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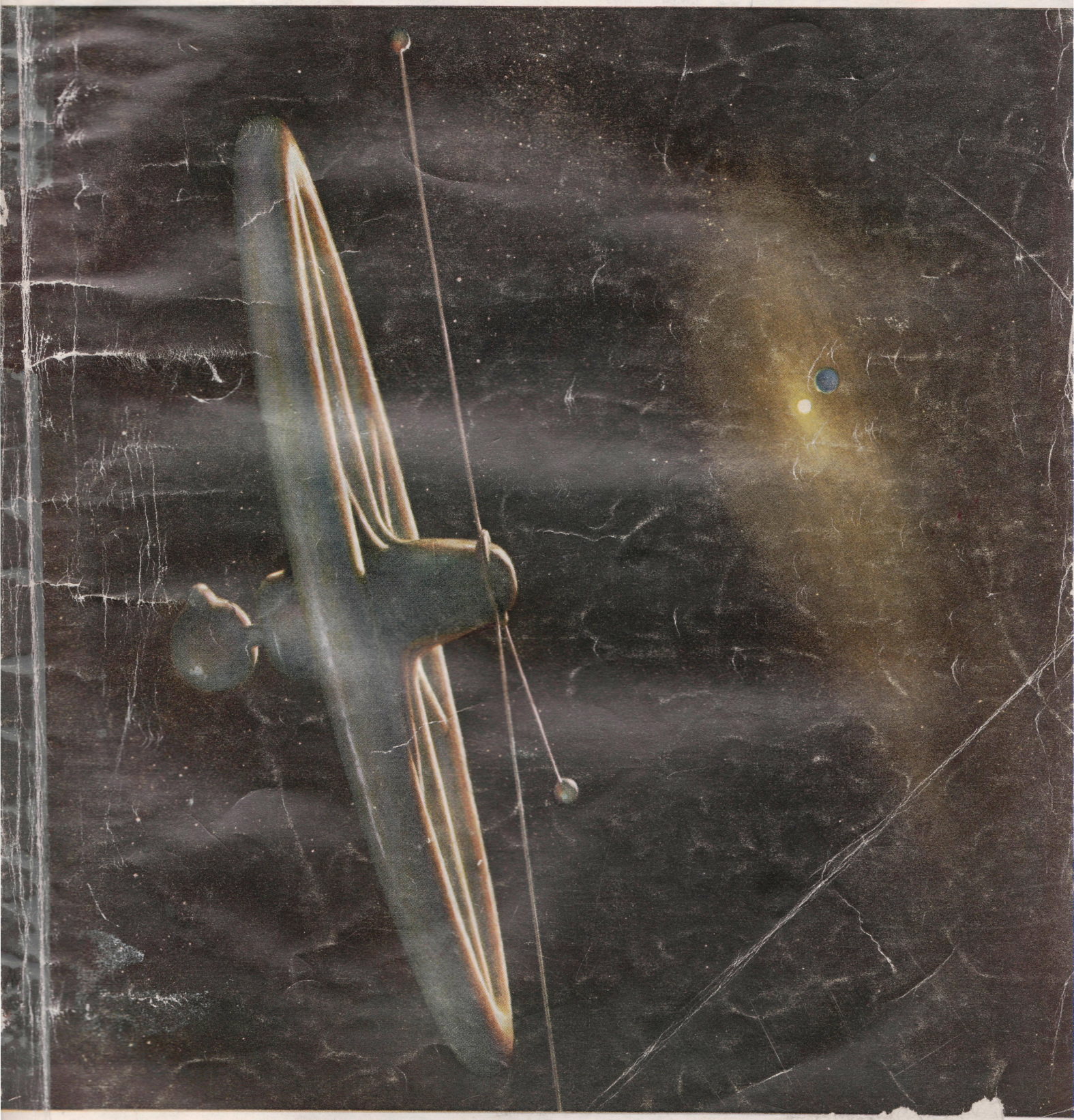

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Virgil

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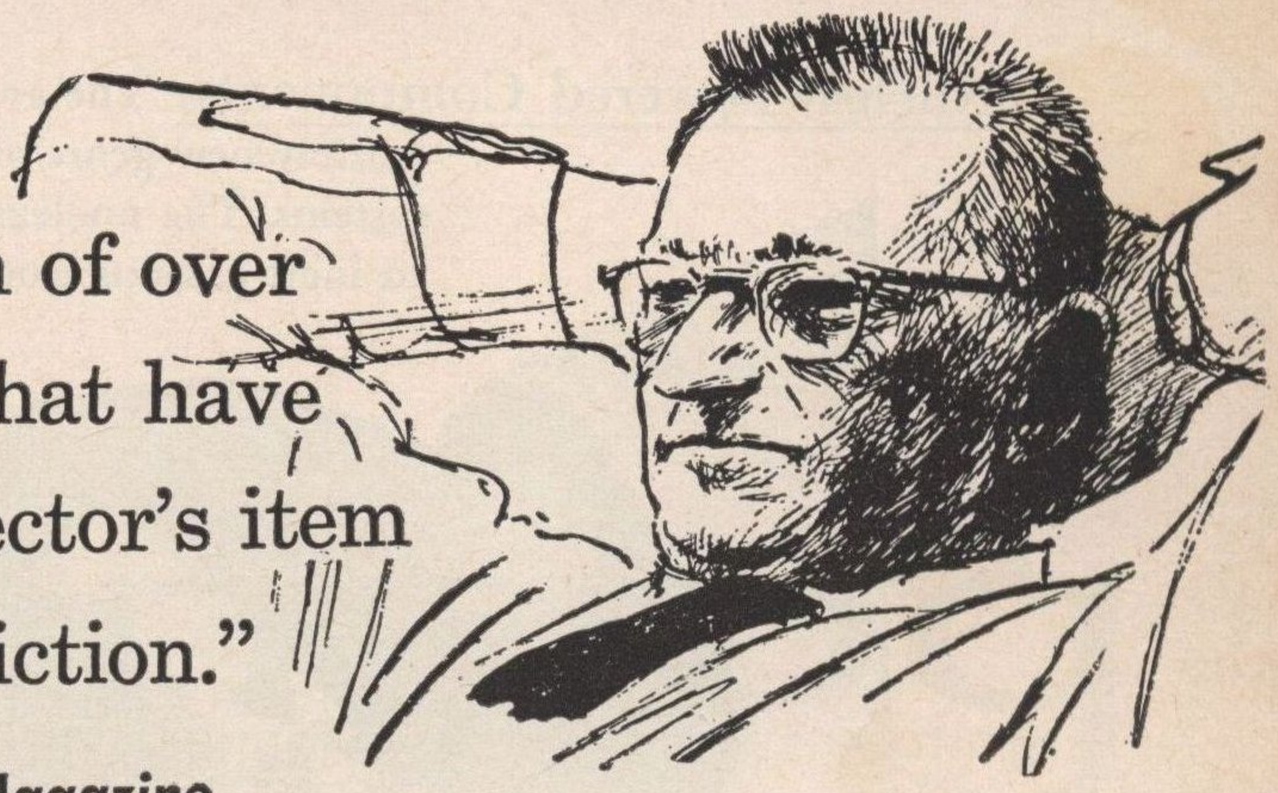

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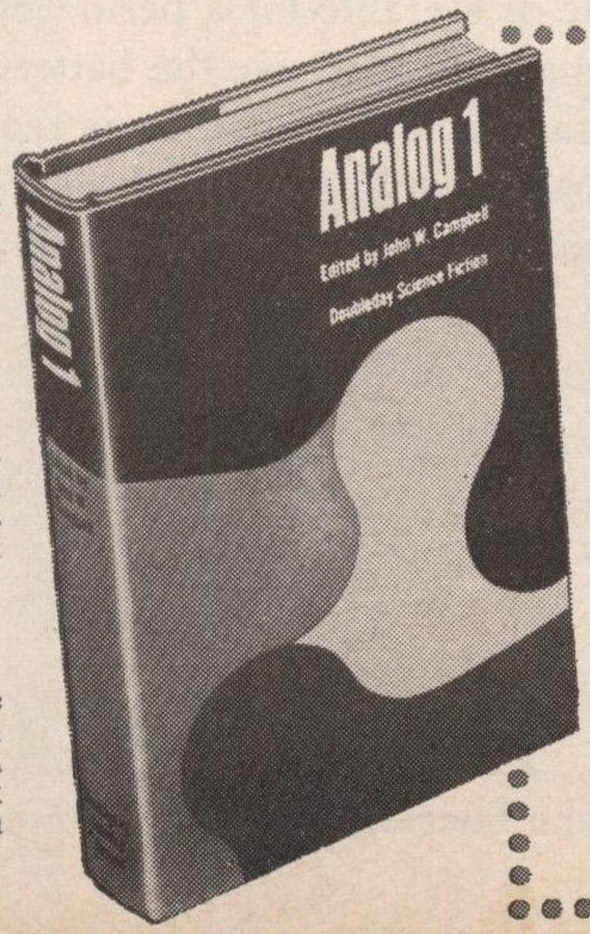
John W. Campbell



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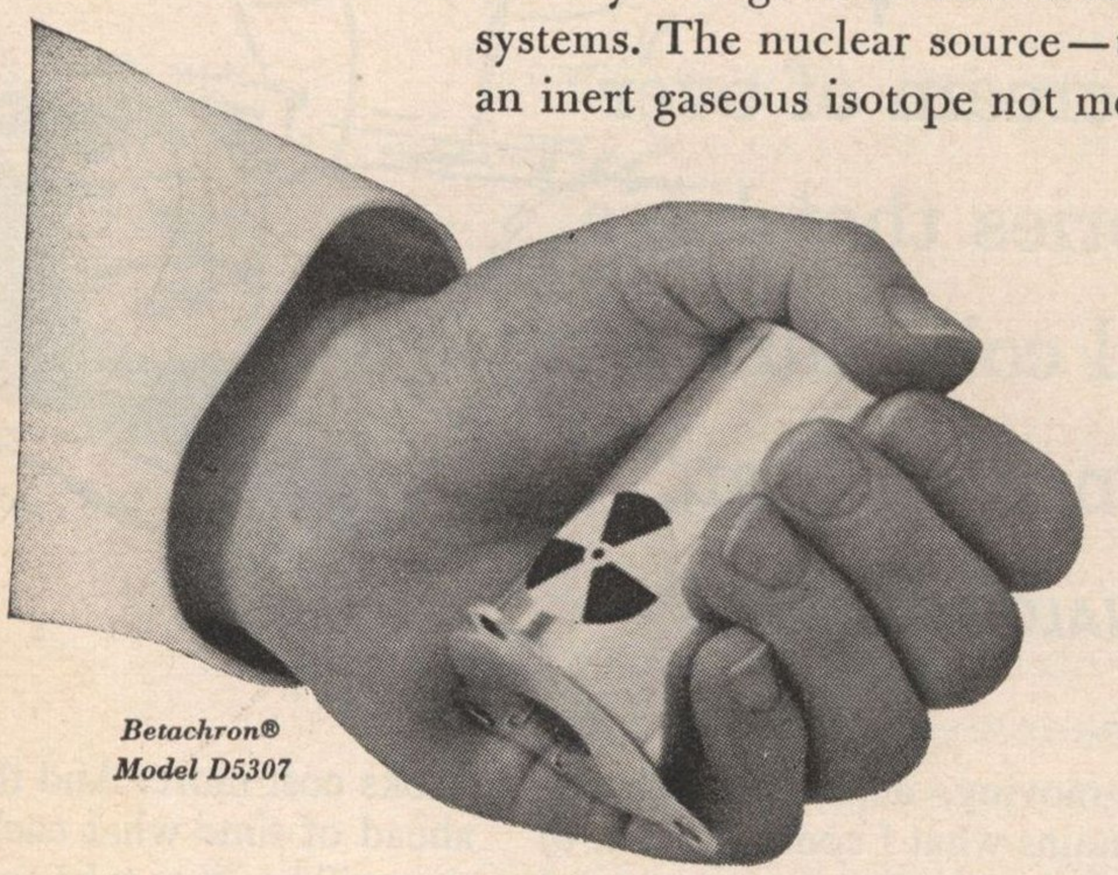

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■—As would be expected, the advent of such a power source has been accompanied more recently by a new wave of components designed around it. Most of the new Leesona Moos components are aerospace-type transducers: small, lightweight, self-powered.

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SHORT STORIES

READERS' DEPARTMENTS

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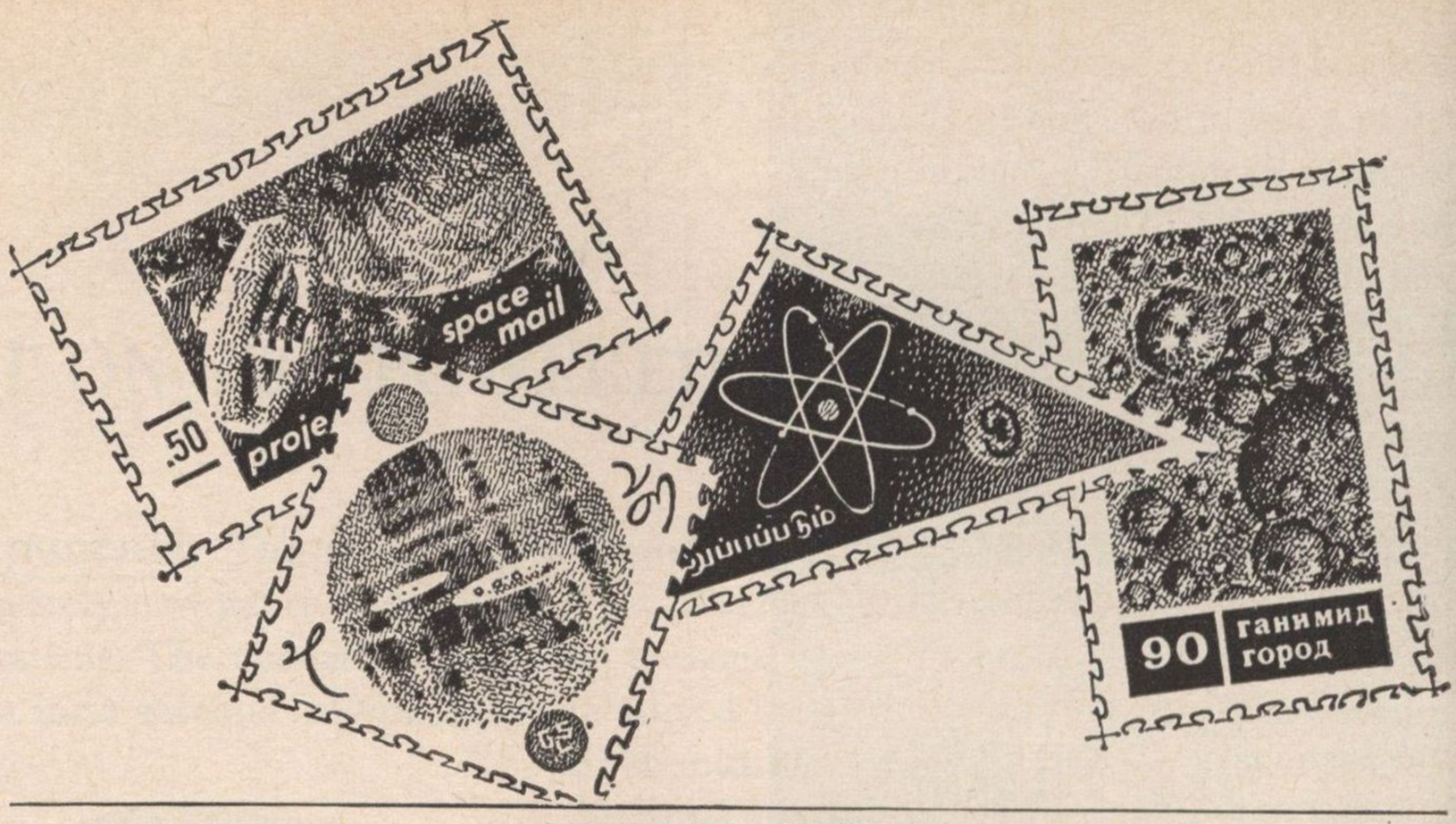
COVER BY JOHN SCHOENHERR



BRASS TACKS

Dear Mr. Campbell:

Perhaps the best place to take up the cudgel you toss out in the June issue is to answer your questions to be given to professors of English grammar. (1) The infinitive form of the verb in the sentence "What hath God wrought" is *to work*. If that looks like a weirdo answer, I might point out (a) *work* and *wrought* in Old English are *wyrcean* and *ge worht*, which look a lot closer—especially when you take away the obsolete prefix *ge-* which hung around until the middle ages in words like y-cleped and ywis, and (b) English once had a letter-swapping characteristic called metathesis, and considered *bird* and *brid* the same word, *burn* and *bryn* the same word – hence brimstone = burn-stone, or rock that burns—and so on and on and on.

(2) The mood and tense of the verb *be* in "Be he live or be he dead" is subjunctive mood, present tense—the same as it is in the more common usage "God be praised."

(3) Sorry, but Chaucer was a lot earlier than Shakespeare, and in "The House of Fame" there is a long dialogue between Chaucer and a dream-eagle which is taking him into the heavens, and most of Chaucer's responses are a monosyllable "Yis!" My favorite pet tame dictionary intimates that *yes* developed in Old English (500 A.D.–1066 A.D.) times from gea (yea) plus swa (so). In Chaucer's Middle English, *yis* is an emphatic form of *yes*.

And so to the heart of the matter. The plain and plaintive fact is that English grammar, far from being illogical, is so intricately logical that hardly anybody bothers to try, even, to figure it out. I tossed out my own grammar books years ago. I taught English in school, briefly, and gave it up largely because in a single year I could only begin to get some of the most basic points across—such as the Truth about Tenses in English. I have identified about sixteen without trying very hard. The basic present tenses run like this, taking *to go* as an example:

Positive form	Negative form	Time (more or less)
I go	I go not (obsolete)	Indefinite time
I do go	I do not go	Emphatic, indefinite time
I am going	I am not going	Temporal present

By "temporal present" I mean the act of doing something in physical time, as opposed to the act of performing or contemplating in the abstract. "I speak English," for example, refers not to a temporal act but to a mental-scholastic capability. "I am speaking English" is the indefinite present, usually tied down in time either by context or by further sentence elements: "I am studying English *in school this year*."

As I told my little monsters when I was teaching school, grammar comes

first and then the grammarians come to try to figure it out—and in English all too many grammarians put the cart before the horse. There are no aboriginal Australian grammarians — and Europeans have been trying for two hundred years to figure out Australian grammar without full success to this day. And, as you indicate in your editorial, most of the decisive steps in English grammar took place while nobody was looking.

I have tried my hand in electronics and grammar—my electronics is rusty now, but in the Forties I held a Radiotelephone First, and a few years ago I spotted an error in the RCA Tube Manual which the editors said they would correct in subsequent editions—and believe me, English grammar is harder, more exacting, and more technical.

If English is the world's most important language, why so little study and research on it? I wish I knew, because communication of facts is—or should be—the most important aspect of any field of endeavor. The bitter fact is that a college graduate in the physical sciences can name his own price, whereas an expert in the language is hard pressed for a decent job.

You say that we should put aside our prejudices long enough to make an honest study of language—meaning thereby, I trust, English; because by comparison the other major languages are as tidy as a printed adding machine tape. What we should put aside is the system which makes the study of English a non-profit undertaking.

LAWRENCE A. PERKINS
682 Orland Street,
Falls Church, Virginia

■ *1. Thanks for the data on "yes". But a question remains; it seems to have been a very rare form in Shakespeare's time—and suddenly became the common term.*

2. The objective selective distinctions in English verbs is not merely temporal. "I see" is not temporally different from "I wash"!

3. And that most complex and arbitrary of modern languages, English, spread farthest!

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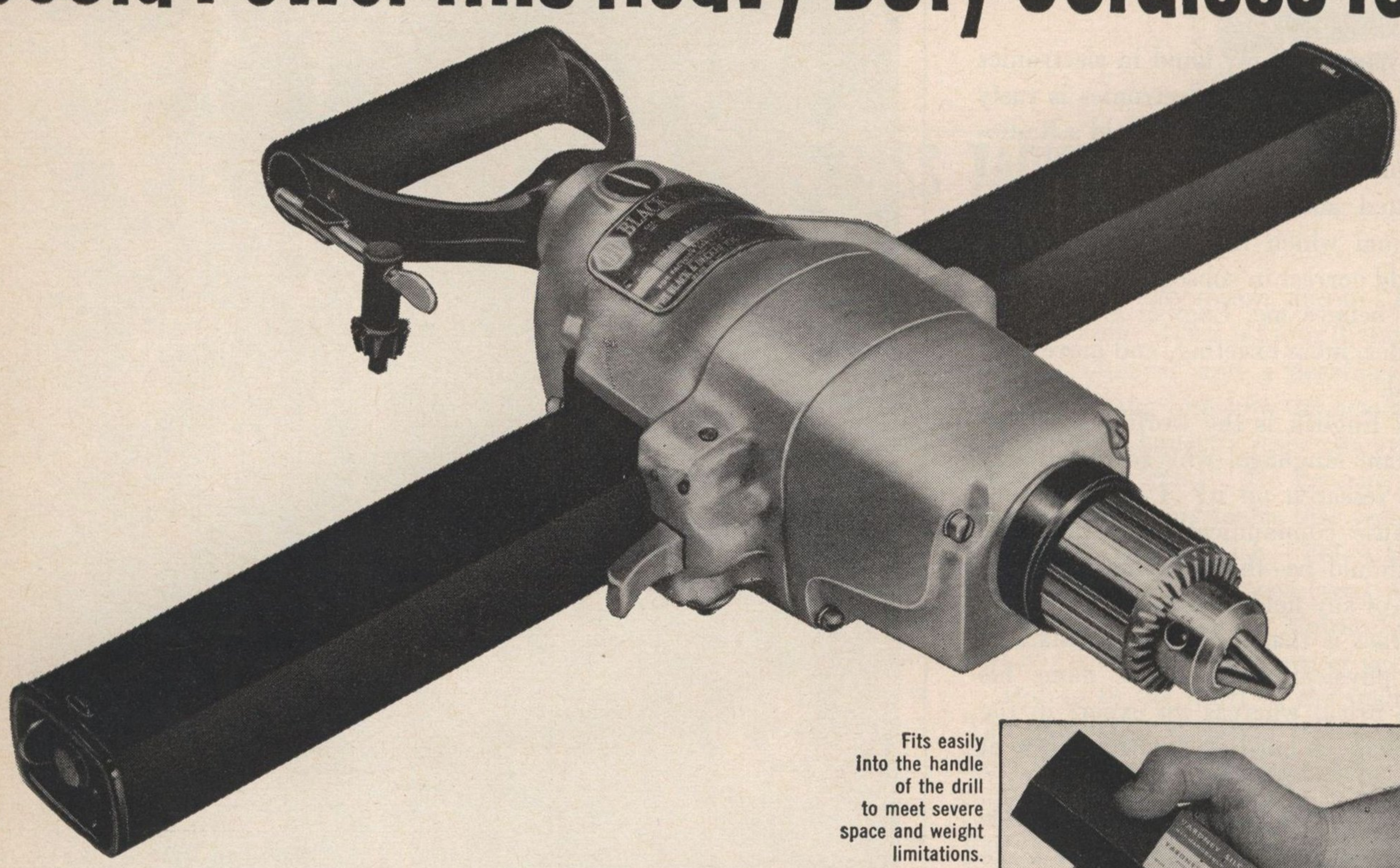

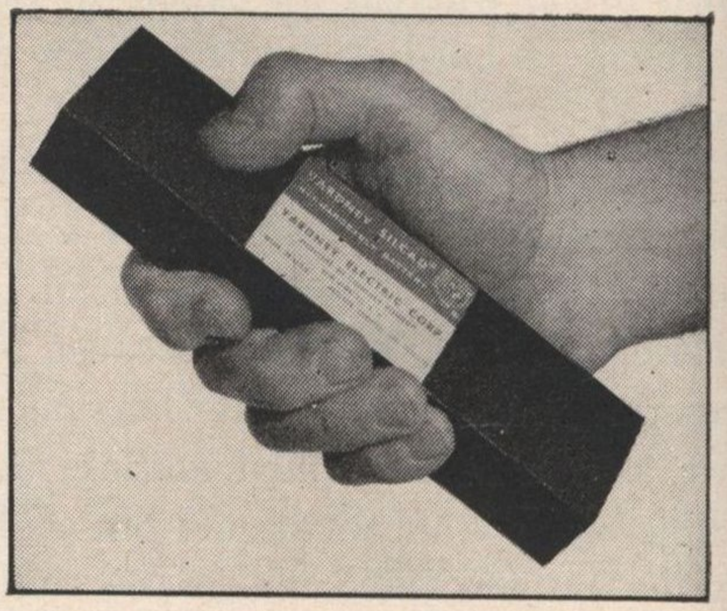

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SEGREGATION

AN EDITORIAL BY JOHN W. CAMPBELL

I am strongly in favor of rigidly segregated schools, and I believe that you are, in fact, in agreement with me—that it is absolutely necessary for the continuation of the United States in the terms we know it that our schools be segregated considerably more rigidly than they are today.

The liberals and do-gooders and those with special advantages to be gained have brought about changes in our schools, in our entire educational system, that is becoming an acute menace to America—and the Supreme Court decision such as the *Brown vs. Board of Education* case (the basic case in the integration cases in the southern schools during the last decade) was a serious mistake.

In the above statements, *I am not referring to racial segregation,* however. I'm referring instead to the overlooked and enormously critical problem of *segregation by individual student ability.*

The reason why the Negro segregation case, *Brown vs. Board of Education,* is so unfortunately tied up in the mess, is that it has been the basis for suits that do, in fact, make for improper integration of students of completely different, and noncompatible inherent learning ability.

The tremendous fuss and furore going on throughout the nation over Negro integration—racial integration in general—has so concentrated attention on that one completely unimportant factor that the really important factors of inherent individual differences have been violently suppressed.

And when I say that racial difference is a "completely unimportant factor," I mean that—and that proposition is, in actuality, what the most rabid integrationist NAACP member holds, too. That *racial differences* are not important.

The trouble underlying all this boiling-over racism is a complicated mass of snarled-up thinking, and horribly ill-defined terms. No one of the groups most violently involved in the dispute has done a half-way honest job of analysis of the facts involved; each is acting on violently emotional Doctrines, Dogmas, and Principles. And none of those doctrines, dogmas or principles has been defined well enough, by any one of the contending groups, to make sense of their own position, or that of any of the other groups.

The result is bad enough with respect to general living conditions; its effect on the educational system is not merely bad; it's disastrous.

I quite deliberately started off this editorial by making a statement that was practically certain to arouse strong antipathy in many readers—for the specific purpose of making it clear that you, too, have been suckered into falling for a propagandist's definition of "segregation" to such an extent that

Continued on page 92


ARCTIC
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THE GEODETIC SATELLITE

Most people today have the idea the Earth is round; anybody who knows anything about such things knows it isn't. But the still-unsettled argument is, "What shape is this planet, anyway?" Tangerine, pear, lemon, pumpkin, potato . . . they're all sort of round. But a geodesist has to know how round!

MARVIN C. WHITING

OFFICIAL PHOTOGRAPHS
COAST AND GEODETIC SURVEY

THE GEODETIC SATELLITE

What is the shape of the Earth? Mankind has been coming up with answers to that question for some time now and some of them are quite amusing. I myself have always been partial to the one with the Earth setting on the shoulders of four elephants, but then I'm poetic or at least would like to think so. The most recent idea has the Earth an oblate ellipsoid of revolution, which is not so poetical but is very scientific.

An ellipsoid of revolution is the surface that will result if you rotate an ellipse around some line. There are a variety of such surfaces and if you've tried to visualize a few of them, and found the result looked more like a doughnut than the Earth, don't feel bad. A doughnut *is* an ellipsoid of revolution. It is just that it is not an oblate one. To get an oblate ellipsoid of revolution you must rotate the ellipse around a particular line, to wit: the minor axis of the ellipse. This is, as I said, not very poetical but very scientific.

So the Earth is an oblate ellipsoid of revolution and that pretty much satisfies everyone these days except for a small group of people who want a more accurate picture. These are the Geodesists.

Geodesy is the science of the shape and the size of the Earth. It is a rather important science in a directly practical way, since all navigation depends on reliable charts and maps, which in turn depend on what the Geodesists say this Earth of ours is shaped like. Nowadays, it's becoming even more important in a military sense, for to send missiles from continent to continent requires a knowledge of the distance between them to a greater degree of accuracy than we now possess.

You may wonder about this. Surely in this modern age when any scientist can casually measure such impossible things as the distance between electrons or the amount of air in a vacuum, they can measure the Earth. Well you would be right. We can measure the Earth and that with quite a bit more accuracy than any physicist can measure the distance between electron shells; however, the problem comes with the little word accuracy.

The physicist gives the orbit of say the electron in the Hydrogen atom as 10^{-8}cm. give or take 10^{-9}cm. which is an accuracy of one in ten (10^{-8} is a short way of writing .00000001). This quite satisfies him, but if a geodesist gave the distance from San Francisco to New York to an accuracy of one in ten it would come out as two thousand five hundred miles give or take two hundred and fifty miles. This value isn't going to be very useful to the pilot say of a transcontinental jet trying to decide how much fuel to carry. The geodesist to make meaningful statements likes to deal with accuracies of at least one in ten thousand.

A geodesist thus might say that the Earth's circumference is 24,899 miles give or take a mile and he is thus claiming an accuracy of one in twenty-four thousand. Until recently this has always been good enough. A plane crossing the Atlantic and finding itself a mile off of its calculated position isn't going to worry about it, for the pilot can see forty miles in any direction, and, if he can't, there are radio beacons to home in on. Things in this world never stand still. However, nowadays we have rockets which we'd like to come down a little closer than a mile from their targets. We have the new technique of inertial navigation, which could eliminate all those expensive radio beacons if, that is, we knew the true distances on the Earth. Also, as we move out into space the question of astronomic distances becomes important. An error of a mile in the distances between two observatories here on Earth means thousands of miles of error in the distances from the Earth to other bodies in our solar system. It is a matter of amazement to me that our Venus probe came anywhere near that planet.

To eliminate all these uncertainties we must have a greater accuracy in distance determination here on Earth, something better than one in twenty-four thousand.

If the reader has any surveying experience, he will know that the United States Coast and Geodetic Survey, which is the Government agency in charge of geodetic surveys in the United States, and incidentally my employer, claims greater accuracies than that. The Coast Survey has established a so-called net of points that completely cover the United States using precise geodetic surveying which is supposed to give an internal accuracy of five in one million. The Coast Survey will give you that distance from San Francisco to New York correct to within sixty feet.

Now this kind of accuracy makes a geodesist real happy, and brings grins of delight to astronomers. Observatories eight thousand miles apart could be pinned down to within two hundred feet with corresponding gains in the astronomic accuracy.

We are not the only country that

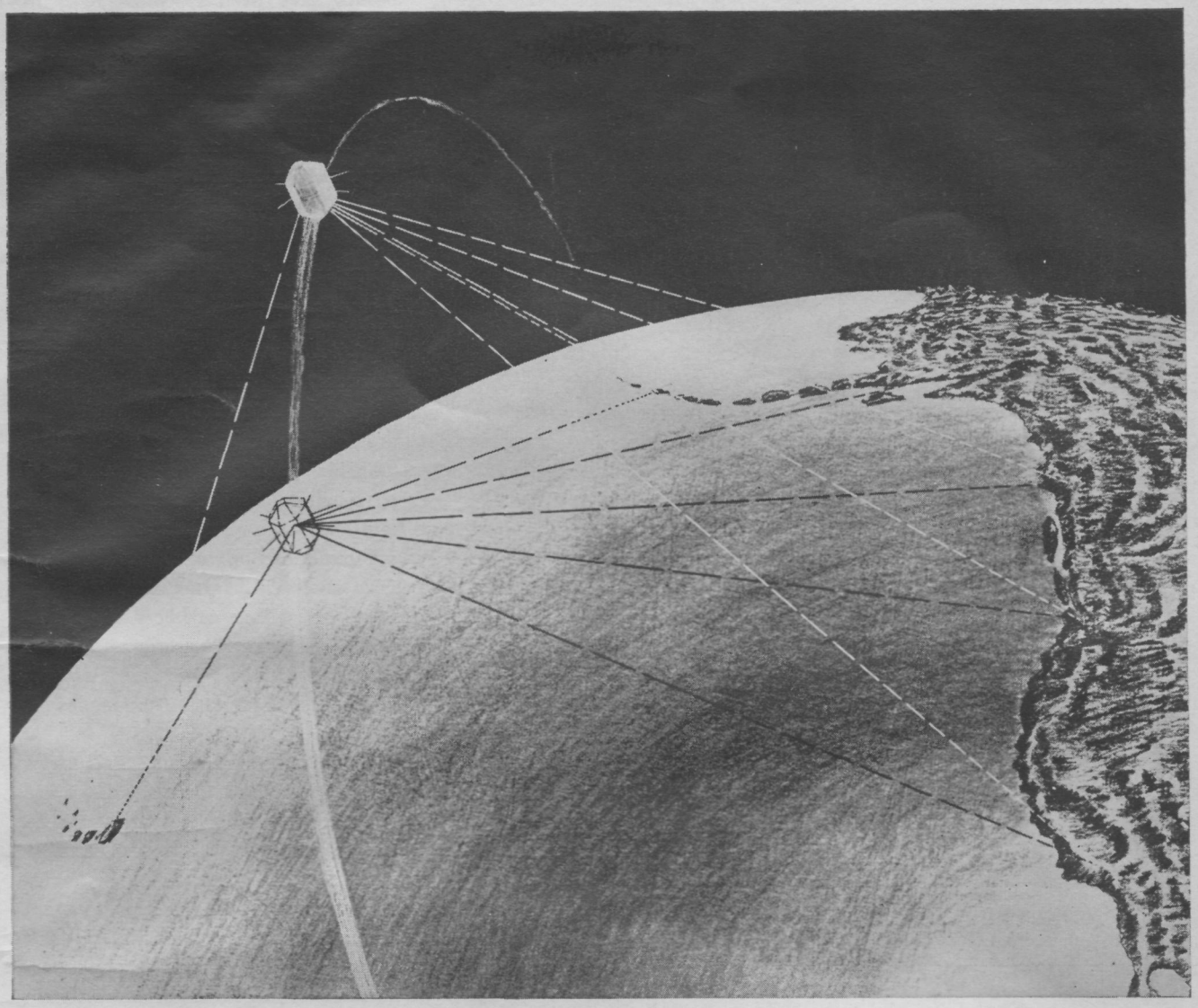


Fig. 1: The triangulation network of Continental North America may be extended to the Island State of Hawaii by means of an artificial satellite photographed against a background of stars.

conducts precise geodetic surveys. The entire European continent is covered by a "net" of points just as well located as those in the United States. The latitude and longitude of each point, we call them Triangulation stations, is known to within a thousandth of a second. Czarist Russia extended this "net" by locating a so-called arc of points completely across Siberia and more recently the Army Map Service ran another arc down through Africa with no other object than tying in the big observatory at Johannesburg, South Africa.

Now if we knew the location—i.e. the latitude and longitude — of the Johannesburg Observatory, and the location of Mount Palomar and its big 200-inch telescope, and also the shape of the Earth, we should be able to compute the distance between them without any trouble.

However, there is a problem, and to make it clear I must go into greater detail as to just what is a geodetic survey. After I've done this I'll go on to explain just how the so-called geodetic satellite solves, or at least how we hope it will solve, this problem.

An engineer wants to know the distance across a river he is going to bridge. So he establishes three points on the ground, which when connected by imaginary lines form an imaginary triangle. (It is really amazing the tangible results we can get from playing around with imaginary lines.) One of the points he puts across the river. Now he cannot measure directly the lengths of the triangle that pass over the river, but he can measure the angles of the triangle and the one length that is on solid ground, and then using high-school trigonometry, he can calculate the other sides and his problem is solved.

This is called triangulation and it is by an extension of this technique, much refined, that a net of geodetic

points have been extended to completely cover the United States. The triangles used by the Coast Survey, however, are much longer, being five to ten miles long or longer. The longer the line the more accurate the angle measurements. There are some lines out in Utah over a hundred miles long. The Coast Survey points are metal markers set in concrete, and many an amateur mountaineer has had his ego deflated by finding one on the top of a peak the mountaineer was sure only professionals could climb.

One old Coast surveyor, who goes under the peculiar name of Nehi, established a station on a mountain and on coming down met a ranger who told him that a man had been killed in a mountain-climbing party that had tried to climb the same mountain with ropes and pitons earlier that day. In justice to those mountain climbers I should say that no one else could get up to Nehi's station to turn angles off of it.

These points are called triangulation stations, and to start out an arc of triangulation the length between two of these points is measured. This is called a base line. Then the angles are measured using theodolites that can measure an angle to within three seconds, and the distances of the unknown sides are then calculated. These sides can then be used as the known length of a new triangle formed with a new point. The angles of this new triangle are then measured and the new lengths are calculated. Then another new point can be brought in and then another and so on completely across the country. Every so often the geodetic surveyor will go out and measure the distance of the ground between two of the triangulation points in order to keep the small errors that are accumulating in his calculated distances from becoming too large.

Knowing all these lengths and angles he need only know the latitude and longitude of one point and from there he can calculate the latitude and longitude of all the rest. Knowing the location of two points on opposite sides of the continent, such as San Francisco and New York, the distance

between them can be calculated directly, as I asserted before, correct to five parts in one million.

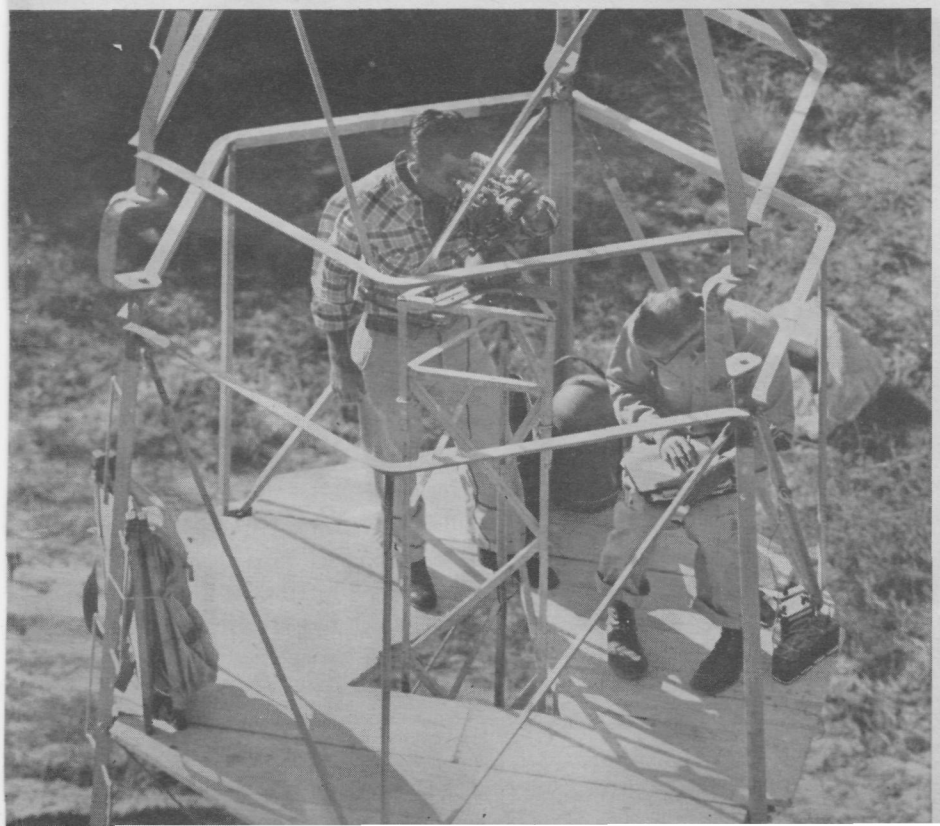
However, there are still some complexities. Over the lengths the geodetic surveyor uses, ordinary high-school trigonometry is not good enough. He must take into consideration the curve of the Earth and do his triangulating with spherical triangles. This is not particularly difficult. Give a modern mathematician a spherical, or rather in this case, an ellipsoidal surface and he can compute on it as easily as an engineer could compute on a plane surface.

This brings up, of course, the question we started with: What is the shape of the Earth? And not just a general idea, but an exact determination of its dimensions. We want an ellipsoid that so closely fits the true topographical surface, that there will be no significant errors introduced when we do our calculations on the ellipsoid, using angles and distances that we measured on the actual surface.

To solve this problem the Frenchman Cassini in the late Seventeenth Century extended a north/south arc of triangulation, which had been started earlier by Picard. (I must somehow contrive to mention Picard because he is the founder of the science of Geodesy). Cassini then divided the measured arc into two parts, one northward from Paris and the other southward. Frenchmen always use Paris as the starting point for anything! He was assuming that the Earth was a sphere. So he now computed the length of a degree of latitude from both parts and found to his surprise that the degree in the northern part was shorter. This meant that the Earth was shaped like a football with the pole through the longest length, that which the mathematicians have called the major axis.

The result of this discovery was one of those battle royals which scientists love to indulge in now and then. According to Newton and his, at that time not yet venerated theory of gravitation, Cassini's Earth was all wrong. Centrifugal force should cause the Earth to bulge at the equator and the Earth should therefore, be flattened at the poles. The English backed Newton and insisted Cassini's measurements must be off. The French stuck to their measurements, and all enlightened gentlemen—and this was the age of enlightenment—decided which theory they liked best and proceeded to argue the subject all over the face of Europe.

Fig. 2 and Fig. 3: Observing party at work atop a Bilby Steel Triangulation Tower. First order theodolite being used.



Finally, the French decided the matter had to be settled by some other method than tavern-house debates, and sent two expeditions—one to Lapland and the other to Peru—to remeasure the degree of latitude—once near the arctic circle, and once on the equator. The measurements in Peru were delayed, and as far as the controversy was concerned unimportant, for as soon as the results from Lapland came in, it was clear from comparison with the work in France that Newton was right and that the poles were flattened. The controversy came to a close with a quip by Voltaire that Maupertuis—the leader of the Lapland expedition—had flattened the poles and Cassini!

From then on the geodesists concentrated on determining the exact shape. Now the ratio of the minor axis to the major axis gives us a value we can use to describe the ellipsoid. The geodesists, just to be difficult, subtract this value from one and call the result "f." Then they take one over "f" and call this "F." When they are talking about the flattening of the ellipsoid they sometimes are referring to "f" and sometimes to "F," so you have got to be on your toes.

Now since 1735 the value of the flattening of the Earth has been determined again and again, and each of these values of "f" determines a reference ellipsoid which we could use to calculate triangulation upon. One such value was determined by Bessel in 1841 using methods similar to Cassini's, but on a much larger scale and using more accurate measurements, and the U.S. Coast and Geodetic Survey adopted it.

Then the Coast Survey picked a point and determined its latitude and longitude using astronomic observations, and then, assuming this was the true location, they proceeded to extend

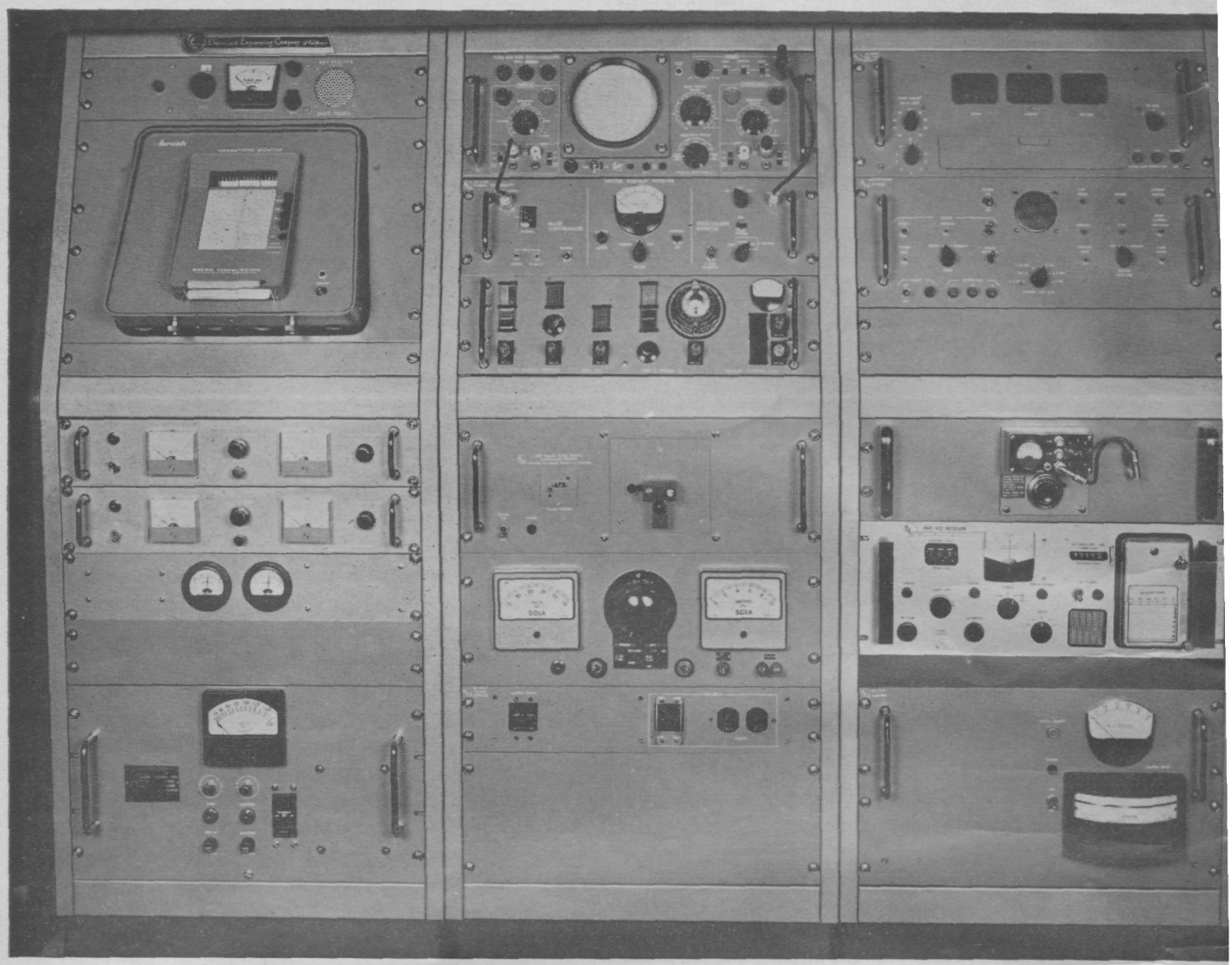


Fig. 4: Satellite tracking camera synchronization console.

a net of triangulation with the angles and lengths measured on the surface and the triangles calculated on the Bessel Ellipsoid. To provide themselves with a check they determined some of those points, as they went along astronomically and compared them with the calculated locations. These shouldn't be alike for the astronomic method gives latitudes and longitudes that differ from the true values in an unpredictable manner. However, they should be close. As the net extended eastward, it was clear something was wrong. The calculated locations were getting farther and farther away from the astronomic.

To understand what was happening consider two circles of different radius that just touch at one point. Think of the upper line as the surface of the Earth and the lower as the Bessel surface and the point of contact as the starting point of the survey. Angles and lengths and astronomically determined locations are all measured on the upper circle while the calculated locations are on the lower circle. The farther you get from the starting point the greater the difference and the larger the error. In short the Coast Survey was using a reference ellipsoid that didn't fit the surface of the Earth in the United States. The Bessel ellipsoid was a fine reference surface in other parts of the world, but not in the United States. The Coast Survey, therefore, scrapped it and chose a newer determination, which, besides the arcs used by Bessel, used also some of the arcs that had been by that time measured in the United States. It was called the Clark of 1866 and is still in use.

If you're jumping a little ahead of me now, you may see the problem I have been leading up to. The net of points in the United States are all on the Clark ellipsoid of 1866, which is made to coincide with the true surface at a station called Meads Ranch in Kansas. The whole arrangement is called the North American Datum. The Europeans have their points on the so-called International Ellipsoid of 1924, which has an equatorial radius of 6,378,388 meters, or about 182

meters larger than the Clark of 1866. The true surface intercepts this reference surface in a point near Potsdam in Germany. The Russians do all their work on the Russian Datum using the Krassowsky 1940 ellipsoid.

Draw a large circle again and then draw another small circle touching it, as before, at one point. Now pick two more points on the large circle and draw to more small circles each touching the large circle at only one point. If you look at the results for a moment, you will understand the problem. Your large circle is the Earth and the three smaller circles are the North American, European, and Russian Datums with their differences from the true Earth much exaggerated.

Now the Palomar Observatory in California has a latitude and longitude determined on the North American Datum. The Johannesburg Observatory has been tied into the International Ellipsoid, so its latitude and longitude is known on the European Datum, but the two Datums have no points in common so the distance between them can not be calculated directly.

So we are right back where we started from. How do we solve our problem.

Here is one way, the simplest way. We extend our net of known points until we reach a point on the other Datum, then by a simple mathematical formula all the points on either Datum can be converted to either reference ellipsoid. This is what was done when the arc of triangulation points was extended through Africa to connect the European Datum with the work that had been done in South Africa. As a result the distance from Greenwich to the Johannesburg Observatory is known to Geodetic accuracy, and I assume the longer distance is being used now to refine astronomic distances. Even so astronomers would still like to tie Johannesburg up with the big 200-inch scope at Palomar. So our task then is to extend an arc connecting the European and the North American Datum.

However, there is one small difficulty yet to overcome or rather a big one, for by any standard I know of, the Atlantic and Pacific Oceans are pretty big. Whenever I think of this, my peculiar imagination always visualizes two surveyors sitting in two boats with a tape measure stretched between them trying to measure their way across the ocean. Needless to say, they would end up with some very seasick values.

The present method for determining the distance across the ocean is to accept the values of latitude and longitude and assume they are both on the same ellipsoid. The distance computed in this manner could be up to a mile in error.

THE GEODETIC SATELLITE

As I said before, the International Ellipsoid gives an equatorial radius for the Earth that is 182 meters different from that of the Clark of 1866 and this could be said to be the order of uncertainty in the equatorial radius. The Equatorial circumference will be 2 pi times the radius, and its order of uncertainty or error is 2 pi times 182 meters, or 1,144 meters. This will be the uncertainty of any long east/west arc on the surface such as the distance across the ocean. If the meters confuse

Fig. 5: BC-4 Satellite tracking camera.

you, remember that there are 1,609 of them in one mile.

