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POWER SUPPLIES FOR SPACE VEHICLES

by J. B. Friedenberg

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JOHN W. CAMPBELL
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KAY TARRANT
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Art Director

ROBERT E. PARK
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WALTER J. McBRIDE
Advertising Manager

Editorial and Advertising office: 420 Lexington Avenue, New York 17, N. Y.

COVER BY SCHOENHERR

"Maybe it'll go away . . ."

■ A Law of Nature is an uncomfortable thing; it goes right on operating whether you like it or not, and, even worse, whether you know it exists or not. It doesn't wait to be discovered before operating; electricity was busily at work in everything from lightning to corrosion of the metal of ships long before it was discovered by Man. Uranium has been steadily giving off particles, and fissioning, since long before Earth was formed, let alone before Man's discovery of (1) uranium, (2) radioactivity or (3) fission.

A Law of Nature can be ignored for ten billion years, and far from going away, it goes about its business quite blindly. Animals that first crawled out of the sea knew nothing about gravity and its effects; a fish can't fall off a cliff and smash itself on the rocks below. The inevitable slow process of elimination set in, eliminating those individuals that did not shun cliff-edges, until, eventually, animals that stayed away from situations where gravity could act lethally evolved. The animals still didn't know anything whatever about the law of Nature; they simply had instincts that said "Do!" with imperative force, and others that said "Don't!" and neither gave explanations, nor discussed the nature of the threats involved.

The hunting carnivores will not eat carion; they have instincts that say "Don't!" so powerfully that only extreme starvation will drive them to eating carion. The instinct says nothing whatever about decay bacteria, normal levels of immune-reactions, or decomposition toxins; it just commands "Don't".

Equally, of course, the carion-eaters haven't the slightest notion about immune-reactions; they simply *have* fantastic immunity and go about their business without knowledge that they have an extraordinary power.

Now let's stipulate that, in 2174,

Johann van Ivanovitch, studying some phenomena at the Bolivian Moon research center near the Sea of Moscow, discovers the Law of Congenicity. By 2190, a considerable body of engineering technology has grown up, and congenic engineering is a rapidly expanding profession.

Necessarily, the Law of Congenicity—and all other laws of Nature yet to be discovered—*exist and operate today*. We may have to wait till 2190 to *use* those laws of Nature—but we're getting the *results* of them, whether we know it or not, always have, and forever will.

The difference between before and after discovery has nothing whatever to do with the reliable functioning of the law of Nature. It only has to do with whether Man uses it, or is clobbered by it. There was a law of Nature relating to the properties of ammonium nitrate in large quantities; it didn't become operative until men made large quantities of the stuff, and stored it. Then it operated with all the absolute reliability of any law of Nature; the German town in which 50,000,000 pounds of ammonium nitrate had been warehoused had a 25 kiloton explosion, without need of nuclear devices. One thing you can say for laws of Nature; they're absolutely reliable. Whether you expect it or not doesn't make a bit of difference; you get the results with perfect and impartial certainty.

But the operation of laws of Nature tends to be like mutation—any totally uncontrolled factor in life is, by long odds, more apt to louse things up than improve them. A "random factor" is simply one that *you* can't see any rhyme, reason, or order in; an undiscovered Natural Law is, then, a "random factor," no matter how rigorously ordered it actually is.

You can, therefore, bet solidly on two basic propositions:

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ILLUSTRATED BY KRENKEL

HIS MASTER'S VOICE

Spaceship McGuire had lots of knowledge—but no wisdom. He was smart—but incredibly foolish. And, as a natural consequence, tended to ask questions too profound for any philosopher—questions like "Who are you?"

By RANDALL GARRETT

■ I'd been in Ravenhurst's office on the mountain-sized planetoid called Raven's Rest only twice before. The third time was no better; Shalimar Ravenhurst was one of the smartest operators in the Belt, but when it came to personal relationships, he was utterly incompetent. He could make anyone dislike him without trying.

When I entered the office, he was sitting behind his mahogany desk, his eyes focused on the operation he was going through with a wineglass and a decanter. He didn't look up at me as he said:

"Sit down, Mr. Oak. Will you have some Madeira?"

I decided I might as well observe the pleasantries. There was no point in my getting nasty until he did. "Thank you, Mr. Ravenhurst, I will."

He kept his eyes focused on his work: It isn't easy to pour wine on a planetoid where the gee-pull is measured in fractions of a centimeter per second squared. It moves slowly, like ropy molasses, but you have to be careful not to be fooled by that. The viscosity is just as low as ever, and if you pour it from any great height, it will go scooting right out of the glass

again. The momentum it builds up is enough to make it splash right out again in a slow-motion gush which gets it all over the place.

Besides which, even if it didn't splash, it would take it so long to fall a few inches that you'd die of thirst waiting for it.

Ravenhurst had evolved a technique from long years of practice. He tilted the glass and the bottle toward each other, their edges touching, like you do when you're trying to pour beer without putting a head on it. As soon as the wine wet the glass, the adhesive forces at work would pull more wine into the wine glass. To get capillary action on a low-gee asteroid, you don't need a capillary, by any means. The negative meniscus on the wine was something to see; the first time you see it, you get the eerie feeling that the glass is spinning and throwing the wine up against the walls by centrifugal force.

I took the glass he offered me (Careful! Don't slosh!) and sipped at it. Using squirt tubes would have been a hell of a lot easier and neater, but Ravenhurst liked to do things his way.

He put the stopper back in the decanter, picked up his own glass and sipped appreciatively. Not until he put it back down on the desk again did he raise his eyes and look at me for the first time since I'd come in.

"Mr. Oak, you have caused me considerable trouble."

"I thought we'd hashed all that out, Mr. Ravenhurst," I said, keeping my voice level.

"So had I. But it appears that there were more ramifications to your action than we had at first supposed." His voice had the texture of heavy linseed oil.

He waited, as if he expected me to make some reply to that. When I didn't, he sighed slightly and went on. "I fear that you have inadvertently sabotaged McGuire. You were commissioned to prevent sabotage, Mr. Oak, and I'm afraid that you abrogated your contract."

I just continued to keep my voice calm. "If you are trying to get back the fee you gave me, we can always take it to court. I don't think you'd win."

"Mr. Oak," he said heavily, "I am not a fool, regardless of what your own impression may be. If I were trying to get back that fee, I would hardly offer to pay you another one."

I didn't think he was a fool. You don't get into the managerial business and climb to the top and stay there unless you have brains. Ravenhurst was smart, all right; it was just that, when it came to personal relationships, he wasn't very wise.

"Then stop all this yak about an abrogated contract and get to the point," I told him.

"I shall. I was merely trying to point out to you that it is through your own actions that I find myself in a very trying position, and that your sense of honor and ethics should induce you to rectify the damage."

"My honor and ethics are in fine shape," I said, "but my interpretation of the concepts might not be quite the same as yours. Get to the point."

He took another sip of Madeira. "The robotocists at Viking tell me that, in order to prevent any further . . . ah . . . sabotage by unauthorized persons, the MGYR-7 was constructed so that, after activation, the first man who addressed orders to it would thenceforth be considered its . . . ah . . . master.

"As I understand it, the problem of defining the term 'human being' unambiguously to a robot is still unsolved. The robotocists felt that it would be much easier to define a single individual. That would prevent the issuing of conflicting orders to a robot, provided the single individual were careful in giving orders himself.

"Now, it appears that *you*, Mr. Oak, were the first man to speak to McGuire after he had been activated. Is that correct?"

"Is that question purely rhetorical," I asked him, putting on my best expression of innocent interest. "Or are you losing your memory?" I had explained all that to him two weeks before, when I'd brought McGuire and the girl here, so that Ravenhurst would have a chance to cover up what had really happened.

My sarcasm didn't faze him in the least. "Rhetorical. It follows that you are the only man whose orders McGuire will obey."

"Your robotocists can change that," I said. This time, I was giving him my version of "genuine" innocence. A man has to be a good actor to be a competent double agent, and I didn't want Ravenhurst to know that I knew a great deal more about the problem than he did.

He shook his head, making his jowls wobble. "No, they cannot. They realize now that there should be some way of making that change, but they failed to see that it would be necessary. Only by completely draining McGuire's memory banks and refilling them with new data can this bias be eliminated."

"Then why don't they do that?"

"There are two very good reasons," he said. And there was a shade of anger in his tone. "In the first place, that sort of operation takes time, and it costs money. If we do that, we might as well go ahead and make the slight changes in structure necessary to incorporate some of the improvements that the robotocists now feel are necessary. In other words, they might as well go ahead and build the MGYR-8, which is precisely the thing I hired you to prevent."

"It seems you have a point there, Mr. Ravenhurst." He'd hired me because things were shaky at Viking. If he lost too much more money on the McGuire experiment, he stood a good chance of losing his position as manager. If that happened some of his other managerial contracts might be canceled, too. Things like that can begin to snowball, and Ravenhurst might find himself out of the managerial business entirely.

"But," I went on, "hasn't the additional wasted time already cost you

money?"

"It has. I was reluctant to call you in again—understandably enough, I think."

"Perfectly. It's mutual."

He ignored me. "I even considered going through with the rebuilding work, now that we have traced down the source of failure of the first six models. Unfortunately, that isn't feasible, either." He scowled at me.

"It seems," he went on, "that McGuire refuses to allow his brain to be tampered with. The self-preservation 'instinct' has come to the fore. He has refused to let the technicians and robotocists enter his hull, and he has threatened to take off and leave Ceres if any further attempts are made to . . . ah . . . disrupt his thinking processes."

"I can't say that I blame him," I said. "What do you want me to do? Go to Ceres and tell him to submit like a good boy?"

"It is too late for that, Mr. Oaks. Viking cannot stand any more of that kind of drain on its financial resources. I have been banking on the McGuire-type ships to put Viking Spacecraft ahead of every other spacecraft company in the System." He looked suddenly very grim and very determined. "Mr. Oak, I am *certain* that the robot ship is the answer to the transportation problems in the Solar System. For the sake of every human being in the Solar System, we *must* get the bugs out of McGuire!"

What's good for General Bullmoose is good for everybody, I quoted to myself. I'd have said it out loud, but I was fairly certain that Shalimar Ravenhurst was not a student of the classics.

"Mr. Oak, I would like you to go to Ceres and co-operate with the robotocists at Viking. When the MGYR-8 is finally built, I want it to be the prototype for a fast, safe, functional robot spaceship that can be turned out commercially. You can be of great service, Mr. Oak."

"In other words, I've got you over a barrel."

"I don't deny it."

"You know what my fees are, Mr. Ravenhurst. That's what you'll be charged. I'll expect to be paid weekly; if Viking boes broke, I don't want to lose more than a week's pay. On the other hand, if the MGYR-8 is successful, I will expect a substantial bonus."

"How much?"

"Exactly half of the cost of rebuilding. Half what it would take to build a Model 8 right now, and taking a chance on there being no bugs in it."

He considered that, looking grimmer than ever. Then he said: "I will do it on the condition that the bonus be paid off in installments, one each six months for three years after the first successful commercial ship is built by Viking."

"My lawyer will nail you down on that wording," I said, "but it's a deal. Is there anything else?"

"No."

"Then I think I'll leave for Ceres before you break a blood vessel."

"You continue to amaze me, Mr. Oak," he said. And the soft oiliness of his voice was the oil of vitriol. "Your compassion for your fellowman is a facet of your personality that I had not seen before. I shall welcome the opportunity to relax and allow my blood pressure to subside."

I could almost see Shalimar Ravenhurst suddenly exploding and adding his own touch of color to the room.

And, on that gladsome thought, I left. I let him have his small verbal triumph; if he'd known that I'd have taken on the job for almost nothing, he'd really have blown up.

Ten minutes later, I was in my vacuum suit, walking across the glaring, rough-polished rectangle of metal that was the landing field of Raven's Rest. The sun was near the zenith in the black, diamond-dusted sky, and the shadow of my flitterboat stood out like an inkblot on a bridal gown. I climbed in, started the engine, and released the magnetic anchor that held the little boat to the surface of the nickel-iron planetoid. I lifted her gently, worked her around until I was stationary in relation to the spinning planetoid, oriented myself against the stellar background, and headed toward the first blinker beacon on my way to Ceres.

For obvious economical reasons, it it impracticable to use full-sized spaceships in the Belt. A flitterboat, with a single gravitoinertial engine and the few necessities of life—air, some water, and a very little food—still costs more than a Rolls-Royce automobile does on Earth, but there has to be some sort of individual transportation in the Belt.

They can't be used for any great distances because a man can't stay in a vac suit very long without getting uncomfortable. You have to hop from beacon to beacon, which means that your *average* velocity doesn't amount to much, since you spend too much time accelerating and decelerating. But a flitterboat is enough to get around the neighborhood in, and that's all that's needed.

I got the GM-187 blinker in my sights, eased the acceleration up to one gee, relaxed to watch the radar screen while I thought over my coming ordeal with McGuire.

Testing spaceships, robotic or any other kind, is strictly not my business. The sign on the door of my office in New York says: *DANIEL OAK, Confidential Expediter;* I'm hired to help other people Get Things Done. Usually, if someone came to me with the problem of getting a spaceship test-piloted, I'd simply dig up the best test pilot in the business, hire him for my client, and forget about everything but collecting my fee. But I couldn't have refused this case if I'd wanted to. I'd already been assigned to it by someone a lot more important than Shalimar Ravenhurst.

Every schoolchild who has taken a course in Government Organization and Function can tell you that the Political Survey Division is a branch of the System Census Bureau of the UN Government, and that its job is to evaluate the political activities of

various sub-governments all over the System.

And every one of those poor tykes would be dead wrong.

The Political Survey Division *does* evaluate political activity, all right, but it is the Secret Service of the UN Government. The vast majority of the System's citizens don't even know the Government has a Secret Service. I happen to know only because I'm an agent of the Political Survey Division.

The PSD was vitally interested in the whole McGuire project. Robots of McGuire's complexity had been built before; the robot that runs the traffic patterns of the American Eastern Seaboard is just as capable as McGuire when it comes to handling a tremendous number of variables and making decisions on them. But that robot didn't have to be given orders except in extreme emergencies. Keeping a few million cars moving and safe at the same time is actually pretty routine stuff for a robot. And a traffic robot isn't given orders verbally; it is given any orders that may be necessary via teletype by a trained programming technician. Those orders are usually in reference to a change of routing due to repair work on the highways or the like. The robot itself can take care of such emergencies as bad weather or even an accident caused by the malfunctioning of an individual automobile.

McGuire was different. In the first place, he was mobile. He was in command of a spacecraft. In a sense, he *was* the spacecraft, since it served him in a way that was analogous to the way a human body serves the human mind. And he wasn't in charge of millions of objects with a top velocity of a hundred and fifty miles an hour; he was in charge of a single object that moved at velocities of thousands of miles per second. Nor did he have a set, unmoving highway as his path; his paths were variable and led through the emptiness of space.

Unforeseen emergencies can happen at any time in space, most of them having to do with the lives of passengers. A cargo ship would be somewhat less susceptible to such emergencies if there were no humans aboard; it doesn't matter much to a robot if he has no air in his hull.

But with passengers aboard, there may be times when it would be necessary to give orders—*fast!* And that means verbal orders, orders that can be given anywhere in the ship and relayed immediately by microphone to the robot's brain. A man doesn't have time to run to a teletyper and type out orders when there's an emergency in space.

That meant that McGuire had to understand English, and, since there has to be feedback in communication, he had to be able to speak it as well.

And that made McGuire more than somewhat difficult to deal with.

For more than a century, robotocists have been trying to build Asimov's famous Three Laws of Robotics into a robot brain.

First Law: *A robot shall not, either through action or inaction, allow harm to come to a human being.*

Second Law: *A robot shall obey the orders of a human being, except when such orders conflict with the First Law.*

Third Law: A robot shall strive to protect its own existence, except when this conflicts with the First or Second Law.

Nobody has succeeded yet, because nobody has yet succeeded in defining the term "human being" in such a way that the logical mind of a robot can encompass the concept.

A traffic robot is useful only because the definition has been rigidly narrowed down. As far as a traffic robot is concerned, "human beings" are the automobiles on its highways. Woe betide any poor sap who tries, illegally, to cross a robot-controlled highway on foot. The robot's only concern would be with the safety of the automobiles, and if the only way to avoid destruction of an automobile were to be by nudging the pedestrian aside with a fender, that's what would happen.

And, since its orders only come from one place, I suppose that a traffic robot thinks that the guy who uses that typer is an automobile.

With the first six models of the McGuire ships, the robotocists attempted to build in the Three Laws exactly as stated. And the first six went insane.

If one human being says "jump left," and another says "jump right," the robot is unable to evaluate which human being has given the more valid orler. Feed enough confusing and conflicting data into a robot brain, and it can begin behaving in ways that, in a human being, would be called paranoia or schizophrenia or catatonia or what-have-you, depending on the symptoms. And an insane robot is fully as dangerous as an insane human being controlling the same mechanical equipment, if not more so.

So the seventh model had been modified. The present McGuire's brain was impressed with slight modifications of the First and Second Laws.

If it is difficult to define a human being, it is much more difficult to define a *responsible* human being. One, in other words, who can be relied upon to give wise and proper orders to a robot, who can be relied upon not to drive the robot insane.

The robotocists at Viking Spacecraft had decided to take another tack. "Very well," they'd said, "if we can't define all the members of a group, we can certainly define an individual. We'll pick one responsible person and build McGuire so that he will take orders only from that person."

As it turned out, I was that person. Just substitute "Daniel Oak" for "human being" in the First and Second Laws, and you'll see how important I was to a certain spaceship named McGuire.

When I finally caught the beam from Ceres and set my flitterboat down on the huge landing field that had been carved from the nickel-iron of the asteroid with a focused sun beam, I was itchy with my own perspiration and groggy tired. I don't like riding in flitterboats, sitting on a bucket seat, astride the drive tube, like a witch on a broomstick, with nothing but a near-invisible transite hull between me and the stars, all cooped up in a vac suit. Unlike driving a car, you can't pull a flitterboat over and take a nap; you have to wait until you hit the next beacon station.

Ceres, the biggest rock in the Belt, is a lot more than just a beacon station. Like Eros and a few others, it's a city in its own right. And except for the Government Reservation, Viking Spacecraft owned Ceres, lock, stock, and mining rights.

Part of the reason for Viking's troubles was envy of that ownership. There were other companies in the Belt that would like to get their hands on that plum, and there were those who were doing everything short of cutting throats to get it. The PSD was afraid it might come to that, too, before very long.

Ceres is fifty-eight million cubic miles of nickel-iron, but nobody would cut her up for that. Nickel-iron is almost exactly as cheap as dirt on Earth, and, considering shipping costs, Earth soil costs a great deal more than nickel-iron in the Belt.

But, as an operations base, Ceres is second to none. Its surface gravity averages .0294 Standard Gee, as compared with Earth's .981, and that's enough to give a slight feeling of weight without unduly hampering the body with too much load. I weigh just under six pounds on Ceres, and after I've been there a while, going back to Earth is a strain that takes a week to get used to. Kids that are brought up in the Belt are forced to exercise in a room with a one-gee spin on it at least an hour a day. They don't like it at first, but it keeps them from growing up with the strength of mice. And an adult with any sense takes a spin now and then, too. Traveling in a flitterboat will give you a one-gee pull, all right, but you don't get much exercise.

I parked my flitterboat in the space that had been assigned to me by Landing Control, and went over to the nearest air-lock dome.

After I'd cycled through and had shucked my vac suit, I went into the inner room to find Colonel Brock waiting for me.

"Have a good trip, Oak?" he asked, trying to put a smile on his scarred, battered face.

"I got here alive, if that makes it a good flitterboat trip," I said, shaking his extended hand.

"That's the definition of a good trip," he told me.

"Then the question was superfluous. Seriously, what I need is a bath and some sleep."

"You'll get that, but first let's go somewhere where we can talk. Want a drink?"

"I could use one, I guess. Your treat?"

"My treat," he said. "Come on."

I followed him out and down a ladder to a corridor that led north. By definition, any asteroid spins toward the east, and all directions follow from that, regardless of which way the axis may point.

Colonel Harrington Brock was dressed in the black-and-gold "union suit" that was the uniform of Ravenhurst's Security Guard. My own was a tasteful green, but some of the other people in the public corridor seemed to go for more flashiness; besides silver and gold, there were shocking pinks and violent mauves, with stripes and blazes of other colors.

A crowd wearing skin-tight coveralls might shock the gentle people of Midwich-on-the-Moor, England, but they are normal dress in the Belt. You can't climb into a vac suit with bulky clothing on, and, if you did, you'd hate yourself within an hour, with a curse for every wrinkle that chafed your skin. And, in the Belt, you never know when you might have to get into a vac suit fast. In a "safe" area like the tunnels inside Ceres, there isn't much change of losing air, but there are places where no one but a fool would ever be more than ten seconds away from his vac suit.

I read an article by a psychologist a few months back, in which he claimed that the taste for loud colors in union suits was actually due to modesty. He claimed that the bright patterns drew attention to the colors themselves, and away from the base the colors were laid over. The observer, he said, tends to see the color and pattern of the suit, rather than the body it clings to so closely. Maybe he's right; I wouldn't know, not being a psychologist. I *have* spent summers in nudist resorts, though, and I never noticed anyone painting themselves with lavender and chartreuse checks. On the other hand, the people who go to nudist resorts are a self-screened group. So are the people who go to the Belt, for that matter, but the type of screening is different.

I'll just leave that problem in the hands of the psychologists, and go on wearing my immodestly quiet solid-color union suits.

Brock pushed open the inch-thick metal door beneath a sign that said "O'Banion's Bar," and I followed him in. We sat down at a table and ordered drinks when the waiter bustled over. A cop in uniform isn't supposed to drink, but Brock figures that the head of the Security Guard ought to be able to get away with a breach of his own rules.

We had our drinks in front of us and our cigarettes lit before Brock opened up with his troubles.

"Oak," he said, "I wanted to intercept you before you went to the plant because I want you to know that there may be trouble."

"Yeah? What kind?" Sometimes it's a pain to play ignorant.

"Thurston's outfit is trying to oust Ravenhurst from the managership of Viking and take over the job. Baedecker Metals & Mining Corporation, which is managed by Baedecker himself, wants to force Viking out of business so that BM&M can take over Ceres for large-scale processing of precious metals.

"Between the two of 'em, they're raising all sorts of minor hell around here, and it's liable to become major hell at any time. And we can't stand any hell—or sabotage—around this planetoid just now!"

"Now wait a minute," I said, still playing ignorant, "I thought we'd pretty well established that the 'sabotage' of the McGuire series was Jack Ravenhurst's fault. She was the one who was driving them nuts, not Thurston's agents."

"Perfectly true," he said agreeably. "We managed to block any attempts of sabotage by other company agents, even though it looked as though we hadn't for a while." He chuckled wryly. "We went all out to keep the McGuires safe, and all the time the boss' daughter was giving them the works." Then he looked sharply at me. "I covered that, of course. 'no one in the Security Guard but me knows that Jack was responsible."

"Good. But what about the Thurston and Baedecker agents, then?"

He took a hefty slug of his drink. "They're around, all right. We have our eyes on the ones we know, but those outfits are as sharp as we are, and they may have a few agents here on Ceres that we know nothing about."

"So? What does this have to do with me?"

He put his drink on the table. "Oak, I want you to help me." His onyx-brown eyes, only a shade darker than his skin, looked directly into my own. "I know it isn't part of your assignment, and you know I can't afford to pay you anything near what you're worth. It will have to come out of my pocket because I couldn't [illegible] justify it from operating [illegible] venhurst specifically told me that he doesn't want you messing around with the espionage and sabotage problem because he doesn't like your methods of operation."

"And you're going to go against his orders?"

"I am. Ravenhurst is sore at you personally because you showed him that Jack was responsible for the McGuire sabotage. It's an irrational dislike, and I am not going to let it interfere with my job. I'm going to protect Ravenhurst's interests to the best of my ability, and that means that I'll use the best of other people's abilities if I can."

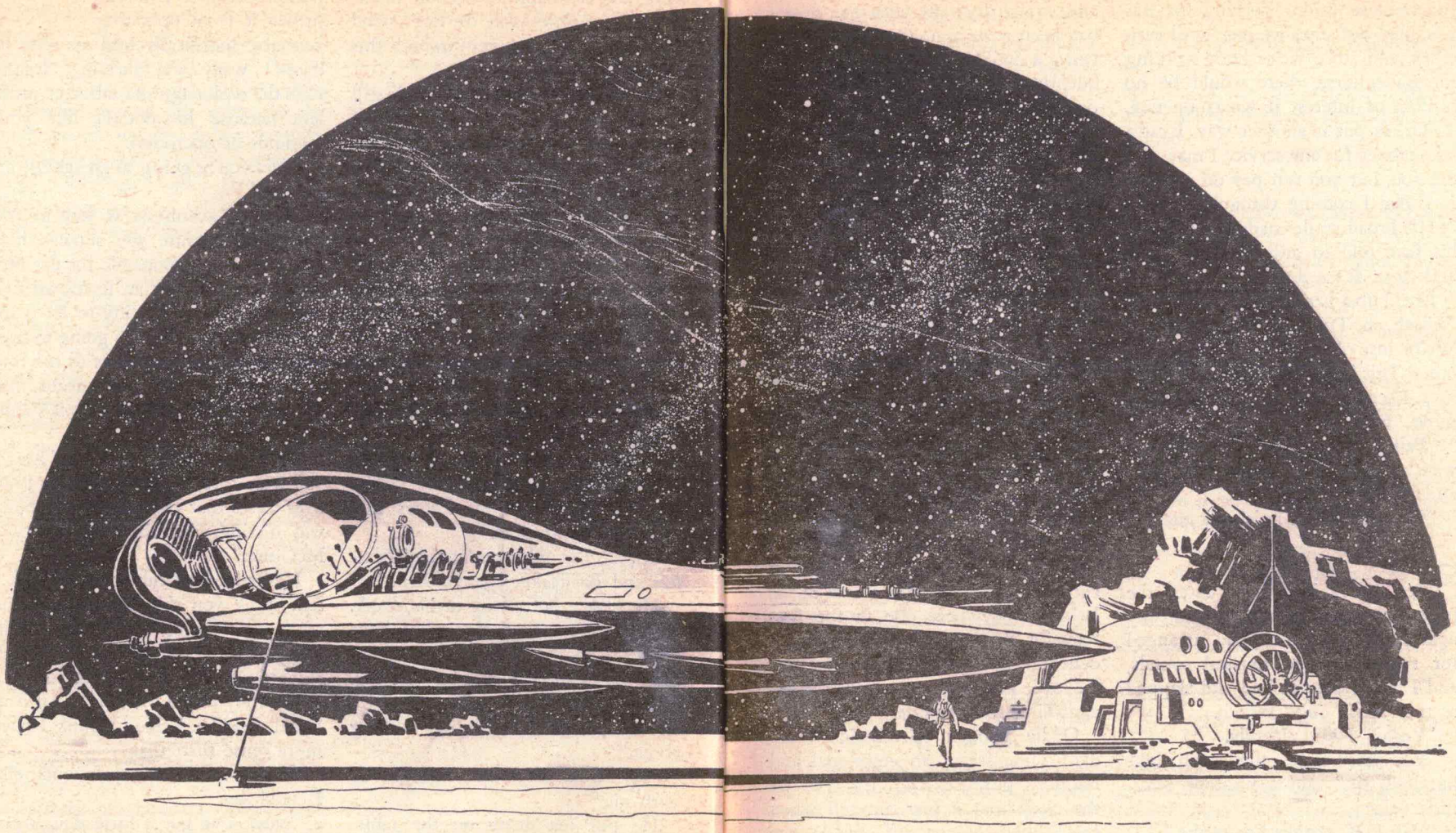
I grinned at him. "The last I heard, you were sore at me for blatting it all over Ceres that Jaqueline Ravenhurst was missing, when she sneaked aboard McGuire."

He nodded perfunctorily. "I was. I still think you should have told me what you were up to. But you did it, and you got results that I'd been unable to get. I'm not going to let a momentary pique hang on as an irrational disklike. I like to think I have more sense than that."

"Thanks." There wasn't much else I could say.

"Now, I've got a little dough put away; it's not much, but I could offer you—"

I shook my head, cutting him off. "Nope. Sorry, Brock. For two reasons. In the first place, there would be a conflict of interest. I'm working for Ravenhurst, and if he doesn't want



me to work for you, then it would be unethical for me to take the job.

"In the second place, my fees are standardized. Oh, I can allow a certain amount of fluctuation, but I'm not a physician or a lawyer; my services are not necessary to the survival of the individual, except in very rare cases, and those cases are generally arranged through a lawyer when it's a charity case.

"No, colonel, I'm afraid I couldn't possibly work for you.

He thought that over for a long time. Finally, he nodded his head very slowly. "I see. Yeah, I get your point." He scowled down at his drink.

"But," I said, "it would be a pleasure to work *with* you."

He looked up quickly. "How's that?"

"Well, let's look at it this way: You can't hire me because I'm already working for Ravenhurst; I can't hire

you because *you're* working for Ravenhurst. But since we may need each other, and since we're both working for Ravenhurst, there would be no conflict of interest if we co-operate.

"Or, to put it another way, I can't take money for any service I may render you, but you can pay off in services. Am I coming through?"

His broad smile made the scars on his face fold in and deepen. "Loud and clear. It's a deal."

I held up a hand, palm toward him. "Ah, ah, ah! There's no 'deal' involved. We're just old buddies helping each other. This is for friendship, not business. I scratch your back; you scratch mine. Fair?"

"Fair. Come on down to my office; I want to give you a headful of facts and figures."

"Will do. Let me finish my guzzle."

Seven and a half hours later, the phone in the bedroom of the company apartment that Brock had arranged for me made loud musical sounds, and I rolled over in bed and slapped at the *"audio only"* switch.

"Yeah?" I said sleepily.

"You asked to be called at oh eight hundred, sir." said a pleasant feminine voice.

"Yah. O.K., thanks. I'm awake."

"You're welcome, sir."

I cut off and blinked the sleep out of my eyes. I'd spent an hour and a half in Brock's office, soaking up all the information he gave me and giving him all the information I could. I hoped that he had been more honest and straightforward with me than I had been with him. The trouble with being a double agent is that you frequently have to play dirty with someone you like, respect, and trust.

I looked at the watch on my wrist. Oh eight oh six, Greenwich Standard Time. The girl had been a little late in calling, but it didn't matter that much.

All over the Solar System, except on Earth itself, the clocks read the same as they do in Greenwich, England. Time zones don't mean anything anywhere except on Earth, where the natives feel that the sun should be at the zenith when the clock says twelve. An irrational concept, to say the least.

Well, not really. Let's say that it's an emotional concept. A man feels better if he has the comfortable notion that the position of the sun has something to do with the numbers on the clock. It gives him a sense of security. Only the fact that a man in the Belt—or anywhere else in the System, for that matter—is not dependent on Sol for lighting purposes makes it possible to establish a Standard Time for everyone.

Oddly enough, Greenwich Standard Time serves an emotional and religious purpose, Too. It's only by the clock that a Jew can tell when the Sabbath begins; it's only by the clock a Catholic can tell when to begin his abstinence on Friday; it's only by the clock that a Moslem can tell when to begin and end the fasts of Ramadan.

And it is only by the clock that the various eight-hour work shifts can operate in the Belt. On Earth, the four-hour workday is standard, but there's a lot more work to be done in the Belt.

I got up and got dressed and took the tubeway to Viking Test Area Four, where McGuire was the ruler of the roost. The guard at the main door took one look at my pass, smiled me in, and headed for his phone as soon as I went inside. By the time I had arrived at the office of Chief Engineer Sven Midguard, the whole staff had been alerted, and the top men were waiting for me in Midguard's office.

Midguard himself met me in his outer office—a graying man in his sixties, still handsome in the telly-idol way, but running a bit to paunch now that he was approaching middle age.

"Mr. Oak! So glad to see you! So glad we could get you to help us."

"Happy to be of service," I said.

"Yes, yes, of course. Come along, come on in and meet the staff. They're . . . uh . . . anxious to meet you."

I'd have bet they would be. As far as they knew, I was just the guy who was supposed to take the boss' daughter to school on Luna, empowered only to make sure she didn't get into trouble, and had accidentally become McGuire's lord and master when I'd gone to take her off the ship. I was an errand boy who'd managed to get control of a spaceship that was worth millions, a layman who was holding up the work of responsible scientists and technicians. In simple words, a jerk.

In spite of the socially acceptable smiles on all their faces, every one of them managed to convey his or her opinion of me by facial expression alone when Miguard introduced me around.

Ellsworth Felder was short, big-bellied, round-faced, and slightly red-nosed, like a well-shaved Santa Claus. He was introduced as the head of the Viking robotics staff, and he shook hands firmly when he said he was glad to meet me.

Irwin Brentwood, the electronocist, was a slight, spare man with the body of a young boy and a gentle, soft tenor voice. His "How do you do, Mr. Oak" was almost apologetic, and his small hand in mine exerted more pressure than I'd expected.

Theodore Videnski looked more like a wrestler than a robotics expert. He was as tall as I was and much wider and heavier, and his expression and voice conveyed the idea that he could have lived a good deal longer without missing my acquaintance.

Vivian Devereaux was the only one of the five who gave the impression that she could, if given a chance, begin to like me. She was a tough-cored, no-nonsense, finely-muscled, alert, and very pretty woman in her late twenties—a not uncommon type in the Belt, although they usually don't come as lovely as that. The red, silver, and blue pattern of her union suit didn't at all distract my attention from the magnificently molded body beneath; I made a mental note to write a letter

to the editor of a certain psychological journal. I decided that if this gal could think as good as she looked, she was probably one hell of a fine mathematician.

The conference room was small, cozy, and ringed with couches. On Earth, they would have been called padded benches, and they would have been uncomfortably hard, but you don't need innersprings and sponge rubber when your weight has dropped by ninety-seven per cent.

Midguard served coffee all around while we all kept up a patter of chatter that served to get us acquainted before we launched into deep thinking and heavy conversation.

"Well," said Midguard, when he finally sat down, "now that Mr. Oak is here, I suggest we begin scheduling our program."

There was a momentary silence, then the boyish Brentwood said, "I think we ought to explain to Mr. Oak just what our problem is."

That was generally agreed on, and for the next half hour I heard another re-run of information I already had. I just tried to look receptive and kept my mouth shut.

". . . So you see," Midguard finally wound up, "in order to put McGuire through his paces, your co-operation is vitally necessary."

"The first thing to do," rumbled the barrel-chested Videnski, "is to run a verbal check on him, to see how the brain is functioning."

"His circuits should be checked, too," said Brentwood softly. "But that can be done later. I'll get my testing equipment ready, so that I can hook it in immediately after you get through with the verbal check." He looked over at Miss Deveraux. "Vivian?"

"I though perhaps it might be quicker if we ran a few straight math checks on him before the verbal check," she said. "It wouldn't take long, and if there's anything wrong in that area, we'll know what to look for in the later checks. Would that be all right with you, Ted?"

Videnski nodded. "Certainly, certainly. Save us some backtracking, maybe."

Nobody asked me anything. I was just a tool; I was the switch that would turn on the machine these people wanted to play with, that was all. I could see a long, boring day ahead for Daniel Oak.

If anything, my prediction was shortsighted. Not only was that day boring, but so were the next three. In effect, I told McGuire that he should let the nice people into his hull and answer all their pretty questions.

After that, there was nothing much to do but stand around and watch while the others worked. Mostly, I watched Brentwood doing his circuit checks; it was a great deal more interesting to watch lights flash and meter needles wiggle and lines dancing on oscilloscope plates than it was to listen to conversations that sounded as if they'd been lifted from C. L. Dodgson's treatise on logic.

"A man is marooned on an asteroid without food or water and only one day's supply of air in the tanks of his vac suit. If there is an emergency air tank on the asteroid, it contains enough air to last him for two weeks. If there is a flare bomb on the asteroid, then there is an air tank. There is either a dismantled communicator on the asteroid or an emergency water supply, but not both. There is either an emergency food package, or flare bomb, or a single hibernine injection; or there is both an emergency food package and a flare bomb, but no hibernine. If there is an emergency water supply, it contains enough water to last the man four days. If there is a hibernine injection, then there is a dismantled communicator on the asteroid. If there is an emergency food package, there is enough in it to last him for one day, and there is a dismantled communicator, but if they are not both there, then neither is there. If there is emergency air tank, then there is an emergency water supply.

"If there is a flare bomb, he can set it off immediately, and rescue will arrive within two days. If there is a dismantled communicator, it will take the man one day to put it together before he can call for help, and rescue will arrive in an additional two days.

"If there is an emergency water tank, there is either a single hibernine injection or a food package or both. If there is a hibernine injection, the man can use it to put himself into suspended animation for exactly twenty-four hours, during which time he will need neither air, nor food, nor water. If there is air, or water, or food on the asteroid, or any two of them or all three, the man will use each at the normal rate until it is exhausted, or the man dies, or he is rescued.

"Assuming that, without hibernine, the man can live for exactly two days without water, exactly one week without food, and exactly five minutes without air, can he be rescued? If so, how long will it be before he is rescued? If not, what is his maximum survival time?

"Does this problem have more than one valid answer? If so, give and explain both.

"Or is the problem unsolvable as given? If so, explain why it is unsolvable."

Sit around listening to that sort of stuff for very long, and you begin to wish you *were* out on an uninhabited asteroid somewhere. Problems like that are the sort of thing that any simple-minded computer can solve in a fraction of a second if they're reduced to binary notation first, but poor McGuire had to do his own mathematical interpretations from English, and the things got more complicated as they went along.

And McGuire went right on answering them in his calm, matter-of-fact baritone.

I remember that particular problem because, while Videnski was reciting it, Brentwood pointed at an oscilloscope plate that had nothing on it but a wide, bright, flickering band of light that wavered a little around the upper and lower edges.

"See that?" he asked in his tenor voice. "That's a tracing of McGuire's thinking processes. Actually, it's a very thin, very bright tracing, but it's moving over that area so fast that you can't see it. A high-speed camera could pick it up, and if the film were projected at normal speed, you could see every little bit of data being processed." Then he patted a small instrument that was sitting near the oscilloscope plate. "Of course, we don't go to all that trouble; we record it directly and analyze it later."

And that analysis can be pretty maddening at times," said a very lovely voice behind me. I turned around and gave Vivian Deveraux my best smile. Her close-cropped blond hair looked a little disheveled, but it didn't make her any the less beautiful.

"What does Videnski say?" I asked. "Is McGuire still passing his exams?"

She smiled. "Ted says that if this keeps up, we can get McGuire a scholarship at Cal Tech." Then she frowned slightly. "It all depends on the analysis, of course. We'll have to see how his timing is, and how many actual computations he's using for each problem. It'll take a lot of work."

I could hear Videnski's voice still droning away in the control room, alternating with an occasional answer from McGuire. Normally, McGuire only used the speaker in whatever compartment I happened to be in, but I'd given him orders to stick with Videnski during the testing. I'd also had him shut off his pick-ups everywhere in the control room, so that our chatter wouldn't be going into his brain along with Videnski's.

In the lounge, where we were, Brentwood had removed a panel that gave him access to the testing circuits. To actually get into McGuire's inner workings and tamper with him would be a lot tougher. McGuire wouldn't allow it unless I told him to, but even if he did, getting to the brain required three separate keys and the knowledge of the combination on the dial of the durasteel door to the tank that held his brain. Explosives would wreck the brain if they were powerful enough to open the door, and so would a torch. Viking Spacecraft had taken every precaution to make sure that nobody stole their pet.

"How long before we can give McGuire his test flight?" I asked. McGuire had been into space once, but it hadn't been a shakedown cruise.

Vivian looked at Brentwood. "Tomorrow, unless something unforeseen shows up, huh, Irwin?"

"That's what the schedule says," murmured Brentwood.

"Great," I said. "Just great. There's schedule, and no one's told me anything about it. Anything else I should know about, perhaps? Some little thing like where we're going, or whether I should pack a bag, or whether I'm even invited along?"

Vivian Devereaux blinked. It was a very pretty blink. "Oh, my goodness. I'm sorry. I guess we haven't kept you very much in touch, really, have we? We're so used to working together that . . ." She let the words trail off with a sheepish smile.

Brentwood chuckled a soft, good-humored chuckle. "I thought the Chief had told you." By "the Chief," he meant Ellsworth Felder, the head robotocist. As far as these people were concerned, Sven Midguard was just a spacecraft engineer.

"Not a word," I said, mentally making a note to find out why Santa Claus Felder had failed to notify me.

"Well, bring a suitcase," Vivian said. "We—or, rather, you—are taking McGuire on a test hop to Phobos. Mars is pretty close right now, so it'll be an easy drive sunwards.

"If all goes well, you're to set him down at Syrtisport, for his first planet landing. Then to Luna for a day or two. Then directly to Earth and Long Island Spaceport. We should know by then how he behaves."

"Why Earth?" I asked. There didn't seem much point to it.

"Keep it under your hat," she said. "Manager Ravenhurst is planning a big publicity campaign. First ship to make the voyage without a human hand at the controls, and all that. I don't know why, but he wants to make a big splash on Earth if McGuire has checked out perfectly as far as Luna."

"Oh. Well, Ravenhurst's the boss." I knew why. The general public didn't know how shaky Viking Spacecraft was, and neither, presumably, did the robotics staff. That knowledge was strictly managerial level. But a big splash on Earth would boost Viking's prestige tremendously, with a possible rise in stock values which would take some of the shakiness out of Viking.

By the time the day's work was over, I'd heard all of Videnski's rumbling baritone that I wanted to hear. I was grateful to get back to the relative silence of my apartment.

I opened a beer, lit a cigarette, and relaxed on my bed for a few minutes before I made a phone call. I punched BANning 6226, and got an answer almost immediately. The screen didn't come to life, but a voice said: "Marty here. Hullo, Oak." He could see me, even if I couldn't see him. If anyone punched that number by accident, Marty would simply turn on a recording that said: "The number you have punched is not a working number; please disconnect and punch again; this is a recorded message." There is no point in letting just anyone get in touch with the Ceres branch of the Political Survey Division through their secret channels.

"Marty," I said, "the test hop is tomorrow." I gave him all the details as I knew them.

"Hm-m-m." He sounded thoughtful. "If either Thurston or Baedecker agents are going to try anything, it seems as though this would be the time to do it."

"I think so, too. Do you have any new information at all?"

"Not much. Thurston's men don't know what Baedecker is up to, as far as we can gather. But the Baedecker agents have an idea that Thurston is trying to take over Viking, and they

don't mind at all; they're evidently hoping that the Ravenhurst-Thurston battle will create enough confusion so that it won't take much push on their part to topple the whole mess and take control. We know most of the regular agents on both sides, and we've managed to get a lot of that information to Colonel Brock so that he can handle quite a bit of the work for us." Marty chuckled a little. "That's what I call a *really* secret agent. Brock has no idea that he's an agent for a service he doesn't even know exists."

"Harrington Brock is a good man, Marty. Don't underestimate him."

"I don't. It's a shame he just doesn't have quite what it takes to be good PSD material."

"I hate to be referred to as 'material', good or bad. Do you have any idea how Baedecker or Thurston might be going to pull the grandstand play?"

"Not a one, so far. How about that robotics team, or the engineers who are working on the ship? Think any of them could be in the pay of a rival?"

"It's possible," I said, "but I don't know which one or ones it might be. I've been watching them for three days, and they all seem on the up-and-up to me. And that worries me."

"How so?"

"You'd think that at least one of them would behave suspiciously by accident once in a while. You know—nerves or jumpiness from purely personal reasons. Hang-over, maybe, or woman trouble. But, no."

"The clue of the dog in the night, huh? Does that mean you suspect all of them?" he asked dryly.

"Sure. Isn't that what a good detective is supposed to do?"

"I wouldn't know; I'm just an information post. I will say this, though: If any of that bunch is connected with either Baedecker or Thurston, he isn't a professional. He's someone who's been contacted secretly and offered a heavy bribe. We're checking back on all of them now, to see if there's anything in their pasts which might indicate that their ethics are not what they should be. Or any unusual circumstance that might indicate blackmail or financial pressure."

"Nothing so far, though?"

"Nothing."

I thought for a second, then said: "Is there any known rival agent in any position to sabotage McGuire on Phobos, Mars, or Luna?"

"Several, in each place. But we'll have agents there to keep an eye on them. To be honest with you, Oak, I don't think there's much to worry about. I don't mean you shouldn't keep your eyes open, but—"

"I know what you mean," I said. "Do my own worrying, and don't worry you with it. All right. Meanwhile, if you get anything I can use, call me. And I'll let you know at this end."

"Fair enough. Good luck."

I wished him the same, and cut off.

I had time for one drag off my cigarette and one swallow of beer before

the ıe chimed. I put my beer dowı ıd pushed the switch for the audio only.

"Yes?" I said.

The face that came on the screen was one I'd never seen before. A man about my age, I thought, or maybe a few years older. His skin was tanned—whether by heredity or sunlight was hard to tell; his features were not distinctive enough to be sure. His hair was medium brown and cut rather longer than the crew cut which is common in the Belt.

"I'm calling for Mr. Daniel Oak," he said in a low tenor voice.

I touched the "vision" button and let the pick-up transmit my image to him. No point in playing cagy just at that time. "Speaking," I said.

"You're Mr. Daniel Oak, of New York?" he asked.

"That's right."

"The confidential expediter?" He seemed to want to make very certain of his quarry.

"That's right," I repeated.

His smile was a little stiff. "My name is Venuccio, Mr. Oak; André Venuccio. I'd like to speak to you about a matter of employment."

"You mean you want a job?" This is a conversational gimmick known as The Deliberate Misunderstanding, or The Innocent Needle.

He twitched his head a little, which might have been a negative shake. "No, no. *I* wish to employ *you,* Mr. Oak."

"Well, I'm pretty busy right now, and I—"

He cut me off with: "Mr. Oak, I have come all the way from Earth to speak to you. I assure you that this is most important. I would like very much to discuss it with you."

"Well, all right. Go ahead."

"Not over the phone. There is a possibility of its being tapped. I would like to meet you personally."

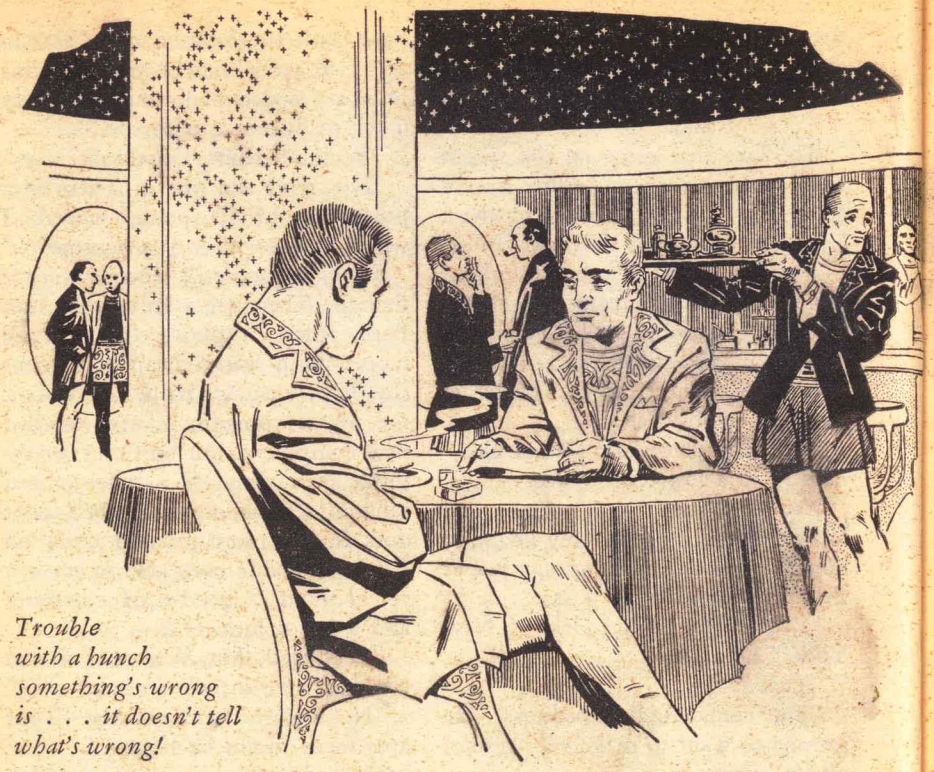
I took a couple of seconds out for thought. There are a lot of places on Earth where a phone line can be tapped with fairly cheap equipment simply because, for economic reasons, the phone company hasn't installed new equipment. But on Ceres, everything goes through a synchronized random scrambler circuit, just as it does in the more modern cities on Earth. Nobody's been able to crack it yet without a good-sized computer and a lot of luck. Still—

"Very well, Mr. Venuccio; if you could be here in half an hour—"

"No, no," he said quickly. "Your apartment might be bugged."

