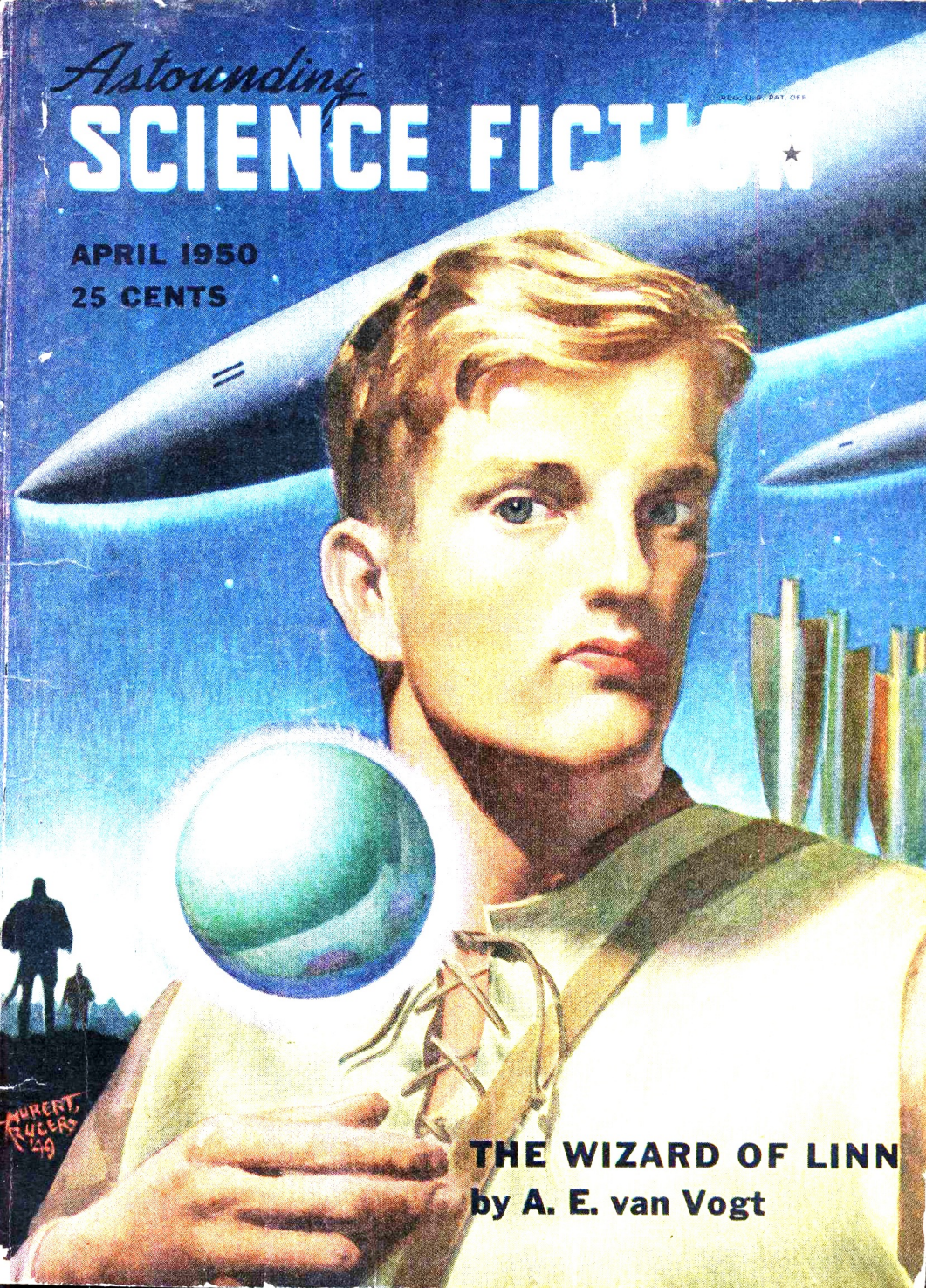
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THE WIZARD OF LINN
by A. E. van Vogt
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CONTENTS

APRIL, 1950 VOL. XLV, NO. 2

SERIAL

NOVELETTE

SHORT STORIES

ARTICLES

READERS' DEPARTMENTS

Editor
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AST—1T

CONTROL CIRCUIT

The most powerful research tool man has developed in the millenniums of human history is an enormously complex device known as a reference library. And it is very decidedly a research tool—one without which most modern science would be next to impossible. There is such an immense mass of data on such an inordinate number of the facets of nature already determined and filed away in references, that no researcher can afford to start his new project without first searching the references to determine what has been done.

A failed experiment is a very useful experiment, for all that it didn't work. It's one of Nature's answers to one of mankind's questions. Nature will invariably answer any question that's asked; the experimenter hopes, naturally, that the answer will be "Yes, that's right!" Of course, the probabilities are always in favor of "No—wrong idea. Try again." Or, even worse, "Yes . . . No . . . Maybe . . . indeterminate!" A library can be enormously helpful in listing all the questions Man has asked Nature . . . and all the answers Nature has given back.

It's like the old game of "Twenty Questions"; to play it, you must think up good, searching, relevant questions—and remember accurately all the answers that have been given to previous questions. Otherwise you'll waste questions repeating lines of investigation that have already been tried.

The mass of man's data has reached such an enormous bulk now that not only is it beyond any human memory, but it is impossible for any human being to remember even the general outline of all that has been done in all fields. Where originally there was the field of "Natural Philosophy," covering all the physical sciences, we have a hundred branches now. And many times the problem that is acutely troublesome in electronics, for instance, could be solved readily if only the electronics specialists knew and used the techniques of microbiology.

The bulk of man's greatest research tool has, in other words, reached such proportions that he can no longer wield it effectively. It is so big and powerful it has become clumsy.

Usually, when men are faced with such a problem, they devise a machine that can handle the big and bulky equipment—a control device that, in its specialized and highly limited way, has more-than-human powers. A library is a more-than-human memory; what research libraries lack is a more-than-human data-finding system. And nowhere has that lack been felt more acutely than in the Atomic Energy Commission.

Co-operation between the United

States Department Of Agriculture and the AEC is developing a device known as the "rapid selector"—a reference library searching machine that can find data quickly. It is still, naturally, in its crude beginning, but it promises to make the immense combined and stored power of ten thousand human minds that lies in libraries available as a single, dextrous and powerful tool, capable of being applied sharply and quickly to any problem. The importance of data is zero—unless it can be found and used where it is relevant and necessary. While the total of Man's knowledge was small in bulk, the library itself was the most important invention. At the present stage, the rapid selector gives the library a new lease on useful life; data whose value was rapidly sinking toward zero by sheer burying regains value immediately.

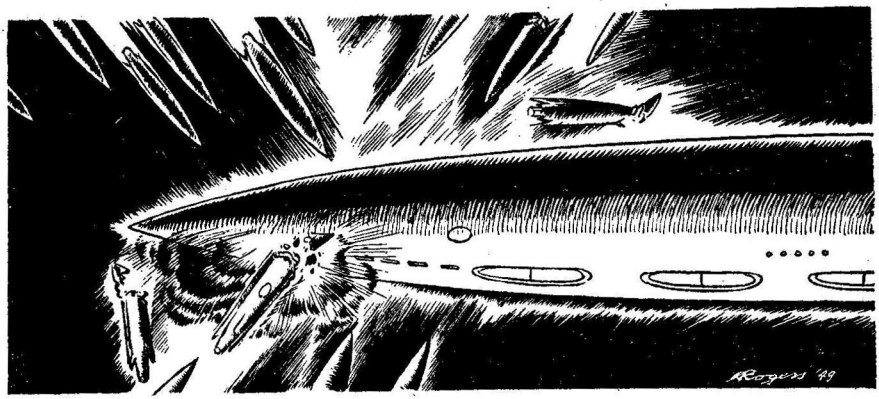
During the war there was a terrific demand for crystal quartz—a demand that could not be satisfied. The Bell Laboratories have now worked out a method of producing it. But another great industrial laboratory, in process of clearing out old files before moving, after the war, to a new location, found in an old laboratory report of 1910 a description of a method of producing quartz crystal. The report had been lost for thirty-five years because no one looked for it; a year's development started in 1940, when the need for quartz crystal became evident, might have given us the supply we needed five years earlier!

What you don't know you know, you might as well not know!

The rapid selector as now developed is built around a reel of microfilm. The microfilm carries, side by side, a frame of research data and a pattern of black-and-white dots. Some sixty thousand references can be photographed onto one reel. The pattern of dots is a file-code that reacts on photoelectric cells; the research worker can punch into the machine the nature of the problem he is interested in, and start the reel. In four minutes, all sixty thousand references will be scanned, and every one that corresponds to the file-code request will be instantaneously photographed onto microfilm copy paper. The machine finds the desired reference, and without slowing the fifteen-thousand-item-a-minute search speed, projects the desired data by means of a millionth-of-a-second flash of light onto a finished print. Any given reference can be cross-indexed as many as six different ways; if more cross references to a given item are wanted, it can be repeated with another six cross-indexings.

This is a crude beginning. The importance is not that it is merely a gimmick for making things easy for the researchers; it is a tool that will make the mightiest of all tools —accumulated knowledge—actually usable. And a civilization can fall for lack of ability to apply its knowledge!

THE EDITOR.



THE WIZARD OF LINN

BY A. E. VAN VOGT

***First** of Three Parts. Lord Clane of Linn had remnants of a destroyed, mighty civilization. And—now he added the remnants of a destroyed alien creature, to find the whole pattern, a pattern immensely greater than he had imagined!*

Illustrated by Rogers

I.

The "child of the gods" had made progress. Born a despised mutation into the ruling family of the half-barbarous, decadent Linnan empire about 12,000 A.D., he had grown up almost unnoticed by those in the family and government who schemed endlessly for power. Contemptuously relegated to the temples for training, he learned the inner meaning of matter from a few wise men who had guessed the secret behind the atom gods. By the time his potential enemies realized that he might be dangerous to their plans, he was too powerful to be destroyed.

He explored the gigantic pits where the atom gods were believed to dwell, and learned that they were remnants of destroyed cities. From

these husks of what had once been megalopolitan centers, he gathered odds and ends of machinery and weapons, including a sphere of energy that absorbed or disintegrated all energy and matter it touched, except—this was a guess on Clane's part, based on the fact that so tremendous a weapon had been unable to defend the vanished civilization—"protected" matter. The sphere reacted to the thought of the person who controlled it.

His discoveries explained many things. They explained the half-mythical stories about a long dead wonderful civilization that had apparently existed some thousands of years before. They gave a clearer picture of how a bow and arrow culture could exist side by side with simple-type spaceships that any skillful metal worker could build, and they offered a partial explanation of the so-called "god" metals which powered the ships. But the mystery of the forgotten disaster remained unexplained.

And then Czinczar and his barbarian hordes from Jupiter's moon, Europa, invaded Linn. He brought with him the dead body of a large, nonhuman creature. Czinczar believed that long ago other such beings had come from the stars and obliterated man's civilization. And though his own attack against the Linnan Empire failed, his statesmanlike attitude toward the welfare of the human race enabled him to convince Clane that the presence of one monster in the solar system implied that another invasion was imminent. Clane who had come across vague references to a Riss enemy in ancient books, was impressed by the barbarian's sincerity. But he rejected Czinczar's demand that he take control of the Linnan Empire. There were too many complications.

There was, for instance, the fact that the new Lord Adviser, Lord Jerrin, was his brother.

In the deceptive darkness of space, the alien ship moved with only an occasional glint of reflected sunlight to show its presence. It paused for many months to study the moons of Jupiter, and the Riss-creatures aboard neither concealed the presence of their ship, nor made a particular display of it or of themselves.

A score of times, Riss exploring parties ran into human beings. Their policy on such occasions was invariable. They killed every human who saw them. Once, on remote Titan, the hilly nature of the terrain with its innumerable caves enabled a man to evade the net they spread for him. That night, after he had had ample time to reach the nearest village, an atomic bomb engulfed the entire area.

For what it was worth, the policy paid off. Despite the casual way their ship flew over towns and villages, only the vaguest reports of the presence of a big ship were spread. And for long no one suspected that the ship was not occupied by human beings.

Their precautions could not alter

the natural order of life and death. Some hours out of Titan, a Riss workman who was repairing a minor break in an instrument on the outer skin of the spaceship, was struck by a meteor. By an immense coincidence, the flying object was moving in the same direction as the ship and at approximately the same speed. The workman was killed by the blow, and swept out into space. On Europa, the largest moon, a Riss one-man exploring craft made its automatic return to the mother ship but without its pilot aboard. Its speedometer registered more than a thousand miles of flight, and those who tried to follow its curving back trail found themselves over mountains so precipitous that the search was swiftly abandoned.

Surprisingly, both bodies were found, the former by meteor miners from Europa, the latter by troops engaged in grueling maneuvers preliminary to Czinczar's invasion of Earth. Both monstrosities were brought to the leader; and, putting together various reports he had heard, he made an unusually accurate guess as to the origin of the strange beings.

His attack on Earth took place a few months later while the alien ship was still in the vicinity of Europa. And his defeat at the hands of Lord Clane Linn followed. The machine from the stars continued its unhurried voyage of exploration. It arrived on Mars less than a month after Lord Jerrin and his army embarked for Earth, and another month went by before its presence was reported to the Linnan military governor on Mars.

A descendant of the great Raheinl, he was a proud young man, who dismissed the first account as a tale of simple imagination, all too common in these regions where education had fallen a victim of protracted wars. But when the second report came in from another section, it struck him that this might be the Martian version of the barbarian invasion. He acted swiftly and decisively.

Police spaceships and patrol craft scoured the atmosphere. And, since the alien made no effort to avoid being seen, contact was established almost immediately. Two of the police craft were destroyed by great flares of energy. The other ships, observing the catastrophe from a distance, withdrew hastily.

If the Riss noticed that they were now in a more highly mechanized part of the solar system, they did not by their actions let it disturb them. If they guessed that in these regions their action meant war, they seemed equally unaware of that.

The governor dispatched a warning to Earth, and then set about organizing his forces. For two weeks his patrol craft did nothing but watch, and the picture that came through was very satisfactory to the grim young man. The enemy, it appeared, was sending out exploring parties in small ships. It was these, on the fifteenth day, that the human-manned ships attacked in swarms.

The technique of assault had been

very carefully worked out. In every case an attempt was made to ram the Riss craft. Four of the attacks were successful. The smashed "lift" boats glittered in the dull afternoon light as they fell to the flat earth below. Swiftly, spaceships darted down, drew the fallen machines aboard, and hastily took off for widely separated landing fields.

It was a major victory, greater even than was immediately suspected. The enemy reacted the following morning. The city of Gadre blew up in a colossal explosion that sent a mushroom of smoke billowing up to obscure the atmosphere for a hundred miles.

The ferocity of the counterattack ended the war on Mars. The alien was left strictly alone thereafter. The youthful Raheinl, stunned by the violence of the response, ordered the evacuation of the larger cities, and dispatched another of a long series of warning reports to Earth. He also sent along for examination the two largest and least damaged of the enemy small craft which he had captured.

It was about a month later that he ceased to receive reports of the ship's presence inside the Martian atmosphere. He concluded that it had departed for Earth, and made out his final report on that basis. He was relieved.

The problem would now be faced by those who were in the best possible position to know if it could be handled at all.

Jerrin put down the first report from Mars as his wife Lilidel entered the room. He rose to his feet, and gravely assisted her and the babe-in-arms she carried—their seventh child—to a chair. Then, uneasily, he returned to his own chair. He had an idea that he was going to hear more about a certain person.

Lilidel began at once. And, as he had expected, it *was* about his brother, Clane. He listened politely, with a sense of dissatisfaction in her, a feeling of exasperation that came to him whenever she tried to influence his judgment for emotional reasons. When she had gone on for several minutes, he interposed gently:

"My dear, if Clane had wanted to seize control, he had two whole months between the end of the barbarian war and my return."

She waited respectfully while he spoke. Lilidel—he had to confess it—was a remarkable wife. Dutiful, good, gracious, discreet, and with an unblemished past, she was, as she had pointed out many times, a model among the women of noble birth.

Jerrin could not help wondering at times what it was about her that annoyed him. It made him unhappy that he had to have thoughts like that. Because, considered in individual segments, her character was perfect. And yet, the woman-as-a-whole irritated him at times to the point of distraction. Once more, he spoke:

"We have to recognize that Clane conducted the barbarian invasion

campaign with remarkable skill. I still don't quite see how it was done."

He realized immediately that he had said the wrong thing. It was a mistake, according to Lilidel, to be too generous with appreciation for the merits of other men. Clane had only performed his duty. There was no reason why he should not retreat now into private life, and restrict his ambition for the good of the family and of the state.

Jerrin listened unhappily. He was seriously dissatisfied with the way he had acted towards his brother's victory. At the very least, a Triumph should have been offered Clane. And yet, his advisers in the Patronate had persuaded him that such recognition would be highly dangerous.

When he spoke again, his reply seemed to be a direct answer to Lilidel. Actually, it was partly a defensive reaction to all the people who had held down his natural impulse to give credit where it was due. He said:

"My dear, if some of the things I've heard about Clane are true, then he could seize control of the government at any time. And I should like to point out one more thing: The idea that the Lord Advisership is now a rightful property of my branch of the family is an illusion. We may hold it, but power slips from a person's grasp even as he thinks he has it firmly gripped. I have here"—he picked up the report from Mars—"a most disturbing message from General Raheinl—"

He was not allowed to change the subject as easily as that. It seemed that if he did not have any ambition for himself, at least he could think of his own offspring. It appeared that it was up to him to insure that his eldest son was confirmed in the succession. Young Calaj was now seventeen years of age, and the plan for him should be made clear at an early date. Jerrin cut her off at last.

"I've been intending to tell you. I have to make a tour of inspection in the provinces, and I am scheduled to leave this afternoon. We'd better postpone this discussion till I return."

Lilidel put in a final word on the subject of how fortunate he was to have a wife who accepted his ever more frequent absences with a heavy but understanding heart.

II.

Somebody said, "Look!"

There was so much amazement and wonder in the word that Lord Jerrin whirled involuntarily. All around him, men were craning their necks, staring up at the sky.

He turned his gaze to follow that collective stare. And he felt a flame-like shock. The ship up there was enormous beyond all his previous experience. He guessed, from his detailed knowledge of the limitations of spaceship construction on Earth, that it was not of the solar system. His mind flashed back to the messages that had come from his military governor on Mars. For a mo-

ment then a feeling of imminent disaster seized him.

His courage flooded back with a rush. He estimated that the stranger was a third of a mile in length. His sharp eyes picked out, and noted for future reference, details of construction dissimilar to anything he had ever seen before. As he watched, the great machine floated by silently. It seemed to be about three miles above the ground, and its speed could not have been very great, because after a minute it was still visible in the distance. It disappeared finally beyond the mists of the eastern horizon.

Before it was out of sight, Jerrin was giving his orders. He had still to receive the message about the destruction of the Martian city Gadre, but he was more cautious than Raheinl had been. The fleet of spaceships and smaller craft which he sent after the stranger had strict orders to keep at a distance.

The preliminary defensive measures taken, Lord Jerrin returned to the City of Linn, and settled down to await reports. By morning, half a dozen messages had arrived, but they added nothing of importance to what he had personally observed. What did count was the arrival about noon of a letter from Lord Clane.

Your Excellency:

I earnestly urge that you order the evacuation from the large cities of all forces and equipment necessary to the defense of the realm.

It is vital that this ship from another sun be destroyed. There is some reason to believe that those aboard are descendants of the same beings who destroyed the legendary civilization of Earth. Riss they were called.

I request that there be a meeting between us as soon as possible. I have a number of valuable suggestions to make concerning the tactics to be employed against the enemy.

Clane

Jerrin read the note several times, and tried to picture the details of the evacuation that his brother was recommending. Considered in its practical details, the enterprise seemed so vast that he put the letter aside angrily. Later he bethought himself, and sent a reply.

Most Excellent Brother:

All necessary and practicable precautions are being taken. I shall be most happy to have a visit from you at any time.

Jerrin,
Lord Adviser of Linn

When that had been sent off, he wondered for the first time how Clane had learned so quickly of the interstellar ship. It seemed farfetched that he also could have seen it personally. The incident was merely one more confirmation of his suspicion that there were supporters of Clane in every branch of the service including, apparently, his own staff.

By evening, when the reports about the ship were coming in steadily, the bitterness of his feeling against his mutation brother yielded to the need for a careful study of the mounting pile of evidence.

Now, the alien ship was crossing the ocean. Then it was over the

mountains. Next, it stopped for an hour above the city of Goram. A hundred small craft emerged from it, and spent the daylight hours exploring the nearby hills.

In spite of Jerrin's orders that none of the visitor's "lift" boats be interfered with, two incidents occurred. They took place at widely separated points, but were similar in outcome. Both resulted from Earth patrol boats venturing within a mile of one of the small enemy vessels.

Observers reported flashes of blue fire. The Earth craft burst into flame and crashed, killing their occupants.

The news, when it reached him, shook Jerrin. But it confirmed him in a plan that had been growing on him. He had been waiting to hear from Mars the outcome of Raheinl's plan. (He took it for granted that the ship which had come to Earth was the same one that had been on Mars. And that it had merely made the journey from the fourth planet to the third one more swiftly than the spaceship which undoubtedly was bringing the report of the Martian governor.) But now it seemed to him the answer was clear.

The alien had come from another star. Soon, it would go back home. Therefore, since those aboard were making no attempt to communicate with him, they should be allowed to carry on as they pleased. Meanwhile, the Linnan fleet would strengthen its defenses, and be ready for a crisis. When he communicated these instructions to his chief of staff, the officer stroked his mustache, and said finally:

"What do you mean—strengthen our defenses? In what way? Have more spears and arrows manufactured?"

Jerrin hesitated. Put in that way, his plan sounded blurred. He said at last, "Be alert. Be ready for sacrifices."

He didn't know what he meant by that, either.

The second day went by while his sense of inadequacy grew. The following morning the officer in charge of the men and women watching Lord Clane and his chief supporters reported that the mutation was moving all his equipment out of his residence in the city of Linn.

Jerrin considered that in a gathering anger. It was exactly the kind of incident that could start a panic, if it became known. He was still seething when a second note arrived from his brother.

Dear Jerrin:

I have received the news of the Martian disaster, and I urge you to order the evacuation of Linn and other cities.

I tell you, sir, this ship must be destroyed before it leaves Earth.

Clane

It was a sharp letter. Its curtness brought the color flooding to Jerrin's lean, tanned cheeks. And for more than a minute the tone, and not the contents, absorbed his full attention. Then he thought, "Martian disaster!"

Holding himself calm, he sent a courier to the field where the official

ships from Mars always landed. The courier returned empty-handed.

"No ship has arrived from Mars for more than a week, your excellency."

Jerrin paced the floor of the palace reception room. He was amazed, and concerned to realize that he believed that Clane had received information which the government did not have. He recognized that the mutation had revealed a personal secret in letting him know by this indirect method that he had a faster means of communiaction with the planets. The willingness to let that secret out seemed significant now.

And yet, he could not make up his mind to accept all the implications in good faith.

He was still worrying about it when Lilidel came in. As usual, she brought one of the children with her.

Jerrin studied her absently as she talked. She was no longer the great beauty he had married, though her remarkably even features remained almost unchanged from the day he had first met her.

Not her face, but her body showed the marks of the years that had gone by, and the children she had borne. Jerrin was not unreasonably critical. He only wished his wife's character had altered as little as her body. He said presently, patiently:

"I want to make one thing clear. A man who cannot protect the empire cannot hold his office. I suggest that you cease worrying about the succession of our Calaj, and

seriously consider the desperate position we are in as a result of the presence of this strange ship."

Quickly, he told her of the messages he had received from Clane. When he had finished, the woman was pale.

"This is what I feared," she said in a tensed voice. "I knew he had a scheme afoot."

The egocentricity of the remark startled him. He pointed out that Clane could hardly be considered responsible for the appearance of the ship. Lilidel brushed the explanation aside.

"What reason he uses doesn't matter," she said impatiently. "When a man has a purpose, any reason is good."

She was going on in the same vein when Jerrin cut her off. "Are you insane?" he said violently. "Let me inform, you madam, that I will not tolerate such nonsense in my presence. If you wish to chatter about Clane's conspiracies against the state, please don't do it to me." His anger aroused by her illogicalness, he forgot for the moment his own suspicions of Clane.

Lilidel stared at him with hurt eyes. "You've never talked to me like this before," she sniffled. She clutched the little girl tightly against her, as if to protect herself from further thrusts.

The action also served to call attention to the presence of the child. There was a pattern to the movement that abruptly pulled Jerrin back along the years, to all the other occasions when she had brought one of their children whenever she came to him with a complaint or a request. *Or a request.* The shock of the thought that came was terrific. He had always been proud of the fact that Lilidel, unlike the scheming consorts of rulers of other days, had never used her relationship with him for private purposes.

Now, he had a flashing picture of the *thousands* of times she had come to him to forward the interest of some individual. She had suggested appointments to positions of varying importance, all the way up to governorships. In her quiet way she had promoted a fantastic number of decrees, orders, and laws, only a fraction of which could possibly have originated in her own mind.

He saw her, suddenly, as the spokesman for a group that had been ruling the provinces he commanded by taking advantage of his preoccupation with military affairs. Through him they had set up a vast organization subservient to their interests. And it was they who wanted to turn him against Clane.

The extent of the betrayal sobered him. It was hard to believe that Lilidel could be aware of the implications of what she had done and was doing. It was easier to believe that her character, too, had been analyzed by clever men, and that she was being used. Unquestionably, however, she must be playing the game consciously as far as she understood it. He did not doubt that she loved her children.

The problem was too great to be acted on immediately. Jerrin said quietly: "Please leave me. I have no desire to talk to you harshly. You caught me at a bad moment."

When she had gone, he stood for a long time undecided, his mind again on Clane's message. At last he thought: *The truth is, I have no solution to the problem of the invading ship. It's time to find out if Clane has.*

His message to his brother was brief and to the point: "Let us meet. Name date, place and conditions."

Clane's reply was, "Will you order the evacuation of all large cities immediately? And then will you come if I send a ship for you?"

"Yes," Jerrin answered back.

III.

There was no sign of Clane when the Lord Adviser's party arrived at the spaceship. Jerrin accepted the implications of that with a grim smile, but there were murmurs of annoyance from his staff. The tension ended as an officer in general's uniform came hurrying down the gangplank. He came up quickly, saluted, and stood at attention, waiting for permission to speak. Jerrin gave it. The man said quickly, apologetically:

"Your excellency, Lord Clane sends his sincere regrets that he was unable to complete certain preliminaries. We are to pick him up at his estate, and he will wait upon you the moment he comes aboard."

Jerrin was mollified. He was no stickler for rules, but he did not have to be told that people who deliberately broke them were expressing unspoken purposes and thoughts, which, on the government level, could mean open rebellion. He was glad that Clane had chosen this way to express his purposes. He was fulfilling the minimum of amenities.

Jerrin was not so indelicate as to inquire the nature of the "preliminaries" that had caused the delay. He took it for granted that they existed only in the imagination.

From the porthole of his apartment, a few minutes later, he watched the land recede below, and it was then that his first alarm came, the first realization that perhaps he had been hasty in risking himself aboard this ship without a large guardian fleet. It seemed hard to believe that his brother would risk a major civil war, and yet such things had happened before.

He could not bring himself to admit openly that he might have walked into a trap, so he did not inform the officers of his party of his suspicions.

He began to feel better when the ship started its descent towards Clane's estate landing field. Later, as he watched his brother coming across the field, the anxiety faded even more. He grew curious as he saw that the men behind Clane were carrying an elongated, troughlike metal object. There was something in the trough that shone, and it seemed to be moving back and forth

in a very slow fashion. It was out of his line of vision before he could decide what it was. It looked like a glass ball.

In a short time the ship was in the air again, and presently an officer arrived with Clane's request for an audience. Jerrin granted the request at once. He was puzzled. Just where was this ship heading?

He had been sitting down; but as Clane entered he rose to his feet. The apartment was ideally constructed for a man of rank to receive homage from lesser mortals. From the anteroom, where the entrance was, three steps led up to the larger reception room beyond. At the top of these steps, as if it was a throne dais, Jerrin waited. With narrowed eyes and pursed lips, he watched his brother come toward him.

He had noticed from the porthole that Clane, as usual, wore temple clothing. Now, he had a moment to observe the effect in greater detail. Even in those spare surroundings, he looked drab and unassuming. In that room, with its dozen staff officers in their blue and silver uniforms, he seemed so terribly out of place that, suddenly, the older man could not believe that here was a threat to his own position.

The rigid hostility went out of Jerrin's body. A wave of pity and understanding swept over him. He knew only too well how carefully that clothing covered the other's mutated shoulders and arms and chest.

I remember, he thought, *when I was one of a gang of kids that used to strip him and jeer at him.*

That was long ago now, more than twenty years. But the memory brought a feeling of guilt. His uncertainty ended. With an impulsive friendliness, he strode down the steps and put his great, strong arms around Clane's slim body.

"Dear brother," he said, "I am glad to see you."

He stepped back after a moment, feeling much better, less cynical, and very much more convinced that this delicate brother of his would never compete with him for power. He spoke again:

"May I inquire where we are heading?"

Clane smiled. His face was fuller than it had been the last time Jerrin had seen him. Some of the angelic womanlike quality of it was yielding to a firmer, more masculine appearance. Even the smile was assured, but just for a moment it gave him the appearance of being beautiful rather than handsome. He was thirty-three years old, but there was still no sign that he had ever shaved.

He said now: "According to my latest reports, the invader is at present 'lying to' over a chain of mountains about a hundred miles from here. I want you to witness an attack I am planning to make against the ship."

It took all the rest of the journey for the full import of that to penetrate.

At no time did Jerrin clearly realize what was happening. He

stood on the ground, and watched Clane examine the enemy ship, which was about three miles distant, a shape in the mist. Clane came over to him finally, and said in a troubled voice:

"Our problem is the possibility of failure."

Jerrin said nothing.

Clane continued, "If my use of the Temple metals fails to destroy the ship, then they may take counter action."

The reference to the god metals irritated Jerrin. His own feeling about the Temples, and of the religion they taught, was from the viewpoint of a soldier. The ideas involved were useful in promoting discipline among the rank and file. He had no sense of cynicism about it. He had never given thought to religion of itself. Now, he felt a kind of pressure on him. He could not escape the conviction that Clane and the others took it for granted that there was something in the religion. He had heard vague accounts of Clane's activities in the past, but in his austere and active existence, with each day devoted to an immense total of administrative tasks, there had never been time to consider the obscure tales of magic that occasionally came his way. He felt uneasy now, for he regarded these things as of a kind with other superstitions that he had heard.

Apparently, he was about to be given an exhibition of these hitherto concealed powers, and he felt disturbed. *I never should,* he thought, *have allowed myself to become involved with these metaphysicians.*

He waited unhappily.

Clane was eying him thoughtfully. "I want you to witness this," he said. "Because on the basis of it, I hope to have your support of a major attack."

Jerrin said quickly, "You expect this attack to fail?"

Clane nodded. "I have no weapons better than those that were available during the olden Age. And if the best weapons of that great scientific era were unable to stave off the destruction that our ancestors barely survived, then I don't see how we can be successful with odds and ends of their science."

He added, "I have an idea that the enemy ship is constructed of materials in which no pattern of destruction can be established."

The meaning of that shocked Jerrin. "Am I to understand that this first attack is being undertaken with the purpose of convincing me to support a *second* attack? And that it is this second attack you are building your hopes on?"

Clane hesitated, then nodded. "Yes," he said.

"What is the nature of your second plan?" Jerrin asked.

He grew pale as Clane outlined it. "You want us to risk the fleet merely as a support?"

Clane said simply, "What else is it good for?"

Jerrin was trembling, but he held his voice calm. "The role you have in mind for yourself to some extent

shows how seriously you regard this matter. But, brother, you are asking me to risk the state. If you fail, they'll destroy cities."

Clane said, "The ship cannot be allowed to return home."

"Why not? It seems the simplest solution. They'll leave sooner or later."

Clane was tense. "Something happened," he said. "It was not a completely successful war for them thousands of years ago. They were driven off then, apparently not aware that they had caused irreparable damage to the solar system by destroying all its cities. If this ship gets back now, and reports that we are virtually helpless, they'll return in force."

"But why?" said Jerrin. "Why should they bother us?"

"Land."

The blood rushed to Jerrin's face, and he had a vision then of the fight that had taken place long ago. The deseperate, deadly, merciless war of two races, utterly alien to each other, one seeking to seize, the other to hold, a planetary system. The picture was sufficient. He felt himself stiffening to the hard necessities. He straightened.

"Very well," he said in a ringing voice, "I wish to see this experiment. Proceed."

The metal case with the silvery ball rolling back and forth in it was brought to the center of the glade. It was the object Jerrin had watched them bring aboard at Clane's estate. He walked over to it, and stood looking down at it.

The ball rolled sedately first to one end, and then back again to the other. Its movement seemed without meaning. Jerrin put his hand down, glanced up to see if Clane objected to his action; and when Clane merely stood watching him, lowered his finger gingerly into the path of that glistening sphere.

He expected it to be shoved out of the way by a solid metal weight.

The ball rolled through it.

Into it, through it beyond it. There was no feeling at all, no sensation of substance. It was as if he had held his hand in empty air.

Repelled by its alienness, Jerrin drew back. "What is it?" he said with distaste.

The faintest of smiles came into Clane's face. "You're asking the wrong type of question," he said.

Jerrin was momentarily baffled, and then he remembered his military training. "What does it do?"

"It absorbs any energy directed at it. It converts all matter that it touches into energy, and then absorbs the energy."

"It didn't convert my finger into energy."

"It's safe to handle while it's in its case. It probably has a limitation on the amount of energy it will absorb, though I have yet to find what it is. That's what gives me hope that it just might be useful against the enemy."

"You're going to use it against *them?*"

Incredibly, it hadn't occurred to him that this was the weapon. He stared down at it, shocked; and the feeling—which had briefly gone away—that he was being made a fool of in some obscure fashion, returned. Jerrin looked around him unhappily. An armor-plated battleship a third of a mile long floated in the mists to the southeast. Down here, a dozen men stood in a forest glade. Nearby, lay the small, open-decked craft which had brought them from their own spaceship some ten miles away. The craft was unarmed except for a score of bowmen and spearmen.

Jerrin controlled himself. "When are you going to attack?"

"Now!"

Jerrin parted his lips to speak again, when he noticed that the silvery ball was gone from its case. With a start he looked up—and froze as he saw that it was floating in the air above Clane's head.

It was brighter now, and danced and blurred, and quivered like something alive. It was a shiningness, insubstantial yet palpable. Featherlight, it floated above the mutation's head, riding with his movements.

"Watch the ship!" Clane pointed.

The words and the movement were like a signal. The "ball" was abruptly gone from above his head. Jerrin saw it momentarily, high in the sky, a gleam against the dark bulk of the great ship. There was a flash of shiningness, and then the fantastic thing was back over Clane's head.

High above them, the great ship rode its invisible anchors, apparently unharmed.

Jerrin said with disappointment, "It didn't work?"

Clane waved at him, a spasmodic movement of his hand. "Wait!" he said. "There may be a counterattack."

The silence that followed did not last long.

A rim of fire appeared along a line of the ship running from the nose to the tail. Miles away in the forest, thunder rolled. It came near, and grew louder. A quarter of a mile away through the brush, there was a bright splash of fire, and then it was a quarter of a mile beyond them, on the other side.

Jerrin noticed that for just a moment while the thunder and flame threatened them, the ball was gone from above Clane. When he looked again, it was back in position, dancing, bobbing, blurring. Clane must have caught his distracted gaze, for he said:

"They couldn't locate us, so they plotted a curve, and struck at intervals along that line. The question is, will they notice that there was no explosion at one of the probable centers of the attack against them?"

Jerrin guessed then that the enemy had plotted an accurate curve, and by some magic science had picked their exact position as one of the areas to attack.

And apparently the shining sphere had absorbed the energy of the attacking force.

He waited, tense.

After five minutes, there was still no sign of a further attack. At the end of twenty minutes, Clane said with satisfaction, "They seem to be satisfied with their counterattack. At least we know they're not superhuman. Let's go."

They boarded the small craft, slid along for a while slowly under a spread of tree branches, then turned through a narrow pass and so into a valley from which the big ship was not visible. As they picked up speed, Clane spoke again:

"I'd like to have a look at those captured craft that Raheinl sent you from Mars. The sooner we act the better. There may be retaliations."

Jerrin had been thinking about that, thinking of how deeply he was committed. An attack had been made, the enemy advised by active means that his presence was resented. The war was on, and there was no turning back.

He asked quietly, "When do you plan to make your second attack?"

IV.

The invading ship had fortunately not come nearer to the city of Linn than about a hundred and fifty miles. So it was natural that its first victim should not be the capitol. A large midland city received the first blow.

The bomb was dropped approximately twenty hours after Clane's attempt to destroy the alien with the sphere. It dropped on a city that had been evacuated except for street patrols and the looters who made the patrols necessary. Dense clouds of smoke hid the damage and the disaster.

Less than half an hour later, a second city was struck by one of the colossal bombs, and the poisonous smoke rose up in its toadstool shape, infinitely deadly and irresistible.

The third city was struck an hour later, and the fourth shortly after noon. There was a pause then, and a host of small craft were seen to emerge from the giant. They explored the outer edges of the four gigantic smoke areas, and flew tantalizingly near Linnan patrol craft, as if trying to draw their fire.

When the news of this maneuver was brought to Clane, he sent a message to Jerrin:

Most Excellent Lord Leader:

It would appear that they were severely surprised by our attack yesterday, and are now trying to draw the fire of more such weapons as I turned against them, possibly with the hope of finding out exactly how much strength we can muster against them.

Having examined the machines captured from them by Raheinl, I am happy to report that one needs only minor repairs, and that we can launch our attack possibly tomorrow night.

Yours in hope,

Clane

Certain characteristics of the alien patrol craft puzzled Clane. As he supervised the work of the mechanics, he had to force himself by effort of will to concentrate on the coarser aspects of the task.

"If I have time," he told himself,

"I'll investigate that attachment to the steering device."

The two machines lay side by side in one of his underground workshops. Each was approximately fifty feet long, and basically of very simple design. Their atomic motors were different from those in Linnan ships only in that they were more compact. The principle was the same. A block of treated metal exploded under control in rocket chambers.

For thousands of years machines thus powered had been flying through the atmosphere of the planets.

Jerrin arrived early in the afternoon of the day set for the attack. He was pale and earnest, and subdued. "Seventeen cities," he reported to Clane, "have now been destroyed. They are certainly inviting us to do everything we can."

Clane led him to the controls of the craft that had been repaired. "I've been experimenting," he said, "with a little attachment they have geared to the controls."

He bent down. "I have a map here," he said. "I want you to mark on it where the enemy ship now is, according to the latest reports."

Jerrin shrugged. "That's easy. It's lying to over—"

"Don't tell me!" Clane's words were quick and sharp, and had the desired effect. Jerrin gazed at him questioningly. Clane continued, "I have an idea in connection with this thing, so put your mark—and don't show it to me."

The older man accepted the map, and touched it with the point of a pencil as closely as possible to the exact location of the ship. He stepped back, and waited. Clane touched a button.

There was a faint throb as the motors sounded in the vast emptiness of the underground chamber. Under their feet, the craft turned slowly on its revolving platform, and steadied. The sound of the motors died away. Clane straightened.

"The nose is now pointing north by northeast. Draw a line on the map in that direction from this cavern."

Jerrin drew the line silently. It passed within a millimeter of the point where he had made his mark. "I don't undertsand," he said slowly. "You mean that this craft *knows* where the mother ship is?"

"It seems so, in a purely mechanical fashion of course."

"Then, very likely, the mother ship knows where it is."

Clane frowned. "It could be, but I doubt it. It would be quite complicated, and somewhat unnecessary, under normal circumstances, to keep track of hundreds of small craft. The small craft, however, must be able to return to the big machine."

He added, "If they knew where this craft was, I think they would have made some effort to get it back."

Jerrin shook his head. "The matter seems of minor importance.

After all, we can locate the invader whenever we want to."

Clane said nothing to that. He had studied detailed reports of how these small ships entered into and emerged from their parent. And for hours now, a possibility had been growing on him.

It was not something that could be explained to a practical man. The whole concept of automatic machinery was as new as it was dazzling.

Zero hour was near.

It grew darker as they waited in the shelter of a mountain. Earlier, there had been desultory conversation between them, but now they were silent. From the men in the rear there came only an occasional mutter of sound.

The plan was made. The fleet had its orders. It was now only a matter of carrying out the attack itself.

"Halloo-oo!"

