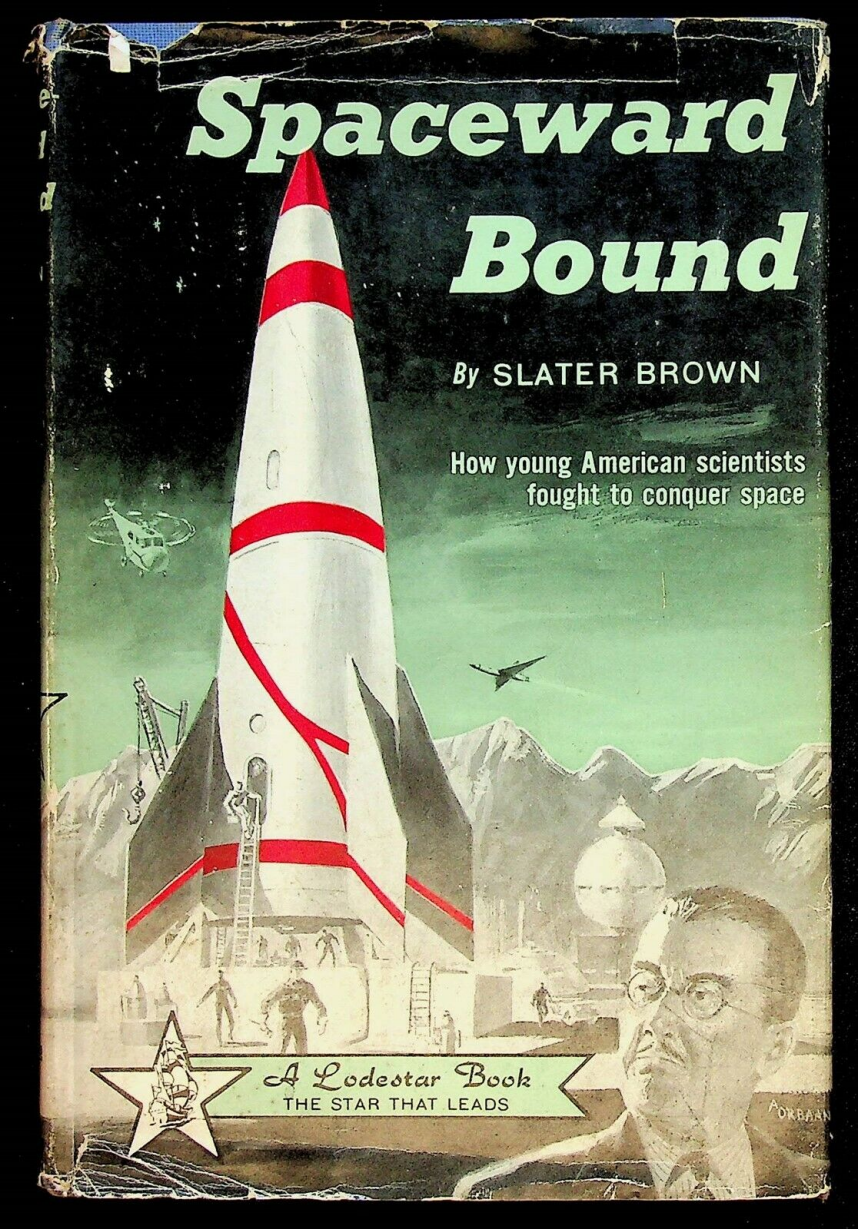
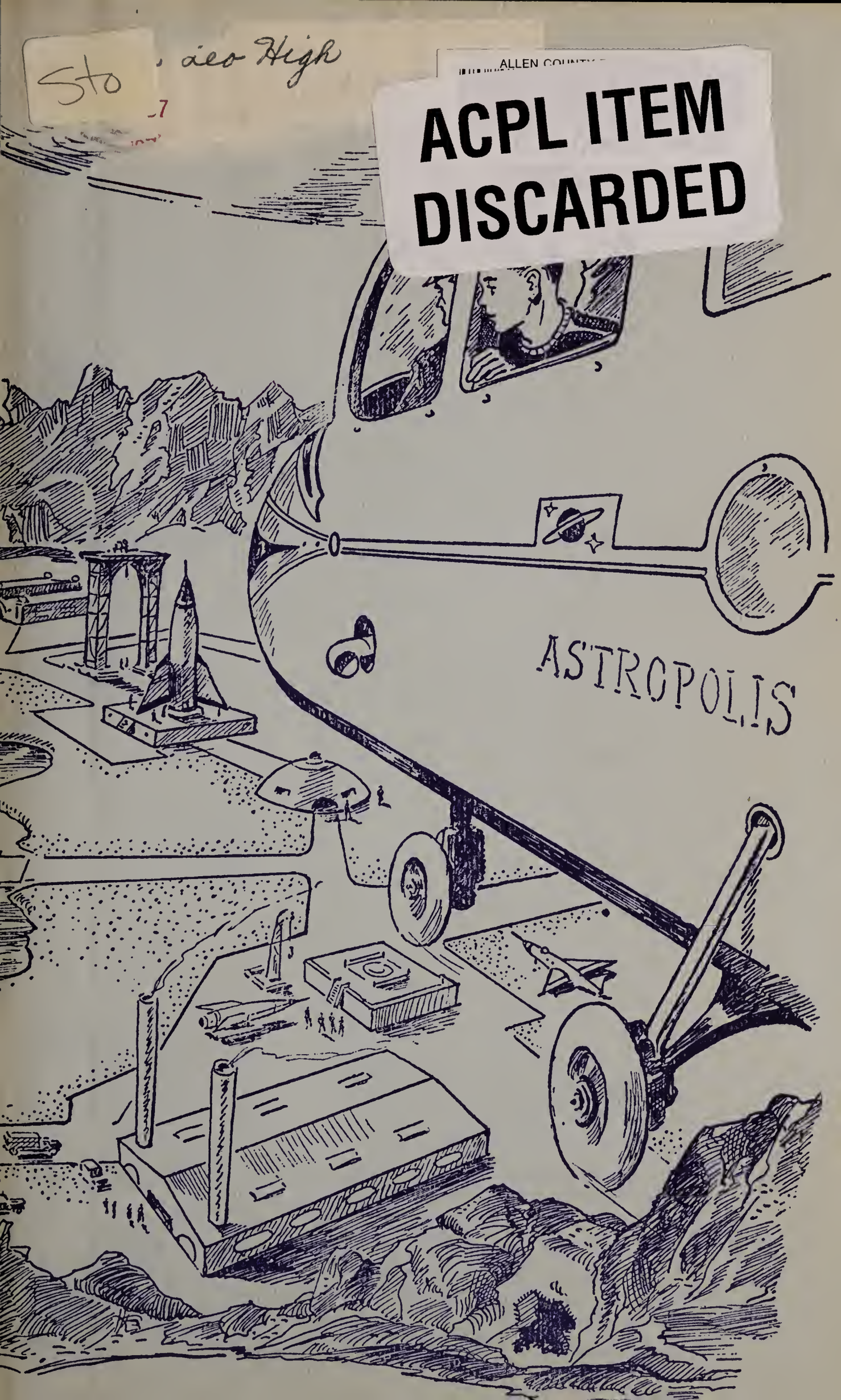
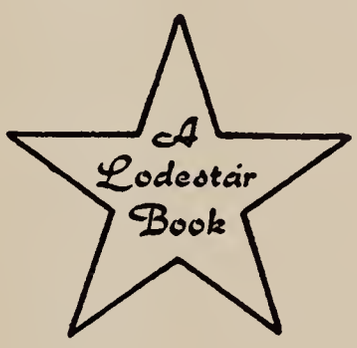

Spaceward Bound
By SLATER BROWN
How young American scientists fought to conquer space
A Lodestar Book
THE STAR THAT LEADS



SPACEWARD BOUND

by SLATER BROWN



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Chapter 1

My first adventure with space flight ended in harsh words. My second adventure ended with fireworks and sudden death. Between these two adventures a great deal happened to me and to some of my friends. They've asked me to tell the story.

I am not a professional story writer. I am an astrophysicist. Until recently I taught that interesting subject at Nutter College. You have probably not heard of Nutter. It certainly isn't famous for its football team, but it has always rated high in the sciences. That is why the Young Astropolitans—Young Citizens of the Stars—organized one of their first chapters at Nutter. And how I first came to know them.

That was back in 1965. It is now 1969.

It was a young chap named Brick, Rusty Brick, who organized the Y.A. chapter at Nutter. At the time, he was a graduate student in engineering and to say that he was crazy about space flight is to put it mildly. He ate books on space flight by the dozen and washed them down with liquid propellants. His enthusiasm was a thing to behold though it led him into a reckless venture that was his undoing. But I'm getting a bit ahead of my story.

The Astropolitan idea was that young people under twenty-three (Brick was twenty-three himself) must organize and build their own space ships. That the future of space flight was not cruising around inspecting the planets, merely for the greater glory of science. Brick's idea was a little more adventurous. Brick wanted to colonize the planets. And with all the young people who were sick of this one.

It was for this purpose that Brick gathered together the first group of Astropolitans at Nutter. They were to be real Citizens of the Stars. Off somewhere in space, on Mars, Venus or any other star or planet available, they could build a new world for themselves. And they could sit on it and laugh at the old folks at home.

Brick had red hair and liked flowery language. He was what you might call the dreamer type. I had never before met a man with red hair who was a dreamer, but then I had never met anyone exactly like Rusty Brick.

It was, I suppose, because he was the dreamer type that I had avoided him, though he had attended several of my courses. But he had occasionally popped up with questions that startled me. "Do you think, Professor," he asked me one day during class, "that it would be possible to grow prickly pears on Mars?"

The class burst into laughter, of course, but I can understand now why Brick asked the question. It wasn't quite so ridiculous as it sounds. Mars, so far as we know, is an arid waste and only desert growth could possibly survive there. The cactus is a desert plant and certain kinds of cacti produce a fruit called prickly pears. They are good to eat and fairly nourishing. Human beings

might be able to live on them. Human beings therefore could live on Mars. Q.E.D.

I'm afraid that I turned off Brick's honest question with a joke, for at that time I thought space flight was a joke, too. I thought of it as an ignorant attempt to bring a comic strip to life and I had an extremely low opinion of comic strips. Moreover, I had a very low opinion of the society Brick was trying to organize—the Young Astropolitans. I did not wish to see the campus overrun with space cadets in their weird suits firing off their disintegrators in my direction.

That was four years ago. Times have changed and I have changed with them. I'm ashamed of the opinions I held then, but I certainly wasn't alone in holding them.

I suppose that when some progressive fish first announced that he was going to try living on land out in the air, he found plenty of learned friends eager to prove to him that it could not be done. I can imagine some fish astronomer like myself saying: "Escaping into the air, are you? Escaping all your problems here by crawling out on the land? Why, my dear finny friend, you'll perish in two flips of your tail. You won't be able to breathe, you won't be able to swim, the sun will roast you, you'll find nothing to eat. Oh, the prospect is far too dangerous! Just stay at home in the good old H_2O. It was good enough for your pappy and it's good enough for you."

And I imagine that the highly intelligent fish, who wanted new worlds to conquer, just went doggedly ahead. And before long he had developed some air-breathing lungs, surrounded his heart with a red, salty

liquid that took the place of sea water, produced a pair of queer-looking things that he called legs and was out on the land basking pleasantly in the sun and eating green vegetables. And not long after, he had changed his fins into wings and was flying about in the air as if he owned it.

But four years ago I was as dubious of space flight as my ancient finny grandfather had been of life on land. So late one afternoon when Brick called at my study and asked if I wouldn't give a talk before his little group of Astropolitans, I at once turned him down.

"I'm afraid I'm too busy," I said. "Besides, I think the idea of space flight is sheer nonsense. If I did speak before your group I'd have to say as much."

"Fine!" Brick said. "You can say anything you please. Bring up all the objections to space flight you can think of. That's what we Y.A.'s want—objections, arguments, problems. We want to know what we have to face. Give us the works."

I must admit that I could not help admiring Brick's spirit and I told him so. "But tell me frankly now," I said. "What's the main purpose of you Young Astropolitans? You just want to tool around in space on a sort of celestial joyride?"

"Don't you know what our idea is?" Brick asked. He pulled up a chair to my desk and sat down. "Let me explain."

I looked at the clock. It was quarter to six and I was due at home for dinner promptly on the hour. My mother, who kept house for me, didn't like me to be late. "Can you make your explanation brief?" I asked.

"Sure," Brick said. "I'll only take five minutes of

your time." Then he proceeded to pull a small pamphlet from his pocket and opened it. "First of all, let me read the opening paragraph in our constitution."

I looked at the clock again. "Is it one of those long-winded things?" I asked.

"You'll soon know," Brick replied. He cleared his throat and began to read. "We, the Young Astropolitans of America, alarmed by the sad state of the world today with its constant wars and its overcrowded cities, convinced that it is beyond repair or redemption, hereby take oath that we will not rest until we have established upon a distant star or planet, under the flag of the United States, a new land where we can raise our children in peace. We therefore dedicate our lives to the task of discovering and exploring, colonizing and developing, a new home for young men and women in outer space. Astropolitans of the World, Unite! You have nothing to lose but this world."

"Not bad at all," I said, "though a bit on the fancy side. But do you chaps really think this world is entirely hopeless?"

"For our children it will be," Brick said. "And that's what we're thinking of. We don't want to pass on to our children the damaged world that our parents have handed on to us."

"So you're determined to build a new world somewhere in outer space?"

"Exactly," Brick said. "A brand new one for our kids."

"Good enough," I said. "But what makes you think this world is going to the dogs?"

"War," Brick said. "Constant war. And what brings

it about? Overpopulation. The world has become an overcrowded slum. In 1950 the population of the world was two billion and a half. It's increasing at the rate of 25 million a year—seventy thousand births every twenty-four hours. By the year 2000 there will be at least four billion people on the earth to feed. And the earth won't be able to feed them. Even at the present time half the children of the world are undernourished."

"So the Young Astropolitans are looking for a new source of food?"

"That's part of it," Brick said. "And moving there when we find it."

"But the engineering problem alone. Even getting one space ship to Mars is a gigantic one. How will you solve it?"

"We've got to," Brick said. "That's how we'll solve it, because we've got to."

"Brick," I said, "I think you're a dreamer."

Brick looked at me. "I thought you'd say that," he said as he stood up. "Well, Professor. You coming to give us a little talk on what a bunch of crackpots we are?"

I thought a minute. There was certainly truth in much that Brick said. I was still under thirty myself and what little I'd been able to see of the world had made me wonder occasionally if I dared bring children into it. But that was being negative and here Brick and his Young Astropolitans were working toward some positive solution. Mad as their idea might be, there was a spirit behind it that I couldn't help admiring. Dreams always come before blueprints, and perhaps I might be of some help when the dreams reached the drawing board. At

least there wasn't much reason why I should spend my time jeering at them.

"I'll be with you," I said. "When do you want me and where?"

Brick grinned. "I thought you'd come," he said. "Eight o'clock Thursday night at our club room in Windsor Hall."

"Good enough," I agreed as I jotted the date down on my desk calendar. "You can count on me."

On Thursday night I appeared at Windsor. The hall, seating about a hundred students, was jammed. After Brick had introduced me, warning his audience of Y.A.'s that I did not sponsor their program, I delivered my lecture.

I think I surprised Brick by what I said. I had experienced a change of heart since I had talked to him. Instead of attacking the Y.A.'s program, I merely pointed out the terrific problems they faced.