He had a point there. He couldn't know that I'd already made sure that my apartment was bug-proof. A self-contained broadcaster isn't much use inside Ceres; the metal walls stop almost any radiation before it can get very far. If my place was bugged, conductors of some kind would have to be used, and I'd gone over the place thoroughly to make sure there was no such thing.

In addition, I'd used one of my favorite gadgets: a non-random noise generator. Because a conversation is patterned, it is possible to pick it out of a "white," purely random background noise, even if the background



Trouble with a hunch something's wrong is . . . it doesn't tell what's wrong!

is louder than the conversation. But my little sweetheart was a multiple recording of ten thousand different conversations, all meaningless, *plus* a lot of "white" noise. After the gadget is connected up, the walls vibrate with jabber that can't be analyzed even by the best of differential analyzers. Only in the hush area away from the walls is it quiet.

But my caller couldn't be expected to know that, and I didn't feel like telling him.

I decided to see how far he'd go.

"Mr. Venuccio," I said in an apologetic tone, "I'm sorry, but my present work will require several more weeks, and—"

"I understand that," he said quickly. He seemed to be a great one for interruptions. "But I assure you that I can make it worth your while. What would you charge for an hour of your time?"

"It would depend on what I'd have to do."

"All you will have to do is listen to me explain my problem and my proposition to you. An hour, at the very most. I could meet you at the *Seven Sisters* in half an hour. This is very urgent, Mr. Oak."

Not to me, it wasn't. But my intuition told me that there was something here I ought to know about. "All right, Mr. Venuccio; I'll be there. It'll cost you a hundred in cash for the consultation fee. Have it with you." In case he didn't know what I charged, that ought to give him some idea.

He didn't flinch. "Very good, Mr. Oak. I'll see you in half an hour, then. Good-by." And his image vanished.

Interesting, I thought. There was something definitely phony about Mr. André Venuccio. His manner of speaking didn't sound natural; it was as though he were attempting to pretend to be something he wasn't.

I made a few phone calls and came up with more information. The last ship directly from Earth had landed four days ago. Mr. Venuccio could have come in by flitterboat, but it didn't seem likely, if he had, as he claimed, come all the way from Earth to see me. Aside from the fact that my staff in my New York office wouldn't have told him where I was, there was also the fact that no André Venuccio had come in on the last ship.

I made two more calls—one to Marty and one to Colonel Brock—and then began to get ready for my appointment with the enigmatic Mr. Venuccio.

The *Seven Sisters* is one of the most elaborate dining clubs on Ceres. It caters strictly to the moneyed class, and is positively drenched in snob appeal. The food is good, the liquor is good, and the entertainment is adequate. Since all three have to be imported from Earth, the first two are expensive and the last one is the best they can get, because most of the top-flight entertainers of Earth don't feel that it's worth their while to go asteroid-hopping.

It is one of the few public places in the Belt where you will be expected to "dress" for dinner. That means a jacket and Bermuda shorts over your union suit.

As far as decoration goes, the *Seven Sisters* is the lushest place in the Belt. The walls of the main dining room, which is about sixty by sixty feet in floor area, are paneled with white oak up to a height of eight feet. Wood is expensive in the Belt; forests on the asteroids share the null class with snowflakes on the sunward side of Mercury.

Above the paneling, the ceiling is domed and black, and a pattern of bright pinlights representing the Pleiades—greatly enlarged—glitters against the blackness.

The floor is decorative traction tile, white and pale blue, with rust-red geometric designs on it. In the middle of the floor, there is a hollow, transparent column, brightly illuminated from below. Four feet in diameter, it rises a dozen feet above the floor to a flat, truncated top that is opaque to prevent the light from hitting the dome overhead and ruining the pseudo-sky effect, and mirrored on the un-

derside to reflect the light back down the column. Inside, thousands of tiny, faceted, plastic gems are kept constantly in motion by forced air currents, swirling up and down the inside of the transparent column—easy enough to do under Cerean gravity. Each spinning gem, scarcely larger than a pinhead, catches the light and scatters it around the room. It's a sort of macroscopic Tyndall effect that is quite impressive.

I told the headwaiter that I wanted Mr. Venuccio's table, and was escorted straight to it. Venuccio was waiting for me.

He stood up as I approached and gave me his stiff smile. He was short—not more than five foot six—and rather lean. I got the impression that his jacket was padded to make his shoulders appear wider than they were.

"Sit down, Mr. Oak," he said in that oddly forced voice of his. "Would you care for something to eat? Or a drink, perhaps?" He already had a drink, still three-quarters full.

"Not just yet. Later, maybe."

I had watched him as he stood up, and I went right on watching him while we sat down. For a man who was just in from Earth, he handled himself remarkable well under low gee. "We may order later," he said to the waiter.

As soon as the waiter was out of earshot, Venuccio leaned toward me, and suddenly he was all business.

One hand slid a banknote across the table. "Here is the hundred we agreed upon, Mr. Oak. I can state my proposition very quickly; you have only to listen."

I palmed the hundred and slipped it out of sight. "You have rented yourself a pair of ears, Mr. Venuccio."

"Very good." He kept his voice low and even. "Do you know anything of the Cronos Water Corporation?"

"Sure. Cronos is one of the companies that mines the rings of Saturn. A lot of the water here in the Belt comes from the ice they ship in. Why?"

"Not exactly," he said, ignoring my question. "They now have full control of their only rival, Titan Enterprises. I am a stockholder in Titan, and I am convinced that there was chicanery involved in the transfer of managership. The Cronos Corporation intends to raise the price of water in the Belt and make a lot of fast money."

"Does the Government know about this?"

"No. Even I can't prove it on paper. That's why I want you to go out there and get the information. It will have to be done quickly, before Cronos can file notice of new prices."

"What do you mean, 'quickly'?"

"You'll have to take the *Warbow,* which is leaving for Luna this evening, in order to catch the *Plunger,* which is leaving Luna for Saturn. There won't be another chance for three weeks, and that will be too late."

It was all very pretty. Saturn was on the other side of the System at the time, and it would be a nice, long trip.

I shook my head. "Sorry, Mr. Venuccio, but, as I told you, I'm already engaged. You'll have to get someone else."

He looked suddenly desperate. "I will pay you well. I'll buy out your present contract, and I'll pay you double for the work."

We spent the rest of his bought-and-paid-for hour haggling. Or, rather, *he* haggled. I asked a lot of questions, and he tried to answer them in order to convince me that I should go, and I just asked more questions.

Exactly one hour from the time I'd been handed the hundred, I stood up. Venuccio was in the middle of a sentence, but I said: "Your hour's up, Mr. Venuccio. The answer is still no. Thank you for your business."

"But—" He started to rise, started to grasp my sleeve.

"Sit down." I didn't say it harshly or angrily, just firmly. He sat. "I don't want to be bothered by any more of this kind of thing. Ever again. Is that understood, Mr. Venuccio?"

He nodded wordlessly, and I left him sitting there.

As I moved toward the door, the headwaiter came towards me. Before he could say anything, I said: "Mr. Venuccio is taking care of the check."

"I know that, Oak," he said in a low voice. "We'll have him tailed when he leaves here." I never would have recognized him; it was Colonel Harrington Brock, wearing a plexiskin mask. "Got any idea of what he wants or who he's working for?"

"He wants me to leave Ceres, which would hold up the testing of McGuire. Offered me plenty for it, too. I'm pretty sure he's wearing a plexiskin mask, too; and I'm almost certain I've heard that voice before, but I can't quite place it."

"We'll find out," Brock said grimly.

Then he gave me a headwaiter's smile and went on his way. I went on out through the ornate doors of the *Seven Sisters.*

When I got back to my apartment, I looked it over carefully. It didn't look as though anyone had made an unauthorized search. I called Marty, and he assured me that the men watching the place had seen no one go in. But I was already fairly certain that the purpose of Mr. Venuccio's appointment had not been to lure me away from my apartment. He wanted me to go a lot farther than that.

I drank a couple more beers and smoked four or five cigarettes while I thought things through, then I got ready for bed, cut the lights, and went to sleep.

The next morning, I showed up at Viking's Testing Area Four with a hot breakfast inside me and my vac suit outside, ready to go sky-climbing with McGuire. McGuire's tall blue spire shone brightly in the sunlight, and looked, as he always did, as though ready to take the leap at any time.

There would be only five of us aboard. Besides myself, there was the short, chubby Ellsworth Felder, head of the robotics staff; the boyish Irwin Brentwood; the tough, taciturn Theo-

dore Videnski; and the lovely Vivian Devereaux.

We made the last-minute checks to make sure everything was ready for the hop to Phobos, and then I took command.

"Plot a one-gee orbit to Phobos, McGuire. Take-off in five minutes."

"Yes, sir," said McGuire. He thought for a minute, then said: "Course plotted, sir."

"Good." I glanced at Brentwood, who had set up his instruments in a semipermanent installation for the trip. "Did you get that, Brentwood?" He nodded.

"All right, McGuire; we're going to be doing a few tests out in space, so, for right now, just follow the curve of the first half—up to five minutes before turnover. I'll let you know what to do then. Warn me at five minutes before turnover; otherwise, just keep going until I give you further orders."

"Yes, sir."

"How much longer until take-off time?"

"Three and a half minutes, sir."

"Begin a countdown at minus thirty seconds. One count every five seconds until minus five seconds, one count per second from there to zero. Lift at zero."

"Yes, sir."

We got everything settled, made sure there were no loose tools lying around, and sat down in the lounge chairs to wait for the lift. Pretty soon, McGuire said: "Minus thirty seconds." Finally, he said "Five . . . four . . . three . . . two . . . one . . . zero."

And we all sank down in the chairs, under the pull of a full Standard Gee of acceleration—one thousand centimeters per second squared.

Ceres fell away from beneath us and slowly receded in the vast blackness of space.

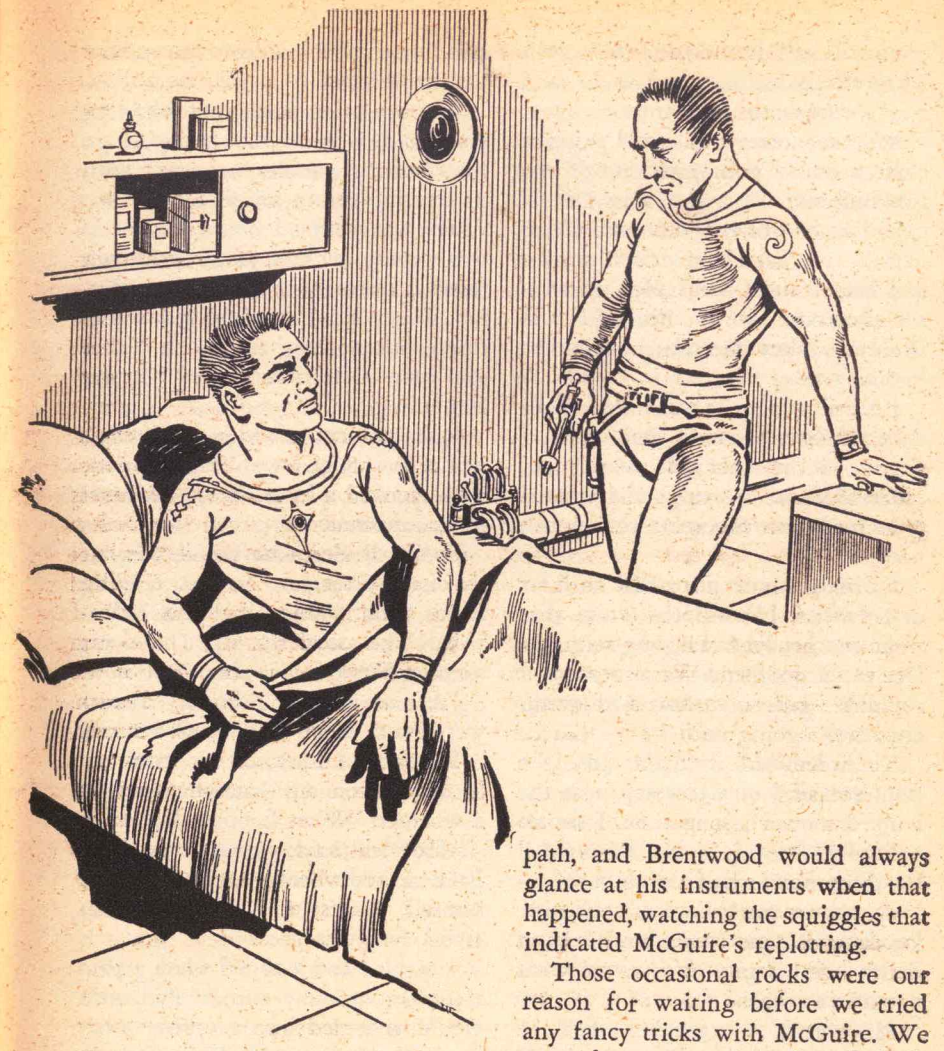
I got up and stretched my muscles, and the others began doing the same. It takes time to get used to a full gee again after spending time in the Belt. Even in a flitterboat, you're in a bucket seat, lying on your back; you can't do any walking around in a flitterboat.

The change in Ellsworth Felder was remarkable. All that chubbiness that had ballooned out under the low gravity of Ceres and made him look like the Cheerful Cherub was pulled into sagging folds under the pull of the ship's acceleration. It made him look fifteen years older. None of the others seemed to be bothered much.

Felder kept his good humor, though. He didn't seem to know that there'd been any change in his appearance. He rubbed his hands together and said: "I, for one, always get hungry when the gravity goes up. May I suggest an early lunch?"

Nobody disagreed with him.

We settled into a routine pretty quickly. There wasn't much to do, since McGuire was taking care of the jobs that require a crew on an ordinary ship. To avoid boredom, we'd brought books and a few decks of cards and various other time-wasters. Several times, McGuire had to change course slightly because of rocks in his



path, and Brentwood would always glance at his instruments when that happened, watching the squiggles that indicated McGuire's replotting.

Those occasional rocks were our reason for waiting before we tried any fancy tricks with McGuire. We wanted to get out into the relatively clear space between Mars and the Belt.

I beat Videnski out of a ten-spot at gin rummy, which, oddly enough, seemed to raise his respect for me. Vivian Deveraux talked with Brentwood for a while, then settled down to reading a book entitled "Some Ap-

plications of Discontinuity in Pattern Theory." Felder munched apples and read a magazine.

We ate another meal amid pleasant chatter, and I went into one of the two bedrooms for a nap. Miss Devereaux had one of the bedrooms all to herself. We men had drawn straws, and Felder and I had ended up with the bedroom while Videnski and Brentwood got the couches in the lounge.

I dozed off, but it was only a light doze. If there were an emergency, I would be the only one who could order McGuire around, and I wanted to be ready to wake up at a moment's notice.

I'd been snoozing for half an hour or so when I heard the noise that woke me up. I'd been lying with my face to the wall, and, for a moment, I couldn't figure out what had awakened me.

Then I heard it again. Just the faintest sound of a footstep near the bunk. I moved just in time. I sat up and turned to see Irwin Brentwood standing near me, holding a hypospray gun in one hand. I jumped him, knocking the gun aside, but his hand didn't lose his grip on it as we went down in a tangle.

He was a lot tougher than he looked. That boyish figure was all wiry muscle, and I was still dopey from sleep—not much, but just enough to impair my efficiency. I got a grip on his gun hand and began slowly twisting it while we rolled over and over on the floor. Then, somehow, he managed to get his other arm loose, and he drove an elbow into my throat.

There was an instant of blinding pain, and I heard the hypogun go *chuff!* as my muscles tightened with the searing fire in my throat.

The next thing I knew, somebody was wiping my face with a cold, wet towel. I opened my eyes. It was Vivian Deveraux. I tried to say something, but nothing came out. There was only a terrible aching in my throat.

Videnski was standing near a chair where Brentwood was seated. Brentwood looked a little dazed; Videnski looked furious.

So did Felder, who was looking at the hypospray gun he was holding in his hand. "Who hired you, Brentwood?" he asked sharply. There was nothing Santa Clausy about him now.

"A man named Borodin," Brentwood said, in an uninterested voice.

I managed to force air past my bruised larynx. All that came out was a whisper. "What happened?"

"He tried to use pythantin on you," Felding said. "But he got the dose himself. That's why he's co-operative."

I nodded and stopped when a pain went through my throat. Pythantin would have made me receptive to any suggestions Brentwood wanted to make.

"What were you supposed to do after you dosed Daniel Oak?" Felder asked the electronicist.

"Tell him to order McGuire to change course, to go to Asteroid MJ3-1990."

I sat up. It was nice just to lie there and have Vivian bathe my brow, but I had more pressing things to do. I didn't feel in the pink of condition, and my throat hurt like hell, but I wasn't in too bad a shape.

"This Borodin," I whispered, "who was he working for?"

"I don't know," Brentwood said. "He didn't say."

We questioned him for another half hour, but it soon became apparent that he didn't know very much. He'd been offered a tremendous amount of money to do the job, and he didn't have the stamina to refuse it. It's guys like Brentwood who gave rise to the saying that every man has his price.

"What'll we do now?" Felding asked at last. "Go on to Phobos, or go back to Ceres?"

"Back to Ceres," I whispered. "Colonel Brock will know what to do with him."

I'd been uneasy ever since my calls to Brock and Marty that morning had disclosed that Venuccio had lost the men who were supposed to be tailing him. It's fairly easy to do on Ceres, if you know how.

"It won't mean much of a delay," I went on. "Ravenhurst can still have his big splash on Earth."

We herded Brentwood into the lounge and bound him to a chair. Then I said: "McGuire?"

"Yes, sir?"

"We're changing course. Return to Ceres."

And McGuire said: "I'm sorry, sir; I cannot obey any orders except those of Mr. Daniel Oak."

I just stood there for a long minute. "I am Daniel Oak," I whispered. But I was fairly certain that the declaration would do me no good whatever.

I was right. "No, sir. You are not Mr. Oak." McGuire is always polite to anyone who speaks to him, even if he doesn't regard that person as human.

"McGuire," I said patiently, "can you see Mr. Oak? Is he on board?"

"Yes, sir. I perceive him seated on the starboard couch in the main lounge."

"Fine. Then your directional audio pick-ups should be able to tell you where this voice is coming from."

"Yes, sir. It is coming from the approximate volume of space now occupied by Mr. Oak's head. But it is definitely not Mr. Oak's voice."

Felder put a hand over his eyes and moaned.

Videnski, who had carefully lighted a cigarette, blew out a cloud of smoke and looked at me. "I got to admit he's right. That is not Daniel Oak's voice."

"Which came first the chicken or the egg?" Vivian said abstractedly.

"What's that got to do with it?" Videnski asked with a scowl.

"A matter of definition," Vivian said. "Somewhere along the line of chicken evolution, it would have been possible to point at a specific bird and say, 'This is a chicken, but its parents were not chickens.' Now, do you define a chicken egg as an egg

laid by a chicken or an egg that hatches out a chicken?"

"That's right," Felder said. "Do you define Oak's voice as any voice coming from Oak or as any voice that sounds like Oak's?"

"Well, you people ought to be able to answer that," I said. "Which is it?"

"Both," said Felder in a dull voice. "When you activated him by giving him his first order, he identified you and the voice as parts of the same unit. If you'd gone hoarse slowly, step-by-step, as it were, McGuire could have made logical adjustments to the change. But this sudden change is too big a jump for his logic to follow; he hasn't got the intermediate steps he needs to put it into syllogistic form."

There was another question I wanted to ask of McGuire. "McGuire, you are not supposed to allow Mr. Oak to come to any harm. Yet you did so. Why?" I was wondering how he'd managed to let Brentwood get away with his attack on me, without at least warning me.

"Mr. Oak was in no danger, sir. He has come to no harm."

"What about Brentwood's attack?"

"Mr. Brentwood did not attack Mr. Oak, sir; Mr. Oak attacked Mr. Brentwood."

The other three looked at me. "In a way, he's right," I said quickly. "When I saw Brentwood standing there with the hypospray, I jumped him."

"That's another one of our problems," said Felder. "How do you define 'harm'? If you broke your arm and a doctor tried to set it without an anesthetic, what would McGuire think when you yelled? Could you and I engage in a friendly boxing match? And since McGuire is supposed to *prevent* harm, he has to be able to define it in advance. Oh, we've had a lot of fun with that one, I'll tell you." There was a thin edge of bitterness in his voice.

"You see what this means, don't you?" Videnski asked, eying me through a cloud of blue cigarette smoke.

"Sure," I whispered. "It means that McGuire will go right on accelerating until I tell him to stop, and I can't tell him that until my larynx heals—if it ever does."

"If it takes a week or two, which is likely," Vivian said, we'll be saying good-by to the Solar System."

"By the time this heals," I said, "we'll be so far out we won't be able to come back. At that distance, the amount of sunlight McGuire will be able to pick up will be negligible, and the atomic fuel will be gone."

Nobody bothered to suggest that we call for help. McGuire had the communications system under control, too.

"One of us," I said, "had better think of something."

In the next several hours, every one of us thought of something, one way or another. Not that it did much good, because none of the ideas were worth much, directly. Indirectly, they told us plenty about what *not* to try.

When Brentwood finally came out from under the effects of the pythantin, even he started thinking furiously about some way out of our predicament. We kept him locked in the bedroom for obvious reasons, but he had just as much stake in getting us back in control of McGuire as we did. After all, there's no law against industrial espionage, and we couldn't prove any charge of sabotage. Even a charge of attempted kidnaping or attempted larceny would be almost impossible to make stand up in court. With a good lawyer, he could get out from under an assault and battery charge. He'd lose his job with Viking, of course, but that was better than losing his life.

His failure to deliver McGuire to Baedecker Metals & Mining might lose him some of the money he'd been promised, but he was prepared for that, too. I knew he was a Baedecker agent, even if he didn't, because I knew who Borodin worked for.

Meanwhile, five brains were trying frantically to think of some way of convincing McGuire that he should obey my orders.

First, I tried reasoning with him.

"McGuire, do you understand what it is that generates the human voice?"

"Yes, sir. A flow of slightly compressed air from the lungs causes vibration of the vocal cords, and this sound is modified by the lips, tongue, and teeth."

"Very well. Now, you see Mr. Oak, do you not?"

"Yes, sir."

"And you see that this voice is being generated by Mr. Oak?"

"I cannot tell that, sir. I have no way of sensing the operation of Mr. Oak's vocal equipment."

"But you can tell that this voice is coming from Mr. Oak?"

"Yes, sir."

"Then it must be Mr. Oak's voice."

"That does not coincide with the facts, sir, therefore the logic is faulty. A comparison of the present voice with the voice of Mr. Oak shows too few points of similarity for identification."

"You won't get anywhere that way," Felder said wearily. "None of the data you give him verbally is used in his final computations, since it doesn't come from Daniel Oak, by his own reasoning."

"That is correct, sir," said McGuire.

"Idiot machine!" said Vivian Deveraux angrily.

I shut up and did some more thinking. Talking only made my throat hurt.

Nobody could argue impressively with McGuire except Daniel Oak, and as far as McGuire was concerned Mr. Oak was keeping an impressive silence.

"Maybe I could write out the orders," I said.

"Nope," said Videnski. "He can read, but information coming in that way isn't counted as orders, not even from you. We should have installed a teletyper, too, but this is a little late for thinking of that."

"McGuire," I whispered, "what sort of proof would be needed to show

you that this is the voice of Daniel Oak?"

"I'm sorry, sir," McGuire said after a moment, "but that information is not in my banks."

"Maybe somebody could imitate Dan's voice," Vivian said hopefully. Videnski and Felder shook their heads in unison.

"No dice," Videnski said rumblingly. "It not only has to sound like Oak, it has to come from Oak."

"Ventriloquism?" Vivian said with a half-hearted grin.

"Wouldn't fool McGuire for an instant," Felder said. "That's an audio-visual trick of the human mind, not of a robot's."

The ship kept on moving. McGuire went serenely on, following his last orders.

We finally reached the point where we were to tired to think, and sleep became imperative. We were nearly two days out of Ceres.

When I announced my intention of taking a snooze, Felder looked at me through groggy, bloodshot eyes. "Hadn't we better sleep in two shifts? I mean, just in case there's another spy among us?"

I shook my head. "No spy would try anything now. There isn't anything to try. We're all safe, as far as that's concerned. I'll go in and sleep in my assigned room. Not even Brentwood could or would do anything to me now."

"For that matter," Felder said, "it's senseless to keep him locked up now. He's harmless until we reestablish control over McGuire. When that happens, we can lock him up again."

"My sentiments exactly," I said in my new hoarse, breathy, susurrant voice.

Brentwood didn't say much when I gave him the news; he just thanked me. I got into bed and worried for a while, but lack of sleep soon cut off my ability to worry. I only woke up once in the next nine hours, when McGuire changed course a trifle to avoid some unseen meteor. Not even the ache in my throat kept me from sleep.

It was Videnski's voice that woke me up. The door of my room was slid open a little, and I could hear him in the lounge. I got to my feet fast, shoved open the door, and went out.

Videnski had grabbed Brentwood by the front of his union suit, and had lifted him off his feet and slammed his back up against the wall. His free hand was swinging back and forth in open-handed slaps that looked as though any one of them should have torn the smaller man's head off. Felder was ineffectually trying to pull Videnski away from Brentwood, but the big man didn't even seem to notice it. Vivian Devereaux was nowhere in sight.

Videnski's harsh baritone was filled with invective that should have made the air as glowingly blue as the inside of an old-fashioned rectifier tube.

I ran across the room, grabbed Videnski by the shoulder and said: "Stop that!"

He stopped. When I throw out an emotional field like that, only a very exceptional man can disobey.

"Let him go," I said.

Videnski released him, and Brentwood slid down the wall, just this side of unconsciousness.

"What's the idea?" I asked.

"I . . . I'm sorry," Videnski rumbled. "Lost my temper, I guess. That . . . I mean, *he*—" He stopped, fumbling for words.

"I know. I heard what you were saying. Sure it's his fault my voice sounds the way it does. Sure he's a spy and probably a saboteur. And if we die, he'll be morally guilty of manslaughter. *And* suicide—remember *that*.

"But slapping him around like that isn't going to do any of us any good, and we need all the thinking we can get if we intend to pull ourselves out of this mess.

"So leave him alone, Videnski. Hear?"

My whispery voice didn't sound very authoritative, but a crisp, firm, commanding baritone does not authority make, any more than iron bars a cage.

"Yeah," he said apologetically. "I'm sorry, Oak. I sort of lost my head. It won't happen again."

I knelt down and took a look at Brentwood. He wasn't actually damaged much, but his face was going to be swollen and bruised. Somehow, I couldn't feel very sorry for him.

I got him to his feet. "Come on, Brentwood; let's go lie down for a while. You'll feel better."

"Yeah," he mumbled through thickening lips. "Thanks."

I got him into his bunk, closed the door on him, and came back to the lounge.

"Anybody dream up any solutions in his sleep?" I asked.

It was apparent that they hadn't. "Maybe Vivian has," Felder said. "She's still asleep."

"Let's not bank on it," I said.

"Oh, I did have one idea," Felder said dispiritedly. "Ted, here, and I were working on it when Brentwood came out. When it didn't pan out, well, that's when the fight started."

"What was your idea?"

"I asked McGuire if he realized what would happen to Mr. Oak if he just kept going. He said he did; that if he ran out of fuel, you'd be marooned and would die. So he's figured out a nice, complicated orbit that will allow him to obey your last order until the very last possible moment. He'll land us on Titan at the very last moment. The trouble is, we forgot to tell him how much food we have aboard, and he's made the assumption that there's plenty for everybody, for an indefinite length of time. But we're going to be plenty hungry by the time we get there. Can you last twelve days without food?"

"I don't want to try it. And of course it wouldn't do any good for you to tell him that we haven't enough food. How about letting him take a look at the food supply?"

"He doesn't know how much is necessary, and he would only have

our word for it that there was no more aboard. One thing I can tell you: if we ever get back to rebuild McGuire, one of the things he's going to have is a lot more sensory devices, so that he can judge more facts on his own hook."

"Agreed," said another voice; "right now, we're dealing with a half-blind idiot." Vivian Devereaux had stepped out of her room and had been listening to Felder explain what he'd tried. Sleep hadn't done her as much good as it might have under other circumstances; the strain was showing on her face.

Sometimes a club . . . or a hammer . . . is the best way to get sense into a situation!

Breakfast was a half-hearted affair. Brentwood stayed in his room, though he accepted the cup of coffee I brought him. The rest of us didn't eat much more than that. I was trying to think our way out of the fix, and so were the others.

Something, some sort of an idea, had been sitting quietly at the bottom of my mind, just barely discernible through the semipermeable barrier that separates the conscious from the subconscious, but I couldn't fish it out.

When I managed to grasp part of it, I said: "Look. The trouble is that McGuire is incapable of connecting my present voice with the voice he's used to. Then it seems to me that our job is to supply him with the missing steps."

"How?" asked Felder.

"One of you—or all of you, if it took that to convince him—could fake a hoarse, whispery voice. You could slowly make your voice worse and worse, so that he could see the steps involved."

Vivian brightened, but Felder and Videnski shook their heads together like the Bobbsey Twins sorrowing over a lost pet.

"What we may do voluntarily," said Felder, "over a relatively long period of time, has nothing to do with what happened to you suddenly and involuntarily. You see, in the long run, he really doesn't *care* about our voices. He doesn't pay any attention to us, really, except as incidental cargo. He has no concept of intelligence, actually; he can't accept any statements of ours unless they're verifiable by McGuire himself."

"Well, we could at least try it," said Vivian.

We did, and Felder was right. McGuire seemed almost condescending in his sorrow for our inability to see that there was no *logical* connection between their whispers and the voice of his Lord and Master, Daniel Oak.

Vivian, who had been standing near Videnski while we were talking to McGuire, suddenly blew up when McGuire assured us that our whispering was a waste of time. She grapped her book—"Some Applications of Discontinuity in Pattern Theory"—and threw it at the wall speaker from which McGuire's voice came. It bounced harmless off the protective grill and fell to the floor. Vivian Devereaux burst into tears.

I put my arm around her, gave Videnski and Felder the high sign to keep thinking, and led her to her room. As soon as I got her settled, I said: "Relax. No matter what happens, we'll get out of it alive. If we stretch our rations, we'll be able to make it to Titan without being more than underweight and hungry."

"It's not that," she said tearfully, "it's the delay. All that time off the schedule."

"But I thought that was what you wanted," I said gently.

"Not any more. I—" She stopped suddenly and looked up at me, her eyes widening. "What are you talking about?" Her voice was as whispery as mine.

"It was the insistence on meeting me at the *Seven Sisters* that gave you away," I said. "Dyeing your hair and combing it straight back, and putting on that plexiskin mask and

the contact lenses—none of that helped conceal that lush figure of yours. It can't be done under a union suit. So you had to put on jacket and shorts, and that meant you had to meet me in some plush restaurant like the *Seven Sisters* or you'd look out of place.

"I knew all that talk about being afraid of being overheard was just that—talk. A directional beam microphone could have picked up every word at our table.

"What made you change your mind about delaying the work on McGuire?"

"Buh-Buh-Brentwood. I duh-didn't know they'd go that far in trying to stop the work. Nuh-nuh-not kih-kidnaping and piracy." She took a deep breath and forced herself to stop sobbing. "I guess they didn't trust me, anyway. Otherwise they wouldn't have put Brentwood on the same job without telling me."

She didn't know that Brentwood was working for Baedecker rather than for the Thurston group. How could she? The difference lay in their tactics. Thurston wanted to take over Viking as a going concern—a little under the weather, perhaps, but still functioning. That meant that they wanted the work on McGuire delayed and complicated, but they didn't want to put him out of the picture completely, since they expected to take over the work as soon as they got control of Viking.

Baedecker, on the other hand, didn't give a care about Viking Spacecraft. They wanted to take over Ceres for their own firm. If that meant that getting rid of McGuire completely would give them what they wanted, then they'd get rid of McGuire.

"Why'd you take the job?" I asked.

"Money. I'm sick of the Belt. I want to go back home, to Earth." Her eyes were quite dry by now, and there was a choked sort of fear in them. "I hate it out here. There's death all around you all the time; sometimes it's just outside your skin, on the other side of the fabric of your vac suit. I wanted to get back home. But all the money is out here in the Belt. Back there, it's all eaten up in taxes and welfare, and nobody has a chance to get a job that really pays. So when they offered me the money—" She stopped and closed her eyes. "I'm scared, that's all. I've been scared ever since I came out here. And now —" She shuddered. "And now we're at the mercy of this idiot machine. I get so scared that I get mad, every time I hear his voice."

If somebody had set a thermonuclear bomb off inside my skull, there couldn't have been more sudden illumination.

I patted her on the shoulder. "You may get your money and more besides," I said.

She shook her head. "I wouldn't take their money now."

I stood up. "I think I can talk you into changing your mind, but right now, I think I have a way of getting McGuire to listen to me, thanks to you."

She looked up at me. "What did I do?"

"You threw a book," I said. "That's enough to win you a pardon as far as I'm concerned. You sit tight and don't let on that I know anything. Nobody else knows anything at all. Not even Brentwood. So keep quiet."

She dried her face quickly and stood up, too. "All right. Whatever you say."

As we went back out into the lounge, I felt a little pleased with myself. If things worked out right—and they would—we now had a double agent inside Thurston's organization. It wouldn't take too long to clear things up, and Miss Devereaux could go back to Earth with a nice piece of change in her pocket.

"What are you looking so happy about?" Videnski asked suspiciously when he saw us.

"I'll show you," I said. "Where's the tool kit?"

Ten minutes later, I had the wall speaker in the lounge out of its housing, but still connected. McGuire hadn't interfered with the work, as he might have if someone else had tried to do it, because he could see perfectly well that it was Daniel Oak who was doing the job, even though Oak hadn't been speaking to him much lately.

Then I said: "McGuire, can you hear me?"

"Yes, sir; I can hear you," came his voice from the speaker.

"Can you hear your own voice?"

"Yes, sir."

"Very well. Now, are you watching what Mr. Oak is doing?"

"Yes, sir."

I picked up a small ball-peen hammer and hit the speaker—not too gently—at just the right place.

"Did you see that, McGuire?" I asked.

"Yes, sir. I saw it." His voice sounded hoarse, muffled, and whispery coming through the damaged speaker.

"Do you see what sudden damage can do to speaking apparatus?"

"I must test," McGuire said, an almost hesitant note in his new voice. He spent fifteen seconds or so saying a series of nonsense syllables that are used as a test for a robot's speaking apparatus. They contain every sound used in English.

When that was over, he said: "The damage inflicted has radically changed the basic patterns of the voice. If an equivalent amount of damage was done to Mr. Oak's vocal apparatus, then the voice which has been speaking must belong to Mr. Oak."

"You saw the damage being done in each case," I said quickly. "You also see that it is the source of the voice that becomes important when the pattern has changed."

"Yes, Mr. Oak. I see that."

I breathed a deep, heartfelt sigh of relief.

Felder looked at me in a sort of numb awe. "How did you figure that out?"

"It came to me in a flash, but the clues were all over the place. McGuire didn't stay on the course I gave

him; he couldn't, if he wanted to avoid meteors. And then, too you said that he ought to have more sensory apparatus, so that he could judge facts. The facts that come into his brain from his own sensory apparatus *have* to be utilized in his memory banks. He didn't have to know all the steps in reasoning that would lead from one voice pattern to another if it could be demonstrated as a *fact*—as an axiom, if you like.

"If *you* tell him that he must change course, he isn't obliged to pay any attention; but if he spots a meteor, he has to accept that as a fact, and he changes course to allow for it. In a sense, then, the meteor is capable of giving McGuire orders, and you aren't."

Felder didn't look any too happy; no one likes to have a point in his own field explained to him by a layman. But he couldn't argue with me.

"There's a great deal more to be done before McGuire can be put into practical service," he said heavily. "We may as well head back to Ceres."

"I don't think so," I said. "McGuire's in good enough shape to let us make the big splash on Earth that Ravenhurst wants to make. He'll need it if Viking is to have enough financial leeway to go on with this project."

"What about . . . what about Brentwood?" Vivian Devereaux asked.

"We can get rid of him at Phobos just as easily as we can at Ceres. If there's any explaining of any kind to do, we can lay the blame on him. He won't be in any position to deny it."

She nodded, understanding exactly what I meant.

There were still plenty of bugs to be worked out of McGuire, but now I could see our way clear to getting both Thurston and Baedecker off our backs for a while.

At that point, Brentwood stuck his head in the door. "What's going on?" he asked in his soft voice.

"We're going on to Phobos, Brentwood," I said. "Go on back to your room and stay there." He withdrew his head. I looked at Videnski. "Go lock him in, Ted. He gives me a pain in the neck."

I got the first laugh I'd heard in forty-eight hours.■

■ ■ ■

BY CHRISTOPHER ANVIL

The thing that makes research so stimulating, so challenging, is that you may or may not get what you want . . . and you may get some quite devastating side effects you didn't think of . . .

uncalculated risk

ILLUSTRATED BY SCHOENHERR

Lieutenant general Lyell Berenger held to the opinion that life would have been much simpler if the human race had never invented Science. General Berenger occasionally tried, as he was trying tonight, to prove this proposition to a friend or acquaintance. Berenger was vaguely aware, as he talked, of the high-pitched laughter in the room, the occasional clink of glasses, and the surflike murmuring of voices around him. In his hand he absently held a glass, two-thirds of the contents of which he had tossed into the fireplace at the first opportunity, and which he had now forgotten. His attention was concentrated on his friend, Senator Vail, who was trying inconspicuously to unload his own glass into a pot holding a kind of lacy fernlike plant.

"In the old days," Berenger said, noting with suspicion the tolerant smile on the senator's face, "back, say, in the time of the early Romans, a soldier's job was difficult and demanding. The army had to be well-equipped, strong, and well-trained. The general commanding needed to be alert, and to know his job thoroughly. The same holds true today. The difference is this: In those days, virtue was rewarded. If a soldier did what he was supposed to, the odds were very great that he would win. In modern times, it's all a hodgepodge. The cause, as the cause of a lot of our troubles, is this pet of yours, Science."

Vail smiled. "Come on, now, Lyell, don't tell me you aren't happy whenever one of our technical teams beats the Russians to the punch."

Berenger nodded. "Yes, and I'm grateful that we were the first to get nuclear fission. But think back a while. How did it seem when the Germans came out with rocket-planes, flying bombs, and V-2s? The trouble is that you can't predict who is going to get what, or when. Military calculations can be completely unhinged by some mild individual who hardly knows one end of a gun from the other, and cares less."

"True," said Vail, who had now succeeded in transferring half his drink to the hapless plant, "but what is going on is doing more than merely upset your plans. Each scientific advance increases the power and well-being of the race as a whole."

"I don't object to Science, within bounds," said Berenger. "But I have reservations as to its violent, uncontrolled, headlong nature. Look, Vail, you speak of 'beating the Russians to the punch.' Doubtless they think of it the same way. It's a race. But where *to?*"

"To greater power and well-being. Obviously, the greater our capabilities, the more we can do. If we race someone, that means we both get there faster. You want to work it all out before we take a step. At that rate, we'd still be figuring out the implications of gunpowder, and wild-eyed theorists would be making radical predictions to the effect that some day in the next two thousand years steam engines would begin to replace the horse—in certain applications."

Berenger nodded. "It would probably be just that bad. But now consider one aspect of this 'race' you like so much. It is *uncontrollable.* Because it is a competition, neither side can stop. The side that stops, loses. Therefore each side *must* go on. Isn't that so?"

"Right. And a good thing."

"O.K. But when you speak of winning an ordinary race, you have in mind a definite physical goal. Suppose, instead, you took a group of men out into the wilderness and told them simply to run, and if any one got ten yards ahead of his nearest opponent, that one would instantly win, and could impose his will, if he so desired, on the other runners. That is more what this race is like, isn't it?"

Vail scowled. "Yes. Go on."

"Ten yards," said Berenger, "is no great distance. In the race we're in, a small definite lead can be conclusive. Now, if either side takes the lead, the other must run faster. Running faster, it is likely to cut down the lead the other side has, which will in turn force the other side to run faster. So it goes."

Vail nodded. "There's something to what you say. It could, in theory, get out of control. But actually, of course, both sides are pretty hard-headed, and this, combined with the natural inertia of human beings, keeps the process from running out of control."

Berenger said, "It may be that the *process* isn't running out of control. But in any race where you are not running on a beaten track, there is the possibility of a sharp surprise to the individual runners. The runners may go very fast, but they take as their standard of performance their position relative to the other runners. None of the runners knows the territory ahead. Now, what happens if, during some desperate spurt, the leader suddenly arrives at the edge of a ravine? *Then* what?"

"A purely rhetorical question," said Vail, smiling. "The scientists are often afraid the military men will do something irresponsible, so I shouldn't be surprised to find a military man afraid the scientists will do something irresponsible. Meanwhile, both sides think politicians are irresponsible. Nobody thinks the other man knows his business. But he does."

"You've missed the point," said Berenger. "It isn't irresponsible for a scientist to make discoveries. That's his business. But making discoveries is like running through unknown territory. Do it too fast and sooner or later, you're likely to get a severe fall.'"

Vail nodded, grinning. "We politicians learn to use words, but to look to reality. The situation you describe *sounds* convincing, but it doesn't fit in with reality. Tell you what. If you're free next week end, why don't you come on out to Iowa with me and see a scientist in action on a real project. It's part of the race between us and the Soviets. Nothing spectacular, but pretty effective, all the same. It'll get your head down out of the clouds and onto solid ground. What do you say?"

Berenger smiled. "I don't think I want my head 'on solid ground,' Vail, but yes, I can get away next week end. I'll take you up on that."

That was how, the next week end, Lyell Berenger came to find himself on the edge of a flat windy field with Senator Vail and a short broad man who'd been introduced as Dr. Franklin Green. The college tower was visible in the distance, but Dr. Green had eyes only for the field, where a tractor was churning methodically back and forth.

"Soil texture," said Dr. Green, stopping to pick up a handful of the rich-looking soil and crumbling it in his fingers, "soil texture is an important matter to the farmer. If the texture is right, rainfall is absorbed, the working of the soil is easy, and plant development takes place naturally. With the wrong texture, everything goes wrong. Now, you've seen this. Let me show you the control plot."

They plodded across the yielding, somewhat spongy soil to a strip of arid ground with a surface like cracked cement. Dr. Green looked at them significantly. "*This* plot wasn't treated. The one you've just seen was. Suppose you gentlemen were farmers. Which plot would you rather farm?"

Berenger glanced from the soft, yielding, even-textured plot to the hard-surfaced plot. Something began vaguely to disturb him. He heard Vail say, "Well, I have no doubt which *I* would rather work, doctor. Is your texturing agent so effective on *all* soils?"

"Not entirely, I'm sorry to say. But we are working at it steadily. We expect to have it ready for commercial use by early next year. First we have to make further tests on a variety of soil types."

Vail said, "What do you expect will be the effect on farming in general?"

Dr. Green said, with a hard effort at modesty, "It should increase the yield, in some cases very considerably."

Berenger and Vail were on the plane the next day before Vail got around to saying triumphantly, "What did you think of *that*?"

Berenger said, "I thought we already had surpluses."

"Yes," said Vail, "and there you hit the sore point on the head." He lowered his voice, "But, you see, some of our allies and a considerable number of the neutrals don't share that problem. They desperately need food. It takes a long time to increase yield by conventional methods. You have irrigation projects, huge quantities of farm machinery to ship overseas, and all kinds of technical training programs to carry out. It's a slow process, it may go head-on against local prejudices, and while you're carrying it out, people are starving. But this new process holds out the possibility of increasing yields by, say, fifteen per cent the first year. It will fit right in with local customs, since nearly everyone is used to adding manure to soil. It isn't expensive, it won't use much shipping space, and it is *immediate*. Now what do you have to say?"

Berenger was silent for a while. Finally he said, "I'll be frank with you. There's something about it I don't like."

"Too big an advance?" Vail looked at him curiously.

Berenger shook his head. "I don't know what it is. I just have an uneasy feeling about it."

Vail smiled, and settled back on his seat. "Not I," he said. "It makes *me* very happy."

Berenger was back at work the next day, and the incident soon slipped into the back of his mind. As the months rolled by, with shifts and changes in foreign affairs, new surprises in technology, and the continuing need to fit these variables into the overall picture, he in time forgot the incident entirely. He was reminded of it by a newspaper article, which first discussed the development in general, then went on:

". . . Thus Dr. Green's development of the Catalytic Texturing Agent will largely do away with problems caused by too-heavy soils. Best of all, from the point of expense, the effect is permanent. The texturing agent, operating on an entirely new principle of ionic interchange, actually generates more of itself over the course of time from the chemicals of the surrounding soil. The proper 'dosage' is scientifically determined by soil analysis, to assure that regeneration of the catalyst proceeds at a rate just sufficient to restore that used up in the course of the soil-conditioning operation. In explaining this, Dr. Green, winner of the McGinnis Medal for Agricultural Chemistry, remarked . . ."

Berenger read back carefully over the article, then, frowning, read on:

". . . Winner of the McGinnis Medal for Agricultural Chemistry, remarked, 'Any catalyst is theoretically capable of handling an unlimited quantity of material. But in practice, the catalyst usually becomes 'poisoned' and ceases to operate. In this instance, the poisoning is offset by the generation of new catalyst. This effect must not, of course, be allowed to proceed too rapidly, or it could have most disagreeable consequences. That is easily avoided by the use of proper initial testing procedures, as has been demonstrated repeatedly in field tests in all types of soil . . ."

Berenger looked up from the paper, sat back, and thought it over. Scowling, he glanced at his watch, picked up a phone, and tried to call Vail. Vail, it developed, was away on a trip, but would be back by early next week. Berenger put the phone down again, thought some more, then picked the phone up and called long-distance for Dr. Franklin Green. In due time, Green came on the line. Berenger first reminded Green of his previous visit, then said guardedly. "I don't ask you to reveal anything that might be classified, doctor. You understand that?"

"Of course," came Green's voice. "There isn't much that *is* classified

about this project, general. It's all perfectly straight agricultural chemistry. We've evolved a new twist that should be useful, that's all."

"Yes," said Berenger, "but I notice that you say the generation of new catalyst mustn't be allowed to proceed too rapidly. Can you tell me, without revealing classified information, what happens when catalytic regeneration *does* proceed too rapidly?"

Green was silent a moment, then said, "Well, you understand, that is amply guarded against by proper preliminary tests."

"Yes," said Berenger, and waited.

Green said, "There's really no need of any such eventuality *ever* arising in practice."

"I see."

"Newspaper reports tend to be somewhat sensational. Actually, we've never had that happen in the field."

"I see," said Berenger. "But—if this information isn't classified—what takes place when it *does* happen?"

There was a considerable silence. Berenger could hear faint voices in the background. Then Green said, "General, I wonder if you could come down here for a few hours this week end?"