So what do we do? How do we tie up our North American Datum with the European Datum? The European and Russian Datums have points in common, so it is no problem to put them together. In fact the United States Air Force has done just that and placed all the known points of the European and Russian Datums as well as the African, Indian, and Japanese, —who incidentally still use the old Bessel of 1841—Datums all on one common Datum which they've chosen to call the World Datum.

The problem then is to connect all the United States points to this World Datum. How do we do it? Well the Air Force has made a connection of a sort. Using radar they have extended an arc across the North Atlantic, establishing points in Labrador, Greenland, Iceland and tying in with points on the European Datum in Scotland. They measured all the lengths in their triangles and then calculated the angles, which is what we call trilateration. This gave them the distance across the Atlantic good enough for aiming rockets, but it is not Geodetic Accuracy. We determine a distance with radar by measuring its travel time between the two points but unfortunately radar waves travel at different speeds depending on the atmospheric conditions of the air between. It is not practical to try to measure the atmospheric variables such as pressure and humidity all along the line to be measured.

Another method would be to connect across the Bering Strait, and we have intersected a few mountain peaks on the Siberian side, which means we have measured two of the angles of a triangle whose third angle is in Siberia. Since we know the distance between the two points in Alaska we can calculate the location of the mountain peak in Siberia. If we knew its location on the Russian Datum, we would have our tie. However, the Soviets are not giving out with that last little bit of information, any more than we are free with the locations of the peaks on the Alaskan side.

This is not just irrational behavior on the part of the U.S. and the U.S.S.R. but has a very practical purpose having to do with the aiming of intercontinental ballistic missiles. You've, no doubt, all seen a diagram of some well-known city with concentric circles superimposed on it indicating the areas of complete destruction, minor destruction, and so on, of an atomic bomb. One 100-megaton bomb could destroy a city the size and shape of St. Louis if it hit dead center. The horror of even imagining such a thing will numb most minds, but soldiers have to be more callous. They know that a missile, because of the difficulty of aiming it, could come down two miles from the center of the city. If they can keep the true distance from missile pad to target unknown, that is another mile of possible error. With a little luck they might get the thing to hit out in the suburbs, which would still knock out two thirds of the city, but that third saved would still add up to a lot of human lives. As a result the military on both sides of the iron curtain worry about things like connecting geodetic datums and have no intention of giving out information that will simplify this problem for their opponents.

Well, if the military situation won't let us throw an arc across the Bering Strait, what else is there we can come up with? Let's look again, for a moment, at that business of determining location from astronomic observations. First of all, how do we do it?

The surveyor sets up over the triangulation point a special instrument called a Meridian Transit Theodolite, which measures vertical angles. He is going to measure the height of certain stars above the horizon. He locates this instrument directly over the point by use of a plumb bob, which is a pointed weight hung at the end of a string. The plumb bob is important and I will go into it in greater detail later. Next he orients his instrument so that the telescope is pointed true north. He does this by sighting on the celestial north pole—or the south pole if he is in the southern hemisphere.

Of course, there is nothing to sight on there but there are some nearby stars he can use. Polaris goes in a little circle around the north pole, so the surveyor consults his ephemeris to find out at what time Polaris will reach its farthest eastward extension. The surveyor then sets the vertical hair in his telescope on Polaris at that moment and then turns his scope westward the fixed number of degrees of arcs, which is equal to the radius of the circle Polaris makes around the north pole. This will result in the telescope being pointed directly at the north pole. The same process can be followed in the southern hemisphere except the circles there are a little larger.

The instrument is now locked so that only vertical movement of the scope is possible. As a result, however we move the scope it will always be pointing at that imaginary line in the sky that astronomers call the meridian. If in imagination we visualized a plane passing through the sphere of the Earth and including the axis of the Earth—the line of the poles—this plane would intersect the surface in a circle that would pass through both poles. This is a circle of longitude. If we extend this plane to intersect that imaginary sphere that the astronomers use to locate stars upon, the celestial sphere, the intersection with this surface is another circle, which now passes through the celestial north pole, and this circle is called the meridian if you happen to be standing directly under it. They identify it by giving it the number of the longitude you are standing on. Thus if the surveyor knew the meridian his telescope is pointed at, he would know his longitude on the Earth.

This is quite simple. The ephemeris tables list for us in what meridian every star is at every moment of the day. If we observe through our telescope that Arcturus crosses the meridian at 2115, we need only look in the book to discover what longitude Arcturus should be passing over at 2115 of that day.

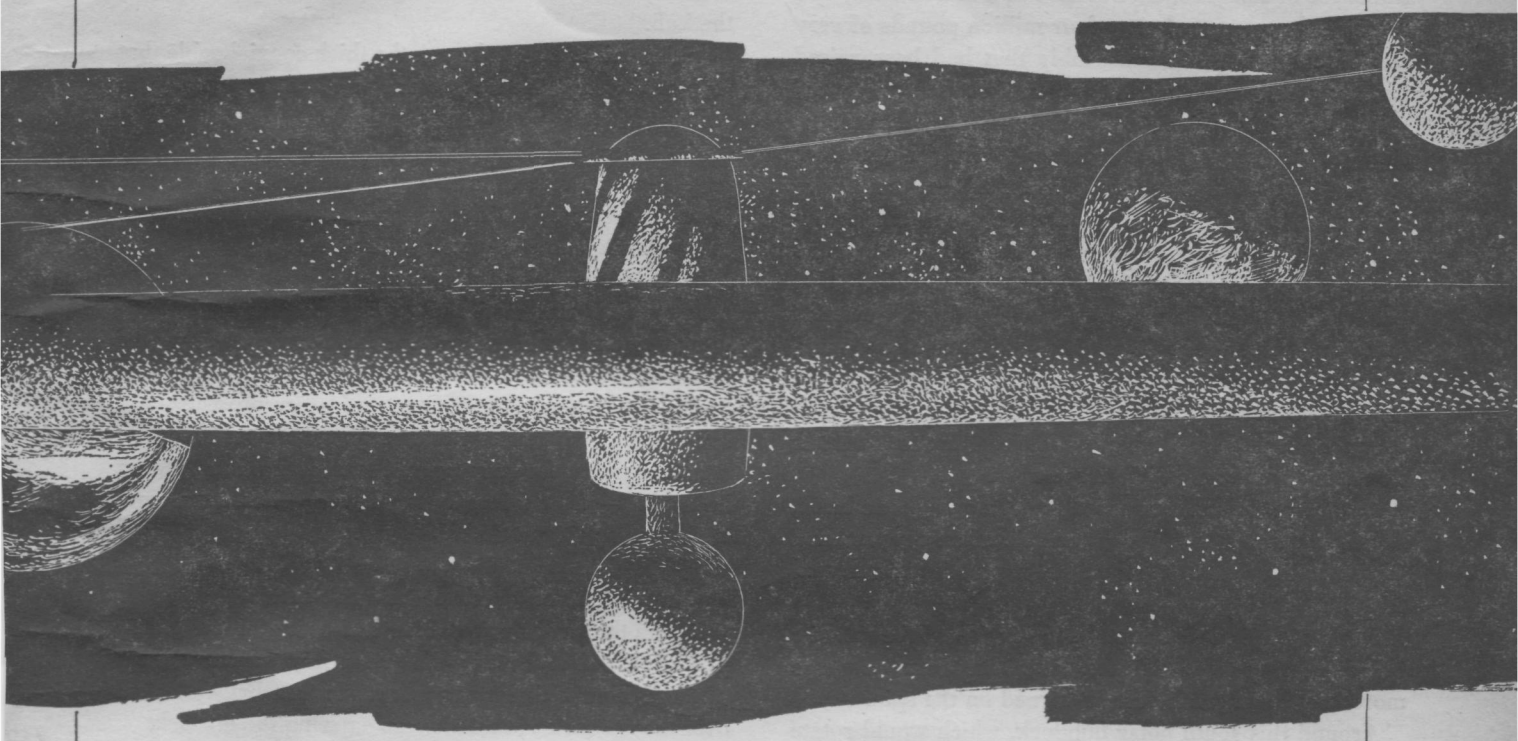
Continued on page 81

"WHERE I WASN'T GOING"

First of Two Parts. "The Spaceman's Lament" concerned a man who wound up where he wasn't going . . . but the men on Space Station One knew they weren't going anywhere. Until Confusion set in . . .

WALT AND **LEIGH RICHMOND**

ILLUSTRATED BY JOHN SCHOENHERR



I studied and worked and learned my trade
I had the life of an earthman made;
But I met a spaceman and got way-laid—
I went where I wasn't going!

THE SPACEMAN'S LAMENT

Making his way from square to square of the big rope hairnet that served as guidelines on the outer surface of the big wheel, Mike Blackhawk completed his inspection of the gold-plated plastic hull, with its alternate dark and shiny squares.

He had scanned every foot of the curved surface in this first inspection, familiarizing himself completely with that which other men had constructed from his drawings, and

which he would now take over in the capacity of chief engineer.

Mike attached his safety line to a guideline leading to the south polar lock and kicked off, satisfied that the lab was ready for the job of turning on the spin with which he would begin his three months tour of duty aboard.

The laws of radiation exposure set the three-month deadline to service aboard the lab, and he had timed his own tour aboard to start as the ship reached completion, and the delicate job of turning her was ready to begin.

U.N. Space Lab One was man's largest project to date in space. It might not be tremendous in size by earth standards of construction, but the two hundred thirty-two foot wheel represented sixty-four million pounds of very careful engineering and assembly that had been raised from Earth's surface to this thirty-six-hour orbit.

Many crews had come and gone in the eighteen months since the first payload had arrived at this orbit—but now the first of the scientists for whom the lab was built were aboard; and the pick of the crews selected for the construction job had been shuttled up for the final testing and spin-out.

Far off to Mike's left and slightly below him a flicker of flame caught his eye, and he realized without even looking down that the retro-rockets of the shuttle on which he had arrived were slowly putting it out of orbit and tipping it over the edge of the long gravitic well back to Earth. It would be two weeks before it returned.

Nearing the lock he grasped the cable with one hand, slowing himself, turned with the skill of an acrobat, and landed catlike, feet first, on the stat-magnetic walk around the lock.

He had gone over, minutely, the inside of the satellite before coming to its surface. Now there was only one more inspection job before he turned on the spin.

Around this south polar hub-lock, which would rotate with the wheel, was the stationary anchor ring on which rode free both the stat-walk and the anchor tubes for the smaller satellites that served as distant components of the mother ship.

Kept rigid by air pressure, any deviation corrected by pressure tanks in the stationary ring, the tubes served both to keep the smaller bodies from drifting too close to Space Lab One, and prevented their drifting off.

The anchor tubes were just over one foot in diameter, weighing less than five ounces to the yard—gray plastic and fiber, air-rigid fingers pointing away into space—but they could take over two thousand pounds of compression or tension, far more than needed for their job, which was to cancel out the light drift motion caused by crews kicking in or out, or activities aboard. Uncanceled, these motions might otherwise have caused the baby satellites to come nudging against the space lab; or to scatter to the stars.

There had been talk of making them larger, so that they might also provide passageway for personnel without the necessity for suiting up; but as yet this had not been done. Perhaps later they would become the forerunners of space corridors in the growing complex that would inevitably develop around such a center of man's activities as this laboratory in its thirty-six hour orbit.

At the far end of the longest anchor tube, ten miles away and barely visible from here, was located the unshielded, remote-controlled power pile that supplied the necessary energy for the operation of the wheel. Later, it was hoped, experimental research now in progress would make this massive device unnecessary. Solar energy would make an ideal replacement; but as yet the research was not complete, and solar energy had not yet been successfully harnessed for the high power requirements of the Lab.

Inside this anchor tube ran the thick coaxial cable that fed three-phase electric power from the atomic pile to the ship.

At the far end of the second anchor tube, five miles off in space, was Project Hot Rod, the latest in the long series of experiments by which man was attempting to convert the sun's radiant energy to useful power.

At the end of the third anchor tube, and comparatively near the ship, was the dump—a conglomeration of equipment, used and unused booster rocket cases, oddments of all sorts, some to be installed aboard the wheel, others to be used as building components of other projects; and some oddments of materials that no one could have given a logical reason for keeping at all except that they "might be useful"—all held loosely together by short guidelines to an anchor ring at the tube's end.

Carefully, Mike checked the servo-motor that would maintain the stationary position of the ring with clocklike precision against the drag of bearing friction and the spin of the hub on which it was mounted; then briefly looked over the network of tubes before entering the air lock.

Inside, he stripped off the heavy, complicated armor of an articulated spacesuit, with its springs designed to compensate for the Bourdon tube effect of internal air pressure against the vacuum of space, appearing in the comfortable shorts, T-shirt, and light, knit moccasins with their thin, plastic soles that were standard wear for all personnel.

He was ready to roll the wheel.

Feeling as elated as a schoolboy, Mike dove down the central axial tube of the hub, past the passenger entrances from the rim, the entrances to the bridge and the gymnasium-shield area, to the engineering quarters just below the other passenger entrances from the rim, and the observatory that occupied the north polar section of the hub.

The engineering quarters, like all the quarters of the hub, were thirty-two feet in diameter. Ignoring the ladder up the flat wall, Mike pushed out of the port in the central axis tunnel and dropped to the circular floor beside the power console.

Strapping himself down in the console seat, he flipped

the switch that would connect him with Systems Control Officer Bessandra Khamar at the console of the ship's big computer, acronymically known as Sad Cow.

"Aiee-yiee, Bessie! It's me, Chief Blackhawk!" he said irreverently into the mike. "Ready to swing this buffalo!"

Bessie's mike gave its preliminary hum of power, and he could almost feel her seeking out the words with which to reprimand him. Then, instead, she laughed.

"*Varyjat!* Mike, haven't you learned yet how to talk over an intercom? Blasting a girl's eardrums at this early hour. It's no way to maintain beautiful relationships and harmony. I'm still waiting for my second cup of coffee," she added.

"Wait an hour, and this cup of coffee you shall have in a cup instead of a baby bottle," Mike told her cheerfully. "Space One's checked out ready to roll. Want to tell our preoccupied slipstick and test-tube boys in the rim before we roll her, or just wait and see what happens? They shouldn't get too badly scrambled at one-half RPM—that's about .009 gee on the rim-deck—and I sort of like surprises!"

"No, you don't" Bessie said severely. "No, you don't. They need an alert, and I need to finish the programming on Sad Cow to be sure this thing doesn't wobble enough to shake us all apart. Even at a half RPM, your seams might not hold with a real wobble, and I don't like the idea of falling into a vacuum bottle as big as the one out there without a suit."

"How much time do you need?"

"On my mark, make it T minus thirty minutes. That ought to do it. O.K., here we go." There was a brief pause, then Bessie's voice came formally over the all-stations annunciator system.

"Now hear this. Now hear this. All personnel. On my mark it is T minus thirty minutes to spin-out check. According to program, acceleration will begin at zero, and the rim is expected to reach .009 gee at one-half revolutions per minute in the first sixty seconds of operation. We will hold that spin until balance is complete, when the spin will slowly be raised to two revolutions per minute, giving .15 gee on the rim deck.

"All loose components and materials should be secured. All personnel are advised to suit up, strap down and hang on. We hope we won't shake anybody too much. Mark and counting."

Almost immediately on the announcement came another voice over the com line. "Hold, hold, hold. We've got eighteen hundred pounds of milling equipment going down Number Two shaft to the machine shop, and we can't get it mounted in less than twenty minutes. Repeat, hold the countdown."

"The man who dreamed up the countdown was a Brain," Bessie could hear Mike muttering over his open intercom, "but the man who thought up the hold was a pure genius."

"Holding the countdown." It was Bessie's official voice. "It is T minus thirty and holding. Why are you goons moving that stuff ahead of schedule and without notifying balance control? What do you think this is, a rock-bound coast? Think we're settled in to bedrock like New York City? I should have known," she muttered, forgetting to flip the switch off, "my horoscope said this would be a shaky sort of day."

Chad Clark glanced up from his position at the communications console across the bridge from Bessie, to where her shiny black hair, cut short, framed the pert Eurasian features of the girl that seemed to be hanging from the ceiling above him.

"Is it really legal," he asked, "using such a tremendously complicated chunk of equipment as the Sacred Cow for casting horrible scopes? What's mine today, Bessie? Make it a good one, and I won't report you to U.N. Budget Control!"

"Offhand, I'd say today was your day to be cautious, quiet and respectful to your betters, namely me. However," she added in a conciliatory tone, "since you put it on a Budget Control basis, I'll ask the Cow to give you a real, mathematicked-out, planets and houses properly aligned, reading.

"Hey, Perk!" Her finger flipped the observatory com line switch. "Have you got the planets lined up in your scopes yet? Where are they? The Sacred Cow wants to know if they're all where they ought to be?"

Out in the observatory, designed to swing free on the north polar axis of the big wheel, Dr. P. E. R. Kimball, PhD, FRAS, gave a startled glance at the intercom speaker.

"I did not realize that you would wish additional observational data before the swing began. I am just getting my equipment lined up, in preparation for the beginnings of the swing, and will be unable to give you figures of any accuracy for some hours yet. Any reading I could give you now would be accurate only to within two minutes of arc—relatively valueless." The voice was cheerful, but very precise.

"Anything within half an hour of arc right now would be O.K." Bessie's voice hid a grin.

"In that case, the astronomical almanac data in the computer's memory should be more than sufficiently precise for your needs." There was a dry chuckle. "Horoscopes again?"

As Bessie turned back to the control side of her console, she saw a hand reach past her to pick up a pad of paper and pencil from the console desk. She glanced around to find Mike leaning over her shoulder, and grinned at him as she began extracting figures from the computer's innards for a "plus or minus thirty seconds of arc" accuracy.

Mike sketched rapidly as she worked, and she turned as she heard him mutter a disgusted curse.

"These are angular readings from our present position," he said in an annoyed tone. "Get the Cow to rework them into a solar pattern."

"Yes, sir, Chief Blackhawk, sir. What did you think I was doing?"

"You're getting them into the proper houses for a horoscope. I want a solar pattern. Now tell that Sacred Cow that you ride herd on to give me a polar display pattern on one of the peepholes up there," he said, glancing at the thirty-six video screens above the console on which the computer could display practically any information that might be desired, including telescopic views, computational diagrams, or even the habitats of the fish swimming in the outer rim channels.

The display appeared in seconds on the main screen, and Mike growled as he saw it.

"Have the Cow advance that pattern two days," he said furiously. Then, as the new pattern emerged, "I should have known it. It looks like we're being set up for a solar flare. Right when we're getting rolling. It might be a while, though. Plenty of time to check out a few gee swings. But best you rehearse your slipstick jockeys in emergency procedures."

"A flare, Mike? Are you sure?"

"Of course I'm not sure. But those planets sure make the conditions ripe. Look." And he held his pencil across the screen as a straight line dividing the pattern neatly through the center.

"Look at the first six orbits. Jupiter's right on the line. And Mercury won't be leaving until Jupe crosses that line." The "line" that Mike had indicated with his pencil across the screen would have, in the first display shown all but one of the first six planets already on the same side of the sun and in the new display, two days later, it showed all six of the planets bunched in the 180° arc with Earth only a few degrees from the center of that arc.

"Hadn't thought to check before," he said, "but that's about as predictable as anything the planets can tell you. We can expect a flare, and probably a dilly."

"Why, Mike? If a solar flare were due, U.N. Labs wouldn't have scheduled us this way. What makes you so sure that means there's a solar flare coming? I thought they weren't predictable?"

"It's fairly new research—but fairly old superstition," Mike said. "You play with horoscopes—but my people have been watching the stars and predicting for many moons. I remember what they used to say around the old tribal fires.

"When the planets line up on one side of the sun, you get trouble from man and beast and nature. We weren't worried about radio propagation in those days, but we were worried about seasons, and how we felt, and when the buffalo would be restless.

"More recently some of the radio propagation analysts have been worrying about the magnetic storms that blank out communications on Earth occasionally when old Sol opens up with a broadside of protons. Surely plays hell with communications equipment.

"Yep, there's a flare coming. Whether it's caused by gravitational pull, when you get the planets to one side of Sol; or whether it's magnetism—I just don't know."

"Shucks," she said, "we had a five-planet line-up in 1961; and nothing happened; nothing at all. The seers—come to think of it, some of them were Indians, but from India," she added, "not Amerinds—the seers all predicted major catastrophes and the end of the world and all kinds of things, and nothing happened."

"Bessie," Mike's voice was serious. "I remember 1961 as well as you do. You had several factors that were different then—but you had solar flares then. Quite spectacular ones. You just weren't out here, where they make a difference of life or death.

"Don't let anybody hold us too long getting this station lined up and counted down and tested out. Because we've got things building up out there, and we may get that flare, and it may not be two days coming," he finished.

With that the Amerind sprang catlike to a hand-hold on the edge of the central tunnel and vanished back towards the engineering station, from which he would control the test-spin of the big wheel.

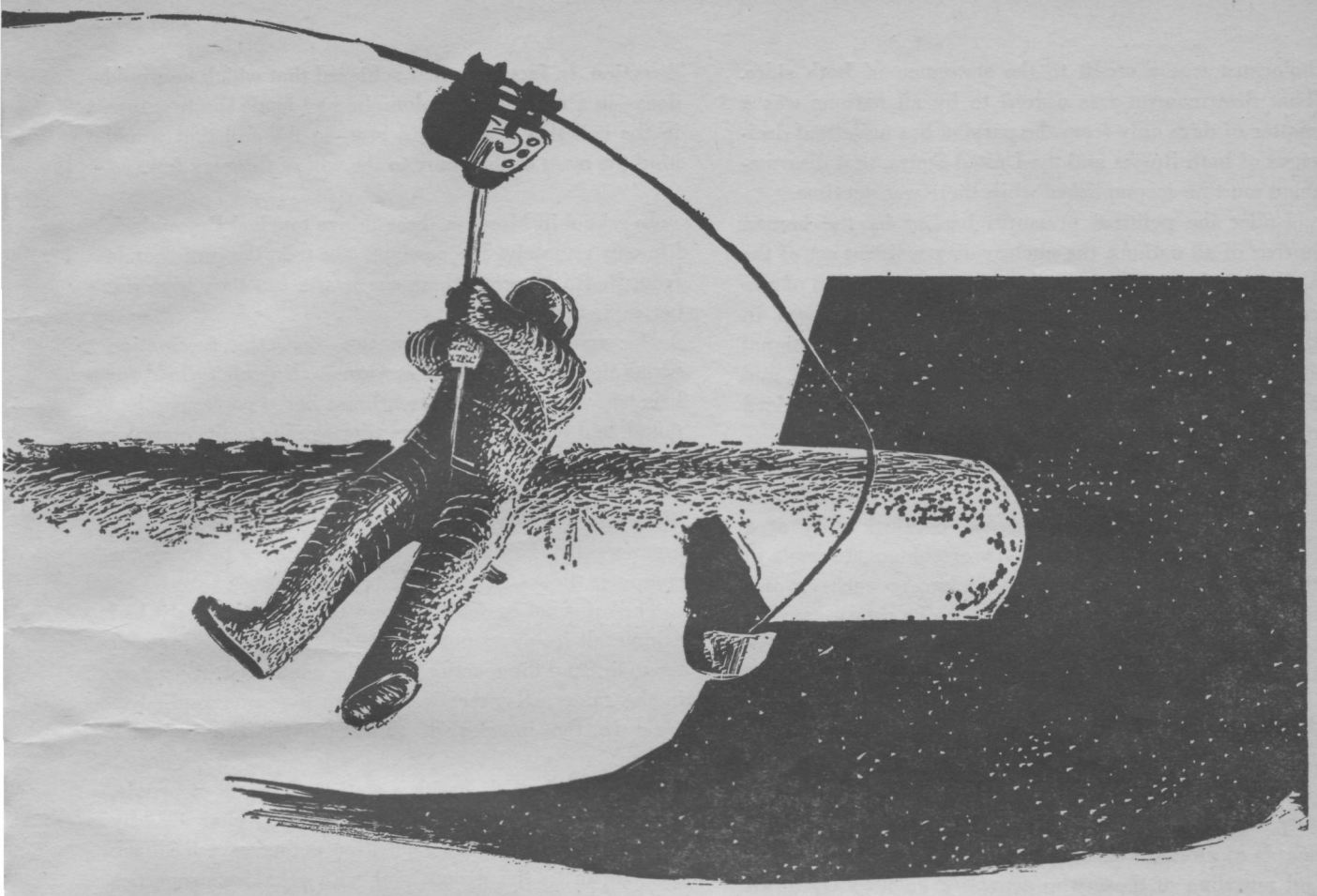
Bessandra Khamar, educated in Moscow, traced her ancestry back to one of the Buryat tribes of southern Siberia, a location that had become eventually, through the vast vagaries of history, known as the Buryat Autonomous Soviet Socialist Republic.

She was of a proud, clannish people, with Monogolian ancestry and a Buddhist background which had not been too deeply scarred by the political pressures from Western Russia. Rebellious of nature, and of a race of people where women fought beside their men in case of necessity, she had first left her tribal area to seek education in the more advanced western provinces with a vague idea of returning to spread—not western ideologies amongst her people—but perhaps some of their know-how. This she had found to be a long and involved process; and more and more, with an increase of education, she had grown away from her people, the idea of return moving ever backwards and floundering under the impact of education.

She had been an able student, though independent and quite argumentative, with a mind and will of her own that caused a shaking of heads amongst her fellow students.

Having sought knowledge in what, to her, were the western provinces of her own country, she had delved not only into the knowledge of things scientific, but into the wheres and whyfores of the political situations that made a delineation between the peoples of Russia and the other peoples of the world.

Somehow she had been accepted as part of a trade mission to South America, and with that first trip out of her own country her horizons had broadened. Carefully she had nurtured that which pleased others in such a way that she had been recommended to other, similar tasks. And eventually she had gone to the U.N. on an extended tour of duty. It was here for the first time that she had heard of the recruitment of a staff for the new U.N. Space



Lab project, and here she had made a basic decision: To seek a career, not in her own country or back among the peoples of her own clan, but in the U.N. itself, where she could better satisfy the urge to know more of all people.

She had, of course, been educated in a time of change. As a child she had attended compulsory civilian survival classes, as had nearly every person in the vast complex of the Soviet Union. She had learned about atomic weapons; and that other peoples for unknown reasons as far as she could determine, might declare her very safety and life forfeit to causes she did not understand.

Later, as she had made her way westward seeking reasons and causes for these possible disasters, and more knowledge in general, her country had undergone what amounted to a revolutionary change. Not only her country, but the entire world had moved during her lifetime from an armed camp or set of camps with divided interests and the ability for total annihilation, towards a seeking of common goals—towards a seeking of common understandings.

The catastrophe that had threatened to engulf the entire world and claim the final conquest had occurred while she was a very junior student in Moscow, when the two major nations that were leaders—or had thought themselves to be leaders, so far as atomic weaponry and such were concerned—had stood almost side by side in horror, and attempted to halt the conflagration that had been sparked by a single bomb landed on the mainland of China by Formosa.

While Russia and the United States had stood forth in the U.N. and renounced any use of atomic weapons, the short and bitter struggle which reached its termination in a mere five days had brought the world staggering to the ultimate brink of atomic war, as the Formosan Chinese made their final bid or control of mainland China.

The flare of atomic conflict had been brief and horrible. Where the bombs had come from had been the subject of acrimonious accusations on the floor of the U.N. The United States had forsworn knowledge, and for a time no one had been able to say from whence they had come. Later, shipping records had proven their source in the Belgian Congo as raw material, secretly prepared and assembled on Formosa itself, and it became obvious to the entire world that an atomic weapon was not something that could be hidden in secrecy from the desires of desperate men.

The Chinese mainland had responded with nuclear weapons of its own; weapons they, too, had not been known to possess, but had possessed.

That the rest of the world had not been sucked into the

holocaust was a credit to the statesmen of both sides. That disarmament was agreed to by all nations was a matter of days only from the parallel but unilateral decisions of both Russia and the United States, that disarmament must be accomplished while there was yet time.

Under the political pressures backed by the human horror of all nations, the nuclear disarmament act of the U.N. had given to the U.N. the power of inspection of any country or any manufacturing complex anywhere in the world; inspection privileges that overrode national boundaries and considerations of national integrity, and a police force to back this up—a police force comprised of men from every nation, the U.N. Security Corps.

The United Nations, from a weak but hopeful beginning, had now stepped forth in its own right as an effective world government. There was no political unity at a lower echelon amongst the states or sub-governments of the world. To each its own problems. To each its own ideologies. To each, help according to its needs from the various bureaus of the U.N. And from each the necessary taxes for the support of the world organization.

In Russia the ideology of Marx-Lenin was still present. And in other countries other ideologies were freely supported. But the world could no longer afford an outright conflict of ideologies, and U.N. Security was charged not only with the seeking out and destruction of possible hoards of atomic weapons, but also with the seeking out and muzzling of those who expressed an ideology at all costs, even the cost of the final suicide of war, to their neighbors.

No hard and fast rules could be drawn to distinguish between a casual remark made in another country as to one's preference for one's own country, and an active subversion design to subvert another country to one's own ideology. But nevertheless, the activity of subversion had become an illegal act under the meaning of "security." And individual governments had recalled agents from their neighboring countries—not only agents, but simple tourists as well. For the stigma of having an agent arrested in another country and brought to trial at the U.N. was a stigma that no government felt it could afford.

Over the world settled a pall. The one place outside of one's own country, where one's ideology could be spoken of with impunity, was within the halls of the U.N. Assembly itself, under the aegis of diplomatic immunity. Here the ideologies could rant and rave against each other, seeking a rendering of a final decision in men's age-old arguments; but elsewhere such discussions were *verboten*, and subject to swift, stiff penalties.

There were some who thought quietly to themselves that perhaps in the reaction to horror they had voted too much power to a small group of men known as Security, but there were others, weary of the insecurity of world power-politics, who felt that Security was a blessing, and would for all time protect all men in the freedom of their own beliefs. The pressures had been great, and the pendulum of political weight had swung far in an opposite direction. In fact, man had achieved that which he would deny—in a reach for freedom, he had made the first turn in the coil that would bind him—in the coil that would bind the mass of the many to the will of the very few.

In school in Moscow, these things touched Bessandra's life only remotely. The concepts, the talk, the propaganda from Radio Moscow, these she heard, but they were not her main interests.

Her main interests were two—one, the fascination which the giant computer at Moscow University held for her; and two, the students around her. People, she had noted, had behavior patterns very similar to the complex computer; not as individual units, though as individual units they could also be as surprisingly obtuse as the literal-minded reaction of the computer; but in statistical numbers they had an even greater tendency to act as the computer did.

The information fed them and their reactions to it had a logic all its own; not a logic of logic, but a logic of reaction. And the reaction could be controlled, she noted, in the same self-corrective manner that was applied to logic in the interior of the computer—the feedback system.

It was obvious that with a statistical group of people, the net result of action could be effectively channeled by one person in an obscure position acting as a feedback mechanism to the group, and with selective properties applied to the feedback.

At one point she had quietly, and for no other reason than to test this point to her own satisfaction, sat back and created a riot of the women students at the University, without once appearing either as the cause or the head or leader in the revolt. The revolt in itself had been absolutely senseless, but the result had been achieved with surprisingly little effort on the part of one individual.

Computers and people had from that day become her tools, whenever she decided to bend them to her will.

Even earlier in her career, she had managed to put her rebellious nature under strict control, never appearing to be a cause in herself; never appearing as a leader among the students; merely a quiet student intent upon the gain of knowledge and oblivious to her surroundings.

Later as she realized her abilities, she had sought council with herself and her Buddhist ancestry, to determine what use her knowledge should serve. And to her there was but one answer: Men were easily enslaved by their own shortcomings; but men who were free produced more desirable results; and if she were to use their shortcomings at all, it must be to bend them in the path of freedom that she might be surrounded by higher achievements rather than sheeplike activities which she found to be repugnant.

Gradually she had achieved skill in the manipulation of people; always towards the single self-interest of creating a better and more pleasant world in which she herself could live.

In rim sector A-9, Dr. Claude Lavalle was having his troubles. Free fall conditions that were merely inconvenient to him were proving near-disastrous to the animals in the cages around him.

Many and various were the difficulties that he had had with animals during his career, but never before such trifles that built *peu à peu*—into mountains.

Claude Lavalle had originally planned to leave his stock of animals, which contained sets of a great many of the species of the small animals of Earth, on their own gravity-bound planet until well after the spin supplied pseudogravity to the ship; but the schedule of the shuttles' loads had proved such as to make possible the trip either far in the future, or to put him aboard on this trip, with spin only a few hours away.

The cages, with their loads of guinea pigs, rabbits, hamsters and other live animals to be used in the sacrificial rites of biochemical research were, to put it mildly, a mess. Provision had been made for feeding and watering the animals under free-fall conditions, but keeping them sanitary was proving a near-impossible task; and though the cages were sealed to confine the inevitable upset away from the remainder of the lab, it was good to hear that the problem was nearly over as the news of the imminent countdown came over the loud-speaker.

Meantime, Dr. Claude Lavalle was having his difficulties, and he wished fervently that his assistants could have been sent up on the shuttle with him.

In rim-sector A-10, the FARM (Fluid Agricultural Recirculating Method control lab, according to the U.N. acronym), Dr. Millie Williams, her satiny brown skin contrasting to her white T-shirt and shorts, was also having her troubles.

The trays of plants, in their beds of sponge plastic and hydroponic materials, were all sealed against free-fall conditions, but should be oriented properly for the pseudogravity as the great wheel was given its rotational spin.

The vats of plankton and algae concentrates were not so important as to orientation, but should be fed into their rim-river homes as soon as possible, although this could not be done until the rim spin was well under control.

The trays, the plants, the plankton, the algae—even a large proportion of the equipment in the lab, were all new, experimental projects, designed to check various features of the food and air cycles that would later be necessary if men were to send their ships soaring out through the system.

The primary purpose of Lab One was a check of the various survival systems and space ecology programs necessary to equip the future explorations under actual space conditions. Her job on the FARM would be very important to the future feeding and air restoration of spacemen; but more important, the efficient utilization of the wheel itself, since success in shipboard purification of air and production of food would free the shuttle to bring up other types of mass.

At present, the ship's personnel were existing almost entirely on tanked air, but within two weeks one of the three air-restoration projects on the satellite—either hers, in which hydroponic plants and algae were the basic purifiers; or projects in the chem and physics labs—would have to be already functioning in the job, or extra shuttles would have to be devoted to air transportation until they were ready.

The provision of good fresh vegetables and fresh, springlike air would almost certainly be up to her department. The other two labs, Dr. Carmencita Schorlemmer in chemistry, and Dr. Chi Tung in physics, were both working on the air-restoration problem by different means—electro-chemistry in the one case; gas dialysis membranes in the other.

The work of the physics labs was operating on the differential ability of various gas molecules to "leak" through plastic membranes under pressure, causing separation of the various molecular constituents of the atmosphere; shunting carbon dioxide off in one direction, and returning oxygen and the inert nitrogen and other gases back to the surrounding atmosphere.

This latter method had proved highly satisfactory back on Earth, where it was separating out fissionable materials in large quantities and high purities from closely similar isotopes; and would now be tested for efficiency versus weight in some of the new problems being encountered in space.

A fourth method, direct chemical absorption by soda lime, had been discarded early in the program, although it was still used in spacesuit air cleaners, and for the duration of the canned air program under which they were now operating.

The lab was like that—no problem has a single solution. And it was the lab's job to evaluate as many solutions as possible so that the best, under different conditions, might be proved and ready for use in later programs.

Paul Chernov, ordinary spaceman—which meant that he had only a little more specialized training than the average college graduate—was working in the dump, surrounded by much of the equipment that remained to be placed aboard Space Lab One, and trying to identify the particular object he sought.

Looking down almost directly over the eastern bulge of the African coast, he sighted what was probably the ECM lathe he was after, and kicked towards it, simultaneously pulling his pistol-gripped Rate of Approach Indicator from the socket in his suit.

The RAI gun, he sometimes felt, was the real reason he'd become a spaceman in these tame days. Even if he couldn't be a space pirate, it gave him the feel.

Humming to himself, he aimed the search beam from the tiny gallium-arsenide laser crystal that was the heart of the gun at the bulky object, and read off the dial at the back of the "barrel" the two meter/second approach

velocity and the twenty-eight meter distance.

He could as easily have set the RAI gun to read his velocity and distance in centimeters or kilometers, and it would have read as well his rate of retreat, if that had been the factor.

Paul's RAI gun might be, to others, a highly refined, vastly superior great-grandson of the older radar that had required much more in the way of equipment than the tiny bulk of this device, but to him, alone in his spacesuit, the galaxy spread around him, it was the weapon with which he had conquered the stars.

In the distance, off beyond the wheel in a trailing orbit, the huge spherical shape of Project Hot Rod glowed its characteristic green—another application of the laser principle, but this one macroscopic in comparison to the tiny laser rate-of-approach gun.

Happily, Paul burst into song.

"There's a sky-trail leading from here to there
"And another yonder showing;
"But I've a yen for gravity—
"This is where I wasn't going!"

From the other side of the dump, Tombu's voice bellowed into his ears over the intercom. "If you're going to audition for the stars, cut down the volume!"

Paul grinned and reached for the volume control.

"O.K., M'Numba, 's m'numba!—I'm a space-yodler from way out. Heave a line over this way and let's get this ECM lathe aboard."

Tombu's "last name" M'Numba had delighted Paul from the moment he'd heard the story of its origin. By the customs of his own country, Tombu had only a single name. However, when he had first enrolled as a student in England there had been a lack of comprehension between him and the rather flustered registrar and, when he had muttered something about "my number," the registrar had misunderstood and put him down as M'Numba. Tombu had let it stand.

Paul Chernov, fine-boned, blond, with an ancestral background of the Polish aristocracy, and his side-kick, Tombu, black, muscular giant from the Congo, were one of the strangest combinations of this international space lab crew. Yet it was perhaps even stranger that the delicate-looking blond youth was a tops machinist, a trade that he had plied throughout his student days in order to economically support an insatiable thirst for knowledge. A trade that had led him to this newest center of man's search for knowledge.

But perhaps the combination was not so strange, for Tombu, also, was of the aristocracy—an aristocracy that could perhaps be measured in terms of years extending far behind the comparable times for any European aristocracy.

Tombu was Swahili, a minor king of a minor country which had never been recognized by the white man when he invaded Africa and set up his vast protectorates that took no account of the peoples and their tribal traditions; protectorates that lumped together many hundreds of individual nations and tribes into something the white man looking at maps could label "Congo."

Tombu himself, educated in the white man's schools to the white man's ways, and probing ever deeper into the white man's knowledge, was only vaguely aware of his ancestral origin. He counted his kingdom in negative terms, terms that were no longer applicable in a modern world. Where national boundaries everywhere were melting further and further into disuse, it would seem to his mind foolish to lay claim to a kingship that had been nonexistent for more than one hundred years over a people that had been scattered to the four winds and ground together with other peoples in the Belgian Congo protectorate.

Odd the combination might be; but together the two machinists worked well, with a mutual respect for each other's abilities and a mutual understanding that is rare to find among members of different races.

Quickly they lashed and anchored the crate containing the lathe and hauled it in towards the main south lock of the big wheel.

These were not the only activities in and around the wheel, or other places in space. Man already had a toehold in space, and that toehold was gradually growing into a real beachhead. Swarms of satellites in their short, fast orbits down close to Earth had been performing their tasks for many years. Astronauts had come and gone, testing, checking, probing however briefly; bravely clawing their way up the sides of the long gravitic well that separated Earth from space.

The moon project that had originally been forecast for immediate accomplishment had met with delay. As yet there was no base on the moon, though men had been there, and this was bound to occur.

But the lab was not here so much as a stepping stone to the moon as it was to provide information for the future manned trips out towards Mars and the asteroids; and in towards Venus and the sun.

Besides research, the big wheel would provide living quarters for men building other projects; would provide a permanent central for the network of communications beams that was gradually encompassing man's world and would eventually spread to the other planets as well. Cooperating with this master communications central, other satellites, automatic so far, occupied the same orbit, leading and lagging by one hundred twenty degrees.

A twenty-four hour orbit would have been more advantageous from the point of view of communications, except for the interference that would have been occasioned by the vast flood of electrons encircling Earth in the outer Van Allen belt. These electrons, trapped by Earth's magnetic field from the solar wind of charged particles escaping the sun, unfortunately occupied the twenty-four hour orbit, and, as their orbit expanded and contracted under the influence of the shifting magnetic field and solar flares, could produce tremendous havoc even in automatic equipment, so that it had been deemed economically impractical to set up the originally-postulated three satellites

in stationary twenty-four hour orbits as communications terminals.

As the next best choice, the thirty-six-hour orbit had been selected. It gave a slow rate of angular displacement, since the satellite itself moved ten degrees an hour, while Earth moved 15°, for a differential rate of only five degrees an hour, making fairly easy tracking for the various Earth terminals of the communications net; and making possible a leisurely view of more than ninety per cent of Earth's surface every seventy-two hours.

The other two power and communications stations which led and lagged Space Lab One by 120° each, would combine to command a complete view of Earth, lacking only a circle within the arctic regions, so that they could provide power and communications for the entire world —a fact which had been the political carrot which had united Earth in the effort to create the labs with their combined technologies.

The danger of such powerful instruments as Hot Rod, concentrating megawatt beams of solar energy for relay to Earth, and which could also be one of man's greatest weapons if it fell into unscrupulous hands, had been carefully played down, and also carefully countered in the screening by the Security Forces of U.N. of the personnel board.

T minus three and counting.

On the zero signal Mike in the engineer's quarters would change the now idly-bubbling air jets in the rim-rivers over to the fully-directional drive jets necessary to spin the fluid in counter-rotation through the rim tanks.

The suiting-up and strapping down were probably unnecessary, Mike thought, but in space you don't take chances.

"T minus two and counting." Bessie's voice rang over the com circuit in officially clipped clarity.

From the physics lab came a rather oddly pitched echo. "Allee allee in free fallee! Hold it, please, as Confusion would say! Paul forgot to secure the electrolite for the ECM equipment. Can't have these five-gallon bottles bouncing around!"

"And we can't have you bouncing around either, Dr. Chi Tung. Get that soup under wraps quick. How much time do you need?" came the captain's voice from his console angled over Bessie's head.

Clark's voice could be heard murmuring into his Earth-contact phone. "T minus two. Holding."

Less than two minutes later, Dr. Chi released the hold by announcing briefly, "Machine shop and physics department secure."

"T minus two and counting . . ."

"T minus one and counting . . ." Bessie continued officially. "Fifty, forty, thirty, twenty . . ."

The faint whine of high-speed centrifugal compressors could be heard through the ship.

"Ten . . ." The jets that had previously bubbled almost inaudibly took on the sound of a percolating coffee pot.

". . . Four, three, two, one, mark."

The bubbling became a hiss that settled into a soft susurrus of background noise, as the jets forced air through the river of water in the circular tanks of the rim.

The water began to move. By reaction, the wheel took up a slow, circular motion in the opposite direction.

Then, gently, the wheel shook itself and settled into a complacently off-center motion that placed Bessie somewhere near the actual center of rotation.

"We're out of balance, Mr. Blackhawk," said the captain, one hand on the intercom switch.

"Bessie, ask the Cow what's off balance." It was Mike's voice from engineering control. "Thought we had this thing trued up like a watch."

But the computer had already taken over, and was controlling the flow of water to the hydrostatic balance tank system, rapidly orienting the axis of spin against the true axis of the wheel.

The wobble became a wiggle; the wiggle became the slightest of sways; and under the computer's gentle ministrations, the sways disappeared and Space Lab One rolled true.

Slowly Mike inched the jet power up, and the speed and "gravity" of the rim rose—from 0.009 to 0.039 to the pre-scheduled 0.15 of a gravity—two RPM—at which she would remain until a thorough test schedule over several days had been accomplished. Later tests would put the rim through check-out tests to as high as 1.59 gee, but "normal" operation had been fixed at two RPM.

In the background, the susurrus of the air jets rose slightly to the soft lullaby-sound that the wheel would always sing as she rolled.

New, experimental, her full complement of six hundred scientists and service personnel so far represented by only one hundred sixty-three aboard, the big wheel that was Space Lab One rotated majestically at her hydrodynamically controlled two revolutions per minute.

She gave nearly half her mass to the water that spun her—huge rivers of water, pumped through the walls of the wheel's rim, forming a six-foot barrier between the laboratories within the rim and the cosmic and solar radiations of outer space.

Arguments on Earth had raged for months over the necessities—or lack of them—for the huge mass of water aboard, but the fluid mass served many purposes better than anything else could serve those purposes.

As a radiation shield, it provided sufficient safety against the cosmic radiations of space and from solar radiations, except for solar flare conditions, to provide a margin of safety for the crew over the three months in which they would do their jobs before being rotated back to Earth for the fifteen-month recovery period.

The margin was nearly enough for permanent duty—and there were those who claimed it was sufficient—but the claim had not been substantiated, and the three months maximum for tour was mandatory.

Originally, shielding had not been considered of vital importance, but experience had proven the necessity. The

first construction personnel had been driven back to Earth after two weeks, dosimeters in the red. The third crew didn't make it. All five died of radiation exposure from a solar flare. An original two weeks' limit was raised as more shielding arrived—three weeks, four, five—now the shadowy edge of the theoretic ninety-day recovery rate from radiation damage and the ninety days required to get the maximum safe dosage overlapped—but safety procedures still dictated that a red dosimeter meant a quick return to Earth whether the rate of recovery overlapped or not.

The question was still open whether more shielding would be brought up to make the overlap certain, or whether it would be best to maintain a personnel rotation policy indefinitely. Some factions on Earth seemed determined that rotation must remain not only a procedural but an actual requirement—their voices spoke plainly through the directives and edicts of U.N. Budget Control —but from what source behind this bureaucratic smokescreen it would have been difficult to say.

As a heat sink, the water provided stability of temperature that would have been difficult to achieve without it. Bathed in the tenuous solar atmosphere that extends well beyond the orbit of Earth, and with a temperature over

100,000 C, maintenance of a livable temperature on board the big wheel was not the straight-forward balancing of radiation intercepted/radiation outgoing that had been originally anticipated by early writers on the subject.

True, the percentage of energy received by convection was small compared to that received by radiation; but it was also wildly variable.

As a biological cultural medium, the hydraulic system provided a basis for both air restoration and food supplies. When the proper balance of plankton and algae was achieved, the air jets that gave the ship its spin would also purify the ship's air, giving it back in a natural manner the oxygen it was now fed from tanks.

As a method of controlling and changing the rate of rotation of the wheel, the rivers of water had already proven themselves; and as a method of static balancing to compensate for off-center weights, masses of it could be stopped and held in counterbalance tanks around the rim, thus assuring that the observatory, in its stationary position on the hub, would not suddenly take up an oscillatory pattern of motion as the balance within the wheel was shifted either by moving equipment or personnel.

In effect, the entire ship operated against a zero-M-I calculation which could be handled effectively only by the computer. The moment of inertia of the ship must be constantly calculated against the moment of inertia of the hydraulic mass flowing in the rim. And the individual counterbalance tanks must constantly shift their load according to the motions of the crew and their masses of equipment that were constantly being shifted during installation. For already the observatory was hard at work, and its time must not be stolen by inappropriate wobbles of the hub.

A continuously operating feedback monitor system was capable of maintaining accuracy to better than .01% both in the mass inertial field of centrifugal force affecting the rim; and in overall balance that might otherwise cause wobbles in the hub.

While such fine control would not be necessary to the individual comfort of the personnel aboard, it was very necessary to the accuracy of scientific observation, one major purpose of the lab; and even so, many of the experimenters would require continuous monitor observation from the computer to correct their observations against her instantaneous error curve.

The mass of water in the rim formed a shell six feet through, surrounding the laboratories and living quarters —walls, floor and ceiling—since its first function was that of radiation shielding.

But the bulk of this water was not a single unit. It was divided into separate streams, twenty in number, in each of which various biological reactions could be set up.

While a few of the rivers were in a nearly chemically pure state, most of them were already filling with the plankton and algae that would form the base of the major ecological experiments, some with fresh water as their medium, others using sea water, complete with its normal micro-organisms supplemented from the tanks of concentrate that Dr. Millie Williams had brought aboard. One or two of the rivers were operating on different cycles to convert human waste to usable forms so that it might reenter the cycles of food and air.

Several of the rivers were operating to provide fish and other marine delicacies as part of the experiment to determine the best way of converting algae to food in a palatable form.

Within, the rivers were lighted fluorescently—an apparent anomaly that was due to the fact that the problems of shielding marine life from direct sunlight in such a shallow medium had not yet been worked out; while the opaque plastic that walled the laboratories within the rivers was a concession to their strength, since the clear plastic that would have provided aquarium walls for the lab and complete inspection for a constant and overall check of the ecological experiments had been overruled by U.N. Budget Control. Portholes at various spots made the seaquariums visible from any part of the rim, but in Dr. Millie's laboratory alone were the large panels of clear plastic that gave a real view into the rivers.

This ecological maze of rivers and eddies and balance tanks; of air jets and current and micro-life; of spin-rate-control and shielding, were all keyed to servo-regulated interdependence that for this self-contained world replaced the stability achieved in larger ecologies through survival mechanisms.

Within the maze, existing by it and contributing to it, were the laboratories concerned with other things, but surrounded by the waters that had made life's beginnings possible on Earth, and the continuance of life possible in space. Man might some day live in space almost totally without water, but for now they had brought a bit of the mother waters with them.

Sitting in complacent control of these overall complexities that must be met with automatic accuracy was the Starrett Analogue/Digital Computer, Optical Wave type 44-63, irreverently referred to by the acronymically-minded as Sad Cow, though more frequently as the Sacred Cow, or simply Cow.

Most of the computer's intricate circuits were hidden behind the bulkhead in a large compartment between the control center and the south polar lock; but it was from this console in the control center that her operation was keyed.

From this position, every function of the wheel was ordered.

This was the bridge.

Spaced equally around its thirty-two-foot ring-shaped floor were the computer's console where Bessie presided; the com center in charge of Communications Officer Clark; and the command console where Captain Naylor Andersen, commanding officer of Space Lab One had his formal, though seldom-occupied post.

At the moment, Nails Andersen *was* present, black cigar clamped firmly between his teeth; hamlike Nor-

wegian hands maneuvering a pencil, he was making illegible notes on a scrap of paper—illegible to others because they were in his own form of shorthand that he had worked out over the years as he tried to make penciled notes as fast as his racing mind worked out their details.

Whether Nails were politician or scientist would be hard to say. Certainly his rise through the ranks of U.N. Bureaus had been rapid; certainly in this rise he had been political, with the new brand of politics that men were learning—world, rather than national politics. Certainly, also, he was a scientist; and certainly he had used his political abilities in the behalf of science, pushing and slashing at red-tape barriers.

