence, said fence-climbing growing more difficult with distance from the magnetic poles.

So this takes care of nature, origin and distribution.

NEXT we come to the problem of protection. It is generally assumed, and correctly so, that incredibly heavy armor or steel, lead or concrete would be needed to stop cosmic rays. From this fact, it is usually reasoned that one will have to find a satisfactory compromise between the weight of armor that can be carried and the amount of protection afforded by that armor. This reasoning, however, is fallacious. It isn't as simple as saying that 3-inch armor will stop 3-inch shells so that you have to worry only about heavier artillery.

When a cosmic ray hits matter — say, our atmosphere — it produces so-called secondary rays which are hardly better than the original rays or "primaries." So after having produced the "secondaries," "tertiaries," etc., etc., you still need enough mass behind or below to stop *all* of them.

Thin armor, then, instead of affording "some" protection, only serves as a source for secondaries without stopping the primaries.

Under these circumstances, it is easy to see why scientists who have investigated these problems have declared bluntly that "a little protection is far worse than none at all." It is like seeking protection against revolver bullets behind several thicknesses of window pane. All you accomplish is to get the bullets *and* glass splinters.

Rocket engineers, naturally, are pleased by this. They much prefer to have a cabin wall as thin and as light as possible, just good enough to stay reliably pressurized. Now it turns out that this is best with regard to cosmic rays, too.

But granting that "partial protection" is worse than none at all, can we do *without* protection?

The answer is a clear *yes.*

We now know the cosmic ray intensity that will be encountered in space. We know how much exposure is permissible for an individual and the top authority in the field, Dr. Hermann J. Muller, has declared that an exposure time of 5 or 6 years would still be safe. The term "safety" refers, of course, to offspring that may be conceived after the exposure. But when it comes to people who do not intend to have additional children, the term "safe" must be used with reference to direct bodily harm.

And that stretches the exposure time very considerably. Quite likely, it is going to give a man far more years in space than he will care to spend out there.

As with all other items in this month's column, this is also in response to a letter. A reader in Cleveland who does not wish to see his name in print wrote me a fairly long letter in which, after innumerable protestations of his devotion to astronomical knowledge, he finally got around to two points. One was a request to tell everything that is known about Jupiter's Red Spot. The other asked whether the Red Spot might be connected with the "flying saucers."

As for the question, the answer is no. I am unable to see any connection between a phenomenon in Jupiter's atmosphere and a set of phenomena of a different type in our own atmosphere.

But I'll be happy to oblige with the information requested.

Jupiter's Red Spot is precisely what the name indicates — a large red spot which can be seen in a good telescope and which shows quite conspicuously on photographs. It is south of Jupiter's equator — in astronomical telescopes and photographs, where the image is reversed, it shows above the equator — and is elliptical in shape. In location, it corresponds to Madagascar on Earth, 20° southern latitude, but in size it corresponds to 3½ times the area of the Pacific Ocean, for the Red Spot extends for about 30,000 miles east to west, and between 7,000 and 8,000 miles north to south. In color, the Red Spot was a decided brick red when strongest, but in the course of time it has been pinkish and even simply gray — one observer told me several decades ago that he had seen it as magenta when he was a young man.

In many books you can find the statement that the Red Spot was discovered in 1878. That is not quite correct. It merely became prominent and conspicuous in that year. But there is an unbroken series of observations for twenty years prior to that date, beginning with one in 1857. A historically minded astronomer, W. F. Denning, spent much time going through older astronomical records and found it on a drawing made by Schwabe on the 5th of September 1831. In fact, it is possible that the first detail ever seen on Jupiter's surface, a dark spot on Jupiter's southern hemisphere, discovered by Robert Hooke in 1664, was what we now call the Red Spot.

We know from our own experience since 1878 that the spot does not have to be red and that it can fade out. The latter might explain the lack of mention between 1664 and the 19th Century.

JUPITER, as you probably know, rotates astonishingly fast for a planet of its size, doing so in a little less than ten hours. Consequently, Jupiter's disk is visibly flattened and streaked with cloud banks, indicating the presence of strong "trade winds." But since we cannot see Jupiter's surface, and since the clouds move with relation to the planet, you find a different rotational velocity if you look at different latitudes.

Near the north pole, you find 9 hours, 55 min. and 42 sec. Near the south pole, it is 9 hours, 55 min., 24 sec.

The southern "temperate current" moves within 9 hours, 55 min. and 5 sec., while its northern equivalent needs 9 hours, 55 min., 38 sec.

The equatorial belt takes 9 hours, 50 minutes and 30 sec., the red spot itself 9 hours, 55 min., and 38 seconds. Since it is largely in an area that requires 9 hours, 55 min. and 23 seconds, it moves slowly with respect to the neighboring cloud bands.

The fact that the rotational period of the spot was different from the period of the atmosphere surrounding it was eagerly seized upon for an explanation. Naturally, the explanations were made up against the background of the astronomical beliefs of the time, some sixty years ago.

Most astronomers were convinced then that Jupiter was still hot, possibly semi-molten, and it was often thought that the four large moons of Jupiter might have a nice, pleasant climate. Even though they could not get much heat from the distant Sun, Jupiter itself probably made up for that.

Another belief that was still around then was the Kant-Laplace hypothesis of the formation of planets and moons. It said, in short, that a rapidly rotating Sun will throw off its equatorial bulge as a ring, which then condenses into a planet, and that a rapidly spinning planet makes its moons in the same manner.