Berenger was silent a moment.

Green said, "I can *show* you, much better than I can tell you. If this seems important to you, I hope you can come down here."

"Yes," said Berenger. "Thank you for the invitation, doctor. I'll be there."

The college looked about the same as when Berenger had been there last, but Dr. Green seemed preoccupied. He opened the door to the darkened laboratory, snapped on the lights, stood aside for Berenger, then locked the door behind them. He led Berenger the length of the room, and up several steps to a smaller laboratory. Inside, on a soapstone-topped bench, sat a very large brown-enameled earthenware crock. Green locked the door behind them, and lifted off the lid of the crock. "Here it is. See for yourself."

Berenger glanced in at a gray-brown glop that looked about the thickness of molasses.

"This is what happens if you add too much of the catalyst?"

"A great deal too much," said Green. "That was made by adding, originally, one liter of conditioner to one liter of untreated soil."

Berenger glanced into the mammoth crock again. Green, he noticed, seemed willing to give him information on request, but he certainly wasn't volunteering it. "So," said Berenger, "you had two liters to start with?"

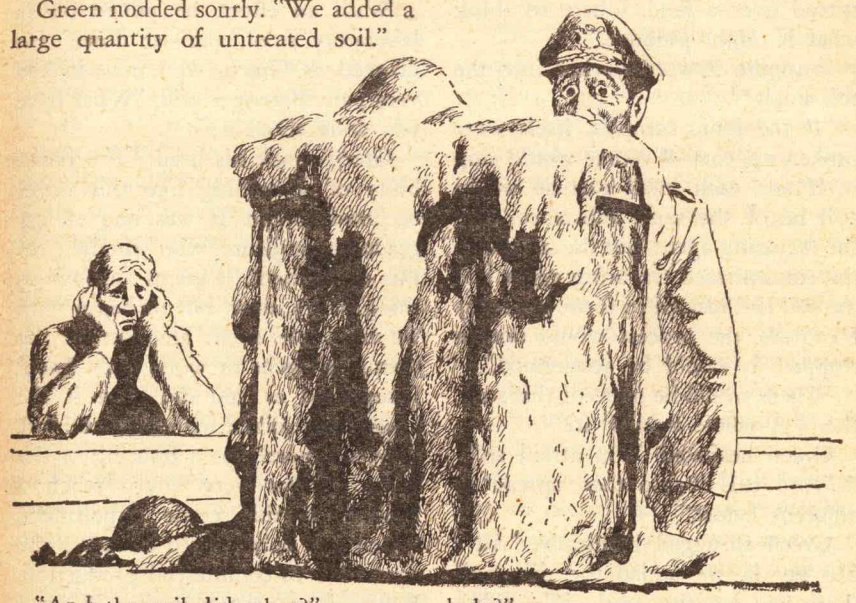
"That's right."

"You've got a lot more than two liters here now. What did you do then?"

"We were disturbed at the results of the experiment. Naturally, we had to allow for a possible malfunction of the equipment used to spread the texturing agent. We also had to consider the possibility that a quantity of the agent might be spilled accidentally. If this caused a breakdown of the soil at the spot where the accident happened, it could result in a . . . a mudhole. We wanted to avoid that."

"Yes," said Berenger patiently, "but where did the rest of this stuff come from? You say you started out with a liter of dirt and liter of catalytic agent. A liter is roughly a quart. This is a lot more than two quarts."

Green nodded sourly. "We added a large quantity of untreated soil."



"And the soil did what?"

"There you see it."

Berenger looked in at the glop. "You mean the original muck transformed the untreated soil into more of itself?"

"As far as we can tell, something like that happened."

"What would happen if we added some more dirt to this?"

"I'd have to try it to know."

"Does this look any different from the stuff you had when you added one liter of texturing agent to one liter of soil?"

"There's more of it, that's all."

Berenger thought this over, and fought off the urge to profanity. Carefully, he said, "Let's say, as a hypothetical case, that a farmer had a container of this texturing agent and dropped it. Would he get a mudhole?"

"Apparently."

"Then what would he do?"

"He would have a serious problem."

"Could he collect the muck in . . . say . . . an empty oil drum, and then put it in his spreader and spread it over the same number of acres he'd originally planned to treat?"

"No," said Dr. Green uncomfortably, "I'm afraid that wouldn't be the thing to do."

"Why not?"

Green hesitated, then said, "The reaction is so complex that, frankly, I don't know how to explain what happens. Normally, the agent is vastly diluted by the soil. When it is used in so large a concentration, the agent itself seems to undergo a change. The result is this—substance. If this were spread over a field, I hate to think what it might produce."

"Suppose it were worked into the soil finely?"

"If the ionic complex itself were broken up, that of course would stop it. If not, each small particle would still be of the same substance. Not the texturing agent, but the substance the concentrated texturing agent and the soil had reacted to form. As far as I can see, the process would not be stopped. It would be accelerated."

"There would be more of this stuff, then? A whole field of it?"

Green hesitated. "I'm afraid so."

"And this would then spread to adjacent fields?"

Green shrugged helplessly. "All I can say is, we added the dirt, and there you see the result. We didn't mix it. We just added it."

"How long did it take?"

"About forty minutes before the reaction was complete."

"So it *would* spread?"

"Apparently."

"Where would it stop?"

"I don't know."

Berenger drew a deep breath, and let it out slowly. In the back of his mind was the awareness that the texturing agent was even now being manufactured. No doubt, it was being loaded onto trucks, transported, unloaded, transferred to ships tied up at docks, perhaps even already being unloaded at foreign ports. His natural instinct was to do something fast. Get on the telephone, bulldoze his way to the highest available authority. Every second might count.

With an effort, he pulled out a laboratory stool, and sat down. He glanced at Green, who now looked very pale. Berenger said, "What have you done about it?"

Green shook his head. "The possibility of something like this never occurred to me. It was one of my graduate students who thought of this experiment. It seems an obvious thing to try, now, but to begin with we had only small amounts of the texturing agent to work with. Later, I supposed as you did, that if the agent were mixed with too little soil, it would merely be a diluting of the agent. I was very angry when I learned of this crude experiment, which was only carried out *after* the agent was in commercial production. Before, it was too expensive. When I finally did realize what this might mean, I tried to explain the situation to the president."

"The President?"

Green shook his head. "The president of the college. He decided I was suffering from overstrain, and refused to take the matter seriously. I wrote a letter to the head of the corporation producing the agent, and got a letter back assuring me that they were using proper safeguards in shipping the agent, and congratulating me again on its discovery. Several days later, I received a whole drum of the texturing agent, compliments of the company. Gradually I began to think perhaps I *was* suffering from overstrain. I locked up the laboratory here, and tried not to think of it."

Berenger noted that his own hammering pulse was beginning to quiet down again. He could now see clearly what he had only sensed before: Any effort on his part to get this picture across would have to be done carefully, or he, Berenger, would also get sent off for a rest cure.

But to do it carefully would take time. While he was doing it carefully, trucks, trains, and ships would be in motion, increasing the likelihood of spillage.

Green said shakily, "It looks bad to you, too, doesn't it?"

Berenger said, "Suppose spillage makes just one mudhole? Small animals will track it around locally. Bits of muck stuck to men's shoes can easily end up forty miles away in an hour. And you said it only took forty minutes for a batch of fresh dirt to get converted to muck?"

Green nodded.

"How long would it take you to carry out complete laboratory tests, check your results, find out how this stuff reacts when finely divided in a comparatively large quantity of earth, how it reacts when treated with various chemicals, what effect heat and cold have on it, and anything else that seems useful?"

Green shook his head, "General, it would take several years to do a thorough job. But I can get my best graduate students and have a rough idea in the next eight or ten hours.

Berenger got up. "Good. I'll get to work right away and see what I can find out."

The next eight hours Berenger spent in long-distance phone calls, and in some nerve-wracking calculations. He discovered that the soil texturing agent was already well-dispersed in stores and warehouses across the United States. Eight ships carrying sizable quantities of the agent in drums were at sea, destined for ports in Europe, Asia, Africa, and South America. The first of these cargo ships was due to dock in London in twelve hours, and others now in American ports were regularly taking on the texturing agent as part of their regular cargoes. There seemed to be no existing legal machinery that Berenger could put in motion to stop the shipment or sale of the substance.

Senator Vail, Berenger discovered, was on a hunting trip in the Canadian woods, and to get in touch with him would be no easy matter.

The president of the chemicals corporation manufacturing the agent was on a cabin cruiser fishing in Long Island Sound, no one knew exactly where, and the cabin cruiser was not equipped with a ship-to-shore radio.

Berenger paused to think things over. He was accumulating information rapidly, but he had yet to discover any way he could do anything about it. Fortunately, since it was the week end, it was unlikely that any of the texturing agent would be sold. But for the same reason, it was hard to get hold of anyone who might know what to do about the situation.

Berenger paused to think what he could do himself. No doubt, he had enough rank so that he could create a stir in the effort to stop the shipments. He could probably even stop, or delay, *some* of the shipments. But, he thought, if a pile of dynamite has twenty lighted fuses eating their way toward it, it isn't enough to put out even nineteen of the twenty fuses. They *all* have to be put out, or the end result will be just the same as if none at all had been put out. And he did not by any means have the authority to stop all the shipments.

Next, Berenger tried to consider who he might reach who would have the authority to stop the shipments.

To begin with, many of the consignments of texturing agent must by now have changed ownership, so that the actual owners would be citizens of various foreign nations. These nations would have different regulations, and to stop all the shipments by any legal procedure would almost certainly be too complicated. After thinking this over it was clear to Berenger that there was probably no individual on the face of the earth with the legal authority to stop all the shipments.

Berenger then tried to think who might have the practical physical power to stop the shipments. This quickly narrowed down to one person. The eight ships at sea could almost certainly be stopped, and most of the sales in the United States in some way blocked, by only one man: the President. But he would never do it without being convinced.

Berenger thought the thing over and could see that it would take more than the assurances of Dr. Franklin Green to convince the President that drastic action was needed. Berenger's own word would mean nothing. A colleague need only say, "I didn't realize you were a soil chemist, Lyell."

Berenger looked at it objectively and saw how it would work out. He could hear a voice saying to the President, "There's a general out here, sir, who claims that the world's about to be eaten up by some kind of fertilizer. Shall I . . . ah . . . get the M. P.'s, sir?"

If it turned out that Green was mistaken, Berenger would never live this down if he lived to be two hundred years old.

Frowning, Berenger sat back to consider Green. Maybe Green *was* in need of a rest cure.

At that thought, Berenger felt both a sense of exasperation over wasted effort, and a sudden relief from tension that he hadn't realized was growing unbearably tight.

And the more he thought of it, the more likely it seemed that Green *was* unbalanced.

And in that case, there was no need to do anything.

Just then, the phone rang.

Berenger warily lifted the phone from its cradle. "Hello?"

"General Berenger?"

"Right here."

"This is Franklin Green. I think you ought to come down to the lab right away."

Berenger frowned. "I'll be right there." He hung up, thinking that now at least he should find out definitely whether the man was right or wrong.

Green met Berenger at the door to the laboratory, drew him inside, and locked the door. Inside, three pale young man in lab coats stood at one of the long benches. They looked up nervously as Berenger came in, and Green made hurried introductions.

Berenger interrupted to say sharply, "What did you find out?"

Green said, "Let me show you." He pointed to several bucketfuls of dirt at the far end of the bench. "We put samples of that in these glass dishes, and added small quantities of the transformed texturing agent to each dish. Some we put in in lumps, others we worked carefully into the soil. There you see the result."

Each of a line of the glass dishes contained the same kind of brown-gray glop that Berenger had seen earlier.

"Worse yet," said Green, "we put a little of this transformed agent into a flask, poured in ordinary tap water, decanted the water over the soil, and look here, the soil is changed just as in the other cases. It was a little slower, that's all."

Berenger felt as if an iron band were tightening around his chest. "What about the effects of chemicals?"

Green shrugged. He removed the top of a bottle of sulfuric acid, and carefully poured it over one of the dishes of glop. The substance swelled up, and gave a faint hissing sound as the acid poured into it. Next, he poured a sodium hydroxide solution over one of the dishes. The gray-brown glop shrank slightly, and cracked, leaving the solution in a pool on top of it.

"Now," said Green, "we have found one hopeful thing. We tried ordinary tap water, as I mentioned. We also tried to obtain a solution, or dispersion, in a saline solution." Green pointed to a dish of damp, but unchanged dirt. "Nothing happened." He glanced around. "Jerry. Show the general what you discovered."

One of the graduate students took a paper heaped with tiny white crystals, shook it over a dish of gray glop, and stirred methodically. The grayish color vanished, the texture changed, and then Berenger was looking at ordinary dirt.

"So," said Green. "The process can be reversed. But you have then sowed the soil with salt."

Berenger shook his head. "Can you show me the actual change, from dirt to glop."

Green glanced at one of his graduate students. "Arthur."

The student spoken to put some dirt from a bucket into a clean dish, took a small lump of glop from one of the other dishes, and began working it carefully and methodically into the dirt.

Berenger watched tensely. After a considerable time had passed, his attention began to waver. With an effort, he held his gaze on the dish, and shifted it from one part to another to try to avoid the hypnotic affect of Arthur's ceaselessly-working hand.

Just when it began to happen, Berenger could not say, but suddenly the dirt was no longer dirt, but the gray-brown stuff that looked and acted like a kind of thick muck.

Berenger drew a deep breath, and straightened up. "Did you duplicate the experiment that started all this?"

Green nodded. "The same result."

"Did you use a different batch of the texturing agent?"

"Yes, we used some from the complimentary drum the manufacturer sent us. So it isn't just a freak side-effect from one batch of the agent."

Berenger said, "What about heat and cold? What effect do they have?"

"Cold seems to have no effect whatever, except that the substance becomes somewhat more stiff. Intense heat, however, reverses the reaction."

Berenger said tensely, "You're sure of that? Heat reverses it?"

In answer, Green lit a burner, and held it so that the flame played on the surface of one of the samples. Where the flame heated it, the gray color was gradually replaced by the look of ordinary dirt. Green took the burner away. The gray coloration gradually returned.

"The heat," said Green, "only penetrated a thin layer. But we heated one sample in an oven. That sample didn't change back, though it became extremely crumbly."

"Did you try adding water?"

"Yes. The soil absorbed it quite well. But it didn't change . . . or hasn't yet, at least."

Berenger looked around at all the samples. The graduate students were standing around looking at the floor, as if they thought they had committed some criminal act.

Green said tensely, "You've got to stop the shipments."

Berenger shook his head, "I don't have the authority."

"Take it to someone who has the authority. Why can't you take it right to the President?"

"For the same reason that you can't simply walk over there and convince the president of your own college. To function at all, the head of an organization has to recognize and weed out crackpots and alarmists. Anyone who walks in and tries to get action on this will get automatically hustled right out again. To convince the President, I'd have to build up a case first."

"Can you do that?"

"It would take too long." Berenger glanced at his watch. "Four hours from now, the first cargo ship will reach Britain. While I'm building my case, shipments will be going over the Canadian and Mexican borders.

Stores will be selling the stuff, and farmers using it. Ships will dock in Africa and South America. While I convince the men who will have to convince the President, this stuff will spread out over the globe. By the time they have him convinced, it will be too late for him to do anything."

Green said, "But there's *got* to be something we can do."

"How is this stuff manufactured? Under a patent?"

"No. The company decided the process was sufficiently unusual to justify trying to keep it a trade secret."

"Did you publish any account of the process?"

"No, I wanted to be sure what I had first. Then I was persuaded not to publish." Green's voice climbed. "But the important thing is, *how can we stop the shipments?*"

Berenger said, "Let me take another look at that stuff that formed first."

"But what does that—" Green saw Berenger's expression, hesitated, then led him down to the little laboratory. He locked the door behind them. "This was just so we could talk alone, wasn't it? What are you thinking?"

"What will happen if we take that stuff out onto the campus and plant it?"

Green swallowed. "It will start the reaction. In time, the whole campus will be affected."

"How fast will it happen?"

"It will depend on how finely we divide it. But what good will that do?"

"Can we make a horrible example? Can we have the grounds one sea of spreading muck?"

"Yes," said Green. "But general, we *can't* do that."

"All right," said Berenger. He sat on the edge of a stool and glanced at his watch. "The first ship docks in London in about three hours and fifty-four mintues. We can go at the problem in slow stages and gamble the whole world. Or we can run the risk here that we will have to run anyway as soon as the stores open on Monday."

Green looked down. In a low voice, he said, "How will we stop it?"

Berenger said grimly, "If heat will stop it, we can stop it all right."

Green nodded slowly. "Yes, I see." He hesitated, then said, "All right."

It was about 4:00 in the morning when Berenger sent for the paratroops. At 5:00 he got through to the Army Chief of Staff, who listened, and then exploded, then listened again.

By 5:30, the college buildings were evacuated, and the headlights of cars competed with the gray light of dawn as excited reporters were held back by police from the expanding edge of the slop. By 6:30 the paratroops had blocked the roads, and the sound of crashing bricks told of buildings toppling as the soil at their foundations softened. By 7:00 the word had gotten to the President, who rejected the whole idea angrily, and sent singed aides scurrying to unload their

own wrath at the "hoax." By this time, the Pentagon was receiving direct reports from the paratroops.

At 8:00, a new set of envoys reached the President, bringing photographs, statements of witnesses, and a statement by Dr. Green. The paratroops reported that the perimeter now appeared to be moving out at the steady rate of about one-and-one-half feet per hour. A penciled notation added the calculation that this would amount to an increase in the diameter of the affected area of seventy-two feet every twenty-four hours, with no end in sight. A brief analysis of the situation by Lieutenant general Lyell Berenger, fortunately on the scene, pointed out the impossibility of transport through such muck as this, the danger of it being seeded in new localities, the dangers of hysteria as the muck spread, the political effects of shipments of similar materials being sent overseas, and the desirability from every viewpoint, of immediate drastic action to end the trouble before it had time to gather any more momentum.

The President looked over the photographs and the reports, glanced at an appended list of ship sailings, read Berenger's recommendations through again, and looked at the Army Chief of Staff.

"Is Berenger reliable?"

"He always has been, sir."

"I want to talk to some of these people on the scene. And I want to be very sure they are the people they represent themselves to be."

"Yes, sir."

At 8:35, the urgent message went out to the British Prime Minister.

At 8:55, British troops were racing the police for the docks.

By 9:00 all the ships still at sea were notified, and the United States Navy was in hot pursuit of one that refused to change its course.

By 9:25, the FBI was at work tracing down all the smaller shipments of the texturing agent.

By 9:40, there was a panic in Chicago, as an excited newscaster announced that a "wall of annihilation is approaching at supersonic speed from the state of Iowa."

By 9:55, the college and its surroundings had been forcibly evacuated by troops and police. By this time, also, the warning messages had been received in the capitals of the NATO nations, the Soviet Union and Japan.

By 10:00, the President was speaking to the nation, and as he spoke, the first jet bomber was already on its way. At the conclusion of his speech, he was handed a slip of paper, and announced that a hydrogen explosion had destroyed the college and surroundings, and was believed to have burned out, by its intense heat, the action of the catalyst.

By 10:55, the Premier of the Soviet Union was receiving Intelligence reports on the situation, and looking it over from a variety of unpleasant angles.

By 11:00, the Pentagon was beginning to subside toward normal, and the Army Chief of Staff was pouring

questions at Berenger, at the end of which he gazed off into the distance and remarked, "So, now if we want to we could drop one drop of this stuff anywhere we want to, and eight hours later have a pool of glop twenty-four feet across. It would be tough on people who depend on stretched out rail and road communications, wouldn't it?"

"Yes, sir," said Berenger. "But I'd hate to start it. They could do it back."

"Oh, but I was just looking at it from their point of view, to see how it strikes them. Besides, they don't yet *know* they could do it back."

And several weeks later, Berenger was talking to his friend, Senator Vail.

"You know, Lyell," said Senator Vail, "that experience kind of knocks the spots off your argument. There's been no activity from the Crater, and the whole business seems to have faded away to nothing. We're still competing with the Russians, and I believe we are all running just as fast as ever. I thought that fall was supposed to finish us."

Berenger smiled and shook his head. "I don't expect to convince you that Science is, inherently, unavoidably, and of its own nature, deadly dangerous. But there's one thing you ought to recognize."

"What's that?"

"When you think it's necessary, you run a risk. But you have to use the right names when you label things."

"What of it?"

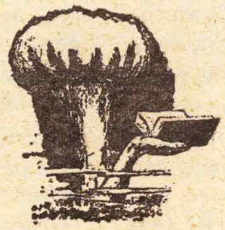
"You haven't used the right name for that experience."

Vail frowned. "What do you mean?"

"That wasn't a fall," said Berenger. "Far from it."

He thought a moment, then added, "*That* was only a stumble."

THE END



■ The field of the experimental Telethink station in the Florida Keys caught the fleeing Morid's attention just as its stolen Federation lifeboat plunged into the outer reaches of nightside atmosphere.

The Morid reacted with the instant decision of a harried wolf stumbling upon a dark cave that offers not only sanctuary but a lost lamb for supper as well. With the pursuing Federation ship hot on its taloned heels, the Morid zeroed on the Telethink signals—fuzzy and incomprehensibly alien to its viciously direct mentality, but indicating life and therefore food—and aimed straight for their source.

The lifeboat crashed headlong in the mangroves fringing Dutchman's Key, perhaps ten miles west of the Oversea Highway and less than two from the Telethink station. The Morid emerged in snarling haste, anticipating the powerplant's explosion by a matter of seconds, and vanished like a magenta-furred juggernaut into the moonlit riot of vegetation that crowded back from the mangroved strip of beach. The Morid considered it a success.

The lifeboat went up in a cataclysmic roar and flare of bluish light that brought Vann, the Telethink operator on duty, out of his goldberg helmet with a prickly conviction of runaway range missiles. It all but blinded and deafened Ellis, his partner, who was cruising with a portable Telethink in the station launch through a low-lying maze of islands a quarter of a mile from Dutchman's Key.

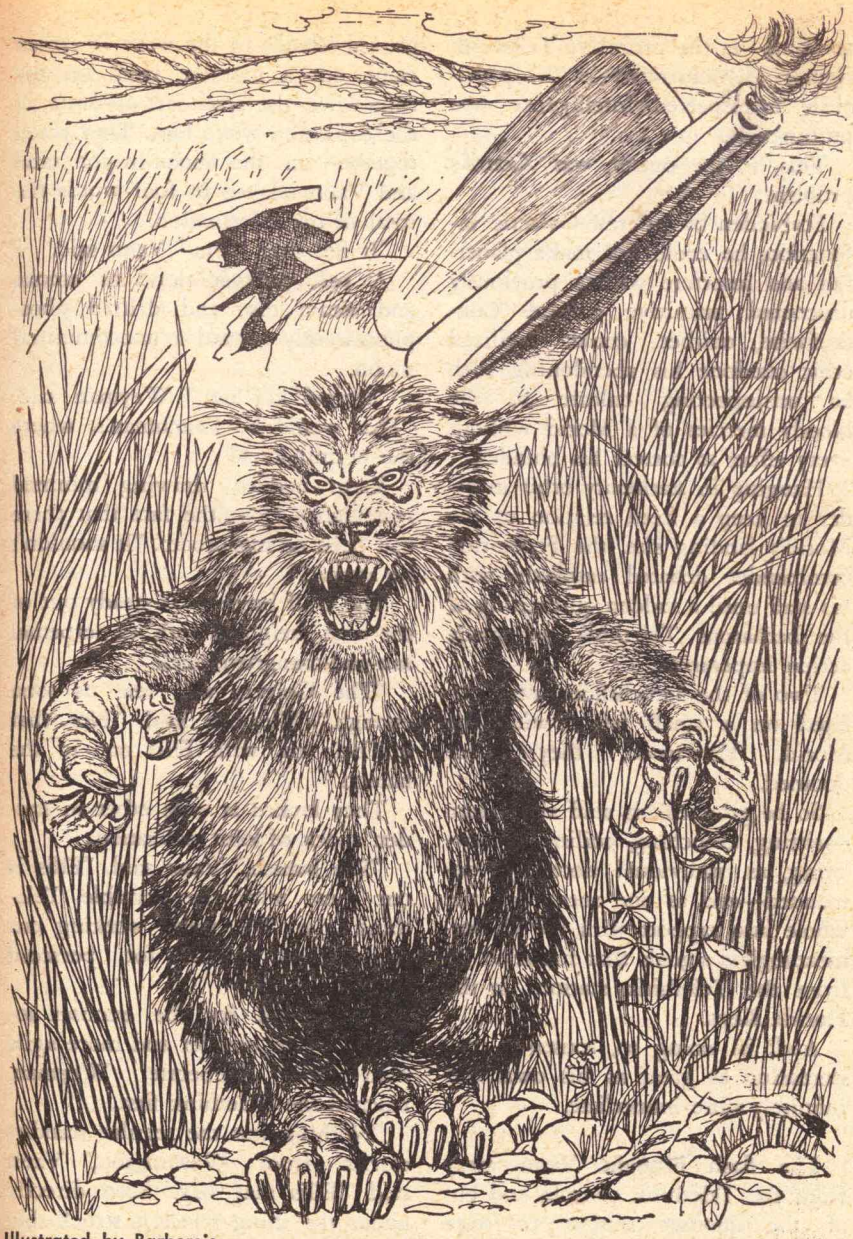
Their joint consternation was lost on the Morid because both at the moment were outside its avid reach. The teeming welter of life on Dutchman's Key was not. The Morid headed inland, sensing abundant quarry to satisfy the ravening hunger that drove it and, that craving satisfied, to offer ample scope to its joy of killing.

The Morid's escape left Xaxtol, Federation ship's commander, in a dilemma bordering upon the insoluble.

It would have been bad enough to lose so rare a specimen even on a barren world, but to have one so voracious at large upon one so

ROUGH BEAST

The most dangerous, utterly vicious carnivorous animal the Galactics knew had escaped... to Earth! Because contact with Earth was forbidden, they knew little of Earth... which led to certain false conclusions. ***BY ROGER DEE***



Illustrated by Barbereis

teeming—as the primitive Telethink signals demonstrated—with previously unsuspected intelligence was unthinkable.

This, at the outset, was Xaxtol's problem:

Forbidden by strictest Galactic injunction, he could not make planetfall and interfere with a previously unscouted primitive culture. Contrariwise, neither could civilized ethic condone his abandoning such an unsuspecting culture to the bloody mercies of a Morid without every effort to correct his blunder.

Hanging in stationary orbit in order to keep a fixed relation to the Morid's landing site, the Federation commander debated earnestly with his staff until a sudden quickening of the barbarous Telethink net made action imperative.

Two of the autochthons were isolated on a small island with the Morid. Unwarned, they were doomed.

So he grouped his staff about him —sitting, crouching, coiling or hovering, as individual necessity demanded—and as one entity put the whole into rapport with the all-but-meaningless signals that funneled up from the Telethink station in the Florida Keys.

And, in doing so, roused a consternation as great as his own and infinitely more immediate.

The flash brought Vann away from the Telethink console and out of the quonset station to stare shakenly across the tangle of mangroved islands to the west. Weyman came out a moment later, on the run, when the teeth-jarring blast of the explosion woke him. They stood together on the moon-bright sand and Vann relayed in four words the total of his information.

"It fell over there," Vann said.

A pale pinkish cloud of smoke and steam rose and drifted phosphorescently toward a noncommittal moon.

"Second key out," Weyman said. "That would be Dutchman's, where the hermit lives."

Vann nodded, drawing minimal reassurance from the fact that there had been no mushroom. "It shouldn't be atomic."

The Gulf breeze was steady out of the west, freighted with its perpetual salt-and-mangrove smell.

"The Geigers will tell us soon enough," Weyman said. "Not that it'll help us, with Ellis out in the launch."

They looked at each other in sudden shock of joint realization.

"The launch," Vann said. "Ellis is out there with the portable Telethink rig. We were working out field-strength ratios for personal equipment—"

They dived for the quonset together. Vann, smaller and more agile than the deliberate Weyman, reached the Telethink first.

"Nothing but the regular standby carrier from Washington," Vann said. "Ellis may have been directly under the thing when it struck. He was working toward Dutchman's Key, hoping for a glimpse of the hermit."

"Maybe he wasn't wearing the Telethink when the blast came," Weyman said. Then, with characteristic practicality: "Better image Washington about this while we're waiting for Ellis to report in. Can't use the net radio—we'd start a panic."

Vann settled himself at the console.

"I'll try. That is, if I can get across anything beyond the sort of subliminal rot we've been trading lately."

He signaled for contact and felt the Washington operator's answering surge of subconscious resentment at being disturbed. With the closing of the net the now-familiar giddiness of partial rapport came on him, together with the oppressive sense of bodily sharing.

There was a sudden trickle of saliva in his mouth and he resisted the desire to spit.

"Washington is having a midnight snack," Vann said. "Rotted sardines and Limburger, I think."

He made correction when the Washington operator radiated indignation. "Goose liver and dill pickles, then, but you wouldn't guess it. Salt tastes like brass filings."

Wyman said shortly, "Get on with it. You can clown later."

Vann visualized the flare of explosion and winced at the panicky hammer-and-sickled surmise that came back to him.

"How would I know?" he said aloud. "We have a man out—"

He recalled the inherent limitation of phonetics then and fell back upon imagery, picturing Ellis' launch heading toward an island luridly lighted by the blast. For effect he added, on the key's minuscule beach, a totally imaginary shack of driftwood, complete with bearded hermit.

He knew immediately when authority arrived at the other end of the net. There was a mental backwash of conversation that told him his orders even before the Washington operator set himself for their relay.

"They want an eyewitness account from Ellis," he told Weyman. "As if—"

Ellis broke into the net at that moment, radiating a hazy image—he was still partially blinded from the glare of the blast—of a lowering key overhung by a dwindling pall of pinkish smoke. In the foreground of lagoon and mangroves stood a stilted shack not unlike the one Vann had pictured, but without the hermit.

Instead, the rickety elevation of thatched porch was a blot of sable darkness relieved only by a pair of slanted yellow eyes gleaming close to the floor.

Climactically, Xaxtol entered the net then with an impact of total information that was more than the human psyche, conditioned to serialized thinking by years of phonetic communication, could bear.

The Washington operator

screamed and tore off his helmet, requiring restraint until he could compose himself enough to relay his message.

Ellis, in his launch, fainted dead away and ran the boat headlong aground on the beach of Dutchman's Key.

Vann reeled in his chair, teetering between shock and lunacy, until Weyman caught him and slid the Telethink from his head. It was minutes before Vann could speak; when he did, it was with a macabre flippancy that Weyman found more convincing than any dramatics.

"It's come," Vann said. "There's an interstellar ship out there with a thousand-odd crew that would give Dali himself nightmares."

Weyman had to shake him forcibly before he could continue.

"They're sorry they can't put down and help us," Vann said. "Galactic r ulations, it seems. But they feel they should warn us that they've let some sort of bloodthirsty jungle monster—a specimen they were freighting to an interplanetary zoo—escape in a lifeboat. It's loose down here."

"Dutchman's Key," Weyman breathed. "What kind of brute could live through a blast like *that?*"

"It left the lifeboat before the power plant blew," Vann said. "They're tracking its aura now. It's intelligent to a degree—about on par with ourselves, I gather—and it's big. It's the largest and most vicious life form they've met in kiloyears of startrading."

He frowned over a concept unsuited to words. "Longer than thousands. Their culture goes back so far that the term doesn't register."

"Ellis," Weyman said. "Tell him to sheer off. Tell him to keep away from that island."

Vann clapped on the Telethink helmet and felt real panic when he found the net vacant except for a near-hysterical Washington operator.

"Aliens are off the air," he said. "But I can't feel Ellis."

"Maybe he isn't wearing his Telethink. I'll try his launch radio."

He had the microphone in his hand when Vann said, "They got the message in Washington, and they're petrified. I asked for a copter to pick up Ellis—and the hermit, if they can reach them before this *thing* does—but they're thinking along different lines. They're sending a squadron of jet bombers with nonatomic HE to make sure the beast doesn't escape to the mainland and devastate the countryside."

Weyman said incredulously, "They'll blow the key to bits. What about Ellis and the hermit?"

"Ellis is to evacuate him if possible. They're giving us twenty minutes before the jets come. After that—"

He didn't have to finish.

At midnight old Charlie Trask was wading knee-deep in the east-side grass flats of his private lagoon, methodically netting shrimp that darted to the ooze-clouded area stirred up by his ragged wading

shoes. An empty gunny sack hung across one shoulder, ready for the coon oysters he would pick from mangrove roots on his way back to his shack.

In his dour and antisocial way, Charlie was content. He had nearly enough shrimp for boiling and for bait, with the prospect of coon-oyster stew in the offing. He had tobacco for his pipe and cartridges for his single-shot .22 rifle and a batch of potent homebrew ready for the bottling.

What more could a man want?

The blast and glare of the Morid's landing on the western fringe of his key jarred Charlie from his mellow mood like a clear-sky thunderbolt. The concussion rattled what teeth remained to him and brought a distant squall from his cat, a scarred and cynical old tom named Max, at the shack.

Damn rockets, was Charlie's instant thought. *Fool around till they blow us all to hell.*

The rosy phosphorescence drifting up from the mangroves a quarter of a mile away colored his resentment with alarm. A blast like that could start a fire, burn across the key and gut his shack.

Grumbling at the interruption of his midnight foray, Charlie crimped the lid tight on his shrimp bucket and stalked back along the lagoon toward his shack. The coon oysters would have to wait.

Five minutes later he reached his personal castle, perched on precarious piling in a gap hewn from the mangroves. The moon made it, to Charlie, a thing of black-and-silver beauty, with Max's yellow eyes gleaming from the porch floor like wicked, welcoming beacons.

Still muttering, Charlie waded out of the shallow-water ooze and stumped in squishing shoes up the ladder to his shack. The shrimp bucket he hung on a wall peg out of Max's calculating reach. He found his pipe in the kitchen and loaded and lighted it, deliberately because the capacity for haste was not in him. His homebrew crock bubbled seductively and he took time out to raise the grimy toweling that covered it and sniff appreciatively.

"Ready to cap by the time I come back and get the shrimp graded," he told Max.

He changed his dripping brogans for a pair of snake-proof boots and took down his .22 rifle from its pegs, not because he really imagined that anyone might have lived through such a blast but because strangers—them radio fellows two keys east, for instance—might take it into their heads to come prying around.

He was halfway across the key when the drone of Ellis' launch entering his lagoon justified his suspicions.

Charlie's investigation was soon over.

A dying plume of steam rising from a circle of battered mangroves told him that no danger of fire impended, and he turned back in relief. It did not occur to him that the pilot

of his hypothetical rocket might be lying desperately injured in the shallow water, at the mercy of sharks and crocodiles. If it had, he would not have moved to help. Any fool who got himself into such a spot, in Charlie's rude philosophy, could get himself out.

The drone of the launch's engine was loud when he reached his shack. The boat, handled by a pilot grotesque in what Charlie took at first for a diver's helmet, was heading directly for his landing at an unsafe speed.

"Serve him right if he shoals on a oyster bed and rips his bottom," Charlie said.

As if on cue, the boat swerved sharply. Its pilot came half erect, arms flung wide in a convulsive gesture. The engine roared wildly; the boat heeled, slamming its occupant against the right gunwale, and blasted straight for Charlie's shack.

Miraculously, it missed the shack's piling and lunged half its length upon the sand. The engine-roar died instantly. The pilot was thrown headlong overside, goldberg helmet flying off in mid-arc, to lie stunned at the foot of Charlie's ladder.

Callously, Charlie stepped over Ellis' twitching form and stumped up the ladder to his shack. Max, who had taken to the porch rafters at the crash of the launch, came meowing gingerly down to meet him.

"It's all right," Charlie told him. "Just some fool that don't know how to handle a boat."

He leaned his rifle against the wall and brought a split-bamboo chair from the kitchen. He was not too late; the bucket, when he took it from its peg, still slithered satisfactorily with live shrimp.

The squawking of the launch radio roused Ellis. He groaned and sat up, dazed and disoriented by the combined shock of Xaxtol's telepathic bombshell and his own rude landing, just as Weyman gave up his attempt at radio contact. In the silence that fell, Ellis would have fainted again except for the chilling knowledge that he was unarmed and afoot on the same key with a man-eating alien monster that might make its appearance at any moment.

He collected wits and breath to stave off the black pall of shock that still threatened.

"Come down from there and help me push the launch off," he called up to Charlie Trask. "We've got to get off this key. Fast!"

Charlie separated a menu-sized shrimp from his bucket.

"You grounded her," he said sourly. "Push her off yourself."

"Listen," Ellis said desperately. "That blast was a ship from space, from another star. A wild animal escaped from it, something worse than you ever dreamed of. We've got to get out of here before it finds us."

Charlie grunted and chose another shrimp.

The Morid, as Xaxtol had pictured it, rose vividly in Ellis' memory, fanged and shaggy and insatiably voracious, a magenta-furred ursine embodiment of bloodlust made the worst by its near-human intelligence.

He described it in dogged haste, his eyes frozen to the tangle of inland underbrush behind the shack.

"No such varmint in these kays," old Charlie said.

The launch radio blared again in Weyman's voice, speaking urgently of jet bombers and deadlines. A glance at his watch brought Ellis up from the sand in galvanic resolution.

"In twelve minutes," he said grimly, "a squadron of planes will pinpoint this key and blast it out of the water. I'm not going to be eaten alive or blown to bits arguing with you. If I can't push the launch off alone, I'll swim."

He scooped up his fallen Telethink helmet and ran for the launch. At the fourth step his foot caught in the iron-hard stump of a mangrove root that had been chopped off inches above the sand and he fell heavily. Pain blinded him; his right ankle lanced with fire and went numb.

He fought to rise and fell again when the ankle collapsed under him.

"Hell," he said, just before blackness claimed him for the second time. "I've broken my leg!"

His twelve minutes had dwindled to seven when Ellis roused. He tried to stand, his twisted ankle momentarily forgotten, and gave it up when the mangroves spun dizzily before his eyes. He couldn't afford to pass out again.

He made one last-ditch bid for help.

"My leg's broken," he yelled up at old Charlie Trask. "Get down here and lend a hand!"

Charlie glowered and said nothing.

Max bounded down the ladder, tail stiffly erect and scarred ears cocked at the underbrush in baleful curiosity.

"The thing is coming this way," Ellis called. "Your cat scents it. Will you let us all be killed?"

Charlie Trask graded another shrimp.

Swearing bitterly, Ellis caught up his Telethink helmet and slid it over his head. He found the net in a welter of confusion. Washington demanded further information; Vann, at the station, was calling him frantically. His own scramble for help-images only added to the mental babel.

On the Federation ship, confusion was nearly as rampant.

Xaxtol's dilemma still held: he could not make planetfall—time was too short for aid now, in any case—but neither could he, with clear Galactic conscience, desert the harried primitives below while hope remained.

Ellis' predicament forced Xaxtol to decision; he could only follow the Morid's aura and relay its progress.

It could not be helped that the relayed image was blurred of definition and weirdly askew; the Morid's visual and auditory range differed so sharply from either human or Galactic that even over the ship's wonder-

fully selective telecommunicator little of the Morid's immediatee surroundings came through clearly. Its aura arrived with a burning intensity that turned Xaxtol and his group faint with empathetic horror, but the fact that the Morid had just made its first kill obliterated all detail for the moment beyond a shocking welter of blood and torn flesh.

Ellis fared a little better under the second telepathic blast than under the first—he managed to snatch off his Telethink helmet just in time.

"The thing just killed something out there," he yelled at Charlie Trask. "It's coming this way. Are you going to sit there and—"

Charlie graded his last edible shrimp, took up his bucket and went inside. The leisurely clinking of homebrew bottles drifted after him, clear and musical on the still, hot air.

Ellis looked at his watch and considered prayer. He had three minutes left.

When the Morid came, Ellis was sitting dumbly on the sand, nursing his broken ankle and considering with a shock-detached part of his mind a fragmentary line of some long-forgotten schooldays poem.

What rough beast is this . . . the rest eluded him.

The underbrush beyond the shack rustled and the Morid's ravening image sprang to Ellis' mind with a clarity that shook his three net-participants to the core—one of them past endurance.

Vann, in the station, said *"Dear God,"* and braced himself for the end. In Washington, the operator fainted and had to be dragged from his console.

Aboard the Federation ship, Xaxtol radiated a shaken "Enough!" and tentacled a stud that sent his craft flashing on its way through subspace.

At Charlie Trask's shack, Max bounded across the clearing and into the brush. There followed a riot of squalling and screaming that brought Charlie out of his shack on the run. Ellis sat numbly, beyond shock, waiting for the worst.

Unaccountably, the worst was delayed.

Charlie came back, clutching a protesting Max by the scruff of the neck, and threw down something at Ellis' feet. Something small and limp and magenta-furred, smeared with greenish blood and very, very dead.

"There's your varmint," said Charlie.

With one minute remaining before the promised bombers roared over, Ellis, with a frozen clarity he had not dreamed he possessed, radiated a final message before he fainted again.

"Call off the jets," he said, in effect. "It's over. The beast is dead. The hermit's cat killed it."

An hour later at the station, his ankle bandaged and his third cup of coffee in hand, Ellis could review it all with some coherence.

"We didn't consider the business of relative size," he said. "Neither did our Galactic friends. Apparently they're small, and so are all the species they've met with before. Maybe we're something unique in the universe, after all. And maybe it's a good thing they didn't land and learn how unique."

"It figures," Weyman said. "Washington let it out on the air that DF stations made a fix on the spaceship before it jumped off. It measured only twenty-two feet."

Vann said wonderingly, "And there were hundreds of them aboard. Gentlemen, we are Brobdingnagians in a universe of Lilliputians."

"I've been trying," Ellis said irrelevantly, "to recall a poem I read once in school. I've forgotten the author and all the verse but one line. It goes—"

"What rough beast is this," Vann quoted. "You were thinking about it hard enough when the debacle in the brush took place. The image you radiated was rough enough—it shocked the pants off us."

"And off the Galactics," Weyman said. "The shoe is on the other foot now, I think."

He went to the quonset door and looked out and up, listening. "Jets. The Washington brass on its way to cross-examine us."

"The other foot?" Vann said. "Don't be cryptic, man. Whose foot?"

"Theirs," Ellis said. "Don't you see? One of these days we'll be going out there to make our own place in the galaxy. With our size and disposition, how do you think we'll seem to those gentle little people?"

Vann whistled in belated understanding.

"Rough," he said.

THE END

IN TIMES TO COME

Next month's issue leads off with a new yarn by Mack Reynolds—"The Mercenary". One of the "If this goes on—" type forecasts of things to come—with a lovely idea for international disarmament thrown in!

Automation makes for ever-increasing lesiure time for the non-creative type of people. Non-creative type people can not, and do not want to, entertain themselves. They demand entertainment—or they'll amuse themselves with riots. Vide the late Roman Empire; corn—even automatically produced and adequate corn—isn't enough. Games are demanded, too. TV helps—but . . . .

Mix well, interact carefully, and come up with one fine grade mess—and one "Mercenary"!

The article next issue is about a genuine suppressed invention—a fantastic new type of storage battery, small as a flashlight cell, yet capable of delivering 150 ampres! I've examined the gadget myself—and the claims made for it are 100% accurate or conservative—and the claims are incredible!

The Editor.

The Iron Jackass

BY JOHN BRUNNER

In solving problems involving human groups,
Justice and Correct Answer are
not necessarily synonymous.
Sometimes Justice stems from fantasy
rather than facts . . .

■ "People!" said Wallmeyer in a disgusted tone. "Me, I'll take robots over people any day of the year."

Marghem half-turned from the big window and scowled over his shoulder. As mayor of Eisenberg he had just about had his fill of the trouble both robots and people could cause. He said, "If that's the way you feel, what are you doing here? Why not go back to Earth, where you'll have all the robot company you could wish for?"

"Believe me," Wallmeyer snapped, "if it wasn't in my contract to stay here till you were satisfied our robots were functioning properly, I'd have gone long ago. On foot back to the spaceport, if necessary!"

The port was two hundred and sixty miles distant across one of the worst deserts New Earth had to offer. Marghem was very much tempted to take Wallmeyer up on what he'd said, contract or no contract. This week or two past, the Terran roboticist had reached a climax of accumulated frustration through being cooped up in the drab surroundings of Eisenberg, and since no one would keep company with him except the mayor—who had to—Marghem had

Illustrated by Krenkel.

absorbed the full blast of his sourness.

Before he could word the invitation, however, Wallmeyer got up from his tubular steel chair the other side of Marghem's steel-plate desk and pointed at a blur in the gray-blue sky.

"Suppose that's him?" he demanded.

Marghem followed his gaze. "It must be," he said. "O.K., let's go and meet him when he lands. I only hope Nagy hasn't got wind of this somehow." He picked up his dust mask from the hook on the back of the office door, but before plunging his face into it he stamped with sudden violence.

"How did this *happen?* Why? They're the best kind of people you could want, here in Eisenberg. Used to be that we had a real spirit of enthusiasm, unity, all wanting to get the work done together. Now I feel like an enemy of the people—I talk about keeping things secret from Nagy, and immediately I start wondering whether the phone operators have broken the scrambler code or whether anyone's sneaked up to this shack and eavesdropped at the window—"

"Think it's my fault?" Wallmeyer said in a ragged tone. "Think I asked to be sent here?"

Marghem gave him a steady look and shook his head. "No," he said. "You were too obviously prepared to hate everything you found here. Come on."

In the anteroom through which they passed on their way to the outside, Joe got to his feet. If it hadn't been for the fact that the face on the front of his head was an impassive metal stamping, Marghem would have sworn the robot looked eager.

"Putting me to work today, boss?" he demanded. You had to call a robot like this *he* for exactly the same reason you had to refer to him as Joe, instead of by his official serial number.

"Not yet, Joe, I'm afraid," said Marghem in a kindly tone. "Pretty soon though."

The robot lowered his seven-foot bulk back to the top of his packing case. He looked positively dispirited. As he and Wallmeyer passed through the exit door, Marghem could have sworn he heard a gigantic sigh. But it could only have been a trick of the wind.

Dust swirled up around them as they plodded down the road to the main square over which the helicopter was now hovering uncertainly. That dust was in its way granulated wealth—ferrosiliceous specks of the mineral for which the town had been baptized Eisenberg, Iron Mountan. But it was also an incredible nuisance, because it stung the eyes unless you wore goggles and in very short order was liable to give you silicosis if you didn't wear a mask. Marghem could put up with all the other inconveniences of living here; masking up to take even a short walk was the one which irritated him.

"Getting worried about Joe," said Wallmeyer when they had covered

most of the distance to the square. His voice had changed completely, and it wasn't only due to the effect of talking through a mask. Marghem fancied he detected tenderness in the words.

"Me, too," he grunted.

"Not the way I am," said Wallmeyer. "Joe's programmed to work, you know. He's been activated for going on two months, and he hasn't been allowed to do a hand's turn. Much more frustration, and he'll suffer the mechanical counterpart of a nervous breakdown. Then what use will he be to you?"

"I know! I know!" Marghem sighed.

They came into the main square Apparently Nagy hadn't got wind of the government agent's arrival, for the only people around were a few curious housewives on their way home from the commissariat center with the weekly issue of provisions. If Nagy had heard, nothing would have stopped him from being on the spot. Marghem began to think that luck was temporarily with him, and as the 'copter settled in a cloud of dust set his shoulders back and tried to look like the mayor of a flourishing and indispensable community instead of like a man unjustly burdened with a whole planet's problems.

Which, of course, he was. But he didn't have to let it show.

When two figures descended from the 'copter, he assumed that one of them would merely be a pilot; they were, naturally, goggled and masked and wore air-conditioned suits like anyone here. He looked them over before addressing them at random.

"Are you Colville?"

"That's right," said the taller and bulkier of the two new arrivals. He put out a gauntleted hand and shook with Marghem. "You must be Mayor Marghem—glad to know you. This is Ira Bell."