Nails was more than most responsible for the very existence of U.N. Space Lab One, and Project Hot Rod besides. He was also a sponsor of many other projects, both those that had been done and those that were yet to be done.

The justification of a space project in these times was difficult indeed; for no longer could nations claim military superiority as a main reason for pushing forward across the barriers of the inner marches of space; for spending billions in taxes in experimental research. For a project to achieve reality now, it must have benefits, visible benefit, for the majority of mankind. It must have as *raison d'être* that had nothing of a military flavor. And occasionally Nails had been hard put to explain why, to people who did not understand; to explain his feeling that men must expand or die; that from a crowded planet there could be only one frontier, and that an expansion outward into space.

Of course there were, Nails admitted to himself, other frontiers. The huge basin of the Amazon had been bypassed and ignored by man, and quite possibly would be in the future as well. The oceans, covering seventy-five per cent of Earth's surfaces also presented a challenge to man, and the possibility of a new frontier of conquest.

But these did not present the limitless frontier for expansion offered by space. Men must look upon them as only temporary challenges, and cherish them as remaining problems, never to be solved for fear of a loss of the problem itself.

Yet space was different. Here man's explorations could touch upon infinities that were beyond comprehension, into that limitless void man could plunge ever outward for thousands of generations without ever reaching a final goal or solving a last problem. Here was a frontier worthy of any man, against which the excess energies of a warrior spirit might be expended without harm to their fellows.

To open a crack in this frontier was Nails' supreme goal, because, once opened, men need never fight again amongst themselves for lack of a place to go or a thing to do.

Space Lab One had been in spin for two days.

On Earth, TV viewers no longer demanded twenty-four hours of Lab newscasts, and were returning to their normal cycles of Meet the Press, the Doctor's Dilemma, the Lives of Lucy, and other juicier items of the imagination that, now that their lab was a functioning reality, seemed far more exciting than the pictures of the interminably spinning wheel and the interviews with scientists aboard that had filled their screens during the spin-out trial period.

On the wheel itself, life was settling into a pattern, with comments about being able to stand upright becoming old hat.

In rim-sector A-9, Dr. Claude Lavalle's birds and beasts had adapted themselves to the light gravity; and their biological mentor had evolved feeding, watering and cleaning methods that were rapidly becoming efficient.

Next door, Dr. Millie Williams' FARM had survived the "take-off" and the plants, grateful for their new, although partial gravity, were now stretching themselves towards the overhead fluorescents in a rather fantastic attempt to imitate the early growing stages of Jack's famous beanstalk.

In the machine shop, Paul Chernov carefully inspected the alignment of the numeric controlled laser microbeam milling and boring machine, brought it to a focus on a work piece, and pressed an activation switch that started the last pattern of tiny capillary holes in the quartz on which he was working. In moments the pattern was completed.

Gently removing the work piece from its mounting, he turned to the open double bulkhead that served as an air lock in emergencies and that separated his shop from the physics lab beyond, where Dr. Y. Chi Tung, popularly known as Ishie, was busy over a haywire rig, Chief Engineer Mike Blackhawk and Tombu beside him.

Reverently, Dr. Chi took the part from Paul's hands. "A thousand ancestral blessings," he said. "Confusion say the last piece is the most honored for its ability to complete the gadget, and this is it.

"Of course," he added, "Confusion didn't say whether it would work or not."

"What does the gadget do?" asked Paul.

'Um-m-m. As the European counterpart of Confusion, Dr. Heisenberg might have explained it, this is a device to confuse confusion by aligning certainties and creating uncertainties in the protons of this innocent block of plastic." The round, saffron-hued Chinese face looked at Paul solemnly.

"As the good Dr. Heisenberg stated, there is a principle of confusion or uncertainty as to the exact whereabouts of things on the atomic level, which cannot be rendered more exact due to disturbance caused by the investigation of its whereabouts. My humble attempt is to secure a sufficiently statistical sample of aligned protons to obtain data on the distortion of the electron orbits caused by an external electrostatic field, thus rendering my own uncertainties more susceptible of analysis in a statistical manner."

Suddenly he grinned. "It's a take-off," he said, "from

the original experiments in magnetic resonance back in '46.

"The fields generated in these coils are strong enough to precess all the protons so that their axis of spin is brought into alignment. At this point, the plastic could be thought of as representing a few billion tiny gyroscopes all lined up together.

"Matter of fact," he said in an aside, "if you want a better explanation of that effect, you might look up the maintenance manual on the proton gyroscopes that Sad Cow uses. Or the manuals for the M.R. analyzer in the chem lab. Or the magnetometer we use to keep a check on Earth's magnetic field.

"So far, about the same thing.

"What I'm trying to do is place radio frequency fields and electrostatic fields in conjunction with the D.C. magnetic field, so as to check out the effect of stretching the electron orbits of the hydrogen atoms in predictable patterns.

"I picked this place for it, because it was as far away from Earth's field as I could get. And Mike, when I get ready to test this thing, I'm going to pray to my ancestors and also ask you to turn off as many magnetic gadgets as you safely can."

Mike was squatting on his heels by the haywire rig, built into what looked suspiciously like a chassis extracted from one of the standard control consoles of the communication department.

Reaching gingerly in through the haywire mass of cables surrounding the central components, he pointed to one of the coils and exclaimed in the tones of a Sherlock Holmes, "Ah-ha, my dear Watson! I have just located the final clue to my missing magnaswedge. I suppose you know the duty cycle on those coils is only about 0.01?"

"Not after I finished with them!" Ishie grinned unrepentant. "Besides, I don't want to squash anything in the field. I just want a nice, steady field of a reasonble magnitude. As Confusion would say, he who squashes small object may unbalance great powers."

While he talked, Ishie had been busy inserting the carefully machined piece of quartz plate that Chernov had brought, into a conglomeration of glassware that looked like a refugee from the chem lab, and flipped a switch that caused a glowing coil inside a pyrex boiler to heat a small quantity of water, which must escape through the carefully machined capillary holes in the plate he had just installed. Each jet would pass through two grids, and on towards a condenser arrangement from which the water would be recirculated into the boiler by a small pump which was already beginning to churkle to itself.

"O.K.," Mike said. "I dig the magnetic resonance part. And how you're using the stolen coils. But what's this gadget?" and he pointed to the maze of glass and glass tubing.

"Oh. Permit me to introduce Dr. Ishie's adaptation of a French invention of some years previous, which permits the developmenot of high voltages by the application of heat to the evaporation of a fluid medium such as water—of which we have plenty aboard and you won't miss the little that I have requisitioned—causing these molecules to separate and pass at high speed through these various grids, providing electrostatic potentials in their passage which can be added quite fantastically to produce the necessary D.C. field which . . ."

As he spoke, Mike's finger moved nearer a knob-headed bolt that seemed to be one of the two holding the glass device to its mounting board, and an inch and a half spark spat forth and interrupted the dissertation with a loud "Yipe!"

"Confusion say," Ishie continued as Mike stuck his finger in his mouth, "he who point finger of suspicion should be careful of lurking dragons!

"Anyhow, that's what it does. There are two thousand separate little grids, each fed by its capillary jet, and each grid provides about ninety volts."

Tombu took the opportunity to inquire, "Have you got that RF field-phase generator under control yet?" He pointed to still another section of the chassis.

"Oh, yes." The physicist nodded. "See, I have provided a feed-back circuit to co-ordinate the pick-up signal with the three-phase RF output. The control must be precise. Can't have it skipping around or we don't get a good alignment."

There was a gurgling churkle from the innocent-looking maze as the "borrowed" aeriator pump from the FARM supplies began returning the condensate back to the boiler.

Major Steve Elbertson stood on the magnetic stat-walk of the south polar loading lock, gazing along the anchor tube to Project Hot Rod five miles away.

"There are no experts in the ability to maneuver properly in free fall," he told himself, quieting his dissatisfaction with his own self-conscious efforts at maintaining the military dignity of the United Nations Security Forces in a medium in which a man inevitably lost the stances that to him connotated that dignity.

Awkwardly, he attached the ten-pound electric device affectionately known to spacemen as the scuttlebug, to the flat ribbon-cable that would both power and guide him to Hot Rod.

As the wheels of the scuttlebug clipped over the ribbon-cable, one above and two below, and made contact with the two electrically conductive surfaces, he saw the warning light change from green to red, indicating that the ribbon was now in use, and that no one else should use it until he had arrived at the far end.

Seeing that the safety light was now in his favor, he swung his legs over the seat—a T-bar at the bottom of the rod which swung down from the drive mechanism—grasped the rod, and pulled the starting trigger.

The accelerative force of one gee, the maximum of which the scuttlebug was capable, provided quite a jolt, but settled down very quickly to almost zero as he picked

up speed and reached the maximum of one hundred twenty miles per hour.

A very undignified method of travel, he thought. Yet for all that, the scuttlebugs were light and efficient, and reduced transit time between outlying projects and the big wheel to a very reasonable time, compared to that which it would take for a man to jump the distance under his own power—and, he thought, without wasting the precious mass that rockets would have required.

The low voltage power supplied by the two flat sides of the ribbon was insufficient to have provided lethal contact, even if the person were there without the insulation of a spacesuit around him, a very unlikely occurrence. Furthermore, the structure of the cable, with the flat, flexible insulation between its two conductive surfaces, made it practically impossible to short it out; and the flanged wheels of the scuttlebug clipped over it in such a fashion that, once locked, it was thought to be impossible that they could lose their grip without being unlocked.

As Steve gained speed along the ribbon, "his" Project Hot Rod was in view before him—appearing to be a half moon which looked larger than the real moon in the background behind it; and seeming to stand in the vastness of space at a distance from the far end of the long anchor tube, a narrow band of bright green glowing near its terminator line.

From the rounded half of the moon, extending sunward, four bright, narrow traceries seemed to outline a nose that ended in a pale, globular tracery at its tip, pointing to the sun.

The narrow traceries were in actually four anchor tubes, similar to the one beside which he rode; and mounted in their tip was the directing mirror that would aim Hot Rod's beam of energy.

Project Hot Rod was actually a giant balloon eight thousand feet in diameter, one-half "silvered" with a greenish reflective surface inside that reflected only that light that could be utilized by the ruby rods at its long focal center; and that absorbed the remainder of the incident solar radiation, dumping it through to its black outside surface, and on into the vastness of space. This half of the big balloon was the spherical collector mirror, facing, through the clear plastic of its other half, the solar disk.

Well inside the balloon, at the tip of the ruby barrel that was its heart, were located the boiler tubes that activated the self-centering inertial orientation servos which must remain operational at all times. If the big mirror were ever to present its blackened rear surface to the sun for more than a few minutes, the rise in temperature would totally destroy the entire project. Therfore, these servos had been designed as the ultimate in fail-safe, fool-proof control to maintain the orientation of the mirror always within one tenth of one degree of the center of Sol.

Their action was simplicity itself. The black boiler tubes were shielded in such a way that so long as the aim was dead center on the sun they received no energy; but let the orientation shift by a fraction of a degree, and one of these blackened surfaces would begin to receive reflected energy from the mirror behind it; the liquid nitrogen within would boil, and escape under pressure through a jet in such manner as to re-orient the position to the center of the tracking alignment.

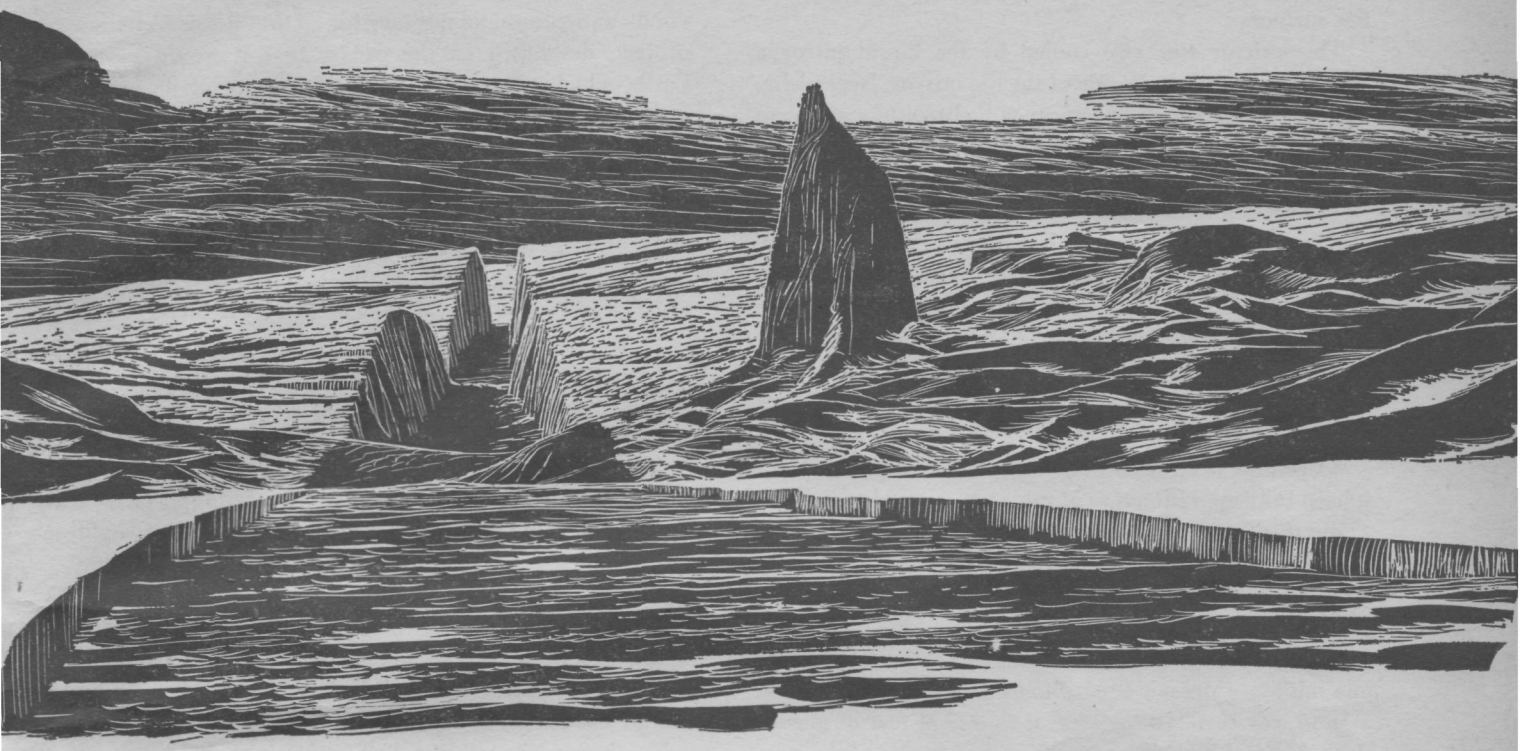
Since the nitrogen gas escaped into the balloon, the automatic pressure regulator designed to maintain pressure within the balloon would extract an equal quantity of gas, put it back through the cooling system on the back side of the mirror, and return it as liquid to the boiler.

These jets were so carefully and precisely balanced that there was virtually no" hunting" in the system.

The balloon itself was attached to its anchor tube by a one hundred meter cable that gave free play to these orientation servos. The anchor point was the exact center of the black outside surface of the mirror-half of the balloon; and beside that anchor point was the air lock to the control center, to which Steve was now going.

From the control room, a column extended up through the axis of the balloon for thirty-five hundred feet—and most of the surface of this column was covered with the new type, high power ruby rods, thirty feet long and one-half inch in diameter, mounted in tubular trays of reflective material which took up sufficient space to make each rod occupy two inches of the circumference of the tube on which it was mounted.

These ruby rods were the heart of the power system, converting the random wave fronts of noncoherent light received from the mirror into a tremendous beam of coherent infrared energy which could be bundled in such a pattern as to reach Earth's surface in a focal point adjustable from here to be something between twenty-two feet in diameter to approximately one mile in diameter.



The banks of rods were so arranged that each of the one hundred sections comprising the three thousand feet of receptive surface at the focus of the mirror formed a concentric circle of energy beams; each circle becoming progressively smaller in diameter, so that the energy combined into one hundred concentric circles, one within the other, as it left the rods; but these circles were capable of the necessary focusing that could bring them all together into a single small point near Earth's surface.

The beam leaving the rods represented three hundred seventy-five million watts of energy, tightly packaged for delivery to Earth. But this was only a small fraction of the solar energy arriving at the big mirror.

The remainder, the loss, must be dumped by the black surface at the back; and to account for the loss in the rods themselves, to prevent their instantaneous slagging into useless globules of aluminum oxide, their excess loss energy must also be dumped.

A cooling bath of liquid nitrogen therefore circulated over each rod and brought the excess heat to the rear of the big lens, where it, too, could be dumped into the blackness of space beyond.

For all its size and complexity, Hot Rod was only a trifle over six per cent efficient; but that six per cent of efficiency arriving on Earth would be highly welcome to supplement the power sources that statistics said were being rapidly depleted.

The spherical shape of the mirror itself, one of the easiest possible structures to erect in space, had dictated the placement of the rods through its center since there was no single focal point for the entire mirror surface.

But it had also added a complication. From this position, the rods could have been designed to fire either straight forward or straight back.

However, due to the hollow nature of the thirty-five hundred foot laser barrel; the necessity for access to the rods from inside that barrel; and the placement of the control booth at its outside end, the firing could only be forward, straight towards the sun on which the mirror was focused.

But to be useful, the beam must be able to track an ever-moving target.

This problem had been solved by one of the largest mirror surfaces that man had ever created—flat to a quarter of a wave-length of light, and two hundred fifty feet in diameter, the beam director, from this distance looking as though it were a carelessly tossed looking-glass from milady's handbag, anchored one diameter forward of the big power balloon.

For all its size, this director mirror had very little mass. Originally it had been planned to be made of glass in much the same manner as Palomar's 200-inch eye. But this plan had been rejected on the basis of the weight involved.

Instead, its structure was a rigid honeycomb of plastic; surfaced by a layer of fluorocarbon plastic which had been brought to its final polish in space, and then care-

fully aluminized to provide a highly reflective, extremely flat surface.

This mirror was also cooled by the liquid nitrogen supplied from the back side of the big mirror. Necessarily so, since even its best reflectivity still absorbed a sufficient portion of the energy from the beam it deflected to have rapidly ruined it if it were not properly cooled.

The several tons of ruby rods in the barrel, with their clear sapphire coatings, were far more valuable than any gems of any monarch that had ever lived on Earth. Synthetic though they were, Steve Elbertson, the project's military commander, knew they had been shipped here at fantastic cost and were expected to pay for themselves many thousands of times over in energy delivered.

As yet, the project had had no specific target; nor had it been fully operational as of midnight yesterday.

But this "morning" for the first time the terrific energy of the laser beam would be brought to bear on the Greenland ice cap—three hundred seventy-five million watts of infrared energy adjusted to a needle-point expected to be twenty-two feet in diameter at Earth's surface, delivering one million watts per square foot, that should put a hole a good way through the several thousand feet of glacier there in its fifteen minutes of operation, possibly even exposing the bare rock beneath, and certainly releasing a mighty cloud of steam.

Focused to this needle sharpness, the rate of energy delivery was many orders of magnitude higher than that delivered by man's largest nuclear weapons only a few yards from ground zero.

Today's test was primarily scheduled as a test of control in aiming and energy concentration. Careful co-ordination of the project by ground control was vital, so that no misalignment of the beam could possibly bring it to bear on any civilized portion of Earth's surface. For, fantastic as this Project Hot Rod might be as a source of power for Earth, Major Elbertson knew that it was also the most dangerous weapon that man had ever devised.

Therefore, the scientists were never alone in the control booth, despite the mile-long security records of each. Therefore, he and his men were in absolute control of the men who controlled the laser.

Therefore, too, Steve told himself, as the time came when there would be a question of command between himself and Captain Nails Andersen, science advisor to the U.N. and commander of Space Lab One, his own secret orders were that he was to take command—and the rank that would give him that command was already bestowed, ready for activation.

Nails Andersen, Steve reminded himself with amusement, had originated the laser project; had fought it through against the advice of more cautious souls; and had, through that project, attained command of the space lab, and the rank that made that command possible, all in the name of civilian science.

But not command of the laser project, Steve told himself.

Not of the most dangerous military weapon ever devised—dangerous and military for all that it was a civilian project, developed on the excuse that it would power Earth, which was rapidly eating itself out of its power sources.

Not in command of that, Steve told himself. Nobody but a military man could properly protect—and if necessary, properly use—such power.

Those were his secret orders; and he had the papers—and the authority from Earth—to back him up. And orders to shoot to kill without hesitation if those orders were questioned.

Meantime, today's peacetime experiment would bring forcibly to the attention of Earth both the power for good and the power for destruction of the laser which he commanded.

Project Hot Rod was manned twenty-four hours a "day." The new shift of scientists—the ones who would turn on the powerful—or deadly—beam, would come aboard in about half an hour. The men who had put the finishing touches on the project during the past shift would remain for another hour. His own crew of Security men shifted with the scientists—but he, himself, shifted at will.

The immensity around him went unheeded as Steve Elbertson, eyes on Project Hot Rod, savored the power of the beam that could control Earth.

In the observatory, Perk Kimball and his assistant Jerry Wallace were having coffee as the various electronic adjuncts to the instruments of the observatory warmed up. Transistors and other solid state components that made up the majority of the electronic equipment in the observatory required no "warm up" in the sense that the older electron tubes had—but when used in critical equipment, they were temperature sensitive, and he allowed for time to reach a stable operating temperature. Then, too, the older electron tubes had not been entirely replaced. Many of them were still in faithful service.

The day would not be spent in the observation which was their main job there, because calibration of many of the instruments remained to be done, and the observatory was behind schedule, having had a good deal of its time taken up in the sightings required by the communications lab and Project Hot Rod.

Both of the astronomers were heartily sick of spending so much of their observational time with recalcitrant equipment; and in making observations of the globe from which they had come. After all, why should an astronomer be interested in Earth? Though admittedly this was the first observatory in man's entire history that had had the opportunity for such a careful scrutiny.

"This flare business, that our captive Indian was predicting," Jerry asked. "Think there's anything to it? Or am I just learning rumors about my profession from lay sources?"

"A rather presumptuous prediction, though he may be right." Perk's clipped tone was partly English, partly the

hauteur of the professional. To him, solar phenomena were strictly sourced on the sun, and if they were to be understood at all, it would be in reference to the internal dynamics of the sun itself.

"The torroidal magnetic fields dividing the slowly rotating polar regions from the more rapid rotation near the solar equator," he said slowly, rather pedantically, but as though talking to himself, "should have far more effective control over solar phenomena than the periodic unbalance created by the off-center gravitic fields when the inner planets bunch on the same side of their solar orbits.

"To imply otherwise would be rather like saying that the grain of sand is responsible for the tides.

"Yet," he added honestly, "the records compiled by some of the communications interests that used to be greatly disturbed by the solar flares' influence on radio communications, seem to indicate that there is a connection. So there is the possibility, however remote, that our captive redskin might be right; or rather, that there is a force involved that makes the two coincidental."

But even as he talked, an unnoticed needle on the board began an unusual, wiggling dance, far different from its ordinary, slow, averaging reactions. Twice, without being noticed, it swung rapidly towards the red line on its meter face; and then on its third approach the radiation counter swung over the red line and triggered an alarm.

From only one source in their environment could they expect that level of X-ray intensity. Without so much as a pause for thought, as the alarm screamed, barely glancing at the counter, Perk reached for the intercom switch and intoned the chant that man had learned was the great emergency of space: "Flare, flare, flare—take cover."

Simultaneously, he flipped three switches putting the observatory, the only completely unshielded area within the satellite, on automatic, to record as much as it could of the progress of the solar flare with its incomplete equipment, while he and Jerry dove through the open air lock down the central well to the emergency shield room in the center of the hub.

It was a poor system, Perk thought, that hadn't devised sufficient shielding for the observatory so that they could watch this phenomenon more directly. "We'll have to work on that problem," he told himself and since his recommendations would carry much weight after this tour of duty, he could be sure that any such system that he could devise would be instrumented.

Major Steve Elbertson, caught in mid-run between the lab and Project Hot Rod, resisted the temptation to reverse the scuttlebug on the line and pull himself to a fast stop, as the flare warning from the observatory came to him over the emergency circuit of his suit, followed by Bessie's clipped official voice saying:

"A flare is in progress. Any personnel outside the ship should get in as rapidly as possible. Personnel in the rim have seven minutes in which to secure their posts and report to the flare-shield area in the hub. Spin deceleration will take effect in three minutes; and we are counting on my mark towards deceleration. Mark, three minutes."

The Security officer squeezed the trigger of the "bug" tighter in a vain effort to force it and himself forward at a higher speed.

The lesser shielding of the Hot Rod control room would not provide a sufficient safety factor even for the X rays that he knew were already around him; but he must supervise the security of the shutdown; and he could only be very thankful that he was already nearly there and would not have to make the entire round trip under emergency conditions.

The scuttlebug automatically reversed and began slowing for the end of its run—tripped by a block signal set in the ribbon cable. As it came to a stop at the end of the long anchor tube, Steve dismounted and kicked over the short remaining distance, which was spanned only by a slack cable to permit the inertial orientation servos of Hot Rod unhindered freedom to maintain their constant tracking of the solar disk.

Passing through the air lock of the control room, he reflected that his exposure would probably be sufficient to give a touch of nausea in the first half hour.

Inside Hot Rod control there was little excitement. The equipment was being turned off in the standard approved safety procedures necessary to turn control over to the laser communication beam which would put the project under Earth control at Thule Base, Greenland, until the emergency was over.

This separate, low-power control beam, focused on Thule Base nearly eighty miles away from the main focus of Hot Rod on its initial target, carried all of the communications and telemetry necessary for the close co-ordination between Thule and the project.

As Elbertson entered, the Hot Rod communications officer was switching each of the control panels in turn to Earth control, while Dr. Benjamin Koblensky, project chief, stood directly behind him, supervising the process. Elbertson took up his post beside Dr. Koblensky, replacing the Security aide who had had the past shift. "Suit up," he said to the man briefly.

As the communications officer completed the turnover, and the other five scientists in the lab left their posts to suitup, the com officer glanced up, received a nod from Dr. Koblensky, and said into his microphone "All circuits have now been placed in telemetry security operation. On my mark it will be five seconds to control abandonment. Mark," he said after another nod from Dr. Koblensky ."Four, three, two, one, release."

His hand on the master switch, he waited for the green light above it to assure him that the communications lag had been overcome, and as the green light came on, pushed the switch and rose from the console.

Major Elbertson stepped behind him, scanned the switches, inserted his key into the Security lock, and

turned it with a final snap, forcing a bar home through the handles of all of the switches to prevent their unauthorized operation by anyone until the official Security key should again release them. In the meantime, no function could be initiated within the laser system by anyone other than the Security control officer at Thule Base on Earth.

Hot Rod was secured, and its crew were taking turns at the lock to make the life-saving run back to the flare-shield area in the hub of Lab One.

Last man out, three minutes after the original alarm, Steve glanced carefully around his beloved control booth, entered the now-empty air lock, and reaching the outside vacuum dove fast and hard toward the anchor terminal and the scuttlebug that would take him swiftly to the big wheel and its comparative safety.

In the gymnasium that served under emergency conditions as the flare-shield area of the hub, long since dubbed the "morgue," the circular nets of hammocks that made it possible to pack six hundred personnel into an area with a thirty-two foot diameter and a forty-five foot length, were lowered. They would hardly be packed this time, since less than one-third of the complement were yet aboard.

Even so, each person aboard had his assigned hammock space, two and a half feet wide; two and a half feet below the hammock above; and seven feet long; and each made his way toward his assigned slot.

At one end of the morgue was the area where the cages of animals from Dr. Lavalle's labs were being stored on their assigned flare-shield shelves; and where Dr. Millie Williams was supervising the arrangements of the trays and vats of plants that must be protected as thoroughly as the humans.

At the other end of the morgue, the medics were setting up their emergency treatment area, while nearby the culinary crew pulled out and put in operating condition the emergency feeding equipment.

The big wheel's soft, susurrus lullaby had already changed to a muted background roar as her huge pumps drew the shielding waters of the rim into the great tanks that gave the hub twenty-four feet of shielding from the expected storm of protons that would soon be raging in the vacuum outside.

The ship was withdrawing the hydraulic mass from its rim much as a person in shock draws body fluids in from the outer limbs to the central body cavities. The analogy was apt, for until danger passed, the lab was knocked out, only its automatic functions proceeding as normal, while its consciousness hovered in interiorized, self-protective withdrawal.

On the panel before Bessie the computer's projection of expected events showed the wave-front of protons approaching the orbit of Venus, and on the numerical panel directly below this display the negative count of minutes continued to march before her as the wave-front approached at half the speed of light.

The expected diminishment of X rays had not yet occurred. Normally, there would be a space of time between their diminishment and the arrival of the first wave of protons; but so far it had not happened.

Six minutes had passed, and the arriving personnel of Project Hot Rod came in through the locks from the loading platform, diving through the central tunnel over Bessie's head and on to the shielded tank beyond.

Seven minutes; and from Biology lab came an excited voice. "I need some help! I've lost a rabbit. I came back for the one I'd been innoculating, but he got away from me, and I can't corner him in this no-gravity!"

Bessie wasn't sure what to say, but Captain Andersen spoke into his intercom. "Dr. Lavalle," he said in a low voice, but with the force of command, "ninety per cent of your shielding has already been withdrawn. Abandon the rabbit and report immediately to the hub!"

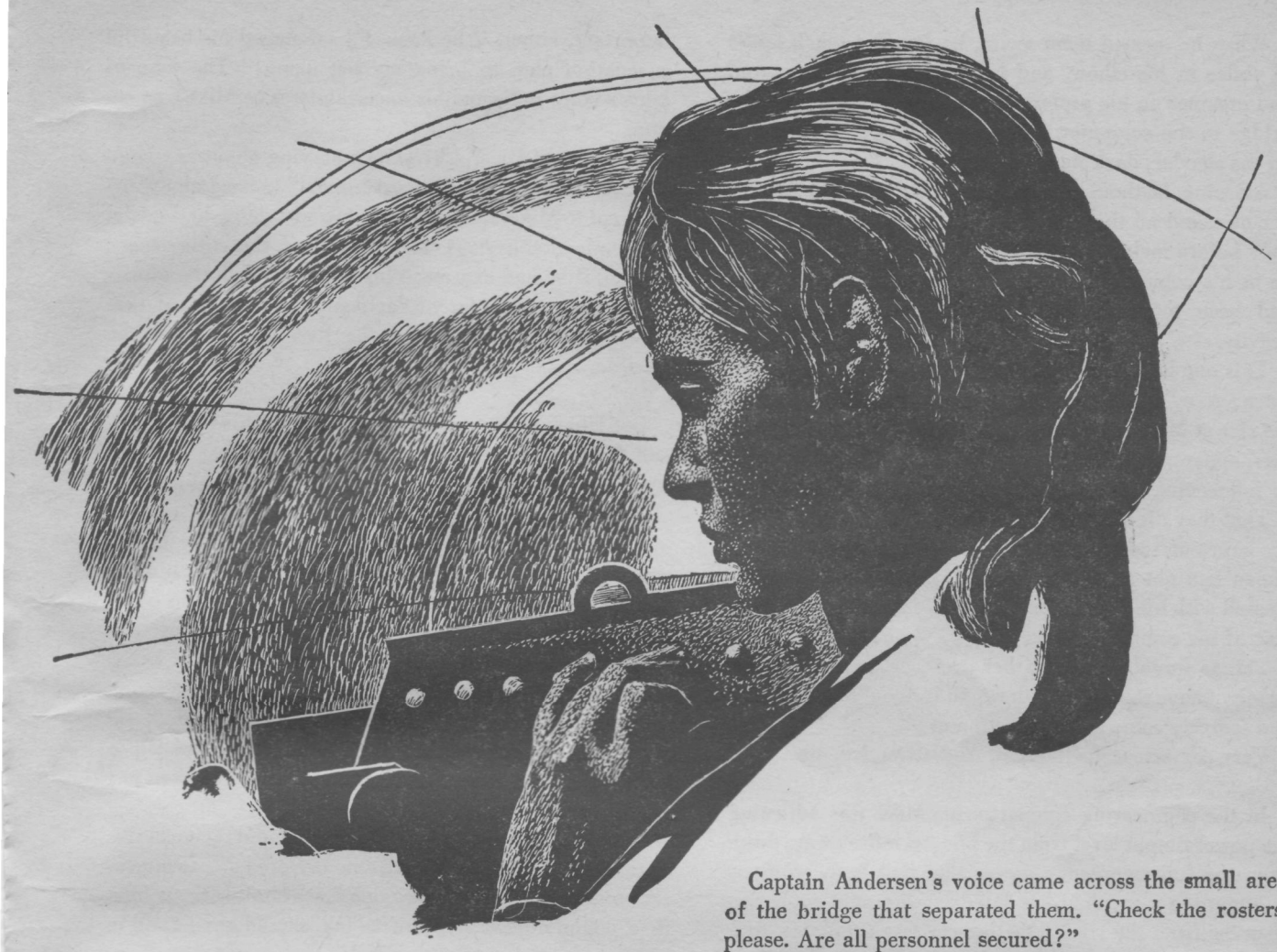
The pumps were still laboring to bring in the last nine per cent of the water that would be brought. The remaining one per cent of the normal hydraulic mass of the rim had been diverted to a very small-diameter tube at the extreme inner portion of the rim, and was now being driven through this tube at frantically higher velocities to compensate for the removal of the major mass, and to maintain a small percentage of the original spin, so that the hub would not be totally in free fall, though the pseudo-gravity of centrifugal force had already fallen to a mere shadow of a shadow of itself, and some of the personnel were feeling the combined squeamishness of the Coriolis effect near the center of the ship, and the lessening of the gravity, pseudo though it had been, that they had had with them in the rim.

As the last tardy technician arrived, the medics were already selecting out the nearly ten per cent of the personnel who had been exposed to abnormally dangerous quantities of radiation during the withdrawal procedure, which included, of course, all the personnel that had been aboard Project Hot Rod at the time of the flare.

Even as the medics went about injecting carefully controlled dosages of sulph-hydral anti-radiation drugs, the beginnings of nausea were evident among those who had been overexposed. However, only the dosimeters could be relied on to determine whether the nausea was more from the effects of radiation; the effects of the near-free-fall and Coriolis experienced in the hub; or perhaps some of it was psychosomatic, and had no real basis other than the fear engendered by emergency conditions.

Major Steve Elbertson was already in such violent throes of nausea that his attending medic was having difficulty reading his dosimeter as he made use of the plastic bag attached to his hammock; and he was obviously, for the moment at least, one of the least dignified of the persons on board.

Displays of the various labs in the rim moved restlessly across most of the thirty-six channels of the computer's video displays, as Bessie scanned about, searching for



dangerously loose equipment or personnel that might somehow have been left behind.

In the Biology lab, the white rabbit that had escaped was frantically struggling in the near-zero centrifugal field with literally huge bounds, seeking some haven wherein his disturbed senses might feel more at home, and eventually finding a place in an overturned wastebasket wedged between a chair and a desk, both suction-cupped to the floor, Frightened and alone, with only his nose poking out of the burrow beneath the trash of the wastebasket, he blinked back at the silent camera through which Bessie observed him, and elicited from her a murmur of pity.

Seven minutes and forty-five seconds. The digital readout at the bottom of Bessie's console showed the computer's prediction of fifteen seconds remaining until the expected flood of protons began to arrive from the sun.

As radiation monitors began to pick up the actual arrival of the wave front, the picture on her console changed to display a new wave front, only fractionally in advance of the one that the computer had been displaying as a prediction.

The storm of space had broken.

Captain Andersen's voice came across the small area of the bridge that separated them. "Check the rosters, please. Are all personnel secured?"

Bessie glanced at the thirty-two minor display panels, checking visually, even as her fingers fed the question to the computer.

The display of the labs, now that the rabbit was settled into place, showed no dangerously loose equipment other than a few minor items of insufficient mass to present a hazard, and no personnel, she noted, as the Cow displayed a final check-set of figures, indicating that all personnel were at their assigned, protected stations in the morgue, in the engineering quarters, and on the bridge.

"All secure," she told the captain. "Evacuation is complete."

"Well handled," he said to her, then over the intercom: "This is your captain. Our evacuation to the flare-shield area is complete. The ship and personnel are secured for emergency conditions, and were secured well within the time available. May I congratulate you.

"The proton storm is now raging outside. You will be confined to your posts in the shield area for somewhere between sixteen and forty-eight hours.

"As soon as it is possible to predict the time limit more accurately, the information will be given to you."

As he switched out of the ship's annunciator system, Captain Nails Andersen leaned back in his chair and stretched in relief, closing his eyes and running briefly over the details of the evacuation.

When he opened them again, he found a pinch bottle of coffee at his elbow, and tasting it, found it sugared and creamed to his preference. His eyes went across the bridge to the computer console, and lingered a moment on the slender, dark figure there.

Amazing, he thought. The dossier, the personal history, her own and all the others aboard, he had studied carefully before making a selection of the people who would be in his command for this time. Not that the decision had been totally his, but his influence had counted heavily.

This one he had almost missed. Only by asking for an extra survey of information had he caught that bit about the riot at Moscow University that had raged around her ears, apparently without touching or being influenced by or influencing her own quiet program.

That they didn't think alike was evident. That this was a competent sociologist, and not just a computer technician had not at first been evident. But Nails was well pleased with his decision in the selection of this particular unit of his command.

Things would go well in her presence, he felt. Details he might have struggled with would iron out or disappear, and scarcely come to his attention at all.

Very competent, he thought. And attractive, too.

In the engineering compartment, Mike was adjusting the power output level from the pile ten miles away, down from the full emergency power that had been required to pump the more than five hundred thousand cubic feet of water from the rim to the hub in seven minutes, to a level more in keeping with the moderate requirements of the lab as it waited out the storm.

As he threw the last switch, he became aware of a soft scuffling sound behind him, and turned to see tiny Dr. Y Chi Tung, single-handedly manhandling through the double bulkhead the bulky magnetic reasonance device on which he had been working when the flare alarm sounded, and having the utmost difficulty even though the near free-fall conditions made his problem package next to weightless.

The monkeylike form of the erudite physicist, dwarfed by the big chassis, gave the appearance of a small boy trying to hide an outsize treasure; but the nonchalant humor that normally poked constant fun at both his profession as a physicist and the traditions of his Chinese ancestors, was lacking.

Dr. Ishie was both breathless and worried.

"Mike," he gasped. "I was afraid to leave it, unshielded. It might pick up some residual activity. Radiation, that is. From those hydrogen hordes outside." He let the object rest for a moment, mopping his head while he talked. "Can you hide it in here? I'm not really anxious to have Budget Control know where some of this stuff went—even though I have honorable intentions of returning the components later—and the good captain down there on the bridge might not consider its shielding important, either, if he knew I'd sabotaged his beautiful evacuation plan to bring my pet along!" The tone of Ishie's voice indicated his uncertainty as to Mike's reception.

The idea of Dr. Y Chi Tung worrying about any components he might have "requisitioned" seemed almost irreverent to Mike. Budget Control would gladly have given that eminent physicist a good half of the entire space station, if he had expressed his needs through the proper channels—as a matter of fact, anything on board that wasn't actually essential to the lives of those on the satellite.

But Ishie seemed genuinely unaware of his true status, and the high regard in which he was held. Besides, Mike suspected in him a constitutional inability to deal through channels.

Recognizing the true sensitivity that underlay Ishie's constant humor and ridicule of himself, Mike kept himself from laughing aloud at the stealth of the man who could have commanded the assistance of the captain himself in shielding whatever he thought it necessary to shield.

Instead, he carefully kept his face solemn while he commented: "It ought to fit in that rack over there." He pointed to a group of half-filled racks. "We can slip a fake panel on it. Nobody will be able to tell it from any of the other control circuits."

Ishie heaved a deep sigh of relief and grinned his normal grin. "Confusion say," he declared, "that ninety-six pound weakling who struggle down shaft with six hundred pound object, even in free fall, should have stood in bed."

It took the two of them the better part of half an hour to get the unit into place; to disguise its presence; and to make proper power connections. Ishie had objected at first to connecting it up, and Mike explained his insistence by saying that "If it looks like something that works, nobody will look at it twice. But if it looks like something dead, one of my boys is apt to take it apart to see what it's supposed to be doing." He didn't mention his real reason—a heady desire to run a few tests on the instrument himself.

The job done, the two sat back on their heels, admiring their handiwork like bad boys.

"Coffee?" asked Mike.

"Snarl. Honorable ancestor Confusion doesn't even need to tell me what to do now. My toy is safe. I am going to bed. I have worked without stopping for two days and now the flare has stopped me.

"Confusion decide to relent. He tell me now: 'He who drive self like slave for forty-eight hours is nuts and should be sent to bed.' I hope," he added, "that the hammocks are soft; but I don't think I shall notice. I know just where to go for I checked in once to fool the Sacred Cow before I went to get my beautiful. Now I go back again."

And without so much as a thank-you, he staggered out,

grasping for handholds to guide himself in a most unspacemanlike manner.

Mike craftily sat back, still on his heels beside the object, and watched until Ishie had disappeared, and then turned his full interest to the playtoy that fortune had placed in his shop.

Without hesitation he removed the false front they had so carefully put in place. He still had a long tour of duty ahead, and it was very unlikely that he would be interrupted, or, if interrupted, that anyone would question the object on which he worked. It would be assumed that this was just another piece of the equipment normally under his care.

Carefully he looked over the circuits, checking in his mind the function of each. Then he went to his racks and began selecting test equipment designed to fit in the empty racks around it. Oscilloscope, signal generator, volt meters and such soon formed a bank around the original piece of equipment, in positions of maximum access.

Gingerly he began applying power to the individual circuits, checking carefully his understanding of each component.

The magnetic field effect, Ishie had explained; but this three-phase RF generator—that puzzled him for a while.

Then he remembered some theory. Brute strength alone would not cause the protons to tip. Much as a top, spinning off-center on its point, will swing slowly around that point instead of tipping over, the spinning protons in the magnetic field would precess, but would not tip and line up without the application of a rotating secondary magnetic field at radio frequencies which would make the feat of lining them up easy.

There, then, were two of the components that Ishie had built into his device. A strong magnetic field supplied by the magnaswedge coils—stolen magnaswedge coils if you please—and a rotating RF field supplied by the generator below the chassis.

But this third effect? The DC electric field? That one was new to him.

In his mind he pictured the tiny gyroscopes all brought into alignment by the interplay of magnetic forces; and around each proton the tiny, planetary electrons.

Yet it was all very well to think of the proton nucleus of the hydrogen atom as a simple top, he reminded himself; but they were more complex than that. Each orbiting electron must also contribute something to the effect.

At that point, Mike remembered, the electron itself would be spinning, a lighter-weight gyroscope, much as Earth has a lighter weight than the Sun. The electron, too, had a magnetic field; more powerful than the proton's field because of its higher rate of spin, despite its lighter mass. The electron could also be lined up.

Somewhere in the back of his mind, Mike remembered having read of another effect. The electron's resonance. Electron para-magnetic resonance.

It, too, could be controlled by radio frequencies in a magnetic field—but the frequencies were different, far up in the microwave region; about three centimeters as Mike recalled—and he went back to his supply cabinet to get another piece of equipment, a spare klystron that actually belonged to the radar department but that was "stored" in his shop.

At these frequencies, the three centimeter band of the electromagnetic spectrum, energy does not flow on wires as it does in the lower frequency regions. Here plumbing is required. But Mike, amongst other things, was an expert RF plumber.

Even experts take time to set up klystrons, and it was three hours later before Mike was ready with the additional piece of haywire equipment which carefully piped RF energy into the plastic block.

This refinement by itself had been done before; but some of the others that Mike applied during his investigation probably hadn't—at least not to any such tortured piece of plastic as now existed between the pole faces of the device.

To have produced the complete alignment of both the protons and the electrons within a mass might have been attempted before. To have applied an electrostatic field in addition to this had perhaps been attempted before. To have done all three, at the same time to the same piece of plastic, and then to have added the additional tortures that Mike thought up as he went along, was perhaps a chance combination, repeatable once in a million tries, one of those experimental accidents that sometimes provide more insight into the nature of matter than all of the careful research devised by multi-million-dollar-powered teams of classical researchers.

When the contraption was in full operation, he simply sat on his heels and watched, studying out in his mind the circuits and their effects.

The interruption of the magnetic resonance by the electrostatic field—by the DC—with the RF plumbing—twisted by—each time the concept came towards the surface, it sank back as he tried to pull it into consciousness.

Churkling to itself, the device continued applying its alternate fields and warps and strains.

"It's a Confusor out of Confusion by Ishie, who is probably as great a creator of Confusion as you could ask," Mike told himself, forgetting his own part in the matter, watching intently, waiting for the concept to come clear in his mind.

Presently he went over to his console, to his pads of paper and pencils, and began sketching rapidly, drawing the interlocking and repulsing fields, the alignments, mathing out the stresses—in an attempt to visualize just what it *was* that the Confusor would now be doing. . . .

In the Confusor itself, a tiny chunk of plastic, four by four inches square and one-half inch thick, resting in the middle of the machine between the carefully aligned pole-faces of the magnet, was subjected to the cumulatively

devised stresses, a weird distortion of its own stresses and of the inertia that was its existence.

Each proton and electron within the plastic felt an urge to be where it wasn't—felt a pseudo-memory, imposed by the outside stresses, of having been traveling at a high velocity towards the north star, on which the machine chanced to be oriented; felt the new inertia of that velocity . . .

Each proton and electron fitted itself more snuggly against the north pole face and pushed with the entire force of its newly-imposed inertial pattern.

Forty pounds to the square inch six hundred forty pounds over the surface of the block, the plastic did its best to assume the motion that the warped laws of its existence said that it already had.

It was only one times ten to the minus five of a gravity that the four by four by half inch piece of carefully machined plastic presented to the sixty-four million pound mass of Space Lab One.

But the force was presented almost exactly along the north-south axis of the hub of the ship, and in space a thrust is cumulative and momentum derives per second per second.

The Confusor churkled quietly as the piece of plastic exerted its tiny mass in a six hundred forty pound attempt to take off towards the north star. And, since the piece itself was rigidly mounted to its frame, and the frame to the ship, the giant bulk of five million cubic feet of water, thirty-two million pounds of mass; and the matching mass-bulk of the ship itself, responded to the full mosquito-sized strength of the six hundred forty pound thrust, and was moved—a fraction of a fraction of a fraction of a centimeter in the first second; a fraction of a fraction in the second; a fraction. . .

On the bridge, the com officer had completed transmitting the captain's detailed report of the evacuation to the hub-shield area caused by the solar flare.

On another line, under Bessie's ministrations, the computer was feeding the data obtained by the incomplete equipment in the observatory in its automatic operation.

The captain himself was finishing a plastic-bottle of coffee, while he wrote up his log.

It was exactly nine minutes since the Confusor had come into full operation.

The fractions of fractions of centimeters had added on the square of the number of seconds; and the sixty-four million pounds of mass of Space Lab One had moved over thirteen meters.

Trailing the wheel ten miles off, was the atomic pile, directly attached to its anchor tube.

Tightening, each with a whanging snap too tiny to be remarked within the mass of the ship, were the cables that attached the various items of the dump to their anchor finger.

But still free on the loose one hundred meter cable that attached it to its anchor, and which had had fifteen meters of slack when the ship first began its infinitesimal movement, was Project Hot Rod.

Nine minutes and twenty-three seconds. The velocity of the wheel with its increasing mass of trailing items, was five point four six centimeters per second. The nearly four million pound mass of Hot Rod was slowly being left behind.

The cable tautened the final fraction of a centimeter. Its tug was not fast, but was unfortunately applied very close to the center of gravity of the entire device, since most of Hot Rod's weight was concentrated in and around the control room.

Five point four six centimeters per second. Four million pounds of mass.

If the shock had been direct, it would have equaled two point eight million ergs of energy, created by the fractional movement of the mighty mass of the ship against Hot Rod.

But the shock was transmitted through the short end of a long lever. The motion at the beam director mirror, a full diameter out from the eight thousand foot diameter balloon that was Hot Rod, was multiplied nearly sixteen thousand times. Hot Rod rolled on its center of gravity, and its beam-director mirror swung in a huge arc. Sixteen thousand centimeters per centimeter of original motion. Eight hundred and seventy-three meters in the first second, before the tracking servos took over and began to fight back.

Hot Rod fought at the end of its tether like a mighty jellyfish hooked on the end of a line.

Gradually the swings decreased. Four hundred meters; two hundred meters; one hundred meters; fifty meters; twenty-five meters—and it had come back to a nearly stable focus on the sun.

But the beam director had also been displaced, and vibrated. Internally, the communications beam to Thule Base had been interrupted; and the fail-safe had not failed-safely.

The mighty beam had lashed out. The vibrations of the directing mirror began placing gigantic spots and sweeps of unresistible energy across the ice cap of Greenland, in an ever-diminishing Lissajous pattern.

By the time the servos refocused the communications beam on Thule, there was no Thule; only a burnt-out crater where it had been.

Slowly, but surely, the giant balloon settled itself to the task of burning a hole through the Greenland ice cap at a spot eighty miles north of that now-burnt-out Thule Base that had originally been planned as a test of its accuracy; and to the simple task of holding that focus in spite of the now steady, though infinitesimal acceleration under which it joined the procession headed by Lab One.

Now that the waves of action and reaction from the shock energy of its sudden start had subsided, Hot Rod's accuracy was proving great indeed; and its beam focus was proving as small as had been predicted.

But the instruments that would have measured those facts no longer existed.

In the engineering control center of Space Lab One, the Confusor churkled quietly and continued to pit its mosquito might against its now nearly seventy-eight million pound antagonist, as the protons and electrons of the plastic that was center to its forces did their inertial best to occupy that position in space towards the north star in which the warped fields around them forced them to belong—the mosquito strained its six hundred forty pound thrust against its giant in the per second per second acceleration that was effective only in the fraction of a fraction of a fraction of a centimeter in the first second, but that compounded its fractions per second.

On the quiet bridge, the captain looked up as the Com Officer said, "Thule Base, sir," and switched on his mike.

"Hot Rod has been sabotaged," a frantic voice on the other end of the beam shouted in his ear without formalities. "She's running wild. Kill her! Repeat, Hot Rod is wild! Kill Hot Rod! Kill—" the mike went dead as Captain Andersen switched to the morgue intercom.

"Hot Rod crew," he said briefly. "Report to the bridge on the double. Repeat. Hot Rod crew. The bridge. On the double."

