Galaxy SCIENCE FICTION

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FEATURING

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By

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THE MOON CONTRACT

IT EXISTS RIGHT NOW!

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A WORLD CALLED MAANEREK

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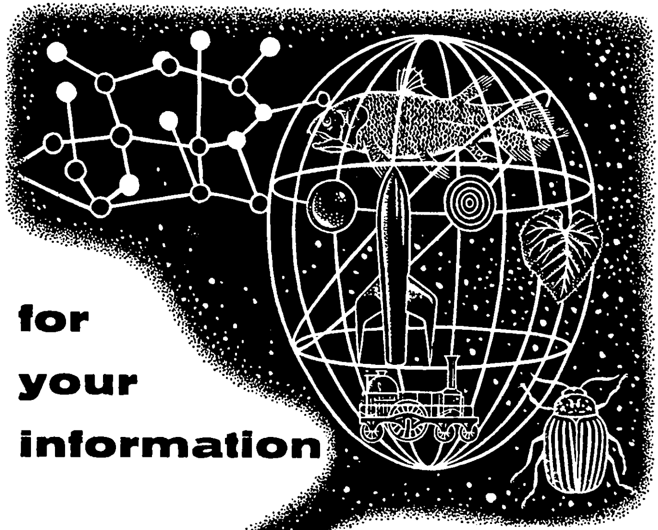
AND OTHER STORIES



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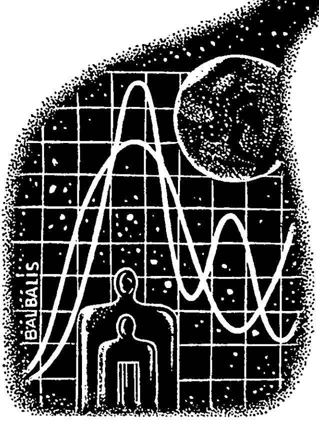

BY WILLY LEY

THE MOON CONTRACT

I HAVE just had to check back to see when my book *The Conquest of Space* first appeared, because the date has some bearing on this story. Well, the copyright note says "First Published in September, 1949," so it must have been in the early summer of that year.

The book, as far as the mechanical processes of production are concerned, had advanced almost to the final stage. Color proofs of the paintings had been made and approved by Chesley Bonestell. Galley proofs of the text had been read and corrected. The page proofs had gone from printer to publisher to author and back the same way. All that was left for me to do was to wait.

One morning during this waiting period, while reading the *New York Times* at breakfast, I found a little box, telling that Dr. Gerard P. Kuiper had found a hitherto unknown small satellite of Neptune. Most interesting, that. I dropped the *Times*, raced to the telephone, dialed my publisher and asked, "Is *Conquest of Space* on the presses?"

The answer was something like, "It might be by now. If you want to know, I can call the printer and ask."

"Do that," I said, "and if they haven't started yet, tell them to wait till afternoon. I'm coming in."

The reason for this telephone call was that I realized that a few passages in the book were suddenly wrong. There was one which read "the lonely moon of Neptune," another one which read "Neptune's single moon" and a third one that said "like Earth, Neptune has only one moon." Don't bother looking it up — the printer had planned to start the press run that same afternoon, and by 11:30, the three passages had been replaced by others which were factually correct and took the same amount of space.

My reason for remembering this now is that I told the editor, while typing the changes, that my statement might be proved wrong for Earth, too, one day. Well, as far as we can tell, it won't be. Earth does have only one moon, we are sure now — *reasonably* sure, that is.

ABOUT two weeks ago, I received a large brown envelope in the mail which said on the outside "Office of Ordnance Research, U. S. Army" and inside there was a 30-page report, on the cover of which it said in letters of diminishing size:

PHYSICAL SCIENCE LABORATORY
State College, New Mexico
Interim Report on
SEARCH FOR SMALL EARTH SATELLITES
for the period 1953-56
By
Clyde W. Tombaugh

Dr. Clyde W. Tombaugh, most GALAXY readers will probably recall, is the discoverer of the planet Pluto, and early in 1954, it became known that the Office of Ordnance Research gave him, via Lowell Observatory and New Mexico State College, a research contract to find out whether Earth might not have another small moon, or possibly moons.