He indicated his companion, who wordlessly shook with Marghem and then with Wallmeyer when he was presented. "Uh . . . you're the pilot?" Marghem suggested.

Ira Bell's goggle-and-masked head shook gently. Colville spoke up. "No . . . uh . . . hope you have no objection, but Ira's here studying folklore and wanted the chance to visit one of our new industrial communities to see what continuity of culture exists between it and its parent communities on Earth, and, of course, Eisenberg is one of our most vital and lively towns."

"Folklore?" said Marghem, taking a pace backward out of sheer astonishment. "Haven't we enough problems that actually matter? For—" He broke off, shrugging. "Well, provided you keep out from under my feet, I guess it makes no odds one way or the other. Let's get up to my office before someone passes the word that you're here; our chief problem, a man called Nagy, works in the rolling and blooming mills at the far end of the valley, but the whole community's in such a tense state he'll get

the news within minutes, probably."

This time when they passed through the anteroom Joe seemed to be quite resigned, and made no attempt to get up or speak. Wallmeyer, walking behind Marghem and Colville with Ira Bell beside him, cast him a worried glance. Directly he had closed the office door, he turned to Colville.

"Look, Colville, something *must* be done, and quickly, if that robot isn't to break down so badly he has to be shipped home for overhaul!"

And stopped.

Taking his place behind his desk and turning to face his visitors, Marghem saw why. Ira Bell was stripping off mask and goggles and shaking out shoulder-long auburn hair from under her cap. That hair framed a perfect oval in which green eyes twinkled apologetically.

"I'm sorry if I startled you," she said in a low, pleasant voice. "Ira is a dreadfully confusing name to have."

Marghem swallowed loudly. He said, "Now look here . . . uh . . . Miss Bell! What I said stands. It's . . . uh . . . well, not so much a shock as a pleasure—" He searched frantically through his mental files for something appropriate and suitably mayor-like, found nothing available, and improvised. "We've got a problem here on which the future economic development of New Earth depends, and with all respect to your doubtless very interesting researches, that's going to occupy my mind and everyone else's in Eisenberg till it's solved!"

"I'm sure Ira fully understands," Colville cut in. "I made it quite clear on the trip here that the town is in a pretty abnormal state right now."

"Abnormal!" said Marghem bitterly. "I prefer *chaotic.*"

"Yes. Well, that's what they sent me out here to fix, if possible." Colville produced from an inside pocket of his suit a file of micronotes and a reader, which he set up on the nearest corner of Marghem's desk and switched on.

"Situation," he said briskly. "Eisenberg is currently producing almost four thousand tons of steel of all grades per week. This is our richest and best-developed strike of ferrous ore; nothing else on the planet touches it for quality. Unfortunately we need at least double its present output if we're to get our new 'copter factory finished on schedule in the new year. We've known about this for four years, going on five. We tried our best to get more manpower. Unfortunately again, metallurgists, millhands, and other skilled technicians aren't to be had in sufficient quantity. Right?"

Marghem scowled and nodded.

"So what else was to be done? We invested six billion credits in forty general-purpose robots from the Terrestrial Automation Corporation—"

Wallmeyer kicked his legs out in front of him, thrust his hands deep in his pockets, and snapped, "And I suppose it's my fault that thirty-nine of those robots are still in their packing cases, unactivated, with the fortieth on the verge of breakdown!"

Colville turned calm eyes on him. "Not at all. Nobody's doubting that your robots will fulfill their functions perfectly, and *more* than double Eisenberg's steel output—once we figure out a way of getting them into service."

"I wish you'd hurry then," Wallmeyer said sourly, standing up and beginning to pace the narrow office from side to side. "I feel like I'll break down myself if I have to stay in this one-reactor town any longer."

Colville glanced at Marghem and raised his eyebrows sardonically. The gesture seemed to indicate sympathy; Marghem found himself thinking that if the government did have to send out an agent to chivvy him along, they could have sent someone far less supportable than Colville. He brightened a bit.

"Mayor Marghem," Colville went on, "up to now all I've had access to, of course, are the weekly progress reports you file. I think it would be much better, and give me a clearer picture, if you could sum the problem up in informal terms."

Marghem leaned back in his chair. He found that Ira Bell's eyes were on him, studying him curiously, and tried not to take any notice. Colville should have known better than to bring a pretty girl, for pity's sake! His spell as mayor of Eisenberg had convinced him that the attitude of the people here towards women and work was the right one: keep 'em well apart!

He said, "The trouble is simple. The people of Eisenberg are the finest kind of people you can find anywhere."

Colville blinked. "Uh . . . could you clarify that?"

"Sure. As Wallmeyer is boiling to inform you, no one in his right mind would *want* to come and live here for pleasure. Eisenberg is a mining and milling town, nothing else." He pointed at a wall map across the office to his right. "You won't find anything superfluous on that plan—no three-dee house, no swimming pool, no pleasurepads, no frills whatever."

"Telling me!" rasped Wallmeyer, still moodily pacing. Marghem ignored him.

"*But* we have the biggest steel mills on the planet, and we feel proud of the fact. That's what brought these people here, Colville. Most of them are Hunkies, Polacks, Slavs of various kinds, both from the United States and from Central Europe. Practically everyone on Earth shares Wallmeyer's opinion—that a man who works when the job can be automated out from under him is off his gyros. These people didn't. They came here, to live in a permanent cloud of dust, because they didn't like to be pensioners of a machine. They're the most fiercely independent people you'll ever find. I love 'em. I think they're wonderful."

"The only drawback," Colville said, nodding, "is that right now everyone else on New Earth is be-

ginning to hate their guts for creating a totally unnecessary bottleneck in steel production. Six billion credits is a sizable slice off the planetary surplus, you know, and nobody's happy to see the robots lying useless in their crates when our whole plan for economic expansion is keyed to their doubling our steel production."

"Look!" said Marghem, drawing a deep breath. "You can't wonder at it, can you? These people love their work; they're proud that *they* are *men* and *they're* doing the job. Back home machines took all that away from them, and they see our attempt to bring GP robots into Eisenberg as the first stage in the same process."

"Mayor Marghem!" said Ira Bell unexpectedly. Distracted, Marghem glanced at her.

"Ah . . . yes, Miss Bell?" he said impatiently.

"Please call me Ira. Everyone does. I'm sorry to interrupt, but could you tell me what compliments these people pay each other?"

"I *beg* your pardon?" Marghem felt confused. "Look, Miss . . . I mean Ira . . . let me make it absolutely clear that I can't afford to be interrupted to help out with your folklore studies when we've got a planetwide problem on our hands!"

"Magarac?" said Ira on a gently questioning note.

"What—? Oh, I see! Yes, Colville, that's absolutely right, and it's a very good illustration of what I've been saying. These people call an outstandingly hard worker *magarac,* which means jackass."

Wonderingly, he interrupted himself to stare at Ira. "How did you know?" he demanded.

Ira shrugged and smiled, and Colville, after pausing a moment to let her answer if she was going to, turned to Marghem again.

"Jackass?" he echoed. "Why?"

"Because a jackass, according to them, is only interested in working and eating. So it's a very high compliment."

"Jackasses are also obstinate," Wallmeyer put in grimly. "That makes it fit perfectly!" He dropped into his chair again and glowered at Marghem.

"Right," Colville agreed. "Well, Marghem, I suppose it's pointless to state the rational counter-arguments to this fear they have of being automated out of a job?"

"I've tried," Marghem said wearily. "I've—"

There was a thunderous hammering at the outside door. Since the office shack, and everything else in Eisenberg, was built out of steel plates as the most available material, the whole place rang about them like . . . like a welkin, Marghem thought wildly, whatever a welkin might be.

"Lay you a small bet," he growled. "That's Nagy come down from the mill having heard that someone arrived by 'copter. Since this brilliant idea of bringing robots to Eisenberg, everyone—me included!—has got pathologically suspicious! I warn you, Colville, the end result of the whole thing will be not that we double steel output, but that we chop it in half."

He got up and stormed through the anteroom to open the door.

"I thought so," he could be heard muttering. "Come on in, Nagy."

The workers' spokesman was huge —almost two meters tall and immensely muscled. He must have come directly from the mill without stopping for anything, for he wore his heatproof suit and carried his dark goggles in his hand. Peeling off his dust-mask he cast a suspicious glare around the office. When it reached Ira, it stopped dead.

Eyes wide, mouth beginning to curve into a smile, Ira returned his stare with interest, and for a moment Nagy's air of hostility dropped completely away. You would have sworn he was preening himself, Marghem thought.

Not for long, though. He recollected what had brought him, hooked his toe around the stem of a nearby chair, and sat down. The chair seemed to bow under his vast weight.

"A'right, what's going on?" he said in a booming voice.

They hammered at it for an hour Marghem was delighted to leave most of the talking to Colville, because Nagy's technique of rebuttal was simple: he just looked as though any sane man ought to realize it was impossible to disagree with him. This was what most often gave Marghem the feeling he was becoming an enemy of the rest of the town.

Still, Colville was pretty good at his own technique of arguing. Without getting heated, he went through the reasons for bringing in robots one by one.

"We've done our best to get additional manpower, and we only turned to considering GP robots as a last resort."

Nagy shrugged. "No news to me," he answered. "Back on Earth, automation has taken the guts out of everybody. No one cares about pride in their work any more—'cept us. That's why we came here. That's why New Earth ought to be more anxious to take notice of us."

"If we don't get the robots integrated into the scheme of production here, we'll have barely half the steel we need for our new 'copter factory. And our whole expansion scheme depends on transport!"

"If you *do* try an' . . . what's your mealymouth word for it? . . . integrate the robots here, we quit. An' you'll be out your entire steel supply." Nagy jutted his chin forward, crossed his arms, and drummed his fingers on his vast biceps. "We saw what happened to people like us at home when they started to automate our mills and furnaces."

"It's absurd to think the same thing could happen here in less than a couple of generations—half a century!" Colville pointed out. "We have so much work we need both men and machines to cope with it."

"Machines, yes. Robots, no. It didn't take more than one generation back home—in some places—to reduce everyone to being a pensioner on a machine's back, though."

"But the resources don't yet exist here to—"

"Resources, mister?" Nagy jerked a huge thumb towards the wall beyond which loomed the Iron Mountain itself. "Forty billion tons of high-grade iron ore out there! We got resources. Maybe you didn't notice them yet."

"I don't mean that kind of resources," Colville said patiently.

Nagy pressed his lips together and shrugged.

Still, an hour was long enough for a first session. Marghem felt a rumbling in his empty stomach and seized a break in the discussion between Nagy and Colville to voice a suggestion he thought everyone found welcome.

"Say, it's close to chowtime," he said. "Nagy, I didn't give our guests a chance to do anything—settle in, show 'em their rooms. Just came straight here."

Ira was looking at Nagy again. He squared his shoulders and got up with a kind of half-bow.

"Wouldn't do anything to inconvenience a lady," he rumbled. "I'd rather try and pour a little more sense into *your* head"—he glared at Colville—"but like the mayor says, it's chowtime an' the old woman's expectin' me."

They all got to their feet. Now that he'd remembered the problem of rooms, Marghem realized it was a problem. He said, "Accommodation's are pretty limited around here, of course—we have no hotels or anything. Wallmeyer, d'you think I could bunk Colville in with you? I only have one free room in my shack, and I guess Ira had better have that."

For obvious reasons. Oh well . . . He saw Wallmeyer looking astonishingly unenthusiastic, and Colville looking tempted to match the roboticist's expression. Nonetheless, that was how it was going to be. As mayor, he put up with plenty. Giving up the nightly privacy of his own room he would *not* endure!

Unexpectedly Nagy cleared his throat. He said, "Uh . . . Mayor Marghem, if you got accommodation trouble, maybe I could fix it. You know I have that room for my boy when he gets his metallurgy degree back home and joins the family—nobody's in it right now."

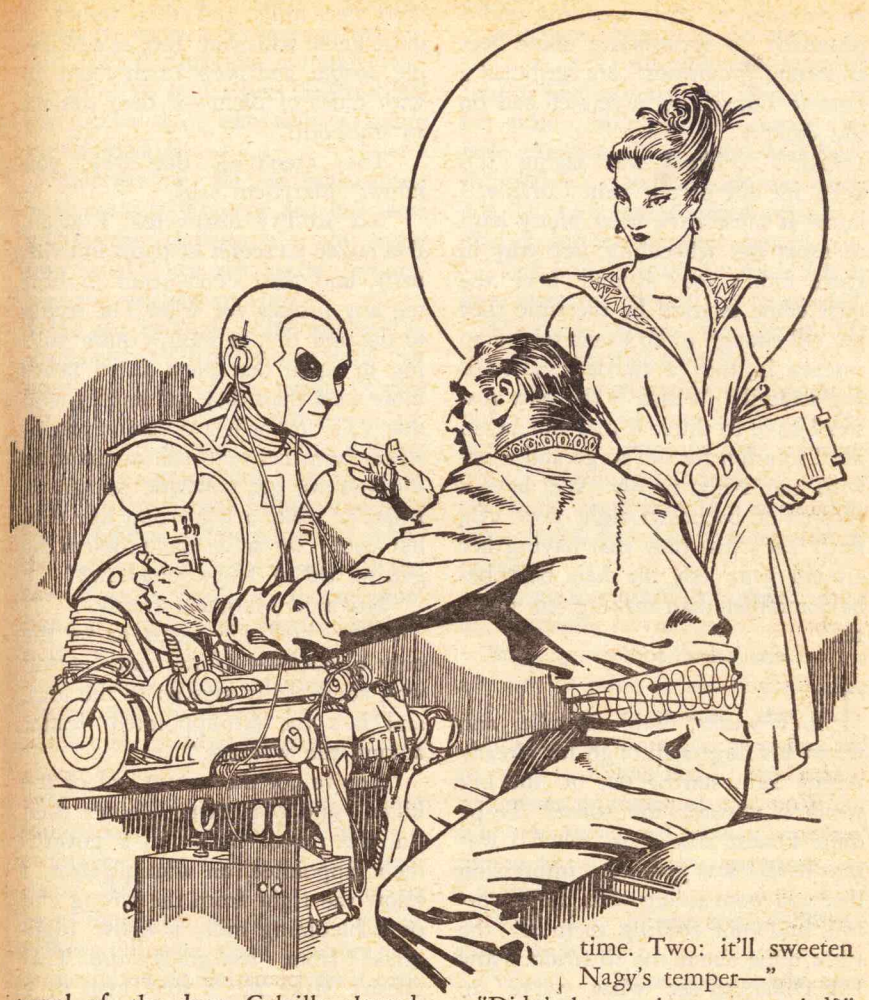
"Thanks, Nagy," Marghem said, relieved. Now the only problem was which of these two, Wallmeyer and Colville, would cause less disruption in the Nagy household.

"Well, I think that's wonderful!" Ira said, briskly gathering her mask and goggles. "Thank you very much, Mr. Nagy. It'd be ideal. I don't have anything to do with this robot problem—I'm just doing some folklore research, and . . ."

The door closed on her and Nagy. Her bright voice was still raised in cheerful explanation of her business at Eisenberg when it faded beyond hearing.

"Thank goodness," said Marghem when he caught up again with what had happened.

Wallmeyer looked at him in annoyance, and then back at the blank



panel of the door. Colville cleared his throat.

"Ah . . . *is* that a good idea?"

"On several counts," said Marghem cheerfully. "One: it means that we can get on with the business in hand and not be distracted all the time. Two: it'll sweeten Nagy's temper—"

"Didn't he say he was married?" Colville cut in. "Sweeten his temper it may do; how about his wife's?"

"Mrs. Nagy only weighs ninety-five pounds or so, but she's kept her husband tame for twenty years without trouble—which reminds me: next

month they celebrate the twentieth anniversary of their wedding and I promised to appropriate some beer and extra provisions." He scribbled a note to himself on a scratch-pad on the desk.

"Ah . . . like I was saying, it'll keep Ira out of our hair. Colville, I know it must have been pretty hard to resist her wheedling, but why in space didn't you? Round here the girls come buxom; by the time they get old enough to be worth taking an interest in, they're married and starting a family! Which is the only reason I have to think it may not be an ideal solution for her to go and room with the Nagy family. We have a surplus of bachelors right now. Ah, nuts! Let's just pray that having her around puts 'em on their best behavior rather than making 'em quarrel."

Three weeks," said Colville, and thrust his fingers through his already untidy hair, staring out of the big window towards the town. "To be quite honest, Marghem, when I was sent here I was given the impression that you were siding with the townsfolk and not feeding them all the right dope about the situation. Now I've come to see what you're up against."

"Thanks," said Marghem. "It doesn't make me any happier."

"Trouble is," Colville frowned, "their objections aren't rational. They're rooted in a subconscious reflex due to fear of being automated out of the only thing they care for—their steel mills and their mines. I quite agree with you: they're admirable people, and New Earth could do with more of them—if they weren't so stubborn!"

"They aren't all that way, you know," Marghem said.

"No, so I've discovered. I mean, I've talked to scores of them individually, and they don't seem to bear me any grudge for what I'm trying to do, and they're mostly quite willing to agree that New Earth needs more steel than they can supply, and that a GP robot is a different proposition from conventional automation — And we get nowhere. Marghem, I hate to make a suggestion like this, but could we solve the problem by getting rid of Nagy somehow?"

"No," said Marghem shortly.

"Why not? He seems to be the only obstacle—he's the only person who consistently says *no* to the idea, and he's the self-appointed leader among the workers."

"You've got the wrong end of the billet," said Marghem. "Point's this: I'm the mayor here. I'm a government appointee, an administrator. I know the right from the wrong end of a blooming mill, I know high-grade from low-grade ore. That doesn't make me a steel man or a member of this community. I get on pretty well with them. But I'm an outsider.

"Nagy, on the other hand, is their actual leader, the boss. Not self-appointed! Urged to the top because he's got all the virtues they admire. He's tremendously strong; he knows steel from ore to finished billet and plate. He talks. He can hold his liquor. He's brought up a family who are going on in the steel business. All that makes him inevitably a leader they'll look to.

"But getting rid of him would solve nothing. You couldn't shift him voluntarily; shifting him any other way would turn the entire community sour against us. Look!"

He got to his feet and pointed to a whaleback shape newly risen beyond the edge of the town. "That's the measure of how much they admire him, Colville! A dome for his twentieth anniversary party four hundred feet across, so they can help him celebrate all together and without getting dust on the food or in the beer. Knocked up in their spare time during a week or so, for the sake of a party lasting six hours, and requiring very nearly as long to take apart again afterwards. No. Nagy is neither the cause of the problem, nor a key to it."

"Then who . . . or what . . . is the key to it?" snapped Colville.

"Maybe there isn't one," said Marghem. "Maybe we're just going to have to resign ourselves to going without our own 'copter factory until things straighten out of their own accord."

"We can't!" said Colville, raising haunted eyes. Marghem knew exactly how he felt.

He was about to speak again when there was a sharp exclamation from the anteroom: Wallmeyer's voice.

"Hey! What do you think you're doing?"

Marghem strode to the door and slid it back. In the anteroom he found Wallmeyer—just peeling off his mask and goggles—facing Ira Bell, who was rising to her feet from the packing case alongside the robot, Joe. The moment Marghem appeared, Wallmeyer raised angry eyes to him.

"Did you tell her she could be in here with my robot?" he demanded.

Marghem shook his head. He gave Ira a puzzled look.

"I came over to give Joe his daily reflex check—he's not standing up so well to this long period without work." Wallmeyer hefted a kit of electronic equipment he was carrying. "And I find *her* in here, talking to him."

"Talking to him?" Marghem raised his eyebrows.

With perfect self-possession, Ira nodded. "I came to see if you were free, Mayor Marghem," she said. "Only I could hear you were having an argument with Harry. You said I was never to interrupt you, so I decided to wait, and then the robot started to ask me some questions, so I answered them."

"What sort of questions?" Wallmeyer barked.

"Why . . . what the people are like outside, and when they're going to let him start work eventually, and so on."

Wallmeyer's face went purple. "Ira, a robot is infinitely more delicate than a human being—misleading information can lead to a snarl-

up in his mental circuits that may cost millions to have overhauled, especially if he has to be sent back to Earth for it!"

"Boss," said Joe anxiously, "the lady was very polite to answer my questions, you know. Don't go on at her like that."

"Thanks, Joe," said Ira with a smile that ought to have melted the robot's heart if he had had one.

"That's as may be," said Wallmeyer shortly. "Marghem, get her out of my way, will you, while I check him over? Joe, you sit down and calm yourself, and we'll see how you are."

I'm sorry," said Ira when the door of the office closed. Her composure had faded a little. "I didn't mean to upset him like that."

"Maybe you didn't," said Marghem comfortingly. Ira had kept her word and hardly bothered him at all in the whole three weeks of her stay; he felt much more kindly disposed towards her than he had when she arrived.

"Oh, goodness!" She gave a little chuckle. "I meant Wallmeyer, not the robot. I haven't upset Joe in the least; in fact I've done him a lot of good. GP robots are always programmed for one specific purpose, the way people are educated in some specialty rather than another, but they have just as much curiosity about how their job fits into the pattern of their universe as you or I have."

She smiled at Harry Colville and sat down.

"You speak very knowledgeably," Marghem said, also resuming his seat. "How come?"

"Mechanical men are a very ancient part of legend and myth," Ira shrugged. "The golem; the brazen men Daedalus created for Minos of Crete; Frankenstein's monster, which passed into folklore from the novel where he was created. So I once did some research on mechanical men in reality as well as legend, and it turned out so well I'm going to use it in my doctorate thesis."

Marghem gave her a look in which surprise and respect were equally mingled. "You don't say!" he muttered. "Well, what can I do for you, anyway? How are you getting on with the Nagy family and everyone else?"

Ira managed to change what might have been a giggle into an adult-sounding chuckle just in time. How old *was* this kid, anyway? Marghem hadn't wondered before.

"I'm doing fine!" she said. "Every eligible bachelor in Eisenberg seems to have started calling on the Nagys. I've been invited into more than sixty homes, and managed to get around to nearly thirty of them; I've talked with people whose ancestors come from the Monongahela Valley and from Czechoslovakia and from Scranton and from Poland and from Gary and from Hungary and from all over!"

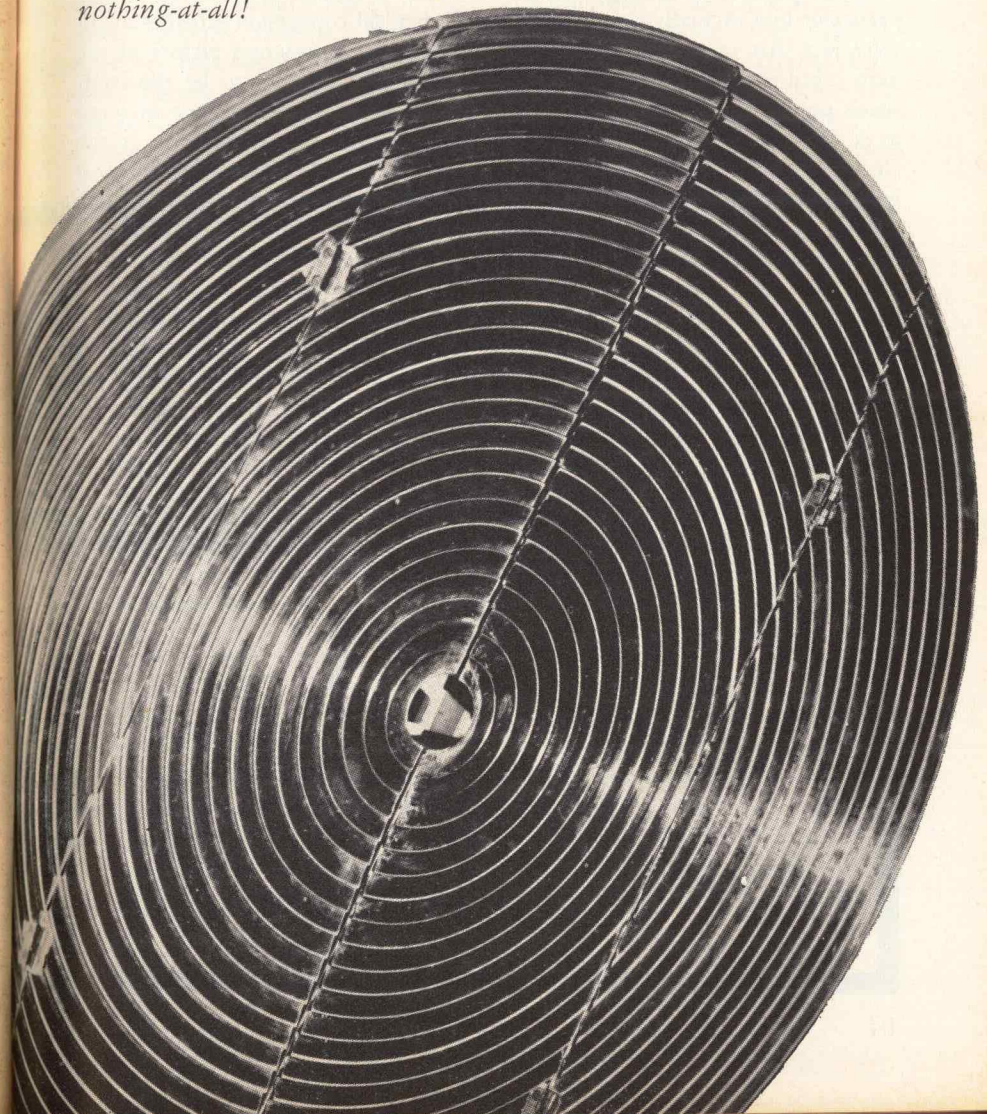
"And is this helping your work?"

« *Continued on page 107* »

Part 2—concerning devices with moving parts, and the problems of mechanical wear in devices that you can't send a mechanic to repair! Of engines that must run without fuel and without failure in the hostile environment of nothing-at-all!

POWER SUPPLIES FOR SPACE VEHICLES

by J. B. Friedenberg



MOVING PARTS SYSTEM

■ The first mechanical solar power supply to be discussed is the *Solar Turbine Power Plant.* Variations on an old theme, this type of space power supply system probably represents the peak of technology along a particular line. Actually—and a good, solid fact that must be faced by the most rabid proponent of the "exotic" space power supply techniques—the most efficient method of generating electrical power known to us today is still the turbine-generator combination, or its reciprocating cousins. State-of-the-art for these mechanical conversion types is very advanced, having developed through the ages since Hero neatly turned the trick back in 130 B.C. However, using boiling water in a one-gee earth environment, with plenty of air or water for cooling, is quite different from boiling a corrosive medium such as rubidium, sodium, ammonia, and others, in a Zero-gee environment, using the sun as a heat source, with cooling supplied by radiation alone, and keeping the system weight in the general neighborhood of a Ping-pong ball!

Rather than discuss the many mechanical conversion schemes available, we will present a picture of the system that appears to be the leading candidate for the office of large power supplies in space. This is the solar powered, Rankine cycle turbine, using mercury or rubidium as the working fluid. As mentioned above, the turbine power system is most useful for large power requirements—as ascertained through systems optimization studies—but it really comes into its own when we talk about a space vehicle that is designed to carry a crew and maintain this crew in the space environment

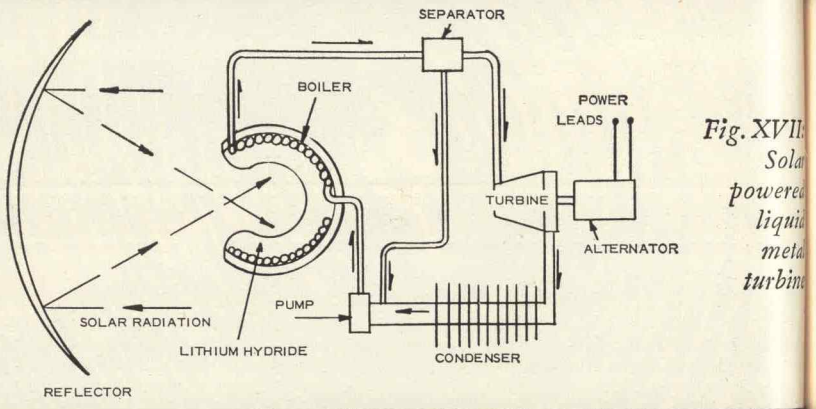


Fig. XVII: Solar powered liquid metal turbine

for weeks and months.

The Samos-Midas family of satellites—even the Explorer and Surveyor types of unmanned vehicles that will eventually soft-land on the moon—require power levels that reach into the high hundreds and low thousands of watts. These vehicles can successfully use, and are designed for, the battery and solar cell power supply systems. However, when we talk about 10 or 20 kilo watts, figures which are representative of the power levels required by a manned vehicle designed for long-term missions, the minimum number of silicon solar cells needed—assuming practically laboratory temperature and orientation control—is about 1,400,000! From the point of view of the cells alone, this is a goodly number worth a goodly buck, but imagine designing the containers, joints, deployment and orientation mechanisms! It is in this range of power levels that the combination of solar collector and turbine-alternator takes over. By 1970, this type of system will actually be in use on a space vehicle.

In this type of mission, the generating system will have to supply 20 kilowatts continuously for a year, at 400 cycles. Inherent in the system must be the capability for storing energy to use during shadowed periods, similar to satellite nightside operations. A vehicle such as this will probably be used for a mission such as intercepting Mars, orbiting for surveillance, then returning to earth. In this case we would use as a design point the incident solar radiant energy felt by Mars, which is estimated to be .6 kilowatts per square meter. This is pretty poor compared to earth's fat 1.4 kilowatts per square meter, but gives us a nicely conservative design, a thing that delights the energy management engineers, but desolates the long-suffering weights people.

Assuming a conversion efficiency of 10%, the total energy absorbed by the conversion system to provide 20 kilowatts will be 200 kilowatts. Calculating re-radiation losses from the boiler, we find that a total of 450

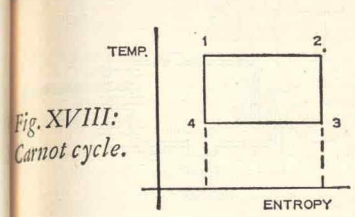


Fig. XVIII: Carnot cycle.

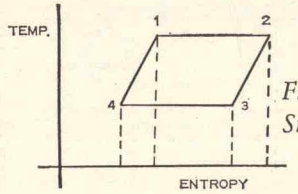


Fig. XIX: Stirling cycle.

kilowatts of solar energy must impinge on the boiler. Now, assuming a collector efficiency of 85%—high, to be sure, but possible in ten years—and using the incident energy near Mars of .6 kilowatts per square meter, the collector needed to supply the 450 kilowatts turns out to have an area of 882 square meters!

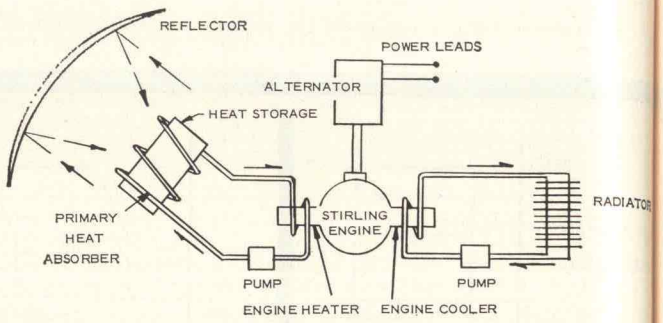


Fig. XX: Solar Stirling engine system.

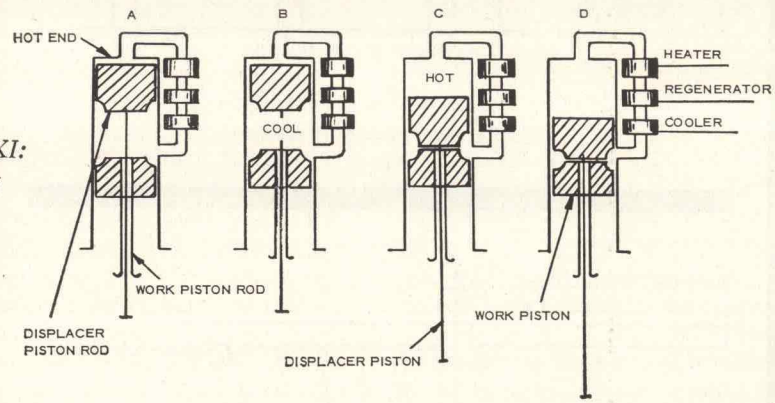


Fig. XXI: Stirling engine work cycle.

If the vehicle mission is such that it will remain in the vicinity of earth, the effect of the incident energy of 1.4 kilowatts per square meter is to reduce the collector area to 388 square meters. Areas such as this are large, but are already in the design stage.

Since we've already chosen the Rankine cycle, we can examine some of the working fluids that can be used. These include mercury, rubidium, sodium, lithium, and cesium, all classed as liquid metals. The first three are already in use in systems under development. They all have boiling points below 1800-2000 degrees K, which is a practical limit based on structural considerations. Because in the Rankine system the fluid must be vaporized as fully as possible, the very high boiling temperature must be maintained constantly in the boiler. This creates rather high-order material stress problems, and going any higher in temperature would pass the practical design limits of today's metallurgy; the boiler tubes would creep, bulge, and rupture.

Schematically, a complete system such as this will appear as shown in Fig. XVII. Starting at the boiler, the fluid is vaporized as completely as possible, and the vapor flows directly to a separator. Here, the small amount of unvaporized liquid is separated from the saturated vapor. The vapor flows into the turbine, expanding through its stages; the turbine runs up to speed, and is regulated to keep the alternator RPM within proper limits. After leaving the turbine, the vapor is condensed in the radiator and flows as a cool liquid into the pump, where it is pumped back to the boiler to start the cycle again. The radiator may require another stage for sub-cooling. Each component must be designed for lowest weight, smallest size, highest efficiency, and highest reliability. That's all!

In designing the turbine, the most important factors entering the picture relate to the corrosive characteristics of the working fluid, the extremely elevated working temperature of the liquid metal, and the very long operating duration. Exotic alloys must be used, as the operating temperatures and corrosivity dictate the downfall of ordinary metals. Even such materials as molybdenum, columbium, and tungsten are marginal, especially for long term use where the creep characteristics of the material become a major design issue. Another vital factor in the system is the corrosivity of the work-ing fluids. If there are any droplets of liquid in the vapor, the corrosive effect jumps sharply up. As a consequence, it becomes of first-order importance to design the boiler, and the passages from it to the turbine wheels, so that no liquid droplets are formed in these areas.

The function of the boiler is to transfer the collected solar energy to the working fluid. At first glance, it would appear that all the working fluid should be vaporized, as this

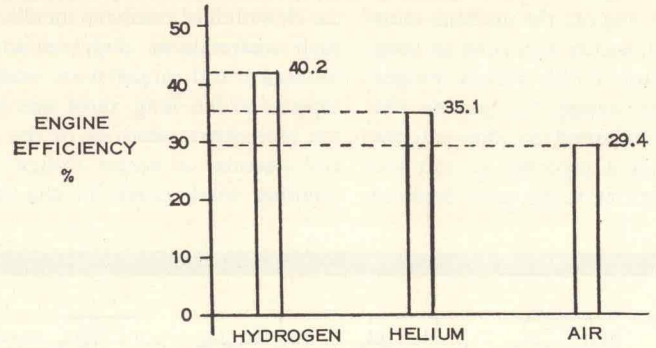


Fig. XXII: Stirling engine efficiency as affected by working medium.

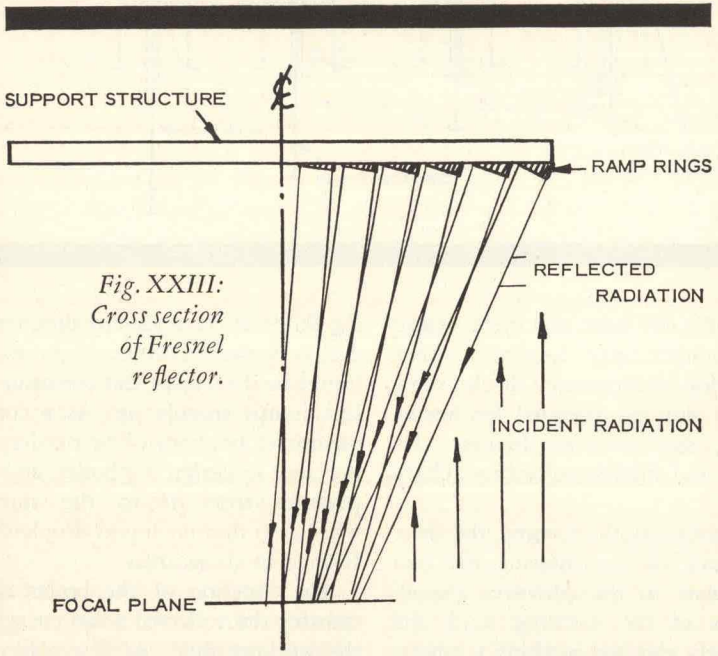


Fig. XXIII: Cross section of Fresnel reflector.

would make available the most energy in the fluid, and would also keep the corrosion problems at a minimum. However, heat transfer calculations show that while this may be practical on the ground, in a space system it becomes untenable: the heat transfer area becomes literally immense. So once again we must trade off efficiency of a single component against overall system efficiency, and accept, for example, 80% vaporization and a relatively small, light boiler. If we insist upon 100% vaporization, we will find that the boiler weight is about ten times the weight of a boiler needed for 80% vaporization!

Obviously, in this case, 20% of the fluid remains liquid. A turbine is designed—at least in this case—to operate with a vapor; liquid in the vapor, besides raising the corrosion problem, drops the efficiency alarmingly, and also cuts the turbine life. Thus, a separator is required. This can be a stationary volute or coil that bleeds off heavy liquid thrown centrifugally to the outside, or an actual motor driven centrifuge. Good separator design is a must in the liquid metal systems.

The next important item in the system is the pump. In designing the pump, once again we are faced with high speed rotating machinery that must operate at constant speed for months on end. Because we can't afford cavitation, the pump will probably be designed as a combination jet-centrifugal type. It is driven off the turbine through a gear train.

So far, we have bumped into rotating machinery in a number of places. Obviously, in this type of system there are a goodly number of rotating components. This situation means that we must have a system of bearings which will operate smoothly, without breakdown, for the long time periods of the mission. Roller and ball bearings do not satisfy; the individual parts fail under the combined high speeds, heavy loadings, and high temperatures. However, it has been found that plain, or journal type bearings, lubricated by a full film of the liquid metal working fluid, will do the job Bearing systems such as these have been fabricated and tested, and will probaby be the type of bearing used in the turbine power system.

Probably the biggest single problem in the bearing area relates to the compatibility of the hot liquid metal with the bearing material. Some materials showing promise for bearing application are the carbides of tungsten and titanium, which are very resistant to the hot, corrosive liquid metals, do not lose strength or shape at the high operating temperatures, and will stand up to the continual abrasive action of the turbine shaft. Incidentally, as is the case with all aspects of space-oriented science, research in bearing technology has virtually become a science in itself, out of which many useful techniques will come for application right here on the ground.

Finally, after the collector has collected, the pump has pumped, the

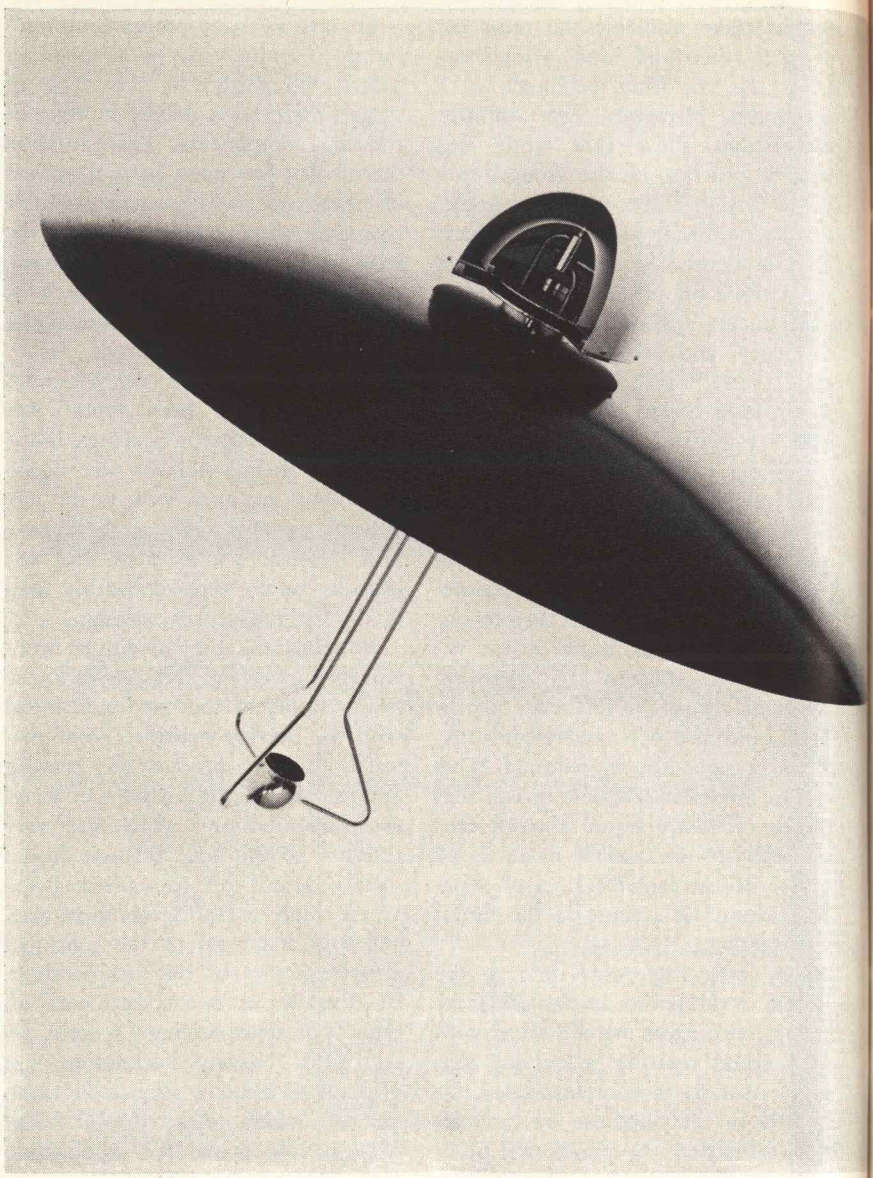


Fig. XXIV: AiResearch solar powered rubidium turbine system.

boiler has boiled, the separator has separated, the radiator has radiated, and the turbine has ?, we arrive at the miniaturized giant that creates the wattage—namely, the alternator. The alternator is either attached through a gear train to the turbine, said gear train operating the alternator at a specific RPM, or is driven directly by the turbine, and its characteristics are matched to the turbine speed. Because of the requirement for continuous operation over very long periods, it is not feasible to use standard alternator designs which employ brushes or commutators. Here, the problem is obviously one of wear. Therefore, we are forced to go to a brushless design, such as the inductor alternator, in which the rotor itself is forged from a magnetic material of high tensile strength. The rotor runs at a high peripheral velocity and RPM, allowing the design of a small package, with consequent low system weight penalty.

We have presented the various working components of the system as if it travels in free space without ever leaving direct sunlight. However, if the system is to supply power to a vehicle that is intended to orbit a planet for surveillance duties, it becomes necessary to add one more major component—the heat storage sink. This has been discussed in relation to the various other power systems, and in the case of the turbine-alternator system, will probably also use the lithium hydride combination. A point to note is that the heat storage component is by far the heaviest in the power supply system, accounting for about 70% of the system weight. (Here's an excellent field for invention.)

Somewhere in the neighborhood of a continuous 10 kilowatt power supply requirement, the power-weight curve of the solar turbine-alternator system catches up with, and passes, the static energy conversion devices using the sun as primary energy source. Following is a weight breakdown of a typical 10 kilowatt turbine-alternator system:

Collector-Reflector	142 pounds
Radiator	36 pounds
Boiler	10 pounds
Pump	5 pounds
Separator	5 pounds
Turbine	20 pounds
Alternator	40 pounds
Piping and Structure	10 pounds
Working Fluid	25 pounds
Orientation Mechanism	70 pounds
Voltage Regulation	10 pounds
Heat Storage	870 pounds
TOTAL	1243 pounds

Refinement of design, which will occur after the initial results are evaluated, will bring the system weight down to about 1,000 pounds. This is not a startlingly low weight, but from here on out, to the higher power levels—20, 40, 100 kilowatts, this type of system walks away with the honors in the solar power arena.

Before leaving the solar Rankine turbine system, let's see what effect the use of rubidium has on system weight, as compared to the mercury

system. In general, of course, the rubidium complex will be very similar, using the same type of components. Differences in the two systems really are created by the somewhat different design philosophies that obtain between companies.

For instance, Sundstrand Aviation of Denver, under contract with the Air Force, is well along with development of a rubidium solar turbine system which differs in design from the above-discussed mercury system, as championed by Thompson Ramo-Wooldridge, mainly in design details. The same type of components are used, in the same sequence and number, with certain modifications and additions which mesh better with the use of rubidium.

One difference is that the Sundstrand system uses a very sophisticatedly designed combined heat storage-boiler section; this section contains two heat sink cavities, one utilizing the familiar lithium hydride, and the other holding sodium fluoride. These work as a two-stage heat sink: the solar enery is reflected through a fancy energy flux trap into both stages, where the heat is held at two different temperatures by the two molten salts.

Fig. XXV: Folding parabolic mirror—Ryan Aeronautical Company. It's not enough that a reflector be able to concentrate sunlight . . .

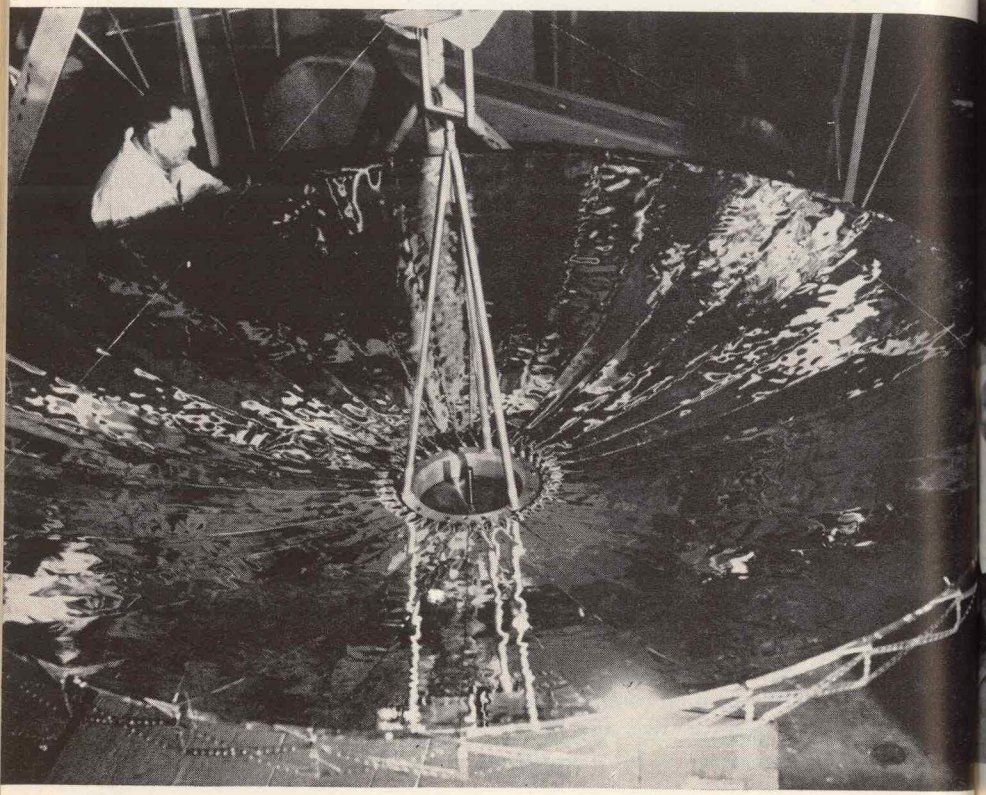
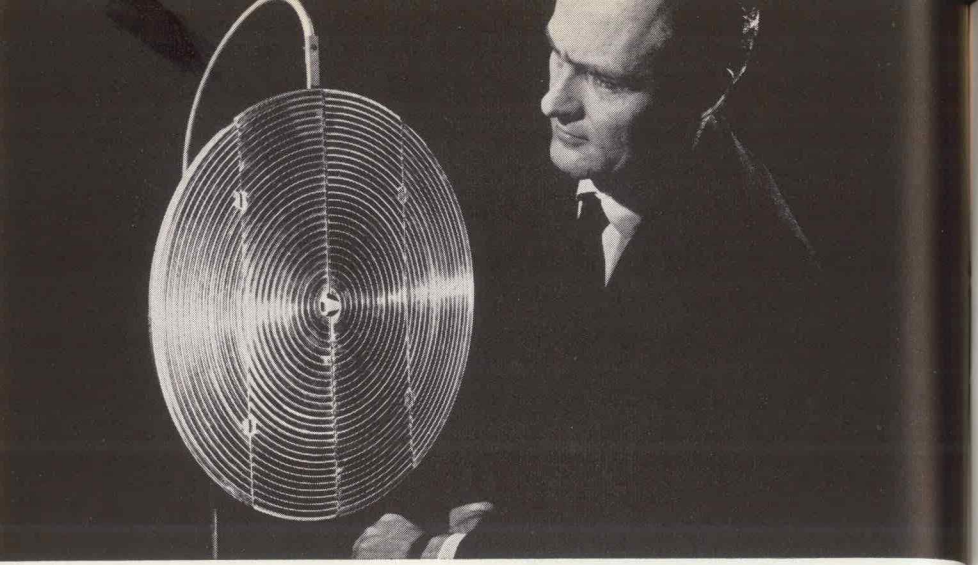


Fig. XXVI: . . . It's got to fold to fit in a rocket vehicle, too!