I took each one up in turn. The engineering problem, the chemical problem of liquid propellants, the biological problem of sustaining human life in space, the mathematical problem of navigating the ship, the astronomical problem of discovering what conditions prevailed on the planets, the aerodynamic problem of supersonic flight through the atmosphere, the metallurgical problem of developing heat-resisting alloys. I pointed out that the problem of space flight involved almost every science known to man and some that man hadn't even touched. I urged them to take their time. Years of study were necessary, years of lab work,

paperwork, experimentation before the first astrocraft manned by a human crew could take flight into deeper space.

I suppose toward the end of my lecture I got pretty stuffy. To urge hot-blooded young men to sit on lab stools for years on end, preparing for something that they want to do in five minutes, is no way of handling the situation. I realize that now, but I didn't then. I realize now that if Columbus had waited for someone to invent a compass before he took off for India, he would still be sitting on some dock in Barcelona twiddling his thumbs. But five years ago I was all for research, research and more research. As a matter of fact I think that I ended my speech with that ringing declaration.

As soon as I had sat down to a very feeble amount of applause a young man in the first row popped up.

"And how long, Professor, do you think that this research will take before we can launch a manned ship into space?"

"Young man," I said, "the research into the astronomical problems alone will take twenty years."

"But," said the young man, "we'll all be aged professors by that time."

"It is better," I said, "to be an aged professor than a dead Astropolitan."

"I don't know about that," the young man remarked quietly and sat down.

Other questions followed, intelligent ones, but some of them were couched in intemperate language. I realized that I was up against a group of well-informed and extremely bright young men who took space flight

deeply to heart. But as I say, some of them lost their tempers and when one of them referred to me as a "microcephalic mossback" I nodded to Brick that I thought it was high time to end the proceedings.

So Brick adjourned the meeting and five minutes later we were alone in the hall. I gathered up my papers.

"I feel I ought to apologize," Brick said as he brought me my portfolio and placed it on the table, "for the snide shots some of my Y.A. friends took at you."

"Didn't bother me a bit," I said. "I was ready for them."

"I guess they need slowing down," Brick said solemnly. "I was glad to hear you urge caution."

"That's what I came here for," I remarked.

"It was sound advice." Brick nodded his head as he handed me my hat. "Yes, sir. Research, research and then more research. Marshal all your facts and *then* go to work."

"That's the idea," I said. "I don't think you people realize how much paperwork and experimentation is still needed."

"I guess we young people don't realize how much groundwork we still have to do."

"It will take years," I said as we started toward the door. "Many a long year before the first space ship takes off."

"Guess you're right," Brick said as he walked along beside me. "Twenty years of research. Then maybe twenty years to ready the ship. Not too bad. I'll be only sixty-three by that time."

"It's a long pull," I was about to say when suddenly

I realized that Brick was pulling my leg. I stopped short and stared at him. He was standing holding the door open for me. "Look here, young man," I said, "are you kidding me?"

"Perish the thought, sir!" Brick replied, looking as innocent as a cherub, though I thought I detected a sarcastic twinkle in his eye. "I thought your advice was swell. However, I must admit that I couldn't help chuckling all the time you were giving it."

We stepped out into the night. It was bitter cold outside. Above the campus the stars glittered like frosty jewels. And ever so far away. We started along the lane that led to my house.

"What were you chuckling about?" I asked. "I don't enjoy being laughed at behind my back."

"Sorry, Professor," Brick apologized. "It was simply that I kept thinking of the letter I got just before I came to the meeting."

"What was it?" I asked. "What was in it that made my lecture so mirth-provoking?"

"I think you'll see the joke when I tell you," Brick replied. "It was an announcement from the Y.A. headquarters in Florida."

"Well," I said, when Brick paused a moment. "What did it say?"

"It was an announcement that they've begun work on the *Astroblast*. It will be the first manned space ship ever to be built and it will be ready to take off in a year."

"You're crazy!" I stopped short and looked at Brick. "I never heard of anything so reckless."

Brick shrugged his shoulders. "Maybe," he said. "Maybe it is a reckless thing to do."

"What will be the destination?" I asked.

"The moon. A round trip to the moon."

"They'll never get back," I said. "Never. Even if the ship gets off the earth, the crew are dead ducks already."

"Hope not," Brick said. "It would be sort of hard on me. You see, Professor, I've been named skipper."

It was soon after this conversation that Brick pulled up his stakes and left Nutter. I was sorry to see him leave, for I never had hopes of seeing him alive again. However, before leaving he had called on me. I asked him questions about the *Astroblast*.

"It's only our first ship," Brick explained. "A small experimental ship with a crew of three. Our destination is the moon, but we'll be satisfied with less."

"What's the ship like?" I asked. "A triple-stage number?"

"No. Only two. Just one booster with a main ship to carry us and the pay load."

"Think you can do it on only one booster?" I asked. "Seems to me that you could hardly break through the atmosphere with only one."

"Oh, they've worked it out. We're using some pretty hot propellants."

"Which means?"

"Fuming nitric acid for one."

"That's hot all right," I said.

"Wild as they come," Brick agreed, with what

seemed like a ring of pride in his voice. "We like our fuels wild. And fast workers besides. And ornery too. A well-behaved rocket fuel is a contradiction in terms."

"I imagine it is," I said. I took my pipe from my pocket and, filling it slowly, stared at Brick. It was evident that Brick and fuming nitric acid had a lot in common. "What are you mixing with the nitric acid for combustion?"

"Hydrazine," Brick said.

"Well, when those two start tangling I imagine you can get almost anywhere," I observed. "Sparks sure will fly."

"And the *Astroblast* along with them," Brick said. "They'll produce in combustion around 4600° Fahrenheit and an exhaust velocity of 9,200 feet a second."

"Sounds as if you might get a lot farther than the moon," I said. "But I hate to think of you sailing off in that flying volcano."

"I wouldn't pass up the chance for the whole world."

"Maybe that's what you're playing to lose," I said. "Thought of that?"

Brick laughed. "You're frightening me, sir," he said. "But anyway, I'd like to keep in touch with you, get your advice even if we don't take it. And then when the *Astroblast* takes off we'd like you to be there."

"I wouldn't miss it," I said. "When do they think the ship will be ready?"

"In a year. For the next six months, though, I'll be touring the colleges, organizing new chapters and raising funds."

"The best of luck," I said. "And I think you'll need

it. But I can't let you go without one word of warning. I think you chaps are going into this thing with just about one half the preparation you need."

"Well, we'll see," Brick said with a grin as he shook my hand. "But remember you have a date with us a year from now."

"I'll be there," I said.

Chapter 2

EXCEPT FOR OCCASIONAL LETTERS from Brick reporting to me the progress being made on the *Astroblast* and one or two meetings of the Y.A. that I attended on the campus, I lost touch with the organization. I still believed that the young people were going about the business of space flight too hastily. And though I had somewhat modified my opinion that twenty years of research were needed, I nevertheless thought that they should have gone into the whole subject more thoroughly than they had.

However, when I received a telegram from Brick that they were all prepared and that the *Astroblast* was to take off on the following Wednesday, I found a substitute to take my classes, and hopping into a plane on Tuesday, I flew to Florida.

After checking in at a hotel, I immediately went to the proving grounds. I had, of course, followed all the details of the projected flight of the *Astroblast* in the daily papers, but I was hardly ready for the scene that greeted me. TV cameras, photographers, radio reporters, newspaper men were swarming about and behaving at their worst.

I had little chance for a real conversation with Brick. Even though it was the evening before the take-

off, he was kept busy. When he should have been resting in preparation for the next day's ordeal, which would certainly be far more strenuous than any football game he had ever played, he was up and about in his room giving last minute orders, shaking hands with various delegations, giving interviews and signing the autograph books of fluttering girls.

However, it wasn't this sort of confusion that depressed me so much as the confusion that seemed prevalent among the Young Astropolitans themselves. Things were being done at the last minute that should have been done weeks, if not months, before. Even as I talked to Brick in the madhouse he called his room, a panicky mechanic stormed in to say that the oxygen bottles hadn't yet arrived.

Bewildered by the tumult, I shook Brick's hand and after pleading with him to get some sleep, I hurried back to my hotel. I didn't sleep a wink myself.

Before the crack of dawn I was up again. I grabbed a hasty breakfast at the hotel and hiring what seemed to be the last available taxi, I rushed out to the field.

In the gray dawn the *Astroblast,* white and ghostlike, rose out of the morning mists that clustered around its base. Y.A. mechanics were hustling about doing their last minute tasks. TV cameras were everywhere again, with all the other agents of press and radio. Flashbulbs popped, women screamed, jeeps roared across the field. I pushed my way through the crowd to where I saw Brick standing with the two other members of the crew. They were being photographed for the hundredth time. I shook their hands. They were wearing padded suits and crash helmets. They looked like three football play-

ers about ready to trot onto the gridiron. And with no more concern.

Brick was grinning. He slapped me on the shoulder. "Well, Professor," he shouted, "so you thought we couldn't make it, eh?"

"You fooled me, Brick," I said, trying to look cheerful, though my heart was in my boots. "Didn't think you folks had it in you."

Just at this moment there were screams in the direction of the *Astroblast.* A young woman in dungarees (a Radcliffe girl, I afterward learned from the newspapers) had smuggled herself aboard and was now being dragged forth with her broken spectacles in one hand and a copy of T. S. Eliot's poems in the other.

It was too much for me, this confusion of farce and tragedy. After waiting for a moment or two longer with Brick, I said goodbye. I hung around until he and his crew mounted the rope ladder. Waving a last farewell to us below, they climbed through the little hatchway and closed it. I started trudging back to my hotel. I didn't think I could bear seeing the takeoff.

I walked slowly across the field, my throat tight with anxiety. Occasionally I turned to take a quick glance at the *Astroblast,* standing grim and silent. Inside, its brave crew of three, I imagined, were strapping themselves into their contour chairs.

Somewhere a college band began wheezing out the "Stein Song." As the last strains died on the chill, mist-laden air, I heard a distant loudspeaker bark out the time count. "Five minutes minus zero!" I quickened my pace. But I had hardly reached the little orange grove

near the entrance gate when a roar shook the very ground I stood on.

I swung around. The *Astroblast* was rising! I muttered a prayer to whatever saint protects wild young men in space ships and fumbled for my binoculars. At least the ship was rising. Faster and faster, but even so, sluggishly. It seemed miraculous that only that spurt of green fire could be lifting the enormous thing.

Holding my field glasses in readiness, I watched the ship rise. It was now gaining speed fast, already a mile up. Then it plunged into a pink, fluffy cloud. As it emerged I was startled to see it burst into flame. But it was only the rising sun, still invisible to us, bathing it in liquid fire. Glowing now like something incandescent, turning slowly with its great fins, straight up and up it rose like a flaming dart, dwindling in size more and more until it had become, even now in my high-powered binoculars, a mere needle point of light in the morning sky.

With a sigh of relief I lowered my glasses. I wondered how Brick and his crew, strapped in the contour chairs, had survived the takeoff. But now I wondered even more how they would survive the vastly more dangerous ordeal of the return to earth.

After waiting for the field to clear of the crowds that covered it, I hurried back to headquarters. I inquired my way to the radio room. Stanton, whom Brick had left in charge, would be there. I found him in a small group of Y.A.'s gathered to hear the first reports from the *Astroblast* itself.

As soon as I entered the room I realized that things

were going badly. Twenty minutes had already passed and no word had yet come from the ship. Y.A.'s stood about studying their fingernails and nervously smoking cigarettes. I lighted one myself. I tried to start a conversation with Stanton but he merely shrugged his shoulders and walked away. I sat down in a chair and resigned myself to the worst. A young chap in a light raincoat, evidently unable to bear the strain, jammed on his hat and strode out of the place.

He had hardly slammed the door behind him when I saw the radio monitor, behind the glass in his soundproof room, raise his hand and bend closer to his instrument. We all froze to attention. But it was a false alarm. A moment later he signaled that nothing was coming in. I lighted another cigarette. My hand was getting shaky. Stanton came over to me, looking glum.

"Not a peep yet," he moaned. "We're all worried."

"How long since the takeoff?" I asked.

"Twenty-six minutes now. They just couldn't have been knocked unconscious that long."

"Maybe the transmitter is on the blink," I suggested hopefully. "Were all the instruments given a thorough test?"

Stanton shrugged his shoulders and studied the tip of his cigarette. "You know how impatient Brick was to get going," he said.

"I was afraid of that," I remarked. "One defective tube, one loose connection . . ."

The idea of Brick's impatience to get going, even at the expense of testing his instruments, was too dismal for me to think about.

Suddenly the door of the radio room banged open.

"He's coming in!" I heard a voice yell.

I jumped to my feet and with the rest of the group crowded into the radio room. I heard Brick's voice jabbering excitedly over the high-frequency intercom. "Couldn't activate the transmitter," he was saying. "Then Sparks found a loose wire. Certainly irritating to hear your voices and not be able to talk back. . . . We're now hitting about twenty-five thousand miles per hour. About ready to shut off power and start coasting. . . . Glorious sight through the astrodome. Stars all shining in a jet black sky."

Stanton stepped up to the intercom. "How was the takeoff?" he asked.

"Knocked us all out for two minutes, but the tape and automatic pilot did the business. . . . Beginning to get a taste of zero gravity. Sparks' pliers just floated across the cockpit. Put Bert on, will you? One of the rockets is kicking up."

As Bert, who was evidently one of the engineers, pushed his way forward, I dropped back.

For an hour or so more I listened to Brick's reports. But finally assured that the *Astroblast* was well on its way, I said goodbye to Stanton, told him I'd phone from Nutter, and hurried to the airfield. I was soon winging my way back to my abandoned classes.

When I reached home I phoned Stanton. As soon as I heard his voice I realized there was trouble. Complications had begun, he told me, but one in particular had them all worried.

"Just about noon," Stanton said, "they ran into a mass of interplanetary dust—a whole cloud of it. It's raised heck with the astrodome. Sand-blasted the trans-

parent plastic so that it's now just so much ground glass They can't see through it. Worse, they can't shoot thei: position."

"Wasn't the astrodome protected?" I asked.

"I guess not. They're flying absolutely blind now. Only have a couple of portholes that happened to be covered. They're trying to navigate through those."

"Sounds impossible," I said. "Any way of giving them a radio beam?"

"We're trying to but it looks black. They're also beginning to complain about the heat. Temperature in the cockpit is well above a hundred."

With this final item of bad news, Stanton hung up.

I didn't phone again until midnight. The news I got was even grimmer.

"We've lost all contact with them," Stanton announced mournfully. "Brick had begun to complain that we were fading and then they began to go themselves. Finally they went out altogether."

"Are they having trouble with excess heat in the ship, too?" I asked.

"Plenty of trouble," Stanton replied. "The sandblasting the ship got evidently affected the insulating paint on the ship's hull. The inside temperature has risen ever since."

"But the radio?" I asked. "Any idea what's gone wrong?"

"Don't ask me," Stanton replied irritably. "All I know is that trouble started just about the time Brick told us they had reached a point twenty-four thousand miles from the moon."

"That's a dangerous spot," I pointed out.

"Dangerous? Is there any spot in space that isn't?"

"At twenty-four thousand miles from the moon . . ." Stanton cut me off.

"Sorry," he said. "But I'm afraid it's good night for now." He hung up.

I was sorry that he cut me off. I should have liked to explain why the point in space I mentioned was particularly dangerous. At twenty-four thousand miles from the moon in a direct line from the earth, the gravity of earth and moon reach a dead center. They equalize each other. And at that point strange things are likely to happen. Gravity and magnetic fields meet in a sort of riptide, a whirlpool of counterforces. The best of instruments might go haywire, and now with the *Astroblast*'s blind eye, its astrodome made useless, I dreaded to think what had happened.