I devoted part of my column in the September, 1954, issue of GALAXY to the news that such a search was on and I explained then why these additional moons, if they existed, had to be quite small.

The story of the second moon of Earth has had a rather tenacious life ever since 1870, which was the year when Jules Verne's *Autour de la Lune* appeared, the second part of his story about the shot to the Moon. In it, Verne provided the three inhabitants of his Moon projectile with a glimpse of the second moon of Earth and explained that a French astronomer by the name of Petit had postulated its existence. Although no figure for the size of this second moon is given in the story, the reader is left with the impression that it must be rather substantial, at least a mile in diameter.

Astronomers declared at a later date that a moon a mile in diameter at the distance given by Petit (4650 miles) would have been discovered by the ancient Babylonians, since it would be, at certain times, a rather easy naked-eye object. Before this fact was presented, several German astronomers had spent some time trying to find Petit's moon, which they punningly called *Kleinchen*. The point of the pun is that *Petit* is the French word for "little" or "small" while *Kleinchen* is German for "the little one." Of course they did not find his moon.

By the time Dr. Tombaugh started his search, it was quite clear that the additional satellite would be measured in feet and not in miles — how many feet depended, naturally, on the distance.

IN THE fall of 1954, the news came that Tombaugh had found two moons, one 400 miles out and another one at a distance of 600 miles. The story went with it that, when this report reached the Pentagon, a general asked suspiciously, "Are they natural?" That story may be true, but the report that two moons had been found was not. If anybody knows how it originated, he is keeping his lips tightly shut. At any event, Dr. Tombaugh wrote me at the time that the report was not true. Moreover, it referred to distances that had not even been investigated at the time.

The search was made by telescopic camera and the sensitivity of the instrumentation was revealed with a sentence that has been quoted quite a number of times since. The equipment, the statement said, could discover a tennis ball at a height of 1000 miles, provided only that it was white. It also could discover a V-2 rocket (which is just short of

47 feet) at the distance of the Moon.

This original statement has since been amended to read that the tennis ball could be found even if it showed itself only in half phase; the V-2 rocket near the Moon would have to be in full phase and also painted white.

Any satellite of Earth — natural or artificial — which is closer than a certain limit would have to move so fast to stay in its orbit that it would rise in the west and set in the east. The limit just mentioned is 22,300 miles from the surface. At that distance, the satellite would have an orbital period of 24 hours and would neither rise nor set but just hang in the sky over one hemisphere and never be visible from the other. Satellites beyond that limit would behave as one expects them to behave.

Let us assume now that we have a satellite 4000 miles from the surface. It would need just four hours to go around the Earth once. Knowing this, one can calculate how fast it would move across the sky. Then an astronomical camera can be geared to sweep across the sky at the same rate.

If the satellite is in the field of vision of the camera, it would show up as a dot on the plate, while the fixed stars in the field of vision would show up as streaks from edge to edge. If that satellite were at, say, 3700 miles, but the camera were set for a sweep for a 4000-mile satellite, it would still show up. It would have made a very short trail, very easily distinguishable from the edge-to-edge star streaks.

It should be clear from this explanation that a satellite search with such equipment is mostly a question of patience, a commodity which must be built-in in any astronomer. It is "merely" a question of adjusting the camera for a whole series of sweeps, corresponding to various satellite distances and orbital periods. If there is one, it must be caught sooner or later.

JUST *one* dot or very short trail on a photographic plate is not enough proof, however. There might be a tiny bubble in the emulsion, a flaw of some kind — I mentioned once in this column that the planet Pluto was missed on a photographic plate (years before Tombaugh found it on another one) because the image happened to have fallen on such a flaw and was taken to be a part of it. To avoid being fooled by such an accidental dot, something else had to be done.

It was this: when the trails of the fixed stars had moved to about the center of the plate, the camera was moved a little bit without closing the shutter. The result of this action was that every star trail, at that point, made a very short vertical line and then continued on a different level. (For faint stars, this short vertical line did not register on the plate.) Now if there was a satellite at the distance for which the sweep was set, it would make *two* dots at the proper distance from each other. That there should be a plate flaw producing this effect was most unlikely.