The rubidium is circulated first through the lithium hydride, where it is boiled and brought to a temperature of 1,200 degrees F. It then continues its journey through stage two, where the sodium fluoride superheats it to about 1,800 degrees F. In this state, the vaporized rubidium is then expanded through a four-stage axial flow turbine, which turns at a design speed of about 24,000 RPM, which in turn drives the alternator and coolant pump. All bearings are lubricated by the rubidium working fluid itself. A thin metal meteoroid shell protects all working machinery. The turbine exhausts rubidium vapor into the center of a circular platelike radiator, where it moves through passages to the rim, and condenses at a temperature of about 650 degrees F. From here it is pumped to the bearings and the boiler, to start the cycle again. The big thirty-six foot diameter solar reflector is made of aluminized mylar—the same stuff that the Echo satellite is made of—and is rigidized by injection of a forming plastic that sets hard.

The use of rubidium in the Rankine turbine system allows a larger spread of working temperature than in the mercury system, due to the higher allowable working temperature of 1,800 degrees F, as compared to mercury's 1,200 to 1,300 degrees F. The increase in latent energy results in higher overall system efficiency, with consequent savings in size and weight for a given power requirement.

For instance, the weight of a com-



plete rubidium system designed to deliver 10 kilowatts in space is close to 750 pounds, as compared to the 1,243 pounds quoted for the mercury system previously. This sort of weight saving, it almost goes without saying, gladdens many a heart during the development cycle of a satellite system that always seems to be pulling a Topsy. Of course, it should be pointed out that the really nice thing about the *mercury* system is that it has a long history of ground usage in stationary power plants behind it; consequently, many of the problems have been worked out. On the other hand, the problems associated with the use of rubidium are still being uncovered.

Fig. XXX shows a photo of a ground-based working model of the rubidium turbine system developed by Sundstrand Aviation—Denver. An artist's conception of a space system is shown in Fig. XXXI.

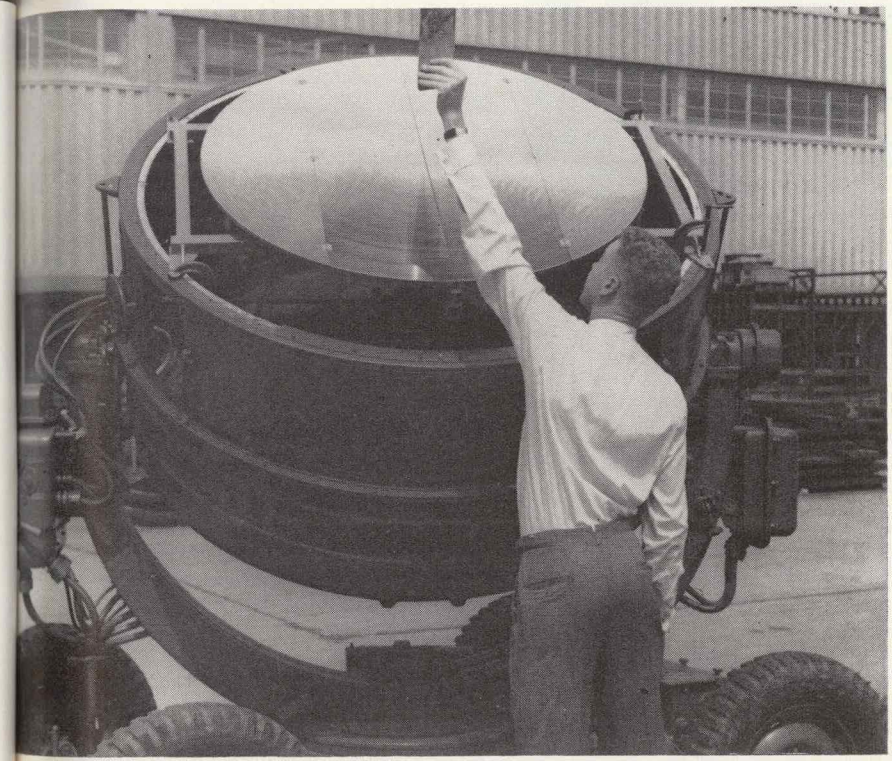
Also in the solar rubidium turbine business is the AiRescarch Manufacturing Division of The Garrett Corp. These people have embarked on an ambitious development program in the Phoenix area, where they are making good use of the exceptionally plentiful solar energy reaching the ground. In Fig. XXIV, we have an artist's conception of the AiResearch rubidium system in space.

The last type of space power supply system to be discussed in this article is the *Solar Stirling Power Plant.*

In 1827, Robert Stirling, a thermodynamically inclined English preacher, dreamed up a rather odd engine based upon a new gas cycle which was also invented by him. Looking

Fig. XXVII: Fresnel reflector—
Allison Division of General Motors.

Fig. XXVIII:
Fresnel reflector—Allison Division of General Motors.
Incidentally—for the home experimenter—equivalent Fresnel lenses, made of sheet plastic, capable of acting as solar furnace units, are available from scientific supply houses such as Edmond Scientific, at very modest prices. They look like transparent phonograph records—and act like ten- to twelve-inch lenses!



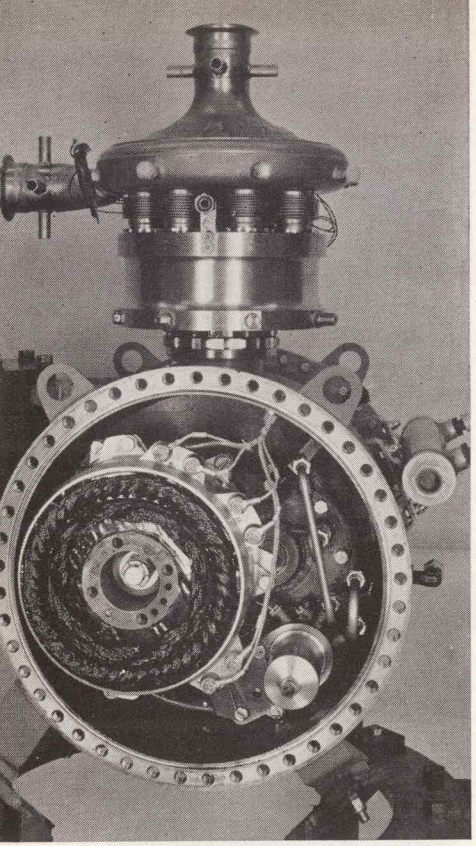
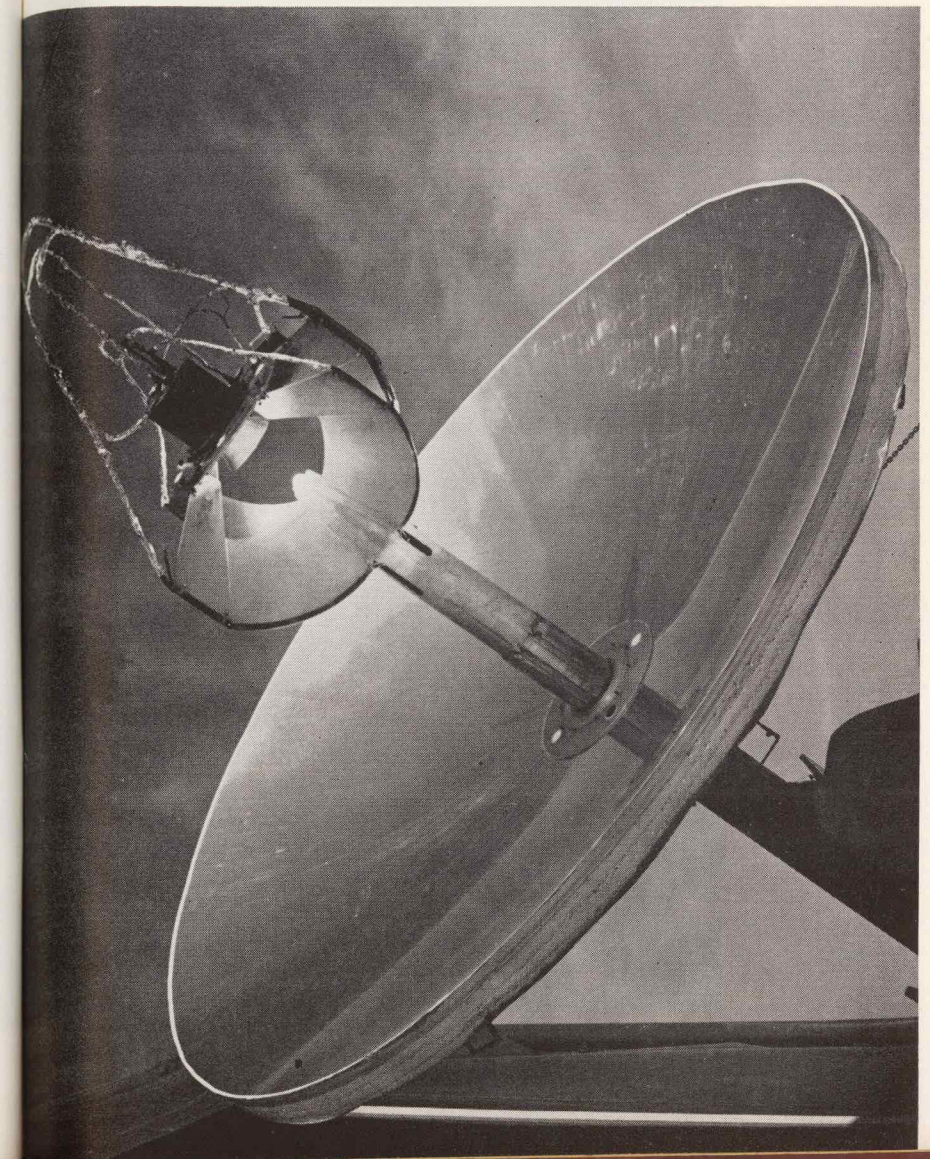


Fig. XXIX: Stirling engine and integral alternator—Allison Division of General Motors.

back on Stirling and his development efforts from the vantage point afforded by the ensuing century and a half, it appears as if he deliberately tried to force the gas cycle into following, as closely as possible, the classical Carnot cycle which delivers —on paper, anyway—maximum heat engine efficiency. We can even imagine his excitement and delight when his paper work showed that his cycle did indeed approach the Carnot heat utilization, although the method he used was obviously a forced and artificial one.

So artificial was the method, in fact, that the contemporary scientific professional types snickered loudly, and pointed out the impossibility of ever achieving high speed action with the Stirling cycle. Fatuously, they concentrated on development of the sturdy steam engine, and of another silly little item that showed much promise—the internal combustion engine. Snickers changed to condescending laughter when Stirling's huge, cumbersome external combustion engines were demonstrated. Although they worked, as predicted by the brethren they chuffed ponderously through the

Fig. XXX: Model of rubidium solar turbine system—Sundstrand Aviation, Denver.



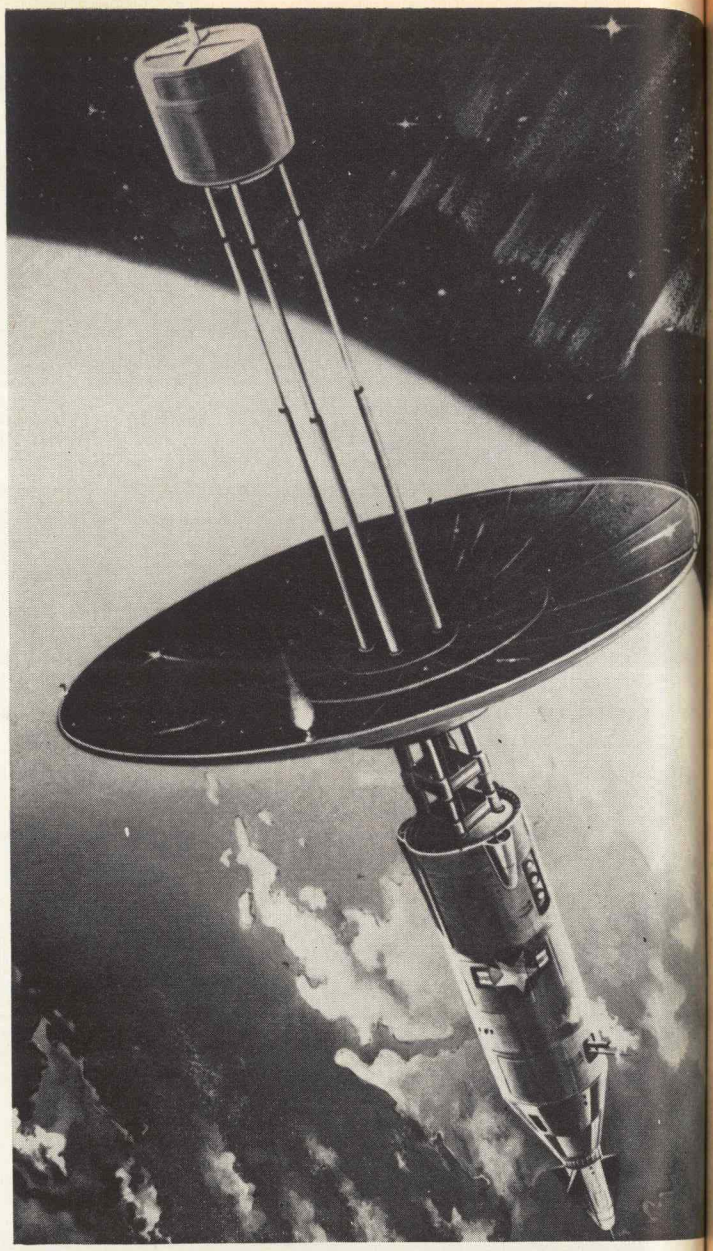


Fig. XXXI: Artist's conception of rubidium turbine space system in orbit—Sundstrand Aviation, Denver.

strangely artificial cycle invented by the good preacher. After a few short years, development petered out, and it was concluded that the cycle, while interesting on paper, was impossible to implement.

Obviously, with the working medium—a gas such as air—separated from the heat source by the cylinder walls, it is not possible to transfer heat rapidly from the gas to a heat sink and back again in a closed cycle. Thus, one could never achieve rapid reciprocation, and the development of high powered engines would necessarily result in huge machines—too large for practical use in a world which was searching for smaller and smaller power packages. Indeed, that intrepid and remarkable engineer, Ericson, of Monitor fame, built a 3,000 horsepower engine for the United States Navy, using a modification of the Stirling cycle, the modification invented by himself and appropriately called the Ericson cycle—which operated at 9 (nine, that is) RPM! It never went into service.

However, time proceeds, and various and sundry milestones of technical development come to pass. New materials appear on the scene, making possible activities that once were termed impossible. Twenty-five or thirty years ago, an enterprising outfit named N. V. Philips Research Laboratories, in the Netherlands, decided that the Stirling Gas cycle looked very interesting. Being knowledgeable, they connected the new-found high-strength steels with the Stirling cycle, and came up with an amalgamation that seemed to deserve another look-see. Accordingly, they instituted a long-term development program which has continued to this day, and has been used as a foundation for a remarkable power conversion system planned for space use.

Let's look at the Stirling cycle.

It is the usual thing to compare all gas cycles to the classically unattainable Carnot cycle, thus checking their possibilities and further assuring the non pareil nature of the Carnot diagrams. On a Temperature-Entropy chart, the Carnot cycle is represented by two isothermals and two isentropics, as shown in Fig. XVIII. The heat rejected during operation 2-3 returns during 4-1, and the ideal cycle continues unabated. In the Stirling cycle, the adiabatics of the Carnot cycle are replaced by constant volume slopes, and the cycle diagram looks like that shown in Fig. XIX.

In the actual Stirling engine, the approximation of the Carnot cycle is accomplished by the ingenious incorporation of a device called a heat regenerator, which is expressly designed to store the rejected heat—usually thrown overboard, thus killing chances of approaching Carnot—so that it can be returned during operation 4-1. In the ideal case, the heat absorbed from the source is the same as in the Carnot cycle, and the efficiency possibilities are also the same—if we have an efficient regenerator.

As stated before, the Philips people saw this potential, and decided to exploit it. The engines they have developed, using heat resistant steel alloys, elevated gas temperatures, and the latest heat transfer techniques, operate at efficiencies equal to or better than internal combustion engines. Operating medium—air or some other cheap gas—reaches a temperature of 1,200 degrees F, and the working pressure reaches as high as 750 psi. Design of the heater, regenerator, and cooler, and the use of high heat transfer rates, small gas volumes, and passages designed for low aerodynamic resistance, has given operating speeds of over 3,000 RPM.

The regenerator—development of which was one of the keys to success —consists of porous coils of wire, is 95% efficient, and can raise or lower the gas temperature 900 degrees F in .01 second! The amount of heat saved in the regenerator is 75% of the heat required to raise the temperature of the gas from its working cool level to its working hot level. And right there is the reason why the Stirling cycle has become so attractive.

Using all this work as background and foundation, the Allison Division of General Motors has had under development, since early 1959, a 3 to 5 kilowatt space power system based on the Stirling engine. The sponsoring agencies are ARPA and the Air Force. So far, in this program, the Allison people have demonstrated a 40% efficient Stirling engine.

Actually, the defunct Stirling cycle was resurrected because when all the gas cycles were investigated for application to space missions, the Rankine and Stirling cycles proved on paper to be just about as practical and efficient as could be found in the field of mechanical heat engines. Also, in the case of the Rankine turbine, other companies were already into development, and the Stirling cycle was still dormant. Both of these systems are closed cycle types, a definite requirement for space missions of any extended duration. Both systems use an external heat source, and don't much care what kind of source it is.

The Rankine cycle has the advantage of being an old-timer on the scene, with its mechanics very well known; the main point of beauty about the Stirling engine is its high inherent efficiency, derived from the particular thermodynamic characteristics of the Stirling gas cycle. Unlike the Rankine cycle, which uses a two-stage working fluid, and must, therefore, change state on the way up to vaporization and on the way down, the advanced Stirling engine uses a pure gas as the working medium. Whereas the Rankine cycle using mercury works best at a radiator temperature of 500 to 600 degrees F—it would be foolish to run the liquid mercury down any further in temperature and then have to heat it all the way back up again—the Stirling cycle is not limited in its maximum and minimum temperatures by cycle considerations, although it is obviously limited in the hot range by structural considerations.

In fact, an analysis of this cycle shows that the minimum weight for a Stirling space power system using a nice conservative upper limit of 1,250 to 1,300 degrees F, occurs with a radiator temperature of about 150 degrees F. In the case of the advanced Stirling system, the high engine efficiency has a very beneficial effect on the overall system weight. Actually, the Stirling engine alone is heavier than a mercury Rankine turbine that develops the same power, but a comparison of the overall system weights, optimized to deliver 3 to 5 kilowatts, shows the Stirling system to be about 40% lighter than the Rankine system. Table I gives the breakdown for this comparison. Table II shows a comparison of the weights of a Rankine and Stirling system designed to the same radiator surface area.

TABLE I.

	Rankine	Stirling	
Solar collector diameter—feet.	32	19	
Radiator area—square feet.	100	160	
Radiator temperature—degrees F.	500	150	
Maximum working temperature—degrees F.	1250	1250	
Engine efficiency.	13%	38%	
Weight of components in pounds.			
Solar collector	300	110	
Primary heat absorber	50	20	
Heat storage	125	45	
Radiator	25	35	
Engine/Alternator	125	235	
Liquid metal	55	40	(coolant)
Structure	115	75	
TOTAL	795	560	

TABLE II

	Rankine	Stirling
Radiator area—square feet.	100	100
Radiator weight—pounds.	25	25
Total system weight—pounds.	795	622

Taking a look at the complete Stirling system and its various components, we find that, in general, it carries the same labels as does the Rankine system shown in Fig. XVII, with the exceptions that no liquid droplet separator is needed, the primary heat absorber is not a boiler, and of course the prime mover is a reciprocator, not a turbine. A schematic of this system is shown in Fig. XX.

Basically, the system works in a manner similar to the Rankine system, and in fact to all the other solar systems. The sun's radiation is collected by a reflecting surface and concentrated on the heat absorber. Here, liquid metal picks up the heat, and is then pumped to the engine heater, which then performs the function of heating the working gas. The liquid metal then returns to the heat absorber to start its cycle again.

As in the other systems, heat is stored in a lithium hydride reservoir during the sunlit portion of the orbit, and the excess designed into the reservoir is released to the engine during shadowed portions of the orbit. The cool end of the engine is kept that way by a liquid metal system that picks up engine heat and circulates through a radiator. The solar reflector is kept continuously oriented sunward within narrow limits by an automatic servo system. Incidentally, the reflector which has been designed as a part of this system is very interesting; we'll delve a little deeper into that further on in this discussion.

Obviously, the heart of the Stirling system is the engine itself. At this point, we can examine—somewhat cursorily, to be sure—the dynamic and mechanical considerations that form the basis of a working advanced Stirling engine design.

To repeat, the Stirling engine uses a closed cycle, a working medium consisting of gas only, and an external heat source. Very high reliability can be attained, as there are no valves, and the engine can be adapted to a mechanical arrangement in which there are no piston side loads, and all torque, gyroscopic forces, and vibrations are canceled or balanced. The absence of an ignition system insures freedom from electrical interference, and also does no harm from a reliability point of view. Once again, praise be to Good Old Sol!

Fig. XXIX shows a photograph of Allison's advanced Stirling engine, with its integral alternator, specifically designed for space power application. The work cycle of this advanced Stirling engine is shown in Fig. XXI. As shown, the cylinder is closed at the hot end, and the work piston seals it at the cool end. In the space between the work piston and the cylinder head, is a displacer piston, whose function it is to move the working gas from the hot end of the cylinder to the cool end through a passageway consisting of, from top to bottom, a heating system, a regenerator, and a cooling system. The working cycle starts with the displacer piston against the hot closed end of the cylinder, and the work piston at

the bottom of its stroke. In this position, the cylinder volume is at its greatest, and the maximum amount of gas is in the cool space, as in Fig. XXIA.

The work piston now moves up toward the closed end of the cylinder, where the displacer piston is being maintained at what might be called top dead center, as shown in Fig. XXIB. This is the "cold" compression end of the cycle. Following the compression of the working gas in the cool chamber, the cool compressed gas is displaced out of the cool chamber by the motion of the displacer piston downward toward the work piston, as shown in Fig. XXIC. As the cool gas moves through the passages toward the hot end, it passes through the heat regenerator and heater. Remember, the gas moved in this manner is a constant volume, so that this portion of the cycle is really a heat addition at constant volume.

At the end of this phase, the pressure has been raised considerably, by the addition of heat, over the pressure attained at the end of the cool compression stage. Now, this pressure increase moves both the displacer piston and the work piston downward; this is the work portion of the cycle, as shown in Fig. XXID. It can be seen that this phase results in expansion of the working gas in the hot chamber, with a consequent heat loss. The displacer piston now returns to the closed end of the cylinder, displacing the gas from the hot chamber to the cool chamber; in transit, it picks up heat from the heater and then deposits it in the regenerator matrix for use in the next cycle.

Naturally, as in all high-speed machinery—especially when the design pushes the state-of-the-art limits as in space applications—there are some tough problems to overcome. For instance, the zero-gee environment creates a lubrication problem which is over and above the already bad lubrication problem associated with operating reliably for periods of a year or more. Under investigation at the present time are two systems which are specifically designed to operate in zero-gee; these are a pressure lubricated system, and an ingenious system that uses a controlled oil mist. In these configurations, plain or roller-type bearings work.

Another area which has forced some ingenious design is that relating to seals. Problems are encountered during engine operation, especially in trying to prevent gas flow around the displacer piston, around the work piston, and along the two independent-but-mutually-sliding piston rods. Also, any oil mist must be prevented from entering the working zones. Some very fancy arrangements are being evaluated; promising designs include such items as spring-loaded Babbitt rings, piston rings made of glass-impregnated teflon, and fabrication of the pistons with a soft metal coat plated on, containing a small amount of dry lubricant.

The advanced Stirling engine efficiency is directly affected by the heat absorption and rejection properties of the working gas. Fig. XXII illustrates the engine efficiencies relative to the use of hydrogen, helium, and air. It appears that hydrogen should be the obvious choice as the working fluid, and for short term operations, say up to a month, it is. However, all gases have the nasty habit of diffusing through the walls of thin-walled containers, even the type of metals used in these space engines, and from this point of view, hydrogen takes the cake. Therefore, we can expect a continuous, fairly rapid, and quite respectable drop-off in engine power after a relatively short period of operation at high pressure, and for periods of a year, hydrogen does not look attractive. Therefore, we have to go to other gases, and accept a lower engine efficiency. Helium, while it also diffuses through metal, can still probably be used in this engine for the required durations, as its rate of diffusion is low enough so that system performance degradation is tenable.

For many of the communication satellite missions, the orbital electrical power requirements do not vary greatly with time-in-orbit. That is, power needs do not change radically from one hour to the next, but remain fairly constant. When we examine the overall aspects of such a mission, one of the recurring items that keeps hitting us is reliability. If our mission involved large variations of power, we would probably have to get pretty fancy in our engine control system design, and try to make the engine put out exactly enough power to cover the minute-by-minute requirements. This would mean adding quite a few complex electronic and mechanical components, such as sensors, timers, feedback circuits, switching elements, actuators, and the like, and would immediately result in lowering the probabilities of success.

Fortunately, many missions maintain a steady requirement, and in these cases, we can use an engine control system of minimum complexity, which will operate the engine continuously at its rated design level. This is designed to cover the peak power requirements, and during periods of reduced requirements, the excess electrical power generated is simply switched out and radiated into space as heat loss. Although this requires a slightly larger radiator, once again a trade-off study shows that this type of control system is undoubtedly the most practical and reliable from a systems point of view.

Some time back, it was mentioned that we'd look at the solar reflector being designed to go along with the Stirling system. To date, there has been a rather special reflector designed, and built in large model form, for evaluation. This reflector can be used, of course, with any other system just as well, but in this case, reflector design was undertaken by the same company that put together the generating system, and the reflector design was integrated from the beginning into the complete system. Therefore, it seems logical to talk about this reflector at this point.

As usual in a space power supply system that has a duration of more than a week or so, the design of this system wound up with a requirement for a heat storage sink; also as usual, further study dictated the choice of lithium hydride. Now, lithium hydride has a melting point of 950 degrees K, and when various heat losses and temperature drops through container walls are taken into account, the design temperature at the heat storage sink must be about 960 degrees K. Thus, in this and other systems using lithium hydride, reflector design has centered about the problem of designing a reflector that will concentrate solar radiation onto a heat sink at a temperature of 960 degrees K.

Some of the problems that we bump into concern requirements relating to high optical efficiency, low weight, low cost, low storage volume, ease of deployment, good capability to withstand the special environment, and reliability. Among these factors, there exists a systems relationship, and the final choice of design always winds up as a sort of optimum set of engineering compromises. After a thorough investigation of reflector theory, reflector state-of-the-art, manufacturing techniques, material technology, and so on, it was decided that the reflector for this system would be a Fresnel type, modified for specific application to the Stirling space system.

The Fresnel reflector is a very interesting configuration, coming close to parabolic reflector efficiencies while using a perfectly flat structure. In fact, many researchers contend that the Fresnel type reflector will afford a greater percentage of radiation being reflected to a desired area, than will a parabolic reflector, especially when you have to use large surfaces of exceeding lightness, due to the extreme difficulty of maintaining the required accuracies in a large parabolic surface.

Essentially, the Fresnel reflector consists of a series of concentric rings in the form of ramps or serrations, the surfaces of which are arranged to reflect into a focal area. Fig. XXIII is a sketch of a cross section of a Fresnel reflector. Each ramp ring is relatively small, and for that reason can be built quite accurately, even if the diameter is large. Because of its flat design, the Fresnel reflector can make use of some of the more exotic lightweight construction materials, for example, the cemented plastic-and-metal honeycombs. Also due to the flat plate design, folding for storage becomes a fairly simple chore—much simpler than for a metal parabolic reflector—and the whole deployment mechanism can be of rather straightforward design.

Figures XXV and XXVI show photographs of a deployable all-metal parabolic mirror, designed and built by the Ryan Aeronautical Company as a working model of a future solar reflector for space use. The

photos in Figures XXVII and XXVIII show some of the working models of Allison's Fresnel reflector development program, which is progressing along with the Stirling engine power conversion system. It looks as if this combination will be tested in space in the foreseeable future, at least in this decade.

It seems that Robert Stirling, the foolish English preacher, was right.

* * *

This paper has presented some of the engineering aspects relating only to those systems using the sun as an energy source. It should be understood that there is as much effort going on in the development of power supply systems using man-made nuclear energy sources, and a major effort is going into the very promising field of fuel cells. The reciprocating engine has not received the brush-off either.

Small thermoelectric and thermionic power generators, using the heat of decay of radioisotopes, have been designed and built as prototype feasibility models. These have been operated very successfully on the ground, and are providing the basic data for design of space vehicle systems. In fact, as stated before, an experimental generating unit of the SNAP family has recently been orbited, and its power is helping to send signals to earth. Also, both thermoelectric and thermionic systems using fast reactors for heat sources are being developed. The use of reactor heat is also being studied in relation to a liquid metal turbine-alternator system. In fact, it can be said that for every solar powered system, there is a nuclear powered counterpart—except, of course, for the solar photovoltaic cell. For the very high power requirements, ranging into the megawatt region, the nuclear fission reactor becomes the paramount energy source, outstripping even the best solar powered systems in power weight ratio by a large amount.

Oxygen and hydrogen are also being investigated as fuels for space power supplies. Included in this group are the fuel cells, which promise fantastic conversion efficiencies because they are not heat engines and do not have to go through the Carnot cycle, and some dandy, tiny reciprocating engines burning oxygen and hydrogen at high efficiencies.

Details of these space power supplies cannot be given in this paper, as they are a complete study in themselves. Suffice to say here that they are all being studied, most are being built, and many will be tested in near and deep space during this decade. ■

■ ■ ■

« *Continued from page 82* »

Marghem found it a relief to be able to talk about something other than the robot question for a change. Maybe he oughtn't to have been so dogmatic about keeping Ira away. He sighed and repressed temptation.

"Oh, wonderfully. Courtship customs, for instance. I'm in the best possible place to observe those, because I'm being courted wholesale. But not just that. This big party tomorrow, for example—it's just like a peasant party in Central Europe, like a christening or wedding feast, crossed with a celebration in the old days in the steel communities of America. There's a tremendously strong substructure of folk tradition binding these people together, which even bringing them off Earth hasn't weakened. In fact, it's strengthened by their having left home, because it's what they most rely on to keep their communal identity."

She hesitated. "By the way, I think the answer to this problem of Joe and the other robots—"

Colville looked at the ceiling, as if to say, *What in the name of all that's holy can* she *know about it?* Marghem ignored him.

"Go on," he encouraged Ira. After all, he and Colville had drained themselves of ideas. Anything, no matter how wild, was better than nothing.

"Well, I mentioned that folklore contains many legends of mechanical men. One of them—"

Under the dome everything was as festive as it could possibly be on New Earth, in Eisenberg. All the families in town had turned out their store of rags and scraps, hoarded as such things had always been hoarded, and chosen the most colorful odds and ends to make into flags and streamers. Red, yellow, blue, green, they looped in festoons above the tables, some of which were groaning under the weight of the carefully prepared delicacies because they were ordinary tables people had brought from home, others of which couldn't because they were lengths of rail or even unfinished billets brought from the mills where they were awaiting shipment.

Barrels of beer and tanks of prunejack were racked around the wall of the dome behind the tables. Through amplifiers at the highest point of the dome poured music from tapes that had been made at home on Earth—a kind of last souvenir before departure. The music was wild and gypsylike. In the center of the floor the young people were dancing equally wildly, shrieking with laughter and sometimes yelling the words of the songs which came over the amplifier.

In a place of honor facing the dance floor sat Nagy, looming tremendously over his little wife, who blushed like a girl every time one of the dancers paused in passing to cry congratulations and thanks for the party. On the other side of her husband from her, Ira Bell sat—and indeed Nagy seemed as proud of hav-

ing her there—as though she were his daughter. She wore a very old but magnificently preserved traditional dress which belonged to Mrs. Nagy, elaborately embroidered, with a short stiff skirt standing out above white stockings and black boots.

Marghem, sitting with Colville and Wallmeyer on the other side of the Nagys, saw young man after young man come up and bow formally to ask Nagy's permission to dance with Ira. One in particular kept coming back time and time again: Paul Horkey was the name, Marghem knew. He was probably very much as Nagy himself had been twenty-odd years ago, very strong, very handsome—in himself, he was one of the reasons why the surplus of bachelors was as big as it was, for most of the unmarried girls were turning down their suitors in the hope that they might be the lucky one who secured Paul Horkey.

Paul Horkey had a rival, though. A little anxiously Marghem watched to see whether this rival—what was the name? Ah, yes—whether this Steve Masaryk was otherwise occupied. He was, dancing with one of the local girls. Fair enough.

Marghem relaxed and turned to Wallmeyer, whose face was as long as a comet's tail. He jabbed him in the ribs.

"Say, aren't you enjoying the party?"

"How can I?" mourned Wallmeyer. "Here they are having themselves a ball, and they don't care that I'm stuck here when I'd rather be back home, they don't care that my robots are lying useless or sitting around waiting to break down—"

A thought struck Marghem. "Have you checked Joe again today? You said he was all right yesterday, in spite of what you were afraid Ira might have done to him."

"Oh, she didn't do him any harm. In fact, he seems in quite good shape, better than I'd have expected after such a long time not working. I wish I could turn him off, but then I'd have to go back to the capital and spend a week at least overhauling him—it's like the shock of concussion, you see."

Colville tapped Marghem's arm. "Say, look!" he said under his breath.

It had finally happened. Paul Horkey and his chief rival Steve Masaryk had arrived at the same time to ask Ira to dance. Laughing, Ira agreed to partner Paul Horkey.

Marghem got up and began to work his way towards the dais.

Presumably Steve was objecting on the ground that Ira had already danced several times with Paul and not with him. Presumably Ira was taking no notice. For by the time Marghem came close they were on the verge of blows.

Everyone stopped dancing. A fight was better than a dance any day.

"Hold it!" barked Marghem into a moment of silence. He apologized to Nagy, who grinned, being plainly full of prunejack and goodwill towards the world.

"Let's settle this the proper way!" Marghem went on. "Instead of fighting about it, let's decide who's the stronger of you two." He looked Paul and Steve up and down, and had to repress a pang of envy, because they were certainly both very muscular and very good-looking. He felt like a dwarf between them.

"Ira?" he demanded, turning to her. "What do you say?"

"Right!" she said, clapping her hands and looking properly pleased that there was to be a contest with her as the prize. "Well, that's easy. There are all sizes of heavy things to lift around here—all these billets of steel! Let's see who can lift the biggest one, and I'll dance with him the rest of the evening. Is that fair?"

By now most of the people in the dome had crowded round. They gave a roar of approval, and that left little choice for Paul and Steve, though Marghem knew from their expressions that neither of them was sure of the outcome. He appointed himself a sort of referee, getting husky men to stagger into the middle of the dome with billets of graduated sizes from about two hundred pounds on up to one which probably weighed the best part of half a ton, New Earth gravity.

Everyone settled down to watch. In a tense silence Steve Masaryk approached the row of billets. Scornfully he passed by the first and smallest, and bent over the next. Taking a careful purchase he braced himself to heave.

Marghem was probably the only person under the dome who saw a movement by the entrance.

Steve straightened, and the steel billet came easily off the ground. There was a bellow of applause.

Equally scornful, Paul now marched forward and took the billet next beyond the one his rival had chosen. Everyone was tense and doubtful. He bent, braced himself, *heaved*—and the billet came away from the ground.

"Magarac!" shouted Ira in her clear, piercing voice. At once there was a new storm of cheers, louder than before. And it began to die instantly.

Slowly people turned away from the contestants to stare at the entrance. There was a movement among the crowd there. People were falling back to let someone pass. Their faces were tautening with anger.

Wallmeyer hadn't moved to go and watch the contest; he was too miserable. But just in case, Colville had stayed at his side to hold him down, because he was going to realize any moment what was happening. And he wasn't going to like it.

For the "someone" coming from the entrance was Joe, the robot.

In an impossible-seeming silence he strode stolidly past Ira, past Paul and Steve and Marghem, and came to the last and biggest of the steel billets. He bent over it. There was a slam and a click of metal on metal as he activated the magnets in his "hands" and placed them on the bil-

let. Then he lifted it up, as easily as a sack of feathers.

"I heard somebody call my name," he said in his pleasant booming voice. "Joe Magarac, that's me!"

For a long instant Nagy stared. Suddenly he whooped with incredulous laughter and slapped his hand on his thigh with a sound like a gunshot. As though that was their cue, everyone in the dome began to laugh and laugh and laugh.

"What's going on?" demanded Wallmeyer. He started to his feet. "Is that my robot there? They'll bust him to scrap! What the—?"

"Hold it, take it easy," said Colville, grasping him by the collar. "We just fixed things about your robots, that's all. There won't be any more trouble, and you'll be able to go home."

Wallmeyer gave him an unbelieving stare.

"Listen to 'em laughing!" said Colville happily. "Think they're going to bust Joe up when they're laughing like that?"

But what happened?" pleaded Wallmeyer, staring across the desk at Marghem.

"Better let Ira tell you. It was her idea," the mayor said.

"You'll give me a swollen head," Ira answered. Once again in her ordinary everyday clothes, she didn't look in the least like a girl who would incite men to quarrel over her. "It's very simple. You see, the reason why people here call each other *magarac*—jackass—and mean it as a compliment is because Joe Magarac is the name of a legendary man of steel, who was born inside a mountain and came down in an ore-car to Hunkietown where he won a weight-lifting contest for the hand of a pretty girl but turned her down because he said he had no time to do anything but work and eat. Then he went to work in a steel mill and pretty soon he'd turned out so much steel by working night and day that they had to close down production. Without work to do, he was lost. So he jumped in with the steel in his furnace and was melted down, and the steel they poured with him mixed up in it was the finest steel that was ever seen, and the mill they built with that steel was the finest in the world."

"So we staged a sort of . . . uh . . . show for the people," said Marghem contentedly. "It was very lucky we'd already decided to nickname him Joe. It didn't take long to explain to him why he had to call himself Joe Magarac. Believe me, Wallmeyer, if all your robots are as intelligent as Joe turned out to be you won't be here much longer."

"I've already sent word that they can bring the others out here at once," Colville put in. "A 'copter will get in with the first three at about noon today."

"But the *risk* you took!" said Wallmeyer prayerfully. "In view of their attitude, they might have smashed Joe to bits!"

"Risk?" countered Marghem. "When the alternative was to leave Joe and his thirty-nine brothers lying about useless?"

Ira coughed gently. "No risk at all," she said. "At least I don't think there was a risk. You see, these legends and traditions and old customs —including the tale of Joe Magarac —are the things people rely on to support them while they're finding their feet in new surroundings. They come to believe them implicitly. Oh, it's not a case of admitting to believing them—just that no one ever dares to cast doubt on them. So when Joe Magarac in person, steel from top to toe and stronger than any two men in the place, turned up, they had no alternative to accepting him."

She got up, smiling at them in turn. "Well, if you'll excuse me . . . Paul Horkey is coming to noon chow with us at the Nagys' place. And I want to apologize for getting him into a row with Steve."

When she had gone, Wallmeyer got to his feet. Staring out of the window, he said, "*Light-years* from Earth! Intelligent robots the crowning achievement of centuries of technology! And it takes a legend—a damnfool legend who knows how many hundred years old—to unsnarl things for us! I'll take robots over people *any* day of the year."

He looked positively hurt when Marghem and Colville burst out laughing. ■

Mirror, Mirror on the Wall . . ."

Want a look at yourselves? As seen, that is, in a peculiar kind of a mirror —the Statistical Mirror?

The full analysis of the data we gathered in the recent reader questionnaire has been worked up statistically, and put out in the form of a genuine, Madison Avenue type advertising promotion booklet—some of which are left over.

The number is limited, but for those of you who want to meet yourselves—these oh-so-suave presentation folios can be gotten by writing in to the Editorial office, sending 50¢ (that's a surplus price; they cost us more than that!) while they last.

Very briefly—you're 92% male, about 33 years old, 38% graduate-degree equipped, and 68% married, and have a family income of about $9,500.

In general—you look pretty healthy and successful!

Details in the above-mentioned booklet.

The Editor.

EPILOGUE

"AND SO EVERY LIVING THING ON EARTH WAS WIPED OUT. AND THEN ..." BUT—WHAT COMES NEXT? WHAT WOULD HAPPEN AFTER EVERYTHING WAS WIPED OUT?

POUL ANDERSON

I

■ His name was a set of radio pulses. Converted into equivalent sound waves, it would have been an ugly squawk; so because he, like any consciousness, was the center of his own co-ordinate system, let him be called Zero.

He was out hunting that day. Energy reserves were low in the cave. That other who may be called One—being the most important dweller in Zero's universe—had not complained. But there was no need to. He also felt a dwindling potential. Accumulators grew abundantly in their neighborhood, but an undue amount of such cells must be processed to recharge One while she was creating. Motiles had more concentrated energy. And, of course, they were more highly organized. Entire parts could be taken from the body of a motile, needing little or no reshaping for One to use. Zero himself, though the demands on his functioning were much less, wanted a more easily assimilated charge than the accumulators provided.

In short, they both needed a change of diet.

Game did not come near the cave any more. The past hundred years had taught that it was unsafe. Eventually, Zero knew, he would have to move. But the thought of helping One through mile upon mile, steep, overgrown, and dangerous, made him delay. Surely he could still find large motiles within a few days' radius of his present home. With One's help he fastened a carrier rack on his shoulders, took weapons in hand, and set forth.

That was near sunset. The sky was still light when he came on spoor: broken earth-crystals not yet healed, slabs cut from several boles, a trace of lubricant. Tuning his receptors to the highest sensitivity, he checked all the bands commonly made noisy by motiles. He caught a low-amplitude conversation between two persons a hundred miles distant, borne this far by some freak of atmospherics; closer by he sensed the impulses of small scuttering things, not worth chasing; a flier jetted overhead and filled his perception briefly with static. But no vibration of the big one. It must have passed this way days ago and now be out of receptorshot.

Well, he could follow the trail, and catch up with the clumsy sawyer in time. It was undoubtedly a sawyer—he knew these signs—and therefore worth a protracted hunt. He ran a quick check on himself. Every part seemed in good order. He set into motion, a long stride which must eventually overhaul anything on treads.

Twilight ended. A nearly full moon rose over the hills like a tiny cold lens. Night vapors glowed in masses and streamers against a purple-black sky where stars glittered in the optical spectrum and which hummed and sang in the radio range. The forest sheened with alloy, flashed with icy speckles of silicate. A wind blew through the radiation absorber plates overhead, setting them to ringing against each other; a burrower whirred, a grubber crunched through lacy crystals, a river brawled chill and loud down a ravine toward the valley below.

As he proceeded, weaving among trunks and girders and jointed rods with the ease of long practice, Zero paid most attention to his radio receptors. There was something strange in the upper communication frequencies tonight, an occasional brief note . . . set of notes, voice, drone, like nothing he had heard before or heard tell of . . . But the world was a mystery. No one had been past the ocean to the west or the mountains to the east. Finally Zero stopped listening and concentrated on tracking his prey. That was difficult, with his optical sensors largely nullified by the darkness, and he moved slowly. Once he tapped lubricant from a cylinder growth and once he thinned his acids with a drink of water. Several times he felt polarization in his energy cells and stopped for a while to let it clear away: he rested.

Dawn paled the sky over distant snowpeaks, and gradually turned red. Vapors rolled up the slopes from the valley, tasting of damp and sulfide. Zero could see the trail again, and began to move eagerly.

Then the strangeness returned—louder.

Zero slid to a crouch. His lattice swiveled upward. Yes, the pulses did come from above. They continued to strengthen. Soon he could identify them as akin to the radio noise associated with the functioning of a motile. But they did not sense like any type he knew. And there was something else, a harsh flickering overtone, as if he also caught leakage from the edge of a modulated short-wave beam—

The sound struck him.

At first it was the thinnest of whistles, high and cold above the dawn clouds. But within seconds it grew to a roar that shook the earth, reverberated from the mountains, and belled absorber plates until the whole forest rang. Zero's head became an echo chamber; the racket seemed to slam his brain from side to side. He turned dazzled, horrified sensors heavenward. And he saw the thing descending.

For a moment, crazily, he thought it was a flier. It had the long spindle-shaped body and the air fins. But no flier had ever come down on a tail of multi-colored flame. No flier blocked off such a monstrous portion of sky. When the thing must be two miles away!

He felt the destruction as it landed, shattered frames, melted earth-crystals, a little burrower crushed in its den, like a wave of anguish through the forest. He hurled himself flat on the ground and hung on to sanity with all four hands. The silence which followed, when the monster had settled in place, was like a final thunderclap.

Slowly Zero raised his head. His perceptions cleared. An arc of sun peered over the sierra. It was somehow outrageous that the sun should

rise as if nothing had happened. The forest remained still, hardly so much as a radio hum to be sensed. The last echoes flew fading between the hills.

A measure of resolution: this was no time to be careful of his own existence. Zero poured full current into his transmitter. *"Alarm, alarm! All persons receiving, prepare to relay. Alarm!"*

Forty miles thence, the person who may as well be called Two answered, increasing output intensity the whole time: "Is that you, Zero? I noticed something peculiar in the direction of your establishment. What is the matter?"

Zero did not reply at once. Others were coming in, a surge of voices in his head, from mountaintops and hills and lowlands, huts and tents and caves, hunters, miners, growers, searakers, quarriers, toolmakers, suddenly become a unity. But he was flashing at his own home: "Stay inside, One. Conserve energy. I am unharmed, I will be cautious, keep hidden and stand by for my return."