The call floated down from the rim of the peak. Jerrin straightened, and then, stepping close, embraced his brother. The darkness hid his tears. "Good luck," he said, "and forgive me for all the things that I have done or said or thought against you."

He stepped down into the darkness, where his own soldiers waited.

The mechanism of the captured Riss-craft functioned smoothly. Like a shadow, the machine rose, climbed, and flitted over the mountain top. Almost immediately, they were in the center of the battle.

The Linnan spaceships were attacking in groups of a hundred, and they came in waves. They were manned by skeleton crews, and they had two purposes: Engage if possible all the enemy's defenses by diving nose first into the torpedo-shaped invader. That was the first purpose.

It was believed the aliens would not care to have their interstellar ship rammed by hundreds of projectiles weighing thousands of tons each.

The second purpose of the attackers was for each crew to leave its ship in a small escape craft a few moments before contact. The theory was that the air would be so filled with lifeboats that the enemy would not notice their own captured machine approaching.

Clane's energy-absorbing sphere was expected to handle any direct attacks.

The sky flashed with flame. Everywhere, Linnan spaceships were burning and falling. Clane saw no lifeboats, however, and the first sick feeling that the men were not getting away, came. There was nothing to do, however, but go ahead.

The crash of Linnan spaceships striking the metal walls of the invader was almost continuous now; and there was no longer any doubt that the enemy's defenses were not capable of coping with such a complicated attack.

Clane thought tensely: "They'll have to leave. We won't have time to get near." It was a possibility

that hadn't occurred to him, earlier.

He had taken it for granted that the big ship would be able to shrug off the Linnan attack without difficulty, and without moving from its position. Instead, it was being seriously hurt.

Beside him, his commanding officer whispered, "I think I see an opening."

Clane peered where the man was pointing, and saw it, too. He felt a chill, for it was directly ahead. Unmistakably, his craft was aiming toward it—or was being drawn toward it. It was possible that the automatic controls of his small machine had activated a door in the mother ship and that they would be able to enter without resistance. His own plan had been to force an entry with a tiny bomb, and it seemed to him he still preferred that method. The problem now was, was this a trap of those aboard, or was the process so automatic that no one paid any attention to newcomers?

It was a chance he had to take. The greatest danger was that the giant machine would start moving.

The light of the air lock proved deceptively dim. He was estimating that it was still more than a hundred feet away when there was a click. The machine slowed sharply, and he saw a blur of dully colored gray walls slide by on either side.

Doors flowed shut behind them and, in front, another set glided open. The small craft, with its thirty-five men aboard, moved sedately forward —and was inside the ship from the stars.

At his camp headquarters, where he had taken his family for refuge, Jerrin waited.

"They're still inside." That was the terse report from his chief field officer.

After nearly eighteen hours, the reality was a virtual death sentence. Jerrin blamed himself. "I should never have allowed him to go," he

told Lilidel. "It's ridiculous that a member of our family should participate in direct assaults."

He had taken part in more than a hundred direct assaults himself, but he ignored that now. He also ignored the fact that only the man who controlled the energy sphere—Clane himself—could possibly carry out the attack that the latter had outlined to him.

Jerrin paced the floor of his headquarters study; and it was several minutes before he noticed that, for once, Lilidel had nothing to say. Jerrin stared at her narrowly, realizing grimly that she and those behind her were not displeased at what had happened.

"My dear," he said finally, "Clane's failure will have repercussions on the whole state. It will mark the beginning and not the end of our troubles."

Still she said nothing. And he saw that in this crisis she was not able to comprehend the issues. She had her own purposes, the purposes of a mother and of the agent of the group that worked through her. His mind went back to the choice the old Lady Lydia, his grandmother, had made in persuading her aging husband that *her* son should be the heir of Linn.

"I must make sure," Jerrin decided, "that the succession is never in Lilidel's giving. It's just about time, also, that I take more interest in the children. I can no longer trust what she has done with them."

That applied particularly to Calaj, his eldest son.

He looked again at his wife, and parted his lips to tell her that, if Clane was alive, he had the power to take over the government at will. He didn't say it. It would serve no useful purpose. In the first place she wouldn't believe it, and in the second it was not completely true. Government depended partly on the co-operation of the governed; and there were factors against Clane of which, fortunately—he was convinced—Clane himself was aware.

The meetings between them had made an amicable co-operation possible. Only an emergency, he was sure, would now alter the shape of things political in Linn.

I shall have to make a will, he thought. *If anything happened to me, if I should die—there must be no confusion.*

He felt oppressed. For a second time in less than a year, disaster had struck at the heart of the empire. First, Czinczar, the barbarian, and now the aliens. From the air he had seen the refugees streaming out of the concealing smoke of cities bombed before they were completely evacuated, and he was conscious of his inadequacy in the face of such a colossal catastrophe. It was that that decided him.

"I refuse," he said, "to believe that Clane has failed. If he has, then we are lost. And my awareness of that fact emphasizes once again his importance in a crisis. He

is the only person qualified to handle a major emergency involving atomic energy. If he is still alive, I intend to do as follows."

She listened wide eyed as he explained about the will he planned to write. Abruptly, her face twisted with fury. "Why, you're mad," she breathed. "Are you serious? You're going to disinherit your own son?"

He gazed at her bleakly. "My dear," he said, "I want to make one thing clear to you and to your private army, for now and always. So long as I am the Lord Adviser, the state will not be regarded as a property which my children automatically inherit. It is too soon to decide whether Calaj has the qualities necessary for leadership. My impression of him is that he is an exceedingly emotional youth who gets his own way far too often. There is no sign as yet of that stability which I have, which Clane has, and which even Tews had to some degree."

The woman's face was softening. She came over to him. "I can see you're tired, darling. Please don't do anything rash until this crisis is past. I'll bring you a cup of tea—strong, the way you like it."

She brought the tea with trembling fingers, and went out with tears in her eyes. The liquid seemed unusually bitter even for his taste, but he sipped it as he began to dictate, first the will, then the letter to Clane. He recognized that he was taking a lot for granted, but his mood continued dark. And it was not until he had sealed the two articles, and put them among his public papers, that he realized that the strain of the past few days had affected his body. He felt very tired, even a little feverish.

He dismissed his secretary, and lay down on a cot under the window. Twenty minutes passed, and a door opened softly, so softly that the sleeper seemed undisturbed. Lilidel came in, took the cup in which the tea had been, and tiptoed out.

It was about an hour later when the intense silence of the room was again broken. The outer door was flung open. A staff officer burst across the threshold.

"Your excellency," he began breathlessly, "the invader has arrived above the camp."

The slim, uniformed body on the cot did not stir.

V.

When Clane's "lift" boat came to rest inside the enemy ship, he saw after a moment that they were firmly held in a kind of metal incasement. The nose of the machine and half the body were buried in that enveloping cradle. All around him were other small craft similarly incased.

The craft had apparently slipped automatically into its own pigeonhole. And there was only one problem. Would the officer at the controls of the big machine notice that the lifeboat just in was one which had been captured on Mars by the human beings?

If he noticed, he gave no sign dur-

ing the vital first minutes that followed.

There were high steps where the casement of the "pigeonhole" ended. Up these steps Clane and his men climbed. They came to an empty corridor. Clane stopped short, hesitated, drew a deep breath—and sent the sphere on its death mission.

It flashed out of sight, came back, disappeared again, and once more came back. For a third time, then, it glided off like a stroke of lightning.

This time it returned—sated.

They found no living creature of any kind. They wandered for hours before they were finally convinced that the huge ship had been captured during those few seconds by a simple process. The sphere had absorbed every alien being aboard. As soon as he was positive, Clane headed for the massive control room.

He was just in time to witness a strange mechanical phenomenon. A huge glassy plate, which had been lightless and soundless when he first passed through the control room, glittered with light flashes and stuttered with apparently meaningless sounds.

Clane took up a position behind a barrier, and, with the sphere bobbing above his head, watched alertly.

Abruptly, the lights on the plate steadied. A shape took form on it, and Clane was shaken as he recognized that the creature was of the same species as the monster that Czinczar had brought from Europa.

Only this one was alive in some curious picture fashion.

The creature stared from the plate into the control room, and it was nearly a minute before his gaze touched Clane. He said something in a series of low-pitched sounds that had no meaning for the mutant. Two other individuals came out of the vagueness behind him, and they also stared through the plate.

One of them gestured in unmistakable command, and roared something. There was a click, and the screen went blank. The sounds continued for a few seconds, and then they also faded.

Hesitantly, Clane ventured farther into the control room. He was trying to understand what he had seen. A picture of living aliens focused from some far place on a shining plate. It was a hard idea to grasp, but he had the sinking conviction that other living aliens now knew what had happened to the first of their ships to reach Earth.

In one mental jump he had to try to comprehend the possibility that communication could be established by other means than smoke signals, light flashes from strategically located mirrors, and courier ships. What he had seen indicated that such communication was possible not only over the face of a planet, but across the gulf of space between stars.

It changed everything. It changed the whole situation. Capture of this one ship actually meant nothing. Other aliens knew that the defense

forces of the solar system had failed to protect their cities. They would be puzzled by the seizure of their ship, but it was doubtful if they would be seriously alarmed.

What one ship had almost accomplished, a fleet would surely be able to do—effortlessly. That would be their attitude; and Clane, swiftly estimating the defense possibilities of the solar system, did not doubt the ability of a powerful force of enemy ships to do anything they pleased.

The entire distance-vision incident was enormously significant. Gloomily, he began to study the control system of the big machine. Nearly four hours went by before he was satisfied that he could guide it for atmospheric travel.

Certain functions of the intricate control board baffled him completely. It would take time and study to master this ship.

He headed the ship for Jerrin's headquarters.

He landed in a lifeboat that trailed the fluttering victory flags of Linn, and in a few minutes was admitted to where Jerrin lay dead.

That was about an hour after the body was discovered.

As he gazed down at his dead brother, Lord Clane noticed almost immediately the evidence of poisoning. Shocked, he stepped back from the cot, and looked down at the scene, trying to assess it as a whole.

The widow Lilidel was on her knees with one arm flung in an apparent agony of grief over the corpse. She seemed anxious rather than grieved, and there was just a hint of calculation in the way her eyes were narrowed. She was tearless.

The tableau interested Clane. He had had innumerable reports about the group that had used this woman to influence Jerrin, and there was a time when he had even intended to warn Jerrin against her.

He found himself wondering where her eldest son, the incredible Calaj, was.

It required only a moment for that wonder to focus into a sharp picture of the potentialities of this situation. He had a sudden vision of Calaj already on his way to Golomb, the little town outside Linn to which the Patronate as well as other government departments had been transferred. Given advance warning, the group behind Lilidel—many well-known Patrons among them—might seize the occasion to proclaim the boy Lord Adviser.

There was explosive material here for a bloody struggle for power. Unless the right action were taken, rumors would spread that Jerrin had been murdered. Some of the rumors would point to the widow, others at Clane himself. Supporters of his own who had reluctantly accepted the noble Jerrin would very possibly refuse to agree that a youth of seventeen should be put into power by their worst enemies. Civil war was not improbable.

Jerrin's secretary, General Marak

—a secret Clane supporter—touched Clane's arm, and whispered in his ear. "Your excellency, here are copies of very important documents. I would not swear that the originals are still available."

A minute later Clane was reading his brother's last will. Then he read the personal letter, of which the essential sentence was, "I intrust my dear wife and children to your care."

Clane turned and gazed at the widow. Her eyes met his briefly, flashed with hatred; and then she lowered them, and thereafter gave no sign that she was aware of his presence.

He guessed that his appearance on the scene was unexpected.

It was time for decision. And yet, he hesitated. He glanced at the high staff officers in the room, all Jerrin men, and still he could not make up his mind. He had a picture in his brain larger than anything that was happening in this room—or on this planet. A picture of a mighty alien fleet heading from some far star system to avenge the capture of their exploring ship. Of course that would be only an additional incitement. Their real purpose would be to destroy every human being in the solar system, and seize all of man's planets—while men fought each other for the petty stakes of governmental power.

With fingers that trembled slightly, Clane folded the two documents and put them in his pocket. Standing here in the presence of his dead brother, so recently become a friend, he hated the political knowledge that made him think automatically, *I'll have to try to get the originals, in case I ever want to use them.*

The revulsion grew stronger. With narrowing eyes and grim face, he gazed not only at this scene before him, but at the world of Linn outside—the intricate association of direct vision and sharp, perceptive memory, the scene he was seeing and all the scenes he had ever witnessed. He remembered his own schemes over the years, his emotional joy in political maneuvering; and now, in one burst of insight, recognized it all for the childish nonsense it had been.

His lips moved. Under his breath he murmured, "Beloved brother, I am shamed, for I knew enough to know better."

It seemed to him, then, that Jerrin had been a greater man than he. All his life, Jerrin had treated politics and politicians with disdain, devoting himself to the hard realities of a military man in an age when war was inescapable.

"Can I do less?" The question quivered in his mind like a flung knife vibrating in the flesh.

Then he saw that he was being sentimental in making comparisons. For his problem was on a level that Jerrin could hardly even have imagined. There was power here for him if he wanted it. All the schemes of Lilidel and her group could not stop him from seizing control by sheer force. Without shame, with-

out modesty, he recognized that he was *the* man of science in Linn.

Clearly, sharply, he perceived his pre-eminence, the enormous stability of his mind, the acuteness of his understanding. Somehow he had it, and others hadn't. It made it necessary now for him to reject the highest office in the land—because he had a duty to the whole race of man. A duty that grew out of his knowledge of the titanic danger.

He could expect no one else to evaluate the extent of that danger, least of all this venal, childish woman and those behind her.

Abruptly, angrily decisive, Clane turned and beckoned General Marak. The latter came forward quickly. To him, Clane whispered, "I would advise you to leave this room with me. I could not otherwise answer for the life of a man who knows what is in these documents." He tapped his pocket, where the copy of Jerrin's will reposed.

It was unfortunate, but that was the grim reality. Intrigue and sudden death.

Without a word to any of the others present, he turned and left the room, Marak following close behind. His problem would be to restrain his more ardent followers from trying to seize power in his name.

And save a world that was almost mindless with corruption.

A few hours later, he landed at his estate. His guards' captain met him.

"Your excellency," he said curtly, "the sphere and its container have been stolen."

"The sphere gone!" said Clane. His spirit sagged like a lead weight.

In a few minutes, he had the story. The guards of the sphere had apparently been ambushed by a larger force.

The captain finished, "When they didn't get back here on schedule, I investigated personally. I found their bodies at the bottom of a canyon. All of them were dead.

Clane's mind was already beyond the crime, seeking the culprit. And swiftly, he focused on one man.

"Czinczar," he said aloud, savagely.

VI.

For Czinczar and his men, defeat at the hands of Lord Clane a few months previously had not been a complete disaster. Before actually ordering his army to surrender, that remarkable logician examined his situation.

At the worst, he himself would not be killed immediately but would be saved for public execution. His men, of course, would be sold into slavery—unless he could persuade Lord Clane to let the army remain a unit. To do that, he must convince the mutation that such a force might be useful to him.

Since his reasoning was soundly based, everything happened as he had hoped it would. Clane transferred the barbarian army, together with a number of crack rebel slave units, to an easily defendable moun-

tain territory. Having regained control of the invincible sphere of energy, the mutation considered himself in control of the situation. He even suspected correctly that Czinczar had held a number of spaceships out in space, where they could still be contacted.

At the time he informed the barbarian leader, "These ships could provide you with transportation to return to your planet. But I warn you, make no such move without my permission. You must know that I can seek you out and destroy you at any time."

Czinczar had no doubt of it. And besides, he had no desire to return to Europa. Great events were in the making, and he intended to be in the center of them.

He began his preparations boldly.

Single spaceships were fitted out for forays. The men assigned to them shouted their disapproval when informed they must shave off their beards, but the leader was adamant. Singly and in the dark of night, spaceships landed at carefully selected points as far as possible from the city of Linn. Out of them sprang bare-faced men dressed like ordinary Linnans. They killed men only, slaves as well as Linnans—and helped themselves over a period of many months to vast supplies of grain, fruit, vegetables, meat, and all the metal and wood that an army might need.

The prisoners had been assigned a minimum existence diet by Clane. Within a week of the surrender they were eating off the fat of the land. From every fire on the mountains came the odor of roasting meat. Within a few weeks there were several women to attend to each fire. Czinczar issued orders that only slave women should be brought to the camp, and that any Linnan women captured by mistake should be killed.

Everyone agreed that this was wise, but suspiciously no women were executed. It seemed clear to Czinczar that the Linnan women, when informed of the alternatives, were only too anxious to masquerade as slaves. And so the purpose of the bloodthirsty threat was served. A huge camp, that might have been disorderly in the extreme, operated for months on a high level of efficiency.

And, because of the tremendous dislocation of normal Linnan life, first as a result of the barbarian invasion and then because of the alien invader, their violent actions went almost unnoticed; their existence was almost literally unsuspected.

The arrival of the invader made possible even bolder activity. In broad daylight barbarian ships would land at the outskirts of cities, and in small groups penetrate past the guardposts without being challenged. These small spying units brought back information from widely scattered points to one of the keenest military minds of the age. As a result, Czinczar knew before the event that an attack was going

to be made against the invading ship. And he also knew the nature of it.

On the night of the attack, he was fully aware of the tremendous issues at stake. He personally accompanied the men who crouched within bow and arrow range of the coffinlike structure which acted as a container for the sphere of energy. He waited until the sphere vanished into the darkness toward the gigantic enemy ship. Then he gave his command. The little group of barbarians swept down upon the half hundred guards around the container.

The darkness echoed with the horrified cries of men bloodily surprised by a superior force. But silence followed swiftly. The barbarians disposed of the dead guards by rolling them over a nearby cliff. Then they settled themselves tensely to wait for the sphere.

It came suddenly. One instant there was nothing; the next, the silver ball was rolling sedately to and fro. Czinczar gazed down at it, startled. It was not the first time he had seen it, but now he realized some of its powers.

Aloud, he said, "Bring the telescope. I might as well have a look inside this thing while we're waiting."

That was a new idea; and the method used was very rough. Two men poked the long, narrow telescope into the outer "skin" of the sphere, and then walked along at a steady pace beside it. It was a problem in timing, and Czinczar's part

was the most difficult. He walked beside the telescope, one eye glued to the eyepiece; and the trick was to establish a rhythm of backward and forward movement.

His first view was so different from anything he might have expected that his vision blurred, and he fell out of step. He organized himself, and looked again. Oddly, the surprise was almost as great, as if his mind had already rejected what it first saw.

He saw a starry universe. He stepped back in confusion, striving to grasp the awful magnitude, the fantastic reality. Then once more he fell in step, and gazed. By the time he straightened up again, he was trying to interpret what he had seen.

The sphere, he decided, was a "hole" in space. Baffled, he stared down at it, as it rolled back and forth. How could a silvery ball-like object be an opening into anything?

He motioned the men to take the telescope away, and then punched his finger into the sphere. He felt nothing at all, no resistance, no sensation.

The finger swelled a little finally, and he remembered that meteor miners had proved space was not cold, but that it was vital to wear an air-tight pressure suit. Lack of pressure would have caused his finger to bloat.

He wondered if he had reached into some depth of space. A finger poking out of nowhere into a vacuum. Thoughtfully, he walked away from the sphere and sat down on a rock. In the east, the sky was beginning to lighten, but still he sat there, still his men waited in vain for the order to leave. He intended to give Clane every opportunity of using the sphere against the aliens.

As the sun edged over the jagged horizon, he stood up briskly, and had the container and the sphere transported to a waiting ship. The vessel had instructions to climb right out of the atmosphere, and take up an orbit around Earth.

Czinczar remembered sharply how Clane had had to come to the city Linn to make use of the sphere against himself. And there was the fact that each time it was used, it had to be transported near the object against which it was to be employed.

Accordingly, the greatest weapon ever conceived was in his possession.

He was not satisfied. Restlessly, he paced the room which was his headquarters, and over and over again examined the facts of his position. Years ago, he had discovered the basic secret of power and success. And now, because the pattern was not complete, he was uneasy.

Men came and went from his room. Spies bringing information. The invading ship was captured. Jerrin was dead. Clane had refused to take advantage of the death, and had instructed his supporters not to oppose the plan to make Calaj the Lord Adviser.

When the man who brought that

latest bit of news had gone, Czinczar shook his head in wonder, and for the first time in all these months something of his terrible tension let up. He himself wouldn't have had the courage *not* to seize power at such an opportune moment. Nor could he visualize the logic of it—even so, the actuality seemed superhuman.

It made him indecisive. He had intended to make an effort to seize the gigantic invader ship when Clane was not on it. With clocklike precision his men completed the preliminaries—but he did not give the final order.

On the sixth day after the death of Jerrin, a messenger came from Clane commanding him aboard the captured giant. Czinczar suspected the worst, but he had no alternative short of open resistance. Since that would quickly bring the main Linnan armies against him, he decided to trust himself to Clane, and to his own analysis of the situation.

At the appointed hour, accordingly, Czinczar and his staff flew in a strongly escorted patrol vessel to Clane's estate. The alien ship floated high above, as they stepped to the ground.

A few guards lounged around. Nowhere was there sign of a force large enough to defend the battleship from a determined air attack. Looking up, Czinczar saw that several dozen air locks were open in the ship, and that a thin but steady traffic moved to and from the openings. It was a picture that his spies had reported in considerable detail, and it baffled Czinczar now as it had earlier. The ship looked helpless, wide open to assault. The very extent of that helplessness had made him hesitate. It was still hard to credit that Clane could be so negligent, but now the barbarian leader silently cursed himself for his failure to take advantage of a military possibility.

For the first time in his grim career he had missed an opportunity. He had a premonition of disaster.

He watched with narrowed eyes, as one of Clane's officers came up. The man saluted the barbarian commanders with stiff formality, and then bowed to Czinczar.

"Your excellency, will you and your staff please follow me?"

Czinczar expected to be led toward the estate residence, which was visible over a low hill about a third of a mile to the south. Instead, the Linnan officer guided them to a small stone building half hidden among thick undergrowth. Once more he saluted and bowed.

"If you will step inside one by one," he said, "so that the machine can take a"—he hesitated over the word—"photograph of you." He added hurriedly, "Lord Clane asked me to assure you that this is essential; otherwise it would be impossible for you to approach the *Solar Star*."

Czinczar said nothing, nor did he immediately allow himself to examine the meaning of the words. He

motioned his officers to go in ahead of him, and watched curiously as each man in turn entered, disappeared for a moment, and then came into sight and through the door. Since he did not ask them, they all knew better than to volunteer information.

Presently, it was his turn. Unhurriedly, Czinczar stepped through the door. He found himself in a room that was bare except for a chair and a table, and the instrument that rested on the table. The chair was occupied by an officer, who rose to his feet and bowed, as Czinczar entered.

The barbarian acknowledged the greeting, then stared curiously at the instrument. It looked as if it had been torn from its metal casing. The metal was fused where it had been cut with torches. Czinczar noted the point in passing, saw also that the machine itself seemed to consist principally of a telescopelike protuberance complete with lens. He turned to the attendant.

"What does it do?" he asked.

The officer was polite. "According to Lord Clane, sir, it takes photographs."

"But that's only another word for portrait," said Czinczar. "Do you mean the machine has made a portrait of me? If so, where is it?"

The attendant's cheeks were slightly flushed. "Your excellency," he confessed, "I know nothing more. Lord Clane asked me to refer all interrogators to him personally." He added, somewhat pointedly, "I believe that he will expect you, now that you are through here."

Czinczar was persistent. "I didn't see you do anything."

"It's automatic, sir. Anyone who stands in front of it is photographed."

"If such a photograph," said the barbarian, "is necessary before I can approach the ship, how was it that Lord Clane and his men were able to enter the vessel a week ago, and capture it, without having their photographs taken?"

It was a rhetorical question, and he scarcely heard the other's protestation of ignorance. Silently, he left the little building, and followed the first officer to a larger liftboat, which was in the act of settling to the ground half a hundred feet distant.

In a few minutes they were whisked up to one of the openings. The liftboat glided through, and gently nosed into a slot. Czinczar stepped out with the others, hesitated as he saw the double lines of guards drawn up to receive them, and then, with the chill of the welcome already upon him, walked wordlessly along a corridor towards a huge door. As he crossed the threshold, and saw the tremendous gallows that had been erected against the far wall, he stopped involuntarily.

The pause was momentary. Imperturbably, he walked forward, straight to the foot of the gallows. He sat down on a lower step, pulled out a notebook, and began to write a farewell address. He was still writing it when, out of the corner of

his eyes, he saw Clane come in. He stood up, and bowed.

The slim young man came over to him, and without any preliminaries said, "Czinczar, you have a simple choice. Produce the sphere, or hang."

"Sphere?" said the barbarian finally. He hoped he sounded properly surprised, but he did not doubt the seriousness of his situation. There were rough minutes ahead.

Clane made an impatient gesture, hesitated, and then grew visibly calmer. "Czinczar," he said slowly, "your skillful reorganization of your forces the last few months had just about decided me to use you in a major enterprise."

The barbarian bowed once more, but his eyes narrowed at the revelation that his activities were known to the mutation. Czinczar neither underestimated nor overestimated the fact. He recognized both the weakness and strength of Lord Clane's position. The great weakness was that he depended too much on himself. He was at the mercy of people who had little or no idea of the relative importance of his possessions or his actions.

And so, during the barbarian assault on Linn, the attackers had seized Clane's house with all its valuable scientific equipment, including the sphere of force. Not knowing the tremendous potentialities of the sphere, they had made the mistake of trying to use it and the other equipment as bait to trap Clane. And thus had let him get near it—and trapped themselves.

The secrecy that made such things possible was a form of strength. But, obviously, once the pattern was understood, the solution was simple. Watch Clane's movements. He could not be everywhere at once. Like other human beings, he needed sleep; he had to take time off for eating. It was impossible for him to be alert continuously.

The fact that he had allowed the barbarian force to reorganize was no evidence that he was capable of foreseeing all the possible eventualities of such an act. His successful capture of the sphere was evidence of that.

Once more, it was Clane who broke the silence. "As you know," he said, "I have defended you from the fate that is normally dealt out to individuals who have the audacity to invade Linn. The policy of executing such leaders may or may not be a deterrent on other adventurers; possibly it is. I saved you from it, and one of your first acts is to betray me by stealing a weapon which you have not the knowledge to use yourself."

It seemed to Czinczar that it was time to make a denial. "I don't know what you're talking about," he protested in his most open-faced fashion. "Has the sphere been stolen?"

Clane seemed not to hear. He went on grimly, "I cannot say honestly that I have ever admired you. You have discovered a simple technique of power, and you keep follow-

ing the pattern. I personally am opposed to so much killing, and I really believe it is possible to reach the heights of power in *any* state, however governed, without stabbing a single person in the back."

He paused; he took a step backward. His eyes were merciless as they stared straight into Czinczar's. He said curtly, "Enough of this talk. Do you yield up the sphere, or do you hang?"

Czinczar shrugged. The pressure of the deadly threat tensed every muscle in his body. But in his tremendously logical way he had analyzed the potentialities of his theft of the sphere; and he still stood by that analysis.

"I know nothing of this," he said quietly. "I have not got the sphere. I did not even know it was stolen until this minute. What is this enterprise on which you planned to use me? I'm sure we can come to an agreement."

"There are no agreements," said Clane coldly, "until I get the sphere." He went on, "However, I see that you are convinced that I won't hang the man who has it, so let us proceed to the actuality. Will you climb the gibbet yourself, or do you need assistance?"

Since there could be no effective opposition, Czinczar turned around, climbed the steps to the top of the gallows, and without waiting for the hangman to help him, slipped the rope over his head. He was pale now, in spite of his confidence. For the first time it struck him that the dazzling career of Czinczar, the one-time scribe who had made himself absolute ruler of the barbarians of Europa, was about to end.

He saw that Clane had motioned the executioner, a Linnan noncommissioned officer, to come forward. The man took up his position beside the lever that would open the trapdoor, and turned to watch Clane, who had raised his arm. The mutation stood tautly in that striking position, and said:

"A last chance, Czinczar. The sphere or death."

"I haven't got it," said Czinczar in a steady voice, but with finality.

Inexorably, Clane's arm swept down. Czinczar felt the trap under him collapse. And then—

He was falling.

VII.

He dropped about a foot, and landed so jarringly that his body vibrated with pain. The tears started to his eyes. He blinked them away. When his vision cleared, he saw that he was standing on a second trapdoor, which had been built below the first.

He grew aware of scuffling somewhere near. He glanced around. His staff officers were struggling with the Linnan guards, trying to reach him. Czinczar hesitated, wondering if perhaps he and they should not attempt to make a fight to the death.

He shook his head, ever so slightly. The fact that he was still alive

underlined his own hard convictions. He raised his golden voice, and presently the barbarian officers ceased their struggles, and stood sullenly looking up at him.

Czinczar spoke directly at them, indirectly at Clane. "If my life is really in danger," he said with resonant positivity, "it will be because Lord Clane has lost his good sense. That would apply even if I had the sphere—"

He realized that Clane would regard the words as an admission, and he glanced coolly at the mutation, inviting comment. Clane scowled; but he picked up the challenge after a moment.

"Suppose that you did have the sphere," he said mildly, "why does that protect you?"

"Because," said Czinczar, and his golden voice had never been steadier, "if I have it, so long as I am alive, you would still have a chance of getting it back. If I die, then that chance goes forever."

"If you had it," said Clane in a grim but ironic voice, "why would you want to hold on to it, knowing that you cannot make any use of it?"

"I would first have to make an investigation," was the barbarian's reply. "After all, you learned how to use it without having any previous knowledge of its operation."

"I had a book," Clane flashed, "and besides I have some knowledge of the nature and structure of matter and energy."

"Perhaps," said Czinczar coolly, "I could get hold of the book—such things do happen."

"I memorized this particular book," said Clane, "and then destroyed it."

Czinczar was politely incredulous. "Perhaps, my agents could discover the place where you burned it," he said. "Or, if I sent them into the homes of the gods, they might find another book."

He realized that tension was building up again, and that no verbal byplay would settle this argument. Clane was stiffening, his eyes narrowing. "Czinczar," he said sharply, "*if* you had this sphere, and you knew that you couldn't ever find out how to use it, would you still hold on to it, knowing the danger that is building up for the human race?"

The barbarian drew a deep breath. He expected a violent reaction. "Yes," he said.

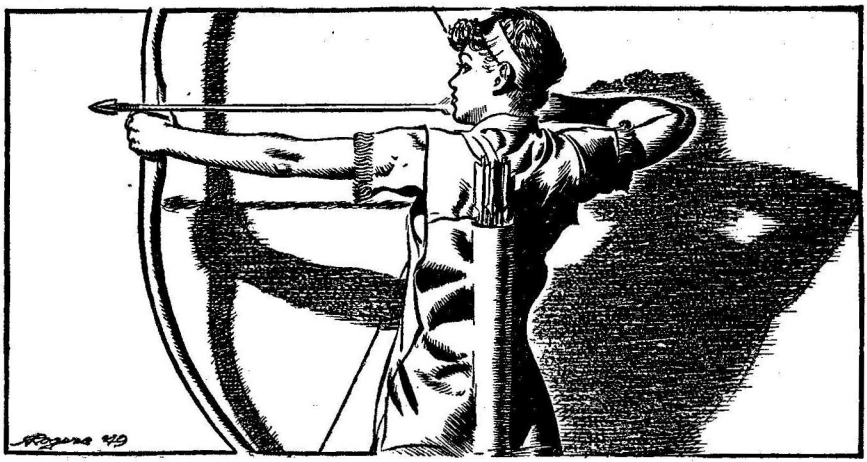
"Why?" Clane was visibly holding himself under control.

"Because," said Czinczar, "I have no confidence in a man who refuses repeatedly to accept power, and who thus rejects the only means by which he can control and direct the defense against a possible invader. And, besides, the sphere is obviously worthless against the Riss."

Clane seemed not to hear that last. "Suppose I told you that I refused to take power because I have a plan of much greater scope."

"I recognize power," said Czinczar flatly, "not the grandiose schemes of a man who is now virtually impotent."

"My plan," said Clane, "is of such



scope that I dare not tell it to a man of your rigid attitudes, for fear that you would regard it as impractical. For once I don't think your imagination could appreciate the possibilities."

"Try me."

"When I have the sphere," said Clane, "and not one second before. As for my being impotent, please note that I have the ship."

Czinczar was scornful. "What are you going to do with it—attack the legal government and make the people love you? That isn't the way a mutation can operate. For you and for your group the moment for taking over the government is past. It will probably not come again until the Riss attack, and by then anything you can do may be too late."

He went on, in an even more violent tone, "Lord Clane, you have been a grave disappointment to me. Your failure has placed my troops and myself in grave danger, because very soon now the *legal* government of Linn will demand that you turn us over, and of course you will also be required to turn over the ship. If you refuse, then for the first time in your life you will be out in the open as a rebel. From that moment on, your days are numbered."

Clane was smiling humorlessly. "I can see," he said, "that you are at your old game of political intrigue, and I am utterly impatient with such childish nonsense. The human race is in deadly danger, and I refuse to argue with anyone who plots and schemes for advantage under such circumstances. Men must mature or die."

He turned aside, and said something to one of the officers who stood near him. The man nodded, and once more Clane faced Czinczar.

The barbarian braced himself for the next step of torture.

Clane said curtly, "Please remove the noose from around your neck, and come over to the tank in the corner to your left."

As he slipped the rope over his head, Czinczar studied the tank. It was a large concrete affair, and he had noticed it when he first came in. It looked enigmatic; he couldn't imagine its purpose.

He was thinking furiously as he came down from the gallows. He said to Clane, "I'm really very persuadable. Why not tell me your plan? I can't give you the sphere as evidence of my good faith because I haven't got it."

Clane merely shook his head impatiently. Czinczar accepted the rejection, and said matter-of-factly, "Do I climb into the tank?"

Clane said: "Take a look inside, and you'll see the arrangement."

Czinczar climbed up curiously, and looked down. The tank was quite deep, and it was empty. At the bottom was a simple hand pump, and there were two chains with clamps fastened to rings imbedded in the concrete floor.

He lowered himself gingerly into the tank, and waited for instructions. He looked up and saw that Clane was looking down at him over the edge.

"Fasten the chain clamps around your ankles," instructed the mutation.

Czinczar did so. They clicked shut with a metallic finality. The metal felt heavy against his flesh and even uncomfortable.

"The chains," explained the mutation, "will hold you down to the bottom of the tank, so that when the water comes in you'll have to pump it out if you want to prevent yourself from drowning." He added, "You can see the approach is very simple. The pump operates easily. The choice you make will be entirely your own. You live or die by your own effort, and at any time you can stop the entire process by agreeing to turn over the sphere. There comes the water now."

It swirled around Czinczar's legs, bubbling up noisily. It was lukewarm, so it felt rather pleasant. Czinczar sat down on the floor, and glanced up at Clane.

"May I make a request?" he asked.

"Does it include handing over the sphere?"

"No."

"Then I'm not interested."

"It's the pump," said Czinczar. "Its presence makes me unhappy. Will you please have it taken out?"

Clane shook his head. "A few minutes from now you might be very happy to have it there." Nevertheless, there was an anxious look in his eyes as he spoke. The reaction was clearly one that he had not expected.

He finished, "If you change your mind at any time, you'll find that the pump can quickly reduce the level of the water."

Czinczar did not answer. The water was swirling around his neck. In a minute it closed over his mouth. He found himself involuntarily re-

laxing so that he could float up a little. He tensed with the expectation of the physical horror that was now only minutes away.

Presently, he was standing up, and he could feel the weight of the chain on his ankles. There was no doubt but that he had reached the limit of that particular method of escaping. And still the water surged higher.

It came up to his mouth again, then his nose. He held his breath as it rose up over his eyes and covered his head. And then, abruptly, he couldn't hold it any longer. Explosively he exhaled—and inhaled.

There was a knifelike pain in his chest, but that was all. The water tasted flat and unpleasant, not as if he was drinking it. Finally, there was no sensation at all. Darkness closed over his consciousness.

When he came to, he was lying over a barrel. He had never felt more miserable in his life. And they were still squeezing water out of him.

He was coughing. Every explosive discharge wracked his body. The pain of returning life was immeasurably greater than the pain of death. But even he realized presently that he would live.

They carried him to a cot, and there after an hour or so, he began to feel normal again. Clane came in alone, pulled up a chair, and sat silently regarding him.

"Czinczar," he said at last, "I am reluctantly compelled to admire your bravery. I despise the animallike astuteness behind it."

Czinczar waited. He refused to believe that his travail was over.

"You have proved once more," said the mutation bitterly, "that a courageous man who is prepared to take calculated risks on the low level of political intrigue can conquer even death. I hate the stupid logic which makes you feel that you have to keep the sphere. If you persist in that madness, we are all dead men."

"If I had this sphere," said Czinczar, "then the logical thing for you to do in a moment of crisis would be for you to forget self and tell me how to work it."

Czinczar spoke in a precise tone, conscious of how dangerous the statement was. It was his first admission by implication of his own vast ambitions. For it was obvious that if he ever learned how to use the sphere, he would thereafter be in a position to seize power at will, and take control of any state.

It also implied that, according to his analysis of Clane's character, the other might actually allow him to have control of the sphere in an emergency involving the destiny of the human race as distinct from any nation.

Clane was shaking his head. "It won't happen, my friend. I do not expect that the sphere will ever again by itself be useful against the Riss. I won't tell you why."

Czinczar was silent. He had hoped, not too optimistically, that somewhere along the line he would

receive a clue about the operation of the sphere. But the information he was getting made the problem seem more, not less, difficult.

Clane continued, "It might appear that I was very careless with the sphere. But long ago I discovered that I could not be everywhere at once. And of course, I repeat, it's quite useless to anyone else. It works on the basis of a mathematical formula relating to the release of atomic energy, and I question whether anyone in the solar system other than myself even knows that there is such a formula."

Czinczar had his clue, and it was bitter to take. He said at last, "What are your plans for me, as of this moment?"

Clane hesitated. When he finally spoke, there was an edge of fire in his tone. "For the past few months," he said, "I have tolerated your murderous forays because I question whether we could have got together such a vast total of food and other supplies by any legal method in my control."

He paused, then continued, "I question also whether it would have been possible to get so many women together without using methods similar to yours. For my purposes, the women are as important as the food."

Once more he paused. And Czinczar had time to feel chagrined. He had thought he knew something of the intricate workings of this man's mind. But now, briefly, he was beyond his depth, and he had the empty conviction that he had been outplayed at his own devious game.

It was a startling thought that his secret forays would now be used for the benefit of Clane's plan. The mutation continued:

"Here is what I want you to do. Tomorrow, the *Solar Star* will fly over to your camp. You will begin to load your equipment aboard the lower decks—there are twenty of them, each capable of holding about ten thousand people and their supplies; so there'll be plenty of room for your entire army and the women."

Czinczar said: "Once I have such a force aboard, what's to prevent me from taking over the ship?"

Clane smiled grimly. "The twenty upper decks are already occupied by a well armed Linnan army group, all young married men accompanied by their wives. Except on the officer level, there will be no liaison between the two groups. In fact, except for an entrance from your headquarters all connecting doors will be sealed."

Czinczar nodded, half to himself. It sounded effective. Every defense of that kind could of course be overcome by bold and astute planning. But that scarcely concerned him now. There was an implication here of a tremendous journey about to be undertaken, and that dominated his thought.

"Where are we going?" he asked sharply. "To one of the outer moons?"

"Wait and see," said Clane coolly.

He stood up, with a frown. "Enough of this. You have your instructions. I have to make a vital journey to the capitol. I want you and your forces to be aboard and ready for flight one week from today. And if you can for once rise above the moronic military idiocy that guides your reasoning, bring the sphere along." His tone was one of suppressed anger.

Czinczar stared at him thoughtfully. "My friend," he said, "you're being emotional. There *is* no escape from political intrigue. This that you suddenly despise is the human environment. The environment of human passion, human ambition. There never has been, and never will be any other climate for you to operate in. A man succeeds or fails to the extent that he can understand and control the unrelenting drives of others of his kind. If he tries to abandon intrigue, the tide will wash over him and his plans as if they never existed. Beware."

He finished automatically, "I haven't got the sphere."

VIII.

The arrow came out of the darkness, whizzed past Clane's head, and lodged in the shoulder of a guardsman.

The man screamed throatily, and clutched at the thin, vibrating wand. A companion leaped to his aid. Other soldiers dived into the alleyway. There was the sound of squealing, almost feminine in its high-pitched alarm and annoyance. Presently, a group of soldiers stalked out of the darkness, dragging a slim, resisting, boyish form.

The injured man, meanwhile, succeeded in tearing the arrow from his flesh. More frightened than damaged, he stood there cursing in a deep, bass voice.