I couldn't sleep that night and at dawn I phoned the Y.A. headquarters again. Stanton's voice seemed lifeless as he told me that there'd been no contact.

"I'm afraid the ship's lost," he muttered. "Even if they landed on the moon I don't know what they could do without space suits."

"How much oxygen were they carrying?" I asked.

"About a hundred pounds. Ten days' supply for three men. Food and water for the same length of time."

"There's still hope," I said.

"But the silence," Stanton groaned. "That frozen silence! I don't think I can take much more of it."

Alas! The frozen silence continued for the ten nerve-wracking days of possible survival, and longer, too, for the doomed ship was never heard from again. It is true that the great telescope at the Palomar Observatory

picked up in its powerful lenses a dark object moving slowly across the face of the moon two days after the *Astroblast* had taken off. But that was the only hint that the crew might still be alive.

A thousand and one rumors and explanations of what had happened filled the newspapers for weeks afterward.

The ship, it was said, had landed safely behind the Iron Curtain in Russia where the crew were being held as prisoners. Other imaginative readers of science fiction had seen it cruising through the midnight skies looking for a place to land.

But other less hopeful specialists suggested bleaker endings for the *Astroblast* and its brave crew. Returning to the earth, the *Astroblast,* they said, had entered our atmosphere at too high a speed and had instantly been transformed into a flaming meteor. Or perhaps the fuming nitric acid used as fuel had clawed its way out of the fuel tank and vengefully devoured the crew, trapped as they were in their minute cabin. Or again, the ship had been riddled by fast-traveling meteorites and in the resulting vacuum the crew's blood had bubbled into an explosive froth. Or still again, the crew had been broiled alive by the sun beating on the naked ship. Or perhaps the mysterious cosmic rays, about which everyone talks but with so little real knowledge, had stricken them. Or again . . .

As for me, I had given up all hope. I wrote the ship off as a complete loss.

But if the loss of the *Astroblast* had been a blow to me, it was a savage, a stunning blow to the Young Astro-

politans. For a while I doubted if they would ever recover from it. For weeks after the disappearance of the *Astroblast* I heard nothing from them. The group at Nutter lost their old enthusiasm. The few meetings I attended were listless and perfunctory. Some among the group, a few diehards, still believed that Brick and his crew were alive, but the majority were of my opinion that it was only wishful thinking.

Discouraged myself, I began to lose interest in the Young Astropolitans. And though I still continued studying the problem of space flight, I took no active part in any program. I went on with my teaching and for three years led my humdrum life on the campus.

Occasionally I heard rumors that the Young Astropolitans had taken a new lease on life. That they had found a wealthy backer, that they had started a school of astronautics in some secret locality (rumor said that it was located in the crater of a volcano!) and that they now had a young director who was a genius.

However, since they did not get in touch with me, I did not get in touch with them. I continued delivering my lectures, but after three years I had become restless. I asked my college for a leave of absence, intending to do a little traveling in Europe. I wanted to see Paris again, Germany where I had studied astronomy, Italy. Then when June came I started packing, looking forward with pleasure to a year abroad.

I never got there. Instead I landed in a place I never had the least desire to live in, nor any expectation of ever doing so. I landed in the crater of a volcano and in the school for astronauts called Astropolis.

It had come about so suddenly that it had all the elements of a dream. And at times a bad one.

The whole business had begun with a phone call from Spender. He identified himself as the general director of the Young Astropolitans and said that he and a colleague wanted to see me on an urgent matter. I told him to come to my house at eight and I'd see him in my study.

At precisely eight my doorbell rang and my mother brought the two young men in. After Spender had introduced himself—Niles Spender was his full name—he introduced me to his friend.

"This is Ted Hackett," he said. "But commonly known as Digits. He's our treasurer and a whiz at math."

I shook hands with Digits. He was a small, shy fellow with glasses and a cowlick.

Spender was a tall, broad-shouldered chap with light hair, a hooked nose and a determined chin. Both the young men seemed about the same age—in their early twenties—but Spender had the assured bearing that made him look older than his companion.

I pulled up some chairs by my desk. When we were all seated Spender made a brief speech. I don't think I need to go into its details. It outlined the original program of the Y.A.'s: the exploration of deep space with the idea of future colonization of some star or planet. He mentioned the ever-increasing population of the world, particularly of such countries as India, and assured me that the only real method of solving the problem was to discover a new world.

"Some decent place to raise our future kids in," Spender said.

Then he mentioned Brick. He said that in spite of his respect for Brick's courage and initiative, he thought Brick had gone at things too impatiently and that his impatience had led him into disaster. That though some Y.A.'s believed Brick was still alive, he personally believed that Brick and his crew were dead. However, since Brick had gone, the entire program had been overhauled and the emphasis was on thorough training.

"We've got a college now going full blast," Spender said. "And if you don't mind my popping the question so abruptly, we'd like you to come and teach there."

Having, as he said, "popped the question," Spender and his companion both stared at me.

"But . . ." I started to stammer, for the question had caught me with my guard down, "but I was planning to go to Europe."

"Come with us instead," Spender said. "We'll double your pay here and give you a lively experience besides."

"I've no doubt of that," I said. "But where is your college?"

Spender turned to Digits. "Tell him where it is," he said. "Folks seem more apt to believe what you tell them."

Digits cleared his throat and looked at me through his heavy glasses. "It's in a volcanic crater," he began. "Or rather, what's known as a *caldera*—Spanish, you know, for cauldron or pot. It would be more appropriate to call ours a soup plate, for the base is a very broad one while the jagged rim surrounding it is five hundred feet high. The base is a basaltic plain six miles across, flat, and a perfect landing field and launching site."

"Is that description satisfactory, Professor?" Spender asked with a grin.

"Perfectly," I said. "But now tell me, simply as a matter of curiosity, is the volcano active or extinct?"

Spender laughed, showing a row of strong white teeth. "Hasn't erupted for a thousand years," he said. "And a perfect site for us. Gives us height for launching, absolute security, protection from wind, and, since it's on an island in the West Indies, a wonderful climate."

I lighted a cigarette. The idea appealed to my taste for adventure, but before coming to a decision I felt like learning a little more about the finances and general nature of the place.

Spender briefly outlined them. The school, he told me, was financed by the Young Astropolitans themselves and by a wealthy Hindu who had become interested in the Y.A. program as a possible solution of the problem of overpopulation which plagued his own country.

"We've never met the Hindu potentate ourselves," Spender confessed. "But a representative of his works with us. His name's Tago. You'll like him. We all do, don't we, Digits?"

"The brightest man we have," Digits said.

"And your buildings?" I asked. "Where would I live?"

"Oh, we have everything you've got here on your campus," Spender said. "Not ivy-clad, perhaps, but everything to house, feed and teach two hundred students."

"A hundred and ninety-three," Digits corrected him. "Plus the professors."

The professors! I had forgotten about the professors. But it reminded me that I hadn't yet asked Spender why he wanted me on his faculty.

"Brick always had a high opinion of your work in space flight," Spender explained. "And then when our Dr. Homberg didn't turn out so well . . ."

"Dr. Homberg?" I asked. "An astrophysicist? Don't think I've ever heard of him."

"Perhaps there's a reason," Spender said darkly. "At any rate we want you to replace him. He's giving us trouble."

"What sort of trouble?"

"He's a brilliant man and all that," Spender began. "And we don't like to lose him as a teacher, but we're beginning to be worried about what he's up to." Spender paused a moment. "We're beginning to believe that he's trying to wreck our program."

"In what way?"

"In every way he can," Spender said. "He's against space flight."

"You see, Professor," Digits put in, "Dr. Homberg wants us to establish a space station and that's it, period. He argues that a space station moving in an orbit a thousand miles above the earth would make it possible to rule the world. That if we could rule the world there'd be no problem of overpopulation. We could solve it simply by pinpointing a couple of H-bombs where they'd do the most good."

"Sounds like one of those bloodthirsty professors," I remarked. "They're a special breed. But tell me, are you having trouble getting him out?"

"That's it," Spender agreed. "He's hanging on like a leech and we don't like to use force. Besides, we're afraid to."

"Why?" I asked.

"Because he knows too much about the new space motors we've recently developed at Astropolis. We're afraid he'll take the secret out with him."

"I understand," I said, my sympathy already aroused when I heard that the Y.A. program was in danger of being undermined and blasted. "Pretty ticklish situation. So my job wouldn't only be teaching, it would be helping you to handle this fire-eater. Sounds mighty difficult."

"We need your help," Spender said. "We're afraid we can't handle him alone. We've got to protect our program."

"I'm not much older than you are," I said, "and I'm always ready to go to bat for young people with ideas like yours." Then I paused and took a deep breath. "When do you want me to come?" I asked.

"You mean that?" Spender exclaimed as he leaped from his chair and came toward me with an outstretched hand. "You'll join us, Professor?"

"Yes," I said. "But name the date quick before I change my mind."

It was soon done. As I was already packed up I found no reason for not agreeing to meet them on the following Thursday at the Miami airport. A half hour later, Spender and Digits left.

Back in my study I looked over the contract for a year that I had signed and the check they had left with

me. Had I made a hasty decision? Was I jumping blindfolded and headlong into a volcano?

The thought troubled me. But there was one thing I had no doubts about. Even though I had never seen the man, I knew that I already disliked Dr. Homberg.

Space stations, H-bombs and Dr. Homberg. No wonder the Young Astropolitans wanted to raise their kids on a distant star!

Chapter 3

My mother was waiting for me at the breakfast table when I came down the following morning. I was feeling glum and rather shaky. I hadn't slept much the night before and in the cold morning light my decision to spend a year at Astropolis already seemed slightly off the beam. Moreover, when I began answering Mother's questions, the whole idea seemed positively goofy.

"Who were those young men who called last night?" Mother began by asking me.

"They were Young Astropolitans," I said briskly as I took a sip of orange juice. "Citizens of the Stars."

"How interesting! And what did these Citizens of the Stars want?"

"They want me to go to Astropolis with them."

"I thought you were going to Europe. Are you now planning to go to Astropolis?"

"Yes, for a whole year."

"And where, pray, is Astropolis?"

"I'm not quite certain of its exact geographical location, but the place itself is in the crater of an extinct volcano."

My mother studied me for a few minutes across the breakfast table. "Are you sure that you are feeling quite yourself?" she asked.

"Never felt better," I replied. "But let me explain."

I then tried as best I could to reassure her. I told her, as I sipped my orange juice, about Astropolis and the idea behind it. I explained in detail why they had selected a crater for their college of astronautics—that a crater gave them total security, altitude from which to launch their space ships and that, situated on an island, they had a clear firing lane to the east. I pointed out that the Young Astropolitans were interested in space flight not as a sport or comic strip adventure, but because they were determined to explore space and find a brand new world.

"They want to find a decent place to raise their future kids," I said.

My mother was sympathetic. But there was still something that troubled her.

"I'm afraid you're running into danger," she said. "Have you looked at your mail this morning?"

I glanced down at the table. Leaning against my coffee cup where I hadn't noticed it was a postcard. I picked it up. It was a picture of Vesuvius in full eruption. Somewhat puzzled, I turned the card over. My address was printed upon it crudely in green ink. But it was the message that startled me. For in large crude letters were the menacing words, "HANDS OFF!"

"Where in the world did this ridiculous thing come from?" I asked as I studied the postmark. It read New York City. "Did this just arrive?"

"In this morning's mail," Mother said. "Do you really think you should go?"

"I've given my word," I replied. "I can't go back on it. I have to be in Miami on Thursday at seven."

"Doesn't that card worry you?"

"Not a bit," I said. "If it was intended as an attempt to scare me off from going, it had the opposite effect."

I shoved the card into my pocket and held out my cup for some coffee.

Early on Thursday morning Mother saw me off at the airfield. I flew to New York and then on to Miami where I arrived promptly at seven. Spender, Digits and a pilot were waiting for me. They transferred my luggage to a small jet and after we ate a brief supper we were on our way.

I was glad to see Spender again. His calm and easy assurance helped to restore my own. He and I perched on a pair of bucket seats while Digits squatted on my suitcase behind the pilot.

In a few minutes the sea was below us. It was already dark, for the sun had set and a full moon was rising in the east. Far to the west on the horizon I could see a row of twinkling lights along some seaside boulevard.

"Have any trouble getting away?" Spender asked me.

"Not much," I said. "But I received this."

I pulled the postcard from my pocket and handed it to him. He held it forward in the glow of the control board and studied it carefully, then passed it to Digits.

"What do you make of it?" Spender asked.

"That's the question I was going to ask you," I replied. "Did you mention to anyone that you were seeing me?"

"Someone may have found out," Spender admitted. "I'm afraid they're watching us like hawks."

"Who is 'they'?"

"Not quite sure." Spender looked puzzled. He glanced at me. "Hope it hasn't disturbed you."

"Not a bit," I said. "Threats like that only stiffen my spine."

"Glad to hear it," Spender observed. "I'm afraid this may only be the first." He took the card from Digits. "Mind if I keep this?"

I told him to do so. Then to change the subject I asked him about the courses he wanted me to give. He described what he wanted: lectures on the rudiments of space flight, the practice and theory, but made as simple as possible for newcomers.

"A sort of introduction to the whole field," he said.

For an hour or more Spender and I discussed the question until the pilot announced that we were about to land.

I looked ahead of us. We were approaching a small island. From the island's center, grim in the moonlight, rose the shattered cone of a volcano. It seemed tremendous in size and very high. We dove toward it.

A few seconds later we were circling above the great empty maw of the crater. It was an eerie sight. A cluster of about twenty buildings gleamed white in the moonlight. We began descending. It was like dropping into one of the vast craters of the moon itself.

We landed neatly on a floodlighted field. Wearily I climbed out of the plane and looked around. On every side of me rose the crater's rim, jagged like a broken molar against the starlit sky. But above the edge to the south, balanced there like a piece of forgotten jewelry, hung the great Southern Cross.

"Know where we are?" I heard Spender asking me.

"If my watch is correct and that is Jupiter a half degree from the moon's limb," I said, "I should place our position slightly south of the island of Martinique."

"Right you are!" Spender exclaimed. "And welcome to Astropolis. But I imagine you'd like to hustle right off to bed."

I agreed that I should like nothing better. We climbed into an awaiting jeep and leaving Digits to take care of my luggage, drove directly to the dormitory where I was to be lodged.

A thermos bottle of coffee and a couple of sandwiches awaited me on the desk in my room. After Spender had made sure I had all I needed, he left, saying that he wanted to go through the mail that had arrived during his absence. A few minutes later Digits brought in my luggage.

When I had unpacked some of my things, piled a few books on my desk and had a bite to eat, I began to feel almost at home.

"A nice friendly atmosphere," I thought to myself as I gazed about at my pleasant surroundings. "Peaceful, quiet. A perfect place for work and serious thought."

I stepped to the window. For a while I gazed out upon the silent *caldera,* flooded knee-deep in moonlight. Then I remembered the postcard.

"The heck they say!" I muttered to myself between my teeth. "If anyone wants a knockdown, dragout fight they're going to find one astrophysicist at least who'll take them on."

Then I undressed and, worn out, tumbled into bed.

I was awakened the next morning by a light tapping on my door. I jumped out of my narrow but comfortable bed with the impression that I had overslept. For a moment I stood in the room, dazzled by the brilliant sunlight that flooded it and not entirely sure where I was. Finally I collected my wits and opened the door.

Digits, with another young man, stood there.

"Come to take you to breakfast," Digits said cheerfully. "This is my friend Blips."

I shook hands with Blips. He was a little taller than Digits, with a happy, freckled face.