As he switched off the intercom, the communications officer spoke urgently. "Captain. I've lost contact with Thule Base."

"Keep trying to raise them," Captain Andersen said. He turned to Bessie. "Give me a display of the Hellmaker," he said; then, almost to himself, "There's still a flare in progress out there. We've got to kill it without sending men into that—"

He cut himself off in midsentence, as the computer displayed both Hot Rod, swaying gently as she fought out the battle of the focus through its final moments, and a telescopic view of Greenland, a tiny, glowing coal of red showing at the center of her focus.

Through the door nearly catapulted the first of the Project Hot Rodders, followed almost on his heels by twelve more.

"Where is Major Elbertson?"

"In sick bay, sir. He got a big radiation dose—"

The captain flipped the intercom key.

"Calling Major Elbertson in sick bay. Report to the bridge on the double, no matter what your condition. This is the captain speaking."

The intercom came alive at far end.

"This is Dr. Green, Captain Andersen. Major Elbertson is unconscious. He cannot report for duty. He was extremely ill from exposure to radiation and we have administered sulph-hydral, antispasmodic, and sedative."

Nails Andersen turned to the project crew.

"Which of you are Security officers?"

Three men stepped forward.

"Are all the project members here?"

"No, sir," said one. "Eight of our men are in sick bay."

"Very well," said the captain. "Now hear this, all of you. There is a saboteur—maybe more than one, we do not know—among you. There is no time to find out which of you it is. However, he has managed to leave Project Hot Rod operational while unattended. You are to turn it off, and to prevent the saboteur from stopping you. Do you understand?"

A voice in back—a rather high voice—spoke up. "Of course it's operational," it said. "We left it operational."

"You . . . WHAT?"

"We left it operational. It's under Earth control. The control center at Thule is in charge, sir."

"Who are you?" the captain asked.

"Hot Rod communications officer, sir. I turned it over last thing before we shut down. Under the instructions of Dr. Koblensky. That's the shutdown procedure."

"Where's Dr. Koblensky?"

"Out. Out like a light," said another voice. "He got a good dose. Of radiation. The medics put him out."

"Who's senior officer here?"

"I'm Dr. Johnston." It was a man in front. Rather small, pedantic-looking. "I'm Dr. Koblensky's . . . well, assistant." The word came hard as though the fact of an assistantship were at the least distasteful.

"Who's senior in Security?"

"I, sir. Chauvenseer."

"Very well. Dr. Johnston and Chauvens . . . sor? . . . are in charge. Now shut down that ruby hellmaker as fast as it can be done."

"But, captain," Dr. Johnston spoke, "we can't turn it off. We haven't the authority. We haven't the Security key. And the radiation won't let up for hours."

"I have just given you the authority. As for the radiation, that's a hazard you'll have to take. What's this about a Security key?" The captain's voice was not gentle.

"Major Elbertson has the key. He has the only key. Without it, the station cannot be removed from Earth control. Earth *is* in control. They can turn it off, captain." Dr. Johnston's voice took on as firm a tone of authority as that of the captain.

"Chau . . . Chau . . . You!" barked the captain. "Get that key!" He waited until the Security officer had disappeared through the door, then turned to the scientist.

"Dr. Johnston, Earth is not in control. I do not know why, and there is no way of finding out. Hot Rod is wild, and *that*," he pointed at the enlarging red spot that centered the computer display, "is what your ruby is doing to Earth.

"You will turn off the project, at gunpoint if necessary," he continued in a grim voice. "If you turn it off volitionally, you will be treated for radiation. If you refuse, you will not live to be treated for anything. Do you understand? How many men do you need to help you . . . and I do mean *you* . . . with the job?" he asked

Dr. Johnston hesitated only fractionally, and Nails An-

dersen mentally put him down on the plus side of the personnel for the shortness of his com lag. Then he said, "The job will require only two men for the fastest accomplishment. You realize, captain that you are probably signing our death warrants—the two of us. But," he added, glancing only casually at the display on the console, "I can understand the need to sign that warrant, and I shall not quibble."

The intercom spoke. "This is Dr. Green, captain. There is no key on the person of Major Elbertson. We have searched thoroughly, sir. I understand the need is of an emergency nature. The key is not on his person. We have taken every possible measure to arouse him, as well, and have been unsuccessful."

Andersen flipped his switch. "Let me speak to the Hot Rod Security officer," he said briefly.

"Chauvenseer speaking, sir," the man's voice came on.

"Do you know what the key looks like?"

"Yes, sir. It looks somewhat like a common Yale key, sir. But I've never seen another just like it."

"There is only the one?"

"Yes, sir."

"Where would he keep it, if not on his person?"

"I don't know, sir. We came straight to the morgue—the shield area, from the air lock. I don't believe he stopped off anywhere he could have put it."

The captain turned to the second Security officer. "Search Elbertson's spacesuit," he said. Then to the intercom, "Search his hammock. Search every spot he went near. That key must be found in minutes. Commandeer as many men as can help in the search without getting in the way."

He paused a moment, then flipped another intercom key.

"Mr. Blackhawk," he said.

The intercom warmed at the far end. "Yes sir?" Mike's voice was relaxed.

"Is there any way to turn off Hot Rod without the Security key?"

"Why sure, captain." Mike's voice held a grin. "I could pull the power switch."

"Pull it. Fast. Hot Rod's out of control."

Mike's hand flashed to a master switch controlling the power that fed Hot Rod, and blessing as he did it the fallacy of engineering that had required external power to power the mighty energy collector.

In the big balloon now happily following the wheel at the end of its tether, the still-undamaged power-off failsafe went into operation. The mirror surface behind each ruby rod rotated into its shielding position, dispersing the energy that the huge mirror directed towards the rods, back into space.

Hot Rod was secure.

Mike received only one further communication from the captain.

"Mr. Blackhawk," he was asked over the intercom, "is there any way that you can secure that Hot Rod power switch so that it cannot be turned on without my personal authorization?"

"Sure, captain, I can—"

The captain interrupted. "Mr. Blackhawk, I should prefer that you not tell me or anyone else aboard the method you will use; and that you make your method as difficult as possible to discover. This I shall leave," he added dryly, "to your rather . . . fertile . . . imagination.

"There is reason to believe that Project Hot Rod was turned on by a saboteur. Your method must be proof against him, and if he exists, he will not be stupid." The captain switched off.

Mike turned to the control panel, and after a few minutes thought busied himself for some time.

Then he headed for the bridge where Dr. Johnston, Chauvenseer, and the captain had dismissed the others and were utilizing every check that Dr. Johnston could dream up to assure themselves that Hot Rod was actually turned off and would remain secure at least for the duration of the flare; and trying as well to find out just what form the sabotage had taken.

Without interrupting the others, Mike seated himself at the subsidiary post at the computer's console on Bessie's right, and got her to brief him while he examined the close-up display of Hot Rod.

After a few minutes he reached over and increased the magnification to its maximum, showing only a small portion of the balloon, then moved the focus to display the control room entrance was well as part of the anchor tube and the cable between the two.

"I think I've found your saboteur, sir," he said.

The captain was at his side almost instantly. "Where is he?" he asked briefly.

"Not he, sir. It. And I'm not sure just where—but look. Hot Rod's cable is taut. There's thrust on the balloon. That probably means a puncture and escaping nitrogen.

"I think," he said, "that the saboteur may have been a meteor that punctured the balloon, and the nitrogen escaping through the hole it made is now producing enough thrust to keep that cable taut. Though," he added thoughtfully, "I don't see why the servos couldn't maintain the beam to Thule—though obviously, they couldn't."

"How dangerous is such a puncture?" asked the captain. "How seriously would Hot Rod be damaged? How soon must it be repaired?"

"The puncture itself shouldn't be too dangerous. Even if all the nitrogen's gone, the balloon's in a vacuum and won't collapse—and that's about the only serious effect a puncture would have. Just a moment. We'll estimate its size by the thrust it's giving the ship," he added, and turned to Bessie.

"Ask the Cow whether we're getting thrust on the ship; and if so, how much. Wait a minute," he added, "if you ask for thrust on the ship, she'll say there isn't any, because Hot Rod would be pulling us, not pushing.

And if you ask her for the thrust on Hot Rod, she hasn't got any sensors out there.

"Hm-m-m. Ask her if we have added any off-orbit velocity; and if so how much."

The computer displayed the answer almost as soon as she received the question.

"Well," said Mike, "that's not too large a hole. Ask her how . . . let's see . . . how many pounds of thrust that velocity represents. That way we don't confuse her with whether it's push or pull."

The Cow displayed the answer, six hundred forty pounds of thrust.

"O.K.," said Mike. "Thanks." Then to the captain and the scientist and Security officer who were waiting beside him: "The puncture is obviously small enough to serve as a jet, rather than to have let the nitrogen out in one *whoosh*, since that would have given you far more than six hundred forty pounds of thrust. Therefore, it will probably be quite simple to patch the hole.

"Nitrogen is obviously escaping, but it wouldn't be worth a man's life to send him out into that flare-storm to patch it. We may even have enough nitrogen aboard to replace what we lose.

"The best I can figure," he said, "is that the meteor must have hit the orientation servos and thrown them off for a bit. We'll have to wait till after the flare to make more than an educated guess, though.

"We shouldn't be too far off-orbit by the time the flare's over, either, even with that jet constant. It'll take quite a bit of work, but we should be able to get her back into position with not too many hours of lost worktime.

"Except for Thule, I'd say we got off fairly light.

"Yes," he added grimly. "it looks like that's what your saboteur was. Rather an effective saboteur, but you'll have a hard time putting him up against a firing wall."

Having satisfied himself as to existing conditions, Mike excused himself shortly and went back to the engineering quarters, but his mind was no longer on Ishie's strange device. He glanced rapidly at the instruments regulating the power flow to the wheel, then stretched out comfortably on the acceleration couch and in minutes was asleep.

The captain, Dr. Johnston and Chauvanseer remained on the bridge another hour, convincing themselves that Mike's analysis was correct, and dictating a report to Earth, before the captain called in an aide to take over the bridge, and the three retired.

In the morgue, Dr. Y Chi Tung, who still slept peacefully as he had since the moment he reached his hammock, muttered quietly in his sleep, "Confusion—"

Mike snapped awake and glanced guiltily at the clock. Six hours had passed.

A situation report from the Cow was the first thing on his agenda any time that he had been out of contact for any length of time, flare or not.

It was not his job to be in constant contact with the complete situation of the ship and its vast complexities; he was not the captain. Nor was it in the manuals that he should have access to the computer's huge memory banks and abilities other than through "channels"—i.e., Bessie. But the book definition of the information he needed for his job, and his own criteria, were somewhat different, and he had built on Earth and installed shortly after he came aboard, a subcontrol link which put him in direct contact with the placid Cow.

His original intention in rigging the link had been to use the calculator for that occasional math problem which might be more quickly resolved with her help; but then the criteria of needed information, curiosity, or both, had got the better of him, and the secret panel hidden in the legitimate control panels of an engineer's console was actually quite a complete link, covering all of the Cow's multiple functions without interfering in any way with Bessie's control links, or revealing its existence. This linkage gave Mike the only direct access to the computer's store of information and abilities other than that of the operator at the control console.

And Mike's secret pride was the vocoder circuit with which he had terminated his link, originated because a teletype system similar to that used at the control console would have been too obvious; and his nimble fingers got all tangled up on a keyboard anyhow.

Bessie might speak to the Cow through the teletype link and switches of her control console; but only Mike had the distinction of being able to speak directly to the big computer, and get the complacent, somewhat mooing answers; and only Mike knew of the existence of the vocoder aboard.

It had taken some care to get used to the literal-minded conversation that resulted; but eventually Mike felt he had worked out a satisfactory communications ability with the overly obvious "cow."

What he wanted now was a situation report. If he simply asked for that, however, he'd have received such miles of data that he'd have been listening for hours. So instead he broke his question down into the facets that he needed.

In a few minutes he had elicited the information that the solar flare was now predicted to be terminated and the major part of the flare protons past their solar orbital position within another ten hours; that Earth coordinates had shifted, indicating their own orbital shift to be a trifle over thirty-seven kilometers north in the past eight hours.

North? he thought. Hot Rod's pull on a taut cable would be to the south.

No. Lab One could be re-oriented to trail the thrusting balloon. But the lab's servos should have prevented that re-orientation unless the thrust were really heavy.

"What is our velocity?" he asked. Temporarily he was baffled by the placid Cow's literal translation of his request as one for an actual velocity, since she had replied with a figure very close to their original orbital speed.

"What is our velocity at right angles to original course?" he inquired.

And the Cow's reply came: "Two-o-o hundred and fifty-seven point seven six ce-entimeters per se-econd."

That should be about right for six hundred forty pounds of thrust for, say, six and a half hours; and the distance of the orbit shift was about right.

But the direction?

"Is Hot Rod pulling us north? he asked.

"No-o-o," came the placid reply.

"If it's pulling us south, then why—" He stopped himself. Any "why" required inductive reasoning, and of that the Cow was not capable. Instead of asking why they were moving north with a south thrust, Mike broke his question into parts. He'd have to answer the "why" himself, he knew.

"Is Hot Rod pulling us south?" he asked.

"No-o-oo," came the answer.

This time he was more careful. "In which direction is the thrust on Hot Rod oriented?" he asked.

"No-oorth."

"Then Hot Rod is—" Quickly he stopped and rephrased the statement which would have had a question in its tone but not in its semantics, into a question that would read semantically. "Is Hot Rod pulling us north?"

"No-o-oo," came the reply.

Carefully. "Is Hot Rod pulling us?"

"No-o-oo."

Mike was stumped. Then he figured a literalness in his phrasing.

"Is Hot Rod pushing or in any other way giving motion to Space Lab One?" he asked.

"No-o-oo," came the answer.

Now Mike *was* stumped.

"Is Space Lab One under acceleration?" he asked.

"Ye-es," said the Cow.

"Then where in hell is that acceleration coming from?" Mike was exasperated.

"We a-are uunder no-o-o acceleration fro-om he-ell," the literal mind told him.

Mike laughed ruefully. No acceleration from hell—well, that was debatable. But no thrust from the hellmaker was not a debatable point. The Cow wasn't likely to be wrong, though her appalling literalness was such that an improperly phrased question might make her seem to be.

Computers, he thought, would eventually be the salvation of the human race, whetting their inventors' brains to higher and higher efforts towards the understanding of communications.

Very carefully now he re-phrased his question. "From what, and from what point, is the acceleration of Space Lab One originating?"

"From the co-ontinu-ous thrust o-originating at a po-oint thirteen fe-et from the a-axial center of the whe-el, in hu-ub section five no-orth, one hundred twelve degrees fro-om reference ze-ero of the engine-eering lo-ongitude reference sta-ation assigned in the con-struction ma-anual dealing with relative po-ositions o-of ma-asses lo-ocated o-on Spa-ace La-ab O-one."

Mike glanced up at the tube overhead, which represented the axial passageway down the hub of the wheel. Thirteen feet from the imaginary center of that tube, and in his own engineering compartment.

Then his gaze traveled on around the oddly built, circular room with its thirty-two-foot diameter. The reference to hub section five north meant this compartment. The degrees reference referred to the balancing co-ordinates by which the Cow kept the big wheel statically balanced during rotation. There was a bright stripe of red paint across the floor which indicated zero degrees; and degrees were counted counterclockwise from the north pole of the wheel.

His eyes strayed across the various panels and racks and came to rest in the one hundred twelve degree area. A number of vacant racks, some holding the testing equipment he had moved there not too many hours before—and churkling quietly in its rack near the floor, Ishie's Confusor of Confusion.

Mike contemplated the device with awed respect, then phrased another question for the Cow.

"Exactly how much thrust is being exerted on that point?" he asked.

The computer reeled off a string of numbers so fast that he missed them, and was still going into the far decimal places when Mike said:

"Whoa! Approximate number of pounds, please."

"A-approximately six hundred forty. You-u didn't speecify the limits o-of the a-accuracy tha-at you-u waanted." The burred tone was still complacent.

"Just what acceleration has that given us?" asked Mike, still looking at the Confusor. "Approximately," he added quickly.

"Present a-acceleration is a-approximately eight point nine five ti-imes te-en to the mi-inus third ce-entimeters per se-econd per se-econd. I ca-an ca-arry that to-o-o several mo-ore de-ecimal pla-aces if you-u wi-ish."

"No, thanks. I think you've told me enough."

Mike stood up.

This, he thought, needs Ishie. And coffee, he told himself as a second thought.

And then as a third thought, he turned back to his secret vocoder panel, and said: "The information you have just given me is to be regarded as top secret and not to be discussed except over this channel and by my direct order. Absolutely nothing that would give any one a clue to the fact that there is a method of acceleration aboard. Understood?"

"Ye-es, Mah-ike."

"O.K."

Mike switched off the vocoder, flipped his intercom to the temporary galley in the morgue, and ordered two breakfasts readied. Then he set off for the morgue.

TO BE CONCLUDED

WAR GAMES

The problem of avoiding war is, basically, that of establishing the conviction that you won't win if you do try it . . . before you try it!

CHRISTOPHER ANVIL

ILLUSTRATED BY GEORGE SCHELLING

Nikolai Bartov, the Premier's personal interpreter, was afraid the ambassador had gone over to the Americans. That was about all it would take to make this trip to the United Nations the worst week Bartov had ever lived through.

The trouble had started over West Rindelia, an insignificant strip of tropical jungle presided over largely by malarial mosquitoes, and coveted by the communist overlord of East Rindelia. Diplomats who had visited the two Rindelias called them "the key to nowhere—the pesthole of Southeast Asia." Veterans who had struggled and sweltered in the Rindelia jungles in 1944 remembered West Rindelia as "Purgatory" and East Rindelia as "Hell." No one wanted either place except the Rindelians, who were loud in their demands for help. And that was the trouble.

Experts who claimed to understand such matters called the Rindelian affair a "prestige crisis." The United States, they said, had let Russia put a wall through divided Berlin, and had thus lost prestige. The Russians had let the United States clamp a blockade on Cuba, and had thus lost prestige. Any sensible person might suppose that this evened matters up, and the two sides were back where they started from, but the experts claimed this wasn't so. According to the experts, these two events climaxed a long series of backdowns by both sides, and malcontents and exasperated allies in each camp were accusing their leaders of having lost their nerve. For either side to back down in Rindelia might shatter the confidence of its allies, permanently damage its prestige, and thus prove a large-scale disaster.

Bartov did not know how much truth there might be in this. But he did know that the Premier showed no sign of giving way. And the American newspapers that Bartov had studied gave every sign that this time the Americans would not yield an inch. The result was a severe strain on the nervous system, which got worse daily, and now rose to a new climax as the Premier, about ready to leave the Embassy for the U. N. Building, demanded to know where Ambassador Palvukin was.

Bartov happened to know where the ambassador was, but he joined the rest of the Premier's party in a glum silence as everyone tried to look blank and inconspicuous like students when the teacher asks a tough question.

The Premier's voice rose angrily. "Where is he? *Where's Palvukin?*"

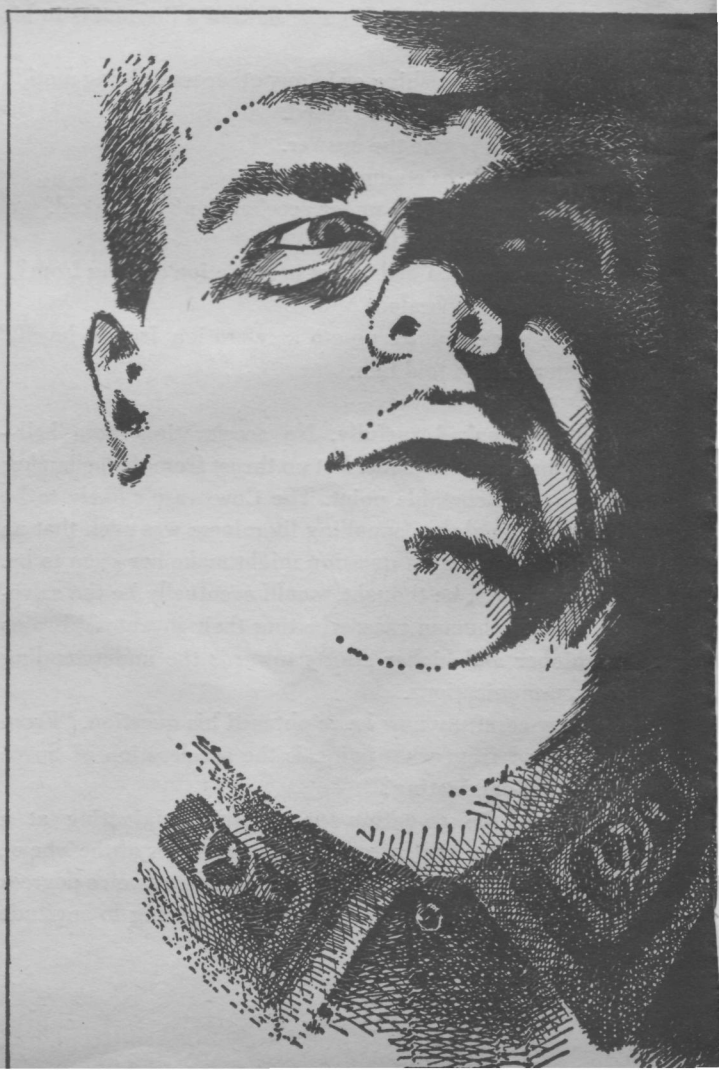
Someone hesitantly cleared his throat. "I believe he was over at the American electronics exhibition. They have a game . . . ah . . . a strategy computer on display over there."

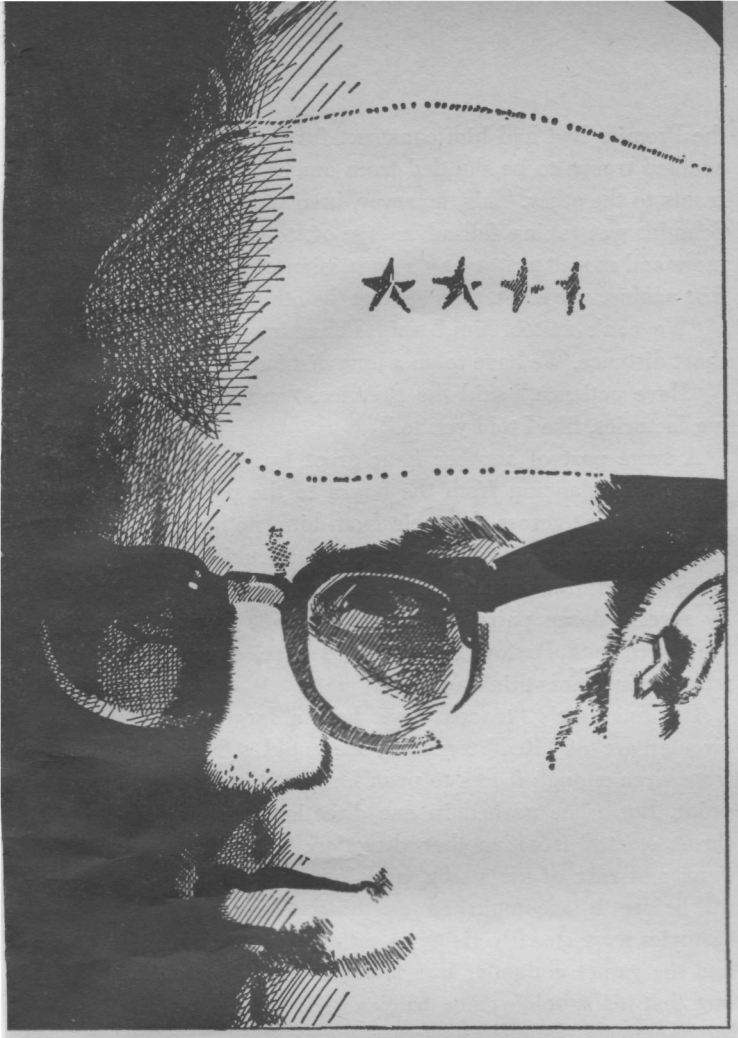
"Send somebody over to get him."

"We've done it. He won't come."

"He *what?*"

"He says he's too busy playing the game. He can't be disturbed. He won't come."





The Premier's expression changed from exasperation to amazement to a look of suppressed rage. He glanced at his watch.

"We'll drag him out by the ears. Come on!"

They went out the door to the street, and piled into the waiting cars. There was uproar and confusion as the police discovered they weren't going to the U. N., but to the Electronics Exhibition. Then this was straightened out, and the procession got in motion. Bartov glanced out at the huge gray buildings gliding past, then the car pulled to the curb.

"Here we are," said someone. They all got out in front of a building with a monster plate-glass window behind which was visible a large room with people grouped around exhibits, and stacks of advertising folders piled up on every table in sight.

"Let's go," growled the Premier, and in a compact group they shoved open the wide all-glass door.

The Premier looked around narrowly. "Where is he?"

Bartov spotted a directory in the wall across from the entrance, and read:

"War Games Computer—2nd Floor."

He translated this, then spotted an arrow lettered "Elevator." The Premier was silent as they went up. The door slid open, and they stepped out into a large room where a sense of excitement tingled in the air.

The Premier immediately growled, "There he is."

They headed across the room toward a sort of big table with two men seated at opposite sides and groups of watchers looking on alertly. The man on the far side of the table was Palvukin, the ambassador. He had a worried look as he hunched over a set of controls.

As the Premier, his face determined, strode toward Palvukin, Palvukin leaned forward, and speaking English, said tensely to the man across the table, "I'll attack with missiles if you don't break off your advance."

The other man smiled coolly, "You use missiles, and so will I."

The Premier glanced sharply from one to the other of them. They both looked perfectly serious.

Bartov squinted at the table. A second look showed him it was no ordinary table, but looked more like a photographic map, in three dimensions. Geographical features were shown in relief; lakes, rivers, and mountains stood out clearly, as did cities, roads, railroads, and forests. He bent over the table, to see that the actual view was apparently under the surface itself, which seemed to be made of some very clear plastic. The effect was that of looking at an actual scene from a considerable height, and the illusion was remarkable in its detail. A pall of smoke seemed to hang over a heavily industrialized region near where Bartov was standing. A tiny train was crawling through a mountain pass, moving away from one industrialized region toward another. So absorbed did he become in examining the details, that Bartov almost missed it when the Premier asked a question, and for a moment he wasn't sure who had spoken, or whether the question was meant for him. Then he realized that Palvukin had the cover off a gray-enameled box that housed a control board lettered "Nuclear Missiles."

The Premier, scowling, put the cover back on the box again.

"But," pleaded Palvukin, "I've got to. Look, here." He pointed at a big lake, along the borders of which it was possible to see tiny tanks, armored troop carriers, and motorized artillery, crawling steadily forward. About them was a large faint blue arrow, like those used in newspaper diagrams of military maneuvers. Looking around, Bartov could see a number of these arrows, which must represent advancing troops, and also a number of straight lines which apparently marked stationary portions of the front. It was easy to see that Palvukin had gotten himself into an unenviable position.

Palvukin was complaining again. "I'll *lose* otherwise."

"Get up," said the Premier, as if to a child. "We have a real game to play."

"There's still time," said Palvukin, glancing at his watch. "I just want to finish—"

Someone coughed. "Comrade Premier. Excuse me. Look there."

Several men in Arab headdress and robes had wandered over to the table, and were looking interestedly at the people on both sides of the board. A number of other Africans and Asians were looking on intently.

A voice with a British accent carried across the room. "The Americans are quite clever with games, you know. Baseball, Monopoly, strip poker. Somehow, they manage to devise games that capture the attention."

The Premier eyed the Afro-Asians intently. They were now leaning across the board, and it was clear from their gestures and facial expressions that they knew which side was winning. They glanced covertly at the Premier and his party, then with respect to the lone individual seated on the other side of the table.

The Premier colored, and glanced angrily at the ambassador. "Who is this you are playing, Palvukin?"

"An American named Schmidt, Comrade Premier."

"Who is he? What does he?"

"He is a . . . er . . . tycoon. He is what they call here a 'pirate.' "

The Premier let his breath out with an audible hiss.

The spectators were drawing up chairs and seating themselves comfortably. People of varied races and nationalities were pouring out of the elevator and coming over to take a look. The Premier's eyes were narrowed, and he glanced back and forth from the spectators to the board. "Hm-m-m," he said.

Bartov moved over to study what was happening on the board.

Along the lake, the little images of the ambassador's troops were steadily falling back, and the ambassador himself was groaning, "But I'll lose the whole district."

"You donkey," said the Premier angrily, "stop croaking and look confident. As far as all these people around us are concerned, the Soviet system is on trial on that board there. Now, start building railroads. And stop hanging onto that piece of worthless desert over there, and bring *those* troops back over here, where they can do some good. How did you get a supply line that long, anyway?"

"Well. he gave way there, so I pushed ahead, and—'

The Premier shook his head in disgust. "Bartov!"

"Yes, sir?"

"Go get some chairs. We're going to be here some time yet."

Bartov hurried off after chairs.

An hour had crept past, and the Premier had divided up various tasks amongst the men in his party, who now sat near various controls, giving suggestions to Palvukin in low voices. The solitary financier across the board had delivered several additional hard jolts, captured the main rail and road junctions north of the lake, and driven in a wedge that in effect divided the front into two halves. Palvukin, perspiring freely, would now have been licked, save for the alternate rail line the Premier had had him construct further back, which enabled troops to be shuttled from one of the separated fronts to the other. This, however, involved a delay that Schmidt was taking full advantage of, to get control of more and more territory by a succession of rapid blows, first against one front, then against the other.

"We can't match him," said Palvukin. "He goes a short distance. We have to go a long distance."

"Have patience," said the Premier, "and keep building factories, like I told you to."

A large part of another hour crept by, and the financier was glancing from the board to the poker-faced group that sat across the table from him, nothing moving but their eyes and their lips, as Palvukin jumped from one control to another, like a marionette operated by several dozen pairs of strings. Schmidt frowned at the board, and Bartov, following his gaze, could guess what the man was thinking.

The financier's "troops" now held a large, roughly circular arc of "Red" territory. He could still concentrate large enough forces to push farther at any selected point. But as he pushed in one direction, the counterthrust started from another direction, to threaten the flank and rear of his attack, and force him to break it off before it accomplished anything. Meanwhile, the factories were steadily rising in sectors out of his reach, and the games computer was taking full account of the fact that his supplies came from a great distance, while his opponents' supply lines were short. Worse yet, the game went along steadily, with no pause while first one side moved and then the other, and as the opposition now had a number of shrewd minds calculating various angles at the same time, his relative overall position was deteriorating steadily. He had, for instance, apparently set up his industries on a basically better plan than the ambassador, but the computer repeatedly gave realistic notice of bottlenecks here and tie-ups there, and it was impossible to devote his attention to these things and to the steadily-progressing battle at the same time.

"Hm-m-m," he said, and settled back. After a little while, he glanced around and spoke briefly to someone standing nearby. That person moved off quietly, and the financier again devoted his attention to the board. His military action now began to take the form of short sharp thrusts apparently intended to do nothing more than keep his opponent off-balance and on the defensive. Bartov noted, however, that an accelerated improvement of the road-net now began to take place on the financier's side of the board. Bartov did not see what good this was going to do. The initiative was plainly passing from one side to the other, and more roads were not going to solve the problem.

A half hour or so passed, and one of the diplomats glanced at his watch, and said to the Premier, "We are going to be late."

"Don't worry, we can finish this up soon, now." The

board was studded with monster industrial complexes on the "Red" side, all joined up by interconnected railroads. The other side showed accelerated growth, and an impressive multiplication and improvement of the road net, together with the shady outlines of what might become a huge industrial expansion. But the actual productive capacity for war goods had now dropped below the "Red" productive capacity, and enormous quantities of war material were piling up behind the lines.

Leaning forward, Bartov could see the tiny symbols of tanks, guns, and troop carriers, stretched out in huge parks, ready to be moved forward when needed.

"We could attack," said Palvukin, in an awed voice.

"Not yet," said the Premier. "When we hit him, we want to hit him so hard we break his back. Keep him stretched out for now. Remember, many people are watching this. Once we smash him, then I can say in my speech that even on an American scientific computer we have proved the superiority of communism over capitalism. Just a little longer, and the time comes."

The "Red" build-up proceeded at a furious pace.

Possibly sensing what was to come, the opposing forces began to fall back.

"Now," said the Premier.

The "Red" troops, massively reinforced, started heavily forward, in a sweep designed to trap a large number of the opposing troops.

The board of the War Games Computer now showed the massive red arrows, and a number of wavering blue lines falling back fast.

Leaning over the board, Bartov could almost believe he was an observer in a plane, watching a great offensive. The setting was unfamiliar, the geography actually matching that of no country on earth, but the movement of the vehicles was complete down to the representation of churned mud in some sectors of the front, and clouds of blowing dust in others.

The "Blue" forces were in full flight, withdrawing so fast that they were pulling well ahead of the pursuit.

"We have won," said Palvukin.

Bartov grinned with pleasure, and looked across to see the expression on the face of the capitalist.

The capitalist had moved into another chair, and was now apparently devoting himself to industry and road-building. The troops were apparently being directed by a big elderly man in a conservative suit, smoking a corncob pipe.

The Red troops were falling steadily behind the fleeing Blue troops.

"Why is this?" said the Premier. "Surely we can go faster than that! Palvukin, put the question to the computer."

Palvukin asked the question. The computer unreeled a length of tape reading: "ROADS THICKLY MINED. SUCCESSIVE WAVES OF TANKS HAVE CHURNED GROUND INTO MUD. HEAVY WEAR ON TANK ENGINES IN SOME REGIONS DUE TO DUST AND INSUFFICIENT PROVISION FOR AIR CLEANERS ON ENGINES."

The Premier glared at an inoffensive scholarly-looking man. "Mikov, you are in charge of tank production. Why is this?"

"I had no idea it was necessary to attend to such fine details, Comrade Premier. Anyway, we have such a production that these little things cannot stop us."

Bartov, observing the huge onrush of the Red armies, nodded agreement. What could possibly stop that? He felt a wave of elation. Somehwere in his mind, an invisible band struck up the "*Internationale.*"

He glanced across the table to observe the effect of this crushing defeat on the capitalist-imperialist.

The American financier was working in intense concentration. The elderly man apparently handling the troops for him had a calm contemplative look, and as he turned to say something to the financier, Bartov got a brief profile view of the bold nose and jutting corncob pipe.

Chills and fever swept over Bartov in successive waves. In his mind's eye, huge naval armadas closed in on tropical islands, and a long peninsula, almost completely conquered, fell apart at a sudden thrust from the sea.

The Premier gave a low exclamation.

Bartov glanced at the board. The "Red" troops were now well into enemy territory. The Blue troops, moving over the excellent road net, were reorganizing fast. As Bartov watched, one of the Blue armies swung rapidly around, and bit into the flank of the Red advance. A confused whirl developed, and then the red arrow outlining the advance disintegrated.

The Premier had put some questions to the computer, which now unrolled its length of tape; Bartov peered over the Premier's shoulder, to read: ENEMY STRATEGIC DISPOSITIONS SUPERIOR. ENEMY TACTICAL HANDLING OF TROOPS VASTLY SUPERIOR.

Bartov tried to tell the Premier who was across the table. The Premier silenced him. "Go get Marshal Malekin. And hurry up!"

Bartov forced his way through the crowd around the table and hurried out.

Finding Malekin, even with the help of the Embassy staff, was no easy job. He was eventually located at the U. N. Building, stupefied with boredom, as nothing was going on there and nearly everybody had gone off to watch some game on TV. He supposed it was either baseball or football, he didn't know which, and couldn't care less. For Bartov, the business of getting the actual picture across to him was like trying to drive spikes into concrete using the bare fist as a hammer. Bartov's desperation finally roused him, but as he went along

toward the electronics exhibit, he kept saying, "What's the sense of it? It's only a game, isn't it?"

"Yes, but it's a very realistic game."

"Bah! You have been humbugged by the Americans. There is a little man inside this machine, and you can't win. I remember when I was a boy, they had a machine that was supposed to play chess. There was a man inside of it."

"But this is scien—"

"It's all a joke. Listen, when the Hitlerites invaded, what do you think stopped them? Tactics? It got cold, that's what really stopped them. Tell me, is there any weather on this calculating machine of yours?"

"Yes, Comrade—"

"What about disease? I remember once when a whole troop of cavalry was laid out flat on its back from—"

Bartov had the sense of terrific pressure building inside him. "Can I say just one thing?"

"Go right ahead, my boy."

"On this fake machine . . ."

"Exactly what it is."

". . . The Premier made a big tank attack, and it slowed down . . ."

"Naturally, the American midgit inside didn't want the Premier to win."

". . . And when the Premier wanted to know why the attack slowed down, a length of tape came out of the machine with a message on it."

The marshal looked interested. "What did it say?"

"It said the retreating enemy had heavily mined the roads, the tank tracks were grinding the earth into muck, and in other regions the churned-up dust was wearing the tank engines out fast because no good air cleaners had been provided for them."

The marshal frowned. "Did the enemy have difficulties like this?"

"He seemed to."

"Hm-m-m. I want to get a look at this computer."

The room as they came in was even more thickly packed than when Bartov had left. He and the marshal shouldered their way across the room, and one look at the board confirmed his worst fears. The captured ground had been lost, and the Blue forces were slicing deep into Red territory. The Red forces appeared to be still moderately numerous and well-supplied, but their disposition suggested a tin bucket with the sides kicked in.

The marshal stared at the board, bent over it closely, grunted, and looked up with an odd expression. The others were eagerly explaining to him how it worked. The Premier said, "We can supply the troops and give them the right general directions, but when the fight comes, everything seems to depend on particulars and timing. We don't have that. You have got to supply that, or we are going to get beat."

"I talk into this mircrophone?" growled the marshal.

"Yes, or you can work this control board if you prefer."

"All right. Leave it to me."

The Red forces, still retreating, began to straighten themselves out, clinging to natural barriers, and striking at any exposed flank that presented itself.

The fight gradually stabilized until a heavy air attack knocked out a great many rail lines on the Red side of the board. It proved impossible to do as much damage to the huge road net on the opposite side of the board.

The marshal then tried dropping a nuclear missile on an enemy jet-engine factory. There was a stir all around him. One of his own jet-engine plants blew up in a hideous glare accompanied by a dull clap and thud that shook the table. The marshal grunted and looked across the board. There were several more Americans over there now. They all seemed to be closely concentrated on the job in hand. Bartov, watching the marshal, could guess his thoughts. From his aggrieved look, he was thinking, "Why are you attacking us?" Then his face cleared as he remembered that it was, after all, just a game. He devoted himself to it, and showed satisfaction as he gradually drove the over-extended Blue forces back. Then their positions were solidly stabilized, and he was unable to get any advantage. A big war-production struggle was getting under way, and the marshal was settling down to a lengthy war of attrition when a younger general, one P. Rudov, appeared at his shoulder, looked over the board, and said, "Bah! All that is old-fashioned. Here, let *me* show you something."

The marshal glanced at the Premier, who nodded.

P. Rudov took his seat. The board rapidly took on a fantastic appearance as vertical envelopment became the rule of the day. Paratroop drops appeared to outflank previous drops of enemy forces, which in turn were defending against previous drops to protect forces attacked by former drops of enemy troops. Both sides teetered on the brink of disaster or sudden victory, but nobody could figure out which it would be. Rudov resorted to tactical atomic weapons to clarify the situation, and his opponent responded with the same thing, pressed down and running over, and the situation resumed its previous uncertainty. New weapons began to appear as each side got renowned scientists busy feeding suggestions into the computer. Some obscure Red expert took a crack at spreading a special type of influenza among the enemy, but it unexpectedly reacted through some odd chain of events, and instead of hitting the enemy went through the Red side of the board like a mowing-machine through a wheat field. Malekin personally knocked the expert senseless, and when the expert came to, the Premier spoke to him in such a way that he passed out again.

Meanwhile, the Blue forces offered a remedy which was partially effective in stopping the spread of the disease. The interlocked mazes of mutually-enveloped airheads were then disentangled and got loose from one another during a temporary truce, following which the two sets of players, now grown almost large enough and official enough to run their own real countries without further help, stared at each other across the board.

At some point, on one side or the other, for some reason, somebody smiled.

Suddenly, both sides looked from the board to each other, the wise experts controlling the little figures, and began to laugh.

As by one impulse, without settling which side was to win the game, they got up, and left the board.

Both sides left the room together, arm in arm, and the good fellowship, despite the language differences, was tremendous.

But then, when they had got down to their cars and split up in groups to go to the U. N., the Premier growled, "It doesn't make any difference. We're in the same place we were in before we played it."

"I still can't see a war over Rindelia," said the marshal.

"No, but then what *do* we do?"

"It's too risky. Nobody knows who'll win, and meanwhile we've got one foot in a beartrap."

The Premier scowled. "They can't back down. Neither can we. Where is the way out of it?"

Gloom descended, and was not dispersed by the proceedings at the U. N. Here the Premier tried alternately thrusting out an olive branch and a loaded cannon, had no particular success with either one, and then waved missiles, satellites, and spaceships in a warning that had a number of neutrals glancing at the exits. When it was over, Bartov had to admit it created a picture in the light of which Rindelia looked remarkably not worth fighting over.

He glanced at the Americans to see how they were taking it, and got an unpleasant shock. The Americans were all looking at the Premier with expressionless faces, and an ugly light in their eyes.

The U. N. session produced no compromise.

That evening came word that the Americans were moving into—not Rindelia—but bases threatening the communist state that had organized the Rindelian guerrilla war.

The Soviet Union issued an ultimatum ordering the immediate withdrawal of these troops.

The United States responded by placing all its forces on a worldwide alert.

The Soviet Union pointed out with biting crudeness the vulnerability of U. S. cities to Soviet missiles.

Large numbers of U. S. nuclear bombers rose into the air.

It suddenly dawned that the unthinkable was happening.

"All this over Rindelia—this dunghill!" cried the Premier. "Have they gone insane?"

It was Marshal Malekin who broke the impasse. "We can't just sit still while this goes on! We have pushed them too far on this, and the only way out is to either attack head-on, which is no good now, or stop pushing and back-pedal fast."

"I won't give way to them on this."

"What if we could fight the war in Rindelia without losing a man?"

"It won't stay confined to Rindelia. The way things are, it will spread like lightning."

"You want that?"

"No! But I won't—" The Premier looked startled. "What are you thinking?"

"I will tell you. It all depends on just how mad they are, and whether they are still susceptible to reason. But there is one thing on our side, thank heaven!"

"What is that?"

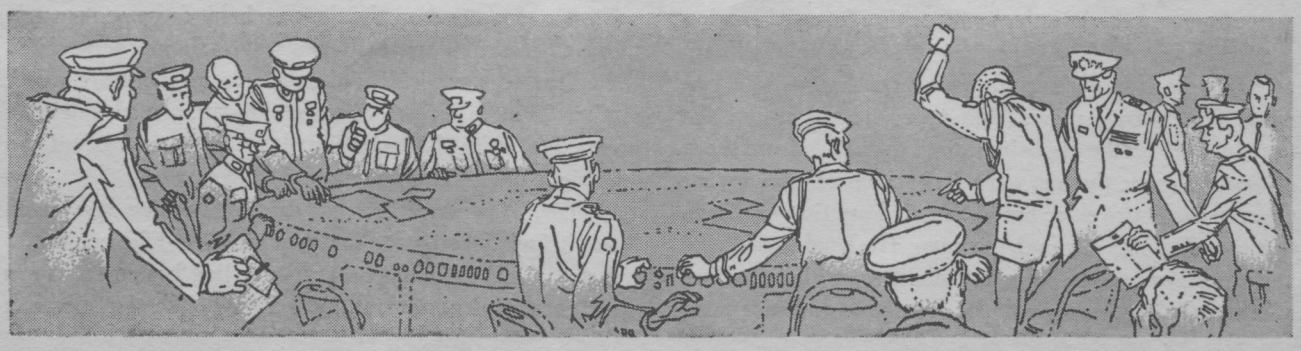
"The Americans will trust their own computer."

The extreme crisis lasted for another six hours.

Then the terrified world had a chance to draw an even breath. Rindelia would be either partitioned or left whole. But the rest of the world could watch the struggle in peace.

Across the big board of the War Games Computer, newly set up to accurately represent Rindelia and surrounding territory, the two sets of uniformed and plain-clothed figures glared at each other. The huge fleet moved in, and the volunteers swarmed across the border.

The war was on. ■



THE THREE CORNERED WHEEL

There is the ancient toast "Confusion to our Enemies!"—
and many's the time that a little well-planned confusion can achieve
far more than military prowess . . .

BY POUL ANDERSON

ILLUSTRATED BY GEORGE SCHELLING

"No!"

Rebo Legnor's-Child, Marchwarden of Gilrigor, sprang back from the picture as if it had come alive. "What are you thinking of?" he gasped. "Burn that thing! Now!" One hand lifted shakily toward the fire in the great brazier, whose flames relieved a little the gloom of the audience chamber. "Over there. I saw nothing and you showed me nothing. Do you understand?"

David Falkayn let fall the sheet of paper on which he had made the sketch. It fluttered to the table, slowly through an air pressure a fourth again as great as Earth standard. "What—" His voice broke in a foolish squeak. Annoyance at that crowded out fear. He braced his shoulders and regarded the Ivanhoan squarely. "What is the matter?" he asked. "It is just a drawing."

"Of the *malkino*." Rebo shuddered. "And you not even belonging to our kind, let alone a Consecrate."

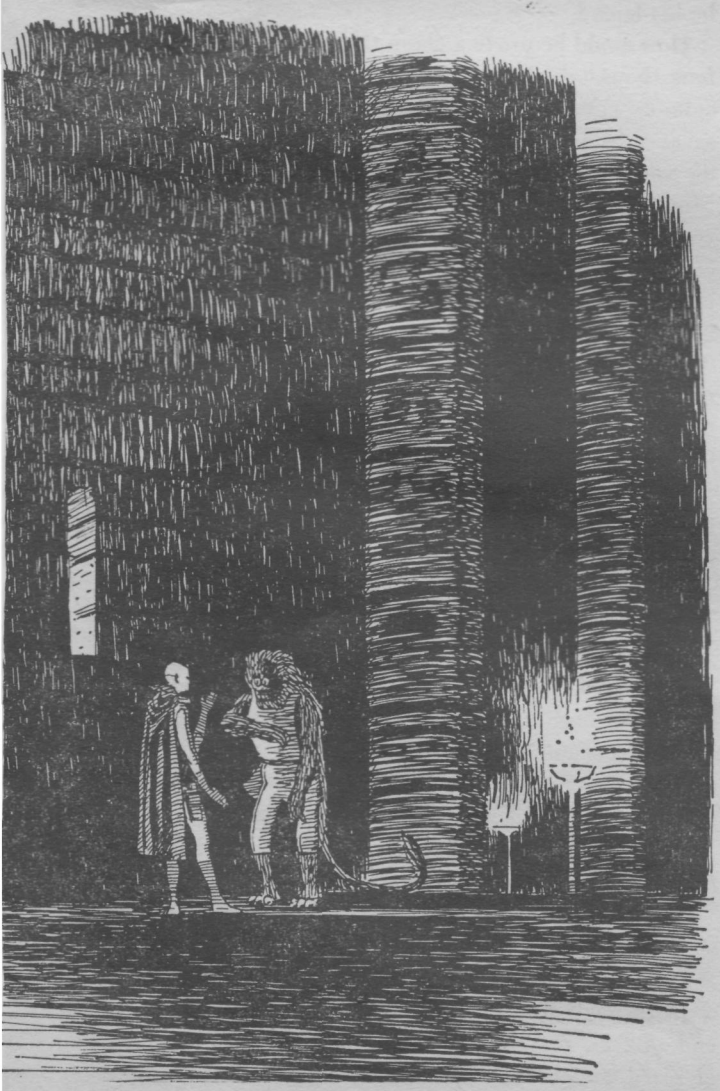
Falkayn stared at him, as if anyone of Terrestrial descent could read expressions on that unhuman face. Seen by the dull red sunlight slanting through narrow windows, Rebo looked more like a lion than a man, and not very much like either. The body was only roughly anthropoid: bipedal, two-armed, but short and thick in the torso, long and thick in the limbs, with a forward-leaning posture that reduced a sheer two meters of height to approximately Falkayn's level. The three fingers had one more joint than a man's, and narrow black nails; the thumbs were on the opposite side of the hands from those of Genus Homo; the feet were digitigrade. Mahogany fur covered the entire skin, but each hair bore tiny barbs, so that the effect was of rough plumage. The head was blocky and round-eared, the face flat, noseless, with breathing apertures below the angle of the great jaws and enormous green eyes above an astonishingly sensitive, almost womanlike mouth. But whatever impression that conveyed was overwhelmed by the tawny leonine mane which framed the countenance and spilled down the muscular back, and by the tufted tail that lashed the ankles. A pair of short scaly trousers and a leather baldric, from which hung a wicked-looking ax, enhanced the wild effect.

Nevertheless, Falkayn knew, inside that big skull was a brain as good as his own. The trouble was, it had not evolved on Earth. And when, in addition to every inborn strangeness, the mind was shaped by a culture that no man really understood . . . how much communication was possible?

The boy wet his lips. The dry cold air of Ivanhoe had chapped them. He didn't lay a hand on his blaster, but he became acutely aware of its comforting drag at his hip. Somehow he found words: "I beg your pardon if I have given offense. You will understand that foreigners may often transgress through ignorance. Can you tell me what is wrong?"

Rebo's taut crouch eased a trifle. His eyes, seeing farther into the red end of the spectrum than Falkayn's, probed corners which were only shadows to the visitor. No one else stood on the floor or behind the grotesquely carved stone pillars. Only the yellow flames acrackle in the brazier, the acridity of smoke from unearthly wood, stirred in the long room. Outside—it seemed suddenly very far away—Falkayn heard the endless wind of the Gilrigor uplands go booming.

"Yes," the Marchwarden said, "I realize you acted unwittingly. And you, for your part, should not doubt that I remain friendly to you—not just because you are my guest at this moment, but because of the fresh breath



you have brought to this truly stagnant land of ours."

"That we have perhaps brought," Falkayn corrected. The future depends on whether we live or die, remember. And that in turn depends on your help." *Well put!* he congratulated himself. *Schuster ought to have heard that. Maybe then he'd stop droning at me about how I'll never make merchant status if I don't learn to handle words.*

"I will not be able to help you if they flay me," Rebo answered sharply. "Burn that thing, I say."