Men were hurrying back from farther along the street. Torches flamed and guttered in the night wind. In that smoky, malodorous atmosphere, the changing patterns of dim light gave only flashing glimpses of faces and bodies. Clane stood silent, displeased with the milling excitement. Presently, when the turmoil showed no sign of abating, he called to an officer, and in a minute a path was cleared for him. Along it the guards dragged the prisoner.

Somebody shouted, "It's a woman!"

The discovery echoed back among the men. Curses of amazement sounded. The woman, or boy—it was hard to decide which in that dim light—ceased struggling. And then settled the question of gender by speaking.

"Let me go, you filthy rats! I'll have you whipped for this. I wish to speak to Lord Clane."

The voice, despite its vicious tone, was feminine. What was more surprising, the accent was that cultivated at the schools where young ladies of noble birth were taught.

The recognition startled Clane out of the icy calm into which the at-

tempt on his life had thrown him. He took it for granted that the attempt *had* been on him, and not on the guard who had actually been struck. He assumed automatically that the assassin was an agent of the group behind Lilidel.

The names of her immediate superiors would have to be wheedled out of her, now that the assassination had failed. That was a natural development, and it concerned him only incidentally. What disturbed him was that she had evidently not considered the serious consequences of her act. In accepting the assignment, she couldn't have known a long established method of dealing with woman assassins. They were turned over to the soldiers.

He stared at her with troubled eyes. It was probably an illusion of the unsteady light, but she seemed little more than a child. At a maximum, he put her age at eighteen. Her eyes gleamed with the passionate fire of a willful youngster. Her mouth was full and sensuous.

He shrugged as he realized that he was yielding her up in his own mind to the punishment established by long practice. He who had recently set himself against so many old customs, could not now afford to offend his own private guard. Slowly, he stiffened to the inevitabilities of the situation.

Because he was angry at her for the decision she was forcing on him, he said with grim curtness, "Who are you?"

"I won't talk here," she said.

"What's your name?"

She hesitated; then, apparently recognizing the hostility in his voice, she said sullenly, "Madelina Corgay."

The identification gave him his second major pause. For it was an old and famous name in Linn. Generals and Patrons had borne that name into the field of battle and with it had signed the laws of the country. The father of this girl, Clane recalled, had died fighting on Mars, a year before. As a war hero, his daughter's action would be excused.

Clane was chagrined to realize that he was already thinking of the political repercussions. But it would be folly to blind himself to the fact that this incident could be highly dangerous to him. He shook his head angrily. With Calaj already voted Lord Adviser, and scheduled to make his triumphal entry into this capitol city of Linn tomorrow morning, the young man's supporters might well make an issue of an affair like this. And yet he had to take into account the expectations of the guards, who would not be interested in excuses. Fortunately, an intermediate decision was possible.

"Bring her along," he said. "I shall question her when we reach our destination."

No one demurred. It was expected that there would be a period of questioning. The crisis would come later.

Clane gave the necessary orders. Presently the procession was mov-

ing again along the street.

Several weeks had gone by since the capture of the invading ship, and it was more than six months since the defeat of Czinczar and his barbarian army from Europa, that distant and little known moon of Jupiter. The Linnan world was still in the process of settling down from those two near catastrophes. But already the survivors were forgetting how great the danger had been. From all parts of the empire the ever-louder voices of discontent echoed.

Commercial interests protested that Czinczar never had been a real threat. And that in any event the danger had been a product of gross negligence by the government. Jerrin had overruled previous objections, but now that Jerrin was dead there was a determined movement under way to nullify the decree which Clane had proclaimed during the barbarian invasion, freeing all loyal slaves. The feverish fury of numberless individuals dispossessed of valuable servants mounted with each passing day. And several ugly rumors had come to Clane that there would probably have been no disasters in the first place if a mutation had not been tolerated for so long in the family of the lord leaders.

That was a direct attack at himself, and one which he could not fight by any means known to him. This was particularly true since he had prevented his supporters from opposing the Patronate vote that gave the Lord Advisership to young Calaj.

Alarmed by the direction the public rage was taking, several of Clane's adherents had already regretted that they had allowed him to persuade them. It was now necessary, they claimed, for him to act before the Lord Adviser Calaj actually arrived in the capitol.

It was just such a scheme that had brought Clane on this night journey through the streets of sleeping Linn. A *coup d'état* was being planned—so the report had come to him upon his arrival in the city only a few hours before—the object of which was to proclaim him Lord Leader.

On his arrival at the palace of the Patron Saronatt, where the conspirators had set up their headquarters, Clane called the leaders to one of the three apartments that were immediately assigned to him. From the beginning, his attitude was under attack. He listened, startled, as former staunch supporters of his assailed his stand in language more violent than any he had ever had used against him. There were sneers and furious tirades. His fear of an alien invasion, when not openly derided, was attacked on the grounds that only as Lord Leader would he be in a position to defend the state. The arguments were much the same as Czinczar's, and were held with equal determination.

Shortly after 3 a.m., a famous Patron denounced his leadership. "I have been invited," he said savagely,

"to join the Lilidel group and I shall accept. I'm through with this cautious coward." That was the beginning. The scramble to desert a sinking ship started then. At four o'clock, when Clane started to speak, his audience had dwindled to a score of men, mostly military leaders who had fought with him against Czinczar. And even they, he saw, were not too friendly. For their benefit, he discussed briefly and austerely the possible nature of the coming Riss attack. He did not tell them what his plans were, but he did offer them an emotional satisfaction.

"Our opponents," he said, "do not, in my opinion, realize as yet what they are doing in promoting this particular mother's boy to the rank of Lord Adviser. Children are concerned with the people around them, not with individuals whom they never meet. Just imagine a child that is now in a position to get its own willful way *every* time." He stood up, and looked around the little group grimly. He said, "I leave this thought with you."

He returned to his own residence, more shaken by the trend of events than he cared to admit. He was on his way to his bedroom when he was reminded by his guards' captain of the assassin.

Clane hesitated. He was tired, and sick of problems. He was not even sure that he was interested in finding out who wanted him dead. Even some of his old supporters might now feel that he was dangerous to them alive. What decided him in the end was his general attitude of curiosity. He attributed his larger success to a habit of quick and thorough investigation of anything that seemed to affect his interest. He ordered the girl brought before him.

She came into the room boldly, spurning the attempt of the guards to lead her in like a prisoner. Seen in the bright light of the oil lamps, she looked older than his earlier impression of her had indicated. He guessed that she was twenty-two or three, or even twenty-five. She was beautiful, by his standards. Her features had the even lines of good looks and keen intelligence. The effect was marred only by the unmistakable insolence of her expression. But he realized that was not necessarily a fault. It was she who spoke first.

"If you think," she said, "that I am the usual type of assassin, you are quite mistaken."

Clane bowed ironically. "I am sure," he said, "that all assassins are unusual."

"I shot at you to attract your attention," she said.

Clane thought back to the moment of the attack. The arrow as he remembered it, had swished by about a foot from his head. For a skilled archer it was a bad shot. The question was, how skillful was she? And how much had the darkness affected her aim. The woman spoke again.

"I belong to the Martian Generals' Archery Club, and two weeks before Czinczar's attack I was runner-up in the championship matches. That's what decided me to take the risk. I was sure I could prove to you that I could have hit you."

Clane said satirically, "Couldn't you have chosen some other method of attracting my attention?"

"Not," she flashed, "if I expected to hold it."

Clane stiffened. This was verbal byplay, and he was not interested. "I'm afraid this is beyond me," he said. "And I'm afraid, too, that we will have to follow a more orthodox method of questioning, and assume the usual reasons for the attack."

He paused, curious in spite of himself. "Just why did you want to attract my attention?"

"I want to marry you," she said.

Clane, who had been standing, walked to a chair and sat down. There was a long silence.

He stared at her with bright eyes that concealed more turmoil than he cared to admit even to himself. He hadn't expected to have his hard crust of worldliness penetrated. He had the distinct and unhappy feeling that if he spoke his voice would tremble. And yet it was natural that he should have a strong reaction.

This young woman belonged to a part of Linn that he had considered forever beyond his reach. She was a part of the society that, except for a few men, had ignored the mutation member of the family of the late Lord Leader Linn. The fact that a girl of her station had decided to try to marry him merely proved that she saw him as a way to power for herself. If the night just passed was evidence, then that might be an error of judgment on her part. But her action was the first break in the dike of social opposition. Politically speaking, she could be very valuable to him.

Clane groaned inwardly as he realized that once more he was evaluating a situation in terms of its advantages to his purposes. He sighed, and made up his mind. He called to the guards captain:

"You will assign an apartment to the Lady Madelina Corgay. She will be our guest until further notice. See to it that she is well protected."

With that, he went to bed. He left instructions as to when he should be roused, and lay awake for a while turning over in his mind his plans for the day. Over and above everything else was the visit he wanted to make to the Central Palace to have another look at the monster that Czinczar had brought to Earth.

It would be important that somebody know something about the physical side of man's deadly enemy.

IX.

Lord Clane awoke about midmorning to the sound of distant singing. It puzzled him for a moment, and then he remembered that today the Lord Adviser Calaj was arriving, and that a fete had been proclaimed.

He ate a hasty breakfast, and then set out for the Central Palace in a patrol boat. As they started to float down for a landing, the pilot sent back a message with one of the guards:

"Your excellency, the Square is filled with people."

Clane ordered, "Land on a side street, and we'll walk the rest of the way."

They landed without incident, and wound their way among the dancers and the musicians. They passed

swaying groups of singing men and women; and Clane, who had never failed to marvel at the antics of human beings, observed them in genuine wonder.

They were celebrating the accession to power of a youth whom they did not know. Sweet voices, raucous voices, good-natured yelling, women wiggling their hips coquettishly, men snatching at bare arms, kissing any pair of feminine lips that happened to be passing—it was in its own way a fascinating show. But in view of the danger that had been so narrowly averted, and of the impending invasion, it was a scene that had implications of disaster.

Physically grown men and women were acting like children, accepting as their ruler a boy whose only apparent qualification was that he was the son of the great Lord Jerrin. Here was so great a love of the childish things of life that all human life was imperiled.

His thought reached that point—and was violently interrupted. "It's that dastardly little priest!" a voice shouted.

The words were flung back among the crowd. There were angry cries of "Evil One!" "Mutation!" "Devil Priest!" The dancing in the near distance came to a stop, and there was a sullen surging of a mass of people to get nearer to him. Somebody yelled: "It's Lord Clane, the man responsible for all our troubles."

A furious murmur swept the throng. Beside Clane, the guards captain quietly motioned to the two dozen guards. The powerful men pressed forward, hands on swords and daggers. Clane, who had been watching the incident develop, stepped forward, a twisted smile on his lips. He raised his arm, and for just a moment received the silence he wanted. He called out in his most resonant voice:

"Long live the new Lord Adviser Calaj."

With that, he reached into a pouch, which he had carried for years for just such a moment as this, and brought it out clutching a handful of silver coins. With a flick of his wrist he tossed the money up into air. The metal glinted in the sun, and came down over a wide area about twenty feet away. Even before it landed another handful sparkled in the air in the opposite direction.

Once more, he called, more cynically this time, "Long live the Lord Adviser Calaj."

The crowd wasn't listening. There were shrieks as people stampeded after the money. Even after Clane's party was clear of the danger, he could hear cries of, "Give it to me, it's mine!" "You wretch, you stepped on my hand!" Feet scuffled, fists smacked audibly on the morning air.

The incident made him bitter. Once again, he had been forced to rely on a technique for handling masses of people. Simple, effective,

cunning, it was a part of the vast fund of information he had about the man in the street.

In spite of his tremendous desire to dissociate himself from such cheap trickeries, he couldn't do it. He recalled what Czinczar had said. He shook his head. There must be some way of arousing people to the fact that this was the eleventh hour of man's destiny. And that for once all men must put aside personal ambition and act in unison against an enemy so ferocious that he refused even to communicate with human beings.

But how? What could he say or do that would strike the vital spark? He who was spending *his* time and energy studying the machines aboard the Riss battleship, a task so colossal and so important that all else paled into insignificance beside it?

Yet here he was, on his way to the palace to do personally what should have been a routine job for one or more subordinates. It wasn't, of course. No one else was qualified for either of the two tasks that had to be done, the political and the scientific. A few years before, he had belatedly started an advanced school for science students; but he'd been too busy to give it proper attention. Politics. Wars. Intrigue. People to see. Spy reports to study. Property management. Exploration. Experiments. New ideas. Each twenty-four hours had gone by like a flash, leaving an ever accumulating variety of things to attend to. One man could do only so much. And now that the crisis was here, he felt the reality of that.

He was still thinking about it when he arrived at the palace gate. The time he noted with automatic attention to detail, was a few minutes before noon. The question in his mind was, would he be allowed inside?

It turned out not to be a problem at all. A distracted captain of the guard admitted him and his staff. Clane headed straight for the refrigeration room. He had no difficulty in finding the body of the dead Riss which Czinczar had brought with him from Europa.

The elongated body of the unhuman creature did not act kindly to the thawing. As the water began to drip from the brown-stained, leathery folds of its skin, an unwholesome stench rose from it. In the beginning, the odor was faint. But it grew stronger.

As the butchers, he had brought along, sawed it into sections, Clane took the pieces and dictated first to one, then to another of his two secretaries. When he was finished with a segment, he handed it to an artist, who drew a lifelike picture of it with sure, rapid strokes.

As the afternoon waned, the odor thickened until it seemed to permeate every crevice of the room. And still Clane examined and dictated, examined and dictated. Gas flames and test tubes were brought into action.

Juices from glands, liquid from the circulatory system of the thing, and fluid from the spinal column were tested with various chemicals, separated into their components, described, named and illustrated for future reference.

Once, when he put his fingers into a sticky goo and tasted it, one of the secretaries fainted. Another time he tried to feed a piece of it to a rat in a cage. The animal, purposely kept hungry, pounced on it—and died a few minutes later, convulsively.

Clane dictated: "The flesh, on examination, proved to be predominately a complex protein structure, so complex in fact that it seemed doubtful if it would be edible by any animal of Earth origin. Rat, to which it was fed, died in 3.08 minutes."

Shortly after the dinner hour, he had the parts of the body returned to the box and put back into the ice room. The task completed, he hesitated. Because it was only the first of his two purposes. The other one required his knowledge of how to ride roughshod over another's will.

Once again, he was back in the role he hated. And there was no alternative.

He sent his party home, and inquired the way to Calaj's apartment. The official he spoke to recognized him, and put his hands to his head, as he said:

"Oh, your excellency, the confusion today is fantastic. We are all worn out."

He quieted long enough to give Clane the directions he desired. There were guards at the entrance of Calaj's apartment, but they sprang to attention when he said, "I am Lord Clane Linn, uncle of the Lord Adviser."

"Shall we announce you, your excellency?" one asked doubtfully.

"No." Clane was cool and positive. "I'll just go in."

He entered.

There was a little alcove, then a large outer room. As he glanced around him curiously, Clane saw Calaj standing on his head beside an open window. He was exhibiting his skill for the benefit of a Martian slave girl. The girl giggled, and then she turned away, and saw Clane. She froze.

She said something, and Calaj came tumbling down out of his upside down pose. He must have heard his mother express fears about Lord Clane, because he turned pale when he saw who it was.

"Uncle!" he said. And Clane did not miss the overtones of alarm in the voice. Calaj was hypnotized by his own anxiety.

In a sense the boy's fears were justified. Clane had no time to waste. He had come to the palace with two objectives, and he had brought along his rod of energy for emergencies. One objective—the examination of the Riss—was accomplished. The other depended on Calaj.

Clane felt remorseless. According to the reports of his spies, this boy was abnormal. If that was so, then he could not be saved. Often in the past, Clane had taken children and grown-ups to a private asylum, and there with all his knowledge had tried to untangle their minds. In vain.

This was no time to hope for success, where so often he had failed before.

Calaj had to be sacrificed. And Lilidel. And all that group behind her.

Destroyed by the madman they had raised to power.

"My boy," said Clane, "I have received instructions from the gods about you. They love you—but you must do their will."

"They love *me?*" said Calaj. His eyes were wide.

"They love you," said Clane firmly. "Why else do you think you were allowed to attain the height of power? Surely, you do not think that any human could have made you Lord Adviser without their permission."

"No, no, of course not."

"Listen, carefully," said Clane, "here are *their* instructions for your future actions. Repeat them after me. You must rule in your own right."

"I must rule in my own right." His voice was dull.

"Let no one in the palace advise you on affairs of state. Whatever you decide will be as the decision of the gods."

Calaj repeated the words with a rising inflection. And then he blinked. "Not even mother?" he asked, amazed.

"Especially not mother," said Clane.

He went on, "You will need new people around you. Be careful for a while, but gradually appoint men of your own choice. Disregard those recommended by your mother and her friends. And now, I have a document here—"

Arrived at home, he wasted no time. "I am leaving at once," he told the heads of the various departments of his household staff. "You will probably not hear from me for a long time. You will conduct yourselves and the estate as in the past."

The guards captain said, "What about the assassin?"

Clane hesitated; then, "I suppose the men are expectant?"

"That they are, sir."

Clane said steadily, "I regard this custom of turning a woman assassin over to the soldiery as a barbarous practice, and it will not take place. First, it would be very dangerous for us all since her family is friendly with the new Lord Adviser. You might stress that point to the men, and then say—"

He made his offer of compensation. It was so generous that there was no doubt of it being accepted.

He finished, "The offer holds for one year. And captain—"

"Yes, sir?"

Clane parted his lips to make his next announcement, then closed them. It was more than just another move in the complex game he was playing, and yet, the political color was there, too.

I've got to rise above all this pettiness, he told himself. In spite of what Czinczar had said, there was more to statesmanship than animal cunning. It all seemed so obvious; so essential. Because if he also played only the game the others were playing, there would be no hope.

His very determination stiffened him. He said quietly: "You may pass the word along to the company officers that the Lady Madelina Corgay will in future be known as the Lady Madelina Linn. All ranks will treat her accordingly."

"*Yes,* sir. Congratulations, your excellency."

"The marriage will take place today," Clane finished.

TO BE CONTINUED

THE ANALYTICAL LABORATORY

Evidently the Christmas Holidays gave you more time to write letters and postcards of comment; certainly we had an unusual number of votes on the January issue of the magazine. Incidentally, I want to thank each of you who have written in those votes; it represents time, trouble, and constructive effort on your part. I can't possibly print all the letters received, or even a large fraction of them, but I assure you every one is read—and each not only affects the scores printed below, but aids me in estimating the general tenor of the readership desires. They are appreciated. An author can ask the editor what he wants; it's very difficult for the editor to get his 100,000 bosses to discuss the subject!

And so letters are appreciated—and these are the scores for the January, 1950 issue.

Place	Story	Author	Points
1.	". . . And Now You Don't"	Isaac Asimov	2.00
2.	Not To Be Opened	Roger Flint Young	2.40
3.	Gypsy	Poul Anderson	3.23
4.	The Xi Effect	Philip Latham	3.50
5.	Old Mother Methuselah	René Lafayette	4.30

And it might be pointed out that Roger Young did all right as a new writer in the field; the wide scattering of opinion indicated a rugged fight for position!

THE EDITOR.

GREED

BY L. RON HUBBARD

Piracy is a remarkable thing. It's usually based on greed—but in a highly peculiar way. Many times it's greed for adventure, for high and dangerous living, rather than greed for wealth!

Illustrated by Brush

It can be said with more than a little truth that a society is lost when it loses its greed, for without hunger as a whip—for power, money or fame—man sinks into a blind sloth and, contented or not, is gone.

There were three distinct classes of men who made up the early vanguard into space—and they were all greedy.

First were the explorers, the keen-eyed, eager and dauntless few who wrenched knowledge from the dark and unwilling depths of the universe.

Next were the rangers, called variously the "space tramps," "space nuts," and "star hobos," who wandered aimlessly, looking, prospecting, seeing what was to be seen and wandering on.

And last were the exploiters, the hard-headed, quick-eyed and dangerous few who accomplished, according to a standard and learned work of the times, the "rape of space".

Each had his hunger. The explorer wanted knowledge and fame and he often laid down his life in an effort to attain them. The space tramp wanted novelty, change, adventure and sojourns in the exotic humanoid societies or solitudes in the wastes. The exploiter wanted gems and gold.

Hard words have been used against these last and it has been charged that their depredations in the first days of conquest committed ravages upon new planets which hundreds of generations could not repair.

George Marquis Lorrilard, sometime lieutenant in the United Continents Space Navy—that pitiful handful of space guards—was an exploiter. The savage libels leveled at him in his days are leveled even now. In the kindest histories, he is "not quite nice". And yet this man broke an impasse of Earth nations which threatened the future of all space conquest and planted the first successful colony in the stars.

He wanted wealth and he made no secret of it. A lean, hardy, ice-eyed man, Lorrilard knew his own desires and he attained them. Lesser men were afraid of him and yet, when one reviews the evidence, he never gave his own kind reason.

Often savage, always decisive and abrupt, George Marquis Lorrilard looms like a giant among his kind. He attained his goals. His fortune, wrested from brutal and inhospitable worlds, at one time amounted to twice the entire national debt of the United Continents and when it was at last dispersed in the reading of his will, it nearly wrecked Earth economy.

But if one seeks to envision him as a palm-rubbing skinflint, cowering behind underlings, one is wrong. Even if that is the impression vengeful historians seek to give, nothing could be further from truth. He commanded his own ships. He fought his own fights. And he died in the act of personal conquest in the stars.

Not too long after exploration had begun in earnest, men found that there was wealth to be had amongst the alien worlds. All they saw, then, was the portable wealth, the fabulous jewels and precious metals and elements, which lay either already mined in the hands of hapless humanoids or was to be had by the merest skimming of the virgin ground. Some of the tales told in these times are not exaggerations. It is actually true that there was an entire mountain of solid gold on Durak and that there was a ruby measuring eighty feet in diameter on Psycho. The humanoids of Darwin of Mizar used solid silver for paving. And into a thousand worlds went the exploiters, close behind the explorers, to extract their due with pick and gun. They fought animals,

humanoids, men and absolute zero—some died and some received their pay.

Few had thought of colonies at this time. Overpopulation on Earth was serious, but the first efforts with Mars had proven so pale that thoughts of new human worlds were few. Earth, as always, was too engrossed in her own travails to think much, as an entire society, about the stars.

An invention had disrupted affairs entirely. And it was a sudden and stopping thing. Heretofore, nearly all research had aided space conquest but now, abruptly, the problems of the Universe had to wait. The Asian government had triumphed.

For many a long year there had been a single Earth, all properly patrolled and controlled by a single government. And the researches had become private affairs. Long sleep had lulled the salons and the armor of their army and navy was almost sunk to rust. In the last year before the political cataclysm, the total United Nations appropriation for defense was less than one tenth its expenditure for education, a thing which, while pretty, is not practical. And for a long, long while, the Asiatic races had slept.

Earth had, as we all know, several human races. But her most energetic were the yellow and the white. And the white ruled and the yellow endured. A country which had been called Russia had almost triumphed once. And then it had failed. Although ostensibly white, it was actually oriental. Sunk into what it considered a trying servitude to the white races, Asia struggled behind her hands and at length, with the One-Earth government grown feeble, struck with suddenness.

The wounds of a forgotten war had festered into a new invention. It was privately done. And it outstripped all the means of offense which could be employed against it.

It was a simple contrivance. We would call it very elementary now. But to Earth it came as a stunning reversal of affairs. It was a "cohesion projector". By using the force which keeps electrons and atoms together, rather than the force which blows them apart, space itself could be made into a solid wall. In an instant then, from a single generator, a column several hundred feet in diameter could be projected upwards for several thousand miles. It was not an elementary force screen such as those in early use to repel missile rockets. It was a solid, if invisible wall. With a slightly greater frequency, it could have made matter, but they did not know that then and indeed, did not find it out for another five hundred years.

With cunning handicraft, the yellow races, under the direction of the ex-federation of Russia, constructed their thousands of generators, passed them secretly to proper points for installation and suddenly announced. with the murder of all the United Nations garrisons within the boundaries of Asia, that they were free from the remainder of the world.

A dozen violent attacks against the rebels ended in defeat for the United Nations. The remaining political entities outside this barrier formed the United Continents under the direction of a major country in North America.

At first no one supposed that any great harm would come of this. The Asians knew better than to attack such excellent missile weapons as the United Continents had and the United Continents had learned with cost not to attack the cohesion barriers of the Asians. Earth was in a fine state of deadlock and consequent intrigue and stayed that way for many years.

It was into this strange situation that George Marquis Lorrilard was born. He went to the United Continents Naval Academy, was graduated in the center of his class, was given a minor warship assignment and was forgotten about as a cog in the machinery of government. In due time, unnoticed in general but always admired by his divisions for his atheltic skill and competence, he became a lieutenant and was placed in command of an outer space patrol vessel, the *State Sahara.*

Only then did he astonish anyone. He attacked the Asian cruiser *Changrin* in the area of Betelgeuse and shot it to such small bits that he experienced trouble afterwards finding out its right name.

Returning to Earth he reported with aplomb the circumstances of the engagement. The United Continents and the Asians had not been at war for a decade. They had pursued their way in space without a clash because there was, after all, a lot of space. There had been tales brought back from time to time of white prospectors being robbed and murdered by Asian military units or vessels but no action had been taken. The general idea was that any man fool enough to cruise space for any purpose did so at his own risk.

George Marquis Lorrilard not only reported—he gave forth a new doctrine, "The Freedom of Space". Heretofore there had been spheres of activity. There were no colonies as such, there were only isolated mines and occasional garrisons and patrols to keep the humanoids in hand.

George Marquis Lorrilard brought to an astonished world some news. The mortality of mines in the strange worlds was not coincident with the risings of humanoids or the happening of cataclysms. The loss of small freighters was only rarely due to collision and mechanical failure. The Asians were establishing fortresses on most of the habitable worlds in easy cruise from Earth and they would soon control space.

People had said it before. But there had not been a bloody fight involved. Lorrilard made front page with his own personal story, "HOW THE *CHANGRIN* WAS BEATEN".

It was an engaging tale. The *State Sahara,* a moldy old cruise vessel, had come upon the *Changrin* in the act of blowing the Gay Mistake

Mining Company of Detroit off the face of New Kansas. The *Changrin* had landed to scoop up a few tons of bar iridium and had barely got into the sky again when the *State Sahara* struck.

It was one of those single ship duels which were so dear to everyone's patriotic heart before big fleet battles usurped the glory of single action. The *Changrin*, being ten times the weight of the *State Sahara* and with a million foot pounds a second more fire power had almost won. And then, with his last erg of charge in the gun condensers, Lorrilard had nailed the enemy through and through.

For two or three days it looked like a war with the Asians but at length everyone decided not to risk it. Lorrilard became excited and said that white superiority in space was glimmering and almost gone and that his government was stupid. They *let* him resign from the Navy.

The Gay Mistake Mining Company of Detroit suddenly presented him with half the iridium he had recovered for them. The Hot Boy Exploit Company, which owned gem deposits on thirty worlds, gave him a check for five million dollars. The August Tart Interests handed him a medal which turned out to be worth twenty millions, being a pie-plate diamond from one of their space mines. And George Marquis Lorrilard presented a very innocent face to an astonished political front. He had not solicited anything or proposed anything—he said.

But in a letter to Jacob Unser, a man much interested in the destiny of white men in the Universe and a later partner in crime, Lorrilard said, "I consider that forts are a sort of trap. However, all we can do is place a new earth out there for a base and operate from it to defend. We cannot afford a patrol navy. We need a raiding base."

Evidently he tried it. There are no records in existence which give any kind of picture of what they did attempt. But there are a few hints.

Lorrilard seems to have tried an inferior sort of cohesion barrier, lacking the answer to an Asian type. And behind its supposed safety, on a new world approximating Earth yet nearer to wealthier planets, he tried to plant a colony which would maintain itself and support a patrol fleet.

However it was attempted, it failed. Some thirty-eight billion dollars and eighteen thousand lives were squandered in the effort to plant that colony—only to have the Asians wipe it out. This is known because a contemporary uses the figures to prove that the planting of colonies in space "is folly which would be attempted only by such a hothead as Lorrilard, the cashiered naval officer."

Other brutal opinions and a government distaste for him—for the Asians could invent weapons at will now behind their barrier and a war would be a chancey thing—drove Lorrilard back into space.

He went at it hard-eyed now, an avowed exploiter. He pretends all

the swashbuckle and the dollar-conscious conversation of your true man of greed. But one wonders if he was not hiding a rather large dream.

He began to raid exposed Asian points. At least fifty other men like him were beginning to engage themselves in this sport now. And Lorrilard became famous or, as his government said, infamous. They apprehended an Asian war as a result of such raids. The Asians apparently apprehended nothing but Lorrilard and his friends. And they rapidly fortified their areas in the outer worlds.

But it seems very peculiar, if historians of the period are right, that nothing was actually done to stop this raiding. Lorrilard landed and departed within United Continent territory at will. He banked fantastic sums, wet, as the Moscow press screamed "with Asian blood" and went forth for others.

He used up several space vessels in the next fifteen years and his losses in personnel were sometimes high. And yet his recruiting was easy indeed. He maintained at his own expense a laboratory in the Andes for research on weapons, battle methods and, fruitlessly, on cohesion.

Two other efforts were made in space to plant colonies which would act as strong points in rival to the Asians, both efforts private and both of them wiped out to a man. And although the United Continents officially shuddered on Earth, diplomatic relations with Asiana were politely maintained. No Asian army dared issue forth from that screen on Earth to attack the superior missiles and arcs of the United Continents and no missile could penetrate Asia. And the blood continued to flow in space.

And the name of George Marquis Lorrilard, as the years went on, became something that Asian mothers used to frighten their offspring into obedience, quiet or sleep. He was forty-six now, in the prime of youth in those times, a wise, cunning fighter who had risen far above mere law.

And the incident happened which brougth him to Stella and started the chain reaction which was to end the deadlock. He was primed with new theories about cohesion barriers, loaded with new weapons and hungry for new gold.

He was familiar with Stella.

It had eight continents and was two thirds covered by salt oceans, which is an approximation of Earth.

In age it had passed through its great mammal period and was entered upon man.

Yes; Man.

Not Homo sapiens, of course, but a very near approach, differing mainly in that he was blue. This humanoid had developed fire weapons, could work rudimentary electricity, had flight of a sort and built cities of considerable extent. He stood about two and a half meters tall, had a brain capacity of a comparative nature to pre-space man and was developed culturally into political entities.

His planet was amusing to rovers and of no value to exploiters. It was almost entirely lacking in precious metals and stones and in radioactive fuels. Therefore, it had been written up as something intriguing for the Sunday papers and otherwise left alone. Many space tramps harbored there, but inbreeding was eugenically impossible and the race stayed the way it was.

Probably colonization would have continued an entire fiasco for the next ten thousand years if it had not been for Stella.

Occasional Asian raids were made on the place to gather slave labor, but the undertaking was dangerous, no matter the value of these creatures to the Asians in extorting minerals from the infinity of worlds. The Asians, therefore, established a sort of super-state on Stella, not interfering with its politics but supporting several fortresses keyed by a main stronghold on a central continent.

Asian mine ships began to harbor there and build up financial reserves

which it would be necessary to report to Asiana and the Asian governor, a man named Kolchein, grew quite sleek. But he erred in setting up a cohesion barrier much larger than he needed and wider than any raider would suspect.

The *Sudden Sunday,* one of the exploiters, ran into this screen at an altitude of two hundred miles, tripped and crashed. As its mission was the peaceful one of landing to repair a depleted crew with Stellan converts, Lorrilard considered it a hostile act.

Perhaps he had never forgiven the Asians for certain actions they had taken against him while he was taking actions against them. Perhaps he was vengeful on account of Peter Gault, the skipper of the *Sudden Sunday* and Lorrilard's friend. Perhaps he sympathized with the relatives of the dead in the city the *Sudden Sunday* had destroyed in crashing. However that may be, it was common knowledge in those times that several hundred billions in cached Asian loot rested under the protection of Kolchein. And Lorrilard's Andes lab had lately sent him a large box.

Lorrilard, in the *Angel's Dance,* a little cruiser of nineteen hundred metric tons and armed with scarcely a foot pound for every thousand foot pounds in the Asian fortress, sat down on Stella.

He had a bully boy crew of two hundred, five bucko officers, and a dozen technicians. His human odds were therefore a million to one against the Stellans and a mere hundred to one against the Asians. So he sent a polite note, carried on a dagger point, to the chief mandate of the Stellan Union of Countries, and actually expected a written reply. But they did not write. A Stellan tank corps flew in at eventide and began to bang away at the *Angel's Dance.*

Some of Lorrilard's hard certitude diminished. Space tramps had been at work with know-how for a hundred years amongst the Stellans and an already considerable culture could protect itself effectively with a thing it called a "hand atomic weapon"—an obsolescence on Earth but a gruesome thing to breast nonetheless.

He lost eight men before he nailed the last remnants of the tank corps to their turrets and left them for the vultures. The attack angered him and an amazed Council of Countries dredged up the contents of their arsenals at the sight of the blue head of the tank corps commander, wrapped up in a big leaf and pinned into a package with his largest medal.

But Lorrilard was quite able. He wasn't there when the newly mustered army arrived—he was waiting a thousand miles up with his fingers on his radiative meteor disintegrators. He did not much like to do it. Things often happened which were unpleasant when the beams, usually fanned out about a ship to wipe out space dust ten thousand miles around

and about, were concentrated into one package and aimed at anything as solid as Stella.

Also, it was illegal.

The Stellan army was blackening the plains below and Stellan high altitude stratosphere battleplanes were raking back and forth in hopes. Lorrilard briefly thanked them for avoiding the Asian main fortress so wide—it was on the north central plateau of another continent—and sighed over the release button.

"I only asked them to attack the Asians with me," Lorrilard said to his chief mate Roseca.

"Then they are more scared of the Asians," said Roseca.

"You mean the Asians," said Lorrilard, "are requiring them to fight. Well, here's for eternity!"

The button went down.

An area two hundred miles in diameter, and comprising all the plain below, smoked, bucked, buckled and caved in. An ocean of molten rocks gushed forth. The beam penetrated the crust of Stella, ate through and reached the liquid core. The guts of the planet gurgled forth. Three quarters of a million Stellans, the pride of the race, eddied as memories in the scarlet writhe.

A lookout crisply sang: "City on two o'clock quarter."

Lorrilard looked at the city through his booster glasses, adjusted them for a smaller field and saw humanoids twisting through the streets, running raggedly and unsuccessfully between great gouts of walls coming down.

A lookout sang: "Seaport at nine o'clock. Tidal wave."

And Lorrilard looked down at the seaport. But he was a little late. He saw only the top of the last steeple toppling, a weather vane still staunchly pointing to a second wave coming in. Lorrilard frowned. The wave should have departed to come back in hours or days and do its engulfing. And then he knew that he had seen the crest of one begun in the vanishing of half an archipelago off the coast.

A lookout sang: "Mountains at five o'clock quarter."

And Lorrilard looked and the mountains were walking forward to meet the incoming sea and as he looked he saw a dozen cities die.

Instantly he was worried. "Roseca! Supposing the Asian fortress goes!"

And that finished the observation of this interesting phenomena for that fortress contained several hundred billions in portable loot, small change perhaps to an exploiter if he mentioned it amongst his fellows, but not to be overlooked.

They shot away from there in a graceful swoop and approached the north continent and its plateau. And there in the early morning sunlight spread the majesty of Asiana, black-walled and grim, white-turreted and proud.

There was one wall fallen in part but every tower stood firm. The ground had moved, moved violently enough to throw a walking man heavily down and keep him there for

several minutes through the successive waves. But every single ejector of the fortress was sending out screen.

"Barriers ahead," said the electrar man at his post on the bridge. He adjusted his dials and read his meters. "Altitude one tenth of a light-year, amplitude one hundred thousand square miles. Not conning. Not conning."

"Steady on the jets," said Lorrilard. "All directors stop. All brakes back one third. All directors stop. Brakes stop. Easy two o'clock jet. Meet her. Steady on the jets. All directors ahead one. All directors stop. Stand to battle quarters! I got a new wrinkle for you, my Asian friends."

Gongs surged through the *Angel's Dance*. Roseca acknowledged stations into his phones.

"All stations manned and ready, captain," said Roseca.

There was a lot of Navy about Lorrilard. There was a lot of Navy about the *Angel's Dance*. And small wonder—since Lorrilard was an academy product, lost to the Navy because it didn't pay quite as well as other things; and the *Angel's Dance* had been built for the United Continents service and had been bought from the building yard when a bought senator had had a bought secretary buy her, condemning her as "unacceptable." Kolchein, down there, was finding her very unacceptable.

Kolchein was fat and Mongolian and apt to do idiotic and unprofitable things when confronted with certain semantic symbols. His fat yellow jowls were bobbing with rage as he glared into the view screen in the command tower. The screen ran all around the tower as a panel of translucence, showing any visible object in its proper compass direction in any desired magnitude and Kolchein ran all around the screen. He was looking for reinforcements. The earthquakes were unusual. They had upset him.

His cringing, whining second in command was also sick from the still trembling ground, but he was more acutely aware of the value of riches and so was more pained at their threatened loss.

"It's a raid!" whimpered Sze-Quon. "It's a raid!" And he wept into a perfumed handkerchief.

"Shut up!" screamed Kolchein. "Be calm! Talk rationally!" He threw a wild hand at the image of the *Angel's Dance*. "You bag of air! You filth! You told me that our spies on Earth gave no slightest intimation of a United Continents expedition to anywhere! You told me their economy forbade long patrols this year! You said—"

"Think of all that beautiful gold!" wept Sze-Quon. "Think of my peach trees beside the gem pools in Shantung! Think of my lovely dancers with diamonds in their hair and my mansion wandering over seven sacred hills. Gone. All gone! Ohhhh!"

"Shut up!" shrilled Kolchein. "Don't weep over what you never had! Think! Think calmly! Tell me any new weapon, any scrap of data!"

"I know I never had it," sniffled Sze-Quon with all the famed stolidity of the oriental, "but I can miss it, can't I? There are no new weapons, Mighty One. All my intelligences—"

"Then what caused those earthquakes?" cried Kolchein, adding with malice, "Dropping the gold you filch from me?"

Sze-Quon dried up a good part of his tears and took his fragile self into the antechamber where the staff was gnawing scraggly mustaches. He came back in a moment, armed with technology.

"It was a concentrated guard-fan in a bundle. We have no concerns, Mighty One. To get close enough to touch this continent so would bring yonder vessel within our arcs." He had taken heart in the anteroom and also a small shot of stedge, one of the Stellan fortifiers against melancholy.

Kolchein grimaced at the screen, glaring so hard that his personality force alone should have disintegrated the visioned ship. And then, abruptly, he stopped. The vessel had changed situation in a certain, precise manner—that was his first clue. Shiphandling was a rare art when it was that good. And only one—

His fear was instantly found to be founded solidly on fact.

A vital, authoritative voice came out of the emergency band speaker and a face glowed above it and the eyes in the face were hard on the screen which mirrored them.

"Kolchein! You want a continent?"

It was good, clear Asian and the only accent in it came, most likely, from a contempt for the language. And it was a good, clear viewscreen.

"Lorrilard!" said Sze-Quon. Either the stedge or the sight of the face revived him. "It's not a naval force! He won't blast us! It's Lorrilard and he won't blast us. You know what he wants! Gold! He won't cut this continent out from under us. He won't— And then his jubilation changed to new tears. "He won't leave any of us alive either," he wept.

Kolchein had a suspicion of sweat on his brow. He commanded one of the strongest strong points in space. And cohesion beams were proof. He had weapons and he had numbers and he had engineers and war-technicians. That was just one ship up there, the *Angel's Dance.*

But it had Lorrilard.

"Shut up, you vile pig!" he screamed at the weeping Sze-Quon. "You *predatil,* you *dourak,* you *soukine-sin!* Command my batteries to shoot on first range! One hundred pounds of gold to the first technician who pots that *svolotch!* Tell them!"

Sze-Quon was just fleeing from the room in a billow of veils and

sleeves when Lorrilard's hard voice ate through the speaker netting.

"One thousand *tons* of gold and transport home to any *predatil* in that fort who will deliver it up to me!"

The speaker had been snagged by Lorrilard's electrar man and now worked both ways.

It was a chilly thing. It was like a purchase already within the fort. And Sze-Quon, suddenly bright-eyed, halted in his tracks and looked at Kolchein.

"A thous—" Sze-Quon checked himself, licking greedy lips. He considered himself, in the tangled politics of those times, as a member of a conquered race and entitled to a free lance hand in saving his own skin. "Mighty One! Mighty One! *Don't!*"

Kolchein's hand weapon jerked twice and Sze-Quon stood for an instant, twisting in a pillar of flames. Then there was nothing where he

had been and only his handkerchief remained, still wet with his tears for a mansion on seven sacred hills.