"How did you get that name?" I asked him when the two had come in. "Sounds like something on a radar screen."

"You're quite right," Blips said. "That's how I got it."

"You see," Digits explained, "we try to give each student here a name that shows what branch of astronautics he's majoring in. Sounds funny to an outsider and I guess it started as a joke. Like my name. But it's useful, especially when you have to call a technician in a hurry."

"I'd better be called Tubes then," I said. "Tube has been the name for a telescope ever since Galileo started peeking through one. From now on I'm Tubes."

Then, gathering up my clothes, I went into the bathroom, took a quick shower and dressed. When I came out into the room, Digits said: "Spender wants to see you."

"Something important?" I asked as I pulled on my jacket.

"I think it is," Digits replied. "He's waiting in his office."

"Can he wait until I've had breakfast?" I asked.

"Sure," Digits said. He opened my door and the three of us trotted down a flight of stairs into the world outside.

The sun had long ago risen above the ragged rim of volcanic rock that encircled the crater and the whole great bowl was flooded with fierce sunlight. I halted for a moment to look around me.

Clusters of low white buildings with oval windows and domed roofs stood neatly placed in a great half circle. At the center rose a large central building, domed like the others, but surmounted with a glass observatory.

In the distance were several hangars, while beyond them, on what appeared to be the proving grounds, loomed an enormous Gantry crane and mobile towers of steel. Beside one of the steel towers stood a rocket ship, gleaming in the morning sun, with little figures in blue coveralls swarming about its base. Near it stood a squat building, shaped like an igloo, with narrow slits for windows. It was, I realized (for I had seen one like it at the Army proving grounds at White Sands), the blockhouse in which observers sat behind concrete walls fifteen feet thick during a rocket firing.

As I had already imagined, no tree or bush was visible, though in certain plots near the great central building I observed a sparse growth of grass. But if all vegetation was absent, a great lake seemed to make up for it. Shimmering blue under the tropical sky, it lay slightly south of the center of the crater and was almost a mile wide. It was an astonishing sight to see, but I

realized that such lakes are not uncommon in old craters. As for the buildings, I remembered now as I looked at them that I had once read of a number of ancient temples that had been discovered by some Peruvian explorers lodged secretly in the vast crater of El Misti. The Astropolitans were only following an ancient tradition.

Digits gestured toward the lake. "Our swimming hole," he said with a touch of pride. "Deep as all get-out and cold as ice, but wonderful in the hot season."

Then as we proceeded along the walk he pointed out the buildings. "That big central one there," he said, "is where Spender's office is, on top in that glass dome. The central building itself is one of the old ones; here before we arrived. They say it was built by ancient natives."

"How did they get in?" I asked.

"People tell us that there used to be a tunnel," Digits explained. "And over there is the gym and the laboratory. That's the lecture hall, that little building is the powerhouse, and that," he continued as a structure loomed into sight from behind the central building, "is our observatory."

It was hardly necessary for Digits to have said so. I recognized it for what it was instantly. But I couldn't understand why Spender hadn't mentioned it before. I asked Digits.

"Well, you see," Digits began, looking slightly embarrassed, "we were sort of afraid to. You see, it's become Dr. Homberg's and we didn't know how you two would get along. We were afraid that there might be . . ." Digits paused, hopelessly searching for a word.

"Difficulties?" I suggested as my dislike of Dr. Homberg rose to new levels. "I'm afraid there'll be serious difficulties if I can't use it."

"Old Dr. Homberg," Blips put in. "I'm afraid you're going to find him a bit crotchety."

"I'm eager to meet him," I said grimly.

"You will," Digits assured me. "He's all over the place. You bump into him everywhere."

We had now reached the dining hall. Through a wide door I entered a huge room, filled with tables and like any commons in a small college. A couple of native servants who, Digits told me, were brought up each morning by helicopter from the neighboring port, were clearing up. Breakfast had evidently been served long before I had arrived, but Blips and Digits brought me some steaming hot coffee, toast, eggs and an enormous glass of orange juice.

While I ate breakfast Digits answered the questions I fired at him about the observatory.

"It's a real big one," he told me. "A forty-inch lens and wonderfully well equipped. It's a gift from Tago, or rather," Digits corrected himself, "from the wealthy Hindu for whom Tago acts here as an agent."

"He's the other person I want to meet," I said. "Tago. Dr. Homberg and Tago."

"You'll find them quite different," Blips observed. "As different as day from night."

"I imagine so," I said.

Breakfast finished, Digits and I, leaving Blips to hurry off to a class he had to attend, walked across the campus to the central building. We climbed to the top floor to the glass-enclosed tower in which Spender had

his office. We reached it by means of a circular iron staircase which entered the office at its very center. We found Spender at his desk scribbling out an order of some kind which he handed to a young chap waiting for it. Digits left me there.

Spender, seeing me, held out his hand. His smile was as pleasant as ever, but I immediately noticed that he was looking worried. After shaking hands with me he tapped on the shoulder a baldish man seated at a table. He was wearing a dark blue linen suit and seemed to be filling out a requisition blank. As Spender's hand touched his back the bald man jumped up, rather startled.

"Dr. Homberg," Spender said. "I want you to meet our new astrophysicist."

I shook hands with Dr. Homberg and looked him over. As I did so I realized with a start that I had met him somewhere before. His little bright eyes set close together, his heavy eyeglasses, his thin mouth and sharp nose, his pudgy hand, were instantly familiar. I had a feeling as the two of us stared at each other, like a pair of stray dogs, that he had also recognized my face, but, like me, could not place it.

"I've heard a good deal about you, Doctor," I said as I relinquished his soft hand. "Been eager to meet you."

"Indeed!" the doctor exclaimed. "You have just arrived at the *caldera?*"

"He came in with us," Spender said.

"Thought I heard a plane coming in," Dr. Homberg observed. "Going to be with us for a while, Professor?"

"As long as they'll let me stay," I said.

"Wonderful! Wonderful!" Dr. Homberg grinned, showing all his teeth, jagged like the rim of the crater itself. "You come directly from the States?"

"Why, yes," I said. "I've been teaching at Nutter."

"And what was it Mr. Spender said your name was?"

I told him my name. Again he struggled to place me.

"You will like it here," he said finally. "Won't he, Spender? And if there is anything I can do to make life interesting, pray let me know."

"There is one way," I said, "that you can make life very interesting for me."

"And that is?"

"Letting me share the observatory with you."

Dr. Homberg picked up the requisition blank he had just written and studied it intently for a few moments.

"I'm sure," Spender put in, "that there will be no difficulties about your using it, Professor."

"Certainly!" Dr. Homberg exclaimed, darting an irritated glance at Spender, though whether it was because he resented Spender's answering my question or because he did not want me working with him, I could not at that moment tell. "Certainly!" he repeated.

Turning to Spender he handed him the requisition. "Will you see that I have this right away?" he said.

Then with a brisk nod to me he picked up his sun helmet and left.

Spender waited until we heard the sound of his footsteps disappear down the stairs.

"There's your Dr. Homberg," he said. "What do you think of him?"

"Me no like," I replied. "And what's more, I don't think I ever did."

"You've met him before?" Spender asked in surprise.

"Yes. But where or when I can't for the life of me remember."

"Try to, will you? It may be important. Did Digits tell you why I wanted to see you?"

"No."

"It's about our friend here, about Homberg himself. I learned last night when I got back here that he's been away. They saw him down at the port. But no one knows how he got there. He didn't leave by any of our planes. I've checked on that."

"What was he doing?" I asked.

"We don't know. But you may be of some help. That's why, just now, I made it evident that I wanted you to work with him at the observatory. We'd like you to find out if you can what the old boy is up to."

"Does he know yet that I've come here to replace him?" I asked.

"He may suspect it," Spender said. "However, try to keep on good terms with him. But above all tell him nothing."

"I'll do my best," I said.

"Everything okay so far?"

"Quite," I said. "I'm very happy."

"Good," Spender said. "But before you go let me give you one of our catalogues. It may help in arranging your lectures."

Picking one from his desk he handed it to me. Then saying that he would see me at dinner, he ended our interview.

Returned to my room, I glanced through the catalogue, inspecting in particular the names of the faculty to see if I knew any of them. I didn't. Except for one. For when I came to Homberg's name I stopped short.

Hearing his name, seeing his face, hadn't rung a bell. But now that I saw the name in print it all came back to me. Homberg. Hamburg. Yes. Suddenly I realized, suddenly I recalled that he was the young instructor who had flunked me at the observatory at Hamburg. But Homberg wasn't his name then. It was von Huegel.

Chapter 4

SPACE FEVER, the desire to explore the dark mystery of things beyond this old and battered earth, is a highly infectious disease. And in Astropolis, where every activity was directed toward the exploration of space, one could hardly avoid coming down with a bad attack.

I suppose in its way it is the same kind of fever for exploration that swept across Europe at the time of Columbus, Henry Hudson, Magellan. It is not so much a feverish thirst for adventure; adventure can be found in a hundred other ways. It is a desire to explore an unknown world.

So as I sat in the small but pleasant study that had been assigned me, with its narrow cot and simple desk, drawing up an outline for my series of lectures on the theory and practice of space flight, I soon became completely wrapped up in my work.

Outside on the campus I could hear the sound of jeeps and trucks, the drone of the big 'copter bringing in freight and supplies from the bordering sea, and occasionally the ear-splitting bellow of a rocket on the testing stand as the flame roared through its tailpipe.

But the noisy activity all around me only increased my enthusiasm for my work. And it would have been

a full-hearted enthusiasm if I hadn't Homberg to think about.

I was in my very early twenties when he had been one of my instructors at Hamburg. For some reason he had developed a special dislike for me, perhaps because I was the only American in his class. And though I knew I was doing my work well (in any of the mathematical sciences you can pretty much tell how you're keeping up) he had flunked me.

I suppose it was because I was young then, and he at least ten years older, that he hadn't recognized me here. But what was his reason for being in Astropolis? If I were correct in believing that he disliked Americans, what was he doing in a place where there was nothing else? And why had he changed his name?

The questions bothered me, filled me with distrust and suspicion. But I felt that I had better do what Spender had asked me: play the game and keep on good terms with him. Perhaps if I succeeded in making friends I'd discover that the mystery about him wasn't as deep as it now seemed.

However, I now had the mystery of space to disclose to the Young Astropolitans. I must start preparing my lectures.

I knew from my experiences with Brick and some of the earlier Y.A.'s that space flight enthusiasts are in a class by themselves. Unlike the run-of-the-mill college students, they wouldn't be scared off by a little theory, or look frightened if I should begin talking about the basic principles on which space craft operate. If they ever were to fly they must have a sound understanding of the whys and the wherefores.

That had been the mistake, I felt, Brick had made. By nature he was reckless and impatient. And though he had an excellent ground training himself, he did not feel that it was necessary for his fellow workers to have one, too. Is it necessary to know all the mysteries of an internal combustion engine before you can take your girl out in the family car? The answer to that is obvious. But space craft, using the principle of the rocket, are still—and I am writing these lines in 1969—in the process of development. And in its earliest stages basic principles count.

I was glad to see that Brick's loss had been Spender's gain. And though the loss was still disputed by a number of the old diehards, the failure of the *Astroblast* was a warning. Enthusiasm has its place, but that place isn't behind a steering wheel. That's where knowledge belongs.

It was knowledge that Spender had asked me to bring to the campus of Astropolis. I could leave enthusiasm for others and go to work on my first lecture. This, I thought, should begin with the rocket. It is upon the principle of the simple rocket that all space craft move, even when operated by atomic fission. And for an excellent reason.

Like gunpowder and printing, the rocket was invented by the Chinese. They discovered that if gunpowder is wadded into a small, tight cylinder of cardboard, tied securely to the upper end of a light shaft of wood, and then lighted, the shaft will sail off into the air much like an arrow. In fact, it behaves so much like an arrow that when the Chinese first used rockets to drive back the Mongols in 1232 A.D. they were called "flying fire arrows."

Their enemies disliked them quite as much as the English disliked the buzz bombs which worked on the same principle during World War II.

Unlike the Germans, however, the Chinese were ignorant of the basic principle on which a rocket works. In my experience, I had come across adults who were quite as ignorant as the Chinese themselves. Many seemed to believe that a rocket moves by pushing itself against the air. But this is not at all the case. A rocket can operate in a total vacuum. The explosive force of the rocket does not push against the air; it pushes against the rocket itself.

There are two simple ways of moving a boat off from shore. One is to stand in the boat and push it off with a pole. The other way is to jump onto the shore and thus set the boat moving in the opposite direction. This latter case is how the rocket works. A man leaping from a boat and the exploding powder leaping from the rocket give both boat and rocket a motion opposite to their own. In other words, boat and rocket are each obeying Newton's Third Law of Motion in its simplest terms: every action is accompanied by an equal but opposite reaction.

Let's take another example of this Third Law in action: the kick one gets from a gun when it is fired. The heavier the charge the bigger the kick. And the kick will be there even though the gun is fired in a vacuum. Now mount a machine gun on a light handcar in a vacuum and start pulling the trigger. The car will take up the recoil of the gun and begin moving in the opposite direction of the bullets. And it will keep moving at an accelerating speed just as long as there is ammunition to fire.

Now a rocket is kicked forward by millions of fiery molecules leaving the tail cone just the way a bullet leaves

the gun. It's quite as simple as that—almost as simple, in fact, as a body being moved by gravity. But because it is simple and direct, because it needs no moving parts, no wheels, no heavy cylinders, no valves, no crankshaft, it is the most efficient motive force there is. And because it can move in a vacuum, it is also the only efficient motor for a ship cruising through empty space.

Compared to a rocket, an ordinary airplane with its propeller to churn the air and its internal combustion engine to drive it is an antediluvian monster. For an airplane, as the name implies, requires atmosphere. It requires atmosphere for its wings to ride on and for its propeller to grip into. In the vacuum of empty space, an ordinary airplane, if you could get its motor to operate by feeding it oxygen artificially, would behave like a fish thrashing its tail uselessly on dry land.

A rocket ship, on the other hand, in which one of the liquid propellants supplies the oxygen to produce combustion, works at its greatest efficiency in outer space. It has no air drag to contend with, no matter how fast it travels, and, as we know, air drag increases with speed. Moreover, when a rocket ship gets far enough away from the earth so that gravitation becomes almost negligible, it doesn't even have gravity to contend with.

But what about the rocket jet? someone might ask. Well, the ordinary rocket jet requires air for its combustion. It lives on air even though its motive force is the same principle as that of the rocket. The rocket jet eats air, and the more air that can be rammed down its throat in flight the faster it can go. It operates like a bat or a chimney swift. The bat flies through the night air with its mouth open. The faster it flies the more insects it can

swallow and under ideal conditions the more insects it can swallow the faster it can fly. So the faster a rocket jet flies, the more air it swallows; and the more air it swallows the more oxygen it can get to operate the turbojets that thrust it through the air. And it would continue gaining speed until its wings became incandescent.

But now to return to the simple rocket that we plan to use in a space ship. As we have seen, the principle on which it operates is so simple that one wonders why it was never used before. But perhaps for the very reason it is so simple, motive engineers overlooked it. They overlooked it mainly because gunpowder and rockets were by tradition regarded as inseparable. Yet as soon as someone discovered that chemicals could be used in place of gunpowder, the rocket jet began roaring on from one improvement to another.

Liquid propellants were what the Germans used in their V-2's. They were the first to use liquid propellants in a big way but they were not the first to discover that it was possible to use them. That honor goes to an eccentric and almost unknown New England scientist by the name of Robert H. Goddard. He lived in the little town of Auburn, Massachusetts, and began terrifying his neighbors' cows way back in the early 1920's by shooting liquid-propelled rockets high into the air above their barns. Finally the frightened neighbors ganged up on him and Professor Goddard was brusquely ordered to take himself and his blooming rockets the heck out.