Falkayn squinted through the murk at his drawing. It showed a large flatbed wagon with eight wheels, to be drawn by a team of twenty fastigas. All the way from the spaceship to this castle, he had been aglow with visions of how awed and delighted the noble would be. He had seen himself, no longer Davy-this-and-Davy-that, hey-boy-c'mere. apprentice and unpaid personal servant to Master Polesotechnician Martin Schuster, but Falkayn of Hermes, a Prometheus come to Larsum with the gift of the wheel. *What's gone wrong?* he thought wildly; and then, with the bitterness common to his seventeen years: *Why does everything always go wrong?*

Nevertheless he crossed the floor of inlaid shells and cast the papier into the brazier. It flared up and crumbled to ash.

Turning, he saw that Rebo had relaxed. The Marchwarden poured himself a cupful of wine from a carafe on the table and tossed it off at a gulp. "Good," he rumbled. "I wish you could partake with me. It is distressful not to offer refreshment to a guest."

"You know that your foods would poison my race," Falkayn said. "That is one reason why we must transport the workmaker from Gilrigor to our ship, and soon. Will you tell me what is bad about the device I have illus-

trated? It can be easily built. Its kind—*wagons,* we call them—were among the most important things my people ever invented. They had much to do with our becoming more than—"

He checked himself just before he said "savages" or "barbarians." Rebo's hereditary job was to keep such tribes on their proper side of the Kasunian Mountains. Larsum was a civilized country, with agriculture, metallurgy, towns, roads, trade, a literate class.

But no wheels. Burdens went on the backs of citizens or their animals, by boat, by travois, by sledge in winter—never on wheels. Now that he thought about it, Falkayn remembered that not even rollers were employed.

"The idea is that round objects," he floundered.

Rebco traced a sign in the air. "Best not to speak of it." He changed his mind with soldierly briskness. "However, we must. Very well, then. The fact is that the *malkino* is too holy to be put to base use. The penalty for transgressing this law is death by flaying, lest God's wrath fall on the entire land."

Falkayn struggled with the language. The educator tapes aboard the *What Cheer* had given him fluency, but could not convey a better idea of semantic subtleties than the first expedition to Ivanhoe had gotten; and those men hadn't stayed many weeks. The word he mentally translated as "holy" implied more than dedication to spiritual purposes. There were overtones of potency, mana, and general ineffability. Never mind. "What does *malkino* mean?"

"A . . . a roundedness. I may not draw it for you, only a Consecrate may do that. But is something perfectly round."

"Ah, I see. A *circle,* we would call it, or a *sphere* if solid. A wheel is circular. Well, I suppose we could make our wheels slightly imperfect."

"No." The maned head shook. "Until the imperfection became so gross that the wheels would not work anyway, the thing is impossible. Even if the Consecrates would allow it—and I know quite well they will not, as much from hostility to you as from dogma—the peasants would rise in horror and butcher you." Rebo's eyes glowed in the direction of Falkayn's gun. "Yes, I realize you have powerful, fire-throwing weapons. But there are only four of you. What avail against thousands of warriors, shooting from the cover of hills and woods?"

Falkayn harked back to what he had seen in Aesca, on his westward ride along the Sun's Way, and now in this stronghold. Architecture was based on sharp-cornered polygons. Furniture and utensils were square or oblong. The most ceremonial objects, like Rebo's golden wine goblet, went no further than to employ elliptical cross-sections, or mere arcs of true circles.

He felt ill with dismay. "Why?" he choked. "What makes a . . . a figure . . . so holy?"

"Well—" Rebo lowered himself uncomfortably to a chair, draping his tail over the rest across the back. He fiddled with his axhaft and didn't look at the other. "Well, ancient usage. I can read, of course, but I am no scholar. The Consecrates can tell you more. Still . . . the circle and the sphere are the signs of God. In a way, they are God. You see them in the sky. The sun and the moons are spheres. So is the world, however imperfect; and the Consecrates say that the planets have the same shape, and the stars are set inside the great ball of the universe. All the heavenly bodies move in circles. And, well, circle and sphere are the perfect shapes. Are they not? Everything perfect is a direct manifestation of God."

Remembering a little about Classical Greek philosophy—even if the human colony on Hermes had broken away from Earth and established itself as a grand duchy, it remained proud of its heritage and taught ancient history in the schools—Falkayn could follow that logic. His impulse was to blurt: "You're wrong! No planet or star is a true globe, and orbits are ellipses, and your little red dwarf sun isn't the center of the cosmos anyway. I've been out there and I know!" But Schuster had drilled enough caution into him that he checked himself. He'd accomplish nothing but to stiffen the enmity of the priests, and perhaps add the enmity of Rebo, who still wanted to be his friend.

How could he prove a claim that went against three or four thousand years of tradition? Larsum was a single country, cut off by mountain, desert, ocean, and howling savages from the rest of the world. It had no more than the vaguest rumors of what went on beyond its borders. From Rebo's standpoint, the only reasonable supposition was that the furless aliens with the beaks above their mouths had flown here from some distant continent. Reviewing the first expedition's reports of how upset and indignant the Consecrates at Aesca had gotten when told that its ship came from the stars, how hotly they had denied the possibility, Schuster had cautioned his fellows to avoid that topic. The only thing which mattered was to get off this planet before they starved to death.

Falkayn's shoulders slumped. "My people have found in their travels that it does not pay to dispute the religious beliefs of others," he said. "Very well, I grant you wheels are forbidden. But then what can we do?"

Rebo looked up again with his disconcertingly intelligent gaze. He was no ham-headed medieval baron, Falkayn realized. His civilization was old, and the rough edges had been worn off its warrior class, off peasants and artisans and traders, as well as the priest-scribe-poet-artist-engineer-scientist Consecrates. Rebo Legnor's-Child might be likened to an ancient samurai, if any parallels to human history were possible. He'd grasped the principles of the wheel at once, and—

"Understand, I, and many of my breed, feel more than simply benevolent toward your kind," he said low. "When the first ship came, several years ago, a lightning flash went through the land. Many of us hoped it meant the end of . . . certain irksome restrictions. Dealing with civilized outlanders should bring new knowledge, new

powers, new ways of life, into this realm where nothing has changed for better than two millennia. I want most sincerely to help you, for my own gain as well as yours."

Besides the need for tact, Falkayn hadn't the heart to answer that the Polesotechnic League had no interest in trading with Larsum, or with any other part of Ivanhoe. There was nothing here that other worlds didn't produce better and cheaper. The first expedition had simply come in search of a place to establish an emergency repair depot, and this planet was simply the least unsalubrious one in this stellar neighborhood. The expedition had observed from orbit that Larsum possessed the most advanced culture. They landed, made contact, learned the language and a little bit of the folkways, then asked permission to erect a large building which none but visitors like themselves would be able to enter.

The request was grudgingly granted, less because of the metals offered in payment than because the Consecrates feared trouble if they refused. Even so, they demanded that the construction be well away from the capital; evidently they wanted to minimize the number of Larsans who might be contaminated by foreign ideas. Having completed the job and bestowed an arbitrary name on the planet, the expedition departed. Their data, with appropriate educator tapes, were issued to all ships that might take the Pleiades route. Everybody hoped that it would never be necessary to use the information. But luck had run out for the *What Cheer*.

Falkayn said only: "I do not see how you can help. What other way can that thing be moved, than on a wagon?"

"Could it not be taken apart, moved piece by piece, and put back together at your ship? I can supply a labor force."

"No." Damn! How do you explain the construction of a unitized thermonuclear generator to somebody who's never seen a water wheel? You don't. "Except for minor attachments, it cannot be disassembled, at least not without tools which we do not carry."

"Are you certain that it weighs too much to be transported on skids?"

"Over roads like yours, yes, I think it does. If this were winter, perhaps a sledge would suffice. But we will be dead before snow falls again. Likewise, a barge would do, but no navigable streams run anywhere near, and we would not survive the time necessary to dig a canal."

Not for the first time, Falkayn cursed the depot builders, that they hadn't included a gravity sled with the other stored equipment. But then, every ship carried one or more gravity sleds. Who could have foreseen that the *What Cheer's* would be out of commission? Or that she couldn't at least hop over to the building herself? Or, if anybody thought of such possibilities, they must have reasoned that a wagon could be made; the xenologists had noted that wheels were unknown, and never thought to ask if that was because of a law. A portable crane had certainly been provided to load and unload whatever was needed for spaceship repair. In fact, so well stocked was the depot that it did not include food, because any crew who could limp here at all should be able to fix their craft in a few days.

"And I dare say no other vessel belonging to your nation will arrive in time to save you," Rebo said.

"No. The . . . the distances we cover in our travels are great beyond comprehension. We were bound for a remote frontier world—country, if you prefer—to open certain negotiations about trade rights. To avoid competition, we left secretly. Nobody at our destination has any idea that we are coming, and our superiors at home do not expect us back for several months. By the time they begin to worry and start a search—and it will take weeks to visit every place where we might have landed—our food stocks will long have been exhausted. We carried minimal supplies, you see, in order to be heavily laden with valuables for . . . uh—"

"For bribes." Rebo made a sound that might correspond to a chuckle. "Yes. Well, then, we must think of something else. I repeat, I will do anything I can to help you. The building was erected here, rather than in some other marchland because I insisted; and that was precisely because I hoped to see more of your voyagers." His hand went back to his ax. Falkayn had noticed before that the heads of implements were heat-shrunk to the handles. Now the reason came to him: rivets would be sacrilegious. The fingers closed with a snap and Rebo said harshly:

"I am as pious as the next person, but I cannot believe God meant the Consecrates to freeze every life in Larsum into an eternal pattern. There was an age of heroes once, before Ourato brought Uplands and Lowlands together beneath him. Such an age can come again, if the grip upon us is broken."

He seemed to realize he had said too much, and added in haste, "Let us not speak of such high matters, though. The important thing is to get that workmaker to your wounded ship. If you and I can think of no lawful means, perhaps your comrades can. So take them back the word —the Marchwarden of Gilrigor cannot allow them to make a . . . a wagon; but he remains their well-wisher."

"Thank you," Falkayn mumbled. Abruptly the darkness of the room became stifling. "I had best start back tomorrow."

"So soon? You had a hard trip here, and a short and unhappy conversation. Aesca is so far off that a day or two of rest cannot make any difference."

Falkayn shook his head. "The sooner I return, the better. We have not much time to lose, you know."

A fresh fastiga—slightly larger than a horse, long-eared, long-snouted, feathery-furred, with a loud bray and a piney smell—waited in the cruciform courtyard. A remount and pack animal were strung behind. A guardsman held the leader's bridle. He wore a breastplate of

reinforced leather, a helmeting network of iron-studded straps woven into his mane, and a broad-bladed spear across his back. Beyond him, lesser folk moved across the cobblestones: servants in livery of black and yellow shorts, drably clad peasants, a maneless female in a loose tunic. Around them bulked the four squat stone buildings that sheltered the household, linked by outer walls in which were the gates. At each corner of the square, a watchtower lifted its battlements into the deep greenish sky.

"Are you certain you do not wish an escort?" Rebo asked.

"There is no danger in riding alone, is there?" Falkayn replied.

"Gr-rm . . . no, I suppose not. I keep this region well patrolled. God speed you, then."

Falkayn shook hands, a Larsan custom, too. The Marchwarden's three long fingers and oppositely placed thumb fitted awkwardly into a human grasp. For a moment more they looked at each other.

The bulky garments Falkayn wore against the chill disguised his youthful slenderness. He was towheaded and blue-eyed, with a round face and a freckled snub nose that cost him much secret anguish. A baron's son from Hermes should look lean and dashing. To be sure, he was a younger son, and one who had gotten himself expelled from the ducal militechnic academy. The reason was harmless enough, a prank which had been traced to him by merest chance; but his father decided he had better seek his fortune elsewhere. So he had gone to Earth, and Martin Schuster of the Polesotechnic League had taken him on as an apprentice, and instead of the glamour and adventure which interstellar merchants were supposed to enjoy, there had been hard work and harder study. He had given a whoop when his master told him to ride here alone and arrange for local help. It was vastly disappointing that he couldn't stay a while.

"Thank you for everything," he said. He swung himself into the saddle with less grace than he'd hoped, under a gravity fifteen per cent greater than Earth's. The guard let go the bridle and he rode out the eastern gate.

A village nestled below the castle walls, cottages of dovetailed timber with sod roofs. Beyond them that highroad called the Sun's Way plunged downhill toward the distant Trammina Valley. It wasn't much of a road. The dirt surface was rough, weed-tufted, bestrewn with rocks which melting snows had carried down year after year from the upper slopes. Not far ahead, the path snaked around a tor and climbed again, steeply.

Falkayn glanced southward. The depot gleamed white on a ridge. Otherwise he himself was the only sign of humankind. Coarse gray grass and thorny trees stretched over the hills, with here and there a flock of grazing beasts watched by a mounted herder. At his back the Kasunian Mountains rose in harsh snowpeaks, a wall across the world. One great moon hung ghostly above them. The ember-colored sun had just cleared the horizon toward which he rode.

Wind roared hollowly, thrusting at his face. He shivered. Ivanhoe was not terribly cold, in this springtime of the middle northern latitudes; the dense atmosphere gave considerable greenhouse effect. But the bloody light made him feel forever chilled. And the fastiga's cloven hoofs beat the stones with a desolate sound.

Forgetting that he was Falkayn of Hermes, merchant prince, he pulled the radio transceiver from his pocket and thumbed the switch. Hundreds of kilometers away, an intercom buzzed. "Hullo," he said rather thinly. "Hullo, *What Cheer*. Anybody there?"

"*Si.*" Engineer Romulo Pasqual's voice came from the box. "Is that you, Davy *muchacho?*"

Falkayn was so glad of this little company that for once

he didn't resent being patronized. "Yes. How's everything?"

"As before. Krish is brooding. Martin has gone to the temple again. He said it would probably be no use trying to talk them out of their prohibition on the wheel, that you called us about last night. I?" Falkayn could almost see the Latin shrug. "I sit here and try to figure how we can move a couple tons of generator without wheels. A sort of giant stoneboat, *quizá?*"

"No. I thought of that too, and discussed the notion with Rebo, when we spent a lot of the dark period hunting for ideas. Not over a road like this."

"Are you certain? If we hitch enough peasants and animals to the thing—"

"We can't get them. Rebo himself, if he drafted all the people and critters he can spare—remember, this is the

planting season in a subsistence economy, and he also has to mount guard against the barbarians—he doubts if there'd be enough power to haul such a load over some of these upgrades."

"You said that quite a few of the *caballero* class were disgruntled with the priests. If they contributed too—"

"It'd take a long time to arrange that, probably too long. Besides, Rebo thinks very few would dare go as far as he will, to help us. They may not like being tied hand and foot to Consecrate policy, when there's a whole world for them to spend their energies on. But quite apart from religious reverence, they're physically dependent on the Consecrates, who supply a good many technical and administrative services . . . and who can rouse the commoners against the Wardens, if it ever came to an open break between the castes."

"So. Yes, Martin seemed to think much the same. We also were threshing this matter last night . . . However, Davy, we should have at least a few score natives and a couple of hundred fastigas at our disposal. if Rebo is willing to help within the letter of the law. I swear they could move a stoneboat over any route. They might have to use winches—"

"Winches are a form of wheel," Falkayn reminded him.

"*Ay de mi*, so they are. Well, levers and dikes, then. The Mayans raised big pyramids without wheels. The task would not be as large, to skid the generator from Gilrigor to Aesca."

"Oh, sure it could be done. But how long would it take? Come have a look at this so-called road. We'd be many months dead before the job was finished." Falkayn gulped. "How much food have we got if we ration ourselves? A hundred days' worth?"

"Something like that. Of course, we could live without eating for another month or two, I believe."

"Still not time enough to get your stoneboat across that distance. I swear it isn't."

"Well . . . no doubt you are right. You have inspected the terrain. It was only a rather desperate idea."

"Wagon transport is bad enough," Falkayn said. "I don't think that would make more than twenty kilometers per Earth-day in this area. Faster, of course, once we reached the lowlands, but I'd still estimate a month altogether."

"So slow? Well, yes, I suppose you are right. A rider needs more than a week. But this adds to our trouble. Martin is afraid that even if we can arrange something not forbidden by their law, the priests may have time to think of some new excuse for stopping us."

Falkayn's mouth tightened. " I wouldn't be surprised." His fright broke from him in a wail: "Why do they hate us so?"

"You should know that. Martin often talked to you while you rode westward."

"Yes. B-but I was sent off just a couple days after we landed. You three fellows have been on the scene, had a chance to speak with the natives, observe them—" Falkayn got his self-pity under control barely in time to avoid blubbering.

"The reason is plain," Pasqual said. "The Consecrates are the top crust of this petrified civilization. Change could only bring them down, however much it might improve the lot of the other classes. Then, besides self-interest, there is natural conservatism. Martin tells me theocracies are always hidebound. The Consecrates are smart enough to see that we newcomers represent a threat to them. Our goods, our ideas will upset the balance of society. So they will do everything they can to discourage more outworlders from coming."

"Can't you threaten revenge? Tell 'em a battleship will come and blow 'em to hell if they let us die."

"The first expedition told them a little too much of the true situation, I fear. Still, Martin may try such a bluff today. I do not know what he intends. But he has gotten . . . well, at least not very *un*friendly with some of the younger Consecrates, in the days since you left. He has told you of his lectures to them? Do not surrender yet, *muchacho*."

Falkayn flushed indignantly. "I haven't," he snapped. "Don't you either."

Pasqual made matters worse by laughing. Falkayn signed off.

Anger faded before loneliness as the hours wore on. He hadn't minded the trip to Gilrigor Castle. That had been full of hope, and riding on animals purchased with gold from a wealthy Aescan, through an excitingly exotic land, was just what a merchant adventurer ought to do. But looked only dreary and sinister. Falkayn's mind whirled with plan after plan, each less practical than the last—recharging the accumulators by a hand-powered generator, airlifting with a balloon, making so many guns that four men could stand off a million Larsans . . . Whenever he rejected a scheme, his father's mansion and his mother's face rose up to make his eyes sting and he clutched frantically after another idea.

There must be *some* way to move a big load without wheels! What had he gone to school for? Physics, chemistry, biology, math, sociotechnics . . . yet, here he was, child of a civilization that burned atoms and traveled between the stars, and one stupid taboo was about to kill him! But that was impossible. He was David Falkayn, with his whole life yet to live. Death didn't happen to David Falkayn.

The red sun climbed slowly up the sky. Ivanhoe had a rotation period of nearly sixty hours. He stopped at midday to eat and sleep a while, and again shortly before sunset. The landscape had grown still more bleak; nothing was to be seen now but hills, ravines, an occasional brawling stream, wild pastures spotted with copses of scrubby fringe-leaved trees, no trace of habitation.

He woke after some hours, crawled shivering from his sleeping bag, started a campfire and opened a packet

of food. The smoke stung his nostrils. Anti-allergen protected him against such slight contact with proteins made deadly alien by several billion years of separate evolution. He could even drink the local water. But nothing could save him if he ate anything native. After swallowing his rations, he readied the fastigas for travel. Because he was still cold, he left the lead animal tethered and huddled over the fire to store a little warmth in his body.

His eyes wandered upward. Earth and Hermes lay out there—more than four hundred light-years away.

The second moon was rising, a mottled coppery disk above the eastern scarps. Even without that help, one could travel by night. For the stars swarmed and glittered, the seven giant Sisters so brilliant in their nebular hazes that they cast shadows, the lesser members of the cluster and the more distant suns of the galaxy filling the sky with their wintry hordes. A gray twilight overlay the world. Off in the west, the Kasunian snows seemed phosphorescent.

Hard to believe there could be danger in so much beauty. And in fact there seldom was. Nonetheless, when a spaceship ran on secondary drive through a region where the interstellar medium was thicker than usual, there was a small but finite probability that one of her micro-jumps would terminate just where a bit of solid matter happened to be. If the difference in intrinsic velocities was great, it could do considerable damage. If, in addition, the lump was picked up in the space occupied by the nuclear fusion unit—well, that was what had happened to the *What Cheer*.

I suppose I'm lucky at that, Falkayn thought with a shudder. *The pebble could have ripped right through Me.* Of course, then the others would have been all right, with no more than a job of hull patching to do. But at his age Falkayn didn't think that was preferable.

He had to admire the way Captain Mukerji had gotten them here. By commandeering every charged accumulator aboard ship, he'd kept the engines going as far as Ivanhoe. Landing on the last gasp of energy, by guess, God, and aerodynamics, took uncommon skill. Naturally, the sensible thing had been to make for Aesca, the capital, rather than directly for Gilrigor. One did not normally by-pass local authorities, who might take offense and cause trouble. Who could have known that the trouble was already waiting there?

But now the spaceship sat, without enough ergs left in her powerpacks to lift a single gravity sled. The accumulators in the depot were insufficient for transportation; besides, they were needed for the repair tools. The spare atomic generator couldn't recharge anything until it had been installed in the ship, for it functioned integrally with engines and controls. And a thousand wheelless kilometers separated the two . . .

Something stirred. One of the fastigas brayed. Falkayn's heart jumped into his gullet. He sprang erect with a hand on his blaster.

A native male trod into the little circle of firelight. His fur was fluffed out against the night cold and the breath steamed from below his jaws. Falkayn saw that he carried a rapier and—yes, by Judas, there was a circle emblazoned on his breastplate! The flames turned his great eyes into pools of restless red.

"What do you want?" Falkayn squeaked. Furiously, he reminded himself that the Ivanhoan's hands were extended empty in token of peace.

"God give you good evening," the deep voice answered. "I saw your camp from afar. I did not expect to find an outlander."

"N-n-nor I a Sanctuary guard."

"My corps travels widely on missions for the Consecrates. I hight Vedolo Pario's-Child."

"I, I . . . David, uh, David Falkayn's-Child."

"You have been on a visit to the Marchwarden, have you not?"

"Yes. As if you did not know!" Falkayn spat. *No, wait, watch your manners. We may still have a chance of talking the Consecrates into giving us a special dispensation about wheels.* "Will you join me?"

Vedolo hunkered, wrapping his tail about his feet. When Falkayn sat down again, the autochthone loomed over him on the other side of the flames, mane like a forested mountain against the Milky Way. "Yes," Vedolo admitted, "everyone in Aesca knew you were bound hither, to see if that which your fellows laid in the sealed building was still intact. I trust it was?"

Falkayn nodded. Nobody in the early Iron Age could break into an inertium-plated shed with a Nakamura lock. "And Marchwarden Rebo was most kind," he said.

"That is not surprising, from what we know of him. As I understand the matter, you must get certain spare parts from the building to repair your ship. Will Rebo, then, help you transport them to Aesca?"

"He would if he could. But the main thing we need is too heavy for any conveyance available to him."

"My Consecrate masters have wondered somewhat about that," Vedolo said. "They were shown around your vessel, at their own request, and the damaged section looked quite large."

That must have been after I left, Falkayn thought. *Probably Schuster was trying to ingratiate us with them. And I'll bet it misfired badly when they saw the circular shapes of things like meter dials—stiffened their hostility to us, even if they didn't say anything to him at the time.*

But how can this character know that, unless he followed me here? And why would he do so? What is this mission of his?

"Your shipmates explained that they had means of transport," Vedolo continued. "That makes me wonder why you returned this quickly, and alone."

"Well . . . we did have a device in mind, but there appears to be certain difficulties—"

Vedolo shrugged. "I have no doubt that folk as learned as you can overcome any problems. You have powers that we thought belonged only to angels—or to

Anti-God—" He broke off and extended a hand. "Your flame weapons, for instance, which the earlier visitors demonstrated. I was not present in Aesca at the time, and have always been most curious about them. Is that a weapon at your belt? Might I see it?"

Falkayn went rigid. He could not interpret every nuance in the Larsan voices, so strangely unresonant for lack of a nasal chamber. But—"No!" he snapped.

The delicate lips curled back over sharp teeth. "You are less than courteous to a servant of God," Vedolo said.

"I . . . uh . . . the thing is dangerous. You might get hurt."

Vedolo raised an arm in the air and lowered it again. "Look at me," he said. "Listen carefully. There is much you do not understand, you bumptious invaders. I have something to tell you—"

In Ivanhoe's thick air, a human heard preternaturally well. Or perhaps it was only that Falkayn was strung wire taut, trembling and sweating with the sense of aloneness before implacable enmity. He heard the rustle out in the brush, and flung himself aside as the bowstring sang. The arrow buried its eight-sided shaft in the earth where he had been.

Vedolo sprang up, sword flashing free. Falkayn rolled over. A thornbush raked his cheek. "Kill him!" Vedolo bawled, and lunged at the human. Falkayn bounced erect. The rapier blade snagged his coat as he dodged. He got his blaster out and fired point blank.

Light flared hellishly for an instant. Vedolo went over in smoke, with a horrible squelch. After-images flew in rags before Falkayn's eyes. He stumbled toward his animals, which plunged and brayed in their panic. Through the dark he heard someone cry, "I cannot see, I cannot see, I am blinded!" The flash would have been more dazzling to Ivanhoans than to him. But they'd recover in a minute, and then they'd have much better night vision than he did.

"Kill his fastigas!" called another voice.

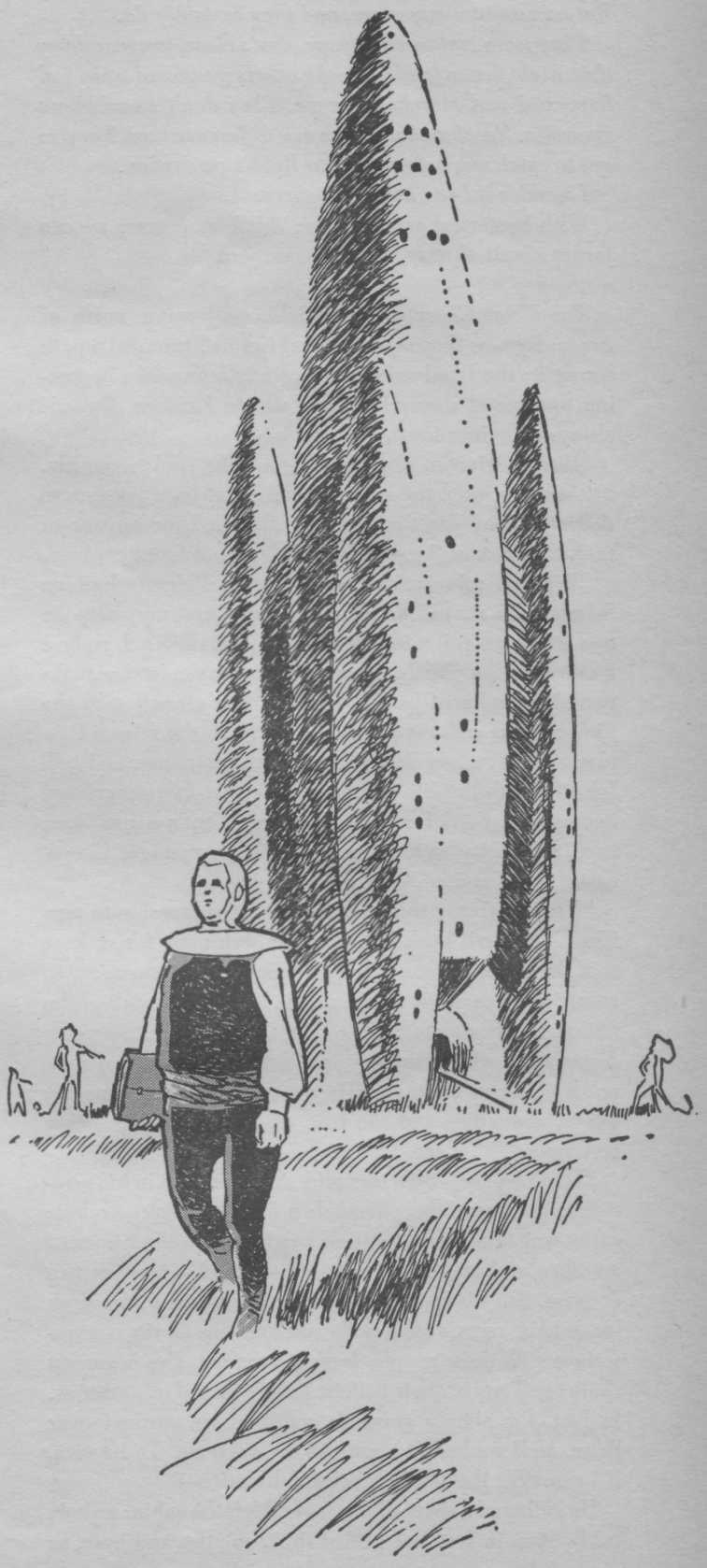
Falkayn fired several bolts. That should make their aim poor for a while longer, he thought in chaos. His lead animal reared and struck at him. Its eyeballs rolled, crimson against shadow-black in the streaming flame-light. Falkayn sidestepped the hoofs, got one hand on the bridle, and clubbed the long nose with his gun barrel. "Hold *still*, you brute," he sobbed. "It's your life, too."

Feet blundered through the brush. A lion head came into view. As he saw the human, the warrior yelled and threw a spear. It gleamed past, flattened shaft and iron head. Falkayn was too busy mounting to retaliate.

Somehow he got into the saddle. The remount shrieked as two arrows smote home in its belly. Falkayn cut it loose with a blaster shot.

"Get going!" he screamed. He struck heels into the sides of his beast. The fastiga broke into a rocking gallop, the pack animal behind at the end of its reins.

An ax hewed and missed. An arrow buzzed over his



shoulder. Then he was beyond the assassins, back on the Sun's Way, westward bound again

How many are there? it whirled in him. *Half a dozen? They must have left their own fastigas at a distance, so they could sneak up on me. I've got that much head start. But no remount any more, and they certainly do.*

They were sent to waylay me, that's clear, to cause delay that might prove fatal while the others wondered what had happened and searched for me. They don't know about my radio. Not that that makes any difference now. They've got *to catch me, before I get to Rebo's protection.*

I wonder if I can beat them there.

With hysterical sardonicism: *Anyhow, I guess we can forget about that special dispensation.*

The *What Cheer* sat in a field a kilometer north of Aesca. By now thousands of local feet had tramped a path across it; the Ivanhoans were entirely humanlike in coming to gape at a novelty. But Captain Krishna Mukerji always rode into town.

"Really, Martin, you should too," he said nervously. "Especially when the situation has all at once become so delicate. They don't consider it dignified for anyone of rank to arrive at the, er, the Sanctuary on foot."

"Dignity, schmignity," said Master Polesotechnician Schuster. "I should wear out my heart and my rump on one of those evil-minded animated derricks? I rode a horse once on Earth. I never repeat my mistakes." He waved a negligent hand. "Besides, I've already told the Consecrates, and anyone else that asked, the reason I go places on foot, and don't bother with ceremony, and talk friendly with low-life commoners, is that I've progressed beyond the need for outward show. That's a new idea here, simplicity as a virtue. It's got the younger Consecrates quite excited."

"Yes, I daresay this culture is most vulnerable to new ideas," Mukerji said. "There have been none for so long that the Larsans have no antibodies against them, so to speak, and can easily get feverish . . . But the heads of the Sanctuary appear to realize this. If you cause too much disturbance with your comments and questions, they may not wait for us to starve. They may whip up an outright attack, casualties and the fear of a punitive expedition be damned."

"Don't worry," Schuster said. Another man in his position might have been offended; a first-year Polesotechnic cadet was taught not to clash head-on with the basics of an alien culture, and he had been a Master for two decades. But his face, broad and saber-nosed under sleek black hair, remained blandly smiling. "In all my conversations with these people, feeling them out, I've never yet challenged any of their beliefs. I don't intend to start now. In fact, I'm simply going to continue my seminar over there, as if we hadn't a care in the universe. To be sure, if I can steer the talk in a helpful direction—"

He gathered a sheaf of papers and left the cabin: a short tubby man in vest and ruffled shirt, culottes and hose, as elegant as if he were bound for a reception on Earth.

Emerging from the air lock and heading down the gangway, he drew his mantle about him with a shiver. To avoid eardrum popping, the hull was kept at Ivanhoan air pressure, but not temperature. *Br-r-r,* he thought. *I don't presume to criticize the good Lord, but why* did *He make the majority of stars type M?*

The afternoon landscape reached somber, to his eyes, as far as he could see down the valley. Grainfields were turning bluish with the first young shoots of the year. Peasants, male, female, and young, hoed a toilsome way down those multitudinous rows. The square mud huts in which they lived stood at no great separation, for every farm was absurdly small. Nevertheless families did not outgrow the capacity of the land; disease and periodic famines kept the population stable. *To hell with any sentimental guff about cultural autonomy,* Schuster reflected. *This is one society that ought to be kicked apart.*

He reached the highroad and started toward the city. There was considerable traffic, food and raw materials coming from the hinterlands, handmade goods going back. Professional porters trotted under loads too heavy for Schuster even to think about. Fastigas dragged travoises with vast bumping and clatter. A provincial Warden and his bodyguard galloped through, horns hooting, and the commoners jumped aside for their lives. Schuster waved to the troop as amiably as he did to everyone else that hailed him. No use standing on ceremony. In the couple of Earth-weeks since the ship landed, the Aescans had lost awe of the strangers. Humans were no weirder to them than the many kinds of angel and hobgoblin in which they believed, and seemed to be a good deal more mortal. True, they had remarkable powers; but then, so did any village wizard, and the Consecrates were in direct touch with God.

Not having been threatened by war in historical times, the city was unwalled. But its area was pretty sharply defined just the same, huts, tenements, and the mansions of the wealthy jammed close together along the contorted trails that passed for streets. Crowds moved by bazaars where shopkeepers' wives sang songs about their husbands' wares. Trousers and tunics, manes and fur, glowed where the red light slanted through shadows that were thick to Schuster's vision. The flat but deep Ivanhoan voices made a surf around him, overlaid by the shuffle of feet, clop of hoofs, clangor from a smithy. Acrid stenches roiled in his nostrils.

It was a relief to arrive at one of the Three Bridges. When the Sanctuary guards had let him by, he walked alone. Only those who had business with the Consecrates passed here.

The Trammina River cut straight through town, oily with the refuse of a hundred thousand inhabitants. The bridges were arcs of a circle, soaring in stone to the island in the middle of the water. (Falkayn had relayed from Rebo the information that you were allowed to use up to

one third of the sacred figure for an important purpose.) That island was entirely covered by the enormous step-sided pyramid of the Sanctuary. Buildings clustered on the lower terraces, graceful white structures with colonnaded porticos, where the Consecrates lived and worked. The upper pyramid held only staircases, leading to the top. There the Eternal Fire roared forth, vivid yellow tossing against the dusky-green sky. Obviously natural gas was being piped from some nearby well; but the citadel was impressive in every respect.

Except for what it cost those poor devils of peasants in forced labor and taxes, Schuster thought, *and what it's still costing them in liberty.* The fact that thousands of diverse barbarian cultures existed elsewhere on the planet proved that Pharaonism didn't come any more naturally to the Ivanhoans than it did to men.

White-robed Consecrates, most of their manes gray with age, and their blue-clad acolytes walked about the pyramid on their business, aloof in pride. Schuster's cheery greetings earned him little but frigid stares. He didn't let it bother him, but bustled on to the fourth-step House of the Astrologers.

In a spacious room within, a score or so of the younger Consecrates sat around a table. "Good day, good day," Schuster beamed. "I trust I am not late?"

"No," said Herktaskor. A lean, intense-eyed being, he carried himself with something of the martial air of his Warden father. "Save that we have been eagerly awaiting the revelation you promised us this morning, when you borrowed that copy of the Book of Stars."

"Well, then," Schuster said, "let us get on with it." He went to the head of the table and spread out his papers. "I trust you have mastered those principles of mathematics that I explained to you in the past several days?"

A number of them looked unsure, but other shaggy heads nodded. "Indeed," said Herktaskor. His voice sank. "Oh, glorious!"

Schuster took out a fat cigar and got it going while he squinted at them. He had to hope they were telling the truth; for suddenly his little project, which he had begun as a pastime, and in the vague hope of winning friends and sneaking some new concepts into this frozen society, had grown most terribly urgent. Last night Davy Falkayn radioed that shattering news about wheels being taboo, and now—

He thought, though, that Herktaskor was neither lying nor kidding himself. The Consecrate was brilliant in his way. And certainly there was a good foundation on which to build. Mathematics and observational astronomy were still live enterprises in Larsum. They had to be, when religion claimed that astrology was the means of learning God's will. Algebra and geometry had long been well-developed. The step from them to basic calculus was really not large. Even dour Sketulo, the Chief of Sanctuary, had not objected to Schuster's organizing a course of lectures, as long as he stayed within the bounds of dogma. Quite apart from intellectual curiosity, it would be useful for the learned class to be able to calculate such things as the volumes and areas of unusual solids; it would make still tighter their grip on Larsum's economy.

"I planned to go on with the development of those principles," Schuster said. "But then I got to wondering if you might not be more interested in certain astrological implications. You see, by means of the calculus it is possible to predict where the moons and planets will be, far more accurately than hitherto."

Breath sucked in sharply between teeth. Even through the robes, the man could see how bodies tensed around the table.

"The Book of Stars gave me your tabulated observations, accumulated over many centuries," he went on. "These noontide hours I have weighed them in my mind." Actually, he had fed them to the ship's computer. "Here are the results of my calculations."

He drew a long breath of tobacco smoke. The muscles tightened in his belly. Every word must now be chosen with the most finicking care, for a wrong one could put a sword between his guts.

"I have hesitated to show you this," he said, "because at first glance it seems to contradict the Word of God as you have explained it to me. However, after pondering the question and studying the stars for an answer, I felt sure that you are intelligent enough to see the deeper truth behind deceptive appearances."

He paused. "Go on," Hertaskor urged.

"Let me approach the subject gradually. It is often a necessity of thought to assume something which one knows is not true. For example, the Consecrates as a whole possess large estates, manufactories, and other property. Title is vested in the Sanctuary. Now you know very well that the Sanctuary is neither a person nor a family. Yet for purposes of ownership, you act as if it were. Similarly, in surveying a piece of land, you employ plane trigonometry, though you know the world is actually round . . ." He went on for some time, until he felt reasonably sure that everybody present understood the concept of a legal or mathematical fiction.

"What has this to do with astrology?" asked someone impatiently.

"I am coming to that," Schuster said. "What is the true purpose of your calculations? Is it not twofold? First, you wish to predict where the heavenly bodies will be with respect to each other at some given date, since this indicates what God desires you to do at that time. Second, you wish to uncover the grand plan of the heavens, since by studying God's works you may hope to learn more of His nature.

"Now as observations accumulated, your ancestors found it was not enough to assume that all the worlds, including this one, move in circles about the sun, and the moons in circles about this world, while the heavenly globe rotates around the whole. No, you had to picture

these circles as having epicycles; and later it turned out that there must be epi-epicycles; and so on, until now for centuries the picture has been so complicated that the astrologers have given up hope of further progress."

"True," said one of them. "A hundred years ago, on just this account, Kurro the Wise suggested that God does not want us to understand the ultimate design of things too fully."

"Perhaps," Schuster said. "On the other hand, maybe God only wants you to use a different approach. A savage, trying to lift a heavy stone, might conclude that he is divinely forbidden to do so. But you lift it with a lever. In the same way, my people have discovered a sort of intellectual lever, by which we can pry more deeply into the motions of the heavenly bodies than we ever could by directly computing circles upon circles upon circles.

"The point is, however, that this requires us to employ a fiction. That is why I ask you not to be outraged when I lay that fiction before you. Granted, all motions in the sky are circular, since the circle is the token of God. But is it not permissible to assume, for purposes of calculation only, that they are not circular . . . and inquire into the consequences of that assumption?"

He started to blow a smoke ring, but decided against it. "I must have a plain answer to that question," he said. "If such an approach is not permissible, then of course I shall speak no more."

But of course it was. After some argument and logic-chopping, Herktaskor ruled that it was not illegal to entertain a false hypothesis. Whereupon Schuster exposed his class to Kepler's laws and Newtonian gravitation.

That took hours. Once or twice Herktaskor had to roar down a Consecrate who felt the discussion was getting obscene. But on the whole, the class listened with admirable concentration and asked highly intelligent questions. This was a gifted species, Schuster decided; perhaps, intrinsically, more gifted than man. At least, he didn't know if any human audience, anywhere in space or time, would have grasped so revolutionary a notion so fast.

In the end, leaning wearily on the table, he tapped the papers before him and said from a roughened throat: "Let me summarize. I have shown you a fiction, that the heavenly bodies move in ellipses under an inverse square law of attraction. With the help of the calculus, I have proved that the elliptical paths are a direct consequence of that law. Now here, in these papers, is a summary of my calculations on the basis of our assumption, about the actual heavenly motions as recorded in the Book of Stars. If you check them for yourselves, you will find that the data are explained without recourse to any epicycles whatsoever.

"Mind you, I have never said that the paths *are* anything but circular. I have only said that they may be *assumed* to be, and that this assumption simplifies astrological computation so much that predictions of unprecedented accuracy can now be made. You will wish to verify my claims, and consult your superiors about their theological significance. Far be it from me to broadcast anything blasphemous.

"I got troubles enough," he added in Anglic.

There was no uproar when he left. His students were as wrung out as he. But later, when the implications began to sink in—

He returned to the ship. Pasqual met him in the ward-room. "Where have you been so long?" the engineer asked. "I was getting worried."

"At the lodge." Schuster threw himself into a chair with a sigh. "Whoof! Sabotage is hard work."

"Oh . . . I was asleep when you came back here, and so did not tell you. While you were out this morning, Davy called in. He is on his way back."

"He might as well return, I suppose. We can't do anything until we get an O.K. from on high, and that'll take time."

"Too much time, maybe."

"And maybe not." Schuster shrugged. "Don't be like the nasty old man in a boat."

"Eh?"

"Asked, 'How do you know it will float?' Whereupon he said, 'Boo!' to the terrified crew, and retired to the cabin to gloat. Be a good guy and fetch me a drink, will you, and then I'm going to retire myself."

"No supper?"

"A sandwich will do. We have to start rationing—remember?"

The scanner alarm roused Schuster. He groaned out of his bunk and fumbled his way to the nearest viewscreen. What he saw brought him bolt awake.

A dozen Sanctuary guards sat mounted below the gangway. The light of moon and Pleiades glimmered on their spears. A pair of acolytes were helping a tall shape, gaunt in its robes, to dismount. Schuster would have known that white mane and disk-topped staff anywhere this side of the Coal Sack.

"Oi, weh," he said. "Get your clothes on, chumlets. The local Pope wants an audience with us."

"Who?" Mukerji yawned.

"Sketulo, the Boss Consecrate, *in* person. Could be I've lit a bigger firecracker than I knew." Schuster scuttled back aft and threw on his own garments.

He was ready to receive the guest by the time that one had climbed to the air lock. "My master, you honor us beyond our worth," he unctuated. "Had we only known, we would have prepared a fitting—"

"Let us waste no time on hypocrisies," said the Larsan curtly. "I came so that we could talk in private, without fear of being overheard by underlings or fools." He gestured at Pasqual to close the inner door. "Dim your cursed lights."

Mukerji obeyed. Sketulo's huge eyes opened wide and smoldered on Schuster. "You being the captain here," he said, "I will see you alone."

The merchant lifted his shoulders and spread his palms at his shipmates, but obediently led the way—in Larsum the place of honor was behind—to that cabin which served as his office on happier occasions. When its door had also been shut, he faced the other and waited.

Sketulo sat stiffly down on the edge of a lounger that had been adjusted to accommodate Ivanhoan bodies. The staff remained upright in one hand, its golden circle ashimmer in the wan light. Schuster lowered himself to a chair, crossed his legs, and continued to wait.

The old voice finally clipped: "When I gave you permission to instruct the young astrologers, I did not think even you would dare sow the seeds of heresy."

"My master!" Schuster protested in what he hoped would be interpreted as a shocked tone. "I did nothing of the sort."

"Oh, you covered yourself shrewdly, by your chatter of a fiction. But I have seldom seen anyone so agitated as those several Consecrates who came to me after you had left."

"Naturally the thought I presented was exciting—"

"Tell me." Sketulo pursed his wrinkled lips. "We will need considerable time to check your claims, of course; but does your hypothesis in truth work as well as you said?"

"Yes. Why should I discredit myself with boasts that can readily be disproven?"

"Thus I thought. Clever, clever . . ." The haggard head shook. "Anti-God has many ways of luring souls astray."

"But my master, I distinctly told them this was a statement false to fact."

"So you did. You are reported to have said that it might, at best, be mathematically true, but this does not make it philosophically true." Sketulo leaned forward. Fiercely: "You must have known, however, that the question would soon arise whether there can be two kinds of truth, and that in any such contest, those whose lives are spent with observations and numbers will decide in the end that the mathematical truth is the only one."

I certainly did, Schuster thought. *It's exactly the point that got Galileo into trouble with the Inquisition, way back when on Earth.* A chill went through him. *I didn't expect you to see it this fast, though, you old devil.*

"By undermining the Faith thus subtly, you have confirmed my opinion that your kind are the agents of Anti-God," Sketulo declared. "You must not remain here."

Hope flared in Schuster. "Believe me, my master, we have no wish to do so! The sooner we can get what we need from our warehouse and be off, the happier we will be."

"Ah. But the others. When can we expect a third visit, a fourth, fleet after fleet?"

"Never, God willing. You were told by the first crew that arrived, we have no interest in trade—"

"So they said. And yet it was only a few short years before this vessel came. How do we know you tell the truth?"

You can't argue with a fanatic, Schuster thought, and kept silence. Sketulo surprised him again by changing the topic and asking in a nearly normal tone:

"How do you propose to move that great object hither?"

"Well, now, that is a good question, my master." Schuster's forehead went wet. He mopped it with his sleeve. "We have a way, but, uh, we have hesitated to suggest it—"

"I commanded that we be alone in order that we might both speak frankly."

Schuster sucked in a lungful of air, reached for a pad and penstyl, and explained about wagons.

Sketulo didn't move a muscle. When at length he spoke, it was only to say: "At certain most holy and secret rites, deep within the Sanctuary, there is that which is moved from one room to another by such means."

"We need not shock the populace," Schuster said. "Look, we can have sideboards, or curtains hanging down, or something like that, to hide the wheels."

Sketulo shook his head. "No. Almost everyone, as an unwitting child, has played with a round stick or stone. The barbarians beyond the Kasunian Range employ rollers. No doubt some of our own peasants do, furtively, when a heavy load must be moved and no one is watching. You could not deceive the more intelligent observers about what was beneath those covers; and they would tell the rest."

"But with official permission—"

"It may not be granted. God's law is plain. Even if you were given leave by the Sanctuary, most of the commoners would fear a curse. They would destroy you despite any injunctions of ours."

Since that was what Falkayn had quoted Rebo as saying, Schuster felt that perhaps Sketulo was telling the truth. Not that it mattered if he wasn't; he was obviously determined not to allow this thing.

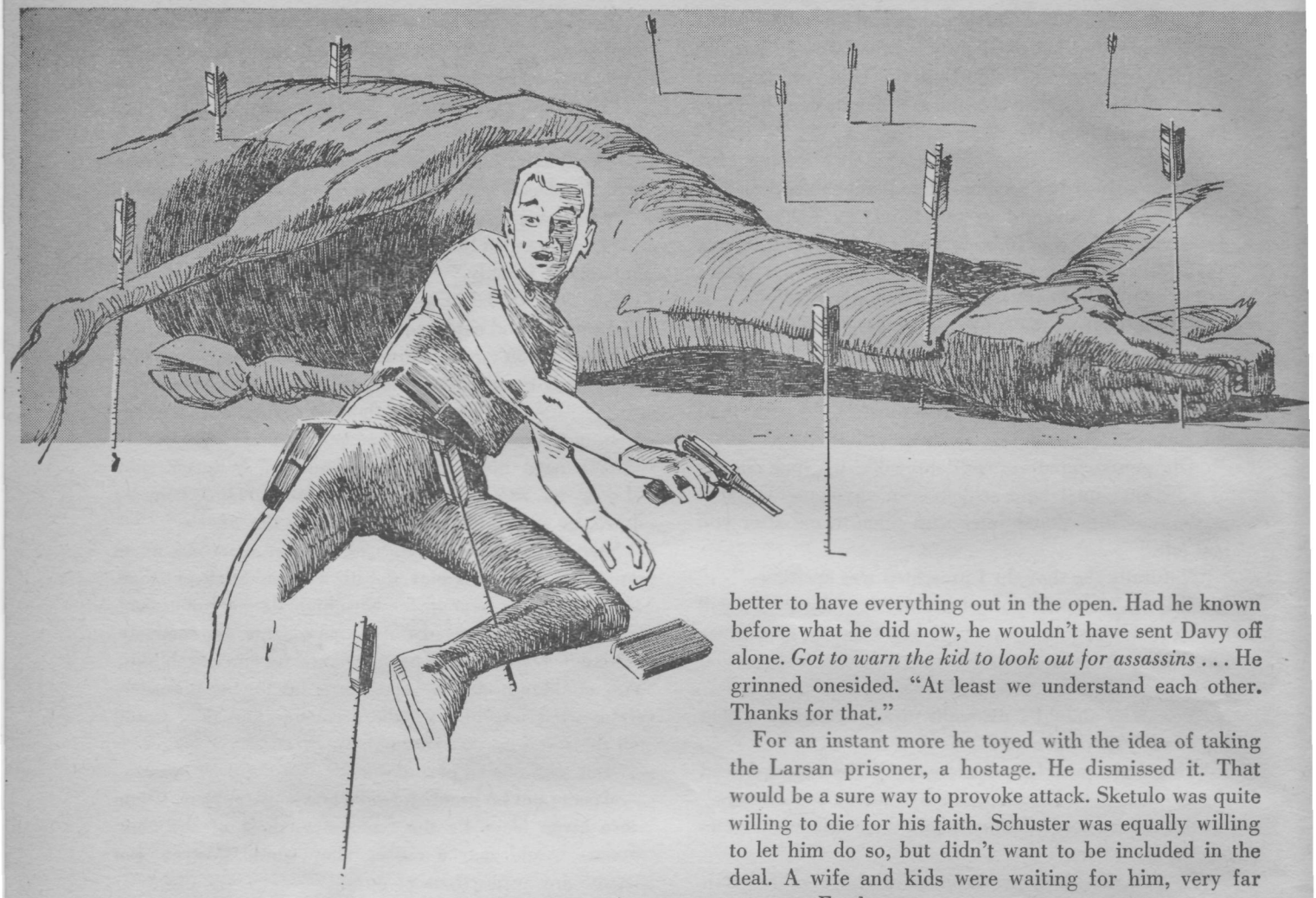
The merchant sighed. "Well, then, my master, have you any other suggestion? Perhaps, if you would furnish enough laborers from the Consecrate estates, we could drag the workmaker here."

"This is the planting and cultivating season. We cannot spare so many hands, least we have a famine later."