"Silence!" called a stridency which all recognized as coming from Hundred. He was the oldest of them, he had probably gone through a total of half a dozen bodies. Irreversible polarization had slowed his thinking a little, taken the edge off, but the wisdom of his age remained and he presided over their councils. "Zero, report what you have observed."

The hunter hesitated. "That is not easy. I am at—" He described the location. ("Ah, yes," murmured Fifty-six, "near that large galena lick.") "The thing somewhat resembles a flier, but enormous, a hundred feet long or more. It came down about two miles north of here on an incandescent jet and is now quiet. I thought I overheard a beamed signal. If so, the cry was like nothing any motile ever made."

"In these parts," Hundred added shrewdly. "But the thing must have come from far away. Does it look dangerous?"

"Its jet is destructive," Zero said, "but nothing that size, with such relatively narrow fins, could glide about. Which makes me doubt it is a predator."

"Lure accumulators," said Eight.

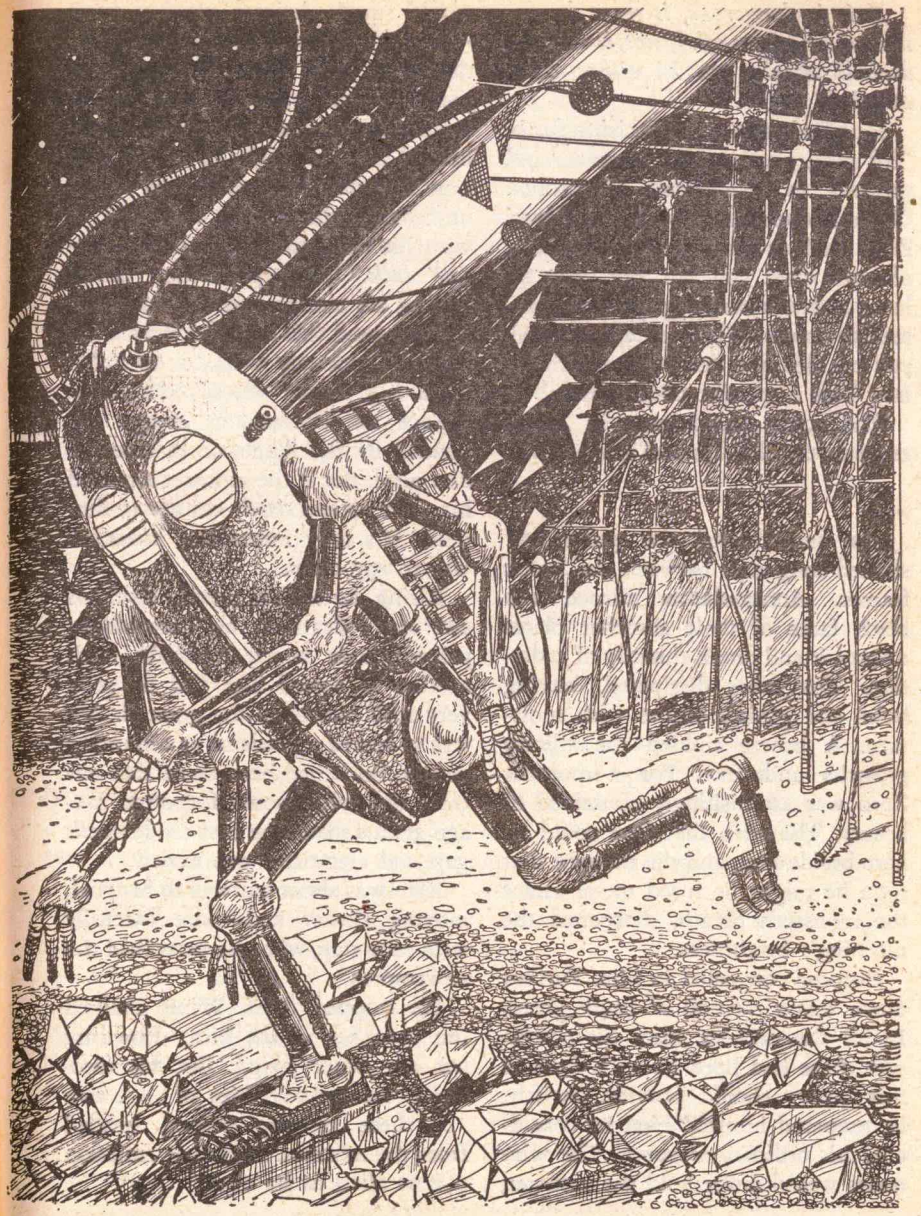
"Eh? What about them?" asked Hundred.

"Well, if lure accumulators can emit signals powerful enough to take control of any small motile which comes near and make it enter their grinders, perhaps this thing has a similar ability. Then, judging from its size, its lure must have tremendous range and close up could overpower large motiles. Including even persons?"

Something like a shiver moved along the communication band.

"It is probably just a grazer," said Three. "If so—" His overt signal trailed off, but the thought continued in all their partly linked minds: *A motile that big! Megawatt-hours in its energy cells. Hundreds or thousands of usable parts. Tons of metal. Hundred, did your great-grandcreator recall any such game, fabulous millennia ago?*

ILLUSTRATED BY MOREY



No.

If it is dangerous, it must be destroyed or driven off. If not, it must be divided among us. In either case: attacked!

Hundred rapped the decision forth. "All male persons take weapons and proceed to rendezvous at Broken Glade above the Coppertaste River. Zero, stalk as close as seems feasible, observe what you can, but keep silence unless something quite unforeseeable occurs. When we are gathered, you can describe details on which we may base a specific plan. Hasten!"

The voices toned away in Zero's receptor circuits. He was alone again.

The sun cleared the peaks and slanted long rays between the forest frames. Accumulators turned the black faces of their absorber plates toward it and drank thirstily of radiation. The mists dissipated, leaving boles and girders ashine with moisture. A breeze tinkled the silicate growths underfoot. For a moment Zero was astonishingly conscious of beauty. The wish that One could be here beside him, and the thought that soon he might be fused metal under the monster's breath, sharpened the morning's brightness.

Purpose congealed in him. Further down was a turmoil of frank greed. In all the decades since his activation there had been no such feast as this quarry should provide. Swiftly, he prepared himself. First he considered his ordinary weapons. The wire noose would never hold the monster, nor did he think the iron hammer would smash delicate moving parts —it did not seem to have any—or the steel bolts from his crossbow pierce a thin plate to short out a crucial circuit. But the clawed, spear-headed pry bar might be of use. He kept it in one hand while two others unfastened the fourth and laid it with his extra armament in the carrier rack. Thereupon they deftly hooked his cutting torch in its place. No one used this artificial device except for necessary work, or to finish off a big motile whose cells could replace the tremendous energy expended by the flame, or in cases of dire need. But if the monster attacked him, that would surely constitute dire need. His only immediate intention was to spy on it.

Rising, he stalked among shadows and sun reflections, his camouflage-painted body nearly invisible. Such motiles as sensed him fled or grew very still. Not even the great slasher was as feared a predator as a hunting person. So it had been since that ancient day when some forgotten savage genius made the first crude spark gap and electricity was tamed.

Zero was about halfway to his goal, moving slower and more carefully with each step, when he perceived the newcomers.

He stopped dead. Wind clanked the branches above him, drowning out any other sound. But his electronic sensors told him of . . . two . . . three moving shapes, headed from the monster. And their emission was as alien as its own.

In a different way. Zero stood for a long time straining to sense and to understand what he sensed. The energy output of the three was small, hardly detectable even this close; a burrower or skitterer used more power to move itself. The output felt peculiar, too, not really like a motile's: too simple, as if a mere one or two circuits oscillated. Flat, cold, activityless. But the signal output, on the other hand—it *must* be signal, that radio chatter—why, that was a shout. The things made such an uproar that receptors tuned at minimum could pick them up five miles away. As if they did not know about game, predators, enemies.

Or as if they did not care.

A while more Zero paused. The eeriness of this advent sent a tingle through him. It might be said he was gathering courage. In the end he gripped his pry bar more tightly and struck off after the three.

They were soon plain to his optical and radar senses among the tall growths. He went stock-still behind a frame and watched. Amazement shocked his very mind into silence. He had assumed, from their energy level, that the things were small. But they stood more than half as big as he did! And yet each of them had only one motor, operating at a level barely sufficient to move a person's arm. That could not be their power source. But what was?

Thought returned to him. He studied their outlandishness in some detail. They were shaped not altogether unlike himself, though two-armed, hunchbacked, and featureless. Totally unlike the monster, but unquestionably associated with it. No doubt it had sent them forth as spy eyes, like those employed by a boxroller. Certain persons had been trying for the last century or so to develop, from domesticated motiles, similar assistants for hunting persons. Yes, a thing as big and awkward as the monster might well need auxiliaries.

Was the monster then indeed a predator? Or even—the idea went like a lightning flash through Zero's entire circuitry—a thinker? Like a person? He struggled to make sense of the modulated signals between the three bipeds. No, he could not. But—

Wait!

Zero's lattice swung frantically back and forth. He could not shake off the truth. That last signal had come from the monster, hidden by a mile of forest. From the monster to the bipeds. And were they answering?

The bipeds were headed south. At the rate they were going, they might easily come upon traces of habitation, and follow those traces to the cave where One was, long before Hundred's males had gathered at Broken Glade.

The monster would know about One.

Decision came. Zero opened his transmitter to full output, but broadcast rather than beamed in any degree. He would give no clue where those were whom he called. "*Attention, attention!* Tune in on me: di-

rect sensory linkage. I am about to attempt capture of these motiles."

Hundred looked through his optics, listened with his receptors, and exclaimed, "No, wait, you must not betray our existence before we are ready to act."

"The monster will soon learn of our existence in any event," Zero answered. "The forest is full of old campsites, broken tools, traps, chipped stones, slagheaps. At present I should have the advantage of surprise. If I fail and am destroyed, that ought still to provide you with considerable data. Stand alert!"

He plunged from behind the girders.

The three had gone past. They sensed him and spun about. He heard a jagged modulation of their signal output. A reply barked back, lower in frequency, the voice of the monster? There was no time to wonder about that. Slow and clumsy though they were, the bipeds had gotten into motion. The central one snatched a tube slung across its back. Pounding toward them, through shattering crystals and clangorous branches, Zero thought, *I have not yet made any overtly hostile move, but*— The tube flashed and roared.

An impact sent Zero staggering aside. He went to one knee. Ripped circuits overwhelmed him with destruction signals. As the pain throbbed toward extinction, his head cleared enough to see that half his upper left arm was blown off.

The tube was held steady on him. He rose. The knowledge of his danger flared in him. A second biped had its arms around the third, which was tugging a smaller object from a sheath.

Zero discharged full power through his effectors. Blurred to view by speed, he flung himself to one side while his remaining left hand threw the pry bar. It went meteorlike across a shaft of sunlight and struck the tube. The tube was pulled from the biped's grasp, slammed to the ground and buckled.

Instantly Zero was upon the three of them. He had already identified their communication system, a transmitter and antenna actually outside the skin! His one right hand smashed across a biped's back, tearing the radio set loose. His torch spat with precision. Fused, the communicator of a second biped went dead.

The third one tried to escape. Zero caught it in four strides, plucked off its antenna, and carried it wildly kicking under one arm while he chased the other two. When he had caught the second, the first stood its ground and battered forlornly at him with its hands. He lashed them all together with his wire rope As a precaution, he emptied the carrier rack of the one which had shot him. Those thin objects might be dangerous even with the tube that had launched them broken. He stuffed the bipeds into his own carrier.

For a moment, then, he lingered. The forest held little sonic noise except the wind in the accumulators. But the radio spectrum clamored. The monster howled; Zero's own

broadcast rolled between sky and mountainside, from person to person and so relayed across the land.

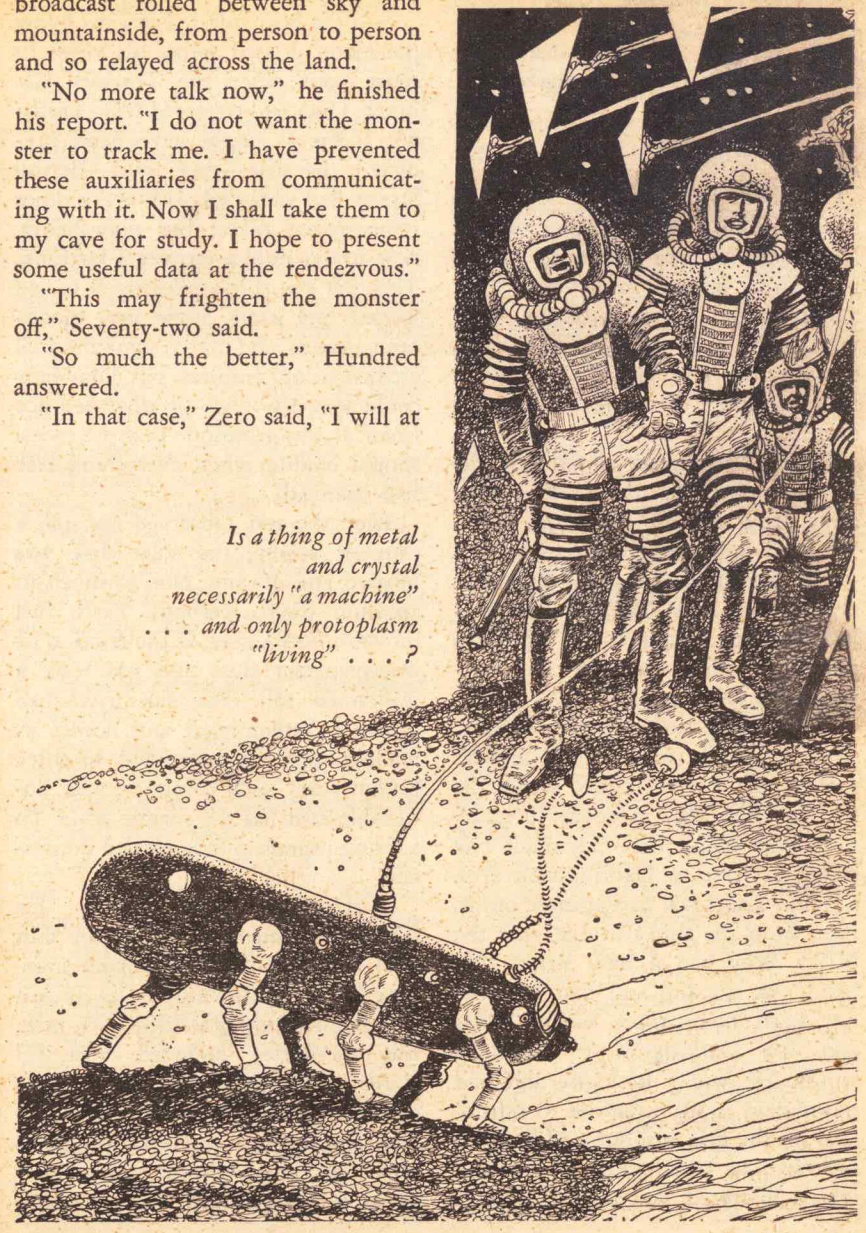
"No more talk now," he finished his report. "I do not want the monster to track me. I have prevented these auxiliaries from communicating with it. Now I shall take them to my cave for study. I hope to present some useful data at the rendezvous."

"This may frighten the monster off," Seventy-two said.

"So much the better," Hundred answered.

"In that case," Zero said, "I will at

Is a thing of metal
and crystal
necessarily "a machine"
. . . and only protoplasm
"living" . . . ?



least have brought back something from my hunt."

He snapped off his transmission and faded into the forest shadows.

II

The boat had departed from the spaceship on a mere whisper of jets. Machinery inboard hummed, clicked, murmured, sucked in exhausted air and blew out renewed, busied itself with matters of warmth and light, computation and propulsion. But it made no more than a foundation for silence.

Hugh Darkington stared out the forward port. As the boat curved away from the mother ship's orbit, the great hull gleamed across his sky —fell astern and rapidly dwindled until lost to view. The stars which it had hidden sprang forth, icy-sharp points of glitter against an overwhelming blackness.

They didn't seem different to him. They were, of course. From Earth's surface the constellations would be wholly alien. But in space so many stars were visible that they made one chaos, at least to Darkington's eyes. Captain Thurshaw had pointed out to him, from the ship's bridge, that the Milky Way had a new shape, this bend was missing and that bay had not been there three billion years ago. To Darkington it remained words. He was a biologist and had never paid much attention to astronomy. In the first numbness of loss and isolation, he could think of nothing which mattered less than the exact form of the Milky Way.

Still the boat spiraled inward. Now the moon drifted across his view. In those eons since the *Traveler* left home, Luna had retreated from Earth: not as far as might have been predicted, because—they said—Bering Straits had vanished with every other remembered place; but nonetheless, now it was only a tarnished farthing. Through the ship's telescopes it had looked like itself. Some new mountains, craters, and maria, some thermal erosion of old features, but Thurshaw could identify much of what he once knew. It was grotesque that the moon should endure when everything else had changed.

Even the sun. Observed through a dimmer screen, the solar disk was bloated and glaring. Not so much in absolute terms, perhaps. Earth had moved a little closer, as the friction of interplanetary dust and gas took a millennial toll. The sun itself had grown a little bigger and hotter, as nuclear reactions intensified. In three billion years, such things became noticeable even on the cosmic scale. To a living organism they totaled doomsday.

Darkington cursed under his breath and clenched a fist till the skin stretched taut. He was a thin man, long-faced, sharp-featured, his brown hair prematurely sprinkled with gray. His memories included beautiful spires above an Oxford quad, wonder seen through a microscope, a sailboat beating into the wind off Nantucket, which blew spray and a sound of gulls and church bells at him,

comradeship bent over a chessboard or hoisting beer steins, forests hazy and ablaze with Indian summer: and all these things were dead. The shock had worn off, the hundred men and women aboard the *Traveler* could function again, but home had been amputated from their lives and the stump hurt.

Frederika Ruys laid her own hand on his and squeezed a little. Muscle by muscle he untensed himself, until he could twitch a smile in response to hers. "After all," she said, "we knew we'd be gone a long time. That we might well never come back."

"But we'd have been on a living planet," he mumbled.

"So we can still find us one," declared Sam Kuroki from his seat at the pilot console. "There're no less than six G-type stars within fifty light-years."

"It won't be the same," Darkington protested.

"No," said Frederika. "In a way, though, won't it be more? We, the last humans in the universe, starting the race over again?"

There was no coyness in her manner. She wasn't much to look at, plump, plain, with straight yellow hair and too wide a mouth. But such details had ceased to matter since the ship ended time acceleration. Frederika Ruys was a brave soul and a skilled engineer. Darkington felt incredibly lucky that she had picked him.

"Maybe we aren't the last, anyhow," Kuroki said. His flat features broke in one of his frequent grins; he faced immensity with a sparrow's cockiness. "Ought to've been other colonies than ours planted, oughtn't there? Of course, by now their descendants 'ud be bald-headed dwarfs who sit around thinking in calculus."

"I doubt that," Darkington sighed. "If humans had survived, anywhere else in the galaxy, don't you think they would at least have come back and . . . and reseeded this with life? The mother planet?" He drew a shaken breath. They had threshed this out a hundred times or more while the *Traveler* orbited about unrecognizable Earth, but they could not keep from saying the obvious again and again, as a man must keep touching a wound on his body. "No, I think the war really did begin soon after we left. The world situation was all set to explode."

That was why the *Traveler* had been built, and even more why it had departed in such haste, his mind went on. Fifty couples scrambling off to settle on Tau Ceti II before the missiles were unleashed. Oh, yes, officially they were a scientific team, and one of the big foundations had paid for the enterprise. But in fact, as everyone knew, the hope was to insure that a fragment of civilization would be saved, and some day return to help rebuild. (Even Panasia admitted that a total war would throw history back a hundred years; western governments were less optimistic.) Tension had mounted so horribly fast in the final months that no time was taken

for a really careful check of the field drive. So new and little understood an engine ought to have had scores of test flights before starting out under full power. But . . . well . . . next year might be too late. And exploratory ships *had* visited the nearer stars, moving just under the speed of light, their crews experiencing only a few weeks of transit time. Why not the *Traveler?*

"The absolute war?" Frederika said, as she had done so often already. "Fought until the whole world was sterile? No. I won't believe it."

"Not in that simple and clean-cut a way," Darkington conceded. "Probably the war did end with a nominal victor; but he was more decimated and devastated than anyone had dared expect. Too impoverished to reconstruct, or even to maintain what little physical plant survived. A downward spiral into the Dark Ages."

"H-m-m, I dunno," Kuroki argued. "There were a lot of machines around. Automation, especially. Like those self-reproducing, sun-powered, mineral-collecting sea rafts. And a lot of other self-maintaining gadgets. I don't see why industry couldn't be revived on such a base."

"Radioactivity would have been everywhere," Darkington pointed out. "It's long-range effect on ecology—Oh, yes, the process may have taken centuries, as first one species changed or died, and then another dependent on it, and then more. But how could the human survivors recreate technology when biology was disintegrating around them?" He shook himself and stiffened his back, ashamed of his self-pity a minute ago, looking horror flatly in the face. "That's my guess. I could be wrong, but it seems to fit the facts. We'll never know for certain, I suppose."

Earth rolled into sight. The planetary disk was still edged with blueness darkening toward black. Clouds still trailed fleecy above shining oceans; they gleamed upon the darkness near the terminator as they caught the first light before sunrise. Earth was forever fair.

But the continental shapes were new, speckled with hard points of reflection upon black and ocher where once they had been softly green and brown. There were no polar caps; sea level temperatures ranged from eighty to two hundred degrees Fahrenheit. No free oxygen remained: the atmosphere was nitrogen, its oxides, ammonia, hydrogen sulfide, sulfur dioxide, carbon dioxide, and steam. Spectroscopes had found no trace of chlorophyl or any other complex organic compound. The ground cover, dimly glimpsed through clouds, was metallic.

This was no longer Earth. There was no good reason why the *Traveler* should send a boat and three highly unexpendable humans down to look at its lifelessness. But no one had suggested leaving the Solar System without such a final visit. Darkington remembered being taken to see his grandmother when she was dead. He was twelve years old and had loved her. It was not her in the box, that strange unmeaningful mask, but

where then was she?

"Well, whatever happened seems to be three billion years in the past," Kuroki said, a little too loudly. "Forget it. We got troubles of our own."

Frederika's eyes had not left the planet. "We can't ever forget, Sam," she said. "We'll always wonder and hope—they, the children at least—that it didn't happen to them too cruelly." Darkington started in surprise as she went on murmuring, very low, oblivious of the men:

"to tell you of the ending of the day.
And you will see her tallness with surprise,
and looking into gentle, shadowed eyes
protest: it's not that late; you have to stay
awake a minute more, just one, to play
with yonder ball. But nonetheless you rise
so they won't hear her say, 'A baby cries,
but you are big. Put all your toys away.'

"She lets you have a shabby bear in bed,
though frankly doubting that you two can go
through dream-shared living rooms or wingless flight.
She tucks the blankets close beneath your head
and smooths your hair and kisses you, and so
goes out, turns off the light. 'Good night, Sleep tight.'"

Kuroki glanced around at her. The plaid shirt wrinkled across his wide shoulders. "Pomes yet," he said. "Who wrote that?"

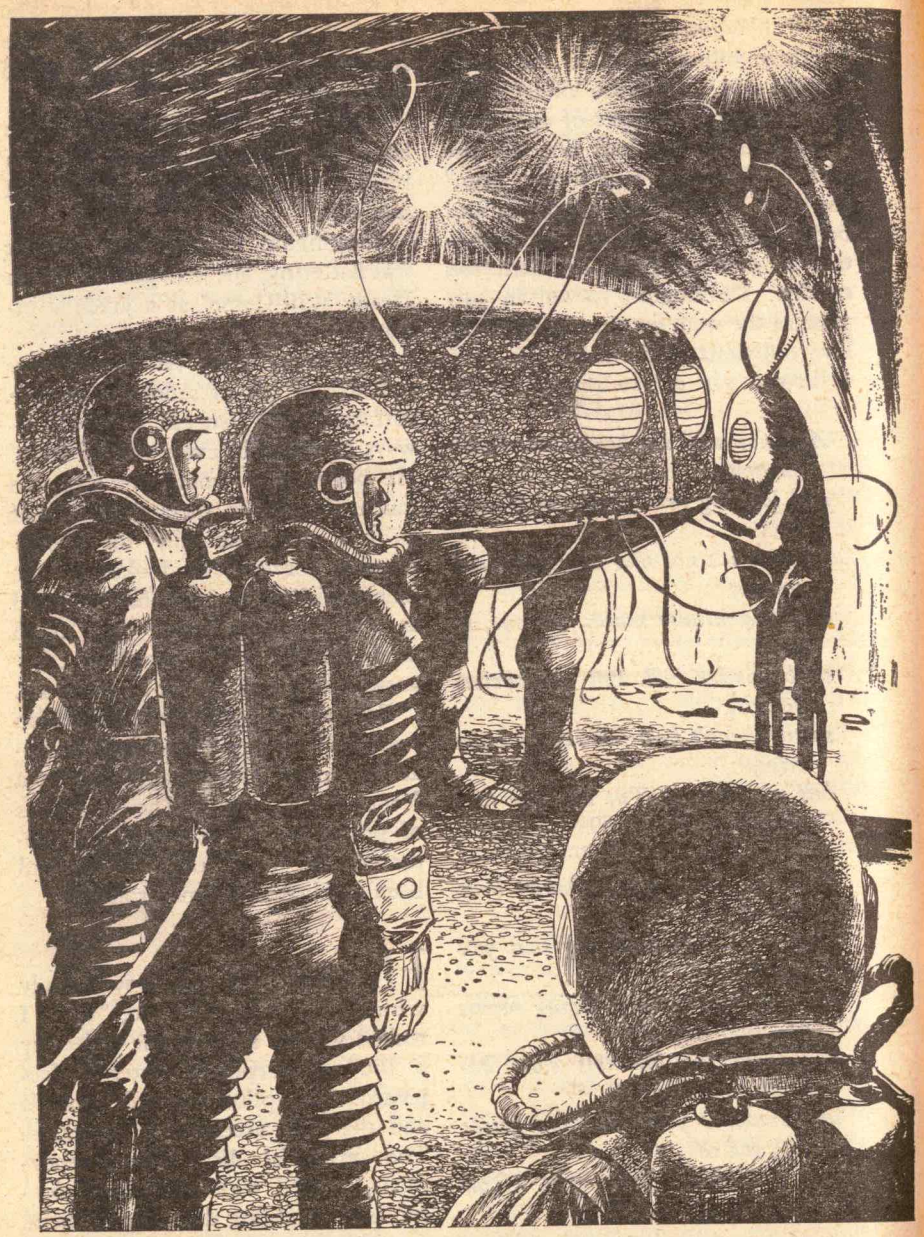
"Hugh," said Frederika. "Didn't you know he published poetry? Quite a bit. I admired his work long before I met him."

Darkington flushed. Her interest was flattering, but he regarded "Then Death Will Come" as a juvenile effort.

However, his embarrassment pulled him out of sadness. (On the surface. Down beneath, it would always be there, in every one of them. He hoped they would not pass too much of it on to their children. Let us not weep eternally for Zion.) Leaning forward, he looked at the planet with an interest that mounted as the approach curve took them around the globe. He hoped for a few answers to a hell of a lot of questions.

For one thing, why, in three billion years, had life not re-evolved? Radioactivity must have disappeared in a few centuries at most. The conditions of primordial Earth would have returned. Or would they? What had been lacking, this time around?

He woke from his brown study with a jerk as Kuroki said, "Well, I reckon we can steepen our trajectory a bit." A surprising interval had passed. The pilot touched controls and the mild acceleration increased. The terrestrial disk, already enormous, swelled with terrifying velocity, as if tumbling down upon them.



Then, subtly, it was no longer to one side or above, but was beneath; and it was no longer a thing among the stars but the convex floor of bowl-shaped creation. The jets blasted more strongly. Kuroki's jaws clenched till knots of muscle stood forth. His hands danced like a pianist's.

He was less the master of the boat, Darkington knew, than its helper. So many tons, coming down through atmospheric turbulence at such a velocity, groping with radar for a safe landing spot, could not be handled by organic brain and nerves. The boat's central director—essentially a computer whose input came from the instruments and whose efferent impulses went directly to the controls—performed the basic operations. Its task was fantastically complex: very nearly as difficult as the job of guiding the muscles when a man walks. Kuroki's fingers told the boat, "Go that way," but the director could overrule him.

Living things live not alone,
but only as part of a system
of interacting things
. . . and self-repair
need not be critical!

"I think we'll settle among those hills." The pilot had to shout now, as the jets blasted stronger. "Want to come down just east of the sunrise line, so we'll have a full day ahead of us, and yonder's the most promising spot in this region. The lowlands look too boggy."

Darkington nodded and glanced at Frederika. She smiled and made a thumbs-up sign. He leaned over, straining against his safety harness, and brushed his lips across hers. She colored with a pleasure that he found oddly moving.

Some day, on another planet—that possibly hadn't been born when they left Earth—

He had voiced his fears to her, that the engine would go awry again when they started into deep space, and once more propel them through time, uncontrollably until fuel was exhausted. A full charge in the tanks was equivalent to three billion years, plus or minus several million; or so the physicists aboard had estimated. In six billion A.D. might not the sun be so swollen as to engulf them when they emerged?

She had rapped him across the knuckles with her slide rule and said no, but you'll have to take my word for it because you haven't got the math. I've studied it as far as differential equations, he said. She grinned and answered that then he'd never had a math course. It seemed, she said, that time acceleration was readily explained by the same theory which underlay the field drive. In fact, the effect had been demonstrated in laboratory experiments. Oh, yes, I know about that, he said; reactive thrust is rotated through a fourth dimension and gets applied along the temporal rather than a spatial axis. You do not know a thing about it, she

said, as your own words have just proved. But never mind. What happened to us was that a faulty manifold generated the t-acceleration effect in our engine. Now we've torn everything down and rebuilt from scratch. We know it'll work right. The tanks are recharged. The ship's ecosystem is in good order. Any time we want, we can take off for a younger sun, and travel fifty light-years without growing more than a few months older. After which, seeing no one else was around, she sought his arms; and that was more comforting than her words.

A last good-bye to Grandmother Earth, he thought. *Then we can start the life over again that we got from her.*

The thrust upon him mounted. Toward the end he lay in his chair, now become a couch, and concentrated on breathing.

They reached ground.

Silence rang in their ears for a long while. Kuroki was the first to move. He unstrapped his short body and snapped his chair back upright. One hand unhooked the radio microphone, another punched buttons. "Boat calling *Traveler,*" he intoned. "We're O.K. so far. Come in, *Traveler.* Hello, hello."

Darkington freed himself, stiffly, his flesh athrob, and helped Frederika rise. She leaned on him a minute. "Earth," she said. Gulping: "Will you look out the port first, dearest? I find I'm not brave enough."

He realized with a shock that none of them had yet glanced at the landscape. Convulsively, he made the gesture.

He stood motionless for so long that finally she raised her head and stared for herself.

III

They did not realize the full strangeness before they donned spacesuits and went outside. Then, saying very little, they wandered about looking and feeling. Their brains were slow to develop the gestalts which would allow them really to see what surrounded them. A confused mass of detail could not be held in the memory, the underlying form could not be abstracted from raw sense impressions. A tree is a tree, anywhere and anywhen, no matter how intricate its branching or how oddly shaped its leaves and blossoms. But what is a—

—Thick shaft of gray metal, planted in the sand, central to a labyrinthine skeleton of straight and curved girders, between which run still more enigmatic structures embodying helices and toruses and Möbius strips and less familiar geometrical elements; the entire thing some fifty feet tall; flaunting at the top several hundred thin metal plates whose black sides are turned toward the sun?

When you have reached the point of being able to describe it even this crudely, then you *have* apprehended it.

Eventually Darkington saw that the basic structure was repeated, with infinite variation of size and shape, as far as he could see. Some specimens tall and slender, some low and broad, they dominated the hillside. The deeper reaches were made gloomy by their overhang, but sun speckles flew piercingly bright within those shadows as the wind shook the mirror faces of the plates. That same wind made a noise of clanking and clashing and far-off deep booming, mile after metal mile.

There was no soil, only sand, rusty red and yellow. But outside the circle which had been devastated by the boat's jets, Darkington found the earth carpeted with prismatic growths, a few inches high, seemingly rooted in the ground. He broke one off for closer examination and saw tiny crystals, endlessly repeated, in some transparent siliceous material: like snowflakes and spiderwebs of glass. It sparkled so brightly, making so many rainbows, that he couldn't well study the interior. He could barely make out at the center a dark clump of . . . wires, coils, transistors? *No,* he told himself, *don't be silly.* He gave it to Frederika, who exclaimed at its beauty.

He himself walked across an open stretch, hoping for a view even vaguely familiar. Where the hillside dropped too sharply to support anything but the crystals—they made it one dazzle of diamonds—he saw eroded contours, the remote white sword of a waterfall, strewn boulders and a few crags like worn-out obelisks. The land rolled away into blue distances; a snow-capped mountain range guarded the eastern horizon. The sky overhead was darker than in his day, faintly greenish blue, full of clouds. He couldn't look near the fierce big sun.

Kuroki joined him. "What d'you think, Hugh?" the pilot asked.

"I hardly dare say. You?"

"Hell, I can't think with that bloody boiler factory clattering at me." Kuroki grimaced behind his faceplate. "Turn off your sonic mike and let's talk by radio."

Darkington agreed. Without amplification, the noise reached him through his insulated helmet as a far-off tolling. "We can take it for granted," he said, "that none of this is accidental. No minerals could simply crystallize out like this."

"Don't look manufactured to me, though."

"Well," said Darkington, "You wouldn't expect them to turn out their products in anything like a human machine shop."

"Them?"

"Whoever . . . whatever . . . made this. For whatever purpose."

Kuroki whistled. "I was afraid you'd say something like that. But we didn't see a trace of—cities, roads, anything—from orbit. I know the cloudiness made seeing pretty bad, but we couldn't have missed the signs of a civilization able to produce stuff on this scale."

"Why not? If the civilization isn't remotely like anything we've ever imagined?"

Frederika approached, leaving a cartful of instruments behind. "The

low and medium frequency radio spectrum is crawling," she reported. "You never heard so many assorted hoots, buzzes, whirrs, squeals, and whines in your life."

"We picked up an occasional bit of radio racket while in orbit," Kuroki nodded. "Didn't think much about it, then."

"Just noise," Frederika said hastily. "Not varied enough to be any kind of . . . of communication. But I wonder what's doing it?"

"Oscillators," Darkington said. "Incidental radiation from a variety of . . . oh, hell, I'll speak plainly . . . machines."

"But—" Her hand stole toward his. Glove grasped glove. She wet her lips. "No, Hugh, this is absurd. How could anyone be capable of making . . . what we see . . . and not have detected us in orbit and . . . and done something about us?"

Darkington shrugged The gesture was lost in his armor. "Maybe they're biding their time. Maybe they aren't here at the moment. The whole planet could be an automated factory, you know. Like those ocean mineral harvesters we had in our time"—it hurt to say that—"which Sam mentioned on the way down. Somebody may come around periodically and collect the production."

"Where do they come from?" asked Kuroki in a rough tone.

"I don't know, I tell you. Let's stop making wild guesses and start gathering data."

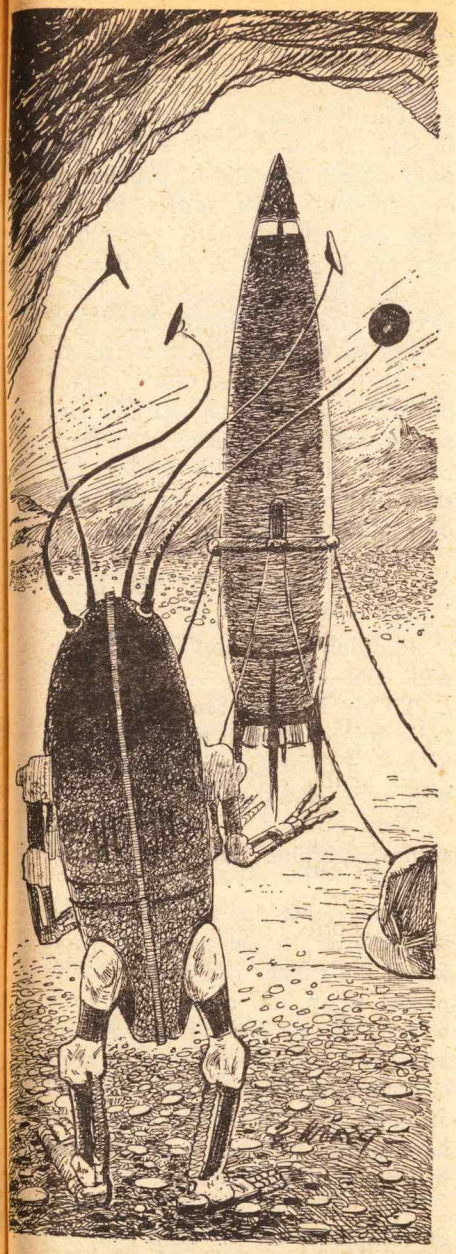
Silence grew between them. The skeleton towers belled. Finally Kuroki nodded. "Yeah. What say we take a little stroll? We may come on something."

Nobody mentioned fear. They dared not.

Re-entering the boat, they made the needful arrangements. The *Traveler* would be above the horizon for several hours yet. Captain Thurshaw gave his reluctant consent to an exploration on foot. The idea conflicted with his training, but what did survey doctrine mean under these conditions? The boat's director could keep a radio beam locked on the ship and thus relay communication between Earth and orbit. While Kuroki talked, Darkington and Frederika prepared supplies. Not much was needed. The capacitor pack in each suit held charge enough to power thermostat and air renewer for a hundred hours, and they only planned to be gone for three or four. They loaded two packboards with food, water, and the "buckets" used for such natural functions as eating, but that was only in case their return should be delayed. The assorted scientific instruments they took were more to the point. Darkington holstered a pistol. When he had finished talking, Kuroki put the long tube of a rocket gun and a rackful of shells on his own back. They closed their helmets anew and stepped out.

"Which way?" Frederika asked.

"Due south," Darkington said after studying the terrain. "We'll be following this long ridge, you see. Harder to get lost." There was little danger of that, with the boat emitting a continuous directional signal. Nonetheless they all had compasses on their wrists, and took note of landmarks as they went.



The boat was soon lost to view. They walked among surrealistic rods and frames and spirals, under ringing sheet metal. The crystals crunched beneath their tread and broke sunlight into hot shards of color. But not many rays pushed through the tangle overhead; shadows were dense and restless. Darkington began to recognize unrelated types of structure. They included long, black, seemingly telescopic rods, fringed with thin plates; glassy spheres attached to intricate grids; cables that looped from girder to girder. Frequently a collapsed object was seen crumbling on the ground.

Frederika looked at several disintegrated specimens, examined others in good shape, and said: "I'd guess the most important material, the commonest, is an aluminum alloy. Though . . . see here . . . these fine threads embedded in the core must be copper. And this here is probably manganese steel with a protective coating of . . . of . . . something more inert."

Darkington peered at the end of a broken strut through a magnifying glass. "Porous," he said. "Are these actually capillaries to transport water?"

"I thought a capillary was a hairy bug with lots of legs that turned into a butterfly," said Kuroki. He ducked

an imaginary fist. "O.K., O.K., somebody's got to keep up morale."

The boat's radio relayed a groan from the monitor aboard the ship. Frederika said patiently, "No, Sam, the legs don't turn into a butterfly—" but then she remembered there would never again be bravely colored small wings on Earth and banged a hand against her faceplate as if she had been about to knuckle her eyes.

Darkington was still absorbed in the specimen he held. "I never heard of a machine this finely constructed," he declared. "I thought nothing but a biological system could—"

"Stop! Freeze!"

Kuroki's voice rapped in their earphones. Darkington laid a hand on his pistol butt. Otherwise only his head moved, turning inside the helmet. After a moment he saw the thing, too.

It stirred among shadows, behind a squat cylinder topped with the usual black-and-mirror plates. Perhaps three feet long, six or eight inches high . . . It came out into plain view. Darkington glimpsed a slim body and six short legs of articulated dull metal. A latticework swiveled at the front end like a miniature radio-radar beamcaster. Something glinted beadily beneath, twin lenses? Two thin tentacles held a metal silver off one of the great stationary structures. They fed it into an orifice, and sparks shot back upward—

"Holy Moses," Kuroki whispered.

The thing stopped in its tracks. The front-end lattice swung toward the humans. Then the thing was off, unbelievably fast. In half a second there was nothing to see.

Nobody moved for almost a minute. Finally Frederika clutched Darkington's arm with a little cry. The rigidness left him and he babbled of experimental robot turtles in the early days of cybernetic research—very simple gadgets. A motor drove a wheeled platform, steered by a photoelectric unit that approached light sources by which the batteries might be recharged and, when this was done, became negatively phototropic and sought darkness. An elementary feedback circuit. But the turtles had shown astonishing tenacity, had gone over obstacles or even around . . .

"That beast there was a good deal more complicated," she interrupted.

"Certainly, certainly," Darkington said. "But—"

"I'll bet it heard Sam talk on the radio, spotted us with radar—or maybe eyes, if those socketed glass things were eyes—and took off."

"Very possibly, if you must use anthropomorphic language. However—"

"It was eating that strut." Frederika walked over to the piece of metal which the runner had dropped. She picked it up and came stiffly back with it. "See, the end has been ground away by a set of coarse emery wheels or something. You couldn't very well eat alloy with teeth like ours. You have to grind it. Either that or dissolve it in some chemical system."

"Hey!" Kuroki objected. "Let's not go completely off the deep end."

"What's happened down there?" called the man aboard the *Traveler.*

They resumed walking, in a dreamlike fashion, as they recounted what they had seen. Frederika concluded: "This . . . this arrangement might conceivably be some kind of automated factory—chemosynthetic or something—if taken by itself. But not with beasts like that one running loose."

"Now wait," Darkington said. "They could be maintenance robots, you know. Clear away rubbish and wreckage."

"A science advanced enough to build what we see wouldn't use such a clumsy system of maintenance," she answered. "Get off your professional caution, Hugh, and admit what's obvious."

Before he could reply, his earphones woke with a harsh jabber. He stopped and tried to tune in—it kept fading out, he heard it only in bursts—but the bandwidth was too great. What he did hear sounded like an electronic orchestra gone berserk. Sweat prickled his skin.

When the sound had stopped: "O.K.," breathed Kuroki, "you tell me."

"Could have been a language, I suppose," said Frederika, dry-throated. "It wasn't just a few simple oscillations like that stuff on the other frequencies."

Captain Thurshaw himself spoke from the orbiting ship. "You better get back to the boat and sit prepared for quick blastoff."

Darkington found his nerve. "No, sir. If you please. I mean, uh, if there are intelligences . . . if we really do want to contact them . . . now's the time. Let's at least make an effort."

"Well—"

"We'll take you back first, of course, Freddie."

"Nuts," said the girl. "I stay right here."

Somehow they found themselves pushing on. Once, crossing an open spot where only the crystals stood, they spied something in the air. Through binoculars, it turned out to be a metallic object shaped vaguely like an elongated manta. Apparently it was mostly hollow, upborne by air currents around the fins and propelled at low speed by a gas jet. "Oh, sure," Frederika muttered. "Birds."

They re-entered the area of tall structures. The sonic amplifiers in their helmets were again tuned high, and the clash of plates in the wind was deafening. Like a suit of armor, Darkington thought idiotically. Could be a poem in that. Empty armor on a wild horse, rattling and tossing as it was galloped down an inexplicably deserted city street—symbol of . . .

The radio impulses that might be communication barked again in their earphones. "I don't like this," Thurshaw said from the sky. "You're dealing with too many unknowns at once. Return to the boat and we'll discuss further plans."

They continued walking in the same direction, mechanically. *We*

don't seem out of place here ourselves, in this stiff cold forest, Darkington thought. *Let's turn around. Let's assert our dignity as organic beings. We aren't mounted on rails!*

"That's an order," Thurshaw stated.

"Very well, sir," Kuroki said. "And, uh, thanks."

The sound of running halted them. They whirled. Frederika screamed.

"What's the matter?" Thurshaw shouted. "What's the matter?" The unknown language ripped across his angry helplessness.

Kuroki yanked his rocket gun loose and put the weapon to his shoulder. "Wait!" Darkington yelled. But he grabbed at his own pistol. The oncomer rushed in a shower of crystal splinters, whipping rods and loops aside. Its gigantic weight shuddered in the ground.

Time slowed for Darkington, he had minutes or hours to tug at his gun, hear Frederika call his name, see Kuroki take aim and fire. The shape was mountainous before him. Nine feet tall, he estimated in a far-off portion of his rocking brain, three yeards of biped four-armed monstrosity, head horned with radio lattice, eyes that threw back sunlight in a blank glitter, grinder orifice and— The rocket exploded. The thing lurched and half fell. One arm was in ruins.

"Ha!" Kuroki slipped a fresh shell into his gun. "Stay where you are, you!"

Frederika, wildly embracing Darkington, found time to gasp, "Sam, maybe it wasn't going to do any

harm," and Kuroki snapped, "Maybe it was. Too big to take chances with." Then everything smashed.

Suddenly the gun was knocked spinning by a hurled iron bar they hadn't even noticed. And the giant was among them. A swat across Kuroki's back shattered his radio and dashed him to earth. Flame spat and Frederika's voice was cut short in Darkington's receivers.

He pelted off, his pistol uselessly barking. "Run, Freddie!" he bawled into his sonic microphone. "I'll try and—" The machine picked him up. The pistol fell from his grasp. A moment later. Thurshaw's horrified oaths were gone: Darkington's radio antenna had been plucked out by the roots. Frederika tried to escape, but she was snatched up just as effortlessly. Kuroki, back on his feet, stood where he was and struck with ludicrous fists. It didn't take long to secure him either. Hog-tied, stuffed into a rack on the shoulders of the giant, the three humans were borne off southward.

IV

At first Zero almost ran. The monster must have known where its auxiliaries were and something of what had happened to them. Now that contact was broken, it might send forth others to look for them, better armed. Or it might even come itself, roaring and burning through the forest. Zero fled.

Only the monster's voice, raggedly calling for its lost members, pursued him. After a few miles he crouched in a road clump and strained his receptors. Nothing was visible but thickly growing accumulators and bare sky. The monster had ceased to shout. Though it still emitted an unmodulated signal, distance had dwindled this until the surrounding soft radio noise had almost obliterated that hum.

The units Zero had captured were making considerable sound-wave radiation. If not simply the result of malfunction in their damaged mechanism, it must be produced by some auxiliary system which they had switched on through interior control. Zero's sound receptors were not sensitive enough to tell him whether the emission was modulated. Nor did he care. Certain low forms of motile were known to have well-developed sonic parts, but anything so limited in range was useless to him except as a warning of occurrences immediately at hand. A person needed many square miles to support himself. How could there be a community of persons without the effortless ability to talk across trans-horizon distances?

Irrelevantly, for the first time in his century and a half of existence, Zero realized how few persons he had ever observed with his own direct optics. How few he had touched. Now and then, for this or that purpose, several might get together. A bride's male kin assisted her on her journey to the groom's dwelling. Individuals met to exchange the products of their labor. But still—this rally of all functional males at Broken Glade, to hunt the monster, would be the greatest assemblage in tradition. Yet not even Hundred had grasped its uniqueness.

For persons were always communicating. Not only practical questions were discussed. In fact, now that Zero thought about it, such problems were the least part of discourse. The major part was ritual, or friendly conversation, or art. Zero had seldom met Seven as a physical entity, but the decades in which they criticized each other's poetry had made them intimate. The abstract tone constructions of Ninety-six, the narratives of Eighty, the speculations about space and time of Fifty-nine—such things belonged to all.