So the old professor packed up his fireworks and moved down to New Mexico, where he was the first to shoot rockets into the cloudless sky above the desert. It's true he didn't get very far, and his rockets didn't fly very

high either. It was left to the Germans to start shooting them a hundred or so miles into space. For just as the Chinese turned the rocket into a military weapon to frighten their enemies' horses, so the Germans developed Goddard's ideas into the frightful and devastating V-2's. While we as a nation were busily developing the atomic bomb, the Germans were trying desperately to develop their V-2. They were convinced that they could lay waste England with them—perhaps even bomb New York City.

The V-2 was a rocket forty-six feet long and weighing fourteen tons when fueled with alcohol and liquid oxygen. It was not a guided weapon and its aim was inaccurate, because at a certain height the power would automatically be cut off and the little graphite vanes in the exhaust stream could no longer steer it. Neither could its fins, for at a height of more than fifty miles, where little atmosphere exists, the fins had nothing to function in. Like an ordinary artillery shell it would go tumbling head over heels until it descended into atmosphere again where the tail fins would straighten it out. It would strike the earth at a speed of three thousand miles an hour, traveling at such a rate that its sound would follow it and the roar of its approach would be heard seconds after the warhead had exploded.

Many of these German technicians had become interested in the rocket through their interest in space flight. Wernher von Braun, the ablest technician among them, declared that his main interest in developing the V-2 was to work out methods of reaching outer space. Though this declaration of von Braun's must be taken with a grain of salt, at any rate he was one of the first among the German scientists to realize how important were Professor God-

dard's investigations into the use of liquid propellants.

Poor Professor Goddard! Ridiculed by his fellow countrymen, abused by his neighbors, he is still better known in Europe than he is in his homeland. . . .

Perhaps, I thought to myself, as I wrote his name down on the paper, it might be a fitting climax to my lecture to speak for a few minutes about his life. I was just beginning a sentence about him when I heard a knock at the door.

I opened it and found, to my surprise, Dr. Homberg standing there, a stiff smile on his bespectacled face.

"I have been sent," he said, as he gave me a military salute, "to announce dinner. Will you come?"

I looked at my wrist watch. I had been so busy getting my things in order, writing some letters and outlining my lecture that I had forgotten lunch and now it was time for dinner. Asking Homberg to wait a moment, I addressed my letters and left my room with him.

Outside I found the sun had already sunk below the crater's rim; the scoriac escarpment, as the geologists would have called it, was in darkness. A crescent-shaped shadow moved like a jagged sickle across the eastern half of the *caldera*. Already lights were blinking in the dormitory windows and the great dome of the central building was aglow with lights. From the various buildings poured students hurrying to dinner.

Except for its strange location in that desolate crater, cut off by the jagged wall from all the world except the world of stars above us, it was like any other college campus at suppertime. The students were calling to one another and as Homberg and I walked along, a student wearing a ski cap tooled softly past us on a bicycle.

Dr. Homberg cleared his throat. "It's a real pleasure to have another astronomer here," he began. "I know we will make a good team at the observatory. I know your name quite well. I've read several of your papers in the learned journals. Ah, they were most brilliant, most profound!"

"Very kind of you to say so," I remarked and then lapsed into silence. I was afraid that the good professor had started his pumping operations by attempting to butter me up. It was true I had published a paper or two on the asteroids, but they were hardly what anyone could describe as either brilliant or profound.

"I wondered when I read them," Homberg continued, "where you had received your training. If you will forgive me, please, for saying so, but they seemed to reflect a mind much more thoroughly trained than that of an American."

"Most of my training was in the States, I'm afraid," I said briefly for I realized that Homberg was fishing around to discover if I knew him, or if he had once met me.

"But you have studied elsewhere? In Europe, may I ask?"

"In one or two foreign universities. And you?"

"Yes, I, too, have studied in foreign universities. In my own Poland and in Germany."

There was a pause.

"The European universities are delightful places to pursue one's studies," I stated.

"You found them delightful?"

"Yes, indeed. I found them most delightful. And you?"

"Oh, very!"

There was another pause. Realizing that this idiotic conversation, in which the two of us seemed to be feinting like a pair of immature and slightly frightened boxers, could not go on much longer, I changed the subject. However, the professor's remarks seemed to imply that he had been unable to place me, though I had the impression that, like myself, he remembered my face.

"It is a delightful evening," I said.

To this he agreed and we proceeded to the dining room conversing harmlessly about the weather. However, as we entered the foyer of the building and were about to enter the dining room with a crowd of students, the doctor halted.

"But you have forgotten to mail your letters!" he exclaimed.

Before I could protest he snatched them from my hand and disappeared outside.

For a moment I stood completely nonplussed, undecided whether or not I should run after him. I tried to remember quickly what I had written, for one of them was a long letter to my mother telling her all the news. Finally deciding that perhaps the doctor would find nothing of any value to himself, even if he were dishonest enough to open them, I pushed my way through the door into the dining room.

At one end stood the great serving table, with huge platters of food to which the students were helping themselves, carrying their meals back to the tables. I went toward it to help myself, but I had hardly moved ten feet when someone seized my arm. It was Spender.

"You're sitting with us," he told me. "The boys will bring us our food."

He then led me to the head table under a great window through which I could see the moon dimly shining. I was then introduced to a number of the professors, all young men, including Tago. I had expected for some reason to find Tago lean and old, but to my surprise he was neither. He was young like the rest of us, with a swarthy face and a thickset body that gave the impression of great strength. Digits I was glad to see there along with several others whom I do not need to mention at this moment.

I noticed that, at one table, set apart from the others, sat about thirty students. I observed that they seemed a good deal less husky than those around them. I asked Spender if there was anything except their size that distinguished them from the others.

"They're our space jockeys," Spender said with a laugh. "They're vulgarly known as the Space Bantams or just the Runts."

"And what's their function here?" I asked.

Spender then explained to me that since on any space craft weight is at a premium—"every man is worth his own weight in nitric acid and not an ounce more"—the crew must be as light as a crew can come.

"Yes, sir," Spender continued. "They are the *crème de crème* here . . . selected with the greatest care. No man sitting at that table is more than five feet four and none weighs more than one hundred twenty-five pounds. Real jockey weight."

"They get special food?" I asked.

"Nothing but proteins, to keep them healthy and

their weight down. They're a tough little bunch of fighting bantams, too." A tone of pride came into Spender's voice. "Our future spacemen!"

"Why isn't Digits among them?" I asked. "Couldn't he make the grade?"

Spender nodded across the table where Digits was bent low over his plate. "Look at him eat," was all Spender said.

Food, as Spender had explained, had been brought to us. It consisted of steak, baked potatoes and other vegetables. I noticed with surprise, when the plate of light metal was placed before me, that the fork and knife were attached to the edge by a thin segment of metal which one had to break off before they could be put to use. Utensils and platter had evidently been stamped out of the same strip of metal.

Spender saw me puzzling over them and laughed.

"Understand the reason for that?" he asked.

I confessed that I didn't.

"It's the way a bunch of mechanically minded men can simplify housekeeping," he explained. "When the meal is over we chuck everything—platters, forks, knives along with the scraps—into a hopper that extracts all the metal from the refuse. The metal—it's an extremely ductile alloy—is then rolled into strips and stamped out again as we need 'em. Simple, eh?"

"Holy mackerel!" I exclaimed. "Who ever thought of *that* brilliant scheme?"

"The engineer just across the table from you. He worked it out at home. Tired of washing dishes for his family."

"Don't even have to stack 'em."

"Right," Spender said. "And sterilizes them besides."

"And how about the cooking? These steaks . . . ?"

"Infrared rays. We use the same method in the training ship."

At this moment Dr. Homberg hustled up to the table. He seemed quite out of breath as he slammed down his plate and sat at the far end. I watched him out of the corner of my eye as he fiddled nervously with his food. Had he, I wondered, found what he was looking for in my letters?

Spender interrupted my gloomy suspicions. "Have a little announcement to make after dinner," he said.

"Important?"

"Rather. Seems the Sinasians have organized a group like ours. Just heard about it from the State Department. I think the boys will like to hear that we've got competitors."

"What are they calling themselves?"

"Astroleaguers. At least that's the way it's been translated. They're evidently imitating us in everything, except our crater."

"Think they've got a Dr. Homberg, too?" I asked.

Spender laughed. "I imagine they're a dime a dozen in that land," he said. He speared a piece of steak with his fork. "By the way, Professor, want a little extra homework?"

I agreed that I wouldn't mind some. "What's the subject?" I asked.

Spender lowered his voice. "It's a brief report I just received from a scientist at M.I.T. on our plans for a thermodynamic reactor to be used for propulsion. Like

everyone else we're trying to develop some way of using atomic power. I submitted our plans to one of the leading specialists in the field. I'm afraid he doesn't think much of it though he makes some valuable suggestions."

"I'd like to see it," I said. "Is it highly technical?"

"Pretty deep," Spender admitted. "That's the reason I'd like you to go through it. I'll send it over."

"How far have you got toward using atomic power?" I asked.

"Quite a distance," Spender said. "Some of our ideas were so far advanced that I didn't dare submit them to the M.I.T. man. We've got 'em locked up in my office. We've even gone into the subject of a photon reactor, using light itself to drive a ship. Out deep in space, where there's no gravity to contend with, light itself might possibly be used. However, the photon thing is still under wraps and we're moving along that line with care."

Then raising his voice again, Spender asked me how I was getting along with my lectures. I explained what I was trying to do.

By the time we had talked that question over, dinner had ended. A gong sounded and in the sudden hush Spender stood up. After a few introductory remarks, he read the statement from the State Department. During the reading he halted several times to point out the resemblance between the Astroleaguers and our own organization.

I was glad to notice, for nothing can disrupt morale more rapidly than the evil virus of suspicion, that Spender took care to deny that there had been any treachery or disloyalty afoot. But he emphasized the fact that

the Astropolitans were now in a competitive field of their own class and they must exert every effort to win.

"We must be the first," he ended his talk, "to launch a manned space craft into the skies. We must be the first to establish a foothold in space. We must plant the flag of the United States and the Young Astropolitans upon the moon!"

Cheers rocked the hall.

Assembly over, Spender walked me to my quarters. The response to his talk had left him in high spirits.

"A fine group of eager beavers," Spender said. "Watch how things hum now." Then a thought occurred to him. "But you haven't seen the place yet. I'll ask Digits to show you around."

"I'm eager to see everything," I confessed. "But there's one thing I'm itching to get hold of even if I didn't come here to use it."

"What's that?"

"The big tube in the observatory."

Chapter 5

THERE'S NOTHING LIKE COMPETITION, as anyone knows, to start things humming and to clear the air. Even the sounds that came into my little study seemed louder, more vibrant. Jeeps flew past my window at a more headlong speed. The rocket motors on their testing stand bellowed murder more lustily.

For a while I sat listening to the sounds that came. Elsewhere they would probably have made it impossible for me to work. At home in my study overlooking my placid campus even the jingle of the Good Humor man going his rounds would knock me off my rocker. But here the sounds stimulated me. Even the bellow of the rockets cleared my head. At least it proved that I wasn't asleep and dreaming.

Or was I?

Here I was lodged in the crater of an extinct volcano with its strange, ancient buildings, its lava caves and its tunnels. The money to support the organization came in part from a nabob faroff in India who wished to discover some outlet for his overpopulated land. The mysterious Dr. Homberg . . .

But enough, I had my lectures to prepare and not much time to waste mulling over mysteries. So pulling

down some books and slipping a piece of paper into my typewriter, I went to work.

My second lecture, I had decided, would treat the two critical velocities in space flight: exhaust velocity and the velocity of escape.

Every Astropolitan, as well as anyone else who wants to know how a space ship operates, will have to deal with exhaust velocity. That is the speed at which the ignited gases shoot out of the exhaust cone and the speed of a space ship is dependent upon it. The faster the jet leaves the cone the faster the ship will move. This is true whether a ship is propelled by ordinary gunpowder, chemicals, atomic fission, or even light. If it were ever possible to use light, the speed of a space ship could reach, theoretically at least, one hundred eighty-six thousand miles per second, for that is the speed at which light travels.

But what is the relation between the speed at which the hot gases leave the jet and the resulting speed of the ship?

Recall Newton's Third Law of Motion: for every action there is an equal and opposite reaction. Now, remember the man jumping ashore from the rowboat. According to Newton's Law (and one's own common sense into the bargain) if the weight of the man and boat are equal and friction is ignored, whatever speed the man has given himself in leaping to the shore will equal the speed at which the boat moves away.

Or again, take the other example I gave: the gun mounted on the handcar. Here, of course, we have a great difference in weight. Let us say that the bullet shot from the gun weighs a thousand times less than the handcar.

When the gun is fired, the handcar, still obedient to Newton's Third Law of Motion, will move in the opposite direction just one thousandth as fast. But if the gun keeps on firing, the handcar will increase its speed until all the ammunition is exhausted.

We will come back to an interesting and important fact about this acceleration later on. But here we must begin talking about molecules, for it is molecules that move our space ship just as the bullets move our handcar.

Gas, like everything else, is made of molecules. They are always in motion. But the warmer they become the more they move about until when the real heat is applied they become very much agitated indeed. In fact when they become very hot they reach a high state of excitement, rush about in a distracted manner banging against each other and against the walls of their container. When they begin doing that they begin exerting what we call pressure.

It is these highly excited molecules seeking escape that move our space ships. When, for example, a combination of oxygen and alcohol is ignited in the combustion chamber of a rocket motor, the two begin to act like a panicstricken mob aboard a burning ferryboat. Inside the boat the molecules, or people, are milling about at a furious rate, banging up against one another and against the walls that hem them in. Now, let us say that only the stern of the ferryboat is open to escape, the bow being completely blocked by trucks and cars. To escape the confusion and fighting, the panicstricken crowd starts jumping off the stern just as fast and as far as they can jump. What happens to the ferry?

It will, obeying Newton's Third Law of Motion, start

moving, just as our rowboat did, in the direction opposite to the one in which the terrified mob is jumping. And it will continue to move, faster and faster, until the last passenger has jumped off.

Now the problem is: What must the loaded ferry weigh so that it will attain the average speed at which each passenger jumped? Or, to put it in technical terms, how much propellant must a space ship carry in order to reach the exhaust velocity of its propellant?

By a complicated mathematical process into which I will not ensnare my students at the present moment, it has been found that the takeoff weight of a ship, which includes fuel and pay load, must be 2.72 times the burn-out weight of the ship before it can reach the exhaust velocity of its fuel. This ratio always remains the same. If a space craft is to travel at twice the speed of its exhaust velocity, the takeoff weight must be the square of 2.72. That is to say, a ship must weigh 740 tons at takeoff and one hundred tons empty, to double the fuel's exhaust velocity. If the velocity is tripled then 2.72 has to be cubed so that the ratio between takeoff and burn-out weight is about twenty to one.

But before we can triple the velocity, if we are using liquid propellants, we reach a dead end. It is a dead end for our engineers because a space ship that must carry such a large proportion of fuel to its own weight becomes an engineering impossibility. The ship would have to be a great bloated fuel tank with little room remaining for instruments, passengers, or even a motor. It would have to be all stomach, like an amoeba. So, as one can plainly see, a space ship, a one-stage space ship, powered by liquid propellants, can theoretically never reach a velocity

of three times that of the exhaust velocity of the fuel that propels it.