Kolchein jerked open the antechamber door and stood glaring at his staff. He read faces well, almost as well as he shot, and what he saw now colored him violently.

"The speakers throughout spoke!" quivered a young captain of arcs. "Is it . . . was it in truth Lorrilard?"

Lorrilard, just then, was walking up and down the command deck of the *Angel's Dance*. He took a bottle from his steward, poured himself a short drink of whiskey, downed it and threw the gurgling quart to Roseca.

"All hands a drink to victory! All hands!" The cooks could be heard padding aft with buckets.

"Range?"

The electrar man looked at his captain. They made a good team when they worked this way, a team despite the fact that this was just a kid with an electronicly-gifted brain. Good-looking kid, too. "Eighteen thousand miles."

Lorrilard looked at the kid. "Keep them coming." He turned to his conmaster. "All directors ahead one. Hard two o'clock. Ease her. Meet her. All directors ahead two."

"Seventeen thousand. Sixteen five. Fourteen—" chanted the kid. The crew tensed as they swooped at the fort.

"Hard seven o'clock! All directors ahead four! Ease her. Meet her. Steady!"

"Sixteen, twenty, twenty-four. Thirty-one thousand miles. Fifty thousand miles. One hundred and ten thousand—"

"All directors back full! All directors stop."

The entire sky, at the point they had turned, went into an aching flare of light as the fort fired, twisting and snapping as great arcs sucked across the dark of space.

The crew breathed easier and grinned.

"Hard six o'clock!" said Lorrilard. "All directors ahead one."

"Ninety thousand, eighty-six . . . seventy-one . . . fifty-three thousand miles. Forty-six—"

"All directors back one. All directors stop."

"Range steady at thirty-seven thousand miles," said the kid.

Lorrilard turned to Paula, his engineer. "Character of activity of those arcs they shot back there?"

"Eighty-third degree psi," said Paula, reading her sample of contaminated space.

"Hook 'em?" said Lorrilard.

Paula had a broken nose from a brawl in some dive but she was still pretty, especially when she smiled. "Think so."

Tomlin, wavetender first, took a tube from Paula and they left the command deck.

"Now you," said Lorrilard to Gustavson, his director division chief,

"tune down close on that force cone and stand by with an interlock."

"Aye, aye," said Gustavson, pushing the electrar kid aside so he could crawl into a booth, newly and economically fitted behind the range panels on this very economical command deck.

"Here we go, kid," said Lorrilard. "Keep 'em coming."

"Ready number six," said Paula from a speaker.

"Stand by, number six," said Lorrilard. "Easy two o'clock. All directors ahead one."

"Thirty-six five—" began the kid, chanting ranges. "Thirty-four. Thirty . . . twenty-seven . . . twenty-one . . . eighteen—"

"All directors ahead four," said Lorrilard. "Hard twelve o'clock. Hold her. Hold her. Let her come!"

The ship was staggering with this brutality. She was being turned wrong side out, pulling herself one hundred and eighty degrees off course.

"Ease her!" said Lorrilard.

"Thirteen thousand two hundred miles—" chanted the kid.

"Meet her!"

The crew had seen the white and black of the fort in their gun directors and they had seen it terribly large. They were swallowing their chews and, like good space bullies, staying on target.

The *Angel's Dance* shuddered. The sky flamed blue-white!

"All directors ahead ten!" And, "COMMENCE FIRE!"

Paula had grappled the arcs and the *Angel's Dance* jerked like a drunk. Every plate of her bucked with the lash of her batteries.

And all down that black and awful sky ran the white fringed fury of eighty-third psi. Backfiring. Boostered and double-ranged by riding back down the fort's own beams.

Lorrilard didn't have to look. He'd figured it out long since.

He was chanting conning commands.

"All directors ahead fifty. Hard six o'clock. Ease her. Meet her. Easy nine o'clock. Meet her. Easy twelve o'clock—" She was moving very fast now.

"Six hundred thousand . . . one and one half million . . . one and one quarter million . . . one million—" chanted the kid.

"Stand by, Gustavson. All directors ahead FULL!"

There was an instant of screaming friction, a thing which rode not on sound waves nor yet existed in finite space. The grapples of the *Angel's Dance* had connected with the force cone and the speed of the intended man-o-war, riding up now to half a light-year, tripped the formulas of velocity and mass.

There was a lurch. Men fell through the ship. The bruised steward, a girl of fourteen, hung on to the bridge ladder up which she had been coming and looked huge-eyed at her

helmet, come off now with a burst strap and hanging midair in defiance of artificial gravity and all else.

Then there was a sag and an easing of the strain as though the *Angel's Dance* had pulled herself out of mud.

"All directors stop. All directors back one. Easy nine o'clock. Easy six o'clock. Let her swing. All directors back two. Meet six o'clock. Steady six o'clock. Let her swing. Meet nine o'clock. Steady as she goes!"

"One half million. Four hundred thousand . . . one hundred thousand . . . seventy thousand—" chanted the kid. "Forty-one thousand— Gee! Gee, captain! Look at that fort!"

People were laughing uncertainly along the battle stations. There was a buzz as arc men tried to shove the pointers away from their viewscreens and see for themselves.

And it was a sight worth seeing—to them.

The fort, the strongest Asian outpost, was in a very queer situation. It resembled a mushroom which has been pulled up by the roots and brought a quantity of dirt with it—providing mushrooms have roots that will hold.

The force screen above it, which would have conducted its batteries to distant ranges not possible at the sides and would have prevented any ship from diving at it, had worked both ways. The batteries silenced by backlash, the force screen could be hit and grappled with a snagger developed in the Andes.

But it would take a madman to hit one like that. A madman like Lorrilard. Who could lay all his money on a formula of velocity and mass and win.

Uprooted before she could disconnect, the fortress was finished and done, the whole mass of it a slab of dirt on its side.

"I wonder," said Lorrilard sympathetically, "where Kolchein vaulted up that gold."

They landed and found out.

They buried it because they could not carry any great part of it away and to this very day on New Earth, nee Stella, there is a tradition of Lorrilard's treasure. But Lorrilard was much too thorough an exploiter. Before the news was out and before the technique could get old, the *Angel's Dance* laid three hundred and ninety major Asian fortresses on their sides and took their contents apart for future reference.

Probably tradition is right. Probably they did miss some. For when they came back to Earth the following year they were trimmed light for battle. They made just one attack. Moscow.

In New York[2], after Earth's politicos had chewed and hewed on a treaty of peace which, amongst other things, disbanded the Asiatic Federation, the Asian delegation was much horrified to know that the entire strength of the "Grand Fleet of the United Continents" consisted of just one cruiser with a new technique and

an exploiter for a captain who had no official standing.

"I say," said the secretary for defense of the United Continents, speaking to Lorrilard and, therefore, speaking with deference, "you gave us a nasty turn you know. We couldn't find the old emergency code you used. Navy hasn't touched it for years. Thought we had an invader from space on our hands when Moscow was hit. Almost rushed aid. Joke, eh?"

"Uhuh," said Lorrilard, looking thoughtfully at his wine.

"However we'll repay you," said the secretary.

"You might make up for Moscow. We couldn't land for its loot," said Lorrilard. "But speaking of something serious, you know, I just had an idea."

"Yes?" very respectfully.

"Stella."

"Do I know her?"

"No, no," said Lorrilard. "It's a planet the Asians had nailed down. Earth-size. Lot of empty towns up there. Lot of machinery. Take about a hundred percent of your excess population if you'd let them go. Build a new earth. That's it. New Earth! Not Stella. New Earth. Say, Mr. President—"

It was a king-size job, but they had a king-size man. There is no evidence to show that he ever ruled it for a single day out of time, but he has been there. He has been there for a long, long time.

If you go there, take a look at the tomb in the valley. The inscription is very thin now, just as the huge statue of him shows the wear of the ages. But it can be read. It says:

George Marquis Lorrilard
Born in Year One of New Earth
Died in Year Ninety of a
Crash Landing on Stigo

He prepared this planet,
Rid it of all Encumbrances,
Organized the first Earth Colony
And equipt it with all necessities
From his own pocket.

Ad astra per aspera

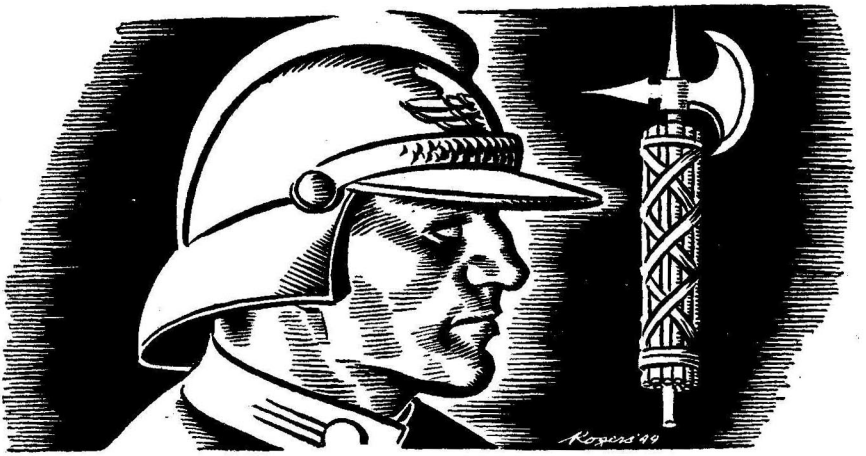
There was a verse below it, but the monument, in the course of time, has sunk so far into the ground that it can no longer be read.

Sunk even further, on this site, although the fact is known to very few, are the decaying metals of a citadel and the body and bones of Kolchein and Sze-Quon.

In Lorrilard's time a large plaque was erected here beaten from solid gold. It reflected the greatness and the coldness of the man, for it was done by his direction.

It was to Kolchein, "whose obstinance and pig-headedness made this great accomplishment possible". But somebody has long since carted it away and melted it up out of greed for the metal. Lorrilard would have understood that.

THE END



OKIE

BY JAMES BLISH

***The** day of the hobo—the always-wandering, always somewhat suspected worker—is eternal. Even when the migratory workers travel between the stars, taking their city with them!*

Illustrated by Rogers

Semantics: belfry or bridge? It depended, as the old saying goes, on the point of view.

The city was a spaceship, and the belfry was a bridge. But the ship was a city, a city of jails and playgrounds, alleys and alley-cats; and the bridge, to be specific, was the belfry of City Hall.

City Hall was the oldest building in the city, and so not many of the other structures could be seen from it. It wasn't tall enough, and there were too many newer buildings around it. Amalfi didn't care. His head was tilted all the way back on his bull neck, and he was looking straight up—straight up at a sun surrounded by starry sable. He had a phone in his hand, from which came intermittent squawks.

"It looks good enough to me,"

Amalfi said, lowering his head grudgingly an inch or two toward the mike. "It's type G or near to it, and Astronomy says two of the planets are Earth-like. And Records says the both of 'em are inhabited. Where there's people, there's work."

The phone quacked anxiously.

"Politics," Amalfi said. The way he said it made it sound fit only to be scrawled on sidewalks. The phone was silenced; Amalfi hung it on its hook and thudded down the archaic stone steps.

Hazleton was waiting for him in the main office, drumming slim fingers upon the desktop. The city manager was an excessively tall, slender, disjointed sort of man; something in the way his limbs were distributed over Amalfi's chair made him also look lazy. If taking devious pains was a sign of laziness, Amalfi was quite willing to call Hazleton the laziest man in the city.

Whether he was lazier than anybody outside the city didn't matter. Nothing that went on outside the city was of any real importance.

Hazleton said, "Well?"

"Well enough," Amalfi grunted. "It's a nice yellow dwarf star, with all the fixings."

"Sure," Hazleton said, with a wry smile. "I don't see why you insist on taking a personal look at every star we go by. There are screens right here in the office, and all the data in the files. We knew even before we could see this sun what it was like."

"I like a personal look," said Amalfi. "I haven't been mayor here for fifteen years for nothing. I can't really tell about a sun until I see it with my own eyes. Then I know. Images don't mean a thing—no *feel* to 'em."

"Nonsense," Hazleton said, without rancor. "And what does your feelership say about this one?"

"It's a good sun; I like it. We'll land."

"All right. Suppose I tell you what's going on out there?"

"I know, I know," Amalfi said. His heavy voice took on a finicky, nervous tone, his own exaggerated version of the speech of the chairman of the City Fathers. " 'The political sit-uation is *ver*-y dis-turbing.' It's the food situation I'm worried about."

"Oh? Is it so bad, then?"

"It's not bad yet. It will be, unless we land. There's been another mutation in the *Chlorella* tanks; must have started when we hit that ultronic nexus near Sigma Draconis. We're getting a yield of about twenty-two hundred kg. per acre in terms of fats."

"That's not bad."

"Not bad, but it's dropping steadily, and the rate of decrease is accelerating. If it's not arrested, we won't have any crops at all in a month or so; and there's not enough crude-oil reserve to tide us over the next-nearest star. We'd hit there eating each other."

Hazleton shrugged. "That's a big If, boss," he said. "We've never had a mutation we couldn't get under

control before. And it's very nasty on those two planets."

"So they're having a war. We've hit that before. We don't have to take sides. We land on the one best suited—"

"If it were an ordinary interplanetary squabble, O.K. But as it happens, one of those worlds—the third one—is a sort of free-living polyp of the old Hrunta Empire, and the inner one is a survivor of the Hamiltonians. They've been fighting for a century, on and off, without any contact with Earth. Now—the Earth's found them."

"And?" Amalfi said.

"And it's cleaning them both out," Hazleton said grimly. "We've just received an official police warning to get out of here."

The invention of Muir's Tape-Mass engine carried early explorers out as far as Jupiter, while the Blackett-Dirac theory of gravity remained a toy of pure mathematicians. Then, abruptly, the theory and the mathematicians had their innings. From the many pages of symbols, and the mumbled discussions of the possible field-strength of a single pole in rotation, the spindizzy sprang as if full-born.

It was amazing that the rusty structure of human society survived that blow at all. For a while, cautiously, the spindizzy was installed only in new spaceships, and there was a brief, a comically brief era of interstellar exploration. The tottering structure fought to retain its traditional balance.

But the center of gravity had shifted. The waste inherent in using the spindizzy only in a ship could not be disguised. Once antigravity was an engineering reality, it was no longer necessary to design ships specially for space travel, for neither weight nor aerodynamic lines meant anything any more. The most massive and awkward object could be lifted and hurled off the Earth, and carried any distance; the Blackett-Dirac effect was hull and overdrive at once. Whole cities, if necessary, could be moved.

Many were. The factories went first; they toured Earth, from one valuable mineral lie to another, and then went farther aloft. They changed Mars into the Pittsburgh of the solar system; the spindizzy had lifted the mining equipment and the refining plants bodily to bring life to that lichen-scabbed ball of rust. The blank where Pittsburgh had been was a valley of slag and ashes. The great plants of the steel companies gulped meteors and chewed into the vitals of new worlds. Others cruised in search of scarce power-metals—

But the social structure did not collapse entirely. The planets had been colonized beforehand; so had many stars. The migrant cities found worlds that refused them landing permits. Others allowed them to land, but exploited them mercilessly. The cities fought; but they were not efficient fighting machines. Earth's own police put them down—

and then, in self-protection, Earth passed laws protecting the cities.

It was a waste to bottle a spindizzy in so small an object as a spaceship, but a war vessel is meant to waste power—the more, the more deadly. The Earth police held their jurisdiction. Earth became a garden planet, Pittsburgh valley bloomed, and rich honeymooners went there to frolic. Old bureaucrats went to Earth to die. Nobody else went there at all.

Above the city the yellow sun was very much smaller. The Okie metropolis, skulking out under quarter drive, crept steadily into hiding within the freezing, blue-green shadow of the ruined giant planet. Tiny moons, a quartet of them, circled in a gelid minuet against the chevrons of ammonia-storms that banded the giant.

Amalfi watched the screens tensely. This kind of close maneuvering, involving the balancing of the city against a whole series of conflicting fields, was very delicate, and not the kind of thing to which he was accustomed; the city generally gave the giants a wide berth. His own preternatural "feel" for the spatial conditions in which he spent his life must here be abetted by every electronic resource at its command.

"Too heavy, Twenty-third Street," he said. "You've got close to a 2° bulge. Trim it."

"Trim, boss."

Amalfi watched the image of the giant planet and its chill handmaidens. A needle tipped delicately.

"Cut!"

The whole city throbbed once and went silent. The silence was a little frightening; the distant hum of the spindizzies was a part of the expected environment, and when it was gone one felt a strange shortness of breath, as if the air had gone bad. Amalfi yawned involuntarily, his diaphragm sucking against an illusory shortage of oxygen.

Hazleton yawned too, but his eyes were glittering. Amalfi knew that the city manager was enjoying himself now; the plan had been his, and so he no longer cared that the city would be in serious danger from here on out. He was taking lazy-folks' pains. Amalfi only hoped that Hazleton was not outsmarting himself and the city at the same time; they had had some narrow squeaks with Hazleton's plans before. That episode on Thor V—

"Now we'll sit tight for a week," Hazleton said, his spatulate fingers shooting the courser of the slide rule back and forth. "Our food will hold out that long. That was a very convincing orbit Astronomy gave us. The cops will be sure we're well on our way out by now—and there aren't enough of them to take care of the two warring planets and to comb space for us at the same time, anyhow."

"You hope."

"It stands to reason, doesn't it?" Hazleton said, his eyes gleaming. "Sooner or later, within a matter of days, they'll find that one of those planets is stronger than the other, and concentrate on it. When that

happens, we'll hightail for the one with the weakest investiture; they'll be too busy to prevent our landing."

"Yeah," Amalfi said. "Which involves us directly with the weaker planet, and gives Earth good reason to disperse us."

"Not necessarily," Hazleton insisted. "They can't break us up for violating a Vacate order. If necessary we can show that the Vacate order was inhumane—and in the meantime, they can't enforce the order while we're under the aegis of an enemy of theirs. We'll—"

The intercom on the flight board emitted a self-deprecatory burp. Amalfi pressed the stud.

"Mr. Mayor?"

"Yep."

"This is Sergeant Anderson at the Cathedral Parkway Lookout. There's a whopping big ship just come into view around the bulge We're trying to contact her now. A warship."

"Thanks," Amalfi said, shooting a glance at Hazleton. "Put her through to here when you make contact." He dialed the 'visor until he could see the limb of the giant planet opposite the one into which the city was swinging. Sure enough; there was a tiny sliver of light there. The strange ship was still in the sunlight, but she must have been a whopper to be visible at all at this distance. The mayor stepped up the magnification, and was rewarded with a look at a tube about the size of his thumb.

"Not making any attempt to hide," he murmured, "but then you couldn't very well hide a thing that size. She must be all of a thousand feet long. Looks like we didn't fool 'em."

Hazleton leaned forward and studied the innocuous-looking cylinder intently. "I don't think that's a police craft," he said. "Police battleships are more or less pear-shaped, and have plenty of bumps. This boat only has four turrets and they're faired into the hull—see?"

Amalfi nodded, thrusting out his lower lip speculatively. "Local stuff, then. Archaic equipment. Muir engines, maybe."

The intercom burped again. "Ready with the visiting craft, sir."

The view of the ship and the blue-green planet was wiped away, and a pleasant-faced young man looked at them. "How do you do," he said formally. The question didn't seem to mean anything, but his tone indicated that he didn't expect an answer anyhow. "I am speaking to the . . . the commanding officer of the flying fort?"

"In effect," Amalfi said. "I'm the mayor here, and this gentleman is the city manager; we're responsible for different aspects of command. Who are you?"

"Captain Savage of the Federal Navy of Utopia," the young man said. He did not smile. "May we have permission to approach your fort or city or whatever it is? We'd like to land a representative."

Amalfi snapped the audio switch and looked at Hazleton. "What do you think?" he said. The Utopian

officer politely and pointedly did not watch the movements of his lips.

"It should be safe enough. Still, that's a big ship even if it is obsolete. They could send their man in a life-craft."

Amalfi opened the circuit again. "Under the circumstances we'd just as soon you stayed where you are," he said. "You'll understand, I'm sure, captain. However you may send a gig if you like; your representative is welcome here. Or we will exchange hostages—"

Savage's hand moved across the screen as if brushing the suggestion away. "Quite unnecessary, sir. We heard the interstellar craft warn you away; any enemy of theirs must be a friend of ours. We are hoping that you can shed some light on what is at best a confused situation."

"It is possible," Amalfi said. "If that is all for now—"

"End of transmission."

"End."

Hazleton arose. "Suppose I meet the emissary. Your office?"

"O.K."

The city manager went out, and Amalfi, after a few moments, followed him, locking up the control tower. The city was in an orbit and would be stable until the time came to put it in flight again. On the street, Amalfi flagged a cab.

It was a fairly long haul from the control tower, which was on Thirty-fourth Street, down to Bowling Green where City Hall was, and Amalfi lengthened it a bit more by giving the Tin Cabby a route that would have put folding money into the pocket of a live one of another age. He settled back, bit off the end of a hydroponic cigar, and tried to remember what he had heard about the Hamiltonians. Some sort of a republican sect, they'd been, back in the very earliest days of space travel. There's been a public furor—recruiting—government suppression—hm-m-m. It was all very dim, and Amalfi was not at all sure that he hadn't mixed it up with some other event of Terrestrial history.

But there *had* been an exodus of some sort. Shiploads of Hamiltonians, going out to colonize, to set up model planets. Come to think of it, one of the nations then current on Earth had had a sort of Hamiltonianism of its own, something called a timocracy. It had all died down after a while, but it had left traces; nearly every major political wave had its vestige somewhere in the inhabited part of the galaxy.

Utopia must have been colonized very early. The Hrunta Imperials, had *they* arrived first, would have garrisoned both planets as a matter of course.

It was a little easier to remember the Hrunta Empire, since it was of much more recent vintage than the Hamiltonians; but there was less to remember. The outer margins of exploration had spawned gimcrack empires by the dozens in the days when Earth seemed to be losing her grip. Alois Hrunta had been merely the most successful of the would-

be emperors of space. His territory had expanded as far as the limits of communication would allow an absolute autocracy to spread, and then had been destroyed almost before he died, broken into duchies by his squabbling sons. Eventually the duchies fell in their turn to the nominal but irresistible authority of Earth, leaving, as the Hamiltonians had left, a legacy of a few remote planets—worlds where a dead dream was served with meaningless pomp.

The cab began to settle, and the façade of City Hall drifted past Amalfi's window. The once-golden motto—MOW YOUR LAWN, LADY?—looked greener than ever in the light of the giant planet. Amalfi sighed. These political squabbles were dull, and they were guaranteed to make a major project out of the simple matter of earning a square meal.

The first thing that Amalfi noticed upon entering his office was that Hazleton looked uncomfortable. This was practically a millennial event; nothing had ever disturbed Hazleton before; he was very nearly the perfect citizen of space, resilient, resourceful, and almost impossible to surprise—or bluff. There was nobody else in the office but a girl whom Amalfi did not recognize; probably one of the many parliamentary secretaries who handled the intramural affairs of the city.

"What's the matter, Mark? Where's the Utopian contact man?"

"There," Hazleton said. He didn't exactly point, but there was no doubt about his meaning. Amalfi felt his eyebrows tobogganning over his bald skull. He turned and studied the girl.

She was quite pretty; black hair, with blue lights in it; gray eyes, very frank, and a little amused; a small body, well made, a little on the sturdy side. She was dressed in the most curious garment Amalfi had ever seen—she had a sort of sack over her head, with holes for her arms and neck, and the cloth was pulled in tightly above her waist; her hips and her legs down to just below her knees were covered by a big tube of black fabric, belted at the top. Her legs were sheathed in token stockings of some sleazily-woven, quite transparent stuff; little flecks of color spotted the sack, and around her neck she had a sort of scarf—no, it wasn't a scarf, it was a ribbon—what *was* it, anyhow?

After a moment, the girl began to look annoyed at his inspection, and he turned his head away and went to his desk. Behind him, her voice said gently: "I didn't mean to cause a sensation, sir. Evidently you didn't expect a woman—?"

Her idiom was as archaic as her clothes; it was almost Elliotian. Amalfi sat down and collected his scattered impressions.

"No, we didn't," he said. "However we have women in positions of authority here; I suppose we were misled by Earth custom, which still doesn't allow woman much hand in the affairs of the military. You're

welcome, anyhow. What can we do for you?"

"May I sit down? Thank you. First of all, you can tell us where all these immense fighting ships come from. Evidently they know you."

"Not personally," Amalfi said. "They know the Cities as a class, that's all. They're the Earth police."

The Utopian girl's piquant face dimmed subtly, as if she had expected the answer and had been fighting to believe it would not be given.

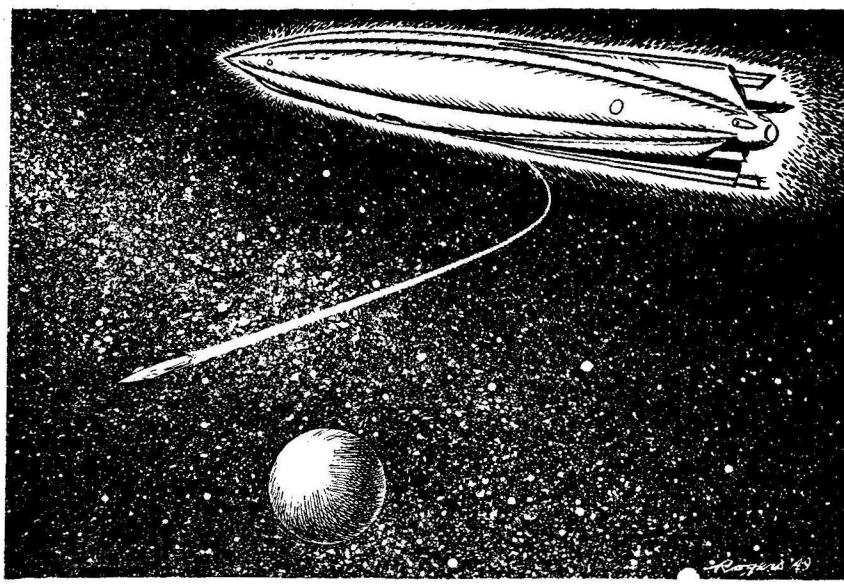
"That's what they told us," she said. "We . . . we couldn't believe it. Why are they attacking us, then?"

"It was bound to happen sooner or later. Earth is incorporating the independent planets as a matter of policy; your friends the Hruntans will be taken in, too. I don't suppose I can explain why. We aren't exactly in the confidence of the Earth government."

"Oh," the girl said. "Then perhaps you will help us. This immense fortress of yours—"

"I beg your pardon," Hazleton said, smiling ruefully. "It is no fortress, I assure you. We are only lightly armed. However, we may be able to help you in other ways; frankly, we're anxious to make a deal."

Amalfi looked at him sharply. It was incautious, and unlike Hazleton, to discuss the city's armament with an officer who had just come from a strange battleship.



The girl said: "What do you want? If you can teach us how those great ships fly, and how you keep your city in motion—"

"You don't have the spindizzy?" Amalfi said. "But you must have had, otherwise you'd never have got way out here."

"The secret of interstellar flight has been lost for nearly a century. We still have the first ship, in our museum; but the motor is a mystery. It does not seem to *do* anything."

Hazleton smiled again. "We can show you what it does," he said. "It is too simple to yield its secret lightly. As for us—we need supplies, raw materials. Oil most of all. Have you that?"

The girl nodded. "Utopia is very rich in it, and we haven't needed it in quantity for nearly twenty-five years—ever since we rediscovered molar valence." Amalfi pricked up his ears, but tried not to show it. The term told its own story; anyone who could affect molecular bonding beyond the usual adhesion effects would have no need for physical lubricants—and if the Utopians thought they had only *re*discovered such a technique, so much the better.

"We can use anything you can give us," the girl went on. Abruptly, she looked very weary in spite of her healthy youth. "All our lives we have been fighting these Hruntan barbarians and waiting for the day when help would arrive from Earth. Now Earth has come—and its hand is against both worlds! Things must have changed a great deal."

"The fault doesn't lie in their change," Hazleton said quietly, "but in that you have failed to change. Traveling away from Earth is like traveling in time; different distances have different year-dates. Stars remote from Earth, like yours, are historical backwaters. The situation becomes complicated when the periods interpenetrate, as your period and the Hrunta Empire have interpenetrated; the two cultures freeze each other by conflict, and when history catches up with them—well, naturally it's a shock."

"On a more practical subject," Amalfi said, "we'd prefer to pick our own site; if we can send technicians to your planet in advance, they'll find a lie for us."

"A lie?"

"A mining site. That's to be permitted, I presume?"

"I don't know," the girl said uncertainly. "We're very short on metals, steel especially. We have to salvage all our wrecks—"

"We use almost no iron," Amalfi assured her. "What we're after is germanium and some rare-earth metals for instruments. You ought to have plenty of those to spare." Amalfi saw no point in adding that germanium was the basis of the present universal coinage; what he had said was true as far as it went, and in dealing with these backward planets there were five or six facts best suppressed until after the city had left.

"May I use your phone?"

Amalfi moved away from the desk, then had to come back again as the girl dabbed helplessly at the 'visor controls. In a moment she was outlining the conversations to the Utopian captain. Amalfi wondered if the Hruntans here understood English; not that he was worried about the present interview being overheard—the giant planet would prevent that most efficiently, since the Utopians used radio rather than ultronic or Dirac communicators—but it was of the utmost importance that the Hruntans should have heard and understood the warning the Earth police had given the city. It was a point that would have to be checked, as unobtrusively as possible.

It might also be well to restrict sharply the technical information the city passed out. If the Hamiltonians—or the Hruntans—suddenly blossomed out with Bethé blasters, fieldbombs, and the rest of the modern arsenal, the police would be unhappy—and would know who to blame. It was comforting to know that nobody in the city knew how to build a Canceller, anyhow; Amalfi had a disquieting mental picture of a mob of Hruntan barbarians swarming out of this system in gravity-powered ships, highjacking their way back to an anachronistic triumph, snuffing out stars like candle flames as they went.

"It is agreed," the girl said. "Captain Savage suggests that I take your technicians with me, to save time. And is there also someone who understands the interstellar drive—?"

"I'll go along," Hazleton said. "I know spindizzies as well as the next man."

"Nothing doing, Mark; I need you here. We've plenty of grease-monkeys for that purpose." Amalfi spoke rapidly into the vacated 'visor. "There; you'll find the proper people waiting at your gig, young lady. If you people will radio us exactly one week from today, we'll be out of occultation and will get the message."

There was a long silence after the Utopian girl had left. At last Amalfi said slowly: "Mark, there is no shortage of women in the city."

Hazleton flushed. "I'm sorry, boss. I knew it was impossible directly the words were out of my mouth. Still, I think we may be able to do something for them; the Hruntan Empire, was a pretty nauseating sort of state, if I remember correctly."

"That's none of our business," Amalfi said sharply. He disliked having to turn the full force of his authority upon Hazleton; but the city manager was for Amalfi the next best thing to that son his position had never permitted him to have—for the laws of all Okie cities contain elaborate safeguards against the founding of any possible dynasty. Only Amalfi knew how many times the younger man's elusive, amoral intelligence had brought him close to being shot by the City Fathers; and a situation like this one was crucial to the survival of the city.

"Look, Mark; we can't afford to have sympathies. What are the Hamiltonians to us? What are they to themselves, for that matter? I was thinking a minute ago of what a disaster it'd be if the Hruntans got a Canceller or some such weapon and blackmailed their way back to a real Empire again. But can you see a rebirth of Hamiltonianism any better—in *this* age? Superficially it'd be better, I'll admit, than another Hruntan tyranny—but historically it would be just as disastrous. These two planets have been fighting each other for two causes that played themselves out centuries ago. They aren't either of them *relevant* any more."

He stopped for a breath, taking the mangled cigar out of his mouth and eying it with mild surprise. "I knew that the girl was disturbing your judgment the moment I realized that I'd have to read the riot act to you like this. Ordinarily you're the best cultural morphologist I've ever had, and every City man has to be a good one. If you weren't in an emotional uproar, you'd see that these people are the victims of a pseudomorphosis—dead cultures, both of 'em, going through the pangs of decay—even though they do think it's rebirth. The cops don't see it that way, but they haven't our point of view. What good does it do you to be a City man if you're going to mix in to some petty border feud? Mark, you might as well be dead—or back on Earth, it's the same thing in the end."

He stopped again. Eloquence was unnatural to him; it embarrassed him a little. He looked keenly at the city manager, and what he saw choked off the springs of his volu-

bility. He felt, not for the first time, the essential loneliness that went with perspective.

Hazleton wasn't listening any more.

There was a battle in progress when the city made its run to Utopia. It was rather spectacular. The Hruntan planet, military in organization and in spirit down to the smallest detail of daily living, had not waited for the Earth police to englobe it; the Hruntan ships, though they were of nearly the same vintage as those manned by the Utopians, were being fought to the limit, fought by experienced officers who were unencumbered by any sniveling notions about the intrinsic value of human life. There was not much doubt as to the outcome, but for the time being the police were unhappy.

The battle was not visible from the city; the Hruntan planet was nearly 40° away from Utopia. It was the steady widening of the distance between the two planets that had first given Hazleton his idea. It had also been Hazleton who had dispatched the drones—proxy-robots less than five meters long, which hung invisibly upon the outskirts of the conflict and watched it with avid television eyes.

It was an instructive dogfight. The police craft, collectively, had not engaged in a major battle for decades; individually, few of the Earthmen had ever been involved in anything more dangerous than a pushover. The Hruntans, vastly inferior in equipment, were rich in experience, and their tactics were masterly. They had forced the engagement in a heavily mined area, which was equivalent to picking a fight in the heart of a furnace—except that the Hruntans knew where the fire was hottest. Their losses, of course, were terrific—nearly five to one. But they had the numbers to waste, and it was obvious that officers who did not value their own lives would be unlikely to value those of their crews.

After a while, even Hazleton had to turn the screen off and recall the drones. The carnage was frightful, not *per se,* but in the mental attitude behind it. Even a hardened killer, after a certain amount of watching men trying to snuff out a fire by leaping headlong into it, might have felt his brains cracking.

The city settled toward Utopia. Outlying police scouts reported the fact—the reports were clearly audible in the city's Communications Room —and those reports would be exhumed later and acted upon. But now, in the midst of the battle, nobody had time to care what the city did. When they had begun again to care, the city hoped to be gone—or invulnerable.

The question of how Utopia had resisted the Hruntan onslaught for nearly a century remained a riddle. It became more of a riddle when the city landed upon Utopia. The planet was a death-trap of radioactivity. There were no cities; there were seething, white-hot pools that would never cool within the lifetime of hu-

manity to show where cities once had stood. One of the continental land-masses was not habitable at all. The very air disturbed detectors slightly. In the daytime the radioactivity was just below the dangerous limit; at night, when the drop in temperature released the normal, microscopic increase in the radon content—a phenomenon common to the atmospheres of all Earth-type planets—the air was unbreathable.

Utopia had been bombarded with fission-bombs and dust canisters at every opposition with the Hruntan planet for the past seventy Utopian years. The oppositions occurred only once every twelve years; otherwise even the underground life of Utopia would have been impossible.

"How have you kept them off?" Amalfi asked. "Those boys are soldiers; if they can put up this much of a battle against the police, they should be able to wipe the floor with you folks."

Captain Savage, perched uncomfortably in the belfry, blinking at the sun, managed a thin smile. "We know all their tricks. They are very fine strategists; I will grant you that. But in some respects they are unimaginative. Necessarily, I suppose; initiative is not encouraged among them." He stirred uneasily. "Are you going to leave your city out here in plain sight? And at night, too?"

"Yes. I doubt that the Hruntans will attack us; they're busy, and besides, they probably know that the police don't love us, and will be too puzzled to call us an enemy of theirs right off the bat. As for the air—we're maintaining a 0.02 spindizzy field. Not enough to be noticeable, but it changes the moment of inertia of our own atmosphere enough to prevent any of your air from getting in."

"I don't think I understand that," Savage said. "But doubtless you know your own resources. I confess, Commander Amalfi, that your city is a complete mystery to us. What does it do? Why are the police against you? Are you exiled?"

"No," Amalfi said. "And the police aren't against us, exactly. We're just rather low in the social scale; we're migratory workers, interstellar hobos, Okies. The police are as obligated to protect us as they are to protect any other citizen; but our mobility makes us possible criminals, so we have to be watched."

Savage's summary of his reaction to this was the woeful sentence Amalfi had come to think was the motto of Utopia. "Things have changed so much," the officer said.

"You should set that to music. I can't say that I understand yet how you've held out so long, either. Haven't you ever been invaded?"

"Frequently," Savage said. His voice was half gloomy and half charged with pride. "But you have seen how we live. At best we have beaten them off; at worst, we cannot be found. And the Hruntans themselves have made this planet a difficult place to live. Many of them succumbed to the results of their own bombing."

"Still—"

"Mob psychology," Savage said, "is something of a science with us, as it is with them; but we have developed it in a different direction. Combined with the subsidiary art of camouflage, it is a powerful weapon. By dummy installations, faked weather conditions, false high-radioactivity areas, we have thus far been able to make the Hruntans erect their invasion camps exactly on the spots we have previously chosen for them. It is a form of chess; one persuades, or lures, the enemy into entering an area where one can dispose of him in perfect safety and with a minimum of effort."

He blinked up at the sun, nibbling at his lower lip. After a while he added, "There is another factor which is most important of all. It is freedom. We have it. The Hruntans do not. They are defending a system which is ascetic in character—that is, it offers few rewards to the individual even once it has triumphed. We on Utopia are defending a system which has personal rewards for us—the rewards of freedom. It makes a difference. The incentive is greater."

"Oh, freedom," Amalfi said. "Yes; that's a great thing, I suppose. Still it's the old problem. Nobody is ever free. Our city is vaguely republican, it might even be Hamiltonian in one sense. But we aren't free of the requirements of our situation, and never can be. As for efficiency in warfare—I question that. Your people are not free now. A wartime political economy has to be a dictatorship. Your people are fighting for steak tomorrow, not steak today. Well—so are the Hruntans. The difference exists, but—a difference which makes no difference is no difference."

"You are subtle," Savage said, standing up. "I think I can see why you would not understand that part of our history. You have no ties; no faiths. You will have to excuse us ours. We cannot afford to be logic-choppers."

He went down the stairs, his back painfully straight, his shoulders thrown back unnaturally. Amalfi watched him go with a rueful grin. The young man was a character; talking with him was like being brought face to face with a person from an historical play. Except, of course, that a character in a play was ordinarily understandable even at his queerest; Savage had the misfortune to be real, not the product of an artificer with an ax to grind.

Amalfi was reminded abruptly of Hazleton. Where was Hazleton, anyhow? He had gone off hours ago with that girl, upon some patently trumped-up errand. If he didn't hurry, he'd be trapped underground overnight. Amalfi did not mind working alone, but there were managerial jobs in the city which the mayor simply could not handle efficiently; and besides, Hazleton might be committing the city to something inconvenient. Amalfi went down to his office and called the Communications Room.

Hazleton had not reported in. Grumbling, Amalfi went about the business of organizing the work of the city—the work for which it had been built, but which it found so seldom. It disturbed him that there was no official contract between the city and Utopia; it was not customary, and if Utopia should turn out, as so many ideals-ridden planets had turned out, to be willing to cheat on an astronomical scale for the sake of its obsession, there would be no recourse under the Earth laws. People with Ends in view were quick to justify all kinds of Means, and the city, which was nothing but Means made visible, had learned to beware of shortcuts.

Hazleton, it appeared, was off somewhere on a shortcut. Amalfi could only hope that the city would survive it.

The Earth police did not wait for Hazleton, either. Amalfi was mildly appalled to see how rapidly the Earth forces reformed and were reinforced. Their logistics had been much improved since the city had last seen them in action. The sky sparkled with ships driving in upon the Hruntan planet.

He sent out an emergency warning at once. The thin resistance which the spindizzy field had offered to Utopia's atmosphere became a solid, hard-driven wall. The spindizzies screamed into the highest level of activity they could maintain without snapping the thread between Utopia and the city; around the perimeter of that once-invisible field, a flicker of polarization thickened to translucence. Drive-fields were building, and only a very few light-rays, most of them those to which the human eye was least sensitive, got through the fields and out again. To Utopian onlookers the city went dark blood-color and became frighteningly indistinct.

Calls began to come in at once. Amalfi ignored them; his flight board was alive with alarm signals, and all the mikes were chattering at once.

"Mr. Mayor, we've just made a strike in that old till, it's lousy with oil-bearing shale—"

"Stow what you have and make it tight."

"Amalfi! How can we get any thorium out of—"

"More where we're going. Damp your stock on the double."

"Com Room. Still no word from Hazleton—"

"Keep trying."