The search was conducted from Lowell Observatory at Flagstaff, Arizona, which, in spite of its generally fine location, had one disadvantage which has to do with the position of the orbits of the unknown satellites relative to the Earth.

There is, as far as I know, no rule that says that a satellite could not circle its planet going from pole to pole. The simple facts are that no such case is known and that it is highly unlikely for various theoretical reasons.

A tiny satellite of Earth could have two possible origins.

One is that it is a piece of débris from the Asteroid Belt which has, for some reason, been drifting inward in the Solar System and has been captured by Earth. That would require such a peculiar sequence of astronomical events that it is not very likely. In most cases, such a piece of cosmic matter drifting in toward the Earth would either simply pass on with a minor change in orbit, or else it would touch atmosphere and crash as a meteorite. Capture by the Earth would be exceedingly rare.

But while capture would be literally a case of much more than "one in a million," it is not impossible. Such a satellite would circle the Earth in about the plane of the ecliptic — the plane of the Earth's orbit around the Sun.

The other possibility has to do with our real and rather large moon. More and more astronomers seem to incline to the belief that the Moon was formed in an orbit around the Earth of loose matter, ranging in size from a few molecules of something to large mountains.

IF THERE were pieces of this "Moon matter" left, they would orbit around the Earth in or very nearly in the plane of the Moon's orbit. Since the plane of the Moon's orbit and the ecliptic are inclined to each other by only five degrees, the search of these two planes is really the same thing, for some deviation from either one or the other must be taken for granted.

The third possibility is that a satellite circles the Earth in the plane of its equator, inclined by 23½ degrees to the ecliptic. But a satellite over the equator would have been pulled into that orbit by the Earth's equatorial bulge, which implies that it would be fairly low. If it weren't, it wouldn't be in that plane. This is where the search from Flagstaff left a hole in the picture. A moonlet circling the Earth over the equator at a lesser distance than 1600 miles from the surface could not be seen—or, rather, photographed —from Flagstaff.

Strangely enough, the search for anything *inside* the orbit of the Moon was really virgin territory. Barring the occasional looking for *Kleinchen* a few Germans had indulged in around the turn of the century, it had never been done. Well, we now know that there is nothing in that region, with the possible exception of equatorial orbits below 1600 miles. For these, Dr. Tombaugh moved to Quito, Ecuador, where such moonlets would be vertically overhead. But the Interim Report was written before this move took place and covered only the work at Flagstaff. It concluded:

> Much of the space about the Earth has been searched. Most of this space has been found to be empty of material moving in the most-likely orbits and large enough to be seen by the present equipment. Some "suspects" have been found on the photographic films, but in all save a few instances it has been possible to determine that the record was not that of a satellite. These images, if not due to defects in the photographic plates, could have been tracks of very small asteroids moving past the earth in their journey around the sun. The several suspects not yet eliminated as satellites are ones which cannot be checked until photographic work has started on the equator. From a statistical point of view, it is more likely that they will turn out not to be satellites. The chance of a discovery of astronomical or geodetic value has, from the beginnnig, been regarded as very small. But a completely negative result, a determination that the space near the earth is free of débris up to a certain size, could have comforting significance to long-range ballisticians and to proponents of space travel.*

THE explanation of the difficulty of capturing moonlets going around the Sun — because they go around the Sun, they are, of course, tiny planetoids or asteroids — implied that any additional satellite that might have been

* This conclusion was written by The Office of Ordnance Research, not by Tombaugh.

found would most probably have been matter left over when the Moon formed. But if such matter was left over, it could go around the Earth in some other ways.

One possibility was that it remained in the same orbit as the Moon, but circling the Earth either 60 degrees ahead of the Moon or 60 degrees behind the Moon. In the case of Jupiter and the so-called Trojan Asteroids, this has been found to be true — many years, incidentally, after it had been advanced as a theoretical possibility.

Having this nice equipment available, it was obvious that Dr. Tombaugh should use it to see whether there might be more moons in the orbit of the Moon. This particular phase of the search had been planned, but by the time the Interim Report was written, it had not been carried out, due largely to bad weather.