Now, different combinations of chemicals in combustion have different exhaust velocities and there are a large number that can be used. Black powder, a solid propellant of course, which was used by Professor Goddard, is one of the slowest. It leaves the combustion chamber at what one might call a slow walk of 1,968 feet per second. Hardly more than twenty-two miles a minute. A combination of alcohol and oxygen (used in the V-2's) has an exhaust velocity of 2.5 miles a second; alcohol and ozone, 2.7 miles per second. Methane mixed with ozone to produce combustion moves out at the rate of three miles per second, while hydrazine and oxygen, about the wildest pair known, have, when they start mixing it up, an exhaust velocity of 5.7 miles per second, 343 miles a minute, or 20,580 miles per hour!

But here we approximate another critical velocity—that of escape.

And here, too, I paused. Time, I thought, for a little ten-minute examination. A bore to everyone, I knew, but a good Astropolitan must get the basic theory of space flight straight.

I wrote down half a dozen questions:

1. Why does a rocket work best in a vacuum?
2. Why is Newton's Third Law of Motion important for an Astropolitan to know?
3. If the push or thrust of the fuel remains constant, why does the ship's speed continue to accelerate?
4. What is the relation between the takeoff weight of a space ship and its burn-out weight when the ship has

reached exhaust velocity? How would you double the velocity?

5. Why are alcohol and oxygen used together?

6. What is the difference between a jet plane and a rocket ship?

Having jotted down these six questions, I returned to the critical velocity of escape.

The velocity of escape is the speed a ship must reach before it can climb over the wall of gravity and escape. For the earth this critical velocity is seven miles per second or twenty-five thousand miles per hour. However, every large body has its own escape velocity which varies according to mass. To escape from the moon, for example, a ship must reach the speed of 1.5 miles per second; from Mars, 3.1.

There is a simple method of discovering what the escape velocity is, for we have only to reverse the direction of motion. That is to say, a body falling from infinity will hit the earth at the rate of seven miles per second which, as we have seen, is our escape velocity.

Every good artilleryman knows that if you fire a shell from a gun in a more or less perpendicular direction it will return to earth at the same speed it left the gun's muzzle. So if we wish to reach the moon and want to discover what speed we must develop before we can get there, we have only to reverse the process and find out at what speed our ship would strike the earth if it were allowed to fall freely toward it.

Calculating the resistance of the atmosphere is extremely complicated, for it depends, not on weight, but on the size, shape and speed of the falling body. In gen-

eral it can be said that air resistance reduces the speed from anywhere between 5 and 10 per cent.

But why, one might ask, does a ship have to reach the speed of seven miles per second in order to leave the earth? Why couldn't it leave at a slower rate and rise as a balloon does until it reaches a point in space where the earth's gravity is nonexistent?

Theoretically this would be possible. Theoretically a space ship, loaded with a tremendous amount of fuel, could travel into deep space at the slow speed of, let us say, a mile a second. But this would be so inefficient a method that, practically speaking, it would be an impossible engineering feat. It would mean that the ship had to carry most of its fuel for most of its trip. No, the most practical method is to exhaust the fuel and get rid of it as soon as possible.

This is the reason why the most efficient method would be to shoot the space ship from a cannon. Then it would leave all the load of fuel behind. This was Jules Verne's idea, back in 1865. His moon ship was shot from an enormous cannon nine hundred feet long, loaded with four hundred thousand pounds of gun cotton. But aside from the fact that the violent acceleration of Verne's ship would have flattened out his passengers like so many pancakes, the tremendous air resistance developed in the nine hundred foot barrel would have choked off all progress. The ship would probably have landed in the grass a few hundred feet from the cannon's mouth.

But the idea was a perfectly sound one, even though it is a hundred years old. For the main idea in getting a ship off the earth is to gain speed as rapidly as one can so that there is as little fuel to carry as possible. It is some-

thing like a mountain climber who must fuel himself with oxygen in order to make a high climb. If he could fill himself up with oxygen before he started he could climb a mountain without lugging along a lot of heavy oxygen bottles with him.

So it is with a space ship. The longer it remains close to the center of the earth's gravitational field, the more fuel it will require to rise. It must reach the escape velocity of seven miles per second as quickly as it can. And once it has reached that speed the motors can be shut off and no power on earth, at least, can prevent it from proceeding freely into outer space.

But here we come to another problem. How can a space ship reach the speed of seven miles per second, or twenty-five thousand miles per hour, if the highest exhaust velocity we can obtain from liquid propellants is nine thousand miles per hour? And if, as we have seen, it is an engineering impossibility to construct a ship that could carry much more than twice its weight in fuel?

Here is where the three-stage ship comes in. After the first two stages, or two lower sections of the ship, have exhausted the fuel they carry, they each in turn are released and drop back to earth. The top stage, with its crew, then continues on its way under its own power.

This method resembles the technique employed by our mountain climbers who are fueled by oxygen. Let us say that there are eight of them who begin the climb, though only one of them plans to reach the peak.

For the first ten thousand feet, five of the group, using their oxygen bottles, push and haul the other three, who, not having to exert themselves, need no oxygen to climb. At the end of the first hitch, when the oxygen of

the five climbers is exhausted, the first five drop back, and two of the remaining three open the valves of their bottles and push and haul the third man until their bottles are exhausted. Here they drop off and the third man, with his bottle intact, opens the valve and climbs to the peak alone.

This method, the "booster method," is one that will be employed to get a space ship up through the air and the gravitational pull of the earth. But there is another method which will be employed, in addition. It is the method of establishing a fuel dump at a certain height above the earth where a ship, bound for deep space, can take on a load of fuel after it has exhausted its own.

Let us return to our hardy mountaineers.

Instead of eight starting out this time, let us say that only seven do, but each man carries a little more oxygen than is necessary to reach fifteen thousand feet. Upon reaching this altitude the seven combine their extra oxygen, cache it, and return to the base camp. Then the eighth man takes off, carrying just enough oxygen to reach fifteen thousand feet. At that point he picks up the cache of oxygen and so proceeds to the top.

It is probable that both these methods will be combined to reach outer space. But the idea of a fuel dump or space station revolving around the earth at, let us say, one thousand miles above us, is one that brings up some other interesting mechanical problems. For how can a space station or fuel dump keep revolving around the earth without expending an ounce of fuel itself?

But here we get into another of Newton's Laws of Motion and here, I thought, was a good place for me to sign off.

Pushing back my chair from my desk, I got up and went to the window. I had ended my work at the proper moment, for as I looked out I saw Digits and Tago hurrying across the campus.

They came into my room in high spirits. Digits had thoughtfully brought my lunch over for I had forgotten to pick it up when I had finished my breakfast. He also handed me an envelope.

"Spender sent this over," he said. "He wants you to go through it. I think he mentioned it to you earlier."

While Tago looked over my books, I opened the envelope and glanced through the document it contained. I saw at once that it was far too technical a report to read casually so I replaced it in its envelope and laid it aside, intending to study it when I had more time. I turned to where Tago was standing.

"By the way, Tago," I said, as I munched my sandwich. "I've just been preparing my lectures and have reached the question of a space station. What's your idea on the subject?"

Tago, who had just opened a book, turned and looked at me.

"I imagine it's the same as yours," he said. "And Digits'."

"In other words, you feel that a space station should be used only as a fuel station."

"For that and other peaceful purposes. As a weather station it would be invaluable. Revolving around the earth every two hours it could give us a perfect picture of what the weather was anywhere. Weather predictions could be made without the possibility of error."

"I take it, then, that you're not interested in the military possibilities."

"Not in the slightest," Tago said. "Our purpose here is to find a new world, not to dominate this one." He closed the book with a snap. "But I'm afraid that there's a group here at Astropolis in favor of what they call 'orbital dictatorship.' "

"You mean Dr. Homberg?"

"Yes," Tago said. "And the little group he seems to be cultivating. In a place like this, shut off from the rest of the world, one is in constant danger from small dissatisfied groups trying to disrupt things and gain power."

"I thought that Homberg was all alone in his opinion about the space station."

"Not at all," Tago said. "He's passed on his own bug to quite a number of the students. Hasn't he approached you yet?"

"Not about that," I admitted.

"He will," Tago said. "I very much fear that he's organizing some sort of underground resistance. I wouldn't be at all surprised to see him and his followers try to get Spender out."

"And Homberg to replace him? That would be a tragedy."

"It would indeed," Tago said. "You wouldn't like to see Spender go, would you, Digits?"

Digits grinned. "I'd like to see Dr. Homberg try. Spender's got some pretty loyal men here. I don't think Dr. Homberg would dare start any funny business."

"Let's hope not," Tago agreed. "But unfortunately I've met many men like him in this world. The hunger for power becomes a madness some people can't control.

They're like dogs that start killing sheep. Once they've tasted blood you can never break them of wanting more."

"You give me the creeps, Tago," I said.

He laughed and shoved the book he held in his hand back into the case. "Ah, it's too nice a day for the creeps," he exclaimed. "Digits and I came here to take you for a walk, not to give you cold shivers. How about it?"

"Nothing I'd like better," I granted. "Let's go."

It was pleasant outside. A breeze that had managed to climb over the jagged rim of the crater swept across the campus, bringing with it a wonderful hint of orange groves and the distant sea. I was beginning to enjoy the place and I confessed as much to my two companions.

"Oh, we all come to like it here," Digits said. "When I first arrived a couple of years ago I thought I couldn't stay here for more than a week. Thought I'd go crazy. But as soon as I began working I forgot how remote from everything we are."

"It's the teamwork," Tago said. "The spirit of co-operation and the knowledge that we're all working for one purpose. But the purpose is important, too. I doubt you'd find such willing workers if there weren't a great future ahead of us."

We strolled along together. We were now close to the observatory and since I had not yet inspected it, I asked my friends if they would mind showing me through it. They agreed and for an hour they stood by while I inspected everything. I was overwhelmed with the amount of fine equipment I found there. Even though I realized that I was to share the place with Dr. Homberg, I looked forward to using the great tube that now stood covered and in darkness under its dome.

From the observatory we moved on to some of the other buildings, the powerhouse, the laboratory, the great hangars, and the great sphere which was being used as a training ship. However, by the time we had come to this last item, I was beginning to suffer from what Digits described as "crater feet" and so reluctantly I returned to my room.

My head was weary and my feet sore but I immediately went to work on the report Spender had sent me to study. In five minutes I was knee-deep in sines and cosines and I stayed knee-deep in them until late that night.

Chapter 6

THE LURE OF THE OBSERVATORY was a hard one for me to resist. Though I spent most of the day working over my course of lectures and studying the report Spender had given me, immediately after dinner each evening I hurried to stare through that forty-inch lens.

For the first few evenings I had it to myself and two assistants, for Dr. Homberg seemed to be busy elsewhere. It's hard for me to describe the pleasure I took in simply ranging the heavens with that great tube. I had, of course, looked through bigger ones, but never before had I had the free use of one myself. I'd always been on a long waiting list with someone standing by ready to elbow me away when my brief time was up.

I was glad I had this occupation at night to keep me busy. Discord, dissension, suspicion, wire-pulling had always thrown me and I must confess that I was beginning to meet Dr. Homberg's underground work everywhere I looked. But with my eye glued to the great telescope, I could forget everything, even space stations and "orbital dictatorship."

However, if the issue of a space station came up, as it seemed bound to do, I felt that my students should be ready to argue the question intelligently. For aside from the practical engineering problem of getting a station

up into space where it could revolve around the earth, there was a whole slew of other problems which involved an understanding of the principles that would keep a space station in its orbit, and why, once it had been set in its orbit, it would continue to revolve around the earth without any expenditure of fuel.

For all practical purposes, space begins at the height of 120 miles above the earth. That is where the atmosphere has become so rare that one doesn't have to consider it in any calculations. There is no longer any air drag to contend with, though, of course, lack of air itself brings up a host of other problems. But if we haven't atmosphere we still have the earth's gravity.

The earth's gravity, as we know, decreases in an inverse proportion to the square of the distance between the center of the earth and the object. From the point of view of a human being this rate of decrease is very slow indeed. Even at the height of 250 miles an object loses only 10 per cent of what it weighed at sea level. A two-hundred-pound man, hoping to lose some weight, would have to climb to 250 miles above the earth in order to reduce his weight twenty pounds. It isn't until we reach distances in the thousands that the loss of gravity becomes really noticeable. This is important for some students to remember. I've met many who seem to think that the atmosphere and gravity end at about the same distance. However, they have only to remember that the earth's gravity even at the distance of two hundred thirty-eight thousand miles is powerful enough to hold the moon in its orbit.

But to return to the problem of a space station. The

first question that always arises is what would keep it up in space?

There are many ways of explaining it. An astronomer would tell us that a space station, once given the proper speed, will not fall down for the same reason that the moon doesn't: that the centrifugal force of the space station in its orbit will counterbalance the gravitational pull exerted by the earth.

But perhaps it might be simpler to explain it the way a physicist would. The first thing a physicist would ask you to do is to imagine a mountain so high that the atmosphere needn't come into any of the calculations. Now upon the top of the physicist's mountain are a number of high-powered cannon each facing in a horizontal direction. We will begin firing them.

The first cannon fires a shell that has a muzzle velocity of a quarter mile a second. The shell upon leaving the cannon will start curving down and will strike the ground not far from the foot of the mountain. We next fire a cannon with a muzzle velocity of a half mile a second and we find that it shoots even farther.

Now, why does this happen? Why does the shell curve down toward the earth and travel farther from the mountain when it has been given a higher velocity? The question seems too simple for an answer, but its simplicity deceives us.

The reason that the shell behaves as it does is that it is obeying two of Newton's Laws at the same time. One of the Laws is that a body in motion, unless operated upon by an exterior force, continues to move at a constant speed along a straight line. This is the motion

that the cannon gives the shell. The second Law operating is Newton's Fourth Law of Motion; i.e., that every body attracts every other body with a force that is directly proportional to the product of their masses, and inversely proportional to the square of the distance between them. In other words, the shell is also obeying the law of gravity and falls toward the earth at a fixed rate of speed. So with both laws operating, the shell simultaneously moves forward and falls.

Now let us increase the muzzle velocity of the cannon. We shall see that the shell tends to follow the curvature of the earth, for the shell's range has become greater. Continue increasing the speed of the shell and we shall finally find the shell traveling all around the earth, or to state it more accurately, it will be "falling" around the earth.

The speed at which a shell, or space ship, would travel around the earth at sea level (atmosphere being ignored) is five miles a second. At greater heights the speed needed to keep a space station circulating round the earth becomes less. For though the space station at sea level would journey around the earth in eighty-three minutes, a space station at the height of 346 miles would do it in ninety-six minutes and still stay in its orbit. At the height of 1,037 miles, where Dr. Homberg was planning to operate his space station, it would revolve around the earth every two hours.

But would a space station need power to keep itself revolving around the earth?

It would not. It would need no more power to keep it revolving than the moon needs fuel to keep it orbiting around the earth every twenty-eight days. For once it has

been set in its motion above the atmosphere, it will find nothing there to slow it down or impede it in its way. It will, to use a technical phrase, be in "free fall" like the two moons that revolve about Mars, or like our own satellite, our moon.

As by all definitions the space station or satellite station is a falling body in "free fall," things inside it will naturally act as if they were in "free fall," too. That is to say they will act as if they had no weight, or, to use another technical term, as if they had zero gravity.

On the surface of the earth we very rarely experience zero gravity for any length of time. We experience it when an elevator starts down or for the first few moments when we jump off a high diving board before the air builds up a resistance to our bodies. It makes us feel as if things had begun to float inside of us and it takes away our breath. But, as I say, the sensation rarely lasts for more than a moment.