"Oh, now, my master, you and I have an identical interest: to get this ship off the ground. My associates at home can send you payment in metals, fabrics, and, yes, artificial food nourishing to your type of life."

Sketulo stamped the deck with his staff so it rang. His tone became a snarl: "We do not *want* your wares! We do not want you! The trouble you started today has snapped the last thread of my patience. If you perish here, despite that accursed rescue station, then God may well persuade your fellows that this is not a good place for such a station after all. At least, come what may, we will have done God's will here in Larsum . . . by giving not a finger's length of help to the agents of Anti-God!"

He stood up. His breath rasped harshly in the narrow metal space. Schuster rose, too, regarded him with a self-



astonishing steadiness, and asked low: "Do I understand you rightly, then, my master, that you wish us to die?"

The unhuman head lifted stiffly over his. "Yes."

"Will your guard corps attack us, or would you rather stir mobs against us?"

Sketulo stood silent a while. His eventual answer was reluctant: "Neither, unless you force our hand. The situation is complex. You know how certain elements of the Warden and trader classes, not without influence, have been seduced into favoring somewhat your cause. Besides, although we could overcome you with sheer numbers, I am well aware that your weapons would cost us grievous losses—which might invite a barbarian invasion. So you may abide in peace a while."

"Until you think of a safe way to cut our throats, hm-m-m?"

"Or until you starve. But from this moment you are forbidden to enter Aesca."

"Nu? That would not be so good an idea anyway, with all those rooftops and alleys for an archer to snipe from. Well—" Schuster's words trailed off. He wondered, momentarily frantic, if this mess was his fault, going so boldly forward, fatally misjudging the situation . . . No. He hadn't foreseen Sketulo's precise reaction, but it was better to have everything out in the open. Had he known before what he did now, he wouldn't have sent Davy off alone. *Got to warn the kid to look out for assassins . . .* He grinned onesided. "At least we understand each other. Thanks for that."

For an instant more he toyed with the idea of taking the Larsan prisoner, a hostage. He dismissed it. That would be a sure way to provoke attack. Sketulo was quite willing to die for his faith. Schuster was equally willing to let him do so, but didn't want to be included in the deal. A wife and kids were waiting for him, very far away on Earth.

He led the old one to the air lock and watched him ride off. The sound of hoofs fell hollow beneath the moon and the clustered stars.

It seemed to Falkayn that he had been riding through his whole life. Whatever might have happened before was a dream, a vapor somewhere in his emptied skull, unreal . . . reality was the ache in every cell of him, saddle sores, hunger, tongue gone wooden with thirst and eyelids sandpapery with sleeplessness, the fear of death battered out of him and nothing left but a sort of stupid animal determination to reach Gilrigor Castle, he couldn't always remember why.

He had made stops during the night, of course. A fastiga was tougher than a mule and swifter than a horse, but it must rest occasionally. Falkayn himself hadn't dared sleep, though, and saddled up again as soon as possible. Now his beasts were lurching along the road like drunks.

He turned his head—the neckbones creaked—and looked behind. His pursuers had been in sight ever since the first pre-dawn paling of the sky made them visible. When was that—a century ago?—no, must be less than an hour, the sun wasn't aloft yet, though the blackness overhead

had turned plum color and the Sisters were sunken below Kasunia's wall. There were four or five of them—hard to be sure in this twilight—only two kilometers behind him and closing the gap. Their spears made points of brightness among the shadows.

So close?

The knowledge rammed home. Energy spurted from some ultimate source, cleared his mind and whetted his senses. He felt the dawn wind on his cheeks, heard it sought in the wiry brush along the roadside and around the staggering hoofbeats of his mount, saw how the snow-peaks in the west were reddening as they caught the first sun-rays; he yanked the little transceiver from his pocket and slapped the switch over. "Hello!"

"Davy!" yelled Schuster's voice. "What's happened? You O.K.?"

"So far," Falkayn stammered. "N-not for long, I'm a afraid."

"We've been trying for hours to raise you."

He'd called the ship while he fled, to relate the circumstances, and contact was maintained until—"Guess I, I got so tired I just put the box away for a minute and then forgot about it. My animals are about to keel over. And . . . the Sanctuary boys are overhauling me."

"Any chance you can reach the castle before they get in bowshot?"

Falkayn bit his lip. "I doubt it. Can't be very far to go, a few kilometers, but—What can I do? Try to make a run for it on foot?"

"No you'd be ridden down, shot in the back. I'd say make a stand."

"Their bows have almost the range of my gun, and they can attack me from every side at once. There's no cover here. Not even a clump of trees in sight."

"I know an old frontier stunt. Shoot your animals and use them for barricades."

"That won't protect me long."

"It may not have to. If you're as near the castle as you say, Ivanhoan eyes ought to spot flashes in the air from your shots. Anyhow, it's the only thing I can suggest."

"V-v-v—" Falkayn snapped his teeth together and held them that way for a second. "Very well."

Schuster's own voice turned uneven. "I wish I could be there to help you, Davy."

"I wouldn't mind if you were," Falkayn surprised himself by answering. Now that was more like how a man facing terrible odds ought to talk! "Oh, I'll have to pocket this radio again, but I'll leave the switch open. Maybe you can hear. Root for me, will you?"

He reined in and sprang to the ground. His fastigas stood passive, trembling in their exhaustion. Not without guilt feelings, he led the pack carrier around until it stood nose to tail with the mount. Quickly, then, he set his blaster to narrow beam and drilled their brains.

They collapsed awkwardly, like jointed dolls; a kind of sigh went from the loaded one, as if it were finally being allowed to sleep, but its eyes remained open and horribly fixed. Falkayn wrestled with the legs and necks, trying to make a wall that would completely surround him. Scant success . . . Panting, he looked eastward. His enemies had seen what he was about and broken into a trot, scattering right and left across the downs before they stopped to tether their spare animals. Five of them, all right.

The sun's disk peered over the ridges. *Wait, the more contrast, the more visible an energy flash will be.* Falkayn fired several times straight upward.

An arrow thunked into fastiga flesh. The boy went on his stomach and shot back. He missed the retreating rider. Crouching, he glared around the horizon. Another Larsan was drawing a bow at him, less than half a kilometer distant. He sighted carefully and squeezed trigger. The gun pointed a long blue-white finger. An instant later it said *crack!* and the Larsan dropped his bow and clutched at his left arm. Two other arrows came nastily near. Falkayn shot back, without hitting, but it did force the archers out of their own range for a little while, which was something.

He hadn't many charges left in the magazine, though. If the Consecrates' hired blades kept up their present tactics, compelling him to expend his ammunition—But did they know how little he had? No matter. They obviously were not going to quit before they finished their job. Unless he was lucky enough to drop them all, David Falkayn was probably done. He discovered he was accepting that fact soberly, not making much fuss about it one way or another, hoping mainly that he would be able to take some of them with him. *Rough on Mother and Dad, though, he thought. Rough on Marty Schuster, too. He'll have to tell them, if he lives.*

Two guards pounded down a grassy slope toward him, side by side. Their manes streamed in the air. When they were nearly in gunshot, they separated. Falkayn fired at one, who leaned so low simultaneously that the bolt missed. The other got off an arrow on a high trajectory. Falkayn shot at him too, but he was already withdrawing on the gallop. The arrow smote, centimeters from

Falkayn's right leg where he sprawled on the ground.

Nice dodge, he thought with the curious dispassion that had come upon him. *I wonder if they've met my kind of defensive maneuver before, or are just making a good response to something new? Wouldn't be surprised if that last was the case. They're brainy fellows, these Ivanhoans. While we, with our proud civilization, we can't respond to so simple a thing as a local taboo on wheels.*

Shucks, it should be possible to analyze the problem—

Two others were galloping close from the right. Falkayn narrowed his blaster beam as far as he could, to get maximum range, and shot with great care. He struck first one fastiga, then another: minor wounds, but painful. Both animals reared. The riders got them under control again and wheeled away. Falkayn turned about in time to fire at the other two, but not in time to forestall their arrows. Misses on both sides.

. . . And figure out precisely what a wheel does, and then work out some other dodge that'll do the same thing.

Where was the fifth Larsan, the one who'd gotten winged? Wait . . . his fastiga stood riderless some distance off. But where was he? These bully boys weren't the type to call it a day just because of a disabled arm.

I got good grades in math and analytics. My discussants told me so. Now why can't I dredge something I learned back then, up into memory, and use it? I could solve the problem for an exam, I'll bet.

Most likely the wounded one was snaking through the taller bushes, trying to get so close that he could pounce and stab.

Of course, this isn't exactly an examination room. Analytical thinking doesn't come natural, most especially not when your life's involved, and it's very, very odd that I should begin on it at this precise moment. Maybe my subconscious smells an answer.

The four riders had gotten together for a conference. They looked like toys at this distance, near the top of a high ridge paralleling the road and sloping down to its edge. Falkayn couldn't hear anything but wind. The sun, fully risen now, made rippling violet shadows in the gray grass. The air was still cold; his breath smoked.

Let's see. A wheel is essentially a lever. But we've already decided that the other forms of lever aren't usable. Wait! A screw? No, how'd you apply it? If any such thing were practical for us, Romulo Pasqual would've thought of it by now.

How about cutting the wheel in slices, mounted separately? No, I remember suggesting that to Rebo, and he said it wouldn't do, because the whole ensemble viewed from the side would still have a circular outline.

The riders had evidently agreed on a plan. They unstrung their bows and fastened them carefully under the saddle girths. Then they started toward him, single file.

What else does a wheel do, besides supply mechanical advantage? Ideally, it touches the ground at only one point, and so minimizes friction. Is there some other shape which'll do the same? Sure, any number of 'em. But what good is an elliptical wheel?

Hey, couldn't you have a trick mounting, like an eccentric arm on an axle that was also elliptical, so the load would ride steady? No, I doubt if it's feasible, especially over roads as dreadful as this one, and nothing but muscle power available for traction. The system would soon be jolted to pieces.

The leading Sanctuary guard broke into a headlong gallop. Falkayn took aim and waited puzzledly for him to come in range of a beam wide enough to be surely lethal. The transceiver made muffled squawkings in Falkayn's pocket, but he hadn't the time for chatter.

Same objection, complexity, inefficiency, and fragility, applies to whatever else comes to mind, like say a treadmill-powered caterpillar system. Perhaps Romulo can flange something up. But there ought to be a foolproof, easy *answer.*

Crouched against the neck of his fastiga, the leading guard was nearly in range. Yes, now *in* range! Falkayn fired. The blast took the animal full in the chest. It cartwheeled several meters more downhill, under its own momentum, before falling. Its rider had left the saddle at the moment it was struck, before the beam could seek him out. He hit the ground with acrobatic agility, rolled over, and disappeared in the brush.

By the time Falkayn saw what was intended, he had already shot the second. It crashed into the barrier of the first. The third rushed near, frightened but under control.

"Oh, no, you don't," the human rasped. "I'm not going to build your wall for you!" He let the other two pound by. As they slewed about, exposing their riders to him, he had the bleak pleasure of killing an enemy. The fourth escaped out of range, jumped to earth, and ran toward the dead animals, leading his own but careful to stay on its far side.

Falkayn's bolts raked the slope, but he couldn't see his targets in the overgrowth and it was too moist in this spring season to catch fire. The third Larsan got to the barrier and slashed his fastiga's throat. It struggled, but hands reached from below to hold it there while it died.

So three warriors had made the course. Now they were ensconced behind a wall of their own, too thick for him to burn through, high enough for them to kneel behind and send arrows that would arch down onto him. Of course, their aim wouldn't be very good—

The shafts began to rise. Falkayn made himself as small as possible and tried to burrow under one of his own slain fastigas.

Something which . . . which rolls, and holds its load steady, but isn't circular—

The arrows fell. Their points went hard into dirt and inert flesh. After some time of barrage, a leonine head lifted above the other barrier to see what had happened. Falkayn, sensing a pause in the assault, rose to one knee and snapped a shot.

He ought to have hit, with a broad beam at such close

range. But he didn't. The bolt struck the barricade and greasy smoke puffed outward. The Larsan dove for cover.

What made Falkayn's hand jerk was suddenly seeing the answer.

He snatched out the radio. "Hello!" he yelped. "Listen, I know what we can do!"

"Anything, Davy," said Schuster like a prayer.

"Not for me. I mean to get you fellows out of here—"

The arrows hailed anew. Anguish ripped in Falkayn's left calf where he crouched. He stared at the shaft that skewered it, not really comprehending for a moment.

"Davy? You there?" Schuster cried across a thousand kilometers.

Falkayn swallowed hard. The wound didn't hurt too much, he decided. And the enemy had ceased fire again. They must be running low on ammo, too. The road was strewn with arrows.

"Listen carefully," he said to the box. It had fallen to the ground, and blood from his leg was trickling toward it. A dim part of him was interested to note that human blood in this light didn't have its usual brilliance but looked blackish red. The rate of flow indicated that no major vessel had been cut. "You know what a constant-width polygon is?" he asked.

A Larsan ventured another peek. When Falkayn didn't shoot, he rose to his feet for an instant and waved before dropping back to shelter. Falkayn was too busy to wonder what that meant.

"You hurt, Davy?" Schuster pleaded. "You don't sound so good. They still after you?"

"Shut up," Falkayn said. "I haven't much time. Listen. A figure of constant width is one that if you put it between two parallel lines, so they're tangent to it on opposite sides, and then revolve it, well, the lines stay tangent clear around the circumference. In other words, the width of the figure is the same along every line drawn from side to side through the middle. A circle is a member of that class, obviously. But—"

The Larsan whose left arm had been scorched to disability sprang from a clump of bushes along the road. There was a knife in his right hand. Falkayn caught the gleam in the corner of an eye, twisted about, and snatched for his blaster where it lay on the ground. The knife arm chopped through an arc. Falkayn shrieked as his own hand was pinned to earth.

"*Davy!*" Schuster cried.

Falkayn picked up the blaster with his left. The muzzle wavered back and forth. He shot and missed. The guard cleared the barrier at a jump, drawing his sword as he sprang. The blade swept around. Probably he had closed his eyes at the moment the gun went off, for he struck with accuracy. The weapon spun clear of Falkayn's lacerated grasp.

The human yanked out the knife that pinned him, surged to his feet, and attacked left-handed. His voice rose to a shout: "A circle's not the only one! You take an equi—"

His rush had brought him under the Larsan's guard. He stabbed, but the point slithered off the breastplate. The native shoved. Falkayn lurched backward. The guard poised his rapier.

"Equilateral triangle," Falkayn sobbed. "You draw arcs—"

A horn sounded. The guard recoiled with a snarl. On the hillside, an archer rose and sent a last arrow at Falkayn. But the human's hurt leg had given way. He went to his knees, and the shaft whirred where he had been.

Another arrow, from another direction, took the sword-wielder through the breast. He uttered a rather horrible rattling cough and fell on top of a fastiga. The surviving Sanctuary agents pointed frantically at the circles on their cuirasses. But arrows stormed from the riders who galloped out of the west, and the episode was over.

Rebo Legnor's-Child drew rein at the head of his household warriors and sprang from the saddle in time for Falkayn to crumple into his arms.

Mukerji entered the wardroom to find Schuster alone, laying out a hand of solitaire. "Where's Romulo?" he asked.

"Off in his own place, quietly going crazy," Schuster said. "He's trying to figure out what Davy was getting at just before—" He raised a face whose plumpness looked oddly pinched. "Heard anything from the kid?"

"No. I shall let you know the minute I do, of course. His set must still be on, I hear natives speak and move about. But not a word from him, and everyone else is probably afraid to answer the talking box."

"And *I* sent him there."

"You could not have known there was any danger."

"I could know the ship was the safest place to be. I should have gone myself." Schuster stared blindly at his cards. "He was my apprentice."

Mukerji laid a hand on the merchant's shoulder. "You had no business on a routine mission like that. Fighting and all, it was routine. Your brains are needed here."

"What brains?"

"You must have some plan. What were you talking to that peasant about, a few hours before sunrise?"

"I bribed him with a trade knife to carry a message for me to the Sanctuary. Telling Herktaskor he should come out for a private conference. Second in command of the astrology department, you may recall; a very bright fellow, and I think more friendly than otherwise to us. At least, he doesn't have Sketulo's fanatical resistance to innovation." Schuster found he was laying a heart on a diamond, cursed, and scattered the cards with a sweep of his hand. "Obviously Rebo showed up, having seen the gun flashes, and dealt with Sketulo's killers. But did he come in time? Is Davy still alive?"

The scanner hooted. Both men leaped to their feet and ran out the door to the closest viewscreen.

"Speak of the devil," Mukerji said. "Take over,

Martin. I shall go back and hunch above the radio."

Schuster suppressed his inward turmoil and opened the air lock. A cold early-morning wind, laden with sharp odors, gusted at him. Herktaskor mounted the gangway and entered. His great form was muffled in a cloak, which he did not take off until the door had closed again. Beneath, he wore his robes. Evidently he hadn't wanted to be recognized on his way here.

"Greeting," said Schuster in a dull tone. "Thank you for coming."

"Your message left me scant choice," said the Consecrate. "For the good of Larsum and the Faith, I am bound to listen if you claim to have an important matter to discuss."

"Have you, ah, been forbidden to enter the ship?"

"No, but it is as well not to give the Chief the idea that he should forbid it." Herktaskor squinted against an illumination which he found blindingly harsh, though it had been reduced well below normal to conserve the small amount of charge left in the accumulators. Schuster led the being to his own cabin, dimmed the lights further, and offered the lounger.

They sat down and regarded each other for a silent while. At length Herktaskor said, "If you repeat this, I shall have to call you a liar. But having found you honorable"—that hurt a little; Schuster's plans were not precisely aboveboard—"I think you should know that many Consecrates feel Sketulo was wrong in immediately banning your new mathematics and astrology. Could he show by scripture, tradition, or reasoning that they contravened the Word of God, then naturally the whole Sanctuary would have joined him in rejecting your teachings. But he has made no attempt to show it, has merely issued a flat decree."

"Are you permitted to argue with him about the matter?"

"Yes, the rule has always been that full-rank Consecrates may dispute freely within the bounds of doctrine. But we must obey the orders of our superiors as long as those are not themselves unlawful."

"I thought so. Well,"—Schuster reached for a cigar—"here is what I wanted to tell you. I wish the co-operation of the Sanctuary rather than its enmity. In order to win that co-operation, I would like to prove to you that we are no danger to the Faith, but may rather be the instruments of its furtherance. Then perhaps you can convince the others."

Herktaskor waited, impassive. Yet his eyes narrowed and seemed to kindle.

Schuster started the cigar and puffed ragged clouds. "The purpose of your astrology is to learn God's will and the plan on which He has constructed the universe. To me, this implies that the larger purpose of the Consecrates is to search out the nature of God, insofar as it may be understood by mortals. Your theologians have reached conclusions in the past. But are those conclusions final? May there not be much more to deduce?"

Herktaskor bowed his lion head and traced a solemn circle in the air. "There may. There must. Nothing of importance has been done in that field since the Book of Domno was written, but I myself have often speculated—Go on, I pray you."

"We newcomers are not initiates of your religion," Schuster said. "However, we too, in our own fashion, have spent many centuries wondering about the divine. We, too, believe," *well, some of us,* "in a single God, immortal, omnipotent, omniscient—perfect—Who made all things. Now maybe our theology varies from yours at crucial points. But maybe not. May I compare views with you? If you can show me where my people have erred, I will be grateful and will, if I live, carry back the truth to them. If, on the other hand, I can show you, or merely suggest to you, points on which our thought has gone beyond yours, then you will understand, and can make your colleagues understand, that we outlanders are no menace, but rather a beneficial influence."

"I doubt that Sketulo and stiff-minded Consecrates will ever concede that," Herktaskor said. His voice took on an edge. "Yet if a new truth were indeed revealed, and anyone dared deny it—" His fists unclenched. "I listen."

Schuster was not surprised. Every religion in Earth's past, no matter how exclusive in theory, had had influential thinkers who were willing to borrow ideas from contemporary rivals. He made himself as comfortable as possible. This would take a while.

"The first question I wish to raise," he said, "is why God created the universe. Have you any answer to that?"

Herktaskor started. "Why, no. The writings say only that He did. Dare we inquire into His reasons?"

"I believe so. See, if God is unbounded in every way, then He must have existed eternally before the world was. He is above everything finite. But thought and existence are themselves finite, are they not?"

"Well . . . well . . . yes. That sounds reasonable. Thought and existence as we know them, anyhow."

"Just so. I daresay your philosophers have argued whether the sound of a stone falling in the desert, unheard by any ears is a real phenomenon." Herktaskor nodded. "It is an old conundrum, found on countless planets, I mean in many countries. In like manner, a God alone in utter limitlessness could not be comprehended by thought nor described in words. No thinking, speaking creatures were there. Accordingly, in a certain manner of speaking,

He did not exist. That is to say, His existence lacked an element of completion, the element of being observed and comprehended. But how can the existence of the perfect God be incomplete? Obviously it cannot. Therefore, it was necessary for Him to bring forth the universe, that it might know Him. Do you follow me?"

Herktaskor's nod was tense. He had begun to breathe faster.

"Have I said anything thus far which contradicts your creed?" Schuster asked.

"No . . . I do not believe you have. Though this is so new—Go on!"

"The act of creation," Schuster said around his cigar, "must logically involve the desire to create, thought about the thing to be created, the decision to create, and the work of creation. Otherwise God would be acting capriciously, which is absurd. Yet such properties—desire, thought, decision, and work—are limited. They are inevitably focused on one creation, out of the infinite possibilities, and involve one set of operations. Thus the act of creation implies a degree of finitude in God. But this is unthinkable, even temporarily. Thus we have the paradox that He must create and yet He cannot. How shall this be resolved?"

"How do you resolve it?" Herktaskor breathed, looking a little groggy.

"Why, by deciding that the actual creation must have been carried out by ten intelligences known as the *Sephiroth* —"

"Hold on!" The Consecrate half rose. "These are no other gods, even lesser ones, and the Book does not credit the angels with making the world."

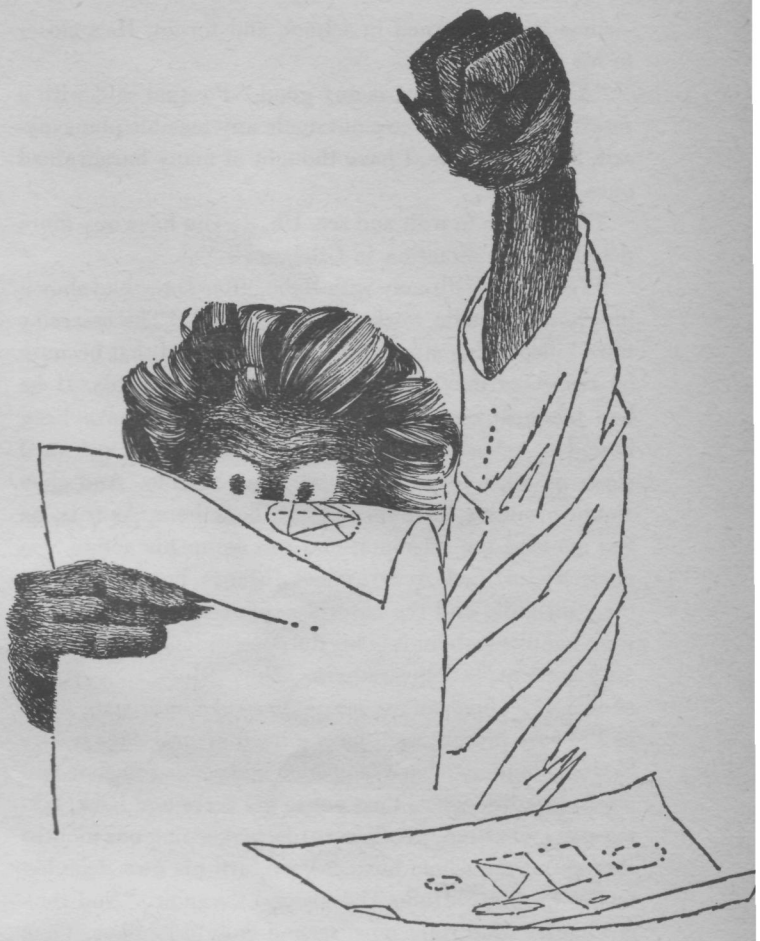
"Of course. Those I speak of are not gods or angels, they are separate manifestations of the One God, somewhat as the facets of a jewel are manifestations of it without being themselves jewels. God no doubt has infinitely many manifestations, but the ten *Sephiroth* are all that we have found logically necessary to explain the fact of creation. To begin with the first of them, the wish and idea of creation must have been coexistent with God from eternity. Therefore, it contains the nine others which are required as attributes of that which is to be created —"

Some hours later, Herktaskor said farewell. He walked like one in a daze. Schuster stood in the lock watching him go. He himself felt utterly exhausted.

If it turns out I've done this to him, to all of them, for nothing, may my own dear God forgive me.

Mukerji hurried from the wardroom. His feet clattered loudly on the deck. "Martin!" he yelled. "Davy's alive!"

Schuster spun on his heel. A wave of giddiness went through him and he leaned against the bulkhead.



"His call came after you went off with that Brahmin," Mukerji said. "I didn't know if I would do harm by interrupting you, so — Yes. He was wounded, hand and leg, nothing that won't heal, you know we need not worry about any local microbes. He fainted, and I imagine that he went directly from a swoon to a sleep. He could still only mumble when he called from Rebo's castle, said he would call back after he had gotten some more rest and explain his idea. Come, Romulo and I have already broken out a bottle to celebrate!"

"I could use that," Schuster said, and followed him.

After a few long swallows, he felt more himself. He set down his glass and gave the others a shaky grin. "Did you ever have anybody tell you you were not a murderer?" he asked. "That's how I'm feeling."

"Oh, come off it," Pasqual snorted. "You are not *that* responsible for your apprentices."

"No, maybe not, except I sent him where I could have gone myself— But he's O.K., you say!"

"Without you here on the spot, that might make very little difference," Pasqual said. "Krish is just a spaceman and I just an engineer and Davy just a kid. We need somebody to scheme our way out of this hole. And you, *amigo mío*, are a schemer by trade."

"Well, Davy seems to have thought of something. What, I don't know." Schuster shrugged. "Or maybe I do know

—some item I learned in school, and forgot. He's closer to his school days."

"Assuming his idea is any good," Pasqual said with a return of worry, "I have not made any feasible plans myself, but believe me, I have thought of many harebrained ones."

"We'll have to wait and see. Uh, do you have any more details on the situation in Gilrigor?"

"Yes, I spoke directly with Rebo, after Davy had shown him how the radio works," Mukerji said. "The assassins were killed in his attack. He said he ordered that because he suspected they were indeed Sanctuary guards. If he had taken any of them prisoner, he would have been bound to release them again, or else face an awkward clash of wills between himself and Sketulo. And they would promptly have taken word back here. As it is, he has avoided the dilemma, and can claim his action was perfectly justified. At arrowshot distance, he could not see their insignia, and the natural assumption was that they were bandits—whom it is his duty to eradicate."

"Excellent." Schuster chuckled. "Robo's a smart cookie. If he finds an excuse not to send a messenger here, as I'm sure he can, we'll have gained several days before Sketulo wonders what's happened and sends someone else out to inquire—who's then got to get there and back, taking still more time. In other words, by keeping our mouths shut about the whole business, we turn his own delaying tactics on him." He looked around the table. "And time is what we need right now, second only to haulage. Time for the Sanctuary to get so badly off balance, so embroiled internally, that no one can think up a new quasi-legal gimmick for stopping us."

"Be careful they are not driven to violence," Mukerji said.

"That's not too likely," Schuster replied. "The attempt on Davy was by stealth; I'm pretty sure Sketulo will disown his dead agents when the news breaks. Any decision to act with open illegality is tough for him, you see. It'd give people like Rebo much too good a talking point, or even an excuse to fight back. Besides, as I already remarked, time should now begin to work against the old geezer."

Pasqual cocked his head at the merchant. "What have you been brewing?"

"Well,"—Schuster reached for the bottle again, liquor gurgled cheerily into his glass—"First off, as you know, I introduced Newtonian astronomy. I disguised it as a fictional hypothesis, but that only makes it sneakier, not any less explosive. Nobody can fool himself forever with a pretense this is only a fairy tale to simplify his arithmetic. Sooner or later, he'll decide the planetary orbits really are elliptical. And that knocks a major prop out from under his belief in the sacredness of circles, which in turn will repercuss like crazy on the rest of the religion. Sketulo foresaw as much, and right away he forbade any use of my ideas. This simply delays the inevitable, though. He can't stop his astrologers from thinking, and some of them from resenting the prohibition. That'll make tension in the Sanctuary, which'll occupy a certain amount of his time and energy, which'll therefore be diverted from the problem of how to burke us."

"Nice," Mukerji frowned, "but a little long-range. The revolution might take fifty years to ripen."

"Admitted. The trend helps our cause, but not enough by itself. So today I got Herktaskor here. We talked theology."

"What? You can't upset a religion in an afternoon!"

"Oh, sure. I know that." Schuster took a drink. His grin broadened. "The *goyim* have been working on mine for two or three thousand years and got nowhere. I only pointed out certain logical implications of the local creed, and suggested some of the answers to those implications which've been reached on Earth."

"So?" Pasqual asked wonderingly.

"Well, you know I'm interested in the history of science and philosophy, like to read about it and so forth. Because of this, as well as some family traditions, I've got a knowledge of the Kabbalah—the system of medieval Jewish theosophy. In one form or another, it had tremendous influence for many centuries, even on Christian thought. But believe you me, it's the most fantastically complicated structure the human race ever built out of a few texts, a lot of clouds, and a logic that got the bit between its teeth. Jewish Orthodoxy never wanted any part of it—much too hairy, and among the Chasidim in particular it led to some wild emotional excesses.

"But it fits the Larsan system like a skin. For instance, in the Kabbalah there are nine subordinate emanations of God, who are the separate attributes of perfection. They're divided into three triads, each denoting one male and one female quality plus their union. There hasn't been much numerology here before now, but when I pointed out to Herktaskor that three points determine a circle, he gasped. Each of these triadic apices is identified with some part of the body of the archetypal man. The first *Sephirah* encircles the lot, which also accords nicely with Larsan symbolism, and the conjunction of them produces the universe . . . Well, never mind details. It goes on to develop techniques of letter rearrangement by which the inner meaning of Scripture can be discovered, a doctrine of triple reincarnation, a whole series of demonologies and magical prescriptions, altogether magnificent, glittering nonsense that seduced some of the best minds Earth ever knew. I gave it to Herktaskor."

"And—?" Mukerji asked very softly.

"Oh, not all. That'd take months. I just told him the bare outlines. He may or may not come back for more. That hardly matters. The damage has been done. Larsan philosophy is still rather primitive, not ready to deal with such strong meat. Religion is theoretically a pure monotheism, in practice tainted with the ghosties and ghoulies of popular superstition, and no one so far has given its premises a really thorough examination. Yet theology

does exist as a respectable enterprise. So the Consecrates are cocked and primed to go off, in an explosion of reinterpretations, reformations, counter-reformations, revelations, new doctrines, fundamentalistic reactions, and every other kind of hooraw we humans have been through. As I've already said, the Kabbalah sure had that effect on Earth. In time, this should break up the Sanctuary and let some fresh air into Larsum."

Schuster sighed. "I'm afraid the process will be bloody," he finished. "If I didn't think it was for the long-range best, I wouldn't have done this thing—not even to save our lives."

Pasqual looked bewildered. "You are too subtle for me," he complained. "Will it?"

"If we can move that generator here within the next few weeks, I'm certain it will. Herktaskor is no fool, even if he is a natural-born theologian. After what happened about the calculus, he'll be discreet about who he picks to talk my ideas over with. But those are good brains in the Sanctuary, hungry to be used. If fact is denied them to work with, theory will serve. The notions will spread like a shock wave. Questions will soon be openly raised. Sketulo can't lawfully suppress discussion of that sort, and the others will be too heated up to obey an unlawful order. So he's going to have his hands full, that guy, for the rest of his life!"

Rebo, Marchwarden of Gilrigor, reined in his fastiga on the crest of Ensum Hill. One hand, in an iron-knobbed gauntlet, pointed down the long slope. "Aesca," he said.

David Falkayn squinted through the day-gloom. To him the city was only a blot athwart the river's metal gleam. But a starpoint caught his eye, and the heart sprang within him. "Our ship," he breathed. "We are there."

Rebo peered across kilometers of fields and orchards. "No armed forces are gathered," he said. "I think I see the townsfolk beginning to swarm out, but no guards. Yet undoubtedly the Sanctuary has had word about us. So it is plain they do not intend to resist."

"Did you expect that—really?"

"I was not sure. That is why I brought so large a detachment of my own warriors." The cuirassed figure straightened in the saddle. The tail switched. "They would have been the ones breaking the law, had they tried to fight, so we would have had no compunctions. Not only the Wardens have chafed at the Consecrate bridle. My troop will be almost sorry not to bloody a blade this day."

"Not I." Falkayn shivered.

"Well," Rebo said, "peaceful or not, you have done more harm to them than I ever could. The world will not be the same again. So simple a thing as wagons—less toil, more goods moving faster, the age-old balance upset. And *I* will use some of that released power to overrun the Kasunians, which means I will be one to reckon with in the councils of the realm. Ever will you people be welcome in Gilrigor."

Falkayn dropped his glance, guiltily. "I cannot lie to you, my friend," he stumbled. "There may never be any more of us coming here."

"I had heard that," said Rebo, "and ignored it. Perhaps I did not wish to believe. No matter now." Pride rang in his tones. "One day our ships will come to you."

He raised his ax in signal. His riders deployed and the huge wagon lumbered over the ridge, drawn by twenty fastigas. The generator and crane lashed atop it glowed under the red sun.

The driver lowered his drag brake, a flat log, so the vehicle wouldn't get away from him on the downhill stretch. Groaning, squealing, banging, and rattling, the thing rocked onward.

It moved on eight rollers. They revolved between planks, the forward pair of which was adjustable by square pegs to permit turning. There were bumpers fore and aft to prevent their escape on an incline. As each roller emerged from the rear, two hooks caught two of the oblong metal eyes which ringed the grooves cut near either end of the log. These hooks were shrunk onto a pair of crossbraced, counterweighted arms mounted high on the wagon bed. The arms were held in place by leather straps within a frame that stopped sidewise motion, and pivoted on shapeless leather pads atop their posts. A couple of workers hauled lustily. The arms swung high. At the limit of their permissible arc, the carefully shaped hooks slipped out of the eyes and the roller fell onto a wooden roof that slanted downward to the front. Two other natives, equipped with peaveys, stood there to make certain of its alignment. It boomed quickly between its guideboards and dropped to the road behind the front bumper. The wagon passed over it, the arms dropped in time to catch the next log, and the cycle began anew.

Each roller had three curved sides.

Draw an equilateral triangle, ABC. Put the point of your compasses on A and draw the arc BC. Move to B and describe AC, then to C and describe AB. Round off the corners. The resulting figure has constant width. It will roll between two parallel lines tangent to it, maintaining that tangency for the whole revolution.

As a matter of fact, the class of constant-width polygons is infinite. The circle is merely a limiting case.

To be sure, Falkayn thought, the rollers on this goldberg of his would wear down in time, approach the forbidden crosssection and have to be replaced. Or would they? Someone like Rebo could argue that this proved the circle was actually the least perfect of all shapes, the degenerate product of a higher-order form. As if the poor old Consecrates didn't have theological problems enough!

He clucked to his mount and rode on ahead of the wagon, toward his ship. ■

Exactly three minutes after the Galactic left the New York apartment of Professor John Hamish McLeod, Ph.D., Sc.D., a squad of U.B.I. men pushed their way into it.

McLeod heard the door chime, opened the door, and had to back up as the eight men crowded in. The one in the lead flashed a fancily engraved ID card and said: "Union Bureau of Investigation. You're Professor Mac-Lee-Odd." It was a statement, not a question.

"No," McLeod said flatly, "I am not. I never heard of such a name." He waited while the U.B.I. man blinked once, then added: "If you are looking for Professor Muh-Cloud, I'm he." It always irritated him when people mispronounced his name, and in this case there was no excuse for it.

"All right, Professor McLeod," said the U.B.I. agent, pronouncing it properly this time, "however you want it. Mind if we ask you a few questions?"

McLeod stared at him for half a second. Eight men, all of them under thirty-five, in top physical condition. He was fifteen years older than the oldest and had confined his exercise, in the words of Chauncey de Pew, to "acting as pallbearer for my friends who take exercise." Not that he was really in poor shape, but he certainly couldn't have argued with eight men like these.

"Come in," he said calmly, waving them into the apartment.

Six of them entered. The other two stayed outside in the hall.

Five of the six remained standing. The leader took the chair that McLeod offered him.

"What are your questions, Mr. Jackson?" McLeod asked.

Jackson looked very slightly surprised, as if he were not used to having people read the name on his card during the short time he allowed them to see it. The expression vanished almost instantaneously. "Professor," he said, "we'd like to know what subjects you discussed with the Galactic who just left."

McLeod allowed himself to relax back in his chair. "Let me ask you two questions, Mr. Jackson. One: What the hell business is it of yours? Two: Why do you ask me when you already know?"

A WORLD BY THE TALE

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Again there was only a flicker of expression over Jackson's face. "Professor McLeod, we are concerned about the welfare of the human race. Your . . . uh . . . co-operation is requested."

"You don't have to come barging in here with an armed squad just to ask my co-operation," McLeod said. "What do you want to know?"

Jackson took a notebook out of his jacket pocket. "We'll just get a few facts straight first, professor," he said, leafing through the notebook. "You were first approached by a Galactic four years ago, on January 12, 1990. Is that right?"

McLeod, who had taken a cigarette from his pack and started to light it, stopped suddenly and looked at Jackson as though the U.B.I. man were a two-headed embryo. "Yes, Mr. Jackson, that is right," he said slowly, as though he were speaking to a low-grade moron. "And the capital of California is Sacramento. Are there any further matters of public knowledge you would like to ask me about? Would you like to know when the War of 1812 started or who is buried in Grant's Tomb?"

Jackson's jaw muscles tightened, then relaxed. "There's no need to get sarcastic, professor. Just answer the questions." He looked back at the notebook. "According to the record, you, as a zoologist, were asked to accompany a shipment of animals to a planet named . . . uh . . . Gelakin. You did so. You returned after eighteen months. Is that correct?"

"To the best of my knowledge, yes," McLeod said with heavy, biting sarcasm. "And the date of the Norman Conquest was A.D. 1066."

Jackson balled his fists suddenly and closed his eyes. "Mac. Loud. *Stop*. It." He was obviously holding himself under rigorous restraint. He opened his eyes. "There are reasons for asking these questions, professor. Very good reasons. Will you let me finish?"

McLeod had finished lighting his cigarette. He snapped his lighter off and replaced it in his pocket. "Perhaps," he said mildly. "May I make a statement first?"

Jackson took a deep breath, held it for a moment, then exhaled slowly. "Go ahead."

"Thank you." There was no sarcasm in McLeod's voice now, only patience. "First—for the record—I'll say that I consider it impertinent of you to come in here demanding information without explanation. No, Jackson; don't say anything. You said I could make a statement. Thank you. Second, I will state that I am perfectly aware of why the questions are being asked.

"No reaction, Mr. Jackson? You don't believe that? Very well. Let me continue.

"On January twelve, nineteen-ninety, I was offered a job by certain citizens of the Galactic Civilization. These citizens of the Galactic Civilization wanted to take a shipload of Terrestrial animals to their own planet, Gelakin. They knew almost nothing about the care and feeding of Terrestrial animals. They needed an expert. They should have taken a real expert—one of the men from the Bronx Zoo, for instance. They didn't; they requested a zoologist. Because the request was made here in America, I was the one who was picked. Any one of seven other men could have handled the job, but I was picked.

"So I went, thus becoming the first Earthman ever to leave the Solar System.

"I took care of the animals. I taught the Galactics who were with me to handle and feed them. I did what I was paid to do, and it was a hard job. None of them knew anything about the care and feeding of elephants, horses, giraffes, cats, dogs, eagles, or any one of the other hundreds of Terrestrial life forms that went aboard that ship.

"All of this was done with the express permission of the Terrestrial Union Government.

"I was returned to Earth on July seventeen, nineteen-ninety-one.

"I was immediately taken to U.B.I. headquarters and subjected to rigorous questioning. Then I was subjected to further questioning while connected to a polyelectroencephalograph. Then I was subjected to hearing the same questions over again while under the influence of various drugs—in sequence and in combination. The consensus at that time was that I was not lying nor had I been subjected to what is commonly known as 'brain washing'. My memories were accurate and complete.

"I did not know then, nor do I know now, the location of the planet Gelakin. This information was not denied me by the Galactics; I simply could not undestand the terms

they used. All I can say now—and all I could say then—is that Gelakin is some three point five kiloparsecs from Sol in the general direction of Saggitarius."

"You don't know any more about that now than you did then?" Jackson interrupted, suddenly and quickly.

"That's what I said," McLeod snapped. "And that's what I meant. Let me finish.

"I was handsomely paid for my work in Galactic money. They use the English word 'credit', but I'm not sure the English word has exactly the same meaning as the Galactic term. At any rate, my wages, if such I may call them, were confiscated by the Earth Government; I was given the equivalent in American dollars—after the eighty per cent income tax had been deducted. I ended up with just about what I would have made if I had stayed home and drawn my salary from Columbia University and the American Museum of Natural History.

"Please, Mr. Jackson. I only have a little more to say.

"I decided to write a book in order to make the trip pay off. 'Interstellar Ark' was a popularized account of the trip that made me quite a nice piece of change because every literate and half-literate person on Earth is curious about the Galactics. The book tells everything I know about the trip and the people. It is a matter of public record. Since that is so, I refuse to answer a lot of damfool questions—by which I mean that I refuse to answer any more questions that you already know the answers to. I am not being stubborn; I am just sick and tired of the whole thing."

Actually, the notoriety that had resulted from the trip and the book had not pleased McLeod particularly. He had never had any strong desire for fame, but if it had come as a result of his work in zoology and the related sciences he would have accepted the burden. If his "The Ecology of the Martian Polar Regions" had attracted a hundredth of the publicity and sold a hundredth of the number of copies that "Interstellar Ark" had sold, he would have been very gratified indeed. But the way things stood, he found the whole affair irksome.

Jackson looked at his notebook as if he expected to see answers written there instead of questions. Then he looked back up at McLeod. "All right then, professor, what about this afternoon's conference. *That* isn't a matter of public record."

"And technically it isn't any of your business, either," McLeod said tiredly. "But since you have the whole conversation down on tape, I don't see why you bother asking me. I'm well aware that you can pick up conversations in my apartment."

Jackson pursed his lips and glanced at another of the agents, who raised his eyebrows slightly.

McLeod got it in spite of the fact that they didn't intend him to. His place was bugged, all right, but somehow the Galactic had managed to nullify their instruments! No wonder they were in such a tizzy.

McLeod smiled, pleased with himself and with the world for the first time that afternoon. He decided, however, that he'd better volunteer the information before they threatened him with the Planetary Security Act. That threat would make him angry, he knew, and he might say something that would get him in real trouble.

It was all right to badger Jackson up to a certain point, but it would be foolish to go beyond that.

"However," he went on with hardly a break, "since, as you say, it is not a matter of public record, I'm perfectly willing to answer any questions you care to ask."

"Just give us a general rundown of the conversation," Jackson said. "If I have any questions, I'll . . . uh . . . ask them at the proper time."

McLeod did the best he could to give a clear picture of what the Galactic had wanted. There was really very little to it. The Galactic was a member of a race that McLeod had never seen before: a humanoid with red skin—fire-engine, not Amerindian—and a rather pleasant-looking face, in contrast to the rather crocodilian features of the Galactic resident. He had introduced himself by an unpronounceable name and then had explained that since the name meant "mild" or "merciful" in one of the ancient tongues of his planet, it would be perfectly all right if McLeod called him "Clement." Within minutes, it had been "Clem" and "Mac."

McLeod could see that Jackson didn't quite believe that. Galactics, of whatever race, were aloof, polite, reserved, and sometimes irritatingly patronizing—never buddy-buddy. McLeod couldn't help what Jackson might think; what was important was that it was true.

What Clem wanted was very simple. Clem was—after a manner of speaking—a literary agent. Apparently the Galactic system of book publishing didn't work quite the way the Terrestrial system did; Clem took his commission from the publisher instead of the author, but was considered a representative of the author, not the publisher. McLeod hadn't quite understood how that sort of thing would work out, but he let it pass. There were a lot of things he didn't understand about Galactics.

All Clem wanted was to act as McLeod's agent for the publication of "Interstellar Ark."

"And what did you tell him?" Jackson asked.

"I told him I'd think it over."

Jackson leaned forward. "How much money did he offer?" he asked eagerly.

"Not much," McLeod said. "That's why I told him I'd think it over. He said that, considering the high cost of transportation, relaying, translation, and so on, he couldn't offer me more than one thousandth of one per cent royalties."

Jackson blinked. " One *what?*"

"One thousandth of one per cent. If the book sells a hundred thousand copies at a credit a copy, they will send me a nice, juicy check for one lousy credit."

Jackson scowled. "They're cheating you."

"Clem said it was the standard rate for a first book."

Jackson shook his head. "Just because we don't have

interstellar ships and are confined to our own solar system, they treat us as though we were ignorant savages. They're cheating you high, wide, and handsome."

"Maybe," said McLeod. "But if they really wanted to cheat me, they could just pirate the book. There wouldn't be a thing I could do about it."

"Yeah. But to keep up their facade of high ethics, they toss us a sop. And we have to take whatever they hand out. You *will* take it, of course." It was more of an order than a question.

"I told him I'd think it over," McLeod said.

Jackson stood up. "Professor McLeod, the human race needs every Galactic credit it can lay its hands on. It's your duty to accept the offer, no matter how lousy it is. We have no choice in the matter. And a Galactic credit is worth ten dollars American, four pounds U.K., or forty rubles Soviet. If you sell a hundred thousand copies of your book, you can get yourself a meal in a fairly good restaurant and Earth will have one more Galactic credit stashed away. If you don't sell that many, you aren't out anything."

"I suppose not," McLeod said slowly. He knew that the Government could force him to take the offer. Under the Planetary Security Act, the Government had broad powers—very broad.

"Well, that isn't my business right now," Jackson said. "I just wanted to find out what this was all about. You'll hear from us, Professor McLeod."

"I don't doubt it," said McLeod.

The six men filed out the door.

Alone, McLeod stared at the wall and thought.

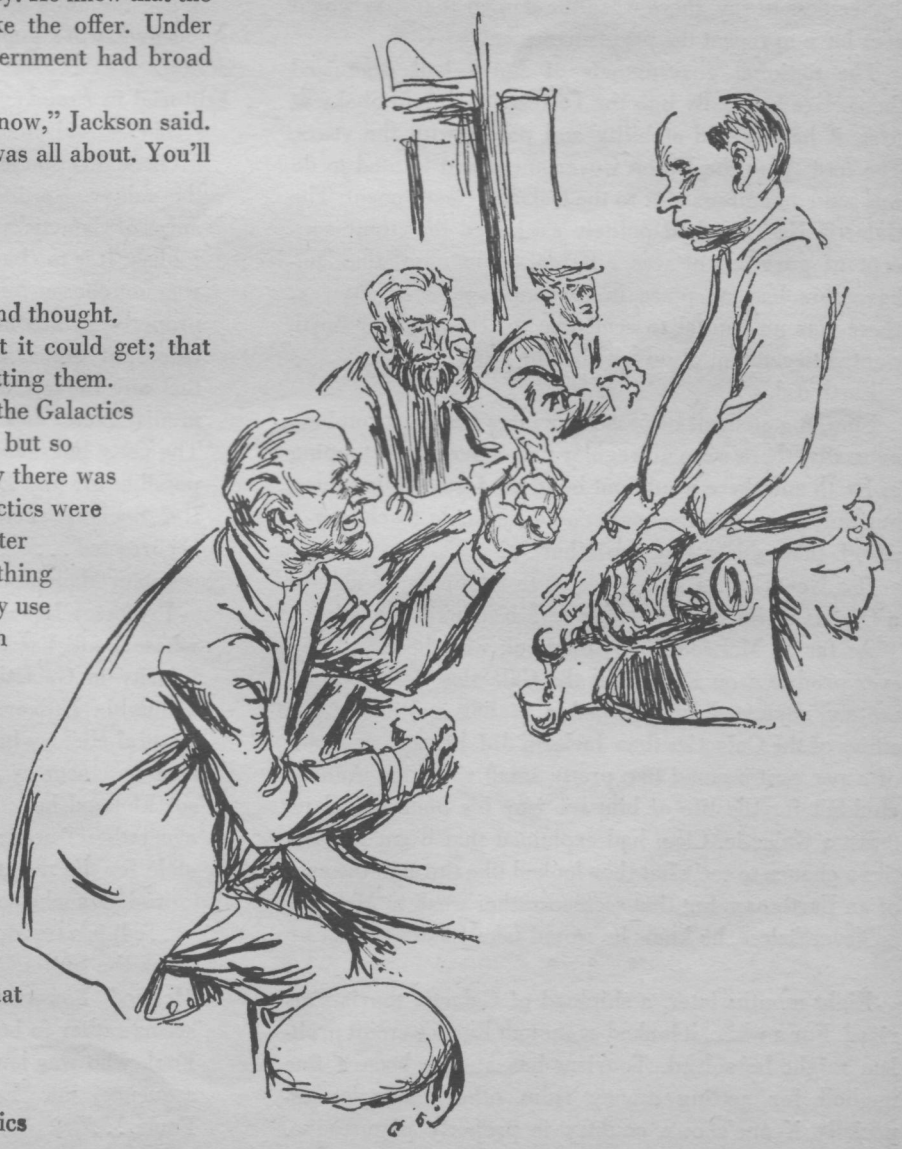
Earth needed every Galactic credit it could get; that was certain. The trouble came in getting them.

Earth had absolutely nothing that the Galactics wanted. Well, not absolutely, maybe, but so near as made no difference. Certainly there was no basis for trade. As far as the Galactics were concerned, Earth was a little backwater planet that was of no importance. Nothing manufactured on the planet was of any use to Galactics. Nothing grown on Earth was of any commercial importance. They had sampled the animals and plants for scientific purposes, but there was no real commercial value in them. The Government had added a few credits to its meager collection when the animals had been taken, but the amount was small.

McLeod thought about the natives of New Guinea and decided that on the Galactic scale Earth was about in the same position. Except that there had at least been gold in New Guinea. The Galactics didn't have any interest in Earth's minerals; the elements were much more easily available in the asteroid belts that nearly every planetary system seemed to have.