But "left-over" Moon matter could still do something else. It could form secondary moons, moonlets of our moon. If such a secondary moon had been found, it would have been the first of its kind in the Solar System. It is perfectly possible that the larger moons in our solar system have such secondary moons, but if they do, they are all too small to be detected from the Earth.

Secondary moons of our moon would have been fairly easy to identify, again if they were large enough to register on the photographic plate. The most likely orbit of such secondary moons would be again in the ecliptic, or else in the plane of the Moon's orbit. Because of this, they would pass between Moon and Earth and then disappear behind the Moon. Twice during every circuit of the Moon, they would be at "greatest elongation," which means farthest away from the Moon either to the east or to the west.

Actually we would see this portion of the orbit strongly foreshortened so that such a secondary moon would remain nearly stationary, to the eye, near greatest elongation for a while. But no matter at what distance it is from the Moon, it would share the orbital movement of the Moon. If you can catch a dot of light, on either side of the Moon, which travels across the sky at very nearly the rate of the Moon itself, you have caught a secondary moon.

YOU probably could, that is, if you did it visually. If you try to do it photographically, chances are that the Moon will cover up the image of the secondary satellite. The Moon is bright enough to ruin everything faint in its vicinity on a plate. Hence this particular search had to wait for an eclipse of the Moon.

As Dr. Tombaugh reported: "The crater Aristarchus is the brightest spot on the moon, and it can be seen in a telescope with some difficulty when the moon is in total eclipse. With a visual guide telescope on the same mounting with the Schmidt camera, one can guide the camera on Aristarchus and prevent the dilution of possible satellite images."

All this had been worked out for the total eclipse of January 18, 1954. "Unfortunately, on the night of the moon's eclipse, the sky was covered by a thick haze."

At the time the report was written, there were hopes for the long-duration eclipse which took place at midnight, November 17-18, 1956. I know that all the amateur astronomers in New York, Long Island and New Jersey were bitterly disappointed, for there was more than just a thick haze. It poured. The weather must have been bad enough to be useless in Flagstaff, too, because no report about a secondary moon has come in yet.

But while Tombaugh's work is virtually definite for the space above 1600 miles (and lower down elsewhere than over the equator), a secondary moon of Earth, a moon of the Moon, and also "Trojan" moonlets in the Moon's orbit, are still possible. Their discovery would, for the time being, be of scientific interest only, but it *would* be interesting.

Naturally an intensive search program of this type had all kinds of "by-products," as Charles F. Capen of the New Mexico College called them in *Sky and Telescope*. A number of meteorites and one bright fireball were caught on the plates. A few others showed very strange zigzag designs — the Naval Observatory's Flagstaff section had released a bunch of meteorological balloons at night without telling anybody. One night, an orange light moved noiselessly from north to south in a straight line; glasses proved it to be the exhaust of a high-flying jet. Another night, they had "Lubbock Lights," but they were a squadron of helicopters.

Six months or so from now, another satellite watch will be on, but then it won't be a natural satellite. We'll have made it ourselves.

MOON ROCKET

COME to think of it, it is really quite a long time since anybody talked about Moon rockets. Twenty-five to thirty years ago, before the time where there was any rocket "hardware," things were different — the Moon rocket was a favorite topic of conversation among rocket enthusiasts.

As the actual engineering research began, the favorite idea of the Moon rocket began to be overshadowed by the nasty reality of an oxygen valve which leaked, and kept leaking no matter what you did about it. And a parachute release that worked was more fascinating by far than the most elegant set of equations. As time went on, all thoughts concentrated first on the high-altitude sounding rocket, then the long-range rocket, and finally on the artificial satellite.

But now the Moon rocket is with us again, in a form which bears little resemblance to the drawings made thirty years ago, but with the encouraging message that it could be built later this year if somebody can be found to sign some papers.

However, a little background is needed first. In Professor Hermann Oberth's writings — from 1923 to 1929 — you can find a discussion of something he called the "optimal velocity." The problem was this: a rising rocket has to fight air resistance, and air resistance goes up very sharply as the velocity increases.