"Calling the flying city! Is there something wrong? Calling the flying—"

Amalfi cut them all off with a brutal swipe at the switches. "Did you think we'd stay here forever? Stand by!"

The spindizzies screamed. The sparkling of the ships coming to invest the Hruntan planet became brighter by the minute. It would be a near thing.

"Whoop it up there on Forty-second Street! What d'you think you're doing, warming up tea? You've got

ninety seconds to get that machine to take-off pitch!"

"Take-off? Mr. Mayor, it'll take at least four minutes—"

"You're kidding me. I can tell. Dead men don't kid. *Move!*"

"Calling the flying city—"

The sparks spread over the sky like a Catherine-wheel whirling into life. The watery quivering of the single point of light that was the Hruntan planet dimmed among them, shivered, blended into the general glitter. Astronomy added its voice to the general complaint.

"Thirty seconds," Amalfi said.

From the speaker which had been broadcasting the puzzled, fearful inquiries of the Utopians, Hazleton's voice said calmly, "Amalfi, are you out of your mind?"

"No," Amalfi said. "It's your plan, Mark. I'm just following through. *Twenty seconds.*"

"Conditions change. You're throwing away a tremendous opportunity."

"Sorry." Amalfi saw a bulge in the field and fought with it briefly. "I don't see any change. *Fifteen seconds.*"

"I'm not pleading for myself. I like it here, I think. I've found something the city didn't have. The city needs it—"

A brief constriction made Amalfi's big frame knot up tightly. Nothing emotional; no; nothing to do with Hazleton; probably some spindizzy operator was hurrying things. He staggered to his feet and threw up in the little washstand. Hazleton went on talking but Amalfi could hardly hear him. The clock grinned and rushed on.

"Ten seconds," Amalfi gasped, a little late.

"Amalfi, listen to me!"

"Mark," Amalfi said, choking. "Mark, I haven't time. You made your choice. I . . . *five seconds* . . . I can't do anything about that. If you like it there, go ahead and stay. I wish you, I wish you everything, Mark, believe me. But I have to think of—"

The clock grinned and brought its thin palms together.

". . . the city—"

"Amalfi—"

"Spin!"

The city vaulted skyward. The sparks whirled in around it.

The flying of the city, normally, was in Hazleton's hands; in his absence—though it had never happened before—a youngster named Carrel took charge. Amalfi's own hand rarely touched the stick except in spots where even the instruments could not be trusted.

Running the Earth blockade to the Hruntan planet was no easy job, especially for a green pilot like Carrel; but Amalfi did not greatly care. He huddled in the flight tower and watched the screens through a gray mist, wondering if he would ever be warm again. The baseboards of the room were pouring out radiant heat, but it didn't seem to do any good. He felt cold and empty.

"Ahoy the Okie city," the ultra-

phone barked savagely. "You've had one warning. Pay up and clear out of here, or we'll break you up."

Reluctantly, Amalfi tripped the toggle. "We can't," he said uninterestedly.

"What?" the cop said. "Don't give me that. You're in a combat area, and you've already landed on Utopia in defiance of a Vacate order. Pay your fine and beat it, or you'll get hurt."

"Can't," Amalfi said.

"We'll see about that. What's to prevent you?"

"We have a contract with the Hruntans."

There was a long and very dead silence. At last the police vessel said: "You're pretty sharp. All right, proof your contract over on the tape. I suppose you know that we're about to blow the Hruntans to a thin haze."

"Yep."

"All right. Go ahead and land, if you've got a contract. The more fools you. Make sure you stay for the full contract period. If you do get off before we reduce the planet, make sure you can pay your fine. If you don't—good riddance, Okie!"

Amalfi managed a ghost of a grin. "Thanks," he said. "We love you too, flatfoot."

The ultraphone growled and stopped transmitting. There was a world of frustration in that final growl. The Earth police accepted officially the Okie cities' status as hobos—migratory workers—but unofficially and openly the cities were called tramps in the wardrooms of the police cruisers. Opportunities to break up a city did not come very often, and were met with relish; it must have been quite a blow to the captain to find the vanadium-clad, never-varying Contract in his way.

But now there were the Hruntans

to cope with. This was the penultimate and most delicate stage of Hazleton's plan—and Hazleton wasn't on deck to administer it. As a matter of fact, if his Utopian friends had heard Amalfi admit to a contract with the Hruntans, he was probably in the hottest water of his career right now. Amalfi tried not to think about it.

The plan had not included signing any contracts with either planet; so long as the city was not committed legally, it could refuse jobs, leave when it pleased, and generally exercise the freedom of the unemployed. But it hadn't worked out that way. The speed with which the police had been reinforced had made it impossible even to approach the Hruntan planet without uncrackable legal protection.

At least the city's stay on Utopia had accomplished most of its purposes. The oil tanks were a little over half full, and the city's treasury was comfortable, though still not exactly bulging. That left the rare-earths and the power-metals still to be attended to; collecting and refining them was unavoidably time-consuming, and would take even longer on the Hruntan planet than on Utopia—the Imperial world, farther out from its sun than Utopia, had got a correspondingly smaller allowance of heavy elements.

But there was no help for it. To stay on Utopia while the Hruntans were being conquered would have left the city completely at the mercy of the Earth forces. Even at best it would have been impossible to leave the system without paying the fine for violating the Vacate order, and Amalfi was constitutionally unwilling to part with the money for which the city had labored; even at the present state of the treasury it might easily have bankrupted them, for work had been very scarce lately.

The intercom had been modestly calling attention to itself for several minutes. Answered, it said, "Sergeant Anders, sir. We've got another visitor."

"Yes," Amalfi said. "That would be the Hruntan delegation. Send 'em up."

While he waited, chewing morosely on a dead cigar, he checked the contract briefly. It was standard, requiring payment in germanium "or equivalent"—the give-away clause that had prevented its use on Utopia. It had been signed by ultraphone—the possession of that tight-beam device alone "placed" the Hruntans as to century—and the work the city was to do left unspecified. Amalfi hoped devoutly that the Hruntans would in their turn give themselves away when it came to being specific on that count.

The buzzer sounded once more and Amalfi pushed the button that released the door. The next instant he was not sure it had been a wise move. The Hruntan delegation bore a strong resemblance to a boarding party. First of all there were an even dozen soldiers, clad in tight-fitting red leather breeches, gleam-

ing breastplates, and scarlet-plumed casques; the breastplates, too, were emblazoned with a huge scarlet sun. The men snapped to attention in two files of six on each side of the door, bringing to "present arms" weapons which might have been copies of Kamerman's original mesotron rifle.

Between the files, flanked by two lesser lights as gorgeously and unfunctionally clad as macaws, came a giant carved out of gold. His clothing was interwoven with golden threads; his breastplate and helmet were gilded; even his complexion was tanned to a deep golden tone, and he sported a luxuriant golden-blond beard and flowing mustachios. He was altogether a most unlikely-looking figure.

He spoke two harsh-sounding words, and boot-heels and weapons slammed against the floor. Amalfi winced and stood up.

"We," the golden giant said, "are the Margraf Hazca, Vice-Regent of the Duchy of Gort under his Eternal Eminence, Arpad Hrunta, Emperor of Space."

"Oh," Amalfi said, blinking. "My name's Amalfi; I'm the mayor here. Do you sit down?"

The Margraf said he sat down, and did. The soldiers remained stiffly "at ease," and the two subsidiary nobles posted themselves behind the Margraf's chair. Amalfi subsided behind his desk with a muffled sigh of relief.

"I presume you're here to discuss the contract."

"We are. We are told that you have been among the rabble of the third planet."

"An emergency landing only," Amalfi said.

"No doubt," the Margraf said dryly. "We do not concern ourselves with the doings of the Hamiltonians; we will add them to our serfs in due time, after we have driven off these upstarts from decadent Earth. In the meantime, we have use for you; any enemy of Earth must be friends to us."

"That's logical," Amalfi said. "Just what can we do for you? We have quite a variety of equipment here—"

"The matter of payment comes first," said the Margraf. He got up and began to pace slowly up and down, with enormous strides, his golden cloak streaming out behind him. "We are not prepared to make any payment in germanium; we need all we have for transitors. The contract speaks of equivalents. What counts as equivalent?"

It was remarkable how the regal manner was snuffed out when it got down to honest haggling. Amalfi said cautiously, "Well, you could allow us to mine for germanium ourselves—"

"Do you think this planet's resources will last forever? Give us the equivalent, not some roundabout scheme for being paid in the metal itself!"

"Equipment, then," Amalfi said, "or skills; at a mutually-agreed valuation. For instance, what are you using for lubrication?"

The big count's eyes glittered. "Ah," he said softly, "You have the secret of the friction-fields, then. That we have long sought, but the generators of the rabble melt when we touch them. Does Earth know this process?"

"No."

"You got it from the Hamiltonians? Excellent." The two minor nobles were beginning to grin wickedly. "We need babble no further of 'mutually agreed valuations,' then." He gestured. Amalfi found himself looking down a dozen rifle barrels.

"What's the idea?"

"You are within our defensive envelope," Hazca said with wolfish gusto. "And you are not likely to survive long among the Earthmen should you by some miracle break free of us. You may call your technicians and tell them to prepare a demonstration of the friction-field generator; also, prepare to land. Graf Nandór here will give you explicit instructions."

He strode toward the door; the soldiers parted deferentially. As Amalfi's hand reached for the button to let him out, the big man whirled. "And you need not attempt to trip any hidden alarms," he growled. "Your city has already been boarded in a dozen places, and is under the guns of four cruisers."

"Do you think you can win technical information by force?" Amalfi said.

"Oh, yes," said the Margraf, his eyes shining dangerously. "We are —experts."

Carrel, Hazleton's protegé, was a very plausible lecturer, and seemed completely at home in the echoing, barbaric gorgeousness of the Margraf's Council Chamber. He had attached his charts to the nearest tapestry, and had propped his blackboard on the arms of the great chair in which, Amalfi supposed, the Margraf usually sat; his chalk traced swift symbols on the slate and squeaked deafeningly in the groined vault of the room.

The Margraf himself had left; five minutes of Carrel's talk had been enough to arouse his impatience. The Graf Nandór was still there, wearing the suffering expression of a man delegated to do the dirty work; so were four or five other nobles. Three of these were chattering in the back of the room with muffled sniggers, and a raucous laugh broke in upon Carrel's dissertation every so often. The remaining peacocks, evidently of subordinate ranks, were seated, listening with painful, brow-furrowing concentration, like ham actors overregistering Deep Thought.

"This will be enough to show the analogy between atomic and molecular binding energies," Carrel said smoothly. "The Hamiltonians"—he had seen that the word annoyed the peacocks and used it often—"have shown, not only that this binding energy is responsible for the phenomena of cohesion, adhesion, and

friction, but that it is subject to a relationship analogous to valence."

The appearance of concentration of the nobles became so grave as to be outright grotesque. "This phenomenon of molar valence, as the Hamiltonians have aptly named it, is intensified by the friction-fields into a condition analogous to ionization. The surface layers of molecules of two contiguous surfaces come into dynamic equilibrium in the field; they change places continuously and rapidly, but without altering the status quo. It is evident that this equilibrium does not in any sense do away with the binding forces in question, and that a certain amount of drag—or friction—still remains; but only about a tenth of the resistance which exists even with the best systems of gross lubrication."

The nobles nodded together. Amalfi gave over watching them; it was the Hruntan technicians which worried him most. There were an even dozen of them. Four were humble, frightened-looking creatures, who seemed to regard Carrel with more than a little awe; they scribbled frantically, fighting to take down every word, even material which was of no conceivable importance.

All but one of the rest were well-dressed, hard-faced men, who had treated the nobles with only perfunctory deference, and who took no notes at all. This type was also quite familiar in a barbarian milieu—head scientists, directors, entirely committed to the regime, entirely aware of how crucial they were to its successes, and already infected with the aristocratic virus of letting lesser men dirty their hands with actual messy laboratory experiments. Some of them, probably, owed their positions as much to a ruthless skill at court intrigue as to any great scientific ability.

But the twelfth man was of a different order altogether. He was tall, spare, and sparse-haired, and his face as he listened to Carrel was alive with excitement. An active brain, this one, doubtless politically unconscious, hardly caring who ruled it as long as it had equipment and a free hand; the man would be tolerated by the regime for his productivity, but would be under constant suspicion. And he was, by Amalfi's judgment, the only man capable of going beyond what Carrel was saying to what Carrel was leaving unsaid.

"Are there any questions?" Carrel said.

There were some, mostly dim-witted, from the technies—how do you build this, and how do you wire that; no one with any initiative would have wanted to be led by the nose in such a fashion The hard-faced men left without a word, as did the nobles, who lingered only long enough to save face. The scientist—he was The scientist for Amalfi's money—was left alone to launch into an ardent, stammering dispute over Carrel's math. He seemed to consider Carrel as an

equal as a matter of course, and Carrel was beginning to look uncomfortable when Amalfi summoned him to the back of the hall.

The scientist left, pocketing his few notes and pulling thoughtfully at his nose. Carrel watched him go.

"I can't hide the kicker from that boy long, sir," he said. "Believe me, he's got *brains*. Give him about two days and he'll have the whole thing worked out for himself. He won't get any sleep tonight for thinking about it; I know the type."

"So do I," Amalfi said. "I also know barbarian Council halls—the arrases have ears. Just pray you weren't overheard, that's all. Come on."

Amalfi was silent until they were safe within the city and in a cab. Then he said, "You have to be careful, Carrel, in dealing with outsiders. You take to it well, but you're inexperienced. *Never* say anything outside the city, even to me, that doesn't fit your part. Now then—I agree with you about that scientist; I was watching him. And now he knows you, so I can't use you against him. Is there someone in your organization who's done undercover work for Mark who hasn't been out of the city here? An experienced hand?"

"Sure, four or five, at least. I can put my finger on any of 'em."

"Good. Find a fairly husky one, a guy that could pass for a thug with a minimum of makeup, and send him to Indoctrination for hypnopaedia. In the meantime, you'll have to see that scientist again. Get a picture of him somewhere, a tri-di if they have them here. When you talk to him, answer any questions he asks you."

Carrel looked puzzled. "*Any* questions?"

"Any technical questions, yes. It won't matter, very shortly. Here's another lesson in practical public relations for you, Carrel. When on a strange planet, you have to use its social system to the best advantage possible. On a world like this one, where the struggle for power is plenty raw, assassination must be very common—and nine chances to one there's a regular Assassin's Guild, or, at least, plenty of free-lance killers for hire."

"You're going to—"

The shocked expression on Carrel's face made Amalfi abruptly sodden with weariness. Training a new city manager was a long and back-breaking task, for so much of the training had to be absorbed the hard way. He felt too old for such a job now, and much too aware of some failure in his methods, the failure which alone had made the job necessary.

"Yes," he said. "It's a shame, but it has to be done. In other circumstances we'd take the man into the city—*he* doesn't care who he works for—but the Hruntans would look for him, and find him, too. There has to be an inarguable corpse; if possible, a local culprit. Your operative, after a suitable

course in this Balkanese they speak here, will scout the rivalries among the scientific clique and try to pin the killing on one of those hawk-nosed lab chieftains. But the man must be killed, for the survival of the city."

Carrel did not protest, for the final formulation was the be-all and end-all of Okie logic; but it was plain that the waste of intelligence the plot necessitated upset him. Amalfi decided silently to keep Carrel exceptionally busy in the city for a while—at least until the Hruntans had their antifriction installations well under way.

In his office, Amalfi took the flexible plastic dust cover off a little-used instrument—the Dirac transmitter. It was the only form of communication which the Hruntans —and, of course, the Hamiltonians —did not have; the want of it had cost them an empire, for it operated instantaneously over any distance. He thrust a cigar absently between his teeth and sent out a call for the captain of police.

The obsolete model had no screen, but the captain's voice told his feelings very graphically. "If you're going to remind me that we're obligated to protect you now that the Hruntans have violated the Contract," he snarled, "save your breath. I've half a mind to blow up the planet anyhow. Some one of these days the Okie laws are going to be changed, and then—"

"You wouldn't have blown up the planet in any case," Amalfi said tranquilly. "The shock wave would have detonated the local sun and destroyed the whole system and your superiors would have had your scalp. What I'm trying to do is to save you some trouble. If you're interested, make me an offer."

The cop laughed.

"All right," Amalfi said. "Laugh, you jackass. In about twenty days you'll be yanked back to patrolling a stratosphere beat on Earth that sees a plane once every two months, and braying about how unjust it all is. As soon as the home office hears that you let the Hruntans and the Hamiltonians join forces, and that the war is going to cost Earth two or three hundred billion and last maybe five years—"

"You're a bum liar, Okie," the cop said. The bravado behind the pun seemed a little strained, however. "They been fighting each other a century now."

"Times change," Amalfi said. "In any event the merger will be forcible, because if you don't want the Duchy of Gort I'm going to offer it to Utopia. They'll be glad to get it. The combined arsenal will be impressive—each side has some stuff the other hasn't, and we couldn't help either of them learning a few tricks from us. However—"

"Wait a minute," the cop said cautiously. "You mean you got the upper hand there already? How do I know you can hold it?"

"You don't risk a thing. All I want is for you to rescind the fine

against us, wipe the tape of the earlier Vacate order, and give us a safe-conduct out of this system. If we don't deliver, you don't pay."

"Hm-m-m." There was a muttering in the background, as if somebody were talking softly over the captain's shoulder. "How'd you pull it off?"

"That," Amalfi said dryly, "would be telling. If you want to play, proof it over."

"No soap. I don't want any record of my withholding evidence of a crime in *your* hands."

"Send it under seal, then. I'll put the whole thing in the Margraf's strong room; you get it back when you get the planet."

After a short silence, the captain said, "Well . . . all right." The tape began to whir at Amalfi's elbow. Satisfied, he broke the contact.

If this coup came off on schedule, it would become legendary—the police would be mighty tight-lipped about it, but the Okie cities would spread it all over the galaxy.

Somehow the desertion of Hazleton made the prospect savorless.

Someone was shaking him. He wanted very badly to awaken, but his sleep was as deep as death and it seemed that no possible struggle could bring him to the rim of the pit. Shapes and faces whirled about him, and in the blackness he felt the approach of great steel teeth.

"Amalfi! Wake up, man! Amalfi, it's Mark—wake up—"

The jaws came together with a terrible snapping report and the wheeling faces vanished. Bluish light spilled into his eyes.

"Who? What is it?"

"It's me," Hazleton said. Amalfi blinked at him uncomprehendingly. "Quick, quick. There's only a little time."

Amalfi sat up slowly and looked at him. He was too stunned to know whether he was pleased or not, and the oppression of his nightmare was still with him, a persistent emotion lingering after dreamed events he could not remember.

"I'm glad to see you," he said, knowing that it would be so later. "How'd you get through the cordons? I'd of said it couldn't be done."

"Force and fraud, the old combination. But—"

"You near didn't make it," Amalfi said, feeling a sudden influx of energy. "Is it still night here? Yes. The big blowup isn't due much before noon, otherwise I wouldn't have been asleep. After that you'd of found no city here."

The door slid aside suddenly and the Utopian girl stood at the sill, her face pinched with anxiety. Amalfi reached hastily for his jacket.

"Mark, we must hurry. Captain Savage says he won't wait but fifteen minutes more. And he won't—he hates you underneath, I can tell, he'd love to leave us here with the barbarians!"

"Right away."

The girl disappeared. Amalfi stared at the prodigal city manager. "Wait a minute," he said. "What's all this, anyhow? Mark, you haven't sold yourself on some idiotic personal rescue mission?"

"Personal?" Hazleton grinned. "No. We're getting the whole city out of here. I wanted to get word to you but the Utopians have no Diracs and I didn't want to tip off the cops. Get dressed, that's a good fellow, and I'll explain as we go. These Hamiltonians have been working like demons, installing spindizzies in every available ship. They'd about decided to surrender to the cops—after all they've more in common with Earth than with the Hruntans—but the spindizzy gave them new heart to fight. To be on the safe side, they made up an escape fleet of twenty-five ships, reconverted light cruisers. They're upstairs now."

"Over the city?"

"Yes. I heard the highjacking of the city—I gather you had the radio on for the benefit of the police, but it came through pretty clearly on Utopia, too. So I sold them on making a sneak raid to escort the city out. It took some selling, but I convinced them they'd get out of this system easier if the cops had two things to think about at once."

He grinned again. "The cops had no notion there were any Utopian ships anywhere near this planet, and they keep a sloppy watch. They know now, of course, but it'll take them a little while to

mass here and by that time we'll be gone."

"Mark, you're a romantic ass," Amalfi said. "Twenty-five light cruisers—archaic ones at that, spindizzies or not!"

"Nothing archaic about Savage's plans," Hazleton said. "He hates my guts for swiping Dee from him, but he knows space combat. This is a survival fleet, for Hamiltonianism, not just people. As soon as we're attacked, all twenty-five of them are going to take off in different directions, putting up a stiff battle and doing their best to turn the affair into a series of individual dogfights. That insures the survival of some of them, of their ideology—and of the city."

"I expected something more from you than a gesture out of a bad stereo," Amalfi said. "Napoleonism! Heedless of danger, young hero leads devoted band into enemy stronghold, snatching beloved sovereign from enraged infidels! Pah! The city's staying where it is. If you want to go off with this suicide squadron, go ahead."

"Amalfi, you don't understand—"

"You underestimate me," Amalfi said harshly. He strode across the room to the balcony, Hazleton at his heels. "Sensible Hamiltonians stayed home, that's a cinch. Giving them the spindizzy was your idea and a smart idea, it made them fight longer and kept the cops busy. But these people who are trying to escape toward the edges of the galaxy —they're the incurables, the fanatics. Do you know how they'll wind up? You should, and you would if there wasn't a woman in your head addling your brains with a long-handled spoon. After a few generations on the rim none of 'em will remember Hamiltonianism. Making a new planet livable is a job for a carefully prepared, fully-manned expedition. These people are the tatters of the military debacle—and you want us to be part of the debacle! No, thanks."

He threw the door to the balcony open so hard that Hazleton had to jump to avoid being hit, and went out. It was a clear night, bitterly cold, and a thousand stars glared through the glow the city cast upon the sky. The Utopian ships, of course, could not be seen: they were too high, and probably were as well as close to invisible and undetectable even close up as Utopian science could make them.

"I'll have a job explaining this to the Hruntans," he said, his voice charged with suppressed rage. "The best I'll be able to do is claim the Hamiltonians were trying to destroy us before we could give them the friction-field plans; and to do that I'll have to yell to the Hruntans for help right away."

"You gave the Hruntans—"

"Certainly!" Amalfi said. "It was the only weapon we had left after we had to sign a contract with them. Your plan for a treacherous Utopian landing became obsolete the moment the police beat us to the

punch. And here you are still trying to use the blunted tool!"

"Mark!" the girl's voice drifted out from the room, frantic with anxiety. "Mark! Where are you!"

"Go along," Amalfi said, without turning his head. "After a while they'll have no time to cherish their ritual beliefs and you can have a nice frontier home, on the ox-bone plow level. The city is staying here. By tomorrow noon the Utopians who stayed put will be in an excellent position to bargain with Earth for rights, the Hruntans will be hornswoggled, and we'll be on our way."

The girl, evidently having noticed the open door, came through it in time to hear the last two sentences. "Mark!" she cried. "What does he mean? Savage says—"

Hazleton sighed. "Savage is an ass, and so am I; Amalfi's right. I've been acting like a child. You'd better get aloft while you have the chance."

She came forward to the railing and took his arm, looking up at him. Her face was so full of puzzlement and hurt that Amalfi had to look away; that look reminded him of too many things best forgotten—some of them not exactly remote. He heard her say, "Do you . . . do you want me to go, Mark? You're staying with the city?"

"Yes," Hazleton muttered. "I mean, no. I've made a terrific mess of things, it appears. Maybe I can help now, maybe not. But I've got to stay. You'd be better off with your own people—"

"Mr. Amalfi," the girl said. Amalfi turned unwillingly. "You said when I first met you that there was a place for women in this city. Do you remember?"

"I remember," Amalfi said. "But you wouldn't like our politics, I'm sure. This is no Hamiltonian state. It's stable, self-sufficient, static—a beachcomber by the seas of history. We're Okies. Not a nice name."

The girl said: "It may not always be so. I'll stay."

The sky began to pale slightly. No one spoke. Aloft, the stars were dimming, and there was no sign to show that a tiny fleet of ships was dwindling away into the boundless universe.

Hazleton cleared his throat. "What's for me to do, boss?" he said hoarsely.

"Plenty. I've been making do with Carrel, but though he's willing, he lacks experience. First of all make us ready to take off at the very first notice. Then cudgel your brains to think up something to tell the Hruntans. You can fancy up my excuse, or think up one of your own, I don't care. You're better at that kind of thing than I ever was."

"So's what's supposed to happen at noon?"

Amalfi grinned. He realized with a violent shock that he felt good. Getting Hazleton back was like finding a flawed diamond that you'd thought you'd lost—the flaw was still there and would never go away,

but still the diamond had been the cleanest-cutting tool in the house, and had had a certain sentimental value.

He explained the plan. Halfway through, Hazleton was far enough back to normal to begin looking amused. When it was over he was chuckling.

"That's a honey," he said. "Still I can see why you weren't too satisfied with Carrel. Amalfi, you're a prime bluffer. Telling me to go off with Savage in that dramatic fashion! Do you know that your plot isn't going to come off?"

"Why, Mark?" Dee said. "It sounds perfect to me."

"It's clever, but it's full of loose ends. You have to look at these things like a dramatist; a climax that *almost* comes off is no climax. We'd better—"

In the bedroom, Amalfi's private phone chimed melodiously, and a neon bulb went on over the balcony doorway. Amalfi frowned and flicked a switch on the railing.

"Mr. Mayor?" a concealed speaker said nervously. "Sorry to wake you, but there's trouble. At least twenty ships were over here a while back. They're gone now but we've got a sort of a refugee, a Hruntan who calls himself Dr. Schloss; he claims the other Hruntans are all out to get him and wants to work for us. Shall I send him to Psych or what? It might just be true."

"Of course it's true," Hazleton said. "There's your first loose end, Amalfi."

The affair of Dr. Schloss proved difficult to untangle; Amalfi had not studied his man closely enough. Carrel's agent had done a thorough job of counterfeiting local politics. It was always preferable, when the city needed a man's death, to so arrange matters that the actual killing was done by an outsider; and in this case that had been absurdly easy to arrange. There were four separate cliques within the scientific hierarchy of Gort, all of them undercutting each other with fanatical perseverance, like shipmates trying to do for each other by boring holes in the hull; besides, the court itself did not trust Dr. Schloss, and took sides sporadically when the throat-cutting became overt.

It had been simple enough to set currents in motion which would sweep Dr. Schloss away, but Schloss had declined to be swept. The moment he became aware of any threat, he came with disconcerting directness to the city.

"The trouble is," Carrel reported, "that he didn't realize what was flying until it was almost too late. He's a peculiarly sane character and would never dream that anybody was 'out to get him' until the knife actually pricked him."

Hazleton nodded. "It's my bet that it's the court that tipped him off—they wouldn't bother trying to sneak up on him."

"That's correct, sir."

"Which means we'll have Bathless Hazca and his dandies here looking for him," Amalfi growled.

"I don't suppose he bothered to cover his tracks. What are you going to do, Mark? We can't count on their starting the antifriction fields early enough to get us out of this."

"No," Hazleton agreed. "Carrel, does your man still have contact with the group that was going to punch Schloss' ticket?"

"Sure."

"Have him rub out the top man in that group, then. The time is past for delicate measures."

"What do you propose to gain by that?" Amalfi said.

"Time. Schloss has disappeared. Hazca will guess that he's come here, but most of the cliques will think he's been killed. This will look like a vengeance killing by some member of Schloss' group—he has no real clique of his own, of course, but there must be several men who thought they stood to gain by keeping him alive. We'll start a vendetta. Confusion is what counts in a fight like this."

"Perhaps so," Amalfi said. "In the meantime, I think we'd better hide Schloss as best we can, before he's spotted by one of Hazca's guard here. That invisibility machine in the old West Side subway tunnel seems like the best place . . . do you remember the one? The Lyrans sold it to us, and it just whirled and blinked and buzzed and didn't do a thing."

"That was what my predecessor got shot for," Hazleton said. "But I know where the machine is, yes. I'll arrange to have the gadget do a little whirling and blinking; Hazca's soldiery are afraid of machinery and would never think of looking inside one that's working even if they *did* suspect a fugitive inside it. Which they won't, I'm sure. And . . . great scott, what was *that?*"

The long, terrifying metallic roar died away into a mutter. Amalfi was grinning.

"Thunder," he said. "Planets have a phenomenon called weather, Mark; a nasty habit of theirs. I think we're due for a storm."

Hazleton shuddered. "It makes me want to hide under the bed. Well, let's get to work."

He went out. Amalfi, reflecting upon the merits of attack as a defensive measure, waved a cab up to the balcony and had himself ferried to the first setback of the theater building. He would have liked to have landed at the top, where the penthouse was, but the cornices of the building now bristled with pompoms and mesotron rifles; Graf Nandór was taking no chances.

The elevator operator refused to take him beyond the seventieth floor. Swearing, he climbed the last five flights of steps; the blue rage he was working up was not going to be counterfeit by the time he reached the penthouse. At every landing he was inspected with insolent suspicion by lounging groups of soldiers.

There was music in the penthouse, and it reeked of the combina-

tion of perfume and unwashed bodies which was the personal trademark of Hruntan nobility. Nandór was sprawled in a chair, surrounded by women, listening to a harpist sing a ballad of unspeakable obscenity in a quavering, emotionless voice. In one jeweled hand he held a heavy goblet half full of fuming Rigellian wine—it must have come from the city's stores, for the Hruntans had had no contact with Rigel for centuries—which he passed back and forth underneath his substantial nose, inhaling the vapors delicately.

He lifted his eyes over the rim of the goblet as Amalfi came in, but did not otherwise bother to acknowledge him. Amalfi felt his blood-pressure mounting and his wrists growing cold and numb, and tried to control himself; it was all very well to be angry, but he needed some mastery over what he said and did.

"Well?" Nandór said.

"Are you aware of the fact that you've just escaped being blown into a rarefied gas?" Amalfi demanded.

"Oh, my dear fellow, don't tell me you've just circumvented an assassination attempt in my behalf," Nandór said. His English seemed to have been picked up from a Liverpudlian—only the men of that Okie city spoke through their adenoids in that strange fashion. "Really, that's a bit thick."

"There were twenty Hamiltonian ships over the city," Amalfi said grimly. "We beat them off, but it was a close shave. Evidently the whole business didn't even wake you or your bosses up. What good are we going to be to you if you can't even protect us?"

Nandór looked alarmed. He pulled a mike from among the pillows and spoke into it for a moment in his own tongue. When he was finished he looked less anxious, but his face was still clouded.

"What are you selling me, my man?" he said querulously. "There was no battle. The ships dropped no bombs, did no damage; they have been pursued out as far as the police englobement."

"Does a deaf man recognize an argument?" Amalfi said. "And how do you dazzle a blind man? You people think that all weapons have to go 'bang!' to be deadly. If you'll look at our power boards, you'll see records of a million megawatt drain over the past half hour—and we don't chew up energy at that rate making soup!"

"That's of no moment," the Graf murmured. "There are a good many ways of consuming energy. Let us suppose instead that these ships who 'attacked' you landed a spy—eh? And that subsequently a Hruntan scientist, a traitor to his emperor, was taken from your city, perhaps in the hope of carrying him back to Utopia?"

His face darkened suddenly. "You interstellar tramps are childishly stupid. Obviously the Hamiltonian rabble hoped to rescue your

city, and were frightened off by our warriors. Schloss may have gone with them—or he may be hiding in the city somewhere. We will have our answer directly."

He waved at the silent women, who crowded hastily out the curtained doorway. "Do you care to tell me now where he is?"

"I keep no tabs on Hruntans," Amalfi said evenly. "Sorting garbage is no part of my duties."

Coolly, Nandór threw the remainder of his wine in Amalfi's face. The fuming stuff turned his eye sockets into fire. With a roar he stumbled forward, groping for the Hruntan's throat. The man's laughter retreated from him mockingly; then he felt heavy hands dragging his arms behind his back.

"Enough," the Graf said. "Hazca's chief questioner will make some underling babble, if we have to hang them all up by their noses." A blast of thunder interrupted him; outside the penthouse, rain roared along the walls like surf. Through a haze of pain, Amalfi found that he could see the lights again, although the rest of the world was a red blur. "But I think we'd best shoot this one at once—he talks rather *more* freely than pleases me. Give me your pistol, you there with the lance-corporal's collar."

Something moved across Amalfi's clearing vision, a long shadow with a knot at the end of it—an arm with a pistol at its end. "Any last words?" Nandór said pleasantly. "No? *Tsk*. Well, then—"

A thousand bumblebees took flight in the room. Amalfi felt his whole body jerk upward. Oddly, he could still see—things continued to take on definition all around him. *The clear sight of the dying—*

"Proszáchá!" Nandór roared. *"Egz prá strastichek Maria, dó—"*

The thunder cut him off again. Somewhere in the room one of the soldiers was whimpering with fright. To Amalfi's fire-racked sight, everyone and everything seemed to be floating in midair. Nandór sprawled rigidly, half-erect, his body an inch or so off the cushions, his clothing standing away from him. The pistol was still pointed at Amalfi, but Nandór was not holding it; it hung immobile above the carpet, an inch away from his frozen fingers. The carpet itself was not on the floor, but above it, a sea of fur every filament of which bristled straight up; pictures had sprung away from the walls and were suspended; the cushions had risen from the chair and moved away from each other a little, then stopped, as if caught by a stroboscopic camera in the first stages of an explosion; the chair itself was an inch above the rug; and at the far side of the room, a bookshelf had burst, and the cans of microfilm were ranked neatly in front of the case, evenly spaced, supported by nothing but the empty air.

Amalfi took a cautious breath. His jacket, which like Nandór's had ballooned away from his chest, creaked a little, but the fabric was elastic enough to stretch. Nandór saw the movement and made a frantic snatch for the pistol. His left forearm was glued to its position above the chair and could not be moved at all. The gun retreated from his hand, then followed it back obediently as Nandór pulled back for another try.

The second try was an even greater fiasco; Nandór's arm brushed one of the arms of the chair, and then it, too, was held firmly, an inch away from the wood. Amalfi chuckled.

"I would advise you not to move any more than you can help," he said. "If you should bring your head too close to some other object, for instance, you would have to spend the rest of your time looking at the ceiling."

"What . . . have you done?" Nandór said, choking. "If I get free—"

"You can't, not as long as your friends have their friction-fields in operation," Amalfi said. "The plans we gave you were accurate enough, except in one respect: your generators can be operated only in reverse. Instead of allowing molecular valence full play, they freeze molecular relationships as they stand, and create adherence between *all* surfaces—not just *like* surfaces. If you had been able to put full power into those generators, you would have stopped molecular movement in place, and frozen us all to death in a split second—but your

power sources are rather puny."

He realized suddenly that his feet were aching violently; the plastic membranes of his shoes were trying to stand away from his flesh, and pressing heavily against his skin. His jaw muscles were aching, too; only the fact that the field traveled over surfaces had protected him from having his teeth jammed away from each other, and even at that it was an effort to part his lips to talk against the pressure.

He inhaled slowly. The jacket creaked again. His ribs ground against his sternum. Then, suddenly, the fabric gave way, and the silver belt which had been woven into it snapped into a tense hoop around his body. His soles hit the straining carpet heavily, and air puffed out of his shoes.

He swung his arms experimentally, brushing his hands past his thighs. They moved freely. Only the silver belt maintained its implausible position, girdling the keg of his chest like a stave, soaking up the field.

"Good-by," he said. "Remember not to move. The cops will let you go in a little while."

Nandór was not listening. He was watching with bulging eyes the slow amputation of six of his fingers by the rings he was wearing.

There was now, Amalfi knew, no longer than fifteen minutes before the overdriven friction-fields would begin to have more serious effects. Normal molecular cohesion could not be disturbed—homogenous objects, stones, girders, planks, would remain as they were, but things which were made up of fitted parts would soon begin to yield to the pressure driving them away from each other. After that, structures joined by binders of smaller coherence than the coherence of their parts would begin to give way: the older buildings, such as City Hall, would become taller and of greater volume as the ancient bricks pulled away from each other—and would collapse the moment the friction-field was removed; more modern constructions and machines would last only a little longer.

And eventually, the human body, assembled of a thousand tubes, tunnels, caverns and pockets, would swell, and strain, and burst—and only a few city men had the silver belt; there had not been time.

Puffing, Amalfi threw himself down the stairs, dodging among the paralyzed, floating guards. The bumblebee sound was very hard on the nerves. At the seventieth floor he found an unexpected problem; the lights on the elevator board told him that the car had been sealed in the shaft, probably by the action of the safety mechanisms when it had been derailed by the friction-fields.

Going down by the stairs was out of the question; even under normal conditions he could never have traveled seventy flights of stairs, and in the influence of the field his feet moved as if in thick mud; the belt could not entirely protect his ex-

tremities. Tentatively he touched the wall. The same nauseous sucking sensation enfolded his hand as he pulled it away.

Gravity . . . the quickest way down—

He entered the nearest office, threading his way among the four suspended, moaning figures who belonged there, and kicked the window out; it was impossible to open it against the field which had sprung it an inch from its socket. Only the amazing lateral strength of glass had preserved the pane, but against a cross-sectional blow it shattered at once. He climbed out.

It was twenty stories down to the first setback. He planted his feet against the metal, and then his hands. As an afterthought, he also laid his forehead against the wall. He began to slide.

The air whispered in his ears, and windows blinked past him. His palms were beginning to feel warm; they were not actually touching the metal, but the reluctant binding energies were exacting a toll. It was the penalty he had to pay for the heightened pull of friction.

As the setback rushed up to him, he flattened his whole body against the side of the building. The impact of the deck was heavy, but it did not seem to break any bones. He staggered to the parapet and slid over, without allowing a split second for second thoughts. The long whistling slide began again.

For a moment after he fell against the concrete of the street, he was ready to get up and throw himself over still another cliff. His hands and his forehead were as seared as if they had been dipped in boiling oil, and inside his telfon shoes his feet seemed to be bubbling like lumps of fat in a rendering vat. On the solid ground a belated vertigo knotted him helplessly for long valuable minutes.

The building whose flank he had traversed began to groan.

All along the street, men stood in contorted attitudes. It was like the lowest circle of all. Amalfi got up, retching, and lurched for the control tower. The bumblebee sound filled the universe.

"Amalfi! Great scott, what happened to you—"

Someone took Amalfi's arm. Serum from the enormous blister which was his forehead flooded his eyes.

"Mark—"

"Yes, yes. What's the matter . . . how did you—"

"Get aloft. Get—"

Pain wrenched him into a ringing darkness.

After a while, he felt his head and hands being laved with something cool. The touch was very delicate and soothing. He swallowed and tried to breathe.

"Easy, John. Easy."

"John. No one called him that. A woman's voice. A woman's hands.

"Easy."

He managed a croaking sound,

and then a word or two. The hands stroked the coolness across his forehead, gently, monotonously. "Easy, John. It's all right."

"Aloft?"

"Yes."

"Who's . . . that? Mark—"

"No," said the voice. It laughed, surprisingly, a musical sound. "This is Dee, John. Hazleton's girl."

"The Hamiltonian girl." He allowed himself to be silent for a while, savoring the coolness. But there were too many things that needed to be done. "The cops. They should have the planet."

"They have it. They almost had us. They don't keep their bargains very well. They charged us with aiding the Hamiltonians; that was treason, they said."

"What happened?"

"Schloss made the invisibility machine work. Mark says the machine must have been damaged in transit, so the Lyrans didn't cheat us after all. He hid Schloss in it—that was your idea, wasn't it?—and Schloss got bored and amused himself trying to figure out what the machine was for; nobody had told him. He found out. We sailed right through the police ring and they looked right through us. We're on our way to the next star system."

Amalfi sighed. The steady, uneventful passage of the cool hands was putting him to sleep. But there was something—

"Dee?"

"Yes, John."

"You say—*we're* on our way."

"Yes, John."

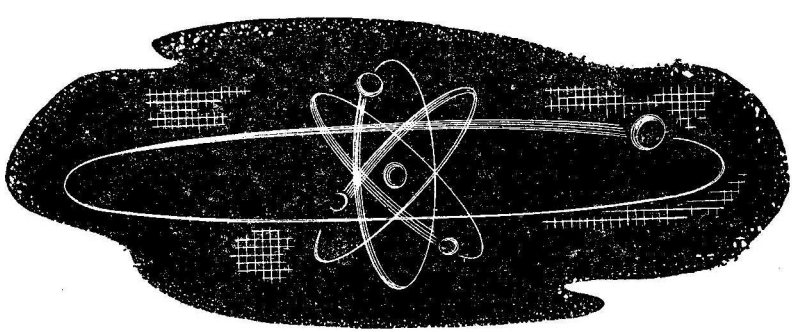
"You, too?"