The Galactics were by no means interested in bringing civilization to the barbarians of Earth, either. They had no missionaries to bring a new religion, no do-gooders to "elevate the cultural level of the natives." They had no free handouts for anyone. If Earthmen wanted anything from them, the terms were cash on the barrelhead. Earth's credit rating in the Galactic equivalent of Dun & Bradstreet was triple-Z-zero.

A Galactic ship had, so to speak, stumbled over Earth fifteen years before. Like the English explorers of the Eighteenth and Nineteenth Centuries, the Galactics seemed to feel that it was necessary to install one of their own people on a new-found planet, but they were not in the least interested in colonization nor in taking over Earth's government. The Galactic Resident was not in



any sense a Royal Governor, and could hardly even be called an ambassador. He and his staff—a small one, kept more for company than for any necessary work—lived quietly by themselves in a house they'd built in Hawaii. Nobody knew what they did, and it didn't seem wise to ask.

The first Galactic Resident had been shot and killed by some religious nut. Less than twenty-four hours later, the Galactic Space Navy—if that was the proper term—had come to claim the body. There were no recriminations, no reprisals. They came, "more in sorrow than in anger," to get the body. They came in a spaceship that was easily visible to the naked eye long before it hit the atmosphere—a sphere three kilometers in diameter. The missiles with thermonuclear warheads that were sent up to intercept the ship were detonated long before they touched the ship, and neither Galactics nor Earthmen ever mentioned them again. It had been the most frightening display of power ever seen on Earth, and the Galactics hadn't even threatened anyone. They just came to get a body.

Needless to say, there was little danger that they would ever have to repeat the performance.

The national governments of Earth had organized themselves hurriedly into the Terrestrial Union. Shaky at first, it had gained stability and power with the years. The first thing the Union Government had wanted to do was send an ambassador to the Galactic Government. The Galactic Resident had politely explained that their concept of government was different from ours, that ambassadors had no place in that concept, and, anyway, there was no capital to send one to. However, if Earth wanted to send an observer of some kind . . .

Earth did.

Fine. A statement of passenger fares was forthcoming; naturally, there were no regular passenger ships stopping at Earth and there would not be in the foreseeable future, but doubtless arrangements could be made to charter a vessel. It would be expensive, but . . .

If a New Guinea savage wants to take passage aboard a Qantas airliner, what is the fare in cowrie shells?

As far as McLeod knew, his book was the first thing ever produced on Earth that the Galactics were even remotely interested in. He had a higher opinion of the ethics of the Galactics than Jackson did, but a thousandth of a per cent seemed like pretty small royalties. And he couldn't for the life of him see why his book would interest a Galactic. Clem had explained that it gave Galactics a chance to see what they looked like through the eyes of an Earthman, but that seemed rather weak to McLeod.

Nevertheless, he knew he would take Clem's offer.

* * *

Eight months later, a shipload of Galactic tourists arrived. For a while, it looked as though Earth's credit problem might be solved. Tourism has always been a fine method for getting money from other countries—especially if one's own country is properly picturesque. Tourists always had money, didn't they? And they spend it freely, didn't they?

No.

Not in this case.

Earth had nothing to sell to the tourists.

Ever hear of *baluks?* The Melanesians of the South Pacific consider it a very fine delicacy. You take a fertilized duck egg and you bury it in the warm earth. Six months later, when it is nice and overripe, you dig it up again, knock the top off the shell the way you would a soft-boiled egg, and eat it. Then you pick the pinfeathers out of your teeth. *Baluks.*

Now you know how the greatest delicacies of Earth's restaurants affected the Galactics.

Earth was just a little *too* picturesque. The tourists enjoyed the sights, but they ate aboard their ship, which was evidently somewhat like a Caribbean cruise ship. And they bought nothing. They just looked.

And laughed.

And of course they all wanted to meet Professor John Hamish McLeod.

When the news leaked out and was thoroughly understood by Earth's population, there was an immediate reaction.

Editorial in *Pravda:*

> The stupid book written by the American J. H. McLeod has made Earth a laughingstock throughout the galaxy. His inability to comprehend the finer nuances of Galactic Socialism has made all Earthmen look foolish. It is too bad that a competent Russian zoologist was not chosen for the trip that McLeod made; a man properly trained in the understanding of the historical forces of dialectic materialism would have realized that any Galactic society must of necessity be a Communist State, and would have interpreted it as such. The petty bourgeois mind of McLeod has made it impossible for any Earthman to hold up his head in the free Socialist society of the galaxy. Until this matter is corrected . . .

News item Manchester *Guardian:*

> Professor James H. McLeod, the American zoologist whose book has apparently aroused a great deal of hilarity in Galactic circles, admitted today that both Columbia University and the American Museum of Natural History have accepted his resignation. The recent statement by a University spokesman that Professor McLeod had "besmirched the honor of Earthmen everywhere" was considered at least partially responsible for the resignations. (See editorial.)

Editorial, Manchester *Guardian:*

> . . . It is a truism that an accepted wit has only to say, 'Pass the butter,' and everyone will laugh. Professor McLeod, however, far from being an accepted wit, seems rather to be in the position of a medieval Court Fool, who was laughed *at* rather than *with.* As a consequence, all Earthmen have been branded as Fools. . . ."

Statement made by the American Senator from Alabama:

"He has made us all look like jackasses in the eyes of the Galactics, and at this precarious time in human history it is my considered opinion that such actions are treasonous to the human race and to Earth and should be treated and considered as such!"

Book review, *Literary Checklist,* Helvar III, Bomis Cluster:

"Interstellar Ark, an Earthman's View of the Galaxy," translated from the original tongue by Vonis Delf, Cr. 5.00. This inexpensive little book is one of the most entertainingly funny publications in current print. The author, one John McLeod, is a member of a type 3-7B race inhabiting a planet in the Outer Fringes. . . . As an example of the unwitting humor of the book, we have only to quote the following:

"I was shown to my quarters shortly before takeoff. Captain Benarly had assigned me a spacious cabin which was almost luxurious in its furnishings. The bed was one of the most comfortable I have ever slept in." Or the following:

"I found the members of the crew to be friendly and co-operative, especially Nem Cronzel, the ship's physician."

It is our prediction that this little gem will be enjoyed for a long time to come and will be a real money-maker for its publishers.

* * *

They haven't hanged me yet, McLeod thought. He sat in his apartment alone and realized that it would take very little to get him hanged.

How could one book have aroused such wrath? Even as he thought it, McLeod knew the answer to that question. It wasn't the book. No one who had read it two and a half years before had said anything against it.

No, it wasn't the book. It was the Galactic reaction to the book. Already feeling inferior because of the stand-offish attitude of the beings from the stars, the Homeric laughter of those same beings had been too much. It would have been bad enough if that laughter had been generated by one of the Galactics. To have had it generated by an Earthman made it that much worse. Against an Earthman, their rage was far from impotent.

Nobody understood *why* the book was funny, of course. The joke was over their heads, and that made human beings even angrier.

He remembered a quotation from a book he had read once. A member of some tribal-taboo culture—African or South Pacific, he forgot which—had been treated at a missionary hospital for something or other and had described his experience.

"The white witch doctor protects himself by wearing a little round mirror on his head which reflects back the evil spirits."

Could that savage have possibly understood what was humorous about that remark? No. Not even if you explained to him why the doctor used the mirror that way.

Now what? McLeod thought. He was out of a job and his bank account was running low. His credit rating had dropped to zero.

McLeod heard a key turn in the lock. The door swung open and Jackson entered with his squad of U.B.I. men.

"Hey!" said McLeod, jumping to his feet. "What do you think this is?"

"Shut up, McLeod," Jackson growled. "Get your coat. You're wanted at headquarters."

McLeod started to say something, then thought better of it. There was nothing he could say. Nobody would care if the U.B.I. manhandled him. Nobody would protest that his rights were being ignored. If McLeod got his teeth knocked in, Jackson would probably be voted a medal.

McLeod didn't say another word. He followed orders. He got his coat and was taken down to the big building on the East River which had begun its career as the United Nations Building.

He was bundled up to an office and shoved into a chair. Somebody shoved a paper at him. "Sign this!"

"What is it?" McLeod asked, finding his voice.

"A receipt. For two thousand dollars. Sign it."

McLeod looked the paper over, then looked up at the burly man who had shoved it at him. "*Fifty thousand Galactic credits!* What is this for?"

"The royalty check for your unprintably qualified book has come in, Funny Man. The Government is taking ninety-eight per cent for income taxes. Sign!"

McLeod pushed the paper back across the desk. "No. I won't. You can confiscate my money. I can't stop that, I guess. But I won't give it legal sanction by signing anything. I don't even see the two thousand dollars this is supposed to be a receipt for."

Jackson, who was standing behind McLeod, grabbed his arm and twisted. "Sign!" His voice was a snarl in McLeod's ear.

Eventually, of course, he signed.

* * *

"'Nother beer, Mac?" asked the bartender with a friendly smile.

"Yeah, Leo; thanks." McLeod pushed his quarter across the bar with one hand and scratched negligently at his beard with the fingers of the other. Nobody questioned him in this neighborhood. The beard, which had taken two months to grow, disguised his face, and he had given his name as McCaffery, allowing his landlord and others who heard it to make the natural assumption that he was of Irish descent.

He was waiting. He had been forced to move from his apartment; nobody wanted that dirty so-and-so, Professor McLeod, around. Besides, his money was running short. He had never seen the two thousand. "You'll get that when the Galactic bank cashes your royalty check," he had been told. He was waiting.

Not hiding. No. That wasn't possible. The U.B.I. could

find him easily when they wanted him. There was no place he could have hidden from them for very long. A man needs friends to stay hidden from an efficient police organization for very long, and John Hamish McLeod had no friends. "Jack McCaffery" had, since he was a pleasant kind of fellow who made friends easily when he wanted them. But he had no illusions about his new friends. Let them once suspect, however faintly, that Good Old Jack McCaffery was really that Professor McLeod, and the game would be up.

The U.B.I. would find him again all right, whenever it wanted him. And McLeod hoped it would be soon because he was down to his last hundred bucks.

So he waited and thought about fifty thousand Galactic credits.

The mathematics was simple, but it conveyed an awful lot of information. To make fifty thousand credits from one thousandth of one per cent royalties on a book selling at five credits the copy, one must needs sell a billion copies. Nothing to it.

$$5X \cdot 10^{-5} = 5 \cdot 10^{4}$$

Ergo: $X = 10^{9}$

McLeod drew the equations on the bar with the tip of a wet forefinger, then rubbed them out quickly.

A billion copies in the first year. He should have seen it. He should have understood.

How many planets were there in the galaxy?

How many people on each planet?

Communication, even at ultralight velocities, would be necessarily slow. The galaxy was just too big to be compassed by the human mind—or even by the mind of a Galactic, McLeod suspected.

How do you publish a book for Galactic, for galaxy-wide, consumption? How long does it take to saturate the market on each planet? How long does it take to spread the book from planet to planet? How many people were there on each planet who would buy a good book? Or, at least, an entertaining one.

McLeod didn't know, but he suspected that the number was huge. McLeod was a zoologist, not an astronomer, but he read enough on astronomy to know that the estimated number of Earth-type planets alone—according to the latest theory—ran into the tens of millions or hundreds of millions. The—

A man sat down on the stool next to McLeod and said something loud enough and foul enough to break the zoologist's train of thought.

"Gimme a shot, Leo," he added in an angry voice.

"Sure, Pete," the bartender said. "What's the trouble?"

"*Tourists,*" Pete said with a snarl. "Laffin' attus alla time like we was monkeys inna zoo! Bunch 'em come inta day." He downed his whiskey with a practiced flip of the wrist and slammed it on the bar. Leo refilled it immediately. "I shunt gripe, I guess. Gotta haffa credit offen 'em." He slapped down a five dollar bill as though it had somehow been contaminated.

The bar became oddly quiet. Everyone had heard Pete. Further, everyone had heard that another shipload of Galactics had landed and were, at the moment, enjoying the sights of New York. A few of them knew that Pete was the bell-captain in one of the big midtown hotels.

McLeod listened while Pete expounded on the shame he had had to undergo to earn half a credit—a lousy five bucks.

McLeod did some estimating. Tourists—the word had acquired an even more pejorative sense than it had before, and now applied only to Galactics—bought nothing, but they tipped for services, unless the services weren't wanted or needed. Pete had given them information that they hadn't had before—where to find a particular place. All in all, the group of fifteen Galactics had given out five or six credits in such tips. Say half a credit apiece. There were, perhaps, a hundred Galactics in this shipload. That meant fifty credits. Hm-m-m.

They didn't need anyone to carry their bags; they didn't need anyone to register them in hotels; they didn't need personal service of that kind. All they wanted to do was look. But they wouldn't pay for looking. They had no interest in Broadway plays or the acts in the night-clubs—at least, not enough to induce them to pay to see them. This particular group had wanted to see a hotel. They had wandered through it, looking at everything and laughing fit to kill at the carpets on the floor and the electric lighting and such. But when the management had hinted that payment for such services as letting them look should be forthcoming, they had handed half a credit to someone and walked out. Then they had gone to the corner of Fifty-first and Madison and looked for nothing.

Fifty credits for a shipload. Three shiploads a year. Hell, give 'em the benefit of the doubt and say *ten* shiploads a year. In a hundred years, they'd add another fifty thousand to Earth's resources.

McLeod grinned.

And waited.

* * *

They came for him, eventually, as McLeod had known they would.

But they came long before he had expected. He had given them six months at the least. They came for him at the end of the third month.

It was Jackson, of course. It would have to be Jackson. He walked into the cheap little room McLeod had rented, followed by his squad of men.

He tossed a peculiar envelope on the bed next to McLeod.

"Letter came for you, humorist. Open it."

McLeod sat on the edge of the bed and read the letter. The envelope had already been opened, which surprised him none.

It looked very much like an ordinary business letter—except that whatever they used for paper was whiter and tougher than the paper he used.

He was reminded of the time he had seen a reproduction of a Thirteenth Century manuscript alongside the

original. The copy had been set up in a specially-designed type and printed on fine paper. The original had been handwritten on vellum.

McLeod had the feeling that if he used a microscope on this letter the lines and edges would be just as precise and clear as they appeared to the naked eye, instead of the fuzziness that ordinary print would show.

The way you tell a synthetic ruby from a natural ruby is to look for flaws. The synthetic doesn't have any.

This letter was a Galactic imitation of a Terran business letter.

It said:

Dear Mac,

I am happy to report that your book, "Interstellar Ark," is a smash hit. It looks as though it is on its way to becoming a best seller. As you already know by your royalty statement, over a billion copies were sold the first year. That indicates even better sales over the years to come as the reputation of the book spreads. Naturally, our advertising campaign will remain behind it all the way. Congratulations.

Speaking of royalty checks, there seems to be some sort of irregularity about yours. I am sorry, but according to regulations the check must be validated in the presence of your Galactic Resident before it can be cashed. Your signature across the back of it doesn't mean anything to our bankers.

Just go to your Galactic Resident, and he'll be happy to take care of the matter for you. That's what he's there for. The next check should come through very shortly.

All the best,

Clem.

Better and better, McLeod thought. He hadn't expected to be able to do anything until his next royalty check arrived. But now—

He looked up at Jackson. "All right. What's next?"

"Come with us. We're flying to Hawaii. Get your hat and coat."

McLeod obeyed silently. At the moment, there was nothing else he could do. As a matter of fact, there was nothing he wanted to do more.

It was no trouble at all for Professor McLeod to get an audience with the Galactic Resident, but when he was escorted in by Jackson and his squad, the whole group was halted inside the front door.

The Resident, a tall, lean being with a leathery, gray face that somehow managed to look crocodilian in spite of the fact that his head was definitely humanoid in shape, peered at them from beneath pronounced supraorbital ridges. "Is this man under arrest?" He asked in a gravelly baritone.

"Er . . . no," said Jackson. "No. He is merely in protective custody."

"He has not been convicted of any crime?"

"No sir," Jackson said. His voice sounded as though he were unsure of himself.

"That is well," said the Resident. "A convicted criminal cannot, of course, use the credits of society until he has become rehabilitated." He paused. "But why protective custody?"

"There are those," said Jackson, choosing his words with care, "who feel that Professor McLeod has brought disgrace upon the human race . . . er . . . the Terrestrial race. There is reason to believe that his life may be in danger."

McLeod smiled wryly. What Jackson said was true, but it was carefully calculated to mislead.

"I see," said the Resident. "It would appear to me that it would be simple to inform the people that he has done no such thing; that, indeed, his work has conferred immense benefits upon your race. But that is your own affair. At any rate, he is in no danger here."

He didn't need to say anything else. Jackson knew the hint was an order and that he wouldn't get any farther with his squad.

McLeod spoke up. "Subject to your permission, sir, I would like to have Mr. Jackson with me."

The Galactic Resident smiled. "Of course, professor. Come in, both of you." He turned and led the way through the inner door.

Nobody bothered to search either of them, not even though they must know that Jackson was carrying a gun. McLeod was fairly certain that the gun would be useless to Jackson if he tried to assert his authority with it. If Clem had been able to render the U.B.I.'s eavesdropping apparatus inoperable, it was highly probable that the Galactic Resident would have some means of taking care of weapons.

"There are only a few formalities to go through," the Resident said pleasantly, indicating chairs with a gesture. The room he had led them to didn't look much different from that which would be expected in any tastefully furnished apartment in New York or Honolulu.

McLeod and Jackson sat down in a couple of comfortable easy-chairs while the Resident went around a large desk and sat down in a swivel chair behind it. He smiled a little and looked at McLeod. "Hm-m-m. Ah, yes. Very good." It was as though he had received information of some kind on an unknown subject through an unknown channel, McLeod thought. Evidently that was true, for his next words were: "You are not under the influence of drugs nor hypnotic compulsion, I see. Excellent, professor. Is it your desire that this check be converted to cash?" He made a small gesture. "You have only to express it, you see. It would be difficult to explain it to you, but rest assured that such an expression of will—while you are sitting in that chair—is impressed upon the structure of the check itself and is the equivalent of a signature. Except, of course, that it is unforgeable."

"May I ask a few questions first?" McLeod said.

"Certainly, professor. I am here to answer your questions."

"This money—is it free and clear, or are there Galactic taxes to pay?"

If the Galactic Resident had had eyebrows, it is likely that they would have lifted in surprise. "My dear professor! Aside from the fact that we run our . . . er . . . government in an entirely different manner, we would consider it quite immoral to take what a man earns without giving services of an exact kind. I will charge you five credits for this validation, since I am rendering a service. The bank will take a full tenth of a percent in this case because of the inconvenience of shipping cash over that long distance. The rest is yours to do with as you see fit."

Fifty-five credits out of fifty thousand, McLeod thought. *Not bad at all.* Aloud, he asked: "Could I, for instance, open a bank account or buy a ticket on a starship?"

"Why not? As I said, it is your money. You have earned it honestly; you may spend it honestly."

Jackson was staring at McLeod, but he said nothing.

"Tell me, sir," McLeod said, "how does the success of my book compare with the success of most books in the galaxy?"

"Quite favorably, I understand," said the Resident. "The usual income from a sucessful book is about five thousand credits a year. Some run even less than that. I'm not too familiar with the publishing business, you understand, but that is my impression. You are, by Galactic standards, a very wealthy man, professor. Fifty thousand a year is by no means a median income."

"Fifty thousand a *year?*"

"Yes. About that. I understand that in the publishing business one can depend on a life income that does not vary much from the initial period. If a book is successful in one area of the galaxy it will be equally successful in others."

"How long does it take to saturate the market?" McLeod asked with a touch of awe.

"Saturate the—? Oh. Oh, I see. Yes. Well, let's see. Most publishing houses can't handle the advertising and marketing on more than a thousand planets at once—the job becomes to unwieldly. That would indicate that you sold an average of a million copies per planet, which

is unusual but not . . . ah . . . miraculous. That is why you can depend on future sales, you see; over a thousand planets the differences in planetary tastes averages out.

"Now if your publishers continue to expand the publication at the rate of a thousand planets a year, your book should easily last for another century. They can't really expand that rapidly, of course, since the sales on the planets they have already covered will continue with diminishing success over the next several years. Actually, your publishers will continue to put a billion books a year on the market and expand to new planets at a rate that will balance the loss of sales on the planets where it has already run its course. Yes, professor, you will have a good income for life."

"What about my heirs?"

"Heirs?" The Galactic Resident blinked. "I'm afraid I don't quite follow you."

"My relatives. Anyone who will inherit my property after my death."

The Resident still looked puzzled. "What about them?"

"How long can they go on collecting? When does the copyright run out?"

The Galactic Resident's puzzlement vanished. "Oh my dear professor! Surely you see that it is impossible to . . . er . . . inherit money one hasn't earned! The income stops with your death. Your children or your wife have done nothing to earn that money. Why should it continue to be paid out after the earner has died? If you wish to make provisions for such persons during your lifetime, that is your business, but the provisions must be made out of money you have already earned."

"Who does get the income, then?" McLeod asked.

The Galactic Resident looked thoughtful. "Well, the best I can explain it to you without going into arduous detail is to say that our . . . er . . . government gets it. 'Government' is not really the proper word in this context, since we have no government as you think of it. Let us merely say that such monies pass into a common exchequer from which . . . er . . . public servants like myself are paid."

McLeod had a vision of a British Crown Officer trying to explain to a New Guinea tribesman what he meant when he said that taxes go to the Crown. The tribesman would probably wonder why the Chief of the English Tribe kept cowrie shells in his hat.

"I see. And if I am imprisoned for crime?" he asked.

"The payments are suspended until the . . . er . . . rehabilitation is complete. That is, until you are legally released."

"Is there anything else that can stop the payments?"

"No unless the publishing company fails—which is highly unlikely. Of course, a man under hypnotic compulsion or drugs is not considered legally responsible, so he cannot transact any legal business while he is in that state, but the checks are merely held for him until that impediment is removed."

"I see." McLeod nodded.

He knew perfectly well that he no more understood the entire workings of the Galactic civilization than that New Guinea tribesman understood the civilization of Great Britain, but he also knew that he understood more of it than Jackson, for instance, did. McLeod had been able to foresee a little of what the Resident had said.

"Would you do me the service, sir," McLeod said, "of opening a bank account for me in some local bank?"

"Yes, of course. As Resident, I am empowered to transact business for you at your request. My fees are quite reasonable. All checks will have to go through me, of course, but . . . hm-m-m . . . I think in this case a twentieth of a per cent would be appropriate. You will be handling fairly large amounts. If that is your wish, I shall so arrange it."

"Hey!" Jackson found his tongue. "The Earth Union Government has a claim on that! McLeod owes forty-nine thousand Galactic credits in income taxes!"

If the Galactic Resident was shocked at the intimation that the Galactic "government" would take earned money from a man, the announcement that Earth's government did so was no surprise to him at all. "If that is so, I am certain that Professor McLeod will behave as a law-abiding citizen. He can authorize a check for that amount, and it will be honored by his bank. We have no desire to interfere with local customs."

"I am certain that I can come to an equitable arrangement with the Earth authorities," said McLeod, rising from his chair. "Is there anything I have to sign or—"

"No, no. You have expressed your will. Thank you, Professor McLeod; it is a pleasure to do business with you."

"Thank you. The pleasure is mutual. Come on, Jackson, we don't need to bother the Resident any more just now."

"But—"

"Come on, I said! I want a few words with you!" McLeod insisted.

Jackson sensed that there would be no point in arguing any further with the Resident, but he followed McLeod out into the bright Hawaiian sunshine with a dull glow of anger burning in his cheeks. Accompanied by the squad, they climbed into the car and left.

As soon as they were well away from the Residence, Jackson grabbed McLeod by the lapel of his jacket. "All right, humorist! What was the idea of that? Are you trying to make things hard for yourself?"

"No, but *you* are," McLeod said in a cold voice. "Get your hands off me. I may get you fired anyway, just because you're a louse, but if you keep acting like this, I'll see that they toss you into solitary and toss the key away."

"What are you talking about?" But he released his hold.

"Just think about it, Jackson. The Government can't get its hands on that money unless I permit it. As I said, we'll arrive at an equitable arrangement. And that will be

a damn sight less than ninety-eight percent of my earnings, believe me."

"If you refuse to pay, we'll—" He stopped suddenly.

"—Throw me in jail?" McLeod shook his head. "You can't get money while I'm in jail."

"We'll wait," said Jackson firmly. "After a little while in a cell, you'll listen to reason and will sign those checks."

"You don't think very well, do you, Jackson? To 'sign' a check, I have to go to the Galactic Resident. As soon as you take me to him, I authorize a check to buy me a ticket for some nice planet where there are no income taxes."

Jackson opened his mouth and shut it again, frowning.

"Think about it, Jackson," McLeod continued. "Nobody can get that money from me without my consent. Now it so happens that I want to help Earth; I have a certain perverse fondness for the human race, even though it is inconceivably backwards by Galactic standards. We have about as much chance of ever becoming of any importance on the Galactic scale as the Australian aborigine has of becoming important in world politics, but a few thousand years of evolution may bring out a few individuals who have the ability to do something. I'm not sure. But I'm damned if I'll let the bonehads run all over me while they take my money.

"I happen to be, at the moment—and through sheer luck—Earth's only natural resource as far as the galaxy is concerned. Sure you can put me in jail. You can kill me if you want. But that won't give you the money. I am the goose that lays the golden eggs. But I'm not such a goose that I'm going to let you boot me in the tail while you steal the gold.

"Earth has no other source of income. None. Tourists are few and far between and they spend almost nothing. As long as I am alive and in good health and out of prison, Earth will have a nice, steady income of fifty thousand Galactic credits a year.

"Earth, I said. Not the Government, except indirectly. I intend to see that my money isn't confiscated." He had a few other plans, too, but he saw no necessity of mentioning them to Jackson.

"If I don't like the way the Government behaves, I'll simply shut off the source of supply. Understand, Jackson?"

"Um-m-m," said Jackson. He understood, he didn't like it, and he didn't know what to do about it.

"One of the first things we're going to do is start a little 'information' flowing," McLeod said. "I don't care to live on a planet where everybody hates my guts, so, as the Resident suggested, we're going to have to start a propaganda campaign to counteract the one that denounced me. For that, I'll want to talk to someone a little higher in the Government. You'd better take me to the head of the U.B.I. He'll know who I should speak to for that purpose."

Jackson still looked dazed, but it had evidently penetrated that McLeod had the upper hand. "Wha . . . er . . . what did you say, sir?" he asked, partially coming out of his daze.

McLeod sighed.

"Take me to your leader," he said patiently. ■

IN TIMES TO COME

Next month's cover—by Jack Schoenherr—goes with John J. McGuire's story "Take The Reason Prisoner" . . . which is, not surprisingly, a story of prison problems.

It's been commented that we've made wonderful technological progress in the last two centuries—"but they haven't improved the nut that holds the steering wheel." Prisons can be improved technologically; theories of the proper function and purpose of prisons change. Unfortunately the nature of human motivations and human aberrations don't yield to theories—and some don't yield to prison. And for some, the only kindly, rational answer may be, "You should drop dead."

Also coming up, a novelette about a piece of rope—a thread really—by Johnathan Blake MacKenzie. Only it isn't, really, a story about a thread—an unusual technological development, with a slightly fantastic tensile strength—but about the problem of what types of cultures can—or can not—afford to accept a highly functional technical device.

When nuclear weapons were first introduced, there was a lot of yak about the question of whether scientists had any "right" to introduce such weapons into the political world we have. How about a technical development that is not deadly to cities but only to individuals . . . if the citizens haven't sense of responsibility enough? ■ The Editor

THE GEODETIC SATELLITE

Continued from page 16

The latitude is not so simple and will require a diagram and a little knowledge of Geometry. If you drop a line from the surface to the Earth's center—such as the plumb bob line extended—it will form an angle with a similar line dropped from the equator at the same longitude. This angle gives a measure of how far the surface point is from the equator. It gets larger the farther north you go. This is the angle we call the Latitude. All the points with the same latitude form circles around the Earth that cross the longitudinal circles at right angles.

Now we can't go down to the center of the Earth and measure that angle, but we can use our knowledge of the relationships between angles in triangles to find an angle up on the surface that is equal to that angle. The angle that does this turns out to be the angle between the North Celestial Pole and the Horizon. (The horizon in this case not being the irregular line where the hills meet the sky but rather the imaginary line on the celestial sphere that is ninety degrees from the zenith, which is the point directly overhead.)

If you want to go through the math, Fig. A plus the four equations give the geometry of the situation and it is simple to see the equality between the latitude and the angle to the north pole, at least it's easy if you fuss around with it a little bit. It's easier yet if you just take my word for it.

So all we have to do is measure the angle between two points neither of which are marked and we know our latitude, which seems to leave us just where we started, but in truth not so. The plumb bob line goes down to the center of the Earth and, extended in the other direction, up to the zenith. If we set our telescope at right angles to this line, it will be pointing at the horizon. We then set the graduated circle in the instrument to read zero when the scope is pointed at the horizon. If we sight on some star as it passes across our meridian, we need only to read the circle to know the angle above the horizon.

We sight on Arcturus or any other handy star and note the time it crosses the hair of our telescope, which is set on the meridian. By this we determine the longitude and at the same instant we measure the angle above the horizon. Say that Arcturus crossed the meridian above the north pole. Twelve hours later we repeat this set of observations, only now Arcturus is crossing the meridian under the north pole. Halfway between these two angular measurements is the angle to the north pole, which is the angle we are seeking.

This appears to be a good way of getting the location of a point on the Earth without bothering with geodetic surveying. That is by measuring on the celestial sphere we are free of the irregularities of the Earth.

Well, it is not so. The catch in this seemingly ideal method is that plumb bob. We determine the meridian by locating two points: the Celestial North Pole and the zenith. The North Pole is always at the same place and is easy to find, but the zenith is more difficult. If we establish a line perpendicular to the Earth at the triangulation point, its extension upward should locate the zenith, and when we placed our instrument over the station using the plumb bob this is what we hoped we were doing. The plumb bob points straight down! Or does it?

The plumb bob is pulled down by the Earth's gravity, and though it may come as a surprise to most of you, the force of gravity is irregular at the Earth's surface and that in an unpredictable manner. If the station we have set our instrument over is, for instance, at the edge of a continental mass, our plumb bob line is going to be deflected toward the sea, since the Earth's crust is thin under the ocean and the dense mass of the so-called Mantle, which is the layer directly under the Crust, exerts a greater attraction on the plumb bob than the continental mass on the other side whose rocks are of lesser density. In other places we might have deposits of iron on one side and lighter material on the other. All these things affect the plump bob and result in a vertical line from the station to the center of the instrument which is different from the true perpendicular that we want. Geodesists call this "the deflection of the vertical." It is usually of very small value. (Fig. B)

This seems to eliminate the astronomic method for determining location to geodetic accuracy. It is quite good enough for ships at sea and has been used by ship captains to determine their location for centuries now,

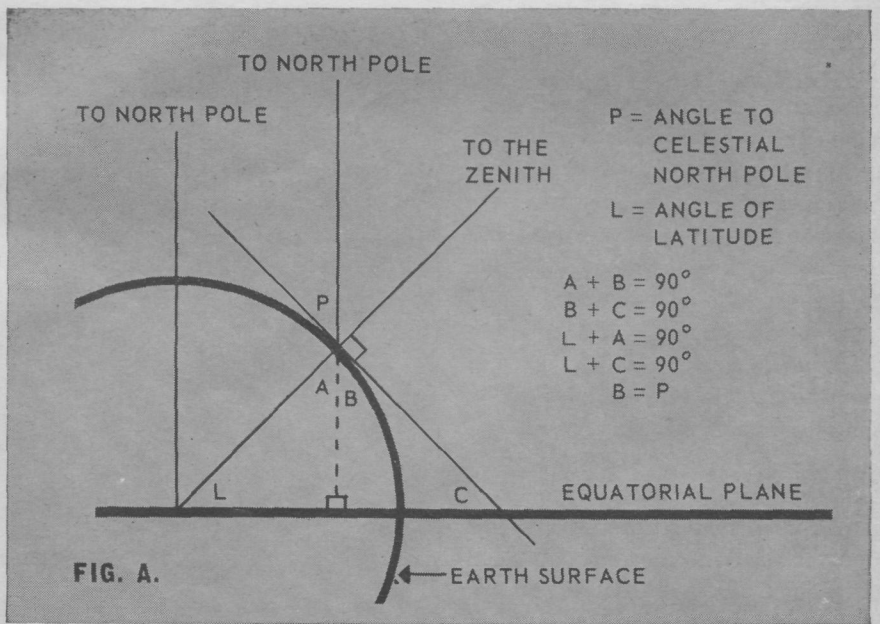


FIG. A.

but a geodetic surveyor has to know the location of his points to much greater accuracy.

Suppose we knew the value of the deflection of the vertical? Then it becomes only a mathematical problem to make corrections to our observations and so determine the true meridian and the correct location and all our problems are solved. In order to find the deflection of the vertical it is necessary, however, to know the force of gravity operating throughout the surrounding region which in practice means gravimetric survey of the entire Earth.

Well in this wonderful modern era they can do just that, and there is a school of Geodesists, who are advocating this solution to the problem of establishing a world datum. They have to wait a while because, though we can determine the force of gravity all over the Earth, at this moment no one is doing it, or at least not enough to satisfy the geodesist. Heiskanen, the leader of this school of thought, manages to end every speech he makes at any geodetic conference with the statement "and we must have more gravity measurements."

The other school, the young turks so to speak, are not willing to wait. They see a way the problem can be solved right now with Geodetic Satellites and they are quite impatient to get started. Needless to say, there have been some hot moments when advocates of the two methods cross swords at international conferences. The fireworks have died down now, but for a while there they flashed bright enough to make me feel proud to be a geodesist.

So now I've finally gotten around to the geodetic satellite, and I hope I'm ready to explain how such a satellite will solve all our problems.

There are two ways the satellite can be used. First, it can be observed simultaneously from four points on the ground, two in one datum and two in the other. Its location is then calcu-

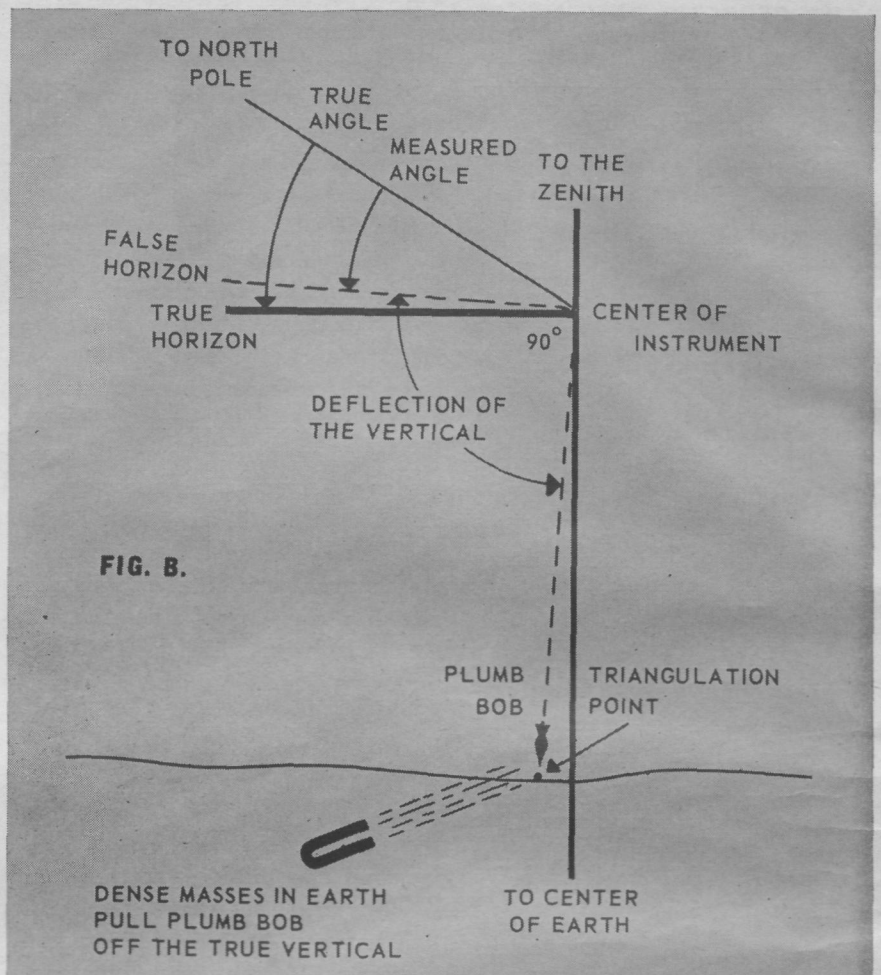


FIG. B.

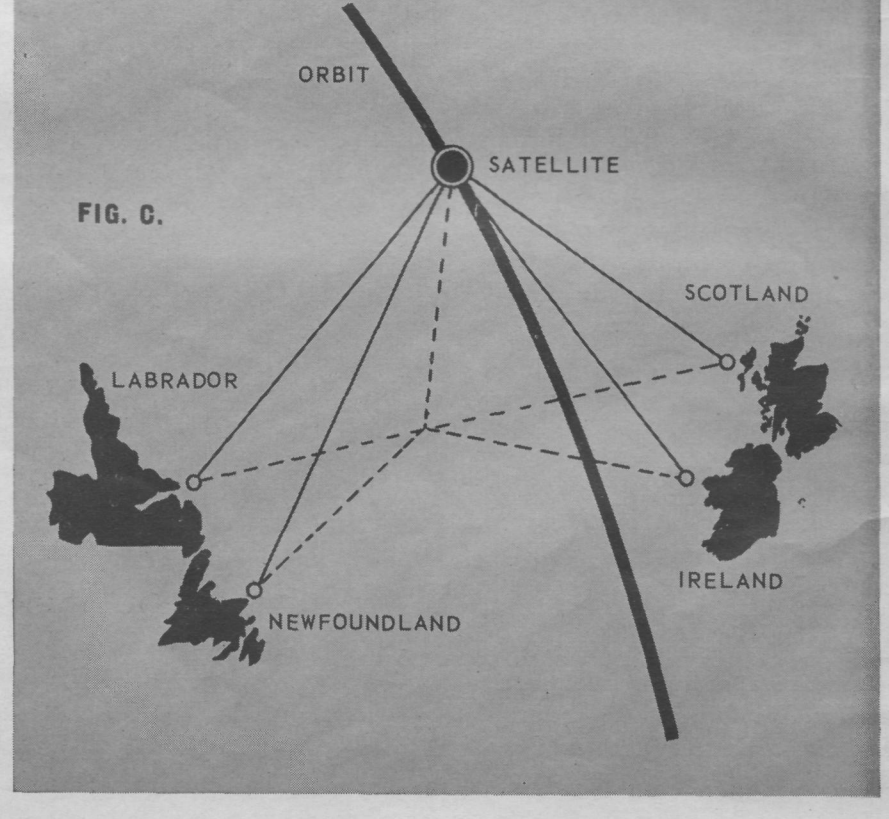


FIG. C.

lated on both datums and the difference is the difference in the two datums. Simple isn't it? Actually in practice it is not so simple, for it is no easy thing to get four widely separated points to see the satellite all at the same moment. Someone has calculated that even, if conditions were ideal and there were no clouds over any of the stations, there would still only be a very few minutes in which all the points could be observing at the same moment, and that is not enough. In geodetic surveying you don't trust any observation unless you have repeated it a dozen times.

This problem is solved by introducing a bit of complexity. If the satellite is in a very accurate orbit, by which I mean an orbit extremely well determined and very stable so that we know where it is at all times, it is not necessary to make simultaneous observations. If two stations in Newfoundland and Labrador simultaneously sight on the satellite at 1500 and two stations in Scotland and Ireland simultaneously sight on the satellite at 1520, and if we know the orbit well enough to be able to say how far the satellite has traveled in the twenty minutes, we can correct for this distance and treat the four sightings as though all had been made at the same moment. (Fig. C)

To do this to the accuracy necessary requires the use of techniques and equipment never before used in geodesy. Instead of merely sighting on the satellite with a transit or a theodolite we use ballistic cameras and take timed pictures of the satellite. This not only gives us many more sightings in the short length of time that the satellite is visible but enables us to locate it against the stellar background. Since the astronomers can tell us where the stars are at any moment, this gives us the vertical angle of the satellite without having to measure it, which is a big help because vertical angles are almost always the least accurate in the geodisist's bag of measurements.

Needless to say the greatest source of possible error in these sightings and calculations lie in our supposed knowledge of the orbit. Is the orbit six hundred forty-three miles and twenty-two feet out or is it six hundred forty-three miles and twenty-one feet? This is the determining factor in what we call a geodetic satellite. The gadgetry it might contain is relatively insignificant beside the question of stability and predictability. It must be in a perfect orbit, so perfect that we can make up ephemeris tables saying where it will be at all times. The dozens of satellites that are already up all have irregular motions that result in making it difficult to predict their location at any moment. We know to within a degree where they will be but this is not geodetically good enough.

The Geodetic Satellite will be put somewhere between the outermost reach of the Earth's atmosphere—so that drag won't affect the orbit—and the Van Allen belts. That is between four hundred and a thousand miles. They hope to get the orbit as close to circular as possible in order to simplify the calculations of the ephemeris and they want to have a flashing light on it so that it can be used while passing through the Earth's shadow. Another idea, that probably won't be included but which is fun to think about, is to include in it an atomic clock that will emit regular timed pulses.

When you are making astronomical observations for determinations of latitude and longitude, you have to check your clock against a standard, which in the United States is usually

Fig. 6: First photograph of Satellite Anna launched on October 31, 1962.

the time pulses broadcasted by the Naval Observatory in Washington, D.C. If, however, you are on the west coast, you have a time lag before the pulses reach you. A satellite emitting a standard pulse from directly overhead would greatly simplify this problem.

Of course, we have a satellite going around the Earth right now that satisfies all our requirements for a geodetic satellite and tables of its position at any moment have already been made and can be found in any standard ephemeris, and that is the Moon. Unfortunately it is extremely difficult to make accurate pointing on anything as big as the Moon. The spots on the Moon, being caused by shadows, are constantly changing their shape and no two sightings will be the same.

Well, if the Moon is too big, you may have asked yourself why not sight on a star? A star is certainly small enough. Yes but it is also to all intent and purpose infinitely distant and we can't use trigonometry to solve triangles that have one vertex at infinity.

Now for the march of events. All the above was theoretical when I started writing this article, but then, on October 31, 1962, it all became just another accomplishment when the Army, Navy, Air Force and NASA combined to put ANNA 1-B into orbit. ANNA has all the characteristics I've listed except the atomic clock. It has an apogee of six hundred forty miles and a perigee of six hundred miles which is as close to circular as one can expect to get at present. It has a flashing light that is activated by command from the ground. Further, it has a radar transponder for range determination, which is just a device that amplifies any received radar signals and rebroadcasts them back to the source.

In short ANNA is a geodetic satellite, and is going to go a long way in answering some of our problems, especially those relating to the shape of the Earth, but at the same time ANNA alone can not do the job because, as the official releases put it, it is not optimized for observation by the civilian scientific community. The command apparatus for activating the beacon is under military lock and seal. The Coast Survey has been able to take a few pictures and I don't doubt the Air Force is busy right now connecting the North American and European Datums, but they'll be keeping the results to themselves.

There was a big fight over ANNA between NASA and the military, for the project was originally completely classified. NASA sensitive of being involved in military projects originally would have nothing to do with it, even though they knew that its scientific value far outweighed its military value. Last summer they got a number of top-ranking scientists—Van Allen was one—to go before the House Space and Astronomic Committee to persuade the lawmakers that the radar tie across the Atlantic I mentioned earlier had solved the problem of aiming rockets to such an extent that the further refinement provided by the Geodetic Satellite, though of great value to the scientific community, no longer was of military importance, and that the whole project should be declassified. The House Committee agreed and ANNA was the result. It is assumed that the follow-up satellites for ANNA will be optimized for observation by the scientific community.

The second use of a Geodetic Satellite is for determining the shape of the Earth more accurately than ever before. This is the real reason that the scientific world was so anxious to get ANNA declassified. It is to me the most fascinating use of all. Unfortunately the math is a little difficult to go into here, which is a sneaky way of concealing that I don't understand the math well enough yet to try to explain it to someone else.

It turns out that not only does the satellite rotate in its orbit but the whole orbit is rotating because of the irregular shape of the Earth below. By measuring this rotation we can get an idea of the shape of the Earth that's causing it.

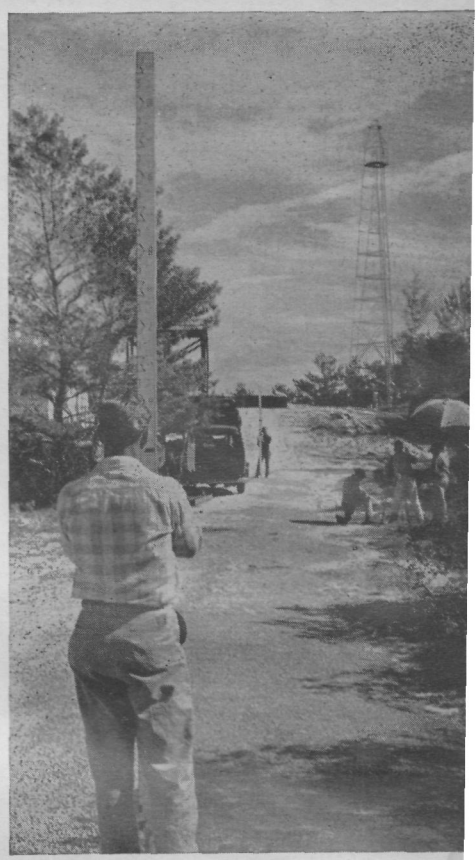


Fig. 7: Level party at work in Florida, Triangulation Tower in background.

They have already, from observing the behavior of the satellites now in the sky, come up with some surprising conclusions. There is a suspicion floating around that the Earth is not an ellipsoid of revolution after all. That, if you removed the hypothetical line we call the equator and looked closely at it, you would discover it is not a circle, as we have always thought, but is also an ellipse with one axis a little shorter than the other. Further they are now beginning to suggest that the gravitational equator is a little canted from the mathematical equator.

Of course, they are not sure. None of the satellites in the sky now were intended to give geodetic information. They are either too close to the Earth, which means much of their irregularities are caused by atmospheric drag, or their orbits are too elongated to be

easily calculated. Further there are not enough ballistic cameras spread widely around the world to enable us to get really accurate fixes of the orbit. Right now most orbits are determined using Minitrack stations which uses radar. This satisfies the missile men but not the Geodesists.

That younger school of geodesists have been using those orbits determined from Minitrack observations and have come up with variations that they think mean something, but the variations are of the same order, almost, as the observations and are barely detectable. Are they really variations, or only the observer's hot breath? Until we get a real geodetic satellite up, optimized for observation by the scientific community, and a widespread net of ballistic cameras established to fix its orbit, and that means Russian cameras too, we won't know.

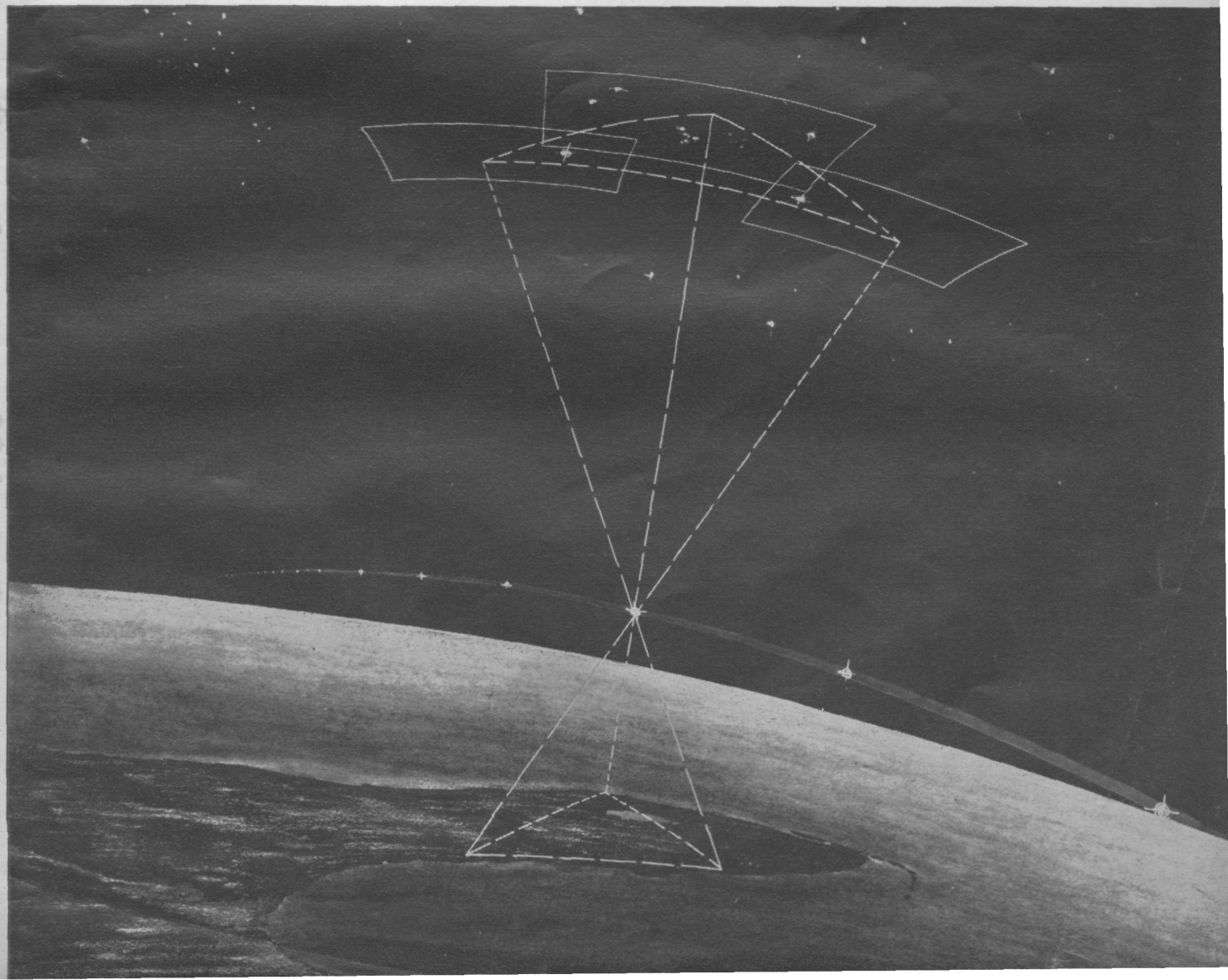
Geodesy is a very unusual science. Unlike the others its goals are attainable. In every other science each new discovery usually reveals a dozen or so new wonders yet to be explained, but once Geodesy has determined the true shape of the Earth it has nothing more to do. Things are moving so rapidly these days that geodesists can contemplate themselves becoming extinct in a very short while. We have the techniques, whether with geodetic satellites or with gravity measurements, in our grasp right now to finally answer that ancient question as to what is the size and shape of the Earth. Then there will be nothing more for us to do.