As far as air resistance was concerned, a slowly accelerating rocket was far better than a quickly accelerating rocket. But while the rocket struggled up through a resisting atmosphere, slowly, it also lost 32 feet per second of velocity every second, because Earth tried to pull it back.

Hence, as far as gravitation was concerned, the quickly accelerating rocket beat the slowly accelerating rocket tailfins down.

There had to be a happy medium, a rocket which did not create too much air resistance for itself and did not lose too much speed to gravity, either. And that was the "optimal velocity."

The first large rockets, the V-2s, happened not to be troubled by that problem. They *could not* accelerate very fast because they were so heavy. By the time they got to be really fast, they were above 60,000 feet, with about 90 per cent of the atmosphere below them. Large rockets which were capable of very high accelerations were still to come. But they came, the big solid fuel rockets we now have, which are mostly used to boost heavy missiles into the air.

If one had tried to fire such heavy solid fuel rockets, or clusters of them, from the surface, there would have been trouble with air resistance. And this is not just theory, for such clusters, named HTVs or Hypersonic Test Vehicles, have been fired to measure air resistance at very high velocities.

IN THE meantime, Dr. James A. Van Allan of Iowa University had tried something else.

There is a medium-sized solid-fuel rocket called the Deacon. When fired vertically from sea level, it can reach a height of 60,000 feet, or not quite 12 miles. Van Allan had the Deacon lifted by a plastic Skyhook balloon to about 12 miles and fired it from there. It went to 55 and 60 miles because it did not have to fight much air resistance.

This rocket-balloon combination was dubbed the Rockoon and some important research work has been done with it recently. More of it will come during the International Geophysical Year.

Knowing all this, we are now ready to understand the new Moon rocket, presented for the first time in a paper read in September, 1956, at the International Astronautical Congress in Rome. The authors of the paper were Kurt R. Stehling and Richard Foster, both of them propulsion engineers for the Naval Research Laboratory and presumably quite busy with the Vanguard satellite-carrier rockets.

The "first stage" of the new Moon rocket is a Skyhook balloon which must be able to lift a rocket weighing 26,574 lbs. to a height of 70,000 feet. This, Stehling said, means a balloon of a capacity of four million cubic feet, adding that three-million-cubic-foot Skyhooks have been built and launched.

The Moon rocket would hang vertically below the balloon and tear through it when ignited. This will not hamper the rocket a bit and will not even cause an avoidable loss of the balloon, for the plastic skin of Skyhook balloons is so thin that they can be used only once; they can never be recovered intact for reuse.

The rocket itself is a three-step affair.

Step No. 1 is a so-called "cluster" of four large solid-fuel units, weighing together 25,000 lbs., but developing a thrust of 236,000 lbs. They would burn for about 20 seconds. At the end of the burning time, the rocket will be 70,000 + 110,000 feet up and will be going with a velocity very close to 13,000 feet per second. At an altitude of 180,000 feet, you don't have to worry about air resistance any more, so the next stage, also solid fuel, will be ignited at once.

The weight of Step No. 2 is 1510 lbs. It will also burn for 20 seconds, producing a thrust of 14,000 lbs. When its fuel is gone, it will be 280,000 feet high and the velocity will be slightly more than 26,400 feet per second.

Then Step No. 3 takes over. Compared to what carried it, it is tiny, a 60-pound solid-fuel rocket with four pounds of "payload" in the nose. It will burn for only 10 seconds, but when it is finished, it will be 352,000 feet up and its velocity will be 39,504 feet per second.

LESS than one minute after the order "Fire!" Step No. 3 will be coasting to where the Moon will be four days later, for the time to traverse this distance will be about four days. The rocket will be too small to be seen in a telescope or to be tracked by radar. But radar ought to be able to track the larger stages, so that there should be enough tracking data for a trajectory computation.

The time of the impact will be fairly well known, but just where the rocket will strike the Moon will not be known in advance. It is possible that observers may miss the impact for this reason. But the four pounds of payload are such that they will make a permanent and telescopically conspicuous mark on the lunar surface.

—WILLY LEY