Direct sensory linkage, when the entire output of the body was used to modulate the communication band, reduced still further the need for physical contact. Zero had never stood on the seashore himself. But he had shared consciousness with Fourteen, who lived there. He had perceived the slow inward movement of waves, their susurrus, the salt in the air; he had experienced the smearing of grease over his skin to protect it from corrosion, drawing an aquamotile from a net and feasting. For those hours, he and the searaker had been one. Afterward he had shown Fourteen the upland forest . . .

What am I waiting for? Consciousness of his here-and-now jarred back into Zero. The monster had not pursued. The units on his back had grown quiescent. But he was still a long way from home. He rose and started off again, less rapidly but with more care to obliterate his traces.

As the hours passed, his interior sensors warned him increasingly of a need for replenishment. About midday he stopped and unloaded his three prizes. They were feebly squirming and one of them had worked an arm loose. Rather than lash them tight again, he released their limbs and secured them by passing the rope in successive loops around their middles and a tall stump, then welding everything fast with his torch.

That energy drain left him ravenous. He scouted the forest in a jittery spiral until he found some accumulators of the calathiform sort. A quick slash with his pry bar exposed their spongy interiors, rich with energy storage cells and mineral salts. They were not very satisfying eaten unprocessed, but he was too empty to care. With urgency blunted, he could search more slowly and thoroughly. Thus he found the traces of a burrow, dug into the sand, and came upon a female digger. She was heavy with a half-completed new specimen and he caught her easily. This, too, would have been better if treated with heat and acid, but even raw the materials tasted good in his grinder.

Now to get something for One. Though she, better than he, could slow down her functioning when nourishment was scarce, a state of coma while the monster was abroad could be dangerous. After hunting for another hour, Zero had the good luck to start a rotor. It crashed off

among the rods and crystals, faster than he could run, but he put a crossbow bolt through its hub. Dismembered and packed into his carrier, it made an immensely cheering burden.

He returned to his prizes. Moving quietly in comparison to the windy clatter of the forest, he came upon them unobserved. They had quit attempting to escape—he saw the wire was shiny where they had tried to saw it on a sharp rock—and were busy with other tasks. One of them had removed a boxlike object from its back and inserted its head (?) and arms through gasketed holes. A second was just removing a similar box from its lower section. The third had plugged a flexible tube from a bottle into its face.

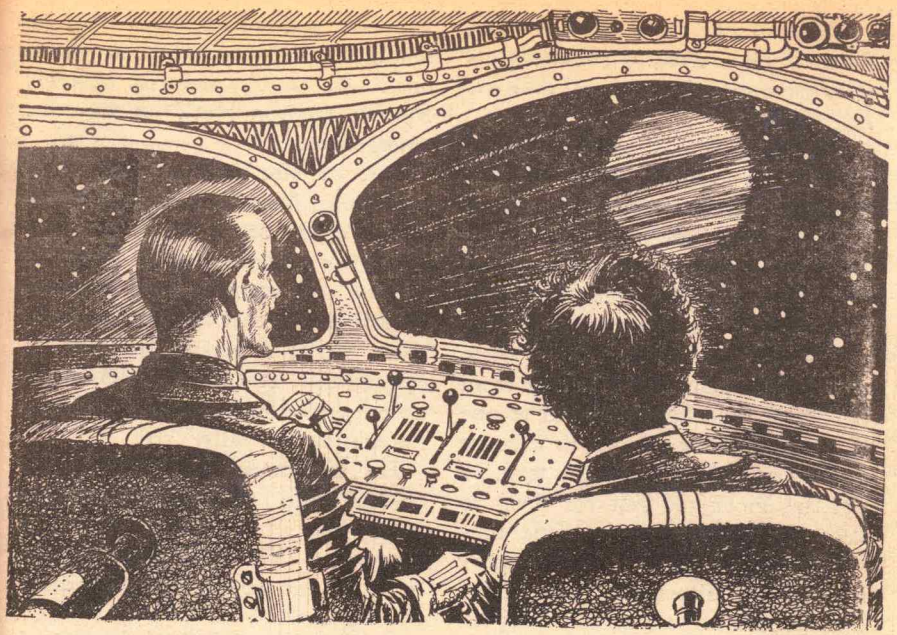
Zero approached. "Let me inspect those," he said, before thinking how ridiculous it was to address them. They shrank away from him. He caught the one with the bottle and unplugged the tube. Some liquid ran out. Zero extended his chemical sensor and tasted cautiously. Water. Very pure. He did not recall ever having encountered water so free of dissolved minerals.

Thoughtfully, he released the unit. It stoppered the tube. So, Zero reflected, they required water like him, and carried a supply with them. That was natural; they—or, rather, the monster they served—could not know where the local springs and streams were. But why did they suck through a tube? Did they lack a proper liquid-ingestion orifice? Evidently. The small hole in the head, into which the tube had fitted, had automatically closed as the nipple was withdrawn.

The other two had removed their boxes. Zero studied these and their contents. There were fragments of mushy material in both, vaguely similar to normal body sludge. Nourishment or waste? Why such a clumsy system? It was as if the interior mechanism must be absolutely protected from contact with the environment.

He gave the boxes back and looked more thoroughly at their users. They were not quite so awkward as they seemed at first. The humps on their backs were detachable carriers like his. Some of the objects dangling at their waists or strapped to their arms must also be tools. (Not weapons or means of escape, else they would have used them before now. Specialized artificial attachments, then, analogous to a torch or a surgical ratchet.) The basic bipedal shape was smoother than his own, nearly featureless except for limb joints. The head was somewhat more complicated, though less so than a person's. Upon the cylindrical foundation grew various parts, including the sound-wave generators which babbled as he stood there watching. The face was a glassy plate, behind which moved . . . what? Some kind of jointed, partly flexible mechanism.

There was no longer any possibility of radio communication with—



or through—them. Zero made a few experimental gestures, but the units merely stirred about. Two of them embraced. The third waved its arms and made sonic yelps. All at once it squatted and drew geometrical shapes in the sand, very much like the courtship figures drawn by a male dune-runner.

So . . . they not only had mechanical autonomy, like the spy eyes of a boxroller, but were capable of some independent behavior. They were more than simple remote-control limbs and sensors of the monster. Most probably they were domesticated motiles.

But if so, then the monster race had modified their type even more profoundly than the person race had modified the type of its own tamed motiles down in the lowlands. These bipeds were comically weak in proportion to size; they lacked grinders and liquid-ingestion orifices; they used sonics to a degree that argued their radio abilities were primitive; they required ancillary apparatus; in short, they were not functional by themselves. Only the care and shelter furnished by their masters allowed them to remain long in existence.

But what are the masters? Even the monster may well be only another motile. Certainly it appeared to lack limbs. The masters may be persons like us, come from beyond the sea or the mountains with great new skills.

But then what do they want? Why have they not tried to communicate with us? Have they come to take our land away?

The question was jolting. Zero got hastily into motion. With his rack loaded, he had no room for his prizes. Besides, being crammed into it for hours was doubtless harmful to them; they moved a good deal more strongly now, after a rest, than when he first took them out. He simply left them tied together, cut the wire loose from the stump, and kept that end in one hand. Since he continued to exercise due caution about leaving a trail, he did not move too fast for them to keep up. From time to time they would stagger and lean on each other for support—apparently their energy cells polarized more quickly than his—but he found they could continue if he let them pause a while, lie down, use their curious artifacts.

The day passed. At this time of year, not long past the vernal equinox, the sun was up for about twenty hours. After dark, Zero's captives began stumbling and groping. He confirmed by direct sense perception that they had no radar. If they ever did, that part had been wrecked with their communicators. After some thought, he fashioned a rough seat from a toppled bole and nudged them to sit upon it. Thus he carried them in two hands. They made no attempt to escape, emitted few sounds, obviously they were exhausted. But to his surprise, they began to stir about and radiate sonics when he finally reached home and set them down. He welded the end of their rope to an iron block he kept for emergencies.

Part of him reflected that their mechanism must be very strange indeed, maybe so strange that they would not prove ingestible. Obviously their cells went to such extremes of polarization that they became comatose, which a person only did in emergencies. To them, such deactivation appeared to be normal, and they roused spontaneously.

He dismissed speculation. One's anxious voice had been rushing over him while he worked. "What has happened? You are hurt! Come closer, let me see, oh, your poor arm! Oh, my dear!"

"Nothing serious," he reassured her. "I shot a rotor. Prepare yourself a meal before troubling about me."

He lowered himself to the cave floor beside her great beautiful bulk. The glow globes, cultivated on the rough stone walls, shed luster on her skin and on the graceful tool tendrils that curled forth to embrace him. His chemical sensor brought him a hint of solvents and lubricants, an essence of femaleness. The cave mouth was black with night, save where one star gleamed bright and somehow sinister above the hills. The forest groaned and tolled. But here he had light and her touch upon his body. He was home.

She unshipped the rack from his shoulders but made no motion toward the food-processing cauldron. Most of her tools and all her attention were on his damaged arm. "We must replace everything below the elbow," she decided; and, as a modulation: *"Zero, you brave clever adored fool, why did you hazard yourself like that? Do you not understand, even yet, without you my world would be rust?"*

"I am sorry . . . to take so much from the new one," he apologized.

"No matter. Feed me some more nice large rotors like this and I will soon replace the loss, and finish all the rest, too." Her mirth fluttered toward shyness. "I want the new one activated soon myself, you know, so we can start another."

The memory of that moment last year, when his body pattern flowed in currents and magnetic fields through hers, when the two patterns heterodyned and deep within her the first crystallization took place, glowed in him. Sensory linkage was a wan thing by comparison.

What they did together now had a kindred intimacy. When she had removed the ruined forearm and he had thrust the stump into her repair orifice, a thousand fine interior tendrils enfolded it, scanning, relaying, and controlling. Once again, more subtly than in reproduction, the electro-chemical-mechanical systems of One and Zero unified. The process was not consciously controllable, it was a female function, One was at this moment no different from the most primitive motile joined to her damaged mate in a lightless burrow.

It took time. The new person which her body was creating within itself was, of course, full size and, as it happened, not far from completion. (Had the case been otherwise, Zero would have had to wait until the new one did in fact possess a well-developed arm.) But it was not yet activated; its most delicate and critical synaptic pathways were still only half finished, gradually crystallizing out of solution. A part could not lightly nor roughly be removed.

But in the end, One's functions performed the task. Slowly, almost reluctantly, Zero withdrew his new hand. His mind and hers remained intertwined a while longer. At last, with a shaky little overtone of humor, she exclaimed, "Well, how do your fingers wiggle? Is everything good? Then let us eat. I am famished!"

Zero helped her prepare the rotor for consumption. They threw the damaged forearm into the cauldron, too. While they processed and shared the meal, he recounted his experiences. She had shown no curiosity about the three bipeds. Like most females, she lacked any great interest in the world beyond her home, and had merely assumed they were some new kind of wild motile. As he talked, the happiness died in her. "Oh, no," she said, "You are not going out to fight the lightning breather, are you?"

"Yes, we must." He knew what image terrified her, himself smashed beyond hope of reconstruction, and added in haste: "If we leave it free, no tradition or instinct knows what it

may do. But surely at the very least, so large a thing will cause extensive damage. Even if it is only a grazer, its appretite will destroy untold acres of accumulators; and it may be a predator. On the other hand, if we destroy it, what a hoard of nourishment! Your share and mine will enable us to produce a dozen new persons. The energy will let me range for hundreds of miles, thus gaining still more food and goods for us."

"If the thing can be assimilated," she said doubtfully. "It could be full of hydrofluoric acid or something, like a touch-me-not."

"Yes, yes. For that matter, the flier may be the property of intelligent beings: which does not necessarily mean we will not destroy and consume it. I intend to find out about that aspect right now. If the monster's auxiliaries are ingestible, the monster itself is almost sure to be."

"But if not— Zero, be careful!"

"I will. For your sake also." He stroked her and felt an answering vibration. It would have been pleasant to sit thus all night, but he must soon be on his way to rendezvous. And first he must dissect at least one specimen. He took up his pry bar.

V

Darkington awoke from a nightmare-ridden half sleep when he was dumped on the cave floor. He reached for Frederika and she came to him. For a space there was nothing but their murmuring.

Eventually they crouched on the sand and looked about. The giant that captured them had welded the free end of the wire rope to an immovable chunk of raw iron. Darkington was attached at that side, then the girl, and Kuroki on the outer end. They had about four feet of slack from one to the next. Nothing in the kit remaining to them would cut those strands.

"Limestone cave, I guess," Kuroki croaked. Behind the faceplate he was gaunt, bristly, and sunken-eyed. Frederika didn't look much better. They might not have survived the trip here if the robot hadn't carried them the last few hours. Nonetheless an odd dry clarity possessed Darkington's brain. He could observe and think as well as if he had been safe on shipboard. His body was one enormous ache, but he ignored that and focused on comprehending what had happened.

Here near the entrance, the cave was about twenty feet high and rather more wide. A hundred feet deeper inward, it narrowed and ended. That area was used for storage: a junk shop of mechanical and electronic parts, together with roughly fashioned metal and stone tools that looked almost homelike. The walls were overgrown with thin wires that sprouted scores of small crystalline globes. These gave off a cool white light that made the darkness outside appear the more elemental.

"Yes, a cave in a sheer hillside," said Frederika. "I saw that much. I kept more or less conscious all the way here, trying to keep track of our route. Not that that's likely to do us much good, is it?" She hugged her knees. "I've got to sleep soon . . . oh, but I have to sleep!"

"We have to get in touch." Kuroki's voice rose. (Thank heaven and some ages-dead engineer that sound mikes and earphones could be switched on by shoving your chin against the right button! With talk cut off, no recourse would have remained but to slip quietly into madness.) "I tried to show that tin nightmare we're intelligent. I drew diagrams and—" He checked himself. "Well, probably its builders don't monitor it. We'll have another go when they show up."

"Let's admit the plain facts, Sam," Frederika said tonelessly. "There aren't any builders. There never were any."

"Oh, no." The pilot gave Darkington a beggar's look. "You're the biologist, Hugh. Do you believe that?"

Darkington bit his lip. "I'm afraid she's right."

Frederika's laugh barked at them. "Do you know what that big machine is, there in the middle of the cave? The one the robot is fooling around with? I'll tell you. His wife!" She broke off. Laughter echoed too horribly in their helmets.

Darkington gazed in that direction. The second object had little in common with the biped shape, being low and wide—twice the bulk—and mounted on eight short legs which must lend very little speed or agility. A radio lattice, optical lenses, and arms—two, not four—were similar to the biped's. But numerous additional limbs were long goosenecks terminating in specialized appendages. Sleek blued metal covered most of the body.

And yet, the way those two moved—

"I think you may be right about that also," Darkington said at last.

Kuroki beat the ground with his fist and swore. "Sorry, Freddie," he gulped. "But won't you explain what you're getting at? This mess wouldn't be so bad if it made some sense."

"We can only guess," Darkington said.

"Well, guess, then!"

"Robot evolution," Frederika said. "After man was gone, the machines that were left began to evolve."

"No," said Kuroki, "that's nuts. Impossible!"

"I think what we've seen would be impossible any other way," Darkington said. "Metallic life couldn't arise spontaneously. Only carbon atoms make the long hookups needed for the chemical storage of biological information. But electronic storage is equally feasible. And . . . before the *Traveler* departed . . . self-reproducing machines were already in existence."

"I think the sea rafts must have been the important ones." Frederika spoke like someone in dream. Her eyes were fixed wide and unblinking on the two robots. "Remember? They were essentially motorized floating boxes, contaning metallurgic process-

ing plants and powered by solar batteries. They took dissolved minerals out of sea water, magnesium, uranium, whatever a particular raft was designed for. When it had a full cargo, it went to a point on shore where a depot received its load. Once empty, it returned to open waters for more. It had an inertial navigation device, as well as electronic sensors and various homeostatic systems, so it could cope with the normal vicissitudes of its environment.

"And it had electronic templates which bore full information on its own design. They controlled mechanisms aboard, which made any spare part that might be needed. Those same mechanisms also kept producing and assembling complete duplicate rafts. The first such outfit cost hundreds of millions of dollars to manufacture, let alone the preliminary research and development. But once made, it needed no further investment. Production and expansion didn't cost anyone a cent.

"And after man was gone from Earth . . . all life had vanished . . . the sea rafts were still there, patiently bringing their cargoes to crumbling docks on barren shores, year after year after meaningless year—"

She shook herself. The motion was violent enough to be seen in armor. "Go on, Hugh," she said, her tone turned harsh. "If you can."

I don't know any details," he began cautiously: "You should tell me how mutation was possible to a machine. But if the templates were actually magnetic recordings on wire or tape, I expect that hard radiation would affect them, as it affects an organic gene. And for a while there was certainly plenty of hard radiation around. The rafts started making imperfect duplicates. Most were badly designed and, uh, foundered. Some, though, had advantages. For instance, they stopped going to shore and hanging about for decades waiting to be unloaded. Eventually some raft was made which had the first primitive ability to get metal from a richer source than the ocean: namely, from other rafts. Through hundreds of millions of years, an ecology developed. We might as well call it an ecology. The land was reconquered. Wholly new *types* of machine proliferated. Until today, well, what we've seen."

"But where's the energy come from?" Kuroki demanded.

"The sun, I suppose. By now, the original solar battery must be immensely refined. I'd make a guess at dielectric storage on the molecular level, in specialized units—call them cells—which may even be of microscopic size. Of course, productivity per acre must be a good deal lower than it was in our day. Alloys aren't as labile as amino acids. But that's offset to a large extent by their greater durability. And, as you can see in this cave, by interchangeability."

"Huh?"

"Sure. Look at those spare parts stacked in the rear. Some will no doubt be processed, analogously to our eating and digesting food. But others are probably being kept for use as such. Suppose you could take whole organs from animals you killed and install them in yourself to replace whatever was wearing out. I rather imagine that's common on today's Earth. The 'black box' principle was designed into most machines in our own century. It would be inherited."

"Where does the metal come from in the first place?"

"From lower types of machine. Ultimately from sessile types that break down ores, manufacture the basic alloys, and concentrate more dielectric energy than they use. Analogous to vegetation. I daresay the, uh, metabolism involves powerful reagents. Sulfuric and nitric acids in glass-lined compartments must be the least of them. I doubt if there are any equivalent of microbes, but the ecology seems to manage quite well without. It's a grosser form of existence than ours. But it works. It works."

"Even sex." Frederika giggled a little crazily.

Darkington squeezed her gauntleted hand until she grew calmer. "Well," he said, "quite probably in the more complex machines, reproduction has become the specialty of one form, while the other specializes in strength and agility. I daresay there are corresponding psychological differences."

"Psychological?" Kuroki bridled. "Wait a minute! I know there is . . . was . . . a lot of loose talk about computers being electronic brains and such rot, but—"

"Call the phenomenon what you like," Darkington shrugged. "But that robot uses tools which are made, not grown. The problem is how to convince it that *we* think."

"Can't it see?" Frederika exclaimed. "We use tools, too. Sam drew mathematical pictures. What more does it want?"

"I don't know enough about this world to even guess," Darlington said tiredly. "But I suppose . . . well . . . we might once have seen a trained ape doing all sorts of elaborate things, without ever assuming it was more than an ape. No matter how odd it looked."

"Or maybe the robot just doesn't give a damn," Kuroki said. "There were people who wouldn't have."

"If Hugh's guess about the 'black box' is right," Frederika added slowly, "then the robot race must have evolved as hunters, instead of hunting being invented rather late in their evolution. As if men had descended from tigers instead of simians. How much psychological difference would that make?"

No one replied. She leaned forlornly against Darkington. Kuroki turned his eyes from them, perhaps less out of tact than loneliness. His girl was several thousand miles away, straight up, with no means for him to call her and say good-by.

Thurshaw had warned the insistent volunteers for this expedition that

there would be no rescue. He had incurred sufficient guilt in letting three people—three per cent of the human race—risk themselves. If anything untoward happened, the *Traveler* would linger a while in hopes the boat could somehow return. But in the end the *Traveler* would head for the stars. Kuroki's girl would have to get another father for the boy she might name Sam.

I wish Freddie were up there with her, Darkington thought. *Or do I? Isn't that simply what I'm supposed to wish?*

Cut that out. Start planning!

His brain spun like wheels in winter mud. What to do, what to do, what to do? His pistol was gone, so were Kuroki's rockets, nothing remained but a few tools and instruments. At the back of the cave there were probably stored some weapons with which a man could put up a moment's fight. (Only a moment, against iron and lightning; but that would end the present, ultimate horror, of sitting in your own fear-stink until the monster approached or the air renewal batteries grew exhausted and you strangled.) The noose welded around his waist, ending in a ton of iron, choked off any such dreams. They must communicate, somehow, anyhow, plead, threaten, promise, wheedle. But the monster hadn't cared about the Pythagorean theorem diagramed in sand. What next, then? How did you say, "I am alive" to something that was not alive?

Though what was aliveness? Were proteins inherently and unescapably part of any living creature? If the ancient sea rafts had been nothing except complicated machines, at what point of further complication had their descendants come to life? *Now stop that, you're a biologist, you know perfectly well that any such question is empirically empty and anyhow it has nothing to do with preserving the continuity of certain protein chemistries which are irrationally much loved.*

"I think it talks by radio." Kuroki's slow voice sounded oddly through the thudding in Darkington's head. "It probably hasn't got any notion that sound waves might carry talk. Maybe it's even deaf. Ears wouldn't be any too useful in that rattletrap jungle. And our own radios are busted." He began to fumble in the girl's pack. "Freddie, I think I could cobble together one working set from the pieces of our three, if I can borrow some small tools and instruments. Once we make systematic noises on its talk band, the robot might get interested in trying to savvy us."

He began to lay out the job. Darkington, unable to help, ashamed that he had not thought of anything, turned attention back to the robots. They were coupled together, ignoring him.

Frederika dozed off. How slowly the night went. But Earth was old, rotating as wearily as . . . as himself. He slept.

A gasp awoke him.

The monster stood above them. Tall, tall, higher than the sky, it bestrode their awareness and looked

down with blank eyes upon Kuroki's pitiful barely-begun work. One hand was still a torch and another hand had been replaced, it was invulnerable and soulless as a god. For an instant Darkington's half aroused self groveled before it.

Then the torch spat, slashed the wire rope across, and Kuroki was pulled free.

Frederika cried out. "Sam!"

"Not . . . so eager . . . pal," the pilot choked in the robot's arms. "I'm glad you like me, but . . . ugh . . . careful!"

With a free hand, the robot twisted experimentally at Kuroki's left leg. The suit joints turned. Kuroki shrieked. Darkington thought he heard the leg bones leave their sockets.

"No! You filthy machine!" He plunged forward. The rope stopped him cold. Frederika covered her faceplate and begged Kuroki to be dead.

He wasn't, yet. He wasn't even unconscious. He kept on screaming as the robot used a prying tool to drag the leg off his armor. Leakseal compound flowed from between the fabric layers and preserved the air in the rest of his suit.

The robot dropped him and sprang back, frantically fanning itself. A whiff of oxygen, Darkington realized amidst the red and black disintegration of his sanity. Oxygen was nearly as reactive as fluorine, and there had been no free oxygen on Earth since —Kuroki's agony jerked toward silence.

The robot reapproached with care, squatted above him, poked at the exposed flesh, tore loose a chunk for examination and flung it aside. The metal off a joint seemed better approved.

Darkington realized vaguely that Frederika lay on the ground close to Kuroki and wept. The biologist himself was even nearer. He could have touched the robot as well as the body. Instead, though, he retreated, mumbling and mewing.

The robot had clearly learned a lesson from the gas, but was just as clearly determined to go on with the investigation. It stood up, moved a cautious distance away, and jetted a thin, intensely blue flame from its torch hand. Kuroki's corpse was divided across the middle.

Darkington's universe roared and exploded. He lunged again. The rope between him and Frederika was pulled across the fire beam. The strands parted like smoke.

The robot pounced at him, ran into the oxygen gushing from Kuroki's armor, and lurched back. Darkington grabbed the section of rope that joined him to the block. The torch was too bright to look at. If he touched its flame, that was the end of him, too. But there was no chance to think about such matters. Blindly and animally, he pulled his leash across the cutting jet.

He was free.

"Get out, Freddie!" he coughed, and ran straight toward the robot. No use trying to run from a thing that

could overtake him in three strides. The torch had stopped spitting fire, but the giant moved in a wobbly, uncertain fashion, still dazed by the oxygen. By pain? Savagely in the last spark of awareness, Darkington hoped so. *"Get out, Freddie!"*

The robot staggered in pursuit of him. He dodged around the other machine, the big one that they had called female. To the back of the cave. A weapon to fight with, gaining a moment where Frederika might escape. An extra pry bar lay on the floor. He snatched it and whirled. The huge painted shape was almost upon him.

He dodged. Hands clashed together just above his helmet. He pelted back to the middle of the cave. The female machine was edging into a corner. But slow, awkward—

Darkington scrambled on top of it.

An arm reached from below to pluck him off. He snarled and struck with the pry bar. The noise rang in the cave. The arm sagged, dented. This octopod had nothing like the biped's strength. Its tool tendrils, even more frail, curled away from him.

The male robot loomed close. Darkington smashed his weapon down on the radio lattice at his feet. It crumpled. He brandished the bar and howled senselessly, "Stand back, there! One step more and I'll give her the works! I'll kill her!"

The robot stopped. Monstrous it bulked, an engine that could tear apart a man and his armor, and raised its torch hand.

"Oh, no," Darkington rasped. He opened a bleeder valve on his suit, kneeling so the oxygen would flow across the front end of the thing on which he rode. Sensors ought to be more vulnerable than skin. He couldn't hear if the she-robot screamed as Kuroki had done. That would be on the radio band. But when he gestured the male back, it obeyed.

"Get the idea?" he panted, not as communication but as hatred. "You can split my suit open with your flame gun, but my air will pour all over this contraption here. Maybe you could knock me off her by throwing something, but at the first sign of any such move on your part, I'll open my bleeder valve again. She'll at least get a heavy dose of oxy. And meanwhile I'll punch the sharp end of this rod through one of those lenses. Understand? Well, then, stay where you are, machine!"

The robot froze.

Frederika came near. She had slipped the loop of cable joining her to Kuroki off what was left of his torso. The light shimmered on her faceplate so Darkington couldn't see through, and her voice was strained out of recognition. "Hugh, oh, Hugh!"

"Head back to the boat," he ordered. Rationality was returning to him.

"Without you? No."

"Listen, this is not the place for grandstand heroics. Your first duty is to become a mother. But what I hope for, personally, is that you can return in the boat and fetch me. You're no pilot, but they can instruct you by radio from the ship if she's above the horizon. The general director does most of the work in any event. You land here, and I can probably negotiate a retreat for myself."

"But . . . but . . . the robot needed something like twenty hours to bring us here. And it knew the way better than I do. I'll have to go by compass and guess, mostly. Of course, I won't stop as often as it did. No more than I have to. But still . . . say twenty hours for me . . . you can't hold out that long!"

"I can try," he said. "You got any better ideas?"

"All right, then. Good-by, Hugh. No, I mean so long. I love you."

He grunted some kind of answer, but didn't see her go. He had to keep watching the robot.

VI

Zero!" his female called, just once, when the unit sprang upon her back. She clawed at it. The pry bar smashed across her arm. He felt the pain-surge within her sensors, broadcast through her communicator, like a crossbow bolt in his body.

Wildly, he charged. The enemy unit crashed the bar down on One's lattice. She shrilled in anguish. Affected by the damage that crippled her radar, her communicator tone grew suddenly, hideously different. Zero slammed himself to a halt.

Her sobbing, his own name blindly repeated, overwhelmed the burning in him where the corrosive gas had flowed. He focused his torch to narrow beam and took careful aim.

The unit knelt, fumbling with its free hand. One screamed again, louder. Her tendrils flailed about. Numbly, Zero let his torch arm droop. The unit rose and poised its weapon above her lenses. A single strong thrust downward through the glass could reach her brain. The unit gestured him back. He obeyed.

"Help," One cried. Zero could not look at the wreckage of her face. There was no escaping her distorted voice. "Help, Zero. It hurts so much."

"Hold fast," he called in his uselessness. "I cannot do anything. Not now. The thing is full of poison. That is what you received." He managed to examine his own interior perceptions. "The pain will abate in a minute . . . from such a small amount. But if you got a large dose—I do not know. It might prove totally destructive. Or the biped might do ultimate mechanical damage before I could prevent it. Hold fast, One mine. Until I think of something."

"I am afraid," she rattled. "For the new one."

"Hold fast," he implored. "If that unit does you any further harm, I will destroy it slowly. I expect it realizes as much."

The other functional biped came near. It exchanged a few ululations with the first, turned and went quickly from the cave. "It must be going back to the flying monster," said One. The words dragged from her, now and then she whimpered as her per-

ceptions of damage intensified, but she could reason again. "Will it bring the monster here?"

"I cannot give chase," said Zero unnecessarily. "But—" He gathered his energy. A shout blasted from his communicator. *"Alarm, alarm! All persons receiving, prepare to relay. Alarm!"*

Voices flashed in his head, near and far, and it was as if they poured strength into him. He and One were not alone in a night cave, a scuttling horror on her back and the taste of poison only slowly fading. Their whole community was here.

He reported the situation in a few phrases. "You have been rash," Hundred said, shaken. "May there be no further penalties for your actions."

"What else would you have had him do?" defended Seven. "We cannot deal randomly with a thing as powerful as the monster. Zero took upon himself the hazards of gathering information. Which he has succeeded in, too."

"Proving the danger is greater than we imagined," shuddered Sixteen.

"Well, that is a valuable datum."

"The problem now is, what shall we do?" Hundred interrupted. "Slow though you say it is, I expect the auxiliary that escaped can find the monster long before we can rendezvous and get up into the hills."

"Until it does, though, it cannot communicate, its radio being disabled," Zero said. "So the monster will presumably remain where it is, ignorant of events. I suggest that those persons who are anywhere near this neighborhood strike out directly toward that area. They can try to head off the biped."

"You can certainly capture it in a few minutes," Hundred said.

"I cannot leave this place."

"Yes, you can. The thing that has seized your female will not logically do anything more to her, unprovoked, lest she lose her present hostage value."

"How do you know?" Zero retorted. "In fact, I believe if I captured its companion, this unit would immediately attack One. What hope does it have except in the escape of the other, that may bring rescue?"

connection with an elaborated spy eye," Seven said.

"If it is," Zero said. "Their actions suggest to me that these bipeds are more than unthinking domesticated motiles."

"Let be!" Hundred said. "There is scant time to waste. We may not risk

"Hope is a curious word to use in the entire community for the sake of a single member. Zero, go fetch back that biped."

Unmodulated radio buzzed in the night. Finally Zero said, "No." One's undamaged hand reached toward him, but she was too far away for them to touch each other. Nor could she caress him with radar.

"We will soon have you whole again," he murmured to her. She did not answer, with the community listening.

Hundred surrendered, having existed long enough to recognize unbendable negation. "Those who are sufficiently near the monster to reach it before dawn, report," he directed. When they had finished—about thirty all told—he said, "Very well, proceed there. Wherever feasible, direct your course to intercept the probable path of the escaped unit. If you capture it, inform us at once. The rest of us will rendezvous as planned."

One by one the voices died out in the night, until only Hundred, who was responsible, and Seven, who was a friend, were in contact with Zero. "How are you now, One?" Seven asked gently.

"I function somewhat," she said in a tired, uneven tone. "It is strange to be radar blind. I keep thinking that heavy objects are about to crash into me. When I turn my optics that way, there isn't anything." She paused. "The new one stirred a little bit just now. A motor impulse pathway must have been completed. Be careful, Zero," she begged.

"I cannot understand your description of the bipeds' interior," Hundred said practically. "Soft, porous material soaked in sticky red liquid; acrid vapors— How do they *work?* Where is the mechanism?"

"They are perhaps not functional at all," Seven proposed. "They may be purely artificial devices, powered by chemical action."

"Yet they act intelligently," Zero argued. "If the monster—or the monster's masters—do not have them under direct control—and certainly there is no radio involved . . ."

"There may be other means than radio to monitor an auxiliary," Seven said. "We know so little, we persons."

"In that case," Zero answered, "the monster has known about this cave all the time. It is watching me at this moment, through the optics of that thing on One's back."

"We must assume otherwise," Hundred said.

"I do," Zero said. "I act in the belief that these bipeds are out of contact with the flier. But if nevertheless they perform as they have been doing, then they certainly have independent function, including at least a degree of intelligence." A thought crashed through him, so stunning that he could not declare it at once. Finally: "They may be the monster's masters! It may be the auxiliary, they the persons!"

"No, no, that is impossible," Hundred groaned. Seven's temporary acceptance was quicker; he had always been able to leap from side to side of a discussion. He flashed:

"Let us assume that in some unheard-of fashion, these small entities are indeed the domesticators, or even the builders, of that flying thing. Can we negotiate with them?"

"Not after what has happened," Zero said bleakly. He was thinking less about what he had done to them than what they had done to One.

Seven continued: "I doubt it myself, on philosophical grounds. They are too alien. Their very functioning is deadly: the destruction wrought by their flier, the poison under their skins. Eventually, a degree of mutual

comprehension may be achieved. But that will be a slow and painful process. Our first responsibility is to our own form of existence. Therefore we must unmistakebly get the upper hand, before we even try to talk with them." In quick excitement, he added, "And I think we can."

Zero and Hundred meshed their intellects with his. The scheme grew like precipitation in a supersaturated pond. Slow and feeble, the strangers were only formidable by virtue of highly developed artifacts—or, possibly, domesticated motiles of radically modified type—the flier, the tube which had blown off Zero's arm, and other hypothetical weapons. But armament unused is no threat. If the flier could be immobilized—

Of course, presumably there were other dwarf bipeds inside it. Their voices had been heard yesterday. But Zero's trip here had proven that they lacked adequate nighttime senses. Well, grant them radar when in an undamaged condition. Radar can be confused, if one knows how.

Hundred's orders sprang forth across miles to the mountaineers now converging on the flier: "Cut the heaviest accumulator strands you can find in the forest. Twist them into cables. Under cover of darkness, radar window, and distraction objects, surround the monster. We believe now that it may not be sentient, only a flier. Weld your cables fast to deeply founded boles. Then, swiftly, loop them around the base of the flier. Tie it down!"

"No," said Twenty-nine, aghast. "We cannot weld the cables to its skin. It would annihilate us with one jetblast. We would have to make nooses first and—"

"So make the nooses," Zero said. "The monster is not a perfectly tapered spindle. The jets bulge out at the base. Slip the nooses around the body just above the jets. I hardly think it can rise then, without tearing its own tubes out."

"Easy for you to say, Zero, safe in your cave."

"If you knew what I would give to have matters otherwise—"

Abashed, the hunters yielded. Their mission was not really so dangerous. The nooses—two should be ample if the cable was heavy—could be laid in a broad circle around the area which the jets had flattened and devastated. They could be drawn tight from afar, and would probably slip upward by themselves, coming to rest just above the tubes, where the body of the flier was narrowest. If a cable did get stuck on something, someone would have to dash close and free it. A snort of jetfire during those few seconds would destroy him. But quite probably the flier, or its masters, could be kept from noticing him.

"And when we do have the monster leashed, what then?" asked Twenty-nine.

"We will do what seems indicated," Hundred said. "If the aliens do not seem to be reaching a satisfactory understanding with us—if

we begin to entertain any doubts—we can erect trebuchets and batter the flier to pieces."

"That might be best," said Zero, with a revengeful look at One's rider.

"Proceed as ordered," said Hundred.

"But what about us?" Zero asked. "One and myself?"

"I shall come to you," Seven said. "If nothing else, we can stand watch and watch. You mentioned that the aliens polarize more easily than we do. We can wait until it drops from exhaustion."

"Good," said Zero. Hope lifted in him as if breaking through a shell. "Did you hear, One? We need only wait."

"Pain," she whispered. Then, resolutely: "I can minimize energy consumption. Comatose, I will not sense anything . . ." He felt how she fought down terror, and guessed what frightened her: the idea that she might never be roused.

"I will be guarding you all the time," he said. "You and the new one."

"I wish I could touch you, Zero—" Her radiation dimmed, second by second. Once or twice consciousness returned, kicked upward by fear; static gasped in Zero's perception; but she slipped again into blackness.

When she was quite inert, he stood staring at the unit on her—no, the entity. Somewhere behind that glass and horrible tissue, a brain peered back at him. He ventured to move an arm. The thing jerked its weapon aloft. It seemed indeed to have guessed that the optics were her most vulnerable spot. With immense care, Zero let his arm fall again. The entity jittered about, incapable of his own repose. Good. Let it drain its energy the faster.

He settled into his own thoughts. Hours wore away. The alien paced on One's broad back, sat down, sprang up again, slapped first one hand and then another against its body, made long noises that might possibly be intended to fight off coma. Sometimes it plugged the water tube into its face. Frequently Zero saw what looked like a good chance to catch it off guard—with a sudden rush and a flailing blow, or an object snatched off the floor and thrown, or even a snap shot with his torch—but he decided not to take the hazard. Time was his ally.

Besides, now that his initial rage had abated, he began to hope he might capture the entity undamaged. Much more could be learned from a functional specimen than from the thing which lay dismembered near the iron block. Faugh, the gases it was giving off! Zero's chemical sensor retracted in disgust.

The first dawnlight grayed the cave mouth.

"We have the flier!" Twenty-nine's exuberant word made Zero leap where he stood. The alien scrambled into motion. When Zero came no closer, it sagged again. "We drew two cables around its body. No trouble whatsoever. It never stirred. Only made the same radio hum."

"I thought—" someone else in his party ventured. "Not long ago . . . was there not a gibberish signal from above?"

"There might well be other fliers above the clouds," agreed Hundred from the valley. "Have a care. Disperse yourselves. Remain under cover. The rest of us will have rendezvoused by early afternoon. At that time we will confer afresh. Meanwhile, report if anything happens. And . . . good work, hunters."

Twenty-nine offered a brief sensory linkage. Thus Zero saw the place: the cindered blast area, and the upright spindle shining in the first long sunlight, and the cables that ran from its waist to a pair of old and mighty accumulator boles. Yes, the thing was captured for certain. Wind blew over the snow-peaks, set forest to chiming and scattered the little sunrise clouds. He had rarely known his land so beautiful.

The perception faded. He was in his cave again. Seven called: "I am getting close now, Zero. Shall I enter?"

"No, best not. You might alarm the alien into violence. I have watched its movements the whole night. They grow more slow and irregular each hour. It must be near collapse. Suppose you wait just outside. When I believe it to be comatose, I will have you enter. If it does not react to the sight of you, we will know it has lost consciousness."

"If it is conscious," mused Seven. "Despite our previous discussion, I cannot bring myself to believe quite seriously that these are anything but motiles or artifacts. Very ingenious and complex, to be sure . . . but *aware,* like a person?"

The unit made a long series of sonic noises. They were much weaker than hitherto. Zero allowed satisfaction to wax in him. Nevertheless, he would not have experienced this past night again for any profit.

Several hours later, a general alarm yanked his attention back outward. "The escaped auxiliary has returned! It has entered the flier!"

"What? You did not stop it?" Hundred demanded.

Twenty-nine gave the full report. "Naturally, after the change of plan, we were too busy weaving cables and otherwise preparing ourselves to beat the forest for the dwarf. After the flier was captured, we dispersed ourselves broadly as ordered. We made nothing like a tight circle around the blasted region. Moreover, our attention was directed at the flier, in case it tried to escape, and at the sky in case there should be more fliers. Various wild motiles were about, which we ignored, and the wind has gotten very loud in the accumulators. Under such circumstances, you will realize that probability actually favored the biped unit passing between us and reaching the open area unobserved.

"When it was first noticed, no person was close enough to reach the flier before it did. It slid a plate aside in one of the jacks which support the flier and pulled a switch. A portal opened in the body above and a ladder was extruded. By that time, a number of us had entered the clearing. The unit scrambled up the ladder. We hesitated, fearing a jetblast. None came. But how could we have predicted that? When at last we did approach, the ladder had been retracted and the portal was closed. I pulled the switch myself but nothing happened. I suppose the biped, once inside, deactivated that control by means of a master switch."

"Well, at least we know were it is," Hundred said. "Disperse again, if you have not already done so. The biped may try to escape, and you do not want to get caught in the jetblast. Are you certain the flier cannot break your cables?"

"Quite certain. Closely observed, the monster—the flier seems to have only a thin skin of light alloy. Nor would I expect it to be strong against the unnatural kind of stresses imposed by our tethers. If it tries to rise, it will pull itself in two."

"Unless," said Fourteen, as he hastened through valley mists toward Broken Glade, "some biped emerges with a torch and cuts the cabes."

"Just let it dare!" said Twenty-nine, anxious to redeem his crew's failure.

"It may bring strong weapons," Zero warned.

"Ten crossbows are cocked and aimed at that portal. If a biped shows itself, we will fill it with whetted steel."

"I think that will suffice," Zero said. He looked at the drooping shape upon One. "They are not very powerful, these things. Ugly, cunning, but weak."

Almost as if it knew it was being talked about, the unit reeled to its feet and shook the pry bar at him. Even Zero could detect the dullness in its noises. *Another hour,* he thought, *and One will be free.*

Half that time had gone by when Seven remarked from outside, "I wonder why the builders . . . whoever the ultimate intelligences are behind these manifestations . . . why have they come?"

"Since they made no attempt to communicate with us," Zero said in renewed grimness, "we must assume their purpose is hostile."

"And?"

"Teach them to beware of us."

He felt already the pride of victory. But then the monster spoke.

Up over the mountains rolled the voice, driven by the power which hurled those hundreds of tons through the sky. Roaring and raging through the radio spectrum, louder than lightning, enormous enough to shake down moon and stars, blasted that shout. Twenty-nine and his hunters yelled as the volume smote their receptors. Their cry was lost, drowned, engulfed by the tide which seethed off the mountainsides. Here and there, where some accumulator happened to resonate, blue arcs of flame danced in the forest. Thirty miles distant, Zero and Seven still perceived the noise as a clamor in

their heads. Hundred and his followers in the valley stared uneasily toward the ranges. On the seashore, females called, "What is that? What is that?" and aquamotiles dashed themselves about in the surf.

Seven forgot all caution. He ran into the cave. The enemy thing hardly moved. But neither Zero nor Seven observed that. Both returned to the entrance and gazed outward with terror.

The sky was empty. The forest rang in the breeze. Only that radio roar from beyond the horizon told of anything amiss. "I did not believe —" stammered Seven. "I did not expect—a tone that loud . . ."

Zero, who had One to think about, mustered decisiveness. "It is not hurting us," he said. "I am glad not to be as close as the hunters are, but even they should be able to endure it for a while. We shall see. Come, let us two go back inside. Once we have secured our prisoner—"

The monster began to talk.

No mere outrageous cry this time, but speech. Not words, except occasionally—a few images. But such occurrences were coincidental. The monster spoke in its own language, which was madness.

Seized along every radio receptor channel there was in him, total sensory and mental linkage, Zero became the monster.

DITditditdit DAH dit-nulnulnul-nul-ditditDAHdah & the vector sum: infinitesimals infinitelyadded from nul-to-INFINITY, dit—ditdit—DA—ditditditnul (gammacolored chaos, *bang* goes a universe scattering stars&planets&bursts-of-fire BLOCK THAT NEUTRON BLOCK THAT NEUTRON BLOCK THAT NEUTRON BLOCK THAT BLOCK THAT BLOCK THAT NEUTRON) oneone***nononul—DATTA—ditdit chitterchitterchitter burning suns & moons, burning stars & brains, burningburningburning Burning DahditDahditDahdit give me fifty million logarithms this very microsecond or you will Burn ditditditdit — DAYADHVAM — DAMYATA

and one long wild logarithmic spiral down spacetimeenergy continuum of potentialgradient Xproduct i,j,k but multiply Time by the velocity of light in nothingness and the square root of minus one (two, three, four, five, six CHANGE for duodecimal computation zzzzzzzzzz)

integral over sigma of del cross H d sigma equals one over c times integral over sigma partial of E with respect to t dot d sigma but correct for nonsphericalshapentropicoordinatetransformationtop&quantumelectrodynamichargelectricalephaselagradientemperature rising to burning Burning BURNING

dit-dit-chitterchitterchitter from eyrie to blind gnawer and back again O help the trunk is burningburningburning THEREFORE ANNUL in the name of the seven thunders

Everything-that-has-been, break up the roots of existence and strike flat the thick rotundity o' the world

RRRIP spacetime across and throw it on the upleaping primordial energy for now all that was & will be, the very fact that it once *did* exist, is canceled and torn to pieces and

Burning
Burning
Burning
Burning

AND the binding energy of a lambda hyperon by a sigma—minus exploding

As the sun fell down the bowl of sky, and the sky cracked open, and the mountains ran like rivers forming faces that gaped and jeered, and the moon rose in the west and spat the grisliness of what he had done at him, Zero ran. Seven did not; could not; lay by the cave entrance, which was the gate of all horrors and corruptions, as if turned to salt. And when God descended, still shouting in His tongue which was madness, His fiery tail melted Seven to a pool.

Fifty million years later the star called Wormwood ascended to heaven; and a great silence fell upon the land.

Eventually Zero returned home. He was not surprised to find that the biped was gone. Of course it had been reclaimed by its Master. But when he saw that One was not touched, he stood mute for a long while indeed.

After he roused her, she—who had been unawake when the world was broken and refashioned—could not understand why he led her outside to pray that they be granted mercy, now and in the hour of their dissolution.

VII

Darkington did not regain full consciousness until the boat was in space. Then he pulled himself into the seat beside Frederika. "How did you do it?" he breathed.

Her attention remained focused on piloting. Even with the help of the director and radio instructions from the ship, it was no easy task for a novice. Absently, she answered, "I scared the robots away. They'd made the boat fast, you see. With cables too thick to pull apart. I had to go back out and cut them with a torch. But I'd barely gotten inside ahead of the pack. I didn't expect they would let me emerge. So I scared them off. After that, I went out, burned off the cables, and flew to get you."

"Barely in time," he shuddered. "I was about to pass out. I did keel over once I was aboard." A time went by with only the soft rushing noise of brake jets. "O.K.," he said, "I give up. I admit you're beautiful, a marvel of resourcefulness, and I can't guess how you shooed away the enemy. So tell me."

The director shut off the engine. They floated free. She turned her face, haggard, sweaty, begrimed, and dear, toward him and said diffidently, "I didn't have any inspiration. Just a guess and nothing to lose. We knew for pretty sure that the robots communicated by radio. I turned the boat's 'caster on full blast, hoping the sheer volume would be too much for them. Then something else oc-

curred to me. If you have a radio transceiver in your head, hooked directly into your nervous system, wouldn't that be sort of like telepathy? I mean, it seems more direct somehow than routing everything we say through a larynx. Maybe I could confuse them by emitting unfamiliar signals. Not any old signals, of course. They'd be used to natural radio noise. But . . . well . . . the boat's general director includes a pretty complicated computer, carrying out millions of operations per second. Information is conveyed, not noise; but at the same time, it didn't seem to me like information that a bunch of semisavages could handle.

"Anyhow, there was no harm in trying. I hooked the broadcaster in parallel with the effector circuits, so the computer's output not only controlled the boat as usual but also modulated the radio emission. Then I assigned the computer a good tough problem in celestial navigation, put my armor back on, summoned every ounce of nerve I had, and went outside. Nothing happened. I cut the cables without seeing any trace of the robots. I kept the computer 'talking' while I jockeyed the boat over in search of the cave. It must have been working frantically to compensate for my clumsiness; I hate to imagine what its output 'sounded' like. Felt like? Well, when I'd landed, I opened the air lock and, and you came inside, and—" Her fists doubled. "Oh, Hugh! How can we tell Sam's girl?"