In a space station, however, orbiting around the earth at 17,500 miles an hour and a thousand miles above the earth's surface, it will not only be our stomachs that float; everything will. Chairs, pencils, liquids, clothing, human beings themselves—everything will act as if it were floating in air. I say "in air," but they would float quite as well in a vacuum for they all have been released from the power of gravity. Things on the moon would float, too, if the moon didn't have a gravity of its own to hold things down, a surface gravity of about one-sixth that of the earth. In other words, a pound there would weigh by the earth's standards only 0.165 of a pound. But the gravity that a space station has of its own would be too minute to have any effect.

Little, still, is known about what happens to the human body when it is submitted to zero gravity for any length of time. It's too difficult to reproduce artificially. A centrifuge can build up gravity by centrifugal force so that a human being will weigh six, eight, fifteen G's—six, eight, fifteen times his normal weight. It is true that aviators have been able, at high speeds and flying in a parabola, to produce zero gravity in the cockpits of their planes but they haven't been able to take it for more than a few seconds. They start to black out and have to pull up into level flight.

The problem of zero gravity is an important one for it is both a help and a hindrance. The crew aboard a space ship must contend with it. For zero gravity will be found there, too, though for slightly different reasons than aboard a satellite station. Floating around in the cabin of a space station or space craft will be no fun. . . .

At this point I decided to end my lecture. And it was high time for me to end it. As I looked up I saw Homberg standing in the door and studying the back of my neck.

He was immediately all smiles.

"Did I disturb you?" he asked in his oily manner as he came toward me. "Working on your lectures?"

I rose to my feet. "Yes," I told him. "Working out my lecture on the space station."

"Indeed!" he exclaimed, his face brightening with interest. Then licking a cigarette paper he eyed me closely. "There seems to be a slight difference of opinion around here on the function of a space station. What's your attitude, may I ask?"

"I was just treating the subject as a mechanical

problem," I said, avoiding his question. "I haven't any opinions on the subject."

"Come, come." Homberg lighted his homemade cigarette. "Everyone has an opinion on the space station. Even Tago."

"I'm unaware what it is," I said. "I've come here merely to teach what I know about astrophysics to the students. My contract with Spender doesn't call for my opinions on anything else."

"Of course." The doctor blew a puff of smoke into the air and gazed around my room. "Just the strictly scientific approach. Well, I suppose it has its own field. But tell me, what do you think of Tago? Didn't I see you two strolling about the grounds yesterday?"

"Why, yes."

"Well, what did you think of him?"

"He gave me the impression of having a great deal of shrewd wisdom."

"Hah!" Homberg exclaimed. "You just hit the word. Shrewd. That's Tago in a nutshell."

"I said 'shrewd wisdom.' "

"Oh, perhaps. Orientals often give the impression of possessing a secret wisdom that no one else west of the Suez Canal can boast of. However, it usually turns out to be sheer poppycock though it often may sound like wisdom. That's what makes it shrewd, as you say."

As I did not respond to this remark there was silence for a moment. Homberg continued. "I came to Astropolis two years ago for the same reason you did, strictly in an advisory capacity, but I soon began wondering."

"About what?"

"About where all the money is coming from." Hom-

berg paused as he studied my face. "About where all the vast wealth that a place like this requires comes from."

"I thought that was clear. I understood that an extremely rich prince in India who had become interested . . ."

Homberg broke into laughter. "How credulous we are! I believed the same thing myself, until I learned better. It's true the money comes from India, but India is not its real source."

I did not know how to reply to this remark. From the very beginning the explanation of where the money supporting Astropolis came from had seemed to be a little fantastic. It was true, I realized, that some of the wealthiest men in the world have been rulers of large and rich provinces in India. Hadn't we all been raised on the newspaper stories of the Aga Khan, whose yearly tribute from his subjects was his own weight in gold? However, in spite of myself Homberg's remarks certainly aroused my curiosity.

"Where do you think the money is coming from?" I asked.

"I will let you guess," he said.

"Is Spender aware?"

"That, I have no way of knowing." Homberg lowered his voice. "Spender is so wrapped up in the project that he doesn't bother with such vulgar matters. He's interested in getting into space and it doesn't matter to him where the money comes from or where he gets it. I don't mean that he's not honorable in every way, I only mean he's—how shall I say it?—a bit on the dreamy side."

I couldn't help getting a bit hot under the collar.

To accuse Spender, with all his brains and executive ability and his sound common sense, of dreaming was downright malice.

"He seems pretty hardheaded to me," I said. "But to return to the source the money comes from. Where do you get this information?"

Homberg smiled and went to my desk. He stood there for a moment thoughtfully tapping the ashes from his cigarette into the ashtray there. "Where do I get my information?"

I saw his eyes roam over my desk, but as there seemed to be nothing there except the outline of my lectures I felt no cause for worry.

"Where do I get it?" Homberg turned toward me with a slight smile. "I shall be very glad to tell you, but not just at this moment." He took a deep breath. "And now how about a little brisk walk over to the observatory?"

I gladly agreed. It was a simple way of getting rid of him. I could drop him off at the observatory and then go about my own affairs. If I pressed him now for any further information he would probably clam up. The few bits he had dropped, I realized, were merely to arouse my appetite for more.

"I haven't seen you any of the evenings at the observatory," I remarked in order to open up a new line of conversation.

"Chess," Homberg said briefly as if my question had interrupted him in some thoughts of his own. Then he suddenly brightened. "Yes, chess. It's my one and only weakness. Do you play?"

I admitted that I did.

"Ah, then!" Homberg said as he took my arm and gave it a little shake. "You must join us. We have a little chess club here, a few rabid chess fans and myself play it until all hours of the night. We even carry on games by mail with chess players in other countries."

"Indeed!" I said. "I've heard of people doing that. Even playing games by telegraph, but my interest hasn't ever been that great. I'm really only a mediocre player, just do it for diversion."

"A wonderful game, but I've known people who have sacrificed their sanity for it. Think of nothing else but gambits and pawns. But you must join us some evening."

"Got a large group?" I asked.

"About twenty or so. Mostly students, with a sprinkling of instructors. We call ourselves 'the Silent Chessmen' and meet in my quarters twice a week."

We had now reached the main building. A number of jeeps stood in front of the main entrance. As we were about to pass by, Digits came bustling out of the front door. Seeing me, he hurried over.

"The boss wants to know if you've finished going over that report I brought over the other day," he said. "Got it with you?"

Somewhat embarrassed, for I had totally forgotten to speak about it to Spender, worried, too, by the fact that I had taken so much time studying it, I asked Digits if Spender needed the report right away.

"He'd sort of like to have it back," Digits observed.

"I'll get it for him right now," I said.

Dr. Homberg, who had started to roll another cigarette, looked up. "The professor and I are on our way

to the observatory," he remarked. "I have an interesting drawing of the configurations on Mars that I'd like to show him. It will only take me a minute or so."

"Oh, that's all right then," Digits said as he turned to me. "Any time soon will be okay, I guess."

"I don't know," I said, still bothered by my negligence. "Perhaps I'd better get it now."

"Oh, come along," Homberg said, taking my arm. "I won't keep you for more than five minutes."

Somewhat reluctantly I agreed to go along. Telling Digits I'd be up to see Spender later, I continued along with Homberg.

As a matter of fact, I needed Homberg's help to rectify a certain deviation of the directional mechanism; my assistant and I had found a little difficulty in adjusting it. Then, too, I was most anxious to see Homberg's drawings. Even at the university I had remembered that his drawings of the moon's craters had filled everyone there with admiration. Besides, anything involving Mars was certainly important as Mars would be one of the first ports of call, so to speak, if any space craft were launched.

"Have you been making Mars your special study?" I asked.

"The moon and the nearer planets always have been," Homberg said. "That's how I became interested in space flight. Now that it's merely a problem for the engineers to work out, I'm beginning to lose my old interest. It's always theory that interests me the most."

"I thought you were interested in a space station."

"I am, intensely," Homberg admitted. "But only theoretically."

"Which means?"

"The military and political aspects. What was it Archimedes said about the lever? Give me a lever and a point to rest it on and I will move the world. Well, give me a space station and an orbit for it to move in and I will rule . . ." He stopped short and threw aside his cigarette with a nervous little laugh. "That is, of course, your United States can rule it."

"I've heard that argument used," I said. "But if I understand correctly, Spender and . . ."

"Spender is a . . ." Homberg burst out, but he caught himself and whatever he had originally intended to say ended only with: "Spender is an adventurer."

There was certainly nothing in his remark that could be denied, and I said nothing. But it was becoming more and more evident to me that Homberg was a man who found it difficult to control his emotions and that his emotions were not only dangerous to himself, but that they were dangerous to everyone. I also detected, I thought, a streak of madness in his nature. However, I am ever wary of looking for madness in anyone. You can always find it even in the most normal of human beings.

We reached the door of the observatory and went in. Homberg left me for a moment to get the plate and drawings. He was soon back with both. He laid them on the table in the small classroom there and I bent over to study them.

I must admit that Homberg's drawing was a masterpiece of care and precision. Drawings of Mars have to be made because the turbulence of the air surrounding the earth is such that a telescopic image never remains steady enough for a time exposure. Only for one fleeting second —and that only rarely, too—does it ever remain station-

ary long enough to see it clearly. For this reason drawings from memory must be made. These drawings require not only native skill in draftsmanship but an accurate visual memory as well. It's a rare gift even in artists, and Homberg, to add to his other accomplishments, seemed to have it to a degree.

Studying his drawing of Mars with its canals and what, at least to me, seemed to be vegetation along their banks and surrounding land, I couldn't help expressing my admiration.

Homberg was delighted with my praise. For a moment his narrow face with its thin mouth and intense, glittering eyes seemed to take on an expression that was positively human.

"So you approve!" he exclaimed.

He then offered to show me other drawings. Indeed, he became quite insistent that I should see them, and before I knew it I had been with him an hour.

Finally freeing myself from his clutches, I hurried back to my room. I had every intention of picking up the report in its envelope and going immediately to see Spender. But when I looked for the envelope on my desk it was nowhere to be found.

Furious with myself for having mislaid it, I ransacked my apartment, tore my clothes out of the closet, emptied the bureau drawers onto my bed and crawled under the bed itself. But the document was gone. I stood in the center of the room wondering miserably what I could say to Spender when I happened to thrust my hand into my coat pocket. I felt something there and drew it out.

Professors have a reputation for being absent-

minded. A professor is quite apt to drop his watch into a glass of water and put his dentures underneath his pillow. He is apt to mislay things. I am not one of these. At least I never had considered myself one, though absent-mindedness, I understand, sneaks up on you from behind. Perhaps I had put the report into my pocket, but I certainly did not remember doing so. However, now that I had it again, I hurried over to Spender's office.

I found him there and fortunately alone. I produced the paper but said nothing of my recent scare.

"Make anything of it?" he asked.

I told him what I thought, that the report was far too pessimistic and that I had caught the M.I.T. professor in several mathematical errors.

"Much obliged," Spender said when I had ended. "But I should have given you a chance to see our own plans for the atomic motor first."

He unlocked a drawer in his desk and took out a large envelope, opened it and showed me some blueprints. "This is what we're working on now," he explained. "If we can get a few more bugs out of it I believe that we have what every astronaut dreams about—a ship powered by nuclear fission. No more slopping around with these dangerous liquid propellants. We Americans beat the world on the atomic bomb and there's no reason why we can't beat the world on atomic-powered flight."

I looked over the plan. "I'd like to study it sometime," I said.

"Glad to have you," Spender agreed. "But it will have to be in this office. I'm afraid of letting this out of my sight. For security's sake it's the only one we keep

here on the crater, though we have another one locked up in a safe deposit box in New York."

"Think this office is a safe enough place to keep a valuable thing like that?" I asked.

"Any fresh reason to think there's danger?" Spender asked. "Something new?"

"Well," I said. "There've been a number of incidents that have occurred since I've been here that sort of bother me. A number of disturbing things I've learned and heard."

"For example?" Spender asked as he took the blueprint from me and, slipping it back into its envelope, locked it up in his desk. "What in particular is troubling you?"

"About Dr. Homberg—that's not his real name."

Spender, having locked the desk drawer, slipped the key in his pocket. "I know it isn't his real name," he said.

"You know it too?" I exclaimed.

"Yes, his real name's von Huegel. Nicolas von Huegel. You've probably heard of him yourself."

"I have," I said. "In fact he once flunked me out of a course in astronomy."

It was Spender's turn to be surprised. "You've known him right along?"

I then explained the circumstance and why I believed that Dr. Homberg had not yet been able to place me. "But why is he going under an assumed name?" I asked.

"He's in hiding," Spender said. "It's a long story and he gave me all the details when he applied for the position here. His own government is trying to trace him.

They want him in their own laboratories. In fact while he was in Europe they tried to kidnap him twice."

"Is that the reason he's suspicious of every newcomer he meets?"

"That's one of his reasons," Spender said. "But he may have several others that concern us. We'd like to find out what they are. Keep on good terms with him, will you? He might let the cat out of the bag. But now I've got to be off to the testing stand. They're fooling around with some new propellants out there and I'd like to see them blow. Want to come?"

I begged off and a moment later left Spender climbing into his jeep.

I walked slowly back to my room. I wondered if I had been entirely justified in not telling Spender of my recent fright over not finding the envelope on my desk when I looked for it. For now, as I walked along, I realized that Homberg could have removed it from my desk, photographed the document at the observatory with the cameras we had there, and slipped it back into my pocket while I was innocently studying his drawings of the canals.

Later that evening, my suspicions of Homberg were further increased. As I went in to dinner Spender handed me a letter from my mother that had just arrived. It was a long letter, giving me all the news.

I was glad to receive it and glad to know that she had received the one Homberg had snatched from my hand to mail. But I was disturbed when she wrote me that my letter seemed filled with fragments of tobacco.

"Are you trying to roll your own cigarettes again?" she asked.

Chapter 7

For all my suspicions about Homberg, baseless or otherwise, I at least found him a great help in my astronomical observations. Mars at that time was at its closest to the earth and I spent my nights with Homberg studying the planet. I had never, as I have said, had free use of a large telescope, and besides that, the altitude of Astropolis with its crystal atmosphere gave the stars a wonderful precision and clearness.

Homberg was, of course, as much interested in Mars as I was, for that was his special field. And though he had several irritating habits, he and I managed to work together as if we were close friends. In fact, I had decided to attend at least one of the meetings of the Silent Chessmen. I will have a good deal to say about this meeting. But now I must report the astonishing incident of which Homberg, I and two students, acting as night watchmen, were witnesses.

It occurred at 2:37 in the morning and had Homberg and I been alone I doubt if anyone would have believed us. But as we had two witnesses, no one questioned our report. In fact the incident became the main subject of conversation for days afterward.

Homberg and I had been working late. We had been studying the configurations on Mars for, as I have said, it

was at its perigee and therefore at its best for observation. In that position it is only sixty-five million miles away—the closest any planet approaches the earth. But it is there for only a brief period and so Homberg and I were wasting no time.

On that particular night, or rather morning, I had become so intent on my work that I had not only forgotten how disagreeable a character Homberg was, but I had forgotten that it was high time for a snack. I did not become aware of this until in an attempt to add a few fine lines to a drawing of Mars I was making, I found that my hand was trembling for lack of food. I suggested to Homberg that we knock off for fifteen minutes and get a bite to eat in the mess room where doughnuts and coffee always awaited anyone who wanted them.

To my surprise Homberg agreed, for he usually turned down any suggestion I made on any subject. The two of us put on our hats and coats, for the nights at that elevation are always frigid, and started for the mess room.