The girl made her fiingertips trace a smile upon his forehead. "Me, too," she said. "The Hamiltonian girl."

"No," Amalfi said. "Not any more, Dee. Now you're an Okie."

There was no answer, but the movement of the cool fingers did not stop. The city soared outward into the raw night.

THE END



THE INSPECTOR'S TEETH

BY L. SPRAGUE DE CAMP

The Inspector's teeth were false, to begin with, and the Inspector had been dead lo, these many years. But the Inspector's teeth nevertheless chewed up the campus organizations considerably!

Illustrated by Cartier

World-Manager Chagas sat waiting for the Osirian ambassador, mentally practicing the brisk handshake and the glassy smile. Across the conference table the first assistant to the manager, Wu, chain-smoked, while the Minister of External Affairs, Evans, filed his nails. Although the faint rasp annoyed Chagas, he gave no sign, imperturbability being one of the qualities for which he was paid. The indirect lighting threw soft highlights from the silver skullcaps covering the shaven crania of the three.

Chagas said: "I shall be glad when I can let my hair grow again like a civilized man."

"My dear Chagas," said Wu, "with the hair you have, I don't see what difference it makes."

Evans put away his nail file and said: "Gentlemen, when I was a kid a century ago, I wondered what it would be like to be on the inside of a great historical moment. Now I'm in on one, I find it queer I'm the same old Jefferson Evans, and not Napoleon or Caesar." He looked at his nails. "Wish we knew more Osirian psychology—"

Wu said: "Don't start that Neo-Paretan nonsense again about Osirians being guided by sentiments, so we need only know which one to play on, like pressing a button. Osirians are rational people; would have to be to invent space travel independently of us. Therefore will be guided by their economic interests alone . . ."

"Neo-Marxist tapioca!" snapped Evans. "Sure they're rational, but also sentimental and capricious like

us. There's no contradiction—"

"But there is!" said Wu excitedly. "Environment makes the man, and not the contrary—"

"Do not start that, I beg," said Chagas. "This is too important to get your systems full of adrenalin over theory. Thank God I am a plain man who tries to do his duty and does not worry about sociological theories. If he takes our terms, the Althing will ratify the treaty and we shall have an Interplanetary Council to keep peace. If he insists on the terms we privately think he is entitled to, the Althing will not ratify. Then we shall have separate sovereignties, and it will be the history of our poor Earth all over again."

"You borrow trouble, chief," said Wu. "There are no serious disputes between our system and the Procyonic. Even if there were, there is no economic advantage to a war at such a distance, even though Osirians have capitalistic economy like Evans' country—"

"Who said wars are always fought for economic advantage?" said Evans. "Ever hear of the Crusades? Or the war that was fought over one pig?"

Wu said: "You mean the war some sentimental historian without grasp of social and economic factors

thought was fought for pig—"

"Stop it!" said Chagas.

"O.K.," said Evans. "But I'll bet you a drink, Wu, that the Osirian takes our offer as it stands."

"You are on," said Wu.

A bell chimed, bringing the men to their feet.

As the Osirian came in, they advanced with outstretched hands, uttering polite platitudes. The Osirian set down his bulging brief case and shook their hands. He looked like a small dinosaur, a head taller than a man—one of the little ones that ran about on its hind legs with its tail stuck out behind to balance. A complex pattern of red-and-gold paint decorated his scales.

The Osirian took the backless chair that had been provided for him. "A kreat pleashure, chentlemen," he said slowly in an accent they could barely understand. This was natural, considering the difference between his vocal organs and theirs. "I haff stuttiet the offer of the Worlt Fetteration and reached my teci-shion."

Chagas gave him a meaningless diplomatic smile. "Well, sir?"

The ambassador, whose face was not built for smiles, flicked his forked tongue out and back. With irritating deliberation he began ticking off points on his claws:

"On one hant, I know political conditions in the Solar System and on Earth in particular. Hence I know why you hat to ask me the things you dit. On the other, my people will not like some of these things. They will consitter many of your demants unchust. I could go ofer the grounts of opchection one py one. Howeffer, since you alretty know these opchections, I can make my point better py tellink you a little story."

Wu and Evans exchanged a quick glance of impatience.

The forked tongue flicked out again. "This is a true story, of the old tays when the mesonic drive had first enapled you to fly to other stars and put your system in touch with ours. Pefore there was talk apout galactic government, and pefore you learnt to guart akainst our little hypnotic powers with those pretty silfer hats. When a younk Sha'akhfa, or as you say an Osirian, hat come to your Earth to seek wistom—"

When Herbert Lengyel, a junior, proposed that they bid Hithasefea, the Osirian freshman, the Iota Gamma Omicron's council was thrown into turmoil. Herb persisted, glasses flashing:

"He's got everything! He's got money, and he's smart and good-natured, and good company, and full of college spirit. Look how he got elected yell leader when he'd been here only a few weeks! Of course it would be easier if he looked less like a fugitive from the reptile house in the zoo, but we're civilized people and should judge by the personality inside—"

"Just a minute!" John Fitzgerald, being a three-letter man and a senior, threw much weight in the council. "We got too many queer types in this fraternity already."

He looked hard at Lengyel, though Herb, who would like to have punched his handsome face, was merely a sober and serious student instead of a rah-rah boy. Fitzgerald went on:

"Who wants the Iotas to be a haven for all the campus freaks? Next thing you'll find a thing like a bug, a praying mantis a couple of meters high, sitting in your chair, and you'll be told that's the new pledge from Mars—"

"Ridiculous!" interrupted Lengyel. "Martians can't stand Earthly gravity and humidity for long—"

"That's not the point. I was speaking generally, and for my money a young dinosaur's not much improvement on a Martian—"

"Another thing," said Lengyel, "we have an anti-discrimination clause in our charter. So we can't bar this man . . . this student, I should say—"

"Yes we can," said Fitzgerald, stifling a yawn. "That refers only to the races of mankind; it doesn't apply to nonhuman beings. We're still a club of gentlemen—get that, gentlemen—and Hithasefea sure ain't no man."

"Principle's the same," said Lengyel. "Why d'you think Atlantic's one of the few universities left with fraternities? Because the frats here have upheld the democratic tradition and avoided snobbery and discrimination. Now—"

"Nuts!" said Fitzgerald. "It isn't discriminatory to pick folks you think will be congenial. It wouldn't be so bad if Herb had merely proposed some guy from Krishna, where they look more or less human—"

"There aren't any Krishnans at Atlantic this year," muttered Lengyel.

". . . But no, he has to foist a shuddery scaly reptile—"

"John's got a phobia against snakes," said Lengyel.

"So does every normal person—"

"Nuts to you, Brother Fitzgerald. It's merely a neurosis, implanted by—"

"You're both getting away from the subject," said Brother Brown, president of the chapter.

They went on like that for some time until a vote was called for. Since Fitzgerald blackballed Hithasefea, Lengyel blackballed Fitzgerald's young brother.

"Hey!" cried Fitzgerald. "You can't do that!"

"Says who?" said Lengyel. "I just don't like the young lout."

After further wrangling, each withdrew his veto against the other's protegée.

On his way out, Fitzgerald punched Lengyel in the solar plexus with a thumb the size of a broomstick-end and said: "You're taking Alice to the game tomorrow for me, see?"

"O.K., Stinker," said Lengyel, and went to his room to study. Although they did not like each other, they managed to get along. Lengyel secretly admired Fitzgerald for being the perfect movie idea of Joe College, while Fitzgerald secretly envied Lengyel's brains. It amused Fitzgerald to turn over his co-ed to Lengyel because he regarded Herb as a harmless gloop who wouldn't dare try to make time with her himself.

Next day, the last Saturday of the 2128 football season, Atlantic played Yale on the home field. Herb Lengyel led Alice Holm into the stands. As usual, when he got near her his tongue got glued to the roof of his mouth. So he studied the pink card he found thumbtacked to the back of the bleacher seat in front of him. On this were listed, by number, the things he was supposed to do with a big square of cardboard, orange on one side and black on the other, when the cheer leader gave the command, in order to present a letter, number, or picture to the opposite side of the stadium.

He finally said: "D'I tell you we decided to bid Hithasefea? Speak it not in Gath, though; it's confidential."

"I won't," said Alice, looking very blond and lovely. "Does that mean that when John takes me to your dances Hithasefea will ask to dance with me?"

"Not if you don't want him to. I don't know if he dances."

"I'll try not to shudder. Are you sure he didn't use his mysterious hypnotic powers to make you propose him?"

"Phooey! Professor Kantor in psych says all this talk about the hypnotic powers of the Osirians is bunk. If a man's a naturally good hypnotic subject he'll be hypnotizable, otherwise not. There aren't any mysterious rays the Osirians shoot from their eyes."

"Well," said Alice, "Professor Peterson doesn't agree. He thinks there's something to it, even though nobody has been able to figure out how it works . . . oh, here they come. Hithasefea makes a divine yell leader, doesn't he?"

Although the adjective was perhaps not well-chosen, the sight of Hithasefea, flanked by three pretty coeds on each side, and prancing and waving his megaphone, was certainly unforgettable. It was made even more so by the fact that he was wearing an orange sweater with a big black A on the chest, and a freshman beanie on his head. His locomotive-whistle voice rose above the general uproar:

"Atlantic! A-T-L-A-N—"

At the end of each yell Hithasefea flung out his arms with talons spread and leaped three meters into the air on his birdlike legs. He got much more kick out of the rooters' reaction to his yell-leading than the players did, since they were busy playing football. Hithasefea himself had

had hopes of going out for intercollegiate athletics, preferably track, until the coach had broken it to him as gently as possible that nobody would compete against a being who could broad jump twelve meters without drawing a deep breath.

As both teams were strong that year, the score at the end of the first quarter still stood 0–0. Yale completed a pass and it looked as if the receiver were in the clear until John Fitzgerald, the biggest of the fourteen right tackles of the Atlantic varsity, nailed him. Hithasefea screamed:

"Fitzcheralt! Rah, rah, rah, Fitzcheralt!"

A drunken Yale senior, returning to his seat after visiting one of the rooms under the stands, got turned around and showed up on the grass strip in front of the Atlantic side of the stadium. There he tramped up and down and bumped into people and fell over the chairs of the Atlantic band and made a general nuisance of himself.

At last Hithasefea, observing that everybody else was too much interested in the game to abate this nuisance, caught the man by the shoulder and turned him around. The man looked up at Hithasefea and shrieked: "I got 'em! I got 'em!" and tried to break away.

He might as well have saved his trouble. The Sha'akhfi freshman held him firmly by both shoulders and hissed something at him. Then he let him go.

Instead of running away, the man threw off his hat with its little blue feather, his furry overcoat, his coat and vest and shirt and pants. Despite the cold he ran out onto the field in his underwear, hugging his bottle under one arm and pretending it was a football.

Before he was finally taken away, the man had caused Yale to be penalized for having twelve men on the field during a play. Luckily the Yale rooters were too far away on the other side of the stadium to understand what was happening, or there might have been a riot. As it was, they were pretty indignant when they found out later, feeling that somebody had pulled a fast one on them. Especially as the game ended 21–20 favor of Atlantic.

After the game Hithasefea went to his mail box in the Administration Building. All the other frosh were eagerly pushing around the pigeonholes to get theirs, for this was the day when fraternity bids were distributed. When Hithasefea softly hissed: "Excuce me, please," they made plenty of room for him.

He took three little white envelopes from his box and scooted for his room in the freshman dorm. He burst in to find his roommate, Frank Hodiak, studying his one bid. Hithasefea sat down on his bed with his tail curling up against the wall and opened his envelopes, slitting them neatly along the edge with his claws.

"Frank!" he cried. "They want me!"

"Hey," said Hodiak, "what's the matter with you? You're drooling on the rug! Are you sick?"

"No, I am cryink."

"What?"

"Sure. That is the way we Sha'-akhfi cry."

"And why are you crying?"

"Pecause I am so happy! I am ofercome with emotion!"

"Well for goodness' sake," said Hodiak unfeelingly, "go cry in the sink, then. I see you got three. Which you gonna take?"

"I think the Iota Gamma Omicrons."

"Why? Some of the others got more prestige."

"I do not care. I am takink them anyway, for sentimental reasons."

"Don't tell me a cold-blooded reptile like you is sentimental!"

"Sure. All we Sha'akhfi are. You think we are not pecause we do not show our feelinks in our faces."

"Well," persisted Hodiak, "what are these sentimental reasons, huh?"

"First"—Hithasefea counted on his claws—"pecause Herp Lengyel iss one. He was the first man on the campus to treat me like a fellow-beink. Second, pecause the kreat de Câmara was a Iota when he attendet Atlantic many years ako."

"Who's this guy de Câmara?"

"Dit you neffer know? My, some of you echucated Earthmen are iknorant of your own history! He was one of the great space pioneers, the founter of the *Viagens Interplanetarias,* and the first Earthman to set foot on Osiris."

"Oh. Another Brazzy, eh?"

"Yes. It wass de Câmara who prought the false teeth of our Chief Inspector Ficèsaqha back to Earth from Osiris, and gafe them to Atlantic when they presented him with an honorary degree. Pefore I leat yells at a game, I go up to the museum and gaze upon those teeth. Their sentimental associations inspire me. I am fery sentimental apout Senhor de Câmara, although some of our people claim he stole those teeth and other thinks as well when he left our planet.

At the first pledge meeting, Hithasefea squatted down humbly among his fellow-pledges, who looked at him with traces of distaste or apprehension. When the prospective members' duties had been explained to them, Fitzgerald and a couple of the other brothers undertook to have a little fun of the sadistic sort associated with initiations. They brought out a couple of wooden paddles, like Ping-pong racquets but heavier, and fired nonsensical questions at the freshmen. Those who failed to answer glibly were paddled for ignorance, whereas those who answered glibly were paddled for being fresh.

By and by Hithasefea said: "Will nopody pattle me?"

"Why, Monster?" said Fitzgerald. "D'you wanna be?"

"Of course! It is part of peink a


ATL
CARTIER

pletch. It would preak my heart if I were not pattled the same as the others."

The brothers looked at each other with expressions of bafflement. Brother Brown, indicating Hithasefea's streamlined stern, asked:

"How can we? I mean, where's his . . . uh . . . I mean, where shall we hit him?"

"Oh, anywhere!" said Hithasefea.

Brother Brown, looking a bit unhappy about the whole thing, hauled off with his paddle and whacked Hithasefea's scaly haunch. He hit again and again, until Hithasefea said:

"I do not efen feel it. Are you sure you are not goink easy on me on purpose? It would wound my feelinks if you dit."

Brown shook his head. "Might as well shoot an elephant with a peashooter. You try, John."

Fitzgerald swung his massive arm and dealt Hithasefea a swat that broke the paddle. He wrung his hand, looked at the other brothers, and said:

"Guess we'll have to consider you constructively paddled, Hithasefea. Let's get on to business."

The other pledges grinned, evidently glad to escape any further beating. As the brothers had been made to feel a little foolish, the fun seemed to have gone out of paddling for the time being. The brothers sternly commanded the pledges to show up at the house the following night for the Thanksgiving dance, to do the serving and mess-work. Moreover they were told to bring three cats each to the next pledge meeting, the following week.

Hithasefea as usual showed up an hour early for his duties at the dance, wearing a black bow tie around his scaly neck in deference to the formality of the occasion. John Fitzgerald, of course, brought Alice Holm, while Herbert Lengyel came stag and hovered uneasily, trying by an air of bored superiority to mask the fact that he would have liked to bring her himself.

When Hithasefea stalked in bearing a tray of refreshments, some of the girls, who were not Atlantic coeds and so had never seen him before, shrieked. Alice, mastering her initial revulsion, said:

"Are you dancing, Hithasefea?"

Hithasefea said: "Alas, Miss Holm, I could not!"

"Oh, I bet you dance divinely!"

"It is not that. At home on Osiris I perform the fertility-tance with the pest of them. Put look at my tail! I should neet the whole floor to myself, I fear. You have no idea how much trouple a tail is in a worlt where peinks do not normally have them. Every time I try to go through a swingink door—"

"Let's dance, Alice," said Fitzgerald abruptly. "And you, Monster, get to work!"

Alice said: "Why, John, I think you're jealous of poor Hithasefea! I found him sweet!"

"Me jealous of a slithery reptile?

Ha!" sneered Fitzgerald as they spun away in the gymnastic measures of the Zulu.

At the next pledge meeting a great yowling arose when the pledges showed up with three cats apiece, for which they had raided alleys and their friends' houses and the city pound. Brother Brown said: "Where's Hithasefea? The Monster's not usually late—"

The doorbell rang. When one of the pledges opened it he looked out, then leaped back with the alacrity if not the grace of a startled fawn, meanwhile making a froglike noise in his throat. There on the doorstep stood Hithasefea with a full-grown lioness on a leash. The cats frantically raced off to other parts of the fraternity house or climbed curtains and mantelpieces. The brothers looked as if they would have done likewise if they had not been afraid of losing face before the pledges.

"Goot evenink," said Hithasefea. "This is Tootsie. I rented her. I thought if I prought one cat bik enough it would do for the three I was tolt to pring. You like her, I trust?"

"A character," said Fitzgerald. "Not only a monster, but a character."

"Do I get pattled?" said Hithasefea hopefully.

"Paddling you," said Fitzgerald, "is like beating a rhinoceros with a fiy swatter." And he set to work with a little extra vim on the fundament of the other pledges.

When the pledge-meeting was over, the brothers went into conference. Brother Broderick said: "I think we'll have to give 'em something more original to do for next time. Specially Hithasefea here. S'pose we tell him to bring . . . ah . . . how about that set of false teeth belonging to that guy . . . that emperor or whatever he was of Osiris, in the museum?"

Hithasefea said: "You mean the teeth of our great Chief Inspector, Ficèsaqha?"

"Yeah, Inspector Fish . . . well, you pronounce it, but that's what I mean."

"That will be a kreat honor," said Hithasefea. "Pefore we go, Mr. Fitzgerald, may I speak to you alone for a moment?"

Fitzgerald frowned and said: "O.K., Monster, but hurry it up. I got a date." He followed the Sha'akhfa out, and the other brothers heard Hithasefea hissing something to him in the corridor.

Then Hithasefea stuck his head in the doorway and said: "Mr. Lengyel, may I speak to you too, now?" And the same thing happened to Lengyel.

The other brothers did not listen to the conversation between Lengyel and Hithasefea because they were more interested in what was happening in the parlor. John Fitzgerald came through, all slicked up in his best clothes, and the lioness tackled him and tried to wrestle

with him. The more he tried to get away the more vigorously she wrestled. He finally gave up and lay on his back while Tootsie sat on his chest and licked his face. As having your face licked by a lion is something like having it gone over with coarse sandpaper, Fitzgerald was somewhat the worse for wear by the time Hithasefea came back into the room and pulled his pet off.

"I am fery sorry," he told them. "She is playful."

The night before the next pledge meeting, shadows moved in the shrubbery around the museum. The front door opened and a shadow came out—unmistakably that of a big, broad-shouldered man. The shadow looked about, then back into the darkness whence it had come. Sounds came from the darkness. The shadow trotted swiftly down the front steps and whispered: "Here!"

Another shadow rose from among the shrubs; not that of a man, but of something out of the Mesozoic. The human shadow tossed a package to the reptilian shadow just as the museum's watchman appeared in the doorway and shouted: "Hey, you!"

The human shadow ran like the wind, while the reptilian shadow faded into the bushes. The watchman yelled again, blew on a police whistle, and ran after the human shadow, but gave up, puffing, after a while. The quarry had disappeared.

Muttered the watchman: "Gotta get the cops on this one. Let's see, who came in late this afternoon, just before closing? There was that little Italian-looking girl, and that red-haired professor, and that big football-type guy—"

Frank Hodiak found his roommate packing his few simple belongings, and asked:

"Where you going?"

"I am gettink retty to leave for the Christmas vacation," said Hithasefea. "I got permission to leafe a few tays aheat of the rest." He shut his small suitcase with a snap and said: "Goot-pye, Frank. It is nice to have known you."

"Good-by? Are you going right now?"

"Yes."

"You sound as if you weren't coming back!"

"Perhaps. Some tay. *Sahacikhthasèf*, as we say in Osiris."

Hodiak said: "Say, what's that funny-looking package you put in your—"

But before he finished, Hithasefea was gone.

When the next pledge meeting was called, Hithasefea, hitherto the outstanding eager-beaver among the pledges, was absent. They called the dormitory and got in touch with Frank Hodiak, who said that Hithasefea had shoved off hours previously.

The other curious fact was that

John Fitzgerald had his right wrist bandaged. When the brothers asked him why, he said:

"I just found myself in my room with a cut on my wrist, and no idea how it got there."

The meeting was well under way and the paddles were descending when the doorbell rang. Two men came in: one of the campus cops and a regular municipal policeman.

The former said: "Is John Fitzgerald here?"

"Yeah," said Fitzgerald. "I'm him."

"Get your hat and coat and come with us."

"Whaffor?"

"We wanna ask you a few questions about the disappearance of an exhibit from the museum."

"I don't know anything about it. Run along and peddle your papers."

That was the wrong line to take, because the city cop brought out a piece of paper with a lot of fancy printing on it and said: "O.K., here's a warrant. You're pinched. Come—" and he took Fitzgerald by the arm.

Fitzgerald cut loose with a swing that ended, *splush,* on the cop's face, so that the policeman fell down on his back and lay there, moving a little and moaning. The other brothers got excited and seized both cops and threw them out the front door and bumpety-bump down the stone steps of the fraternity house. Then they went back to their pledge meeting.

In five minutes four radio patrol cars stopped in front of the frat house and a dozen cops rushed in.

The brothers, so belligerent a few minutes before, got out of the way at the sight of the clubs and blackjacks. Hands reached out of blue-clad sleeves towards Fitzgerald. He hit another cop and knocked him down, and then the hands fastened onto all his limbs and held him fast. When he persisted in struggling, a cop hit him on the head with a blackjack and he stopped.

When he came to and calmed down, on the way to the police station, he asked: "What is this all about? I tell you, I never stole nothing from a museum in my whole life!"

"Yes, you did," said a cop. "It was the false teeth of one of them things from another planet. O'Riley, I think they call it. You was seen going into the museum around closing time, and you left your fingerprints all over the glass case when you busted it. Boy, this time we'll sure throw the book at you!"

Next day Herbert Lengyel got a letter:

Dear Herb:

When you read this I shall be en route to Osiris with the teeth of Chief Inspector Ficèsaqha, one of our greatest heroes. I managed to get a berth on a ship leaving for Pluto, whence I shall proceed to my own system on an Osirian interstellar liner.

When Fitzgerald suggested I steal the

teeth, the temptation to recover this relic, originally stolen by de Câmara, was irresistible. Not being an experienced burglar, I hypnotized Fitzgerald into doing the deed for me. Thus I killed three birds with one stone, as you Earthmen say. I got the teeth; I got even with Fitzgerald for his insults; and I got him in Dutch to give you a clear field with Miss Holm.

I tell you this so you can save him from being expelled, as I do not think he deserves so harsh a penalty. I also gave you the Osirian hypnosis to remove some of your inhibitions, so you shall be able to handle your end of the project.

I regret not having finished my course at Atlantic and not being finally initiated into Iota Gamma Omicron. However, my people will honor me for this deed, as we admire the refined sentiments.

Fraternally,

Hithasefea.

Lengyel put the letter away and looked at himself in the mirror. He now understood why he had felt so light, daring, and self-confident the last few hours. Not like his old self at all. He grinned, brushed back his hair, and started for the house phone to call Alice.

"So, chentlemen," said Hithasefea, "now you unterstant why I have decidet to sign your agreement as it stants. I shall perhaps be criticized for giffink in to you too easily. But you see, I am soft-hearted apout your planet. I have been on many planets, and nowhere havĕ I peen taken in and mate to feel at home as I was py the Iota Gamma Omicron fraternity, many years ago."

The ambassador began to gather up his papers. "Have you a memorantum of this meetink for me to initial? Goot." Hithasefea signed, using his claw for a pen. "Then we can have a formal signink next week, eh? With cameras and speeches? Some tay if you feel like erecting a monument to the founders of the Interplanetary Council, you might erect it to Mr. Herbert Lengyel."

Evans said: "Sir, I'm told you Osirians like our Earthly alcoholic drinks. Would you care to step down to the Federation bar—"

"I am so sorry, not this time. Next time, yes. Now I must catch an airplane to Baltimore, U. S. A."

"What are you doing there?" said Chagas.

"Why, Atlantic University is giffink me an honorary degree. How I shall balance one of those funny hats with the tassel on my crest I do not yet know. But that was another reason I agreet to your terms. You see, we are a sentimental race. What is the matter with Mr. Wu? He looks sick."

Chagas said: "He has been watching his lifelong philosophy crumble to bits, that is all. Come, we will see you to your aircraft."

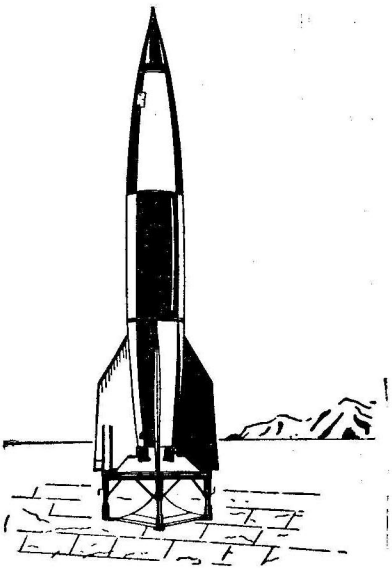
As Wu pulled himself together and rose with the rest, Evans grinned wryly at him, saying:

"After we've dropped the ambassador, I think I'll make it a champagne cocktail!"

THE END

OUR TURBULENT ATMOSPHERE

BY WILLY LEY



***Concluding** the story of atmospheric research up to the present era of V-2s, and radiofrequency ionosphere exploration, spectroscopes and hypersensitive bolometers!*

Part 2

I mentioned that American engineers tied small transmitters to balloons in the hope of following their flight in spite of darkness or haze or clouds. Just what happened—or didn't happen—on the French battlefields is not known, presumably the information was secret at first and later, after it was declassified, nobody bothered to write it up. In 1921 a German engineer by the name of Herath released balloon-borne spark transmitters but also without success, the signals could be picked up only over such short ranges that it was not worth while; confirming the scoffing of those who maintained that a spark transmitter's acoustical range was greater than its electrical. But two years after Herath, W. R. Blair of the United States Signal Corps repeated the experiment and succeeded in tracking a balloon for twenty minutes and to an altitude of twenty thousand feet.

It could be done, as was also confirmed by experiments in France, but it didn't mean much. The transmitter could only say "I am here!" but could not tell anything else yet. The idea was to take one of those

instrument sets as had been originally developed by Assmann, Besançon and Hermite and make a transmitter broadcast their readings. And suddenly the news came that Professor Pyotr A. Moltchanoff of Slutsk in Siberia had done just that, he had succeeded in transmitting temperature and pressure readings from an unmanned balloon. It was a genuine Russian "first" and it was the beginning of what is now called "telemetering" but should be called "radio-telemetering". Moltchanoff was the first to accomplish radio-telemetering, telemetering over a wire had been started in 1877 by the Dutch instrument maker Olland of Utrecht.

Lecture experience has taught me that telemetering of any kind is regarded as such advanced magic by many people that they don't even ask how it is done, feeling sure that only the initiated could possibly understand it. For this reason I'll explain Olland's method with the aid of a factory clock which shows hours and minutes and also seconds by means of a sweep hand. Supposing you have a seashore station which is to inform you about the rise of the tide and about the direction of the wind. Now we take our factory clock and gear a float to the long or minute hand, while a weather vane is geared to the short or hour hand. The sweep hand we leave alone to travel round the dial once every sixty seconds. Every time it passes over the "12" it makes a short contact. Every time it passes over the other hands it makes a contact too, the contact for one of the two hands lasting a little longer than that for the other. Each contact sends an electric impulse through a wire, and at the other end of the wire you get a short impulse at regular intervals from the "12", which is called the "reference pulse" while the other two supply the actual readings.

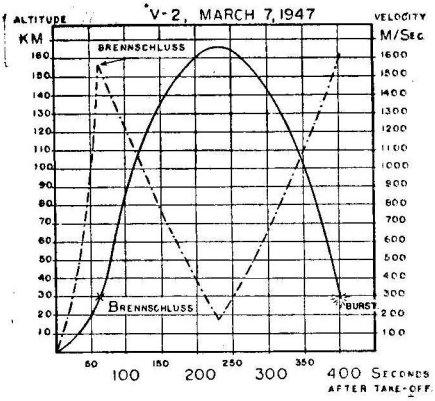
It was a modification of this system which Moltchanoff used, except that the wire was replaced by a carrier wave. A lot of such systems were thought up and tried, and some actually used, during the interval from 1930 to 1940. One, invented by a Finnish scientist, Dr. Vilho Väisälä, transmitted readings by changing the wave length of the carrier wave. The most customary American system is the so-called Diamond-Hinman circuit which operates with modulations of the carrier wave. One of the most recent ones uses a record with *concentric* grooves—not a spiral groove as in ordinary records—each groove carrying letter combinations in Morse code. The sensing instruments have arms which reach into those grooves and broadcast their reading by the groove they picked. There are three sensing instruments, for air pressure, temperature and humidity and they jab at the record in sequence with an interruption for reference, like this: pressure, temperature, humidity, pause, pressure, temperature, humidity, pause, and so on, until

something or somebody gets tired. All this goes over the same carrier wave, but you can imagine that you have a lot of readings to take so that you have to add "one more wire"—if you think of Olland's method—or "one more wave length"—you can have two-channel systems, five-channel systems or whatever.

Very ingenious instruments indeed, but something has to carry them upstairs. Airplanes were used when convenient, but the bulk of the carrying of such radio sondes was done by small rubber balloons which expanded as they rose. Finally they burst and the package of instruments came back by parachute, not so much for the sake of recovery, which was never very good, but in order to avoid damage claims. Most of the carrying balloons burst between fifteen and twenty kilometers only rarely did one go higher. People who advocated rockets as instrument carriers for the sake of higher altitudes—and also because a rocket does not get stuck at a low altitude because there happen to be icing conditions around—were usually informed by meteorologists that they did not care much since conditions in the stratosphere did not influence conditions in the troposphere. This is almost certainly wrong, although you can probably do without stratosphere conditions for an ordinary weather forecast.

Suddenly the V-2 was available, instruments could be carried to one hundred fifty kilometers or better and now we are really beginning to learn something about the high atmosphere. The balloons just rose above the tropopause, the V-2 goes considerably beyond the stratopause. Because newspaper releases cannot be too technical most of the public thinks that these rockets carry instruments in their war heads only. Actually, when you look at a V-2 ready for a stab into the ionosphere you see—or could see if the metal skin were transparent—research instruments stuck into every bit of empty space. Most of them are in the war head, of course, but some were located in the compartment below the war head which houses the rocket's own guiding instruments. Some could be crammed into the main section where there was a small space between the two fuel tanks. Others were fitted into the hollow stabilizing fins. As for antennae, they were sometimes strung from the stabilizing fins to a point higher up on the rocket, or else trailing antennae were used which the rocket pulled out of their boxes when it rose.

One major difficulty was presented by the simple fact that a V-2, coming back from a high altitude trajectory, does about as much damage with a war head full of cosmic ray counters as it would with a war head full of TNT. Of course nobody cares about a sixty-foot crater in the New Mexico desert but the sad fact was that the rocket itself formed part of the debris, in very small and useless fused pieces. And while most of the information gath-



V-2 high altitude shot of March 7, 1947. Velocity and altitude vs. time. Solid curve is altitude, refer to left-hand column. Dash-dot curve is velocity, refer to right-hand column. Brennschluss took place at the 65th second, the peak attained 230 seconds after take-off, while air burst was achieved 400 seconds after take-off. If the missile had fallen in one piece, impact would have taken place at about the 420th second.

ered by the instruments can be telemetered some things just have to be recovered. Film, for example, whether it took a picture of the horizon or of alpha particles. And seeds which have been carried to high altitudes to be exposed temporarily to the conditions of near-empty space have to be found and planted if the experiment is to be of any use. A parachute for the whole rocket was out of the question. One could probably build a parachute which can carry four tons, the returning weight, but it probably would not fit into the available space, even if all the space were turned over to the parachute.

To supply some instruments with small individual parachutes is an obvious thought and it was tried, too. So far the outcome is doubtful, sometimes an observer claimed to have seen a floating parachute but then it was not found and one can't be sure whether the observer might not have been mistaken. And even if he did see a floating parachute it is by no means certain that it also carried its instrument, it might have torn off instead of pulling the instrument out.

Pondering the problem somebody found the answer. The rocket buried itself in the desert in a deep impact crater because it struck the ground nose first like a bomb. It struck with a high velocity because it is nicely streamlined—up to the moment of impact—and the stabilizing fins keep the tail up. In short the empty rocket had nice ballistic characteristics, after all it was designed with that end in view. Destroy these characteristics and you'll get much less of an impact. If, for example, you broke the war head off the falling rocket that war head, by itself, would probably tumble through the air and strike the ground at an odd angle. The after body ought to do even better. It would not have a nose at all, but a jagged hole in front. The stabilizing fins would try to straighten it out while falling, of course, but they would be handicapped by having the heaviest component left, the motor and the turbine-pump aggregate, at the wrong

end. The after body should pancake through the air in such a manner that it would hardly attain enough velocity to break through a pavement.

Now the American experts had added other features than just the research instruments. They had built an emergency cutoff into the rocket, to cut off the fuel flow in case something went wrong. As it turned out it was a most useful device— I have seen it applied in the case of Rocket No. 14. This emergency cutoff could also be used for the radio signal which would blow the war head off the body. To accomplish the "air burst", as it was dubbed, one pound of TNT was placed on each of the four upright struts of the rocket body, just below the war head. The radio signal did its duty and the four one-pound charges went off. An observer saw what happened through a powerful glass, he told that a smoke cloud enveloped the whole rocket—and then the rocket came out of the smoke cloud in one piece and crashed as if nothing had happened. And the telemetering men also reported that most of the instruments had continued broadcasting afterwards.

After this had happened once more the men of the Applied Physics Laboratory, in charge of instrumentation for Rocket No. 9 took sterner measures, consisting of a pound of nitrostarch reinforcing each pound of TNT, "fired from a central source by dual strands of primacord actuated by two No. 3 electric caps." That separated the war head which, ironically, was never found afterwards. But the main body did pancake to the ground, looking afterwards as if it had dropped, oh say from the roof of a hundred-foot high assembly shed. From then on the air-burst method was used whenever advisable, the burst being placed at about thirty kilometers so that the dense air had a good chance to retard the pieces. (A burst at a still higher altitude would scatter them over too large an area.)

The V-2s have, as everybody knows, taken pictures of the earth, they have measured pressures and temperatures directly right up into the ionosphere. They have brought back some highly interesting information about the ozone layer formed by the sun's ultraviolet radiation at around twenty kilometers. Some indication about the existence of that ozone layer had been brought back by the Stratosphere Balloon "Explorer II" in 1935. But the balloon could enter only the sole of that layer, nobody could tell how high it would extend and any three scientists pondering that question arrived at four different answers. V-2 not only established the upper limit—around 37 km—but found a *double* layer, separated by a layer with comparatively little ozone. On October 10, 1946 that separating layer was just at twenty kilometers, with maximum intensities at about sixteen and twenty-six kilometers.

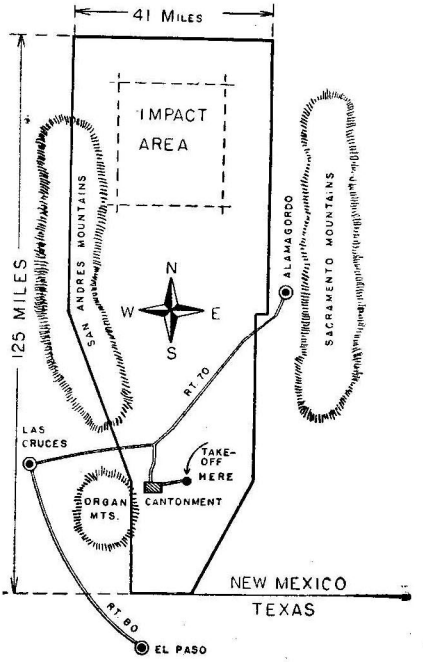
An interesting experiment which,

however, failed was first tried with Rocket No. 13. It can be readily understood that the conclusions which astronomers draw from the observations of meteors need a few assumptions about which one cannot be absolutely sure. Now if it were possible to produce a few artificial meteors about which a number of things—like particle size, probable velocity—are known one would get comparison values which will confirm or correct the assumptions. Some black powder, exploding from the large rocket which would not be disturbed much by such a small and weak explosion, might furnish some clues. Preparations were made for what was called the powder puff experiment. The engineering end of it worked, but compared to the velocity of the rocket the black powder exploded much too slowly, instead of obtaining "puffs" merely "streamers" were obtained which were of no use, except for showing that there was a high wind.

Something more powerful was needed and the shaped charge of a rifle grenade looked like the answer. Consequently Rocket No. 17, which happened to establish the altitude record for V-2s, was equipped with rifle grenades which were to fire their shaped charges at high altitudes, thus producing the equivalent of a low density meteorite The best available information indicates that the shaped charges did not go off, the fragments of the rocket which were examined afterwards could not answer the question, since the charges may have gone off either when the air burst was made or when the war head hit the ground. Incidentally the air burst was delayed by over a hundred seconds and the device which functioned so sluggishly for this purpose was the same that was intrusted with the discharge of the grenades.

By now the condensed results of Rockets No. 1-24 are available. (See page 123.)

While these shots were being made, furnishing confirmation of theoretical results—such as the vertical distribution of temperature—and



White Sands test area.

providing entirely new things, such as a spectrum of the sun taken from *above* the ozone layer and therefore far more complete than the nicest observatory spectrum, scientists began to feel that the V-2 was quite wonderful, but too big. They wanted two things, a smaller and cheaper rocket on the one hand, and a large rocket with variable payload on the other. As for the large rocket with variable payload—V-2, of course, was designed for a war head of standard weight—the Navy's *Viking* is the forthcoming answer. As for the smaller rocket there had first been some hopes for the WAC Corporal, but it had two drawbacks. One was that it did not quite penetrate the stratosphere, the other that it just

RECORD OF V-2 FIRINGS FROM WHITE SANDS

No.	Date	ALTITUDE km.	ALTITUDE mi.	RANGE km.	RANGE mi.	REMARKS
1.	March 15, 1946	——	——	——	——	Static test.
2.	April 16, 1946	5.5	3.4	8.6	5.4	Fin fell off, EC, G. E.
3.	May 10, 1946	113.9	70.8	57.1	35.4	Demonstration, G. E.
4.	May 29, 1946	112.0	69.6	60.5	37.6	Normal, G. E.
5.	June 13, 1946	164.5	102.2	64.3	40.0	Air Burst failed, G. E.
6.	June 28, 1946	107.9	67.0	64.5	40.1	Air Burst Failed, NRL.
7.	July 9, 1946	133.5	83.0	98.1	61.0	4° too much tilt, G. E.
8.	July 19, 1946	5.5	3.4	1.8	1.1	Explosion at 27 sec. Ox. pump failed, G. E.
9.	July 30, 1946	167.3	104.6	109.7	68.2	Air Burst, war head not found, APL.
10.	Aug. 15, 1946	6.4	4.0	1.2	0.7	Steering failed, EC, exploded on impact. P. U.
11.	Aug. 22, 1946	0.1	0.06	1.3	0.8	Gyro failure, EC, W. L.
12.	Oct. 10, 1946	174.0	108.0	23.0	14.5	Cameras carried, NRL.
13.	Oct. 24, 1946	105.0	65.2	29.0	18.0	59 sec. burning time, black powder puffs, APL.
14.	Nov. 7, 1946	0.4	0.24	8.0	5.0	Rocket traveled horizontally, EC at 39 sec. P. U.
15.	Nov. 21, 1946	101.0	62.8	19.0	11.8	Poor burning, W. L.
16.	Dec. 5, 1946	153.0	95.0	211.0	131.1	Tilted at take-off and tumbled, NRL.
17.	Dec. 17, 1946	183.0	113.7	31.0	19.3	Highest to date, grenade exp. APL.
18.	Jan. 10, 1947	119.0	74.0	40.0	24.9	Cosmic ray study, Air Burst, NRL.
19.	Jan. 23, 1947	47.0	29.2	26.0	16.1	Spiraled in flight, G. E.
20.	Feb. 20, 1947	109.0	67.7	31.0	19.2	Air Burst, AMC.
21.	March 7, 1947	162.0	100.6	58.0	36.0	Atmosph. studies, NRL.
22.	April 1, 1947	121.0	75.2	43.0	26.7	Successful, APL.
23.	April 8, 1947	103.0	64.0	31.0	19.3	Cameras carried, APL.
24.	April 17, 1947	143.0	88.9	72.0	44.8	Normal, G. E. and Signal Corps.