HERE we had a massive planet, spinning exceptionally fast. Moreover, a planet with many moons and a planet which was still hot. Wasn't it logical to assume that Jupiter was giving birth to another moon? At any rate, a number of astronomers accepted this idea and thev prob-ably expected to see the Red Spot separating itself from tne ball of the planet to take up a semi-independent existence as another of Jupiter's moons.

When that did not happen, the explanation was turned around. The difference in rotational motion might indicate that the Red Spot revealed the true motion of Jupiter's surface, hence the spot we saw was not the "event" itself, but merely a reflection of something that had taken place down below.

Since the crust covering the fiery mass of the planet was probably very thin, it was easy to assume that a break had occurred which flooded an area of continental dimensions with lava. The cause for the break might have been purely local, a "geological" event, or else the break might have been caused by the crash of a minor planet or an unknown moon of Jupiter.

At least the second explanation had the advantage that it could be clearly visualized and understood. Unfortunately, as we know now, it cannot be true. Not that we consider a crash of a minor planetoid into Jupiter unlikely — that has probably happened quite often — but our ideas about Jupiter itself have changed greatly.

Being, in round figures, 86,600 miles in diameter, Jupiter occupies 1350 times as much volume as the Earth. But its weight is only 318 times as great. So there cannot be an atmosphere some 300 or 400 miles deep with a just-crusted-over lava core at the bottom of it. The planet simply does not weigh enough for that.

The present concept of Jupiter, for this and other reasons, is that its atmosphere, consisting mostly of hydrogen with some methane and ammonia, is 30,000 miles deep, obviously with enormous pressures in its lower layers. Then follows what is called the Ice Mantle, some 10,000 miles thick, consisting of various "ices," frozen water, frozen ammonia, frozen methane. And only inside this ice mantle is there a rather small rocky and metallic core.

The Red Spot, then, must be an atmospheric phenomenon, located in the upper layers. We don't know what it is, because chemistry and meteorology for an atmosphere like Jupiter's are sciences which don't yet exist.

—WILLY LEY

ANY QUESTIONS?

What caused Gabriel Daniel Fahrenheit to place "zero" arbitrarily 32 *degrees below freezing? There are* 180 *degrees between freezing and boiling by his scale. Does this have anything to do with the number of degrees in a semi-circle? How does F. compare with Celsius and centigrade?*

Battell Loomis
201, 19*th Street*
Manhattan Beach, Calif.

Yes, Herr Fahrenheit of Danzig did act in an arbitrary manner when he placed his "zero" 32 degrees below the freezing point of water. But he had some justification for picking this particular temperature—it was the coldest he could produce (by mixing snow and salt) on a cold winter's day.

The range of 180° F. between freezing and boiling has no reference to the 180 degrees of arc in a half-circle; this is prob-arc in a half-circle; this is probably accidental. The upper fixed point was not the boiling point of water, originally. Fahrenheit thought that the temperature of the blood of an adult would be best, for it was then believed that this was a constant, provided the man was healthy. According to some historians of science, he took the blood temperature to be 96°, while others say that 100° was intended. Both values miscarried, as we well know, for a man with a blood temperature of 100 is decidedly a "patient."

Even though, in Europe, centigrade degrees are called Celsius degrees—translators often slip up on this—there is a difference. It was the Swedish astronomer Prof. Anders Celsius who was the first to propose that the temperature interval between freezing and boiling of uncontaminated water under sea level pressure be divided into 100 degrees. But he wanted to call the boiling point "zero" and the freezing point "100" (or minus 100). On the centigrade scale which is now in use, zero is the freezing point and

100 the boiling point of water.

The Kelvin degrees—named after the British physicist William, Baron Kelvin — are the same as centigrade degrees, but counted from absolute zero (— 273.1 on the centigrade scale) to avoid having to fuss with minus degrees.

Fifty years ago, the English-speaking countries used the scale of the German Fahrenheit, the French, the Italians, Spaniards and others that of the Swede Celsius, but the Germans and Russians still clung to that of the Frenchman René Antoine Ferchault de Réaumur. On that scale, now fortunately extinct, zero was the freezing point of water, but the boiling point was 80 degrees.

A few months ago, I ran across the term googolplex which was described as

$$10^{10^{10}}$$

Is this same as 10^{100}*? I know that a googol is usually written as a one followed by* 100 *zeros.*

Jay Olins
17332 Sunburst St.
Northridge, Calif.

Your last sentence is correct. A googol (of which its author, Dr. Edward Kasner, says that "it is not even approximately a Russian author") is a one followed by a hundred zeroes, in mathematical notation 10^{100}. A googolplex is defined as a one followed by a googol zeroes, in mathematical notation

$$10^{10^{100}}$$

or if you want to lessen the probability of typographical errors and misreading

$$10^{(10^{100})}$$

Of course your figure

$$10^{(10^{10})}$$

is much larger than 10^{100} since that is only $10^{(10^{2})}$. This number does not have a separate name, however.

Is uranium the heaviest element naturally occurring on Earth?

Jerry O'Neill
Silver Springs, Md.

From the way you use the term "heaviest element," it seems to me that you mean atomic weight rather than specific gravity. In either case, uranium is not the heaviest element naturally occurring on Earth — plutonium is.

The heaviest uranium isotope has a weight of 238. Plutonium has a weight of 239.

As for specific gravity or density, osmium is at the top of the list with a density of 22.5 times that of water. The density of uranium is 18.7. I don't know whether or not the density of plutonium has been officially released.