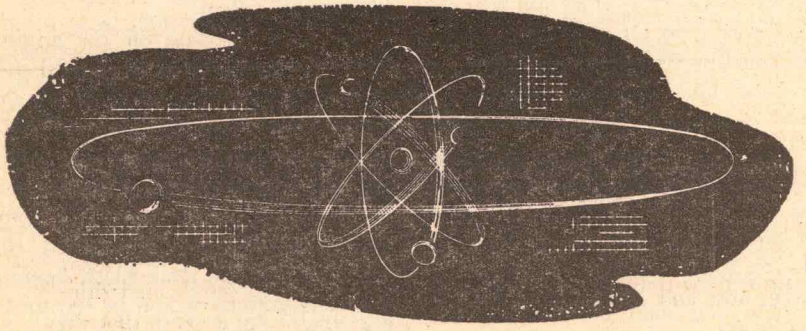
He didn't answer.

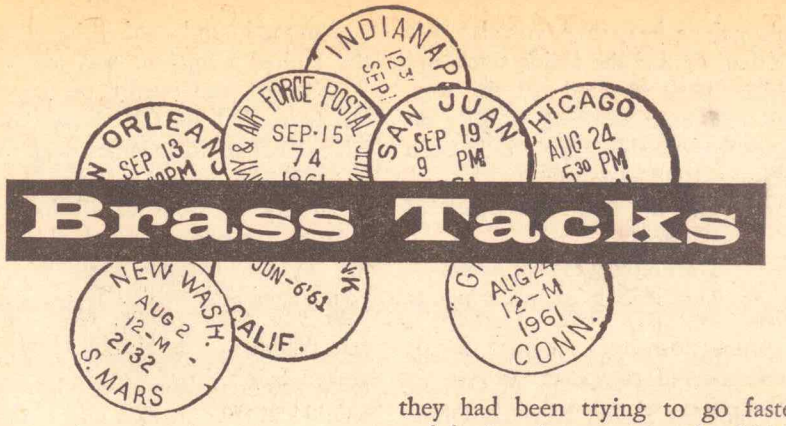
With a final soft impulse, the boat nudged against the ship. As grapnels made fast, the altered spin of the vessels put Earth back in view. Darkington looked at the planet for minutes before he said:

"Good-by. Good luck."

Frederika wiped her eyes with hands that left streaks of dirt in the tears. "Do you think we'll ever come back?" she wondered.

"No," he said. "It isn't ours any more." ■





Brass Tacks

Dear Mr. Campbell:

That editorial on Scientific Lynch Law could have been phrased a bit differently. It has also been called Institutionalism, namely the idea that I had a hard time getting here, you will have to work hard to prove anything to me. The Armed Forces have had a fine example of it for a long time.

About forty years ago there was a lot of squabbling about the role of aircraft in anything. Aviators felt that they could manage most any trick and the ground pounders questioned them bitterly. The Mitchell courtmartial came of this argument. He made charges that could only be settled by a trial, as they amounted to accusation of treasonable stupidity against the commanders of Army and Navy.

As time went by, the air-minded folks got their innings, and finally established the United States Air Force, complete with blue suits and entirely new dictionaries. For years they had been trying to go faster and farther through winged vehicles. Someone came up with copters and at least one big shot claimed that it was a blind alley in aeronautics. He told an Army commander who wanted a few that they were useless, and anyhow the army men didn't need them. Came 1950, and the versatility of the chopper was shown on many occasions. They are temperamental, delicate, slow, and so forth. They can also do things nothing else can.

Rocket missiles do not need wings, and for a while, this item did not get much notice in the AF R&D system. Now, look. The Aerospace Force is in full cry after the self-contained blowtorch. Winged missiles are passé.

Then also we have the cherished view of many in or out of the service that We Are The Smartest Tribe. By now, we should have learned that the Russians are capable of tricks also. They have a deadly knack of making complicated things simple. This does not mean that they

can't make a few fancy ones also. We felt that we had the inside track and paid no heed to tales that the Russians had been working steadily on things for years that we'd only been on since 1954 seriously.

Moral? The butterfly has wings of gold
The firefly, wings of flame.
The bedbug has no wings at all
But he gets there just the same.—John P. Conlon, 52 Columbia Street, Newark, Ohio

The old—and always fatal!—game of "Now we're on top, it's time to stop changes." But somewhere else, someone who isn't on top wants changes . . .

» » »

Dear Sir:

I have just read your editorial in the July issue (BRE) about the "Constitution for Utopia." Your argument slayed me at first, as your arguments usually do, and then I started a bit of figuring. You suggest that the people with the top twenty per cent of income are necessarily the above-averagely-competent ones. The figures in the table refer to all incomes in the United Kingdom during 1959, the latest figures available:

Income Group	No. of Incomes
£10,000 and over	17,000
£ 5,000—£10,000	62,000
£ 2,000—£ 5,000	386,000
£ 1,000—£ 2,000	2,005,000
£ 800—£ 1,000	3,100,000

The total number of all incomes in the United Kingdom was just over 26,000,000; and twenty per cent of this figure is 5,200,000. Now the total number of all incomes over £800 is 5,570,000, which is near enough to twenty per cent of all incomes.

With the present standard of living in the United Kingdom, any young man educated to degree standard expects to start his first job at about £800. My wife, who is admittedly brighter than most (how else would she have snaffled me?) started her first job at over £1,000. And most bricklayers at the age of nineteen have a pay packet around £800 a year.

The way we think in the United Kingdom now, you've arrived when you make about £1,500. A standard of living that equates in the popular mind with better-than-average competence may be said to be around £2,000. (And you must keep the mob happy, especially in Utopia.) The table shows that the number of people whose income exceeds £2,000 is less than half a million, or two per cent of the working population. And is this figure high enough to guarantee that there will be the concomitant qualities of "wisdom, benevolence and competence"?

Or is it just that poor old Britain has lost her chance of getting into Utopia on the ground floor?—Michael Spencer

Of the many letters received here commenting on the "Constitution for Utopia" editorial, this is the ONLY one that shows the writer took time out to find out what "the top twenty per cent" of incomes actually meant! The ONLY one that found out what the group was before blowing off about the "selfish, greedy rich"!

The basic point of the top twenty per cent suggestion was that it is a group large enough to represent a group, not a clique. That the top twenty per cent necessarily earn their own living, and manage their own affairs with more prudence than most—and yet are far from being a snobbish, self-centered clique. They have a tremendous diversity of interests—from the self-respecting, self-supporting bricklayer to the young college graduate. But earned-income requirement eliminates café society playboys, and welfare parasites alike.

The level that equates in the public mind to "better than average" is much, much too high . . . because the real average of the real human population is so very much lower than we are willing to believe. Be it remembered that, necessarily, half the population must fall into the group of "subnormal" in intellgence —the moron-idiot group must, by definition of "norm", constitute half the population!

» » »

Dear John,

Your recent interest in Psi has me thinking . . .

Remember how close you came in your predictions about the A-bomb? And SF has an awfully good record of "I told you so's" . . .

So how close are we to some practical Psi breakthroughs? And I wonder how many readers of Analog have wondered if they didn't have a few Psi talents, and tried to find out. I've wondered. I've experimented, and read everything good I could lay hands on concerning Psi. Seems to me we've come to the point with Psi that we have come to in other scientific ventures—it's time to move from theory to practice. Any suggestions?—Brian Doud

Well—you can start with the pipe-locating dousing rods—which are already practical, engineering psi!

» » »

Dear Friends:

More Editorial-Articles like Pie in the Sky—only please take time to revise like you usually do for plain editorials. I expect you were rushing to meet a deadline. But since you wrote this the press has run a story that the Ruskies ARE also working on an antigravity device. Of course, experts were quick to say nothing practical could come of it. The Ruskies may also have an advantage in that they apparently do not believe that they are God and spend no time expecting a miracle to bless their efforts. Why bother with the Galapagos Islands or the Malagasay Republic? New Zealand is soon to be abandoned by U.K.'s entry into the European Common Market—the

whole country will be for sale cheap. The Government would welcome entry of the large packet of capital needed for space and antigravity research. If Alternate markets are not available for NZ in Japan and USA, it appears likely that Russia will be able to take control by the gradual process of buying surplus wool, meat, butter, cheese that N.Z. can't find a market for. So, please pass the word along to the boys with space capital: NZ with 2.2 million english-type people and plenty mountains is available—George D. Krouse, Harrison Street, Featherston, New Zealand

I understand Australia has troubles —and lots of desert land for space-base work—too!

» » »

Dear Mr. Campbell:

The conjunction of the September article "Scientific Breakthrough," by H. C. Dudley with the coming conjunction of six planets—including the earth—suggests what will shortly be proved to be science fantasy or breakthrough. Next February we will have these six cellestial magnets lined up in series for the first time in 25,000 years. The electromagnetic fields of these magnets is bound to interact in ways that it is worth speculating on. Conceivably this conjunction would become a linear accelerator as well as a magnetic field of such power as to remagnetize the earth in line with this field. Were this the case we might have a repetition of an event that took place around twenty-five thousand years ago—and may have taken place on the previous occasion of the conjunction of these planets. That event caused the sudden freezing of mastodons living in a temperate environment by temperatures so low as to constitute a quick freeze—at the same time as the land on which they lived became located near the pole of the earth.

This is a hypothesis that astronomers and physicists could do some quick figuring on and then compare notes with the geologists. But there won't be time for it to be the subject of science fiction, for the fact will be with us too soon.

It is interesting that this event will be with us about the time that mankind is preparing to blow himself up in atomic warfare. Such fun to be alive and to watch the show!—Griscom Morgan, Route 1, Box 275, Yellow Springs, Ohio.

Well, if Astrological forces have any reality at all, now is the time to prove it! If they can't predict what that extreme an alignment will do—they can't do much predicting!

» » »

Dear Mr. Campbell:

As I write this letter another one of those irritating Russian Spaceships is swarming over my head. (I can't find that flyswatter.) This time it's a big one, and I can almost see the little cosmonaut thumbing his nose.

Your editorial of the August Analog is made more painfully clear by the orbiting of *Vostok II.* The subsequent news reports mention—rather offhandedly—the Great Event, then, with long face and little emotion, quote Expert Estimates of the status of the United States. Space Program: "Maybe in 1962—", or, "Can't possibly be speeded up—".

Then comes the fearless and remarkably well-timed proposal to negotiate a means of controlling the range of the monster Soviet spaceships. (Extend national borders into Space.) After all, such manned vehicle *just might* house a menace to World Peace.

And so it goes. (And goes.)

We're going to have to make one Hell of a breakthrough to break through the laziness, inattention, apathy, et cetera that hold our incentive, *and the means for incentive,* down. In this respect I think you, sir, should receive hearty thanks for more than one well-aimed "boot in the pants".—George C. Copenhaver, Jr., 8120 Chaz Place, La Mesa, California.

And it is now clear that Russia, as of August 1961, has the ability to establish a manned orbital space-station, by combining several Vostok loads into a station.

» » »

Dear Sir:

The story "Hanging by a Thread," by David Gordon, was interesting and ingenius, but it belabors an issue which is, or is on its way to being, a "dead duck". There was another story some years back in ASF about a spacesuit that was not fully tested. This story also made the point that the whole is greater than the sum of the parts. Admittedly, the problem of the one shot emergency beacon is different from the spacesuit, but this problem has a simple solution. If you need a hundred bullets, beacons, rocket motors, or whatever that cannot be tested without destruction, you simply make 1 hundred+n items, take n samples at random from the lot and shoot them off. If any item fails, you automatically reject the lot until you find out why it failed and can check the remaining items to determine whether or not the fault is repeated. While this method is not infallible, the chances of a basic design flaw getting by will be negligible.

This is not a new idea. I have been dealing with Government Specifications for nearly ten years and there are umpteen specifications and standards which tell you how to determine n, how to pick your samples from the lot and how the test is to be run. On a recent proposal which called for delivery of fifty small solid fuel rockets, the manufacturer determined that it would be necessary to manufacture nearly a hundred rockets to meet the requirements for firing tests. While this is not typical for a production run, it gives an idea of the precautions that are practiced.

Incidentally, there are a couple of

other echoes in this issue. "Status Quo" reminded me of "E for Effort" and "Lost Translation" reminded me of the story of the guy who won a war by feeding the enemy computer Lewis Carroll's "Jabberwock".

I am not listing AnLab preferences because I find it almost impossible to rate the stories. Besides, I find the editorials and, lately, the articles more interesting than the stories. By the way it was quite a shock when I opened this issue and didn't find an editorial behind the title page. Next time you hide it, warn me.

I am a little puzzled by your classification of "The Four Faced Visitors of Ezekiel" and "Apollonios Enlists" as short stories. Perhaps you need a new department called "Speculations."

Another change of subject. When I read your first editorial on the Dean Drive and the reaction to it, I was a bit skeptical, not so much of the drive or, at least, the concept, but of the reactions that you described. However, as soon as I tried get somebody interested in it, my skepticism vanished. It took me twenty-five minutes to talk a top-flight Engineering Consultant into even looking at the patent, and at that, I was wasting my time. He looked at it, but he didn't see it. His reaction was, I'm afraid, typical. On the same subject, I am enclosing a photocopy of an article published a year ago by the same magazine that recently published a report that the Dean Drive would not work. Note that they accept without comment the concept of producing "rectilinear momentum" in free space "without expelling mass" and go on to talk about maintaining a 1 g environment in a vehicle accelerating at 100 g (shades of E. E. Smith). As far as I can determine by checking subsequent issues of the magazine, this article didn't generate any controversy at all. I suspect this is because they related it to unified field theory, quantum mechanics, and mass-energy conversion. These concepts are esoteric enough so that most people—(myself included)—don't really understand them, so they aren't frightened. Dean's trouble is that he didn't spend five years on a Government-funded study program. He just went ahead and built a machine for somebody else to explain.—Douglas S. Price, 4201 Dunnel Lane, Kensington, Maryland.

"Hanging by a Thread" was based on an actual incident. Of course things are supposed to be cross checked—but an idiot can always succeed in making a fool of the wisest plans. One nuclear-device test failed because someone achieved the impossible—he plugged in an 11-pin polarized plug 180° wrong, it's impossible to do that—but he did!

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Dear John:

The November issue of *Analog* was up to it's usual standards. However, something rankles. Mr. Smith's amusing article "A Problem in Communication" presents a theory on the disappearance of the dinosaurs which, unfortunately, is at variance with presently available medical information. To wit, the figure quoted by Mr. Smith for the speed of propagation of human neural impulses, 10 feet per second, is low by at least one order of magnitude.

For instance, *The Science of Biology* by Paul Weisz quotes this velocity as "about 100 yards per second." *Schiffre's Family Medical Encyclopedia* gives the figure as between 200 and 300 feet per second and according to *Modern Biology* the velocity of neural impulses in the human body is approximately 270 miles per hour or 400 feet per second, certainly a far cry from the figure given by Mr. Smith. We were unable to obtain any data to confirm or disprove Mr. Smith's speed of 3 feet per second for reptiles. However, a difference of a factor of 100 between the respective speeds in reptiles and humans seems a bit unlikely.

If on the other hand, we maintain Smith's ratio of 3 to 1, we get a speed of 90 feet per second in the brontosaurus. To salvage his entertaining theory, using his figure of 30 seconds maximum elapsed time from head to tail for survival of the brontosaurus, we obtain a brontosaurus 2700 feet long. The problem now is not "Why have we found no small brontosauri?" but "What happened to the big ones?"—Richard Matgun, Kent Acherson, Denis Morrow, John McLeod, University of Notre Dame, Notre Dame, Indiana.

Not all nerve trunks show the same speed in human nervous systems. The extremely high-speed nerves are associated with the balance sensing system—critically important to an erect biped! Observed reaction times in 6-foot man, however, do suggest a 60 foot dinosaur would be a sucker for a modern wolf, however!

» » »

Dear Mr. Campbell:

The progress of study on the Dean Device is of very great interest to me. As necessary pursuit of the Almighty Shekel denies me time for researching it at all thoroughly, I have not been able to locate anything to add to my copy of the patent and those features and editorials concerning Mr. Dean's invention in my collection of ASF.

Occasional references to the Dean Drive in Brass Tacks and your editorials have mentioned in passing other writings on the subject.

I believe my interest in the "Deanerator" is similar in measure to that of a good share of your readership, and I'm sure that a fair portion of these are similarly short of info concerning it.

I submit, accordingly, the suggestion-cum-request that a bibliography on the Dean patent, in the measure that it can be conveniently compiled, be inserted in some soonish issue of ASF, and that it be expanded and updated as further convenient.

I think a lot of us would appreciate it.—Jerry Andre, Miami Springs, Fla.

the Reference Library

P. Schuyler Miller

TOUR DE FORCE

■ To a degree, and from the point of view of ordinary fiction, all science fiction is a *tour de force*—an "adroit and ingenious accomplishment," ignoring Webster's qualifying "merely." What may or must seem to the uninitiate outrageously farfetched or implausible themes and events are involved in every story. Indeed, the more plausible these themes become—such as atomic energy, nuclear bombs, and trips to the Moon—the sooner they are ejected by "real" science fiction.

Within the field itself, many or most of the "great" books and stories are *tours de force* on another level: Stapledon's "Last and First Men," for example, and "The Skylark of Space" when it was new. Even with our greater sophistication and experience with such themes and matters, the author grabs us and drags us along, completely convincing us of the reality of the world he is creating and the plot he is unfolding, by the adroit and ingenious exercise of his imagination and writing ability.

Now there's another of the breed: Daniel F. Galouye's "Dark Universe"—a Bantam paperback original, No. J-2266, giving you one hundred fifty-four extraordinary pages for forty cents. It's going to be near the top when the nominating votes are counted for best novel of 1961.

Because Galouye has truly created the "country of the blind" that H. G. Wells only suggested. He shows us a cavern society where there has been no light for generations—where the very meaning of the word has been distorted and perverted by religious dogma and ignorance—where plant life of a kind has been bred to live on the heat-energy of hot springs instead of the light-energy of a lost Sun, and cattle to live on them, and men to live on both. It is a world some of whose people still fumble and stumble in the dark, while others have learned or inherited the ability to use sound in place of sight, "seeing" rather fuzzily by the reflected sound waves from the noisemakers in their cave villages, and more clearly by the high-pitched rattle of their clickstones with its finer resolution.

It is a world where another outcast breed has been developing, able to see by infrared—heat. These Zivvers are killed or exiled, and have found a home of their own in the endless caverns; the two peoples raid each other for food and slaves.

We explore this world and its society through the keen senses and alert but troubled mind of Jonas, son of their chief, the Prime Survivor. Jonas is a maverick who cannot help wondering what lies behind the legends and the rituals and prohibitions. He ventures over a tumbled-down wall into the forbidden Original World from which their people came in the long ago—and draws on them, out of that place of horror and mystery, amorphous manlike monsters and an utterly strange new force, a *silent* sound.

It is impossible to describe the fascinatingly detailed and complete way in which this whole world and its society are built up in "Dark Universe," without giving away more of the reality behind the semblance. It is the author's right, especially in a book of this kind where how the story is told is so much more important than the story itself, to let truth creep on his readers as it finally creeps on Jonas. He explains one mystery only to unveil another, reaches one solution only to open the door on an impasse.

It's "only" a *tour de force* among *tours de force*—and it's terrific!

* * * * *

Some time ago, when I reviewed the American edition of Tsiolkovsky's "Beyond the Planet Earth" here, I said that its mixture of scientific explanation and—for its time—way out extrapolation should have been a "natural" for the early *Amazing Stories*. I wondered why Hugo Gernsback hadn't brought it to his readers as he did some of the best French and German science fiction of the time. A letter from Mr. Gernsback, which I should have passed on to John Campbell for "Brass Tacks" or quoted here long ago, confirms my guess: he didn't use it because he didn't know about it.

"As perhaps you know," Mr. Gernsback says in part, "the late C. A. Brandt was Literary Editor of *Amazing Stories* beginning with July 1926. I have no hesitancy about say-

ing that I considered Brandt the greatest authority on science fiction anywhere at that time. Brandt had a great collection of every imaginable science-fiction story, possibly the greatest at the time. He was fluent in many languages and at one time he brought to my attention the name of Konstantin E. Tsiolkovsky. I had never heard of him before 1926, and the book Brandt was talking about had nothing to do with Tsiolkovsky's science fiction, but rather with his theoretical space flight and rockets.

"As far as I can remember, there wasn't then in existence an English translation of Tsiolkovsky's early work, and while I am fluent in French and German, I cannot read Russian. It would seem that neither Brandt nor I knew of the story "Beyond the Planet Earth." If I had heard about it, it is certain that we would have run it sooner or later in *Amazing Stories* or *Amazing Stories Annual*."

Mr. Gernsback points out that, in *Science Wonder Stories* in the Summer of 1929, he published the serious study of space flight by Captain Hermann Noordung, which he had translated from the German. In later issues of *Wonder Quarterly* he added science fiction by Otto Willi Gail—"The Shot into Infinity", "The Stone from the Moon"—and others.

"In 1926 I knew, of course, that the Russians had used rockets as far back as World War I and that they had done a good deal of work with such missiles," Mr. Gernsback continues. "I am of the firm opinion that the Russians did not particularly care to publicize their rocket work or anything connected with it for the simple reason that they considered it in the military domain, and were not too anxious to tell the West much about their early work. This paid dividends and put them way out front, where they still are today."

Mr. Gernsback enclosed his editorial from the June, 1961 issue of *Radio-Electronics*—written before the first Russian cosmonaut went up—in which he decries the wasted time and effort of the "Man into Space" program of both Russia and the United States, spending on a propaganda effort what might have gone into putting a data-collecting robot on the Moon. He cites, in the editorial, the fifty-year-old work of Tsiolkovsky, Goddard, and Oberth, in which much that has now been confirmed empirically was worked out theoretically.

Science fiction gets a certain amount of grudging acclaim from the "outside" world these days for having foreseen such developments as atomic energy and the space program. What is overlooked is that the writers, editors and publishers of science fiction have to be a lap or two farther in advance of the rest of the world, or these "pioneering" stories would never be written.

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SHOCK! by Richard Matheson. Dell Books No. B-195. 1961. 191 pp. 35¢

Stacked up on the end of my table are fourteen paperbacks published by leading S-F publishers during the middle months of 1961, which are horror or fantasy instead of science fiction. This already constitutes a trend, and if they sell it may lead to the resurrection of such magazines as *Weird Tales*, or even—is it possible?—*Unknown Worlds*.

These thirteen stories by Richard Matheson should probably be considered a fifteenth member of the horror column, but there are enough science-fiction tales and borderliners in the collection to warrant this attention.

The author's macabre humor and his ability to twist familiar situations into grim parodies of themselves have probably helped keep him busy scripting Hollywood shiver-shows like the alleged version of Poe's "The Pit and the Pendulum." Most of the stories in this lot come from *Playboy, Fantasy & Science Fiction,* and *Galaxy*—which had one out-and-out weirdy, "Long Distance Call," under the name "Sorry, Right Number."

The one really outstanding story in the book is unrelievedly grim: "Dance of the Dead." We see a somewhat sheltered teen-age girl, out with more sophisticated friends, watching a "loopy" dance—once of the living undead who have survived the next annihilation. Look around you for the seeds and feel your bowels crawl: this is, in a way, the counterpart of "sick" humor. So are two or three other stories, which can be taken as a "straight" portrayal of psychopathic distortion, very much like Ray Bradbury but more brutal. "The Distributor," for example, is the little man who deliberately goads a quiet neighborhood into murderous, insane frenzy. It's his job. In "Legion of Plotters" a paranoid goes over the edge and strikes back at the persecuters all around him. And haven't you longed to do just as he does? Then there's "The Holiday Man" who experiences every death and maiming in the holiday traffic toll, so that the morning's reports will be accurate.

There are comedies here, too, but comedy with a death's head behind the clown mask. "The Creeping Terror"—in which Los Angeles becomes openly alive and engulfs the world. "One for the Books," in which a janitor finds himself suddenly absorbing all sorts of knowledge—for someone else. "Mantage"—fantasy, if you like—in which a man lives like a screen treatment. "The Splendid Source"—not grim, for a change—which explains where the great dirty jokes come from.

What else? "The Children of Noah", if it's set in our time, is just growing horror; if it's supposed to be in the future, call it a kind of technical S-F. "Lemmings," very brief, very effective, totally unexplained, brings mankind to its end. "Long Distance Call" is straight horror with a supernatural ending; "Death Ship" has an interplanetary setting but is also supernatural. "The Edge" is the *doppelganger* theme again, professional but minor.

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THE MEMORY BANK, by Wallace West. Avalon Books, New York. 1961. 221 pp. $2.95

You might call this one about par for Avalon's course—not one of their occasional stars, but far from their worst. It is an action-packed space opera built around a novel technique for achieving immortality of sorts—sweeping one's memories under the rug, so to speak, and clearing the brain for a fresh start at regular intervals.

Earth has wiped itself out, driving mankind to the stars. The Memory Bank society has established itself on the Centauran planets; beyond them are the Barbarians descended from the first space pioneers; threatening them both are the powerful Siriuns. Decadence and vigor snipe at each other while the aliens grin, but Our Hero brings everything out all right in the end. Heck, even the Siriums turn out to be nice guys—just a little hungry, scared and misguided, that's all.

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SOVIET RESEARCH ON GRAVITATION, by Maurice A. Garbell. U.S. Department of Commerce, Business and Defense Services Administration, Office of Technical Services, Washington 25, D.C. Mimeographed; 352 + 27 pp. $5.00

Getting government publications is sometimes a tedious business. Sometimes your money goes to the publishing agency, and sometimes to someone quite different. I suggest a postcard of inquiry to the agency named above, or to the Gravity Research Foundation of New Boston, New Hampshire, through which I got my copy. The latter organization is sincere and not a hoax, though for all I know it may have attracted its circle of crackpots. Its moving spirits are Roger Babson, the financial analyst, and Clarence Birdseye, father of the frozen juice of the same name. They award annual prizes for essays on gravitation, and although the first few might have been won by someone with a good encyclopedia, the awards—which *are* paid—are going to increasingly meaty papers by physicists and mathematicians.

This is a rather curious document, which presents what to one layman reads like the best simple account of present ideas on gravitation now available. It seems that a Russian physicist and mathematician, K. P. Stanyukovich, made a series of statements to the Russian press and in magazines, between 1954 and 1958, implying that Soviet science was ready to demonstrate a breakthrough in the nullification and/or control of gravitation. This was supposed to happen at temperatures near absolute zero—possibly through the use of anti-matter—and would lead to the annihiliation of some ninety per cent of the weight of satellites and space craft.

Naturally interested and conceivably perturbed over this announcement from a member of the Interplanetary Flight Commission of the Russian Academy of Sciences, the Air Information Division of the Office of Technical Services hires the Garbell Research Foundation of San Francisco to investigate Stanyukovich's status as a physicist, his work in the field of gravitation, and anything else that could be learned about Soviet work on gravitation. The report, covering the period up to March 1960, was in when a paper published by Stanyukovich in 1959, in the Bulletin of the All-Union Astronomical and Geodesic Society of the Academy of Sciences, turned up. This destroyed one conclucion—that Stanyukovich seemed to have no background of work or serious pronouncements on gravitation—but did nothing to change the equally important conclusion that the "breakthrough" was moonshine. This paper, "The Problem of the Physical Nature of Gravity," is now added as a twenty-seven-page appendix.

The survey begins with a precis of current ideas on the nature of gravitation, both as expressed in the writings of "outside" physicists and in those of the leading Russian and other Iron Curtain scientists. This section on "The problem of gravitation" is admirably clear; I hope physics texts make use of it. This is followed by better than a hundred pages of titles, including some abstracts, of Soviet and Western papers on gravitation, and this in turn by English translations of articles by several top Soviet physicists.

The conclusions do not lend any encouragement to classic science fictional ideas of space travel via antigravity, either of the Cavorite or controlled-field variety. Soviet physicists seem to be split into the same two camps as Westerners: the relativists, who look on gravitation as a geometric property of curved space, and the quantum mechanics school, which think in terms of gravitational waves propagated by moving masses. There have been some attempts to reconcile the two approaches, with no particular success. The conclusion from both points of view is that the forces involved are so small that they are not about to take anybody's ship anywhere.

Stanyukovich, by the way, is the same headline-prone individual who made the Western press with his announcements that Phobos, the Martian moon, is an artificial satellite, and—I believe—that the 1908 meteor fall in Siberia was a nuclear explosion. He has also had thoughts on the Abominable Snowman, and he described *Sputnik I* two years before it went up. The author of this appraisal seems uncertain whether to brand him a publicity hound or a "name" scientist assigned to job of stirring up the wonder and amazement of the home folks and the warmongers over the way, about as Mr. Hearst used to agitate Americans through his revelations in the *American Weekly*.

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THE 6th ANNUAL OF THE YEAR'S BEST SF, edited by Judith Merril. Simon and Schuster, New York. 1961. 384 pp. $3.95

Should the science fiction/fantasy

field ever be reduced to one magazine, with the circulation of a *Life,* the literary status of *Harper's,* the advertising income of one of the big women's magazines, and the unpredictable *zing* of *Playboy* or *Mad,* there is just one person qualified to edit it—Judith Merril. Apart from the circulation and the income, she does it every year in her "Year's Best SF," and this year's collection is right up there with the best of the six she has done.

What other anthologist, I ask you, would have the pure, galloping eclecticism to include a "Pogo" cartoon, another by *Playboy*'s Shel Silverstein, three already classic conventioneering ballads—rather two blues and a ballad—complete with music, G. Harry Stine's "How to Think a Science Fiction Story" from his Analog article "Science Fiction is Too Conservative," and a *Punch* parody by Kingsley Amis which transfers a Hemingway theme to a science-fiction setting and tells it in Hemingwayese—what other anthologist *does* give us all this, along with a balanced *bouillabaisse* of science fiction and fantasy yarns, served up piping hot?

The previous paragraph was getting unmanageable, or I would have gone on with the catalog of unusual gems in this sixth "Best"—second from Simon and Schuster. There is one of patent attorney "Leonard Lockhard's" accounts of the problems of Messrs. Saddle and Spardleton, which originated here in Analog. In this one Arthur C. Clarke tries to patent his unquestioned invention of a TV-relay satellite—and he himself contributes that parable (?) from *Playboy,* "I Remember Babylon," in which a Red Chinese agent explains the uses his employers have for a TV satellite. Facing that is a cartoon from *Punch;* on the page before that, a jingle from *Harper's.* You'll find another of Isaac Asimov's reports on that remarkable compound, thiotimoline—here in 1960—and a grand parody by Hilbert Schenck, Jr. of Edwin Lear's "Owl and the Pussycat"—and another *Punch* cartoon that bites all the deeper now that Enos is back after another banana.

Astounding/Analog makes out better than it has in the last few years. I've mentioned the three articles: there are, in addition, John Brunner's outrageous "Report on the Nature of the Lunar Surface," Christopher Anvil's "A Rose by Other Name" which does rather more for semantics than van Vogt did, and Dean McLaughlin's novelette, "The Brotherhood of Keepers," which turns anthopology inside out and examines its guts.

On the science-fiction side, there is also Ward Moore's "The Fellow Who Married the Maxill Girl"—a fellow with a green thumb, from a world of such folk—from *Fantasy & Science Fiction.* There is Marshall King's "Beach Scene"—*Galaxy*—in which an infant with strange powers meets strangers on his distant world. There is Rosel George Brown's "David's Daddy" from *Fantastic,* in which a teacher uses a child's strange power to resolve a tragedy, and that other sage seer of children, Zenna Henderson, with "Something Bright" from *Galaxy,* in which another child sees and understands what an adult could not. And there is Joseph Whitehill's *tour de force* from *F&SF,* "In the House, Another," which objectivizes the familiar into the unfamiliar.

Back a bit, Miss Merril has assembled three short, very different but basically ironic treatments of the Abominable Snowman theme: William Sambrot's rather sentimental, "straight" "Creature of the Snows" from the *Saturday Evening Post,* Fredric Brown's condensed snapper, "Abominable," from *Dude,* and R. Bretnor's "The Man on Top" from *Esquire,* which is about climbers instead of Snowmen. Richard McKenna—*F&SF* again—has a story that is almost counterpoint to Dean McLaughlin's in "Mine Own Ways," again offering a fresh view of the relations between men and aliens on a far world.

And there is my own favorite, neither science fiction nor fantasy but an indescribable blend of both, Brian W. Aldiss' "Old Hundredth," written for the one hundredth issue of the British SF magazine, *New Worlds.* A stranger little story there has seldom been.

Fantasy? We have left Holley Cantine's comedy of duplication, "Double, Double, Toil and Trouble" from *F&SF,* Bernard Wolfe's gently human "The Never Ending Penny" from *Playboy,* R. C. Phelan's evocation of an old *Unknown* gambit in *The Reporter,* "Something Invented Me," and a choice chunk of a novel I missed—and never saw reviewed—"J.G., the Upright Ape" by Roger Price. J.G., be it known, is a Silver Gorilla, and if you take him as seriously as his biographer does, perhaps this should be catalogued science fiction rather than fantasy.

There is, however, no doubt about Elizabeth Emmett's "Enchantment"—the *Post* again—as delicate and fine a fantasy as any of the masters ever wrote.

I find that I have overlooked two science-fiction stories and two of the "who would have thoughts" with which I opened this catalogue. Henry Slesar did the very short, obvious and ironic "Chief" for *Playboy*—another post-atomic-war tale. Howard Fast's "The Large Ant" from *Fantastic Universe* is the most ordinary of his stories in this vein. Ray Bradbury is represented by his factual or conjectural article from *Life* on "A Serious Search for Weird Worlds"—Project Ozma, and life in space. And Lester Del Rey has a chillingly bitter "Psalm," which also appeared in the late *Fantastic Universe.* It begins: "The AEC is my shepherd; I shall not live."

Praise be, they *do* go right on making 'em like this—year after year.

« *Continued from page 5* »

1. All the Laws of Nature that are ever to be discovered, in the whole course of the *n* billion years of future time, are operating today.

2. Since we don't know about them, they're acting as apparent random factors—and by extremely long odds, that means almost certainly destructively.

The undiscovered natural laws have, in times past, been called "malign Fate", or "the anger of the Gods" and more recently—and more technically—called anything from "instrumental error" through "poor noise-ratio" to "Finagle's Laws."

When a scientist performs an experiment that should be a crucial experiment, doing X if theory Alpha is correct, and Y if theory Beta is the right one, and it does Z . . . he redesigns the experiment because of instrumentation troubles. So maybe he missed discovering the Law of Congenicity in 1962 instead of in 2174 .

I most urgently recommend to your attention, if you haven't seen it, the article on Clerk Maxwell's famous first color photograph, by the three-color separation process, in the November, 1961 issue of *Scientific American.* It's a magnificent example of the way unknown laws of Nature louse up experiments with perfect impartiality; in this case, Maxwell was totally ignorant of a critical law of Nature, proceeded blindly along an intrinsically impossible route . . . and got precisely the results he expected because of a *second* law of Nature he knew just as little about!

His famous three-color separation photograph, from which the whole science of color photography took off . . . *could not be made on any film available at that time!* Maxwell thought—wrongly—that the silver halide films were less sensitive to green and red than to blue; he was unaware of the thing Einstein worked out later—that the work-function and photon energy relationships were such that silver halide of old-style wet collodion emulsions is absolutely and totally incapable of reacting to red light. It's not a matter of a statistical distribution function, but an absolute energy barrier limit. Therefore Maxwell's films *could not possibly* record either the red or the green image.

But he got three-color separation!

Because he was equally ignorant of the ultra-violet spectrum, which his films were sensitive to, and that his color filters didn't work at all as he thought, and the glass lens he used wasn't transparent to some of the spectrum actually involved in the experiment!

It's one of the most magnificent accounts of a world-famous experiment that succeeded, and established for all time a principle that had absolutely no bearing on the actual experiment, I've ever seen.

Natural laws can be guaranteed to function—and the probability that one unknown law will cancel the effect of another law you know nothing about, as in Maxwell's classic blunder, can be vaguely imagined, but never calculated, of course.

The very concept of Natural Law is a lot newer than we, who have grown up with it, realize; living in a culture that is based on it, we can't imagine very readily what the alternative basic concepts could be, and were. That's always difficult—partly because to consider an alternative to one's own deepest, foundation postulates is disquieting to the highest possible degree, emotionally so objectionable as to drive us strongly toward flat, absolute rejection.

Primitive tribal philosophies—they may not think in terms of "This is our philosophy," any more than a horse thinks in terms of "I must absorb more oxygen to make up for the consumption of glycogen in my muscles," but in each case, the reality of the operation is there!—hold a very different postulate; that there is no order in Nature, but only Wills. Why is the storm? Because the Gods—or the Demons—wanted it that way. Even as late as the Greek times, the same basic concept prevailed.

This belief holds that all objective things exist because a Will, a subjective force, so determined. And the nature of those subjective-power entities they envisaged can best be understood by modern people, by remembering the overall structure of Greek mythology. The Olympians were a bunch of willful, arbitrary, bickering, whimsical, inconsistent, and utterly unrestrained—except by each other's willfullness!—overpowered—and oversexed—adolescents. There is no dignity in Zeus going in for wild masquerades to cheat on his shrewish wife! The whimsical nature of the gods and demons the primitives "knew" ran the world and all its events can be judged from the aspect the Olympian Gods had, even in Greek times!

Now the essence of the primitive concept might be stated, "The material universe is ruled by subjective forces, which are completely whimsical and inconsistent."

That is, actually, a double-barreled postulate, which seems quite singular to the primitive. A Will, in his concept, is by automatic inherent nature whimsical and arbitrary and inconsistent; to him the postulate is simply, "Subjective Wills rule the material world."

Since unknown natural laws will invariably appear to be purely random factors—utterly disordered—the primitive observations bore out his postulate beautifully. Because *all* natural laws were unknown laws to him!

That double-barreled postulate can, however, be broken down in two ways:

1. Deny the first phrase, and maintain "The real world is not influenced at all by whimsical subjective forces."

2. Or deny the second phrase, and hold "The material world is not real, it is created and changed by subjective powers, *which are not whimsical, but lawful.*"

The first modification is, of course, the postulate on which the West is based; the second is the basic postulate of Oriental philosophy. The half-baked crackpot mystic just dotes on the second proposition—minus the last phrase, in which is the rigorous discipline which the crackpot fringe never likes.

The West has, inevitably, been the source of all the great technological achievements . . . and the East has been the source of all of Man's greatest ethical philosophies.

The West has vigorously, not to say violently, denied and rejected the concept of "subjective *reality,*" holding solidly that "subjective" and "reality" are inherently mutually exclusive concepts.

The concept that the Oriental means exactly what he says in "Material things are illusion; only Mind is real,"—sincerely and deeply means it, in a literal sense—is almost impossible for the Westerner to understand. That a nit-witted crackpot of the feather-brained type might believe it, or that the inmate of a state-operated refuge for broken minds might—yes. But that a mature, disciplined mind could hold such utter and obvious rubbish . . . !

And it's equally hard for the Oriental to imagine how a Westerner can hold that only matter and physical forces are real, how any mature, disciplined mind can ignore the obvious fact that thought is not a physical entity, that even the self-blinded Westerner must see subjective facts are certainly as real as the facts of magnetic fields, for instance . . .

The basic difficulty being, of course, that each has accepted one half of a full truth. The Westerner still holds the ancient, primitive-tribal postulate that all subjective things are whimsical, arbitrary, inconsistent, and fundamentally without law or order. His observations through the centuries have fully confirmed that; subjective facts are certainly as real as wishes and emotions, have been completely random factors in life, having no value except to interfere with orderly, rational, physical realities.

Because Western man knows as little about the natural laws of Subjective Reality as did the primitive tribesman—perhaps, actually, less than the tribal witch doctor did. True, the witch doctor didn't know them as *laws,* but he did have a number of rules of thumb that worked. After all, one can't properly say that a Roman engineer knew the *laws* of the physical chemistry of mortar; he just used the stuff because it worked.

And naturally, Western men fear subjective reality; it's a destructive, disorganizing, upsetting system, whenever it does operate—a thing to be denied and avoided in every possible way.

Naturally; an unknown Natural law will usually manifest itself in destructive, or obstructive, manifestations, because that's most probable. And so long as the West flatly denies any possibility of there being any such things as *laws* of subjective reality—we are denying the concept

"reality" as we now mean that term. To us, in this century, "reality" and "ordered, lawful" are inseparable; the idea of a whimsical "reality" we can't imagine. And since we *know* subjectivity is whimsical, that proves it isn't reality at all.

Hm-m-m . . . but who proved that we *know* subjectivity is whimsical? "The rain falleth on the just and the unjust alike," was stated originally because rain represented a completely lawless, arbitrary, unpredictable factor in living. They *knew* it was lawless. Today we know it is Lawful.

Instincts evolved by a process of elimination—usually a grim and final elimination; they give us answers to problems that were never understood at any time by any of the ancestral forms that evolved those answers. We live by reason of them, without understanding—and, now, without understanding the immense validity of those instincts! We handle most of the problems the existence of subjective reality laws present quite handily—just as we handle most of the problems an oxygen-water environment presents quite handily, without the slightest notion of the exceedingly complex chemistry required to do so. (What metal, widely available in the Earth, can stand the corrosive conditions human skin readily endures? Science is trying to build a fuel cell that can breathe air and fuel, and produce power—and finding that low-temperature air-breathing trick a really cagey one!)

A billion billion ancestors painfully—and lethally—paid for the rules of thumb that were incorporated in us as instinctive subjective mechanisms—just as other, earlier ancestors bought and paid the full price for a complete education in organic chemistry.

A Congolese tribesman can get along quite well, denying that chemistry exists, or that, if it exists, it is important, and further, if it existed and were important, it has nothing to do with him . . . because some three billion years of evolution have provided him with a working level of chemistry that no Western student has yet even started to approach.

But the Congolese is about to learn that chemistry exists, and is important, and is crucially important to him. The chemistry of propellant powders, and internal combustion engines, and nerve gases are about to enter his life—and his anciently learned, inherited chemical mechanisms aren't able to handle those problems.

Our inherited mechanisms at the subjective level have stood us in good stead; we've been able to deny their very existence, and still survive!

But something exists there—and it had best be looked into. Because the degree to which subjective louse-ups are striking today is reaching the point of no return.

Consider, for a moment, that our stupid, ignorant, superstitious ancestors, who were so misguided as to believe that there was such a thing as a nonphysical reality, might in

actuality have worked out a few rules-of-thumb at that level, as Damascus armorers had worked out some workable techniques for making fine steel —without understanding, and with invalid theory, but workable.

Now reports of what those rule-of-thumb experts, called enchanters, were reputed to be able to do have come down to us—garbled, no doubt, and exaggerated, and loaded with the fear-hate-denial of Western culture's rejection of anything of the subjective nature. Still . . . some of the data may be usable.

May I call to your attention that the traditional descriptions of how an enchanted individual behaved bear a most remarkable resemblance to the known behavior patterns of a man with an acute compulsive or repressive neurosis?

That any psychiatrist or doctor knows that psychosomatic illnesses can kill—and *not* because the patient "knows about it," but because he does *not* know about it at any useful, reachable level.

If it can be shown, in any way, that so much as *one* instance of an unknown Law of Subjective Nature exists—then there exists an unknown factor that we can absolutely depend on to act as an apparent random—no matter how rigidly lawful it in fact may be. That if so much as one law of Subjective Nature exists, it becomes probable that more than one exists.

With that in mind . . . try using the dowsing rods for locating pipes.

If you can do it—the fundamental postulate of Western Culture is false. And you'll understand the deep, emotional resistance to exploring a real-world phenomenon in the minds of the Guardians of the Culture—the professional educators.

If you can do it—then it is *not* true that there is no reality but physical, and that "subjective" and "reality" are mutually exclusive terms.

You have subjective mechanisms just as real, just as hard-won by evolving ancestors, as your chemical mechanisms.

The difference is that your intellect is, now, able to help your biochemistry recover from an accidental chemical onslaught—and to avoid chemical dangers by reasoned thought.

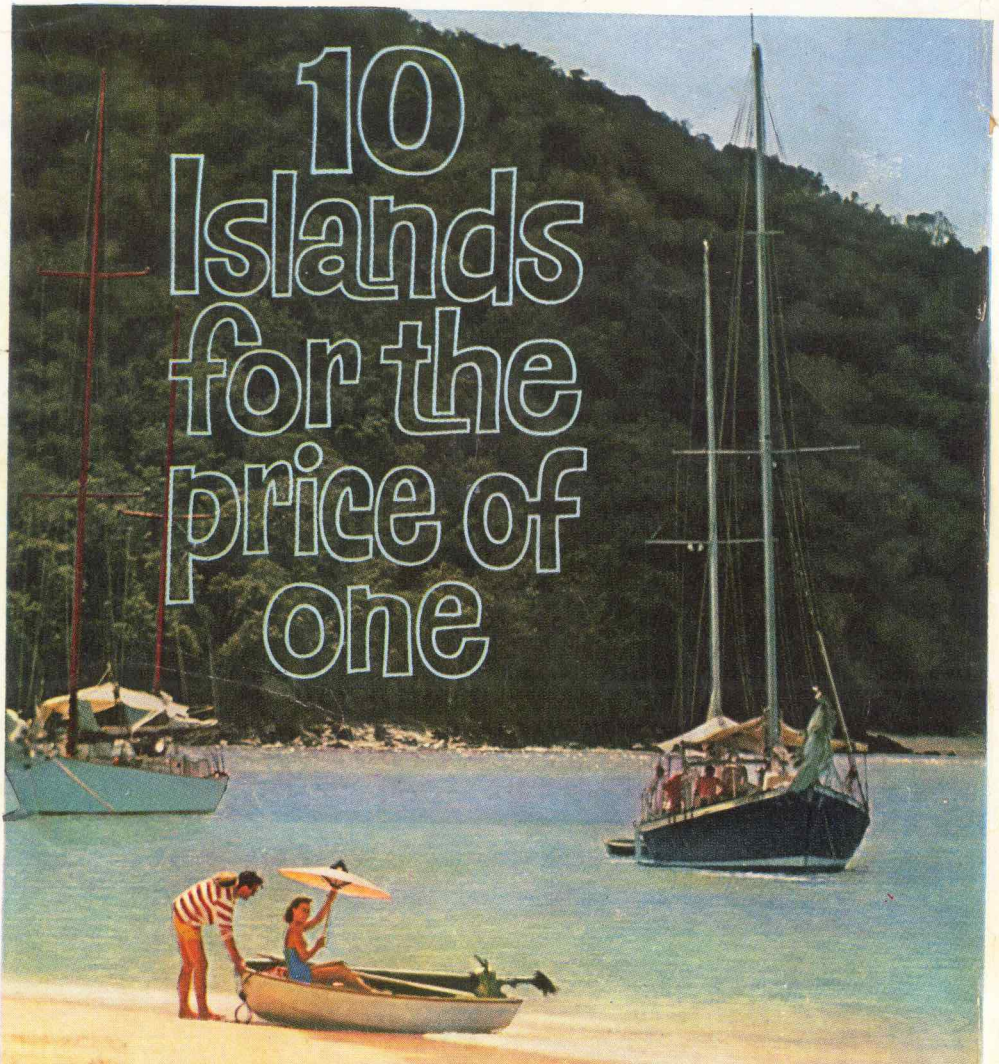
But your intellect is totally ignorant of what constitute deadly dangers to your subjective mechanism, or how to help a subjective metabolism recover from accident, attack, or disease.

Just possibly, it's time Western culture matured enough to get over the "either-or" syndrome, and acknowledge that *both* physical-objective, *and* nonphysical-subjective realities exist. That neither is an exclusive Ruler of All—that the world is certainly not an illusion. But that, equally, mind is no illusion, either.

Because we do not know that a natural law exists, the fact that we ignore it, definitely will not make it go away.

There's a much greater chance that *it* will make *us* go away.

The Editor.



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