The letters under "Remarks" have the following meaning: EC means that the "Emergency Cutoff" was used, stopping fuel flow to the motor by radio order from the ground. The others refer to the agency primarily involved for instrumentation for that flight. G. E. means General Electric; NRL means Naval Research Laboratory; P. U. means Princeton University; APL means Applied Physics Laboratories of Johns Hopkins University; AMC means Air Material Command and W. L. means Watson Laboratories.

did not have much space for instruments.

For this reason the rocket *Aerobee* —called also *Venus* temporarily before it was finished—was developed. The rocket itself is cylindrical, with a diameter of fifteen inches, equipped with three small stabilizing fins. The overall length is two hundred twenty-six inches of which eighty-eight inches represent the Instrumentation Cone, actually it is not a cone but an ogive. The *Aerobee* is launched by means of a solid fuel booster which imparts a velocity of some three hundred meters per second and then drops off. The *Aerobee's* own motor keeps going for forty-five seconds and accelerates the rocket to a maximum velocity of about thirteen hundred meters per second, resulting in a peak altitude of about one hundred ten kilometers. The payload can be made to vary between one hundred and two hundred fifty pounds, influencing performance, of course. The first *Aerobee* was fired on November 24, 1947, but because of excessive tilt the emergency cutoff had to be used after thirty-five seconds. The second, fired on March 5, 1948 was fully successful and since then many *Aerobees* have journeyed into the lower ionosphere, a number of them having been fired from shipboard. Just in passing it may be mentioned that a set of photographs of the earth which got into the newspapers as "pictures taken from V-2s" were actually taken from an *Aerobee* rocket. Since naturally not every frame of such a film is useful it so happens that the *Aerobee* pictures which were published were taken from a higher altitude than the corresponding V-2 pictures, even though the V-2 can go much higher than the *Aerobee*.

"Blazing Heat Found At High Altitudes" is the headline of a newspaper clipping I have in front of me and the reference is to a V-2 shot made on March 7, 1947—Rocket No. 21—which telemetered data to the ground from which it could be concluded that the temperature between fifty and sixty kilometers was three hundred twenty degrees Kelvin, counting from absolute zero. This makes 47° C or 116.6° F. My first guess is that the newspaper writer thought that 320° K must be at least 320° F and probably more. He probably wondered whether the rocket melted.

Now Rocket No. 21 happened to be devoted especially to atmosphere research. It also happened to be especially successful, everything went well and in addition to other things the temperature of the skin of the war head was measured. The problem of the heat of the rocket's skin had worried the Germans, too, when they designed it. They had measured it by putting plugs of alloys of different melting points into the skin of the rocket and looking after the test firing which alloys had melted and which had not. They found that the highest temperature at any point was around 650° C—1200° F—but

they also knew that this high heating took place while the rocket was falling, entering dense layers of the atmosphere with ever increasing velocity. That the rocket would get very hot—as one uses that term when it comes to metals—while ascending was unlikely and the measurements taken at White Sands confirmed this opinion.

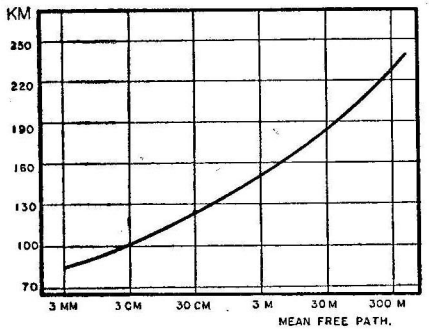
As regards a higher temperature in the upper stratosphere, that had been taken for granted for quite some time. It had been the explanation advanced by Professor Whipple for the "zone of silence"; air of different temperature would act as a mirror for sound waves, just as the ionized layers acted as mirrors for electric waves. Temperature, it had been guessed correctly, would begin with a fairly high value at the bottom, where the ground warms the air—not the other way round—then fall off for a while, rise again, fall off some more and in the end do something which could not be predicted too well.

In 1946 things had progressed far enough so that the NACA could prepare a table of conditions from twenty kilometers to one hundred twenty kilometers, the lower ionosphere. All kinds of research, the rockets coming in only at the tail end, had indicated that the ideas of Teisserenc de Bort, and later of Wegener and Arrhenius, about the "stratified" stratosphere did not hold true. The stratosphere was not uniformly cold, as they had thought. Nor was it without winds, some meteor trails had demonstrated that

V-2, NO. 21; MARCH 7, 1947

TIME since take-off (sec.)	HEIGHT (km.)	VELOCITY along trajectory (m/sec.)	PRESSURE (mm. Hg.)	TEMPERATURE of skin* of war head (degrees C.)
0	1.2†	0	660	22
10	1.7	109	630	22
20	3.5	260	495	22
25	5.0	348	410	22
30	7.0	438	300	25
35	9.4	530	210	35
40	12.3	646	130	45
45	15.9	810	76	62
47.5	18.0	900	52	77
50	20.4	995	33	87
52.5	23.0	1090	23	97
55	25.9	1200	14.5	108
57.5	29.0	1305	9.6	118
60	32.4	1420	5.8	124
65	39.9	1540	2.3	135
70	47.5	1490	.95	142
75	54.8	1440	.40	147
80	61.8	1390	.18	156
100	87.5	1200	.003	160

*Temperature measured 446 millimeters below extreme point of war head.
†Represents the height of White Sands launching area above sea level.



Mean free path of molecules in the atmosphere between eight-five and two hundred forty kilometers, according to H. S. Tsien.

conclusively. And it certainly did not show any separation of the gases, we are now satisfied that the composition of the air does not vary to any noticeable extent between bottom and stratopause, not counting the phenomenon of the ozone layer. Of course there is much less air in a cubic mile of space fifty kilometers up, but the percentage composition is the same.

Table II gives some excerpts from the second set of NACA tables, in intervals of five kilometers. The reason why the first line in that table, for twenty kilometers altitude, does not agree perfectly with the last line in Table I is due mainly to one factor. In the first set of NACA the standard value for gravity had been used throughout, in the new set, extending to much higher altitudes, the inverse square law had to be taken into consideration. And because of the specialized questions which mis-

TABLE II

The Atmosphere from 20 to 120 km, according to NACA Techn. Note 1200

Height km	Temperature °C	°K	Pressure kg/m2	Weight kg/m3	Speed of sound m/sec.	Mean free path NACA mm	Mean free path Grimminger mm
20	— 55.0	218.0	568.4	8851 x 10^{-5}	296.0	0.0011	0.001
25	— 55.0	218.0	261.0	4059 "	296.0	0.0022	0.003
30	— 55.0	218.0	120.1	1864 "	296.0	0.0047	0.006
35	— 33.0	240.0	56.48	795 "	310.6	0.011	0.014
40	+ 3.7	276.7	29.35	358 "	333.5	0.024	0.03
45	+ 40.3	313.3	16.56	178 "	354.9	0.05	0.07
50	+ 87.0	350.0	9.970	96 "	375.1	0.09	0.11
55	+ 87.0	350.0	6.167	59 "	375.1	0.15	0.18
60	+ 87.0	350.0	3.820	36.6 "	375.1	0.24	0.29
65	+ 46.4	319.4	2.315	24.3 "	358.3	0.36	0.46
70	+ 15.9	288.9	1.335	15.5 "	340.7	0.56	0.68
75	— 14.7	258.3	.725	9.4 "	322.2	0.92	1.06
80	— 33.0	240.0	.3675	5.1 "	310.6	1.68	2.2
85	— 25.7	247.3	.1877	2.4 "	325.2	3.39	4.2
90	— 7.5	265.5	.1029	1.2 "	347.1	6.64	8.0
95	+ 10.8	283.8	.0602	.61 "	369.2	12.1	14.5
100	+ 29.0	302.0	.0373	.34 "	391.5	20.7	29.6
105	+ 47.3	320.3	.02406	.21 "	403.2	34.1	48.4
110	+ 65.5	338.5	.01589	.13 "	414.5	54.4	76.6
115	+ 83.3	356.8	.01074	.08 "	425.5	84.8	117.5
120	+102.0	375.0	.00740	.05 "	436.3	129.0	192.6

sile designers and their ilk were likely to ask a few things were added which had not been in the first set, speed of sound, for one.

The most interesting column, to my mind, in that table is the one which gives the "mean free path". Everybody knows that the molecules of the air are in steady and rapid motion, a motion which increases with rising temperature. At sea level, and at standard temperature—+ 15° C = 59° F—you have 2.568×10^{19} or 25,680,000,000,000,000,000 molecules per cubic centimeter. They are all in rapid motion and, naturally, bump into each other rather frequently. Between collisions they move in a straight line and the average distance which they manage to move in between two collisions is called the "mean free path". The mean free path for standard sea level conditions has been calculated and is 9.744×10^{-6} cm which means slightly less than one ten thousandth of a millimeter. At eighty kilometers, the altitude in which the clouds from the Krakatoa catastrophe hovered, the mean free path is close to two millimeters, at ninety kilometers it has grown to around seven millimeters—a fraction above one quarter inch—and at one hundred kilometers it has grown to between twenty and thirty millimeters, depending on how the calculation is made. In short the mean free path up there is about one inch long.

Still more recently G. Grimminger of the Rand Corporation in Santa Monica, California, has extended calculations of this kind to even higher altitudes as part of a report written for the United States Air Force. Some of his figures are given here as Table II A. The mean free path for one hundred fifty kilometers altitude works out to an even two meters, at two hundred sixty kilometers it has grown to two hundred twenty-nine meters and at three hundred kilometers to seven hundred seventy-nine meters! The number of particles per cubic centimeter for that altitude turns out to be 3,210,000,000 and that is an interesting figure. Because it was always said that a really good hard vacuum made in the laboratory will leave only a little more than 3,000,000,000 molecules per cubic centimeter. The "atmosphere" at three hundred kilometers, therefore, corresponds to

TABLE II A

Some values from the Grimminger Report, his Table 14

Km	°C	°K	Particles per cubic centimeter	Mean free path in meters	Speed of sound m/sec.
137.1	+ 171.1	444.1	3.44×10^{12}	0.727	470
152.4	+ 232.5	505.5	1.25×10^{12}	2.000	502
182.9	+ 355.3	628.3	2.30×10^{11}	10.90	no value
228.6	+ 539.4	812.4	3.19×10^{10}	78.60	" "
259.1	+ 662.2	935.2	1.09×10^{10}	229.00	" "
274.3	+ 723.6	996.6	6.75×10^{9}	371.00	" "
300.0	+ 827.0	1100.0	3.21×10^{9}	779.00	" "

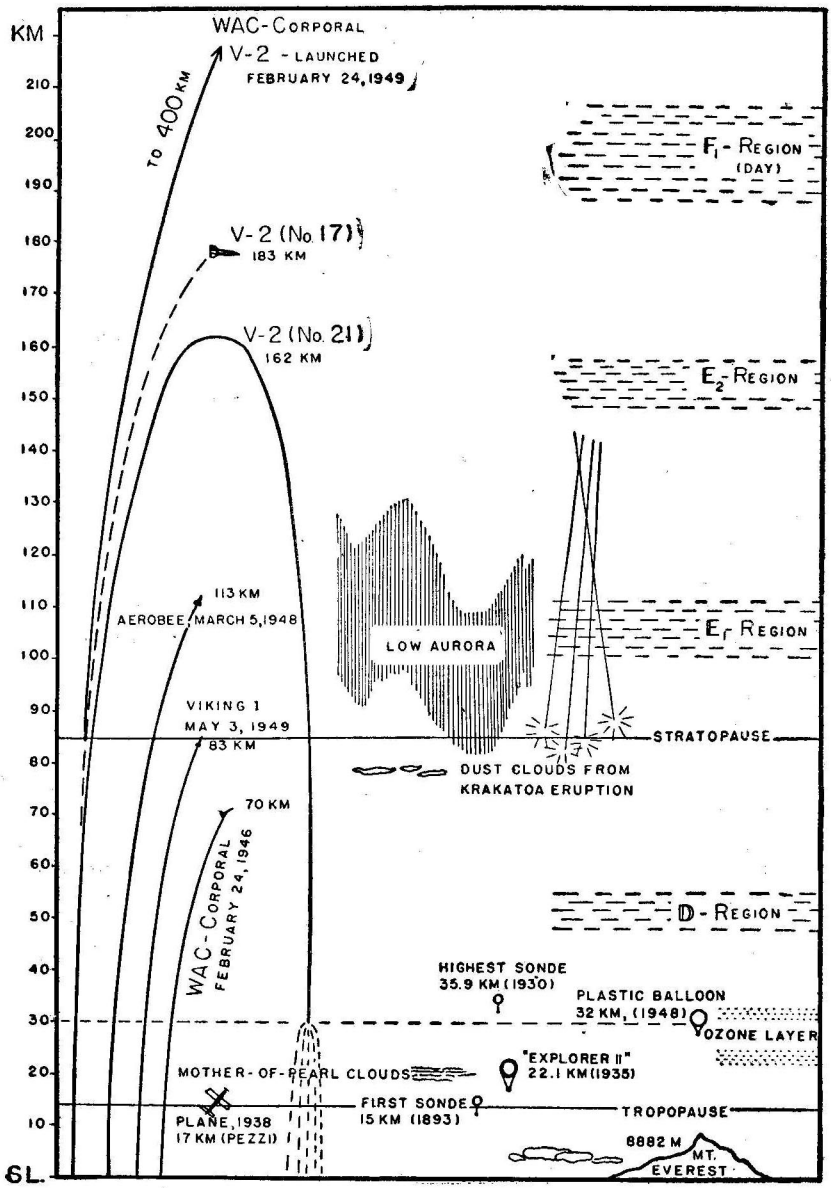
about the best vacuum we can produce at the bottom of the air ocean.

Now the trouble with many of the figures in Tables II and II A is that they will be greatly misleading to many. The *Aerobee* rocket went to one hundred thirteen kilometers in March 1948, let's say one hundred fifteen kilometers because our abbreviated table does not contain the figures for one hundred thirteen kilometers. Ahem, so that rocket will heat up to 83.3 degrees centigrade, the speed of sound is 425.5 meters per second and if the rocket should still move with, say 850 m/sec.—the muzzle velocity of a high powered rifle—its Mach number will be just 2.0. Not with a mean free path of almost one meter, my friend!

All these ideas about Mach number, speed of sound and temperature are bottom layer concepts, they all have a hidden assumption which says that the air "is a perfect gas, obeying the general thermodynamic equation of state". It means that the air is a continuous medium. With a mean free path of a meter or so it isn't any more. Pressure has been exchanged for the impact of individual molecules. Since sound means the propagation of a pressure disturbance in air, it is no longer propagated. Consequently the "speed of sound" is now only the numerical result of a certain equation, but no longer an actuality that could be measured by two observers shouting to each other.

It is probably correct to say that at high altitudes, say from the stratopause on, sound and speed of sound no longer have a value at all, they have petered out, simply disappeared, because of the long distance between gas molecules. The problem of the shock wave is similar, but complicated by the fact that the size of the object has to enter into the picture in some manner. At an altitude where air resistance already consists of the impact of individual air molecules for a bullet moving through, it is still a semblance of a continuous medium for a V-2 rocket. And where density has degenerated to the point where a V-2 experiences the impact of separate molecules a spaceship still finds a continuous medium. Experts are not in a very perfect agreement at this moment how thin a shock wave can be, but they are agreed that it must be more than one mean free path. Some consider five to seven times the mean free path a probable thickness, others are willing to grant twice the mean free path as minimum thickness. At one hundred eighty-three kilometers, the V-2 record, the mean free path is eleven meters, it would need an enormous disturbance, a big ship, to produce shock waves which would have to be about a hundred feet in thickness.

In that altitude the value for temperature—three and a half times that of boiling water—has also lost the meaning attached to that word down here at sea level. Temperature, by definition, is the velocity of the molecules, and from that point of view the temperature at one hundred



Atmosphere cross section, Model 1949.

eighty-three kilometers is three hundred fifty-five degrees centigrade. But when Miss Smith moans that it is "a hundred"—meaning 100° F or 37.8° C—she is not thinking of the velocity of the air molecules. She has something in mind which falls under the classification of heat transfer, she means that a dish of ice cream, left on the desk, will first melt and then assume the temperature of 100° F. With only 2.3×10^{11} particles around per cubic centimeter that does not apply any more. To use a comparison, not completely valid but the best I can think of, you might as well expect people in an assembly hall to die of heat because the hall is being heated by two pinheads glowing at three thousand degrees.

So we might say that at the stratopause, or somewhere in that region, temperature "disappears" too, the same as sound and speed of sound and shock waves. Physicists are beginning to talk of "kinetic temperature" under these circumstances, but the terminology has not yet settled.

In short, our surface concepts hold more or less true up to the stratopause, as does the composition of the air. From then on the surface concepts are no longer there and the composition actually begins to change. At sea level we had the customary seventy-eight percent of N_2 plus 21 percent of O_2 plus one percent of argon and rarer gases. Near the stratopause we probably have simply eighty-two percent N_2 and eighteen percent O_2. But above the stratopause we begin to get oxygen atoms, O instead of O_2. At one hundred twenty kilometers, it is believed, we have—in round figures—thirty percent O and seventy percent N_2. Whether the N_2 changes to N, too, in still higher altitudes is under discussion at the moment, but it does not seem likely.

And where is the limit of the atmosphere according to present day concepts? Well, that is, unfortunately, completely a matter of definition. At two hundred eighty kilometers we have the F_2-Layer which reflects certain frequencies of radio waves at least half the time, so we can definitely say that there is still "atmosphere" of some sort at two hundred eighty kilometers, since it has a property left. But above the F_2-Layer all doors are open.

Grimminger has constructed three models, which I'll call G-I, G-II and G-III, based upon three sets of assumptions. In his first model he defines the "limit" of the atmosphere as the height where the properties of the atmosphere become the same as those of interstellar gas, better called interplanetary gas in this connection. The "kinetic temperature" of this gas is assumed to be 10,000° K., the calculation ends up with two particles per cubic centimeter at 10,657 km—6,622 miles—from the surface.

The Model G-II is based on the idea of a height h* above which there are so few molecules that a particle, starting from that height h*

with escape velocity, would actually escape because it would not suffer a collision—on the average. This height h* can be calculated to be somewhere between five hundred seventeen and seven hundred twenty-two kilometers. Above h*, then, there is a region where each molecule describes a dynamical orbit in a gravitational field, the area of "molecular satellites" which Dr. Lyman Spitzer has termed the "exosphere". Working on this basis Grimminger found ten particles per cubic centimeter in 1,931 km—1,200 miles—altitude and *less than one particle per cubic centimeter* in 2,253 km —1,400 miles. Model G-III attempts to combine the assumptions of Model G-II with the effects of diffusion equilibrium. In that model there are still twenty particles per cubic centimeter at forty thousand kilometers.

These three models are indubitably only the first groping attempts and will certainly be superseded by others. Grimminger himself quotes in his report a letter written to him by Dr. Lyman Spitzer, saying: "It is difficult to reconcile the high temperatures found for the upper atmosphere of the earth with what is known about the atmosphere of Mars . . . one would suppose that the temperature of the upper atmosphere of Mars would be about the same as for the earth. At such a high temperature the carbon and oxygen atoms would have left Mars long ago, in contradiction to the observed presence of these elements. The answer to this dilemma is certainly not clear, since the various lines of evidence pointing to a high temperature for the upper atmosphere of the earth seem rather strong. However, one cannot wholly exclude the possibility that the temperature of the earth's upper atmosphere may be considerably less than that which we have been led to assume."

And there you are.

It won't even help us to send a rocket halfway to the moon to photograph the earth. The result would only be what al-Biruni calculated eight hundred years ago, the pictures would show the ninety kilometers or so which have optical properties. In all probability the "exosphere" will remain a theoretical battleground for decades to come.

Not that it matters very much, for practical purposes there is nothing in the way above one hundred eighty kilometers.

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THE END

IN TIMES TO COME

Next month's issue will, I believe, cause one full-scale explosion across the country. We are carrying a sixteen thousand word article entitled "Dianetics . . . An Introduction to a New Science," by L. Ron Hubbard. It will, I believe, be the first publication of the material. It is, I assure you in full and absolute sincerity, one of the most important articles ever published. In this article, reporting on Hubbard's own research into the engineering question of how the human mind operates, immensely important basic discoveries are related. Among them:

A technique of psychotherapy has been developed which will cure *any* insanity not due to organic destruction of the brain.

A technique that gives any man a perfect, indelible, total memory, and perfect, errorless ability to compute his problems.

A basic answer, and a technique for curing—not alleviating—ulcers, arthritis, asthma, and many other nongerm diseases.

A totally new conception of the truly incredible ability and power of the human mind.

Evidence that insanity is contagious, and *is not hereditary.*

This is no wild theory. It is not mysticism. It is a coldly precise engineering description of how the human mind operates, and how to go about restoring correct operation tested and used on some two hundred fifty cases. And it makes only one overall claim: the methods logically developed from that description *work.* The memory stimulation technique is so powerful that, within thirty minutes of entering therapy, most people will recall in full detail their own birth. I have observed it in action, and used the techniques myself.

I leave it to your judgment: Will such an article be of interest to you? It is not only a fact article of the highest importance; it is the story of the ultimate adventure—an exploration in the strangest of all *terra incognita;* the human mind. No stranger adventure appeared in the Arabian Nights than Hubbard's experience, using his new techniques, in plowing through the strange jungle of distorted thoughts within a human mind. To find, beyond that zone of madness, a computing mechanism of ultimate and incredible efficiency and perfection! To find that a fully sane, enormously able and altruistic personality is trapped deep in every human mind—however insane or criminal it may appear on the outside!

THE EDITOR.

U-TURN

BY DUNCAN H. MUNRO

***There** are lots of reasons for deciding on suicide. None of them are exactly sane. Except this one, which isn't really!*

Illustrated by Orban

He came slow-footed off the rocket ramp with one thought recurrent in his mind, *We are scientific and completely civilized—therefore I am going to die.*

Nearby officials gave him no more than the usual cursory glances as he wandered across the landing area toward the exit gates. Outside, he stood on the rim of the city street, surveyed it with eyes half-blinded by thought.

We are scientific and completely civilized—therefore I am going to die. His teeth chewed around lightly with the tip of his tongue. *It will be easy. They will make it easy for me. Afterward, I shall neither know nor care. I have been nonexistent before—I was dead before I was born.*

His gaze shifted to the overcast sky, the dull gray Earth-sky so different from that of Mars. Rain was dropping in a steady torrent, but none touched him, not a drop. The great plastic roof caught it and bore it all away. The street remained warm, dry, dustless, dirtless, germless. A street of the sanitary age, a street designed for cleanliness, comfort and total independence of the elements.

An electro-taxi hummed smoothly along the road, the silver balls of its antenna spinning almost to invisibility as they sucked at power sources broadcast from faraway. He signaled it, his hand moving as though stubborn determination had overcome its own inherent unwillingness. The cab sighed as it stopped. Its driver regarded him impassively.

"Where to, mister?"

Climbing in, he said: "Life Terminal Building."

Lips parted in readiness to repeat the instructions, the cabbie changed

his mind, firmed his mouth, said nothing. Switching power, he started off, covering ground at little better than a crawl while he brooded over the wheel. His passenger endured the snail's pace without reproof and exhibited the fatalistic patience of one whose mind is made up and has never been known to unmake it. Several sleek electro-sporters flashed past at speed that made air blasts rock the creeping vehicle but failed to shake the driver from his mood.

Reaching the great marble entrance of Life Terminal, the passenger watched his machine depart at swifter pace. He had another look at the sky, the street, the even, architectural line of high roofs between the two. Then he mounted the forty steps leading toward the crystal doors, starting off with a reluctant right foot, followed by a reluctant left, gradually overcoming the pedal inertia and increasing his speed until he arrived at the top practically at a run.

Behind the crystal lay a circular floor flowered in mosaics from the center of which arose a gigantic hand of sparkling granite, five or six times the height of a man, with one mighty finger raised in warning. Imprisoned within the hand was a vibratory command which came to his aural-esp like an urgent cry.

"Stop! Think! What have you left unfinished?"

He walked steadily around the hand toward the far counter, his rubberoid feet-pads moving silently. Behind the counter a sweet-faced girl in white uniform came erect as he neared. Her full lips parted.

"Can I help you, sir?"

He gave her a wry smile. "I am afraid you can."

"Oh." Her blue eyes registered sudden understanding. "You are not here to make inquiry? You wish to . . . to—"

"Yes," he said. It echoed hollowly around the hall, made a solemn sound in the overhead cupola. "Yes."

The granite hand vibrated. "Stop! Think! What have you left unfinished?"

"Third door on the right," she whispered.

"Thank you."

She watched him all the way to the door, watched him as he shoved it open and passed through. Even after he had gone she continued to survey the door as if she wanted no part of it whatsoever.

The man occupying the room behind the third door bore no resemblance to an executioner. He was plump, jovial, quick to rise at his visitor's entrance, swift to shake his hand and give him a seat. Resuming his own chair, he slid a bunch of forms into convenient position on his desk, held his pen poised in readiness, eyed the other inquiringly.

"Your name?"

"Douglas Mason."

He wrote it down, said: "Age?"

"Two hundred eighty-seven."

"Ah, then you have had a third rejuvenation?"

"Yes." Mason fidgeted. "Do we have to fill up forms even for this?"

"Not at all." The official studied him carefully, found him tall, slender, gray-suited, tired-eyed. "A civilized state makes no claim upon the life of any individual citizen. Anyone has the unalienable right to end his life, for any reason he considers adequate or for no reason at all, even at the merest whim, provided that the method of accomplishing the said ending does not cause discomfort or distress to fellow citizens."

"I know my rights," assured Mason.

"Therefore," the official went on, as if reciting an oft-repeated rite, "we must recognize your choice regardless of whether or not you see fit to co-operate in this matter of form-filling. If you do not care to answer our questions it will make not the slightest difference—but the data we need is very useful and we would greatly appreciate your help."

"Help?" repeated Mason, rubbing his chin. He gave the same wry smile he had bestowed upon the girl outside. "I was under the impression that I could no longer be of help to anybody."

"Many have that idea. Usually they're wrong. In fact," continued the plump man, waxing still more jovial, "I have officiated here for twenty years and have yet to meet the individual who is completely useless."

Mason said: "I suspect you of wanting to talk me out of this." He leaned forward, his tone hard. "My mind is made up!"

"Would you care to tell me on what ground?"

"There is no reason why I should. If a person decides to die he has reasons which seem good and sufficient to himself." Mason thought a moment, added, "I have several reasons, and the best of them is that I do not fear death."

"Nor life?" put in the official. His fat face suddenly seemed not so fat. It had taken on a sudden shrewdness.

"Nor life," confirmed Mason without hesitation. He carried on, "When all one's purposes have been achieved, all one's ambitions realized, all one's friends long departed, and one has to retire for sheer lack of anything further to do, life ceases to be life. It becomes mere existence, a waiting-time. I can stand only so much of that."

The official shrugged resigned shoulders. "It is not for me to argue your motives much as I would like to." He indicated the forms. "May I fill these up, or do you refuse to oblige?"

"Oh, go ahead," said Mason.

The other prepared his pen. "Married?"

"Never had the time."

"Really?" He put it down with a faint touch of incredulity. "No children then?"

"What do you mean by that?"

"You have never functioned as a donor?"

Mason snapped: "I disapprove of such practices even if they are embodied in our civilization."

"They are necessary because they are helpful to someone," the other retorted. "The driving force behind our present-day science is the need to help people. Would you rather have it as it was in barbaric ages when science was misapplied?"

"I'm not so sure I wouldn't. Things were messier but a darned sight livelier."

"You prefer them lively?"

"At this stage, yes!" Mason continued in the manner of one pondering aloud rather than talking. "I have an alabaster villa with a forty-acre cactus garden on Mars. It represents the *ne plus ultra* of something or other. In many ways it is also a mausoleum. Within it I can suffer the nagging pain of acute boredom in total comfort. What little work has still to be done is reserved for the young ones, the first and second rejuvenations. Earth is civilized. Venus is civilized. So is Mars. So is the Moon underneath its few scattered domes. Everywhere is civilized, orderly, regulated, under control."

"Everywhere?" echoed the official, raising his eyebrows.

"Even the jungles are artificial ones designed for the edification of the curious and the coddled," Mason went on, a hint of contempt in his tones. "Full of cultivated plants and cunningly doctored animals. The

lion at last lies down with the lamb. Pah!" He eyed the other. "For centuries the Chinese used an ancient curse: 'May you live in interesting times!' It isn't a curse any more. It's a blessing. We're scientific and civilized. We've got so many rights and liberties and freedoms that one can yearn for chains for the sheer pleasure of busting them and shaking them off. Reckon life would be more livable if there were any chains left to bust."

"I doubt that," asserted the official. "People are very happy until eventually the frustration of idleness overcomes them. It's a long, long time before that occurs." He pointed his pen. "On your own showing it has taken most of three centuries for you to reach this stage."

"Yes," admitted Mason, "because I had a good spell of plenty to do. Now, I've got nothing. Fairly soon I'll be due for a fourth rejuvenation. What's the use of it? A man can hang around too long." He leaned forward, hands on knees, face taut. "Know what I think? I think science has overdone it."

"Not necessarily."

"It has," Mason insisted. "I'm telling you that science has us all trapped between its accomplishments and failures. It has got us to Venus and Mars. It can get us no farther. The outer planets are completely beyond reach of any human being in any human-built spaceship. No rocket-fuel concoctable can do it. That's been admitted time and time again. Science has taken us right up to the last frontier—and I've got a press-button, fully automatic alabaster villa right on it! Science can go no farther—so it has turned inward and civilized what it's got. Result is we're pinched in, confined in absolute freedom, and made so all-fired happy that we could burst into tears."

The official pulled a face expressive of unvoiced but polite disagreement, remarked pointedly, "Isn't it somewhat incongruous that one so condemnatory of science should seek its aid in escaping it?"

"I conform to the conventions in finding my way out," retorted Mason. "Besides, I readily admit that science has its uses—only I think it has gone too far."

"You may have something there," said the other, enigmatically. "I often wonder where it will stop."

"It has stopped to all intents and purposes. Anything which turns inward, upon itself, has stopped."

"That is an opinion to which you, as a citizen, are fully entitled." The official's manner made his own opinion clear. Shuffling his forms, he selected one. "However, since you have made the finality of your decision most obvious, I have no choice but to sign your warrant."

"Ye gods, so I must have a warrant!" Mason bent forward, took it after it had been signed, waved it around like a white flag. "What do I do with this?"

Nodding toward another door, the official said: "Take it through there

and give it to the attendant arranger. He will consult you about the manner of your passing."

"You put it so prettily," commented Mason. He waved the flag again. "Well, thanks for everything. See you in the next world."

"The meeting will take place only when my constitution can stand no further rejuvenations," promised the other.

The arranger proved to be tall, thin, bald and taciturn. He took the warrant, scanned it carefully.

"Do you prefer it swiftly or slowly?"

"What a question. Who on earth wants to die slowly?"

In funereal tones, the arranger said: "I am not talking about the act of dying, but the condition of death. Do you prefer it soon or after a certain interval?"

"Better make it soon." Mason paused, then added with grim humor, "Otherwise I might weaken and change my mind."

"That has happened."

"So?"

"Often," confirmed the arranger.

"It's a new one on me," Mason confessed. "I've never heard of anyone getting this far and living to tell the tale."

"Nobody tells the tale. Secrecy is the price of freedom."

"In that case I can change my mind at any time up to the final moment and walk straight out providing I swear to say nothing?"

"Yes." The other looked him over. "But somehow I don't think you will. Unless you do your thinking fast you'll be one of the many who have put off mind-changing until it is too late."

"I get you," said Mason. "But I've already weakened six times in the past two years. I don't soften a seventh." He examined the room. Except for a desk and a calendar, it was bare. "Mind telling me how it will hit me?"

"Unawares."

"I know that much, but how?"

The arranger said: "The method is adapted to the individual case."

"I'm only curious."

"You won't be—afterward," promised the other. He went on, "The procedure is that you go through that door, take the automatic elevator up to the Life Terminal hotel and select any room you please. They are all most comfortable and—"

"Take the elevator to *where?*" said Mason loudly.

"The hotel," repeated the arranger imperturbably. "You will reside there, comfortable, entertained, happy in the company of others, until the culmination which will occur only when you are thoroughly at ease and completely off guard. That may mean hours, days or weeks before the end, according to the psychology of the subject, but as a method it is merciful."

"So I just sit around and wait for it?"

"There are adequate diversions. Nobody broods. Indeed, there is no

cause to brood, since a subject either weakens and goes or stubbornly sees it through."

"You can tell me no more than that?"

"At this stage," said the arranger pointedly, "I cannot imagine you caring very much."

"Which I don't," assured Mason. "Not a hoot. Do I get on with the job or are there further indispensable bureaucratic preliminaries?"

The other winced. "There are two forms I should fill. If you're in such a hurry I'll let them go blank." He pointed to the nearer of two doors. "You can take your choice. That is the way out." He indicated the other one. "That also is the way out."

Mason went boldly to the first, opened it, looked through. Beyond lay the mosaic hall with its granite hand.

"Stop! Think! What have you left unfinished?"

He tried the other door. Behind stood the elevator, bare, metal-lined, with a red stud in one wall.

Stepping inside, he peered out, said with a touch of ghastliness, "Going up?" Then he closed the door, jammed his thumb on the red stud and instantly realized that this was it!

The stud sank under his thumb while he watched it fascinatedly and lacked the power to release his pressure. It appeared to go down with an awful slowness born of a time-sense distorted by peril. The approach to death is difficult; the contact tremendously breath-taking. His pores were wide open, his body tense, his mind whirling when the stud closed a circuit and the mock-elevator performed its designed function.

There was only a pale-blue luminescence in the air and a split second of immense agony during which his body seemed to be torn into a million pieces and further dispersed to its last molecule.

Voices murmured deep in a colorless haze, slow-mouthing voices that advanced upon him, then receded, then came back. They sounded close to his ears, and whispered away through illimitable distances and again returned. There was a peculiar rhythm to this vocal coming and going like the steady swing of a wave through positive and negative amplitudes enormously stretched in time. It was quite a while before he could distinguish words.

"Three in succession. That plays hob with the odds."

"Dunno so much. The odds take account of inevitable runs. You're taking too short a view."

"Or maybe they're getting better?"

"I'd like to think so, but I just can't see it."

Mason sat up, held his head. The voices ran away, ran back. "Give him a shot . . . yep, just there." Someone stuck a pin in him. He opened his eyes, snapped at a gray-bearded man, "Go easy, will you? I've got a fat nut."

"You're lucky," remarked a sec-

ond, heavily built man standing close by his side. "Some have only half a nut, others none at all."

"And some never use more than half anyway," said Mason. He ceased nursing his head, put his hands on the floor and helped himself upright. The room whirled momentarily, then steadied.

The graybeard eyed him speculatively, hitched a blue, long-snouted gun more comfortably over one hip, went behind a desk. Sitting down, he pawed a printed form into position, licked the end of a primitive pencil, looked at Mason again.

"Name?"

Mason teetered, felt the bulky man's hand steadying him, protested hoarsely, "Holy smoke, do we have to go through all that again?"

"What I want," informed the graybeard, "are three things: your name, your remaining rejuvenation-run and your qualifications."

"Douglas Mason, twenty-four, suicide," he gave succinctly.

The bulky man chipped in with, "Hah-hah!" When Mason turned to look at him, he added, "You've been foxed."

"Shut up, Corlett." The graybeard registered mild annoyance. "I've told you repeatedly that arrivals must be cushioned against mental shock." He showed white teeth, and his beard waggled as he concluded, "You're no cushion."

"And I'm no hothouse flower," said Mason. "Neither of you need be afraid of me wilting."

Corlett said: "Hah!" again and added, "Listen to that, Dexter. He doesn't want any cushions."

The graybeard named Dexter leaned over his desk, spoke sharply to Mason.

"Just what do you mean?"

"It's like this," explained Mason. "I'd got nothing left to do but sit around and think. For a while I thought of all sorts of things, most of them futile, all innocuous. I was a useless cog in a big machine. I was waiting to be discarded."

"I know," assured Dexter. "I'm no babe myself."

"Then one day a lecturer on the video set me off on a new tack. He'd been praising our civilization, its scientific exactitude, its perfection. It worked so wonderfully, he said, because every man had his place and every place its man. All the cogs interlocked, the big and the small, mutually necessary. It was a morale-lifter, the old it-all-depends-on-you technique."

"Well?" prompted Dexter.

"Then he blundered. He opined that our inability to reach the outer planets was really a blessing in disguise. Our setup was so complicated and highly organized that a sudden rush of cogs elsewhere would make it fall apart. There would be chaos. The machine of super-civilization couldn't run if losing its parts faster than they could be replaced."

"That makes sense," contributed Corlett. "But what of it?"

Mason said: "I stewed it over in my alabaster villa on Mars." He

turned his head, looked at Corlett. "Do you know that there is no alabaster on Mars?"

"No."

"Well, there isn't. It set me back a million credits to drag the lot from Earth more than a century ago. It was shot across space by vibro-transference in loads of two thousand pounds which, at that time, represented the limit per boost over that distance. They had to send four times as much as was needed because three-quarters of it reintegrated wrongly at the focal point and ceased to be alabaster. That's the trouble with vibro-transference. As a process it's ultra-swift but darned temperamental."

"Go on," urged Dexter, watching him.

"Humans make the Earth-Mars runs by rocket. It's slow but certain. They get across alive, in one piece, and still in human shape." He paused, rubbed his head which still contained a faint and peculiar fizzing. "Just for the ducks of it I spent four years working out the odds on a human being getting himself dumped alive and kicking on an outer planet, by vibro-transference. I made the load limit per boost something over two hundred pounds."

"Two eighty-four," corrected Dexter.

"And I made the odds appallingly low. No more than three chances in a thousand."

"Seven," said Dexter.

"As good as that? They must have improved."

"They have. There is always improvement."

"Anyway," Mason went on, "the odds against stood so murderously high that obviously it was a job to be reserved exclusively for lunatics or would-be suicides. In other words, *for the few cogs who become superfluous on their own showing.*"

"Of which you were one?" queried Dexter. He stroked his beard, cast a thoughtful look at Corlett, returned his gaze to Mason.

Mason nodded agreement. "You'd get a scramble for new frontiers—if everyone knew they were available, within reach. There is no similar enthusiasm for the death house. The self-confessed superfluous can be handled where the downright adventurous cannot; their numbers are less and they don't matter much."

"So you put two and two together?"

"And made it four. I thought of the basic rights of individuals craftily established by law, of occasional puffs of publicity for Life Terminal's facilities, and of the fact that as far as further rocket efforts are concerned the experts don't seem to be really trying -yet scientists are notorious fidgets even in their sleep. Why shouldn't they keep trying? Answer: because they've got there!"

Dexter emitted a brief chuckle, said: "There's one flaw in your complaint about scientific secrecy. If you can think this out all on your ownsome, why shouldn't a million

others do likewise—and start the dreaded rush?"

"Because the conclusion remains a suspicion until one can get proof." Mason's expression became slightly lugubrious. "There's where the powers-that-be do have me foxed. I put over my best act from the moment I stepped on Earth, I bet on those seven chances in a thousand and I got through pure, white and uncontaminated. I was born lucky. I got the evidence."

"And now you're stuck with it," Corlett interjected again. "There are eight hundred of us here. At the rate the newcomers reintegrate recognizably, it will be a long, long time before we're eighty thousand, much less eight million. So we haven't got much: no airplanes, no rockets, no video, no rejuvenation plant, no dream-gardens, no alabaster villas, no vibro-boosters. You can't go back. You can't return from the dead waving your evidence triumphantly."

"I know it." Mason pursed his lips good-humoredly, let his eyes linger on the blue sheen of Dexter's gun. "The big-brains have made a tricky setup, a very neat play. This is life after death—and nobody can return to say that it isn't. The play can't be broken until we've grown big enough and powerful enough to build a civilization of our own."

"You said it!" agreed Corlett emphatically.

"But it worries me none," Mason went on. "I wanted proof for my own satisfaction alone. I've turned right around and gone back to where I started—at the bottom, with a spade in my hands."

"You'll need more than that," promised Dexter. He patted the weapon at which Mason was still looking. "This place isn't so amiable as it might be."

"So much the better. Chains were made to be busted. There will be no more rejuvenations, and I haven't got long. Give me a gun and a spade and let me get started."