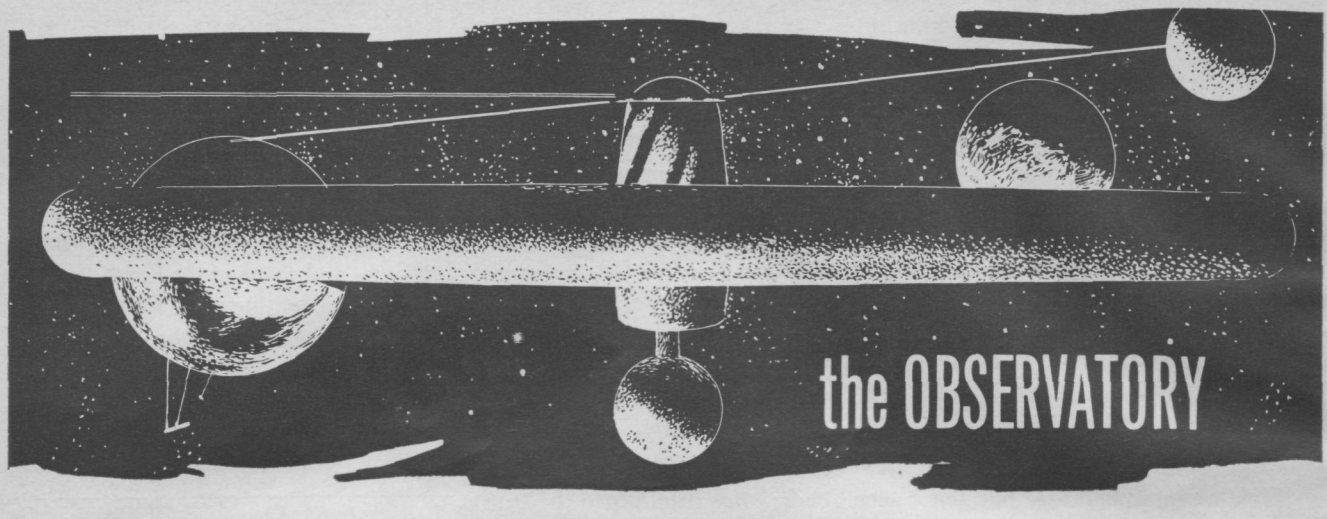
Of course, if I may borrow a joke from the astronomer Stern, there is still the question of the size and shape of the moon. Or is that Selinodesy? ■

Footnote:

Poor geodesist! The happy dreamer isn't listening to the geologists; he thinks that once he learns the Earth's shape, he can actually expect it to stay that way . . .!

Fig. 8: Cameras at 3, widely separated points in Florida photograph simultaneously an artificial satellite against their respective star backgrounds.





the OBSERVATORY

Gradually, Mankind is working outward into Space. To date, May, 1963 at this writing, no human being has yet left the Earth's atmosphere, and I include cosmonauts and astronauts, because the orbits of all the manned capsules have been protected from free space by hundreds of miles of atmosphere. True—too little for ordinary aerodynamic effects, but enough to make some enormous differences.

The reason is fairly simple; the Russians' high-thrust boosters could probably put a Mercury-type very-light capsule into a high enough orbit to get beyond the six hundred miles or so of Earth's atmosphere, but the Atlas lacks the thrust needed. It takes more energy to achieve a stable orbit after climbing six hundred miles against Earth's gravity field than it does to orbit at one hundred and fifty. But that's actually a secondary and minor reason; the major reason is the effect of the Van Allen radiation belts, and of the protons from the Sun. That upper atmosphere may be mighty tenuous in mechanical and aerodynamic terms—but it's a marvelously protective blanket for stopping radiation.

However—we're going out there. At first it will be for studying what we can do with vehicles, and to get basic how-to-survive-in-space information. Eventually, we'll be using Space industrially. (Some use of it starts with the Telstar program, of course.)

In between, and running concurrently, there will be scientific use of Space. And that's what I think the Science Fiction Fraternity can do some genuinely valuable work on, beginning now.

The modern rocketships were designed, in some considerable measure, in the pages of science-fiction magazines. Sound technical thinking was invested in the early stories; the speculation done there served as a take-off point for the design projects that came along later.

We can't design a space Observatory today; we don't have the data needed. But we can start roughing out the program, and the instrument problems.

This won't make for good stories; observatories are too passive for that. It isn't science . . . yet. Nobody can write a professional article about the problems.

But a lot of you readers can do some speculation—and throw in a few words of comment on instrument problems, or solutions, or call attention to problems that aren't at first apparent.

Eventually, the Neptune Orbit Observatory we mentioned in these pages in December 1961 will be wanted, but for now, let's try to rough out what can be and should be included in an Earth Orbital observatory.

First, what kind of Earth orbit? Not in the Van Allen belt certainly. That means it'll have to be pretty well out—beyond the twenty-four-hour orbit, for instance. Suppose we put it really well out—say out far enough to orbit the Moon, as a sort of sub-satellite? That would have some disadvantages—the motions will be sort of complex, making reducing the data to correlate with Earth-based data really interesting, but modern computers can handle that as easily as they could any other. Hm-m-m . . . matter of fact, lessee, now . . . if it's in an Earth-orbit, it's in an orbit around a satellite of the Sun, which satellite (Earth) follows an orbit complicated by the gravitational effects of its sister-satellite, the Moon. While if the station is in an orbit around the Moon, it's orbiting a satellite of the Sun (the Moon!) which follows an orbit complicated by the gravitational effects of its sister satellite, Earth!

One of the advantages to be gained by orbiting the Moon is that regularly, the vast bulk of the Moon's enormous mass will shield the satellite observatory station from all Earth's radiations. The radio-astronomers might

find that an extremely desirable feature. Also, there would then be the chance for such things as neutrino studies involving a sort of three-step shielding system; direct exposure to the Sun, then shielded by the mass of the Moon, and finally, shielded by the mass of Earth and the Moon.

Perhaps we should start figuring on putting the satellite observatory in a Moon-orbit, rather than an Earth-orbit.

Now as to instruments: There, we're going to run into some exceedingly fancy new kinds of headaches! The astronomer's favorite mirror surface these days is aluminum on glass or quartz—recently, aluminum-on-metal. The aluminum is applied by vacuum evaporation. The prepared mirror-blank is put in a tank, with an electric heating coil that holds a supply of metallic aluminum. The tank is evacuated, and then the coil turned on to heat, and thus vaporize aluminum. The metal vapor condenses on all available cool surfaces—including the mirror.

Fine . . . only if you try using that mirror in the *really* hard vacuum of interplanetary space . . . "Look, Ma! No aluminum!" It's apt to evaporate away again, with all interplanetary space to evaporate into.

Of course, out there in space, we won't have the problem that has beset every astronomer since Galileo peeked through his opera-glass telescope; "seeing" troubles. I can't do anything worthwhile from my home location, because of the metropolitan haze (locally complicated because of the Bayonne refinery complex. It produces not a solid-particle haze, but a liquid-droplet haze that puts pretty haloes around the Moon and brighter stars.) The great 100″ telescope at Mount Wilson is having troubles now with the lights of the Pasadena metropolitan complex—and the effect of the heat-energy balance an industrial-residential area imposes. Out of the atmosphere, all these problems would be left behind. It's said that if the Mount Palomar giant were outside the atmosphere it would be able to resolve several of the nearer stars as disks.

But . . . if we get a telescope outside the atmosphere, how big should it be? Inside the atmosphere, for various complex reasons—which I hope to get an article on—a small telescope can do as well or better than the observatory giants! That is, they can do as well or better when working on brightly illuminated targets, where the observations to be made are of the precision positional type, rather than photometric or spectrographic. For getting pictures of the Moon, for instance, the little Questar, about equal in bulk and weight to a portable typewriter, has done about as high-resolution a job as the observatory giants. But the Moon is a target glaring under the full light of the Sun; a standard camera exposure if you want a picture of the Moon itself is 1/1000th sec. at F 5.0 on Plus X film. You're photographing a landscape in full sunlight, remember!

For planetary observation, small telescopes have the advantage that the precision of figure can be better. Ideally, the spectroscopists would like to have a diffraction grating about 12 to 18 inches square—but no one yet has been able to achieve the required precision of ruling lines on a 12-inch grating. That *size* is too tough—maintaining perfection of alignment over that span. For precision positional astronomy, perhaps the ideal space telescope won't be a 200-*foot* mirror.

And another problem may come up. If a large blank is figured on Earth, the shape ground into it will be influenced by gravity, because by the laws of stress and strain, there is no such thing as an inflexible material. The mirror will sag under gravity, so that if it is given an absolutely perfect shape on Earth (it can't be done, of course, but suppose it could) then when it was lifted into space, and the load of weight relieved—no stress, no strain, and the shape is changed!

Evidently its final figure should be applied when it is in orbit.

But . . . you know, they discovered during WWII that a lot of lubricants turned out to be remarkably effective abrasives in very low air-pressure conditions. Graphite was the prime example; it had been used since electrical engineering began for brushes in motors and generators because it was lubricant, and a reasonably good conductor of electricity. In very low air pressure, however—it turned out that graphite was a high-power abrasive; it was the adsorbed air that was doing the lubrication! With the air gone, the graphite chewed the commutators to pieces in a hurry. Can mirrors be ground to shape satisfactorily in a hard vacuum?

Again, for purely spectroscopic work, or work of that type where positional precision is not required half so much as enough light-energy to work with, is a real precision-shaped mirror essential? Could useful results be obtained, for instance, with a mirror that was too inaccurate to be able to separate the components of Sirius or Procyon even—but could gather enough light from Sirius to cause retinal burn if you carelessly looked directly at the image? Say a mirror five hundred feet or so in diameter—

The radio-astronomers will have their problems, too, in deciding what

the OBSERVATORY

sort of structure they want. With weight limitations removed, they can have enormously large structures, and achieve figures good enough to focus even microwave energy with reasonable sharpness . . . only they won't be able to steer the huge dishes. "No weight" means "no net applied force producing acceleration," but in order to rotate the huge dish, they'd have to apply force. And that would mean sag, warp, twist, and loss of worthwhile effect. The whole dish could be set to scan at any desired rate; being in orbit around the Moon, and the Moon orbiting around the Sun would add some further scan effects. But radio astronomers learned to be patient about such things, since the days when Jansky first detected cosmic-radio radiations. He detected the pulses because Earth's rotation steered his antenna around once in 23 hours, 56 minutes, approximately. (There are 365 ¼ days in a solar year—but 366 ¼ in a sidereal year!)

What sort of shielding can be given the astrophysicists, biologists, chemists, physicists, et cetera, who are assigned the chance to work in Space Station L-1 (for Lunar 1)? There's a normal level of general radiation Out There—solar X rays, the usual wandering ions and electrons. But there are also Solar Flares—and they are not to be trifled with. Not only would they be enormously dangerous to human beings, but they'd ruin any photographic materials the station had in stock!

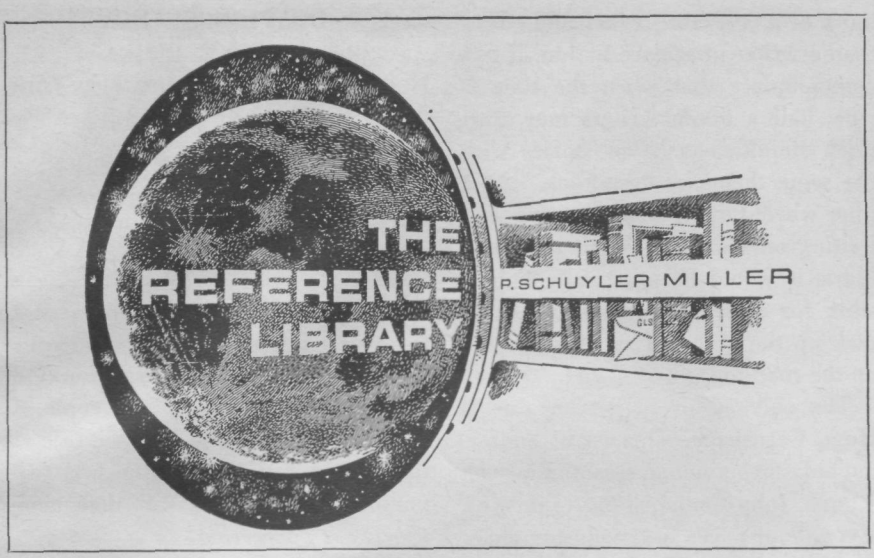
So . . . this is a wide-open come-all invitation to men in a position to do some speculating, and calling-of-attention to problems of a space observatory to make comments and suggestions. I'll try to run a selection of pieces, discussing the problems—and a selection of answers. Pros in the business are invited to send in sticky problems both now-on-hand and ones they already know are in the immediate future. There's a lot of engineering talent among this readership; somebody may have just the answers you need.

One of the major troubles in technology today is that a man has so much trouble keeping up with the literature in his own field that he has no time to read other fields—and so doesn't know that the problem he's struggling with was solved eight years ago and is now a standard laboratory technique in an entirely different field of work. Biologists were struggling with the problem of micromanipulators capable of dissecting the nucleus of a single cell—while the necessary devices had long since been perfected and used widely commercially in the phonograph record industry. The cutting stylus of a recording machine is an electronically controlled mechanical cutter capable of extremely rapid and extremely precise response; models have been developed that depend on piezoelectric forces, while others use magnetostriction effects. Both give extremely rigid, extremely precise, and extremely rapid-response mechanical movements of adequate range. But it was nearly two decades before the biologists discovered that their problem had long since been solved!

(And I'm willing to bet offhand that biologists could provide geologists with some selected strains of bacteria that could do a very nice indicator job of detecting specific minerals down to parts-per-hundred-million, and do it within twenty-four hours on a readily visible scale!)

Let's design that first Space Station L-1, not "from the ground up," but from "space inward!"

THE EDITOR.



MAKERS AND SHAPERS

I am sure most readers of Analog have seen one or more of the articles by Sam Moskowitz — biographical sketches of leading science-fiction and fantasy writers of past and present — which have been appearing in various magazines during the last six years. The series started in the extinct *Satellite*, and most recently has been at home in *Amazing Stories* and *Fantastic*.

Twenty of the articles, partially revised to eliminate errors and add continuity, are now collected in book form as "Explorers of the Infinite: Shapers of Science Fiction," published by World Publishing Co. of Cleveland and New York for $6.00. They pick up the history of science fiction and its practitioners with Cyrano de Bergerac in 1657 and brings it down to the beginning of what a Mesoamerican archeologist would call its "florescent" period with the late Stanley G. Weinbaum, who died in 1936. A final chapter drops the names of several more recent writers, but scarcely serves to bring the record up to date. A second book is obviously called for, and is partially written in the form of uncollected articles on the present-day masters.

"Explorers of the Infinite" is at the same time an essential part of any serious science-fiction library, and a disappointment. It is a disappointment because the author—as attested by his off-the-cuff talks at many regional and world science-fiction conventions—knows more, and more interesting things about his subject than he has entrusted to print. It is a disappointment because he has been a bit too scholarly in hewing to his line, and at the same time not scholarly enough in checking information that comes from secondary sources.

Such dogmastic criticisms as these, of course, need support. To understand what I am driving at, you will first have to understand the organization of the book, which is a good and fruitful one.

What Sam Moskowitz has done is to write a rambling, episodic history of the genre we now call science fiction—Chapter 19 explains how we came to give it that name—in the form of appreciations of a series of men and a few women who originated certain traditions, and who had a part in shaping those traditions into what we know today. Drawing on his own vast collection and personal knowledge of obscure and almost forgotten books, he has to some extent shown the effect of such landmark books as "Frankenstein," Verne's and Wells' novels, Edgar Rice Burroughs' Martian stories, and A. Merritt's fantastic romances on other writers of their time and on the burgeoning science-fiction field.

To treat all of these peripheral writers adequately would have produced an encyclopedia—not a single 354-page volume keyed to "modern readers." Someone, perhaps the author and perhaps his editor, has kept the vehicle on the turnpike and refused to let it wander off along enticing byways. But in doing so—to stick doggedly to my metaphor—they have missed lookouts which give a clearer view of the main road than you can get from the 'pike itself.

A book like this must be so exhaustively researched that it is a double disappointment when it has not been thoroughly researched. Various of the Burroughs Bibliophiles, for example, leapt into the breach when the original article on Edgar Rice Burroughs appeared, and corrected errors which had been perpetuated for years in secondary references. Yet the chapter on Burroughs still has the order of the Mars book confused—"Thuvia" preceded "Chessmen"—and it says there are twelve novels in the series, whereas there are only ten to date, with an eleventh promised by Canaveral Press next year.

More serious, perhaps, is the perpetuation of some bibliographical myths about H. G. Wells and "The Time Machine." Moskowitz repeats the statement that a version of the story appeared as "The Rediscovery of the Unique" in *Fortnightly Review* for July 1891. Title and date are correct, but the item is an article on semantics that emphasizes the differences between statistical behavior and that of individual atoms, animals or individuals. There is nothing in it that has any remote bearing on "The Time Machine," but there is at least one paragraph well worth quoting as a companion to some of John Campbell's editorials:

"Science is a match that man has just got alight. He thought he was in a room—in moments of devotion, a temple—and that his light would be reflected from and display walls inscribed with wonderful secrets and pillars carved with philosophical systems wrought into harmony. It is a curious sensation, now that the preliminary splutter is over and the flame burns up clear, to see his hands lit and just a glimpse of himself and the patch he stands on visible, and around him,

THE REFERENCE LIBRARY

in place of all that human comfort and beauty he anticipated—darkness still."

No wonder H. G. Wells could write science fiction!

Much ado about small details, you say? Consider that this book will go on the reference shelves of libraries that do not have and will never have the books and especially the "ephemera"—the magazine stories—it cites. Students will use it as a primary reference, where in spots it turns out to be somewhat less than secondhand in its specific information. For example, I also doubt the statement that sections of "The Time Machine" appeared as a series of articles in *The National Observer* in 1894, if only because the story *was* serialized in 1894-1895 in *The New Review*, and it is unlikely that two contemporary literary magazines would have run the same story at essentially the same time, or that Wells would have sent it to both. However, *The National Observer* is not in the Pittsburgh libraries, so I could not check. I could check *The New Review*, and the serial was *not* called "The Time Traveller's Story," although one part was. The beginning is somewhat different from the version we all know, and there was an additional short episode, which Moskowitz describes, dropped in the book. Perhaps, like Avalon in our time, the publisher was committed to a specific number of pages.

A major shortcoming, or lack, is a chapter dealing with the utopian novelists of the late nineteenth century, and their rather impressive influence on sociological thinking as well as literature. Butler's "Erewhon" and Bellamy's "Looking Backward," with their sequels and imitations, are not in the index let alone a chapter .

It seems to me, too, that the author sees far more imitation—or is it more polite to say "derivative writing"?—than is fair or just. This may be a matter of experience: Sam Moskowitz is more of a collector/reader and editor than a writer of science fiction. It is a commonplace that when the time is ripe, half a dozen writers may start work simultaneously on stories with the same theme or "gimmick." At a time when Lowell was lecturing and writing on his belief in an inhabited Mars, it would be practically impossible for adventure novelists not to pick up the hint and set their heroes on the road to the red planet.

The only editor to get his due is Hugo Gernsback. This is, of course, not only fitting but an essential in such a book. John Campbell has to do with a couple of pages in the closing chapter, "The Future in Present Tense," and this primarily to establish his place as an author and as the discoverer or builder of the present-day giants of science fiction who developed their literary personalities in the pages of this magazine and its predecessors. John will undoubtedly get his due in the second volume, covering the writers of the generation since Weinbaum —but it seems to me that more should have been made of the creative part played by Bob Davis of the Munsey magazines, in the decades before Gernsback, by finding new writers and encouraging established writers to try their hand at "different" stories.

One final complaint: Sam — who holds very strong and very definite opinions about the quality of certain stories and the ability of certain writers—has submerged these opinions far too much, in an evident attempt to be objective. A synopsis of an unobtainable book or magazine story tells the student of science fiction very little about the place the story plays in the development of the genre. Themes can be followed, but not influences, in such a chronicle.

"Explorers of the Infinite" is going to be an essential reference for anyone interested in the field. There surely must be a second book to bring the chronicle down to the present. Then it is unlikely that anyone will attempt anything similar for at least a generation. It is unfortunate that Sam Moskowitz has held himself back to the extent that he has.

DOLPHIN ISLAND
by Arthur C. Clarke
Holt, Rinehart & Winston, New York
1963 • 187 pp. $3.50

PENELOPE
by William C. Anderson
Crown Publishers, New York.
1963 • 215 pp. $3.95

These two books, appearing almost together, offer two approaches to the future relationship between mankind and what Clarke calls "the People of the Sea." That was, in fact, the title of the version serialized in the first two numbers of the new SF magazine, *Worlds of Tomorrow*.

Both books take off from the investigations which have been publicized by Dr. John C. Lilly in his "Man and Dolphin"—now available for 75 cents in Pyramid's outstanding *Worlds of Science* series of paperbacks. That is, they describe the results of a breakthrough in the efforts to communicate with the dolphins, whose big, complex brains suggest to some biologists that they may be as advanced as ourselves.

Beyond that point, no two books could be more different. "Dolphin Island" is a minor juvenile, though apparently not one of the Winston SF juvenile series. Its hero, a teen-age orphan, accidentally stows away on a hover-craft bound for Australia. When it is wrecked, he is rescued by a school of dolphins that take turns pushing his makeshift raft a hundred miles across the Pacific to a research station on the Great Barrier Reef.

In a relaxed, offhand manner the author introduces his greenhorn to the marvelous world of the Reef, describes the already successful attempts to talk with some of the dolphins, and sets up a very pretty scientific and ethical problem when the school of dolphins that rescued Johnny Clinton ask the humans to help wipe out their hereditary enemies, the killer whales. This situation is rather like what would occur if a delegation of chimpanzees were to come to Congress or the UN for help against the gorillas—a race less ebullient and likable than chimps, but quite possibly more intelligent. In a most un-Clarkelike manner, the

scientists nibble a little at this problem but leave it unsolved, while Johnny and the dolphins carry out a rescue mission after a typhoon has wrecked the research station.

"Penelope" is something else again—a free-wheeling, rollicking, sometimes bawdy farce in the Thorne Smith manner. It is written by a Lieutenant Colonel in the U.S. Air Force Space Branch, who is personally acquainted with the current attempts to communicate with dolphins, porpoises and their kin. He is shown on the back of the jacket, swimming with his happy heroine, who appears on the front in an artist's conception of one of the lively swimming-pool parties at which she is a guest of honor.

Captain Gregory Williams, ostensible hero of the book and sponsor of Penelope—she winds up marrying a white Greek porpoise named Demetrius in the grand ballroom of the *Lusitania*—is an extremely serious, thoroughly dedicated scientist with a knack for getting into trouble. Fortunately, his friends and associates include a red-headed Texas million-heiress, an almost equally well fixed and free-wheeling Air Force pilot, a competent and well-stacked assistant named Lucy Watson whose father is a Pentagon-grade big shot in the Navy, an equally c/ws German refugee housekeeper whose misadventures with a tape recorder reveal that Penelope not only speaks fluent English but has a Deep Florida accent from her Marineland adolescence, and assorted convivial characters, including some remarkable Texas and Florida undertakers.

You're unlikely to have had such uninhibited yet wholesome fun since Thorne Smith died. If Hollywood buys the book, pray that they get a producer, director and cast with imaginations.

SLAVE PLANET
by Laurance M. Janifer

Pyramid Books, N.Y.
No. F-840 • 1963 • 142 pp. 40¢

On paper and in synopsis this book poses a knotty problem of sociology and anthropology. Fruyling's World is a planet extremely well supplied with the metals that Earth and the worlds of the Terran Confederation must have. On the other hand, it is too far away for it to be economical to send human miners and processors there or to set up automated mining, smelting and fabricating plants. Associated Metallic Products Ltd. has solved this multiple problem by enslaving the reptilian natives of the planet—the "Alberts." Intelligent enough to accept a revealed religion, but with no technology of their own, they are bred, trained, used, punished and destroyed by the formulas worked out by AMP's Psych Division and Dr. Anna Haelingen, its head.

Dr. Haelingen's approach to her intermeshed problems is one of hard-minded directness. This is what I am hired to do; this is what I have to work with; this is how it can best be done; this is how it *will* be done. The rights and wrongs of slavery never enter into her thinking, but they do haunt some of the human instructors and overseers. She has techniques to handle them too—let them blow off steam at forbidden parties—but she gets one who doesn't go to parties. Simultaneously, there has been a leak to the press and the public back on Earth, and for purely political reasons the Confederation sends a fleet to rescue the enslaved Alberts. Meanwhile, too, a few of the Alberts have been thinking about their status and what slavery really is. They never had it so good, but . . .

The situation dissolves into action before anyone really comes to grips with the underlying question: can slavery be justified? Dr. Haelingen goes down, sticking to her guns to the bitter end. The freed reptiles are on their way to unhappy squalor on a bureaucratically maintained reservation, and will probably be right back in the mills, working for less than the subsistence they got as slaves. The worried semihero and potential heroine has been blotted out in the war to liberate the Alberts. The histories are homogenizing and predigesting the entire matter.

Once this would have been a standout book. Now, we have had too many that are better. Good try, though.

THE MAN WHO FELL TO EARTH
by Walter Tevis

Gold Medal Books, N.Y.
No. K-1276 • 1963 • 144 pp. 40¢

This original SF novel is written by the man who did the script of the notable movie, "The Hustler." It handles an old theme with highly professional competence, and misses most of the pitfalls that "outside" authors dig for themselves when they venture into science fiction. Not quite all, though, for Anthea, the planet from which "Thomas J. Newton" falls to Earth in an archaic lifeboat, is in our own solar system, a hundred million miles from Earth. There is no such planet. Anthea's year is not quite one and a half of ours. There is no such planet and—if the hundred million mile distance holds—no such physics.

The Antheans, multiracial and multinational, have made their world into a desert. "Newton" has been sent to Earth with their last fuel resources, to build a ship which will bring his two hundred remaining people here. Disguised as human beings—they are humanoid—they will infiltrate scientific, business and government circles, take over human society, and save us from going any further along their own path. Crash-landing among the Kentucky strip mines, Newton pawns some jewelry to get eating money, then begins to parcel out Anthean science and technology where it will bring him the quickest return. When the millions begin to roll in, he begins to build his ship. But his success is too good to last.

Ordinary as all this may be in outline to any hardened SF reader, let it be said that Walter Tevis handles it all extremely well. "Newton" develops as a real person—though not as a real extraterrestrial, as a Theodore Sturgeon or a Cordwainer Smith might have portrayed him. His purpose on Earth is allowed to develop slowly, bit by bit. Yet things go too smoothly, and his eventual fate at the hands of a CIA and FBI that refuse to believe the truth is as inevitable as if the ancient Greek Fates were arranging it.

Let's hope Mr. Tevis explores our field again, but takes a little more trouble with the trivia.

SEGREGATION

(Continued from page 7)

it's almost impossible today to read a statement without reacting to that propaganda – value. Just what does "segregation" mean? What's "a segregated school."

Any non-co-educational school is segregated by sex.

We have rigidly segregated washrooms all over this country, not just in the South. Segregated by sex. And don't get sloppy in your thinking and say, "But that's *natural!* How else could it be?" Remember that neither the highly civilized Japanese, nor the Finns consider it "natural."

I noticed in a Savannah, Georgia, paper the other day that a Negro and a white woman were contending for some elective office in a local campaign. A century ago, both contenders would "naturally" have been barred.

"Segregation" means Negro-vs.-white, does it? For Pete's sake, friend, *please* straighten up your thinking and your terminology enough so that rational communication, outside of the propaganda-broadside method, is possible!

"To segregate" means nothing more than separation of a mixed collection into groups having determinably different characteristics. Like segregating ripe fruit from green fruit.

The *Brown vs. Board of Education* case didn't make segregation, as such, illegal; it made segregation *on the basis of race alone* illegal. It's still perfectly legal to have a school rigidly segregated on the basis of sex, of course. Or segregated on the basis of blindness, or on the basis of requiring that all registrants have graduate degrees before being admitted.

The trouble with the *Brown vs. Board of Education* decision stems not from law, but from libertarian assumptions that were built into that case, and from "scientific evidence" that seems to be definitely inadequate, and which has been attacked as actually fraudulent.

Propaganda can produce some results that are straight out of fantasy, fairy stories, and the *Alice* books. Propaganda has the wonderful characteristic that Adolf Hitler—one of history's most expert and effective propagandists—very clearly stated; a lie told often and loud enough will overcome truth. Particularly if a considerable number of people would *like* to have it be true. Then the Big Lie becomes That Which Should Be True Whether It Is Or Not . . . and dedicated believers in the lie arise to *make* it true.

Among the Big Lies of current cultural propaganda are a set of meaningless noises that sound like important, deeply philosophical Truths—because they strike many people as being desirable.

Among examples are:

"Everyone has a right to his own opinion, so long as it doesn't interfere with anyone else."

"All men are equal."

"What goes up must come down."

"There's nothing new under the Sun."

You can extend that list of philosophical-sounding noises almost as far as the trajectory of Mariner II . . . which went up, isn't going to come down, and is a new satellite of the Sun. They all *sound* important, and they can be quoted with the philosophical-authoritative pompousness appropriate at various times when they support your dearly-beloved position, so they tend to seem as though they ought to be true whether they are or not, so they just must be true.

That business about opinions, now; what does the stupid thing mean? That you are free to think anything you want to, no matter how insane it may be, so long as no one else has the slightest interest in what you think. So long as your ideas aren't of any importance whatever, to anyone else, and don't influence your behavior in any degree that bothers anyone else, you can think anything you darned well like, and nobody will give a damn.

Note carefully that if you decide you want to be a hermit, however, that interferes with other people's opinions; they have the opinion you should work for a living, for instance, so under that doctrine of no-interference, you do *not* have a right to the opinion "I want to be a hermit" since it does interfere with someone else.

The problem is, was, and always will be "What rights exist between people when opinions *do* interfere?" Obviously there's no problem so long as opinions *don't* clash! That silly-season statement about non-interfering opinions is, of course, a perfectly sound proposition to answer a problem that never exists.

So . . . let's have some thinking about what to do when opinions do seriously, definitely, interfere; that is the real, human problem.

As to "all men are equal," that bit of nonsense is equally meaningless. Can you tell me one, single respect in which men are equal? Equal before God? Not if you accept any of the religions which hold that God segregates sinners from saints! And offhand I can't think of any religion which holds that God (or the Gods) don't judge, evaluate, and make distinctions between men.

"Equal before the Law?" Oh . . . yeah . . .? You mean a man of IQ 50 is held to have the same responsibilities and duties as a man of IQ 150? That all men must pay equal taxes? That some men, who are licensed doctors, don't have, under the law, special rights and special duties? That attorneys don't have special rights, privileges and duties before the law? (An attorney can't be summoned to jury duty.)

The difficulty is that God decided for reasons not clear to us that men should not be equal—and He created them with inherent differences. And men cannot undo that fact. But doctrinaires can sure try!

The deadly part of it is that men can make unequal individuals equal by one method; they can cripple the strong, until the best has been sabotaged down to the level of the worst. They can take away the "unfair advantage" of the intelligent by crippling his abilities, punishing his achievements, and destroying his powers, until he is less competent than the normal. In times past, Kings and Tyrants

held that they held the "power of Life and Death"; no King or Tyrant in all history has ever held the power of Life. They have, however, held the power of death and destruction and crippling.

The doctrinaire—the Tyrant Liberal—today, holds that ancient power of Death and Destruction—and that is his weapon to achieve what he Just Knows is Right and Just—to make all men equal, despite God's unfairness in making some men more capable than others.

In the current cultural situation, it's been made easy to see that intransigent southern segregationists are seeking to suppress the competent individual Negro, to make him less-than-equal to the not-so-bright whites.

What's not so easy to see in the fog of emotionalism, is that the libertarians and do-gooders are seeking to suppress the unusually competent individual *of any race* for the achievement of their doctrinal ideal of equality.

Here's where the trouble comes: a school system that "rewards" the more-competent student with more work, harder tasks—and no increased privilege, no increased status or desirable reward is, in fact, effectively punishing his display of ability. Suppose the reward for superior achievement in the classroom—finishing the assigned tasks more quickly—was being given the "privilege" of scrubbing the floors, polishing the windows, and tending the school grounds. Or running errands for the students who were slower and hadn't finished their assignments yet.

Who would, obviously, be the "second-class citizens" of that school? The students who were so stupid they acted bright, of course!

Such a system of punishment-for-extra-achievement is almost inevitable in a school not segregated by intelligence and ability. For any individual, a certain level of problem represents a stimulating challenge; a higher level of difficulty becomes an overwhelming task that defeats him, discourages, and drives him to withdraw his effort. A too-low level of task simply bores him, and he will seek more interesting tasks, or seek to do the assigned task in some more stimulating manner.

The extra-competent, in a randomly selected class, will present to the normal and subnormal the fact that the work can be done with ease, quickly, and simply—that it can be done offhand as a sort of game. They slap the dullards in the face with the clear fact that children their own age—not just teachers!—can do that work offhand. The honors student who finally gets around to doing the term paper the last weekend before it's due . . . and earns an A+ for one afternoon's work, while the rest of the class spent four to six weeks researching and rewriting to get a passable paper.

The super-competent, too, can earn the enmity of the teacher in a normal school. Karl Frederick Gauss, for instance, could have expected to be punished for one trick he pulled. In a grade-school arithmetic class, when he was about seven, the teacher had told the class to add all the numbers from 1 to 100—this being a good way to keep the children usefully busy while the teacher got some of his own work done.

Young Karl Frederick, however, was up with his answer in about two minutes. Young Karl Frederick had not added all the numbers from 1 to 100; he'd developed for himself the formula for the sum of a series of numbers, and instead of *working* the problem, had *solved* it—in a matter of seconds. His answer was, of course, absolutely correct — which took the teacher some minutes to check.

But young Gauss was lucky beyond expectation; that teacher was wise. He recommended Gauss to the local Duke as a proper subject for patronage; Gauss' family was poor and could not have given him an education.

In an educational system dedicated to the problem of producing equality—such a teacher is out of place. That teacher was not producing equality; by seeing that Gauss got special reward for remarkable ability, the teacher exaggerated an already existant inequality.

Unsegregated schools are injurious to the subnormal and the geniuses alike. The subnormal, discouraged and overwhelmed by the equality-for-all problems presented them, withdraw from the hopeless effort of education, and achieve far less than their already limited potentials. An equality-for-all school does not allow the less-talented to develop the maximum of the abilities they do have.

And it does not allow the abnormally competent to develop their high talents. It's stupid to expect a normal school teacher, herself oriented to everybody-ought-to-be-equal and nobody - has - a - right - to - special - advantages, to welcome the idea of some ten-year-old who can outthink her, penetrate the errors of her logic, call her on sloppy statements, and do a job of research in the library such that the teacher is forced to acknowledge her lack of information on her subject.

But... now we run into a very nasty aspect of the *Brown vs. Board of Education* decision, and its subsequent development.

Recently, several towns in New Jersey have been forced to "integrate" their "segregated" schools; the basis of the NAACP suit was that one school had a ninety per cent Negro enrollment, and the other a ninety per cent white enrollment. This, they contended, constituted *de facto* racial segregation.

That particular town had a population distribution by areas that made that the natural result. The NAACP was, of course, just as hotly against that sort of population distribution—but that wasn't the legal point in the case.

It was decided that because of the fact that registration did not show a proportional representation by race, that therefore there was *de facto* segregation.

That is not a logical or valid conclusion.

It certainly falls in the class of "data insufficient for the conclusion proposed."

Yet that is an accepted proposition—and that proposition alone would be enough to cause great difficulty in setting up segregated-by-student-ability schools.

There is a never rigorously proven assumption that's thrown around in all racial arguments that all races show the *same* distribution curve of intelligence and ability. *That has not been proven.*

There's adequate evidence to the contrary, available from a number of lines of analysis. First, in a normal distribution curve, the number of individuals—in a statistically significant large population—in any one range gives the scale of the curve; from the curve, then, the number in any other range can be predicted. That is, if we find one hundred twenty-five high geniuses at IQ 180, knowing the shape of the distribution curve, we can predict how many individuals of IQ 100 there will be in this population, et cetera.

Now *if* all races have the same distribution curve, then knowing the population of the group, we can predict how many super-high geniuses will appear.

Something seems to be wrong; some gears slipped somewhere. The assumptions don't match the facts. The Caucasian race has produced super-high-geniuses by the dozen in the last five thousand years; the Oriental race has, also. The Negro race has not. And it's the super-high geniuses, not the ordinary, or run-of-the-mill geniuses, that lift a people from one level of civilization to another. The Industrial Revolution, for example, depended on a number of super-high-geniuses, backed up by a corps of high geniuses, working with an army of geniuses. The super-high-geniuses are never educated; they educate themselves, because there's no one around to teach them. Who could teach Abraham Lincoln, for instance? Who could teach Leonardo da Vinci? Certainly Newton did have formal schooling—but the schools he attended were attended by a lot of other young men, and there does not seem to have been any sudden flood of Newtons coming from them. "Educational opportunities" never exist anywhere for the super-high-geniuses.

The fact that the Caucasian race has produced more super-high-geniuses in the last five thousand years suggests that the distribution curve for the Caucasian race does not in fact match that of other races.

I'm not talking about text-book type psychological-testing geniuses here; I'm talking about the individual of super-high, unmatchable pragmatic achievement. Anyone who says that Newton wasn't a super-high genius is off his rocker.

These super-high geniuses produced achievement that promoted the survival ability and adaptability of their race. Pasteur made it possible for men to adapt to disease-saturated areas by intellectual act that had, theretofore, been uninhabitable save by the slow process of genetic selection and evolution. This achievement made men more adaptable.

You don't have to rate those achievements in any special cultural terms—increased adaptability is the pay-off coin in the evolution of living things! The great chemists made it possible for human beings to eat rocks, drink petroleum, and be nourished. The race is more adaptable because of their genius—and that is a positive gain in absolute, not merely cultural, terms!

There is an indication, then, that the white race may in actual fact have a distribution curve that does not match that of the Negro.

Note the important factor in citing the super-high geniuses; *educational opportunities play no part whatever in the development of any super-high genius.* There is not, never was, and never can be anywhere or anywhen, in any land or race, a school for educating super-high geniuses. The thing that characterize the super-high genius is his ability to self-educate to totally new and hitherto undiscovered horizons. They are *always* self-made men. Newton needed calculus to solve his gravitational problems—and he lacked the educational opportunity. Nobody ever taught him calculus. So he had to invent it.

Karl Frederick Gauss wasn't taught to find the sum of a series of numbers; he invented it.

The super-high genius, then, is an indicator of a people that is not dependent on educational opportunities —because the opportunities never exist for any of them!

And there is other and more ordiary evidence that proportional representation of races is not the right answer.

To carry out a really wide-spread, long-continued, massive testing program, involving tens of thousands of individuals, and keeping track of them for some years, is an expensive proposition. The money for such a program is not easy to come by.

Most of the discussions of racial distribution of intelligence has been based on pretty limited samples, or quite inadequate testing. The old WWI Army Alpha intelligence test results, for instance, are still among the few massive test-score result records, and are still being used simply because they're available.

The schools system of Savannah, Georgia, since 1954, has carried out a massive testing program. Standard IQ tests, Mental maturity tests, and scholastic achievement tests were given to all students in the Savannah school system, and punched-card records kept for nine years, and the results computer analyzed.

The results showed that, at beginning grade-school level, the Negro children had a fifteen per cent crossover with the white children's scores. (That is, fifteen per cent of the Negro children scored at or above the level of the norm of the white children.) At high school level, the crossover had dropped to two per cent.

Now let's just consider for a moment the emotional fireworks that would result from setting up a school system that was strictly, honestly segregated purely by individual student competence, simply using those figures for discussion purposes.

Assume that we have a city with a fifty-fifty distribution of Negro and white poplation, and that we set up two school systems; one for those above the white norm, and one for those below that norm.

The Doctrine, Dogma and Princi-

ples boys will be out for Hell and hallelujah. *Both* sides will be. The intransigent white segregationists will be shrieking in defense of their violated Principle of the Color Bar. Their howls of rage will be exceeded, however, by the violent anguish of the NAACP, at the destruction of their Principle of Proportional Representation. But those howls won't be audible above the far louder and angrier screams of the parents of the children who have been officially designated "incompetent; second-class citizen." The whites will, of course, be peculiarly violent about that, because that's precisely what they've been afraid of for a century or so—the admission that some Negroes are superior to some whites.

The acute psychological pain resulting from such a system will be very real indeed—and will, curiously, bring the underlying principles of the *Brown vs. Board of Education* case into the thing in a sort of back-handed manner!

The basis for the Supreme Court's decision in *Brown vs. Board of Education* was testimony by a psychologist that segregation imposed psychological hurt on the rejected Negro children.

The Court's decision, then, was, in effect, that it was illegal to cause someone psychological hurt.

So we now have a very interesting question that needs resolution; if it hurts an individual to be told the truth, is it illegal—unconstitutional—to make him aware of that truth? Of course, that general idea is part of our present cultural philosophy—the poor, misguided sadist shouldn't be made unhappy about his misdeeds. And this poor, disturbed child shouldn't get severe punishment just because he slugged the corner cigar-store owner, stole his money, and set fire to his place. It isn't *nice* to hurt people; it should *never* be done, because it isn't Kind and Good and Brotherly.

So . . . if it's unconstitutional to cause psychological discomfort, we can't have segregated-by-intelligence schools; they'll make some people extremely unhappy.

And if segregation-by student-ability turns out—as we have reason to expect—to produce a system in which proportional representation of races does not exist . . . why, we can't have segregation by ability for that reason either.

Then, of course, the liberal-do-gooder group just *knows* everybody should be equal, whether they are or not, and they know that schools are intended to produce equality, not education anyway.

All in all, practically everybody has motivations for wanting the present unsegregated school system to continue in American education.

The problem the United States faces is very simple: We have developed the highest standard of living the world has ever known, by developing the potentials of technology—of applied education.

But this process has certain penalties; it is, in a very real sense, a specialization in the evolutionary sense. Now we have developed this technology, we cannot do without it. The population which we are, today, supporting in luxury could not be supported, even at a subsistence level, without technology. Those wheat surpluses that are troubling the nation aren't due to the innate fertility of the soil; they're due to applied agricultural science — to biochemistry and genetic science and soil technology.

The civilization that we in America know today is based on and dependent on high-level technology—and that of course means high-level technicians.

Inasmuch as men are not equal, not all boys can be trained to be technicians—and it is the sheerest insanity, the sheerest refusal to face reality, to believe for a moment that all children can be so trained. Only those children originally gifted with the required potentials can have those potentials developed into the needed abilities.

Now an educational system dedicated to the proposition that if all men aren't equal, we're gonna teach 'em to be, can only equalize men downward—it has the power of death, but not the power of life. The power of Life is reserved to God—and any people that mistakes itself for a collective form of Diety is doomed.

Today, despite long and loud campaigns for more young scientists, our technical schools are getting fewer applicants than they were before—fewer registrants from an increasing population!

The medical profession is having serious troubles, too. The doctors in most communities now are working fifty hours a week routinely, and sixty hours a week commonly—and they do not do so because they get paid time and a half for overtime. I mentioned that doctors represent a group of men who are not equal before the law; their inequality seems to be resented. Certainly the public is making life miserable for them. A doctor is required by law to stop and render aid if he passes a highway accident—and today they hate to do so, because it quite commonly means a malpractice suit. The man the doctor saves by his emergency treatment is quite apt to sue for a few hundred thousand dollars; you see everybody knows that doctors carry insurance, and you can always get somebody to get on the stand and prove that his hindsight is better than the sued doctor's foresight, and testify that if such and such had been done, maybe the patient wouldn't have the scars he has.

In the Great American Lottery—suing after an accident—it pays better to sue the doctor that saved your life than the man who nearly killed you; doctors carry bigger insurance policies.

And besides, them there rich doctors oughta pay fer things; nobody's got any business being rich, cause people are equal, ain't they?

Medical schools for some reason are having difficulty getting enough registrants—even when they rather desperately lower their standards for admittance. Anybody who chooses medicine as a career today has to be pretty much of a peculiar type; his reward for saving lives is malpractice suits. He's required to work fifty to sixty hours a week . . .

Then we have another interesting technological problem. It's the problem of interconnections and interactions among communicating units. The telephone people ran into it long ago; when you double the number of telephone subscribers, you don't just double the number of switching connections required—it increases exponentially. The original system was handled by human operators; as it became more complex, machine-switching became essential. As of now, to handle the telephone switching problem in New York City, even if *all* employable women in the service area were employed as operators, the system would be unable to function.

As intercommunication increases, the problem of switching increases drastically.

That's happening in the problem of business organization. The number of interacting businesses in this country today is so great that the number of business executives required is also straining the limits of our capacity. But the "switching" involved there is decision-making, judgment-application—which is the factor machines can't handle.

It takes human beings of trained potential—men trained to think, think accurately and quickly.

A breakdown in any one of those three areas—science technology, medical technology or business technology—will mean a collapse that will be most interesting to historians of the future.

It will be the first time in history that a culture collapsed because of the failure of the educational system.

Never before has a culture been dependent on efficient education, so it has never before been possible.

It won't be at all interesting to those involved. Old-timers will be talking about the good old happy days of the early 1930s, when all we had to worry about was a Depression.

If the Supreme Court finds that the Constitution forbids segregated schools that make the incompetent unhappy—then it's time to start a campaign for a constitutional amendment that holds that Truth is never illegal, no matter how painful it may be.

The Editor.

Alice in SONY land

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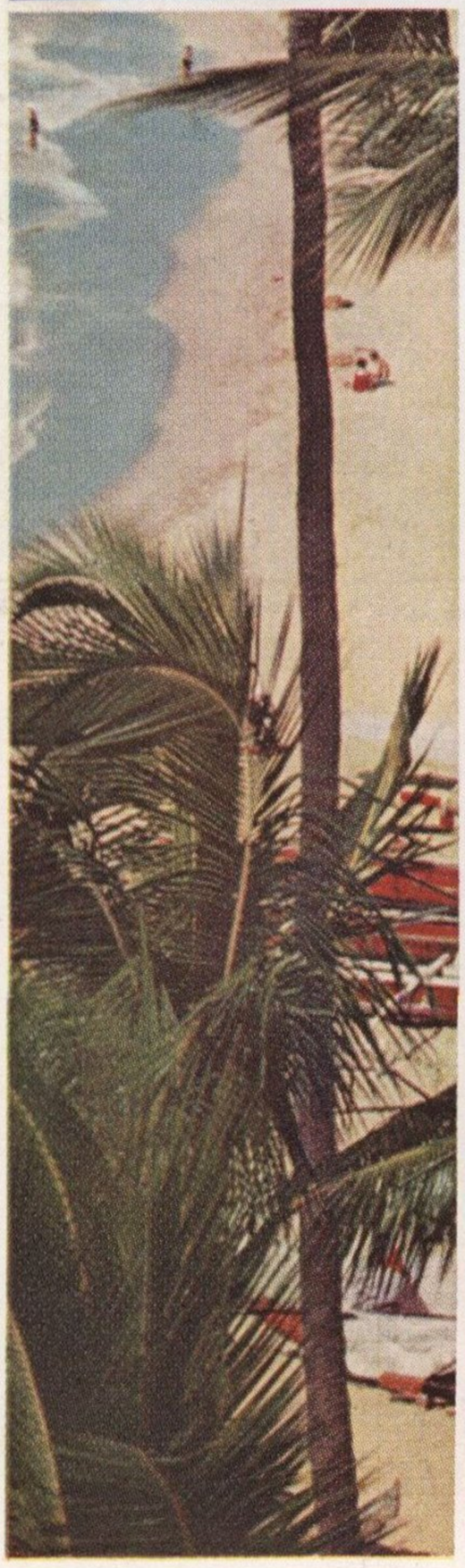

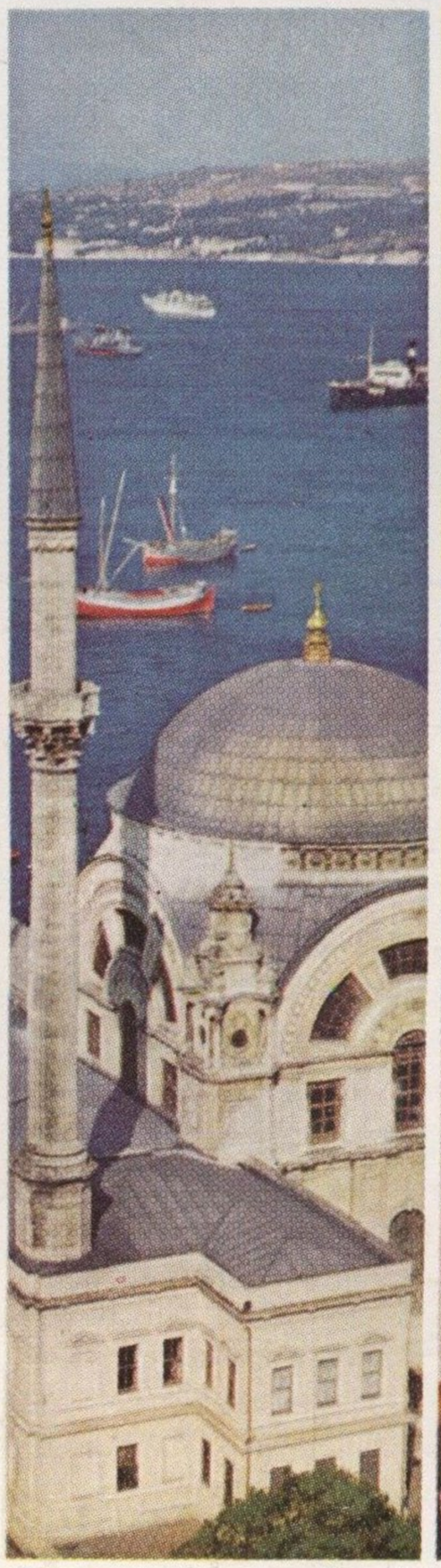

Honolulu, Tokyo, Istanbul, Paris—typical ports-of-call for 50,000 'Round the World passengers last year