They found both for him, took him outside. He leaned on the spade, smelled the heavy air, looked at the small group of crude stone houses standing nearby. His gaze swung from there, studied the great red spot on the monstrous thing poised brilliantly overhead. His feet shuffled around in queer purple grass.

He said: "As one Callistrian to a couple of others, that's a mighty fine sight!"

THE END

* * * * * *

BOOK REVIEW

"The World Below," by S. Fowler Wright. With an introduction by Everett F. Bleiler. Chicago: Shasta Publishers, 1949, viii + 344 pp., $3.50.

This novel, which originally appeared about 1930, is one of the most remarkable science-fiction stories ever written. In fact it is one of the few stories to which all the adjectives used by science-fiction magazines in their titles could well be applied. It is so unusual in its concepts that if you asked me offhand what it was about, I should have to say: "I can't tell you, exactly; read it yourself."

However, to grapple with the subject as best we can, it is a time-travel story in which the narrator is sent ahead by time-machine into the future, half a million years from now, to look for a couple of other temporal explorers who have gone ahead but failed to return.

He arrives in the future in pitch darkness. When daylight appears he finds himself on a road running along the base of a high cliff, the cliff so regular and perpendicular that it looks artificial. On the other side of the road there stretches away, as far as he can see, a plain covered with cabbagelike plants eight feet high. After walking a long way along the road he finds a portal in the cliff, but big enough for the entrance to an airship hangar. No life does he see aside from the "cabbages".

Finally, while resting in the entrance to the portal, he sees a furry manlike creature running along the road toward him. When the creature sees him it leaps off the road in surprise, whereupon with a horrid scream one of the plants shoots out tentacles and seizes it . . .

And the narrator is off on his adventures in the strangest future-world yet. He learns that the furry creature, a slim seallike, monkey-like, and froglike organism, is one of the race for which he has no name but Amphibians, a sexless aquatic species, one of whom accompanies him during most of his months of wandering. They are ethereal, sensitive creatures with a

high standard of morality and a horror of unnecessary killing; they do not even eat as ordinary organisms do. They communicate with each other and with the narrator telepathically, at such terrific speed that they can get off a speech of several pages in a few seconds.

Presently the narrator finds himself going with an Amphibian to try to rescue one of their leaders from the Killers, a race of little dwarfish caricatures of humanity, whose actions are controlled in turn by a group of intelligent but malevolent yellow lizards. The Amphibians, while they accept the help of the narrator, regard themselves as so far above him morally and intellectually that to them he is merely a new kind of animal, and a rather revolting one at that.

But dominating all these and many other strange life-forms are those whose name the narrator can only translate as "Dwellers", who live underground in tunnels beneath this continent. They have the form of great hairless yellow-skinned men, so large that the narrator is to them as a rat or squirrel would be to us. Their intellectual stature is as advanced as their physical, and the narrator soon learns that if they catch him they will have no compunction about killing or vivisecting him if it seems expedient, as with any other specimen. Despite their power, however, the Dwellers have their own troubles; they are dying out, and are at war with a race of giant insects from another continent.

For atmosphere the book is absolutely unsurpassed, and for exciting action it rates high. However, a good deal of the wordage is devoted to long philosophical arguments—which sometimes take place, most inopportunely, in the midst of hot action—between the hero and his Amphibian companion. And here the book's chief weakness appears, for while many of the ideas are interesting, the hero—a bit of a twerp—makes a very poor case for his own time and culture. The author seems to have been suffering from *Weltschmerz,* 1920-30 or Lost Generation variety.

The same flaw appears in many Utopian novels such as C. S. Lewis' "Out of the Silent Planet" —which "The World Below" resembles in so many respects as to make one suspect unconscious plagiarism on somebody's part—H. G. Wells' "Men Like Gods," and Dennis Wheatley's "They Found Atlantis." In each case the author, in his anxiety to make a case against modern life, sets up a straw-man—a portrayal of Western Civilization with its faults exaggerated and its positive accomplishments ignored. Against this he opposes an ideal society wherein all these faults have been arbitrarily abolished by the author's fiat. The result is a setup in which poor Western Civilization has no chance, and no more interesting than most setups.

Actually there is no evidence that

there has ever been an ideal society of the sort described in these books. All the other twenty civilizations on record have shared some of the faults of the present one and have suffered from others of their own. And whether human beings *could* construct such an ideal society, or whether—as assumed here—another species could do better, are unanswerable questions.

The hero, as I say, is something of a twerp. He engages in long and rather juvenile arguments on the morality of wearing or not wearing clothes—a question that seemed of more moral significance when the book was written than it does now. And he condemns to death a group of bat-men from the hollow interior of the earth—cf. the *Pellucidar* stories and "The Eye of Balamok"—because he does not like their moral standards, though he is not so pleased to be held in contempt by other species who don't like his either. However, if you or I were suddenly thrust into an environment as strange as this one, we should no doubt prove inadequate in some respects also.

Despite its minor faults, the book is still one of the most original and absorbing tales in the whole field. You won't be able to put it down until it's finished, and when you do you will feel exhausted as by a strenuous and perilous experience. Which should be sufficient recommendation by any science-fiction book-buyer.

L. Sprague de Camp

AND A CATALOG REVIEW—

The Tracerlab company, of Boston, Massachusetts, specializes in atomic equipment, both apparatus for work in the field, and radioactive supplies for research. Where the Atomic Energy Commission supplies raw materials, Tracerlab, and other similar companies, offer a sort of retail service—they sell the radioactive atoms made up into desired compounds. Immensely important to research, the prices on these items make them—regarded just as chemicals—slightly costly. For instance, the September, 1949 catalogue of Tracerlab lists the following:

RC-1	Barium Carbide (60%)	$150/mc
RC-2	Acetylene	350/mc
RC-3	Sodium Cyanide	250/mc
RC-4	Methanol	250/mc
RC-5	Methyl Iodide	285/mc
RC-6	Sodium Acetate (carboxyl labeled)	225/mc
RC-7	Ethyl Acetate (carboxyl labeled)	275/mc
RC-8	Ethanol (methylene labeled)	300/mc
RC-9	Ethyl Iodide (methylene labeled)	350/mc
RC-10	Toluene (ring labeled)	500/mc
RC-11	Benzoic Acid (ring labeled)	550/mc
RC-12	Benzene	600/mc
RC-13	Sodium Acetate (methyl labeled)	350/mc
RC-14	Ethyl Acetate (methyl labeled)	375/mc
RC-15	Ethyl Alcohol (methyl labeled)	425/mc
RC-16	Ethyl Iodide or Bromide (methyl labeled	$475/mc
RC-17	Glycine (carboxyl labeled)	450/mc
RC-18	Alanine (carboxyl labeled	450/mc
RC-19	Hexaethyltetraphosphate (methylene labeled)	450/*
RC-20	Triethylphosphate (methylene labeled)	400/*
RC-21	Benoic acid (Carboxyl labeled)	225.00
RC-22	Glycine (Methylene labeled)	600.00
RC-23	Bromoacetate (Carboxyl labeled)	325.00
RC-24	2, 4-D (Carboxyl labeled)	650 00

*Prepared from 1 millicurie of C-14 labeled ethyl iodide.

Incidentally, that ethanol there, while usually called "drinkin' alcohol", would not merely make a standard-strength highball price-tag look like a corporation's annual budget—it'd be slightly lethal. It would probably kill the pallbearers too!

PIEZOELECTRICITY

BY E. L. LOCKE

***Take** a crystal of the right kind, squeeze it, and you get electricity. A minute amount, as everybody knows, but enough to make a microphone, or a phonograph pickup work. But now —they've got a power generator that could turn out two thousand volts at seventy-five amperes from squeezing crystals!*

In 1880, the brothers Curie discovered a brand new physical effect —that electricity could be squeezed out of at least one solid body. Their experiment was a simple one. They took a thin slab of crystalline quartz faced with metal electrodes which were connected to an electrometer. Then they put a heavy weight on the crystal and observed that the electrometer was suddenly deflected. When the weight was removed, the deflection was in the other direction. Thus they established that a mechanical force could give rise to a charge of electricity and that the size of the charge generated was proportional to the applied weight. Since the new effect was the generation of electricity by the application of pressure it was named *piezoelectricity*.

The effect was small and no one got unduly excited over the discovery. Fortunately, the smallness of an effect is no surefire guarantee that it is destined to remain unimportant. Witness, for instance, the first electrical generator built by Faraday. Its output was also minute but look at the electrical power industry that grew up around it. In the same way, this trifling piezoelectricity effect has become one of

the cornerstones of modern communications. There is even a speculative chance that sooner or later it may give the conventional generator of electric power a run for its money. But that is getting ahead of our story.

It took quite a long time before the potentialities of the new effect were appreciated. Of course, the physicists did do some work on it as they are apt to do with any new physical effect. In 1881, the French physicist Lipmann predicted that a converse effect should exist and in the same year the brothers Curie verified it experimentally. In the converse effect a voltage is applied to the crystal electrodes. It is then observed that the crystal changes its dimensions very slightly. If the polarity is of one sign, the crystal expands. If the polarity is reversed, the crystal contracts. The change in the dimensions is, for a given crystal, proportional to the applied voltage.

These are curious effects, one must admit. How can this business of squeezing electricity out of a solid be accounted for? It took a Lord Kelvin to come up with an explanation that held water. His argument ran along the following lines. Quartz is merely a crystalline version of silicon dioxide—common sand—having the chemical formula SiO_2. The chemical bond that holds this molecule together is the attraction between the four units of positive charge on the silicon atom and the two units of negative charge on each of the two oxygen atoms. The atoms in a single molecule of sand are so placed that the molecule, as a whole, is electrically neutral.

Let us now carry these ideas over to the quartz crystal. Imagine an array of regular hexagons nested together as in old-fashioned bathroom

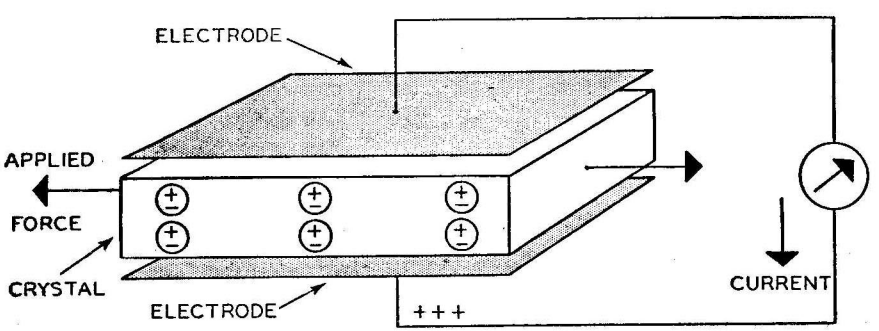


Fig. 1: Conversion of mechanical energy into electrical energy by a crystal.
Free negative charges in the wire flow toward the positive charge separation in the crystal. The free positive charges in the wire flow in the opposite direction. Together they constitute a flow of electric current.

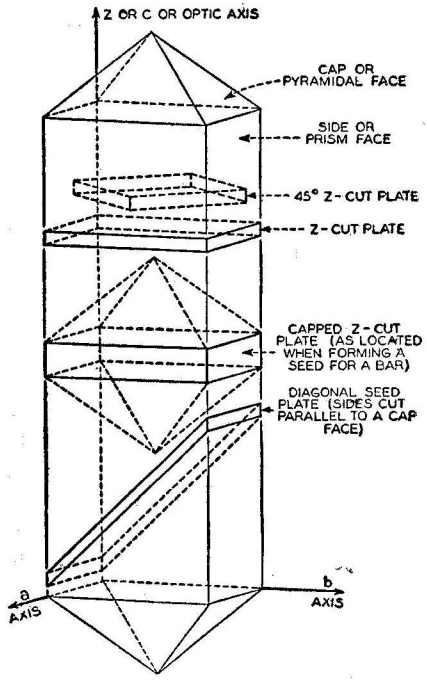


Fig. 2: There are many ways of cutting piezoelectrically active crystal slabs from the natural crystal.

tile floors. Take a vertex on a hexagon and put a silicon atom on it. On the next vertex place two oxygen atoms. Repeat the process until all vertexes of all the hexagons carry atoms, alternately silicon and—double—oxygen. Now we have a picture of the quartz crystal lattice in a plane perpendicular to the so-called optic axis. It is not too hard to see that the alternate positive and negative charges placed on the vertexes of the hexagons leaves the crystal electrically neutral. This must be so because the center of gravity of the positive charges coincides exactly with that of the negative charges.

What happens if we try to compress the crystal or stretch it? The answer is that the perfect hexagons become slightly deformed and are no longer regular. The consequence of this is that within each hexagon the center of gravity of the positive charges no longer falls exactly on the center of gravity of the negative charges. Hence the crystal as a whole is no longer electrically neutral. How this can result in the flow of an electric current can be seen from Figure 1. This shows a thin slab of quartz in tension, with the electrodes connected together. Assume that the direction of charge separation is that shown by the plus and minus signs within the circles. Then the free negative charges in the wire will be drawn toward the electrode next to the positive charge. Similarly the free positive charges in the wire will flow toward the electrode next to the negative sign. The charges flow until the whole system is again electrically neutral. It is this flow of charge that constitutes the observed current. When the tension is released the current flow is in the opposite direction. Hence, if an alternating force is applied to the crystal, the current will surge back and forth cyclically. If a suitable load is inserted into the circuit, the mechanical work done on the crystal will appear as electrical energy. This is the basis of the electrical generator to be described later in this article.

It must not be thought that all crystals are piezoelectric. The question as to what types of crystals can be electrically active has received a great deal of consideration. It turns out that of the thirty-two classes of crystals that can exist, twenty can be piezoelectric. However, crystals that have a center of symmetry can not possibly be active. Since ninety percent of all crystals in nature have such symmetry, the number of natural crystals that are actually active is rather small. A survey made some years ago showed that out of eight hundred thirty minerals listed, only seventeen were so by actual test. And all except quartz had some hooker attached which left it unsuitable for large scale commercial use.

Crystals, particularly those not having a center of symmetry are complicated structures. It is, therefore, not surprising that the physical properties of a given crystal may vary a great deal with the direction that the measurement is made relative to the crystal axes. For practical applications, a relatively thin slab is cut from the crystal. The orientation of the cut then determines the values of the physical constants of that particular slab. Thus, the dielectric constant, the elastic constants and the piezoelectric effect can be chosen, within practical limits, so that a given slab will do the best job in any particular application. A particularly valuable property of certain cuts is that the crystal performance is substantially independent of temperature. This is just exactly what is needed for control of broadcast transmitters.

From the standpoint of practical applications, the subject of piezoelectricity lay dormant until World War I when the French Government requested Professor Langevin to devise a method for detecting submarines. It occurred to Langevin that the piezoelectric effect and its converse could be used for this purpose. He constructed a mosaic of thin, crystalline quartz which was to be submerged in the water, suitably cased, of course. By applying a spurt of alternating voltage to the crystals, he set the crystals into a corresponding mechanical vibration. This motion in turn was impressed on the

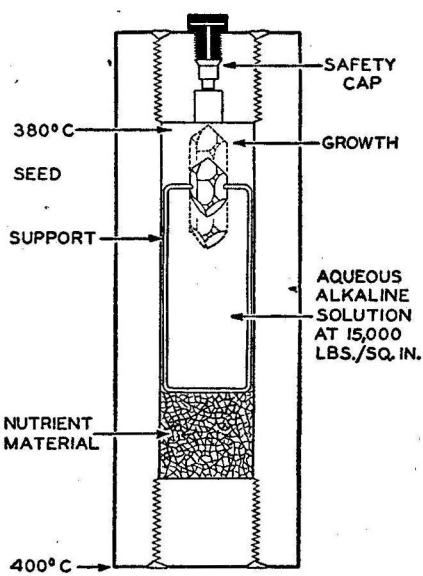


Fig. 3: Section through bomb used to grow quartz crystals.

water and resulted in a beam of underwater high frequency sound of corresponding duration. When this struck an obstacle, such as a submarine, some of the sound was reflected back and picked up by the quartz mosaic. In turn, this set up a voltage which could be detected. By measuring the time interval between the generation of the sound and the return of the echo, the distance to the submarine could be determined. The whole apparatus could be described as being an acoustic precursor of the modern radar. While this apparatus was not perfected in time for use in World War I, it did receive extensive use in the last war.

The ice having been broken by Langevin's idea, the practical applications of piezoelectricity increased apace. Nicholson of the Bell Telephone Laboratories grew crystals of Rochelle salts, a material having much greater electrical activity than quartz. He constructed and demonstrated loud-speakers, microphones and phonograph pickups using this effect. He was also the first man to use a piezoelectric crystal to control the frequency of an oscillator.

This last item is so important an achievement that it is worth looking at in a little more detail. Oscillators form the starting point of every communication system. This is true even in speech, the larynx being the oscillator in this case. In all such systems, something has to carry the intelligence to be transmitted. In all except the newest systems, this carrier is a train of alternating waves. It is very important that the frequency of the alternations be kept constant within small limits. Otherwise the receiver may either not respond to the signals or at the least the message may be badly distorted. The frequency of oscillation is controlled by a tuned or resonate circuit of some form. If the frequency is to be constant, it is necessary that the resonant circuit have very small energy losses, that is, be very sharply tuned. It is also required that the properties of this resonant circuit be substantially independent of temperature.

The first of these requirements is not easily met with conventional electrical circuits. Nicholson's work with Rochelle salts pointed the way out of this difficulty. We have already mentioned that when an alternating voltage is applied to the crystal, its dimensions undergo cyclic changes. That is, the crystal vibrates at the same frequency as the applied voltage. If the proportions of the crystal are such that it is mechanically resonant at the desired frequency, the crystal will behave as if it were an electrically resonant circuit. Since the energy losses in a mechanical system are apt to be very much less than in conventional electrical circuits, crystal resonators are much more sharply tuned and hence make better oscillators, potentially.

We must not, however, forget about the second requirement, that of temperature stability. Unfortu-

nately, Rochelle salts crystals are quite sensitive to temperature changes and hence they did not come into large scale use. Nevertheless, Nicholson's work pointed the way to an important new path. All that was needed was for someone to come along with a material that was not so sensitive to temperature changes.

The answer to this one was furnished by Professor W. G. Cady of Wesleyan University. His answer was our old friend quartz. It was much more stable than Rochelle salts. Furthermore he established that with proper design, the energy losses in this material could be reduced to fantastically low values. For well prepared specimens carefully mounted in an evacuated container the energy loss per cycle of oscillation could be as low as one part in a hundred thousand. In circuit parlance this is a Q of about five hundred thousand! Put it another way, the resonance curve of such a crystal suitable at the lower edge of the radio broadcast spectrum would be only one cycle wide at the half-energy points. To top off all this, later research showed that it was possible to obtain crystals of quartz with zero temperature coefficient. The trick is to cut the slab out of the raw crystal at a certain definite orientation with respect to the natural axes of the quartz. This insensitivity to temperature variations makes such specially cut crystals practically ideal elements for oscillators and precision clocks.

It was Professor Cady who opened up another important field of application for crystals. He argued that since a crystal in an oscillator acts as a resonant circuit, why not use such resonant elements to make frequency selective circuits. While his

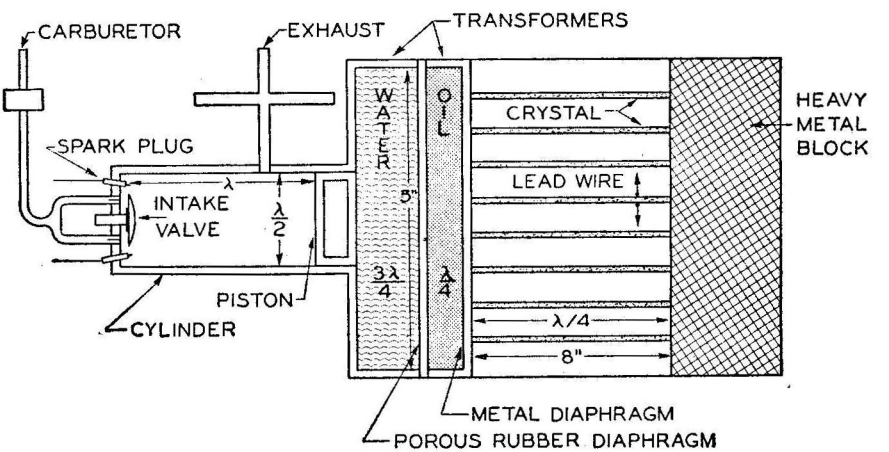


Fig. 7: Design for a piezoelectric power generator.

circuit was very rudimentary, the idea was of basic importance in its field. The idea was soon extended by others. More particularly, W. P. Mason of the Bell Telephone Laboratories showed how combinations of crystals and other electrical elements could be used to produce very superior wave filters. This is a device of considerable importance in long-distance telephony where many messages are to be transmitted over the same coaxial cable. The telephone wave filter is a glorified cousin of the well-known radio tuning mechanism. The manner in which the filter is used is analogous to having several hundred radios, all tuned to different stations. Thus the large number of messages can be put on the same cable and then sorted out at the far end. A similar use of quartz crystals is in military communication sets.

In the last twenty years, piezoelectric crystals have found many uses. One common use is in phonograph pickups. These operate on the converse effect. The motion of the phonograph needle strains the crystal and causes a voltage proportional to the needle motion to appear across the electrodes. Similar in principle are the microphones. An important war time use of crystals was in the so-called Sonar, which is a refinement of Langevin's submarine detector. Other applications are in depth finding and the generation of high intensity sound waves in liquids. One interesting application has been to the homogenization and sterilization of milk. The intense waves that are generated will disperse the butter fat in the milk and at the same time kill the bacteria.

An interesting proposal, one that seemingly involves a paradox, is the so called cordless telephone. The idea here is to get rid of the necessity of holding the telephone receiver to the ear and yet not use a loudspeaker. This can be accomplished by the following dodge. The incoming message is raised in frequency, that is, modulated upward to the point where the ear is incapable of hearing it, by its normal process of hearing. This signal is impressed on a piezoelectric crystal which then transforms the signal into an inaudible acoustic signal. The ear picks this up and hears the message! The paradox is, how can the ear hear an inaudible signal? The answer goes like this. The eardrum is connected to the inner ear through a two-lever mechanical linkage called the "hammer and the anvil". If a very intense sound wave impinges on the eardrum, some slippage takes place in the ball and socket joint between the two levers. Consequently, the motion of the anvil is not a perfect copy of the signal impressed on the eardrum. In fact the motion is rather badly distorted. This means that the inner ear receives many spurious frequencies. In circuit terminology, the linkage becomes a demodulator when it is overloaded. Among the distortion products reaching the inner ear is the origi-

nal message which, of course, is audible.

The manifold uses of piezoelectric crystals, particularly for communication uses, put a bad strain on the only available natural source, namely, Brazilian quartz. Crystals, free from imperfections and large in size were hard to find. In fact, even before the war made such demands on quartz crystals for military radios, the Bell System foresaw that the supply would not be adequate for normal telephone use. It was obvious that something had to be done.

There were two lines of attack open: One was to produce artificial crystals that did not exist in nature and the other was to try growing quartz crystals artificially. Both lines of effort were eventually successful.

The earliest man-made piezoelectric crystal is Rochelle salts. It was not hard to grow and it was highly piezoelectric, much more so than quartz. The main trouble with it was that it would not stand temperature changes. The physical constants changed considerably with a few degrees change in temperature and if the temperature went a little too high, the water of crystallization would be driven out, leaving behind a crumbly mass or mess.

Extensive research turned up a number of much more satisfactory alternatives. The best of these were ammonium di-hydrogen phosphate

and ethylene diamine tartarate. In self-defense against these mouthfuls, the people working with these crystals simply call them ADP and EDT respectively. Both of these materials are electrically more active than quartz, a very valuable feature. Both are adaptable to large-scale production and during the war huge quantities of each were used.

The general principles of crystal growing may be brought out in connection with ADP crystals. One of the men who helped develop the process likes to think of crystal growing as having many points of similarity to farming. Both the crystal grower and the farmer start with seeds which are planted and harvested and both are dependent on the weather. The crystal grower's weather is the constancy with which he can maintain the required temperatures over a period of several months. And just as a farm crop can be ruined by an unseasonable snowstorm, so can a crop of crystals be ruined by its own form of snowstorm, a precipitation of small crystals. To cap the parallelism, the farmer's fertilizer contains nitrogen and phosphate, the same ingredients that the grower of ADP uses.

To grow these crystals, all one has to do in principle is to take any small seed crystal of whatever shape, circulate a supersaturated solution of the nutrient around it and then slowly drop the temperature a fraction of a degree per day. The growing seed removes the salt from the solution but the solution still stays supersaturated because the solubility of the salt decreases with temperature.

As one might suspect, the actual growing is by no means as simple as the above sounds. The temperature control apparatus must be precise and reliable for months on end. Very small amounts of impurities can cause much trouble. The circulation of the nutrient must be just so. And to add to the troubles, the crystal has some rather nasty growth habits. To see just what the troubles are, look at the sketch of an ADP crystal shown in Figure 2. One of these troubles is that the ADP crystal grows only on the pyramid faces if the nutrient is pure. Thus, if the seed crystal dimension along the *a* or the *b* axes is small, the grown bar will be long and slender. Such a bar is valueless since for circuit uses the crystals ought to be at least an inch long along these axes. This difficulty can be fixed but it takes about six months of work. The trick is to take a seed crystal, about one third of an inch in cross-section, and try to make it grow in a solution to which some ammonia has been added. Unfortunately, spurious seeds form very easily in this solution. The cure for this is to harvest and replant the crop very many times during the six-month period. The resulting bars are then free from flaws and have the required cross-sectional area of $1\frac{1}{2} \times 1\frac{1}{2}$ inches. Once you have such a bar, you are out of the woods, so to speak. All that is necessary from now on is to cut slices like the one marked

"Capped Z cut plate" in Figure 2. By orienting this plate properly with respect to the direction of nutrient circulation, the pyramidal caps are grown. The capped crystal is now reoriented in the tank and the growth now takes place on the surfaces of the pyramids, thus lengthening the crystal. Using the techniques described, crystals eighteen inches long and six inches on each side have been grown successfully.

Having these very fine substitutes for quartz, one might have thought that the problem of supply was well in hand. It did not turn out that way. While the ADP and EDT crystals are very good indeed, they lacked some of the desirable properties enjoyed by quartz. Quartz is extremely stable with time and hence there is no aging problem to speak of. Once an element has been adjusted, it stays put. It is also much stronger mechanically than the organic crystals. This means that it is capable of handling much larger electrical loads without breaking than the substitutes. It also means less breakage from handling. This is quite a point in the favor of quartz since it was found that by merely holding a thin EDT crystal in one's hand, enough temperature stresses would be induced to crack the crystal. So the demand for quartz kept going up and up. By 1944 the situation was very tight. Despite the inducement offered by the increase in

price of raw quartz, no new producing areas had been uncovered. Then too, there was the everpresent fear that Brazil would clamp an export embargo on the material to prevent the undue depletion of this valuable resource. So, there was nothing to do but to look into the possibilties of growing quartz crystals artificially.

How would one go about growing quartz? A glance at the physical tables shows that it melts in the neighborhood of 1,470 degrees C. Trying to grow crystals out of a melt at these temperatures is definitely not an attractive proposition. Is the crystal soluble? Yes, in hydrofluoric acid and alkalies, with a consequent chemical change. This prospect does not look inviting either. So what now?

Fortunately, the problem of how Nature managed to grow quartz crystals has been a matter of interest to the geologists for a long time. When our Army occupied Germany, it was found that Professor Richard Nacken had investigated the problem and after twelve years of experimentation with hydrothermal processes had achieved partial success. What Nacken had found was that if he added one half percent of sodium carbonate to water and raised the solution to its critical temperature and pressure, the quartz went into solution. To get these conditions, he took a steel "bomb"—a strong cylindrical container—filled thirty percent full of water and raised the temperature to about 370 degrees C. At this temperature and the corresponding pressure of thirty-two hundred pounds per square inch, the water and steam have equal densities and hence the bomb filled up. In the bottom of the bomb he put a quantity of amorphous silica and near the top he put a small seed crystal. This arrangement was based on the observation that amorphous quartz is ten times as soluble as the crystalline variety. Hence he had a condition where, in the vicinity of the seed, the solution was highly supersaturated with respect to the seed, causing some of the dissolved silica to deposit out on the crystal. This was fine as far as it went but it did not go far enough. For the first six hours there was a growth of 6/1000 of an inch. Thereafter the rate decreased rapidly until at the end of twenty-four hours only 2/1000 of an inch was added and then the process quit entirely. The Germans never did find out why this happened or what could be done about it.

In 1946 the Bell Telephone Laboratories decided to follow up this work. They found the trouble eventually. It turned out that the silica insisted on depositing out on the amorphous quartz in the form of small crystals. Since the solubility of the nutrient was now exactly the same as that of the seed, the process could not possibly go on. It had starved itself to death by shutting off its own food supply.

In trying to make a go of the process the Bell Laboratories made nearly one hundred fifty experi-

ments using amorphous silica as the nutrient. They tried varying the size and shape of the bomb, the solution concentration and composition, adding other agents to the solution, varied the temperature and the pressure, tried agitation and cyclic variations of temperature and a great many other things.

From what was learned of these failures plus a lot of hard thought, the investigators, Buehler and Walker arrived at a very satisfactory solution, one that appears capable of commercial use. They constructed a bomb of the type shown in Figure 3 and filled it eighty percent full of water with five percent sodium carbonate added. The seed crystal was put near the top, the nutrient down at the bottom and the whole arrangement was heated to a temperature of about 400 degrees C. Under this condition the process worked beautifully. And what was the nutrient? Broken, scrap quartz crystals! That was what really made the trick work.

The process of growth appears to go on as follows. When the bottom of the bomb is at four hundred degrees, the top is at a somewhat lower temperature, say three hundred eighty degrees, with the pressure being fifteen thousand pounds per square inch. The temperature differential causes a convection current that circulates rather rapidly from the bottom to the top and back again. At this temperature and pressure,

silica dissolves rather easily. This dissolved silica is carried to the top by the convection currents. The top being cooler, the solution is supersaturated there and the excess silica is deposited on the seed. The depleted solution then falls to the bottom where it is reheated and dissolves more of the nutrient.

The rates of growth are considered excellent. It is found possible to get one tenth inch per day, day after day. A striking sample of growth is shown in Figure 4. But this is not all. In the interest of economy in production, the investigators tried mounting several seeds in the same bomb. Figure 5 shows the results. Despite the fact that the seeds were one below the other and the bottom one was quite close to the bottom of the bomb, the lowest crystal grew only thirty percent less than the top one. So, for all practical purposes, the problem of growing quartz crystals may be considered to have been licked.

The results obtained are of interest to the geologists. Figure 6 shows two crystals that were grown under identical conditions. Identical, except for one little item: The bomb in which the large crystal was grown had a minute leak! For reasons that have not been completely settled, the leak resulted in a much more rapid growth. (The large crystal does not have the perfection of the smaller one, which is unfortunate.) This accidental result suggests that perhaps the geologists were wrong in postulating that natural crystals required thousands of years to grow. It now appears possible that if the dissolved silica escaped through cracks through the earth's surface, the large natural crystals could have been formed in a few days rather than centuries.

The direct generation of electrical power from heat has been the dream of engineers for a long time. It is easy to see why this should be so. The mechanisms used for the generation of electricity from heat have always required an intermediate step, namely, the conversion of the thermal energy into mechanical energy. The real trouble with this step is the cumbersomeness of the machinery required. The mechanical motions are large and there are massive parts moving at high speeds. This is true for an engine or turbine whether gas or steam.

Now it begins to look as if the picture may be changed by the piezoelectric power generator. It still does not satisfy the dream of direct conversion. It does, however, get rid of the large motions and the massive moving parts. The largest motions in the device are of the order of two tenths of an inch. The weight of the moving part associated with the largest motion is of the order of one ounce.

This sounds fine but what are the catches? The biggest one is that there is a definite upper limit to the power that may be obtained from a single unit. This limit appears to lie at about thirty kilowatts. If more

power is needed, several such units must be operated in parallel. Another catch is that the electrical power is delivered at a frequency of say five thousand cycles. It is quite difficult if not impossible to generate the power at the conventional power frequency of sixty cycles. A third catch is that while the idea has received experimental verification, there are a lot of points about the device that will give the design engineers quite a headache to work out. But it should be emphasized that the problems are engineering problems and not problems requiring the discovery of new principles.

What is the structure of the engine and how does it function? Figure 7 shows the rudiments of the device disclosed by its inventor, W. P. Mason of the Bell Laboratories. Some of the refinements introduced by the inventor are omitted in the interest of showing the basic principles more clearly. The device really consists of three basic units, namely, the vibration engine, the "transformer" and the generator proper.

The vibration engine consists of a metal cylinder having an intake valve and spark plugs at one end and a very light piston at the other end. When the valve is opened, a charge of explosive mixture is drawn from the carburetor. Ignition of the charge creates a high pressure region at the intake end. This pressure then propagates as an acoustic wave toward the piston at a speed of about twelve hundred feet per second. When it reaches the piston,

this acoustic wave is reflected and starts traveling back to the intake end. However, while the reflected wave is on its journey toward the intake, the pressure at this point is quite low. In fact, it is well below atmospheric pressure. This then is a suitable time to admit another charge of the mixture and then to close the valve.

When the wave does reach the intake, ignition takes place again and the process repeats. To attain a uniform, cyclic condition, the cylinder should be a half wave length long or a multiple of it. Under this condition a standing wave pattern is set up in the cylinder. Actually, the frequency of oscillation, that is, the number of explosions per second is fixed by the crystal generator element. It is clear that the element should be operated at resonance so as to obtain the maximum output. It is also desirable that the resonance frequency be as low as possible. But this resonance frequency depends on the length of the crystal; the longer the crystal the lower the frequency.

For a variety of reasons, eight inches is the maximum convenient length to use. As a quarter wave length vibrator, this resonates at five thousand cycles. Hence the length of the vibration chamber should be such that it is a half wave length also at five thousand cycles. This comes out as one and one half inches. Or if we like a longer cylinder, we can take it to be three inches, et cetera. The diameter of the cylinder should not exceed a half wave length, that is, one and one half inches in this case. The diameter must be kept down to this value to avoid the generation of undesired modes of vibration which would sap the output of the vibration engine.

Let us now look at the generator. It consists of a stack of rather thin crystals, about eight inches in length, cemented at one end to a metal diaphragm and on the other end to a massive metal block. Each crystal is coated with thin, vapor-deposited metal electrodes to which the lead wires are attached. The crystals may thus be electrically connected in any desired manner. If, somehow or other we can get the vibratory power into the diaphragm, from the engine, the vibration of the diaphragm will be transmitted through the crystal and will result in the generation of an electric current. It is easy to see that the crystals will have their greatest motion at the diaphragm end and no motion to speak of at the end anchored to the metal block.

We have mentioned that the piston of the vibration engine has a motion of say two tenth inches. The crystals could not possibly follow this rather large motion. In fact they would break long before this amplitude was attained. This makes it necessary to interpose something between the piston and the crystals so that all the energy of the piston motion can be absorbed by the crystals without breaking. This something is the transformer.

In ordinary mechanics, if we have a small force and a large motion available, the use of a lever will give us a small motion with a large force. In vibratory mechanics a lever is called a transformer. But levers can be liquid in type, too. The well known hydraulic press is a good example of one. This is merely a vessel filled with a liquid, closed off at the two ends with movable pistons, one small, the other large. If we push on the small end, a small force, will make it travel a long way. The large piston will have a much smaller motion but it can overcome a large force. This is exactly the sort of device needed between the vibration engine and the crystals.

It turns out that for efficient operation a double leverage or transformer action is needed. The first transformer uses water which, in turn, acts on the second transformer filled with oil. The two are separated by a porous rubber diaphragm which keeps the two liquids separated. The porous rubber has a lot of air in it which has the same effect as if the oil were filled with very fine air bubbles. The object of this is to secure the correct leverage from the second transformer. These two transformers in tandem then permit an efficient flow of energy from the small force-large amplitude piston in the cylinder to the small motion-large force condition demanded by the crystals.

The design as described can be

packaged in a cylinder about six inches in diameter and two feet in length. It will deliver about three kilowatts. The crystals are worked at a power density of about sixty watts per square centimeter. It is estimated that by refined design, this figure could be raised by a factor of ten. The output of the generator would then be thirty kilowatts.

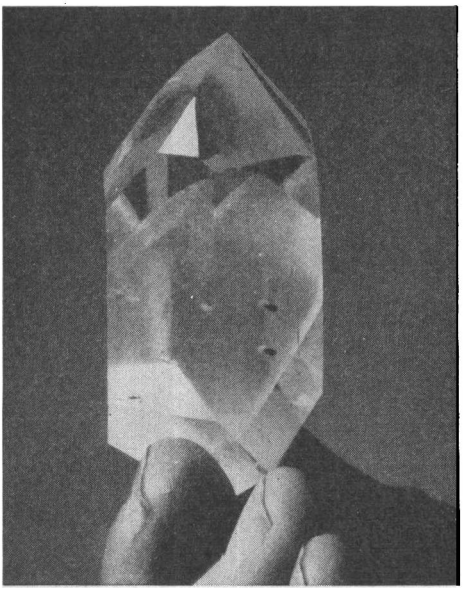
It is interesting to make a weight comparison with some other forms of power generators. The weight of the thirty kilowatt generator would come to about one hundred pounds, or about two point five pounds per horsepower. A large fraction of this resides in the metal block used for backing up the crystals and could be designed out if desirable. The large airplane motors come at about one pound per horsepower, but of course, this does not include the weight of the generator one would have to hook on to make a strict comparison.

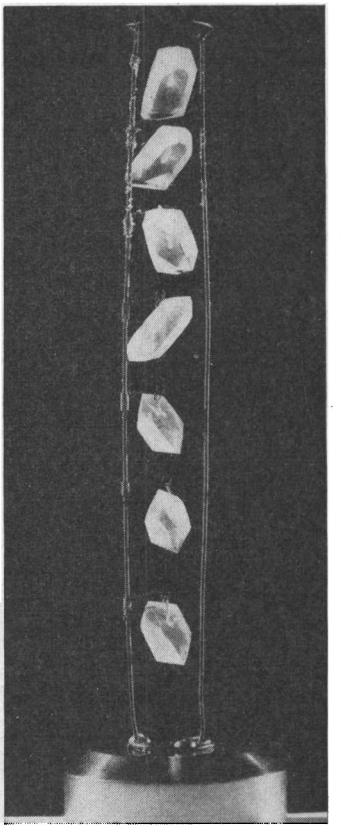
High-frequency electric motors have been built for grinder operation which weigh about six pounds per horsepower. If one of these were driven by a gasoline engine, the combined weight would run to about ten pounds per horsepower, or about four times as much as the crystal design. All in all, the crystal unit will make a very attractive power generator when it becomes available.

Of course, the explosion engine is not the only possible driving source for the crystals. Mason has built a design run on water power. He converted the power in a steady flow of water into high-frequency oscillatory energy through the use of the water hammer principle.

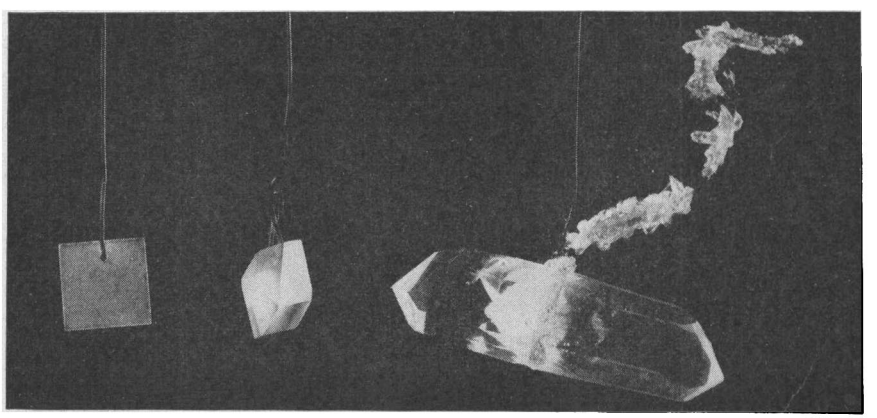
The future for the use of piezo-electric devices looks bright. Nor should a by-product, the techniques for artificial crystals be overlooked. The idea of dissolving quartz in water, which, *a priore* looked so preposterous, leads one to wonder how soon will large diamonds be grown, using what solvent?

THE END





Above (Fig. 4): Perfect synthetic quartz crystal. Original seed plate visible inside. Right (Fig. 5): Series of growing quartz crystals in harness used in bomb. Below (Fig. 6): Spurious seeds resulting from a leak in the crystal-growth bomb.



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