It was a wonderfully clear night, each star sparkling brilliantly as if with a life of its own. We started across the campus toward the mess hall. I remember that as we walked along, Homberg in his crude fashion was pooh-poohing the idea that the canals on Mars were anything more than volcanic fissures lying between craterlets on the surface and that any semblance of vegetation was caused, not by any works of irrigation that the Martians had constructed, but by the volcanic steam rising through these fissures.

"Mars is a lifeless planet, almost without oxygen," he was saying. "Venus is surrounded by clouds of form-

aldehyde. It is absurd to try to reach either. A fantastic . . ."

It was in the middle of this sentence that it happened.

A loud explosion rent the air over us. Stunned by its violence above the crater, whose sides echoed and reechoed the sound, Homberg and I stopped dead in our tracks and stared above us. But we had looked for hardly more than a second when a blinding flash of steel-blue light engulfed the entire *caldera.*

So brilliant was the flash that both of us instinctively bent down and covered our eyes with our hands, for the light was more than the retina could tolerate. For several seconds we remained in this position, but as I stood there, still shielding my eyes in case another flash came, I thought I heard (though Homberg later denied that he had heard it) the distant, hardly perceptible drone of a plane.

"What in heaven's name was that?" I finally managed to exclaim.

"A fire ball," Homberg instantly announced as he gazed heavenward.

"Nonsense!" I said. "There weren't any evidences of its being a meteor. It just was there suddenly above our heads. No streak of light before or after."

"Probably from Mars then," Homberg suggested sarcastically. "You folks are always trying to fill the heavens with life and mystery. It was a fire ball."

At this moment two students who had been acting as watchmen hurried up to us in a high state of excitement.

"What was that?" they both shouted in the same breath.

"It was a fire ball," Homberg repeated positively.

"But, Homberg," I pointed out, "we heard the sound of an explosion *before* we saw the flash. In the case of a fire ball we would have heard the report *after* seeing the flash. Sound waves travel . . ."

"It was a fire ball," Homberg stubbornly proclaimed.

As nothing seemed to budge him from this conviction, I asked the two students if they had heard the sound of a plane. Neither of them had.

"We were making the rounds and had just left the centrifuge building," one of them explained, "when we heard the report. We both looked up and saw the flash. I can still see it when I close my eyes."

"What do you suppose is up?" the other student asked. "Photographing us?"

I had not thought of that disturbing idea and as the four of us walked along toward the mess hall I turned the idea over in my mind. It was a possibility that I hated to admit for I was trying hard to down my suspicions that we had enemies both abroad and within.

While I was doing my best to explain the whole thing as some not unusual phenomenon of nature, Homberg was using the incident to impress the two young men with his obstinate ideas that no life is possible beyond this planet.

"A flying saucer, hah? A space ship from Mars, hah? That's always the easiest way for lazy minds to explain a natural event. Take those famous canals on Mars that the professor and I have been studying. Built by engi-

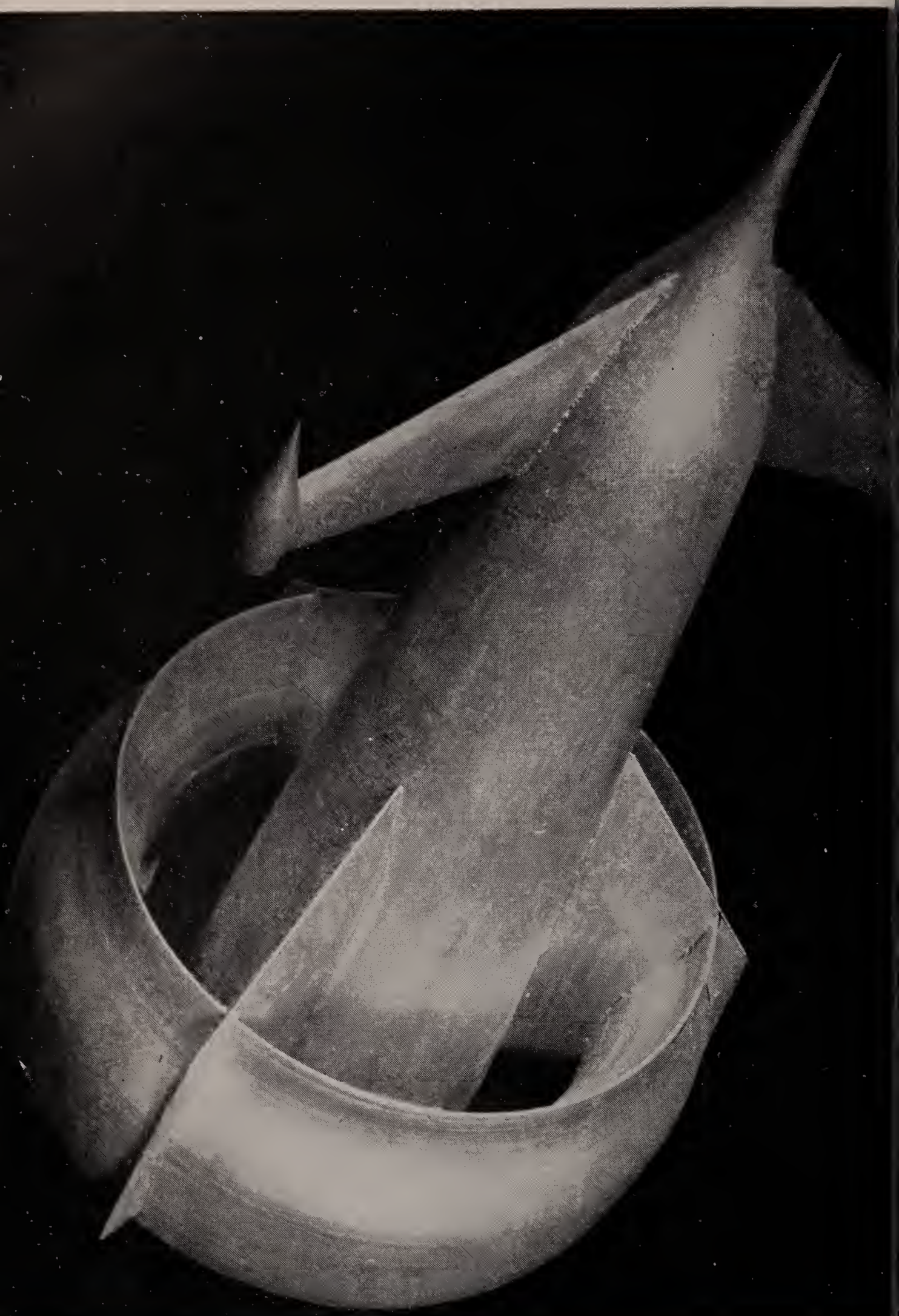
(*Wide World*)

One of the Young Astropolitans, ready for high altitude flying, stands atop a jet plane.

A Young Astropolitan tests a space suit.

(*Collier's Photo from United Press*)

The Astroblast prepares to take off.



(*Weitmann, Black*

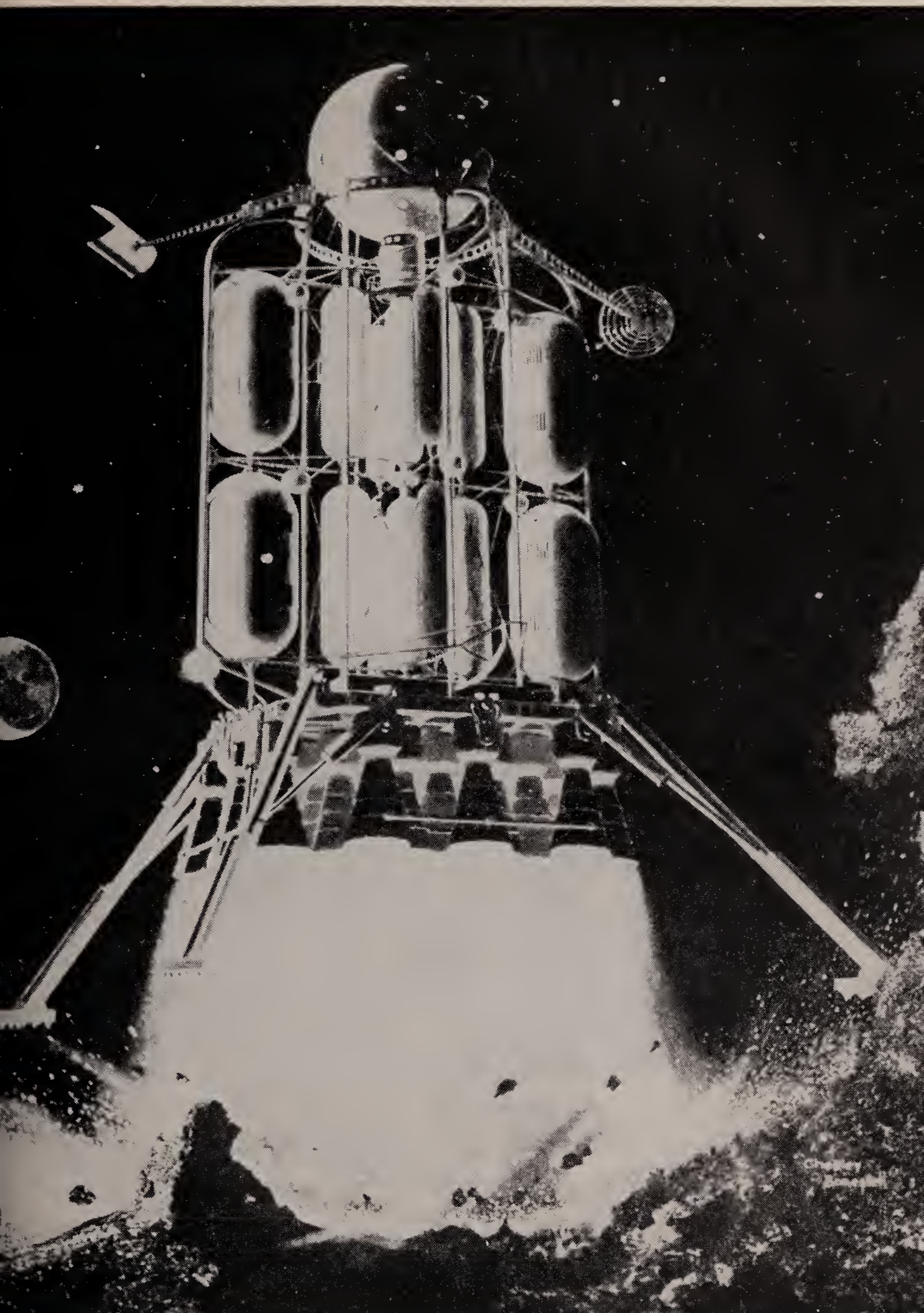
Model of one of the rockets constructed at Astropolis.

(*Weitmann, Black Star*)

The take-off of one of the rockets from Astropolis.

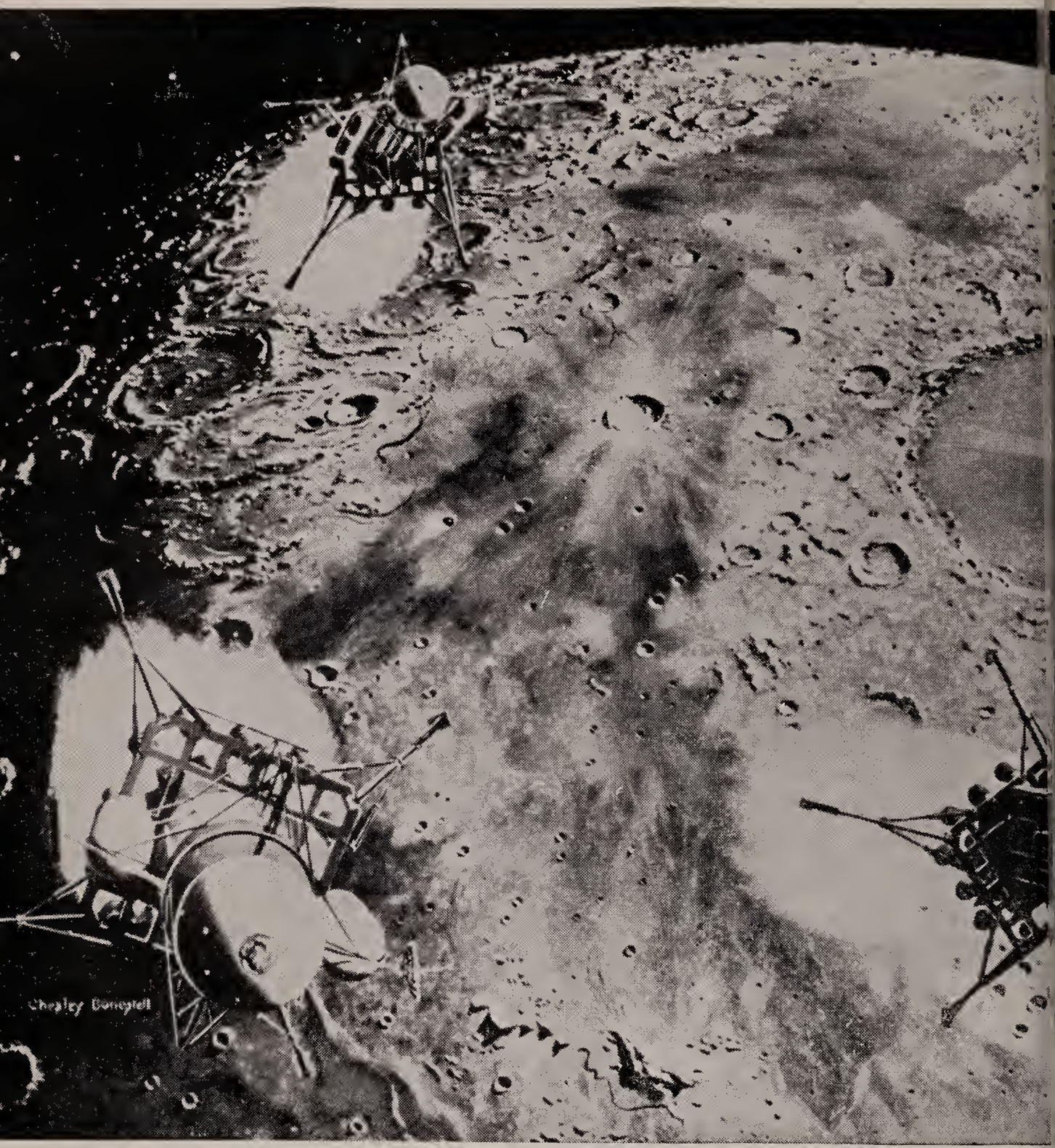
(*Weitmann, Black*

Working on a cooling apparatus at Astropolis.



(*Collier's Photo from United Press*)

The spaceship takes off from the crater.



(*Collier's Photo from Ur d*

An artist's projection of the arrival of space ships on the moon

neers? Poppycock. They're volcanic fissures. If there's any life on Mars it's lichen, the lichen that grows in the rarefied air of our mountaintops. But can lichen dig canals? No. That was a fire ball."

I failed to see why Homberg found this argument so convincing and I was about to ask him again about the sound preceding the flash when one of the students saved me the trouble.

"That is easily explained," the doctor replied. "The explosion took place before the fragments entered the atmosphere and became incandescent."

It was a ready answer, but hardly an accurate one. Tired of arguing with Homberg, I did not point out to him that if the explosion had taken place in a vacuum no sound could have reached us. But I let it go and as we had reached the mess hall I got my coffee and doughnuts. Having gulped them down, I hurried back alone to the observatory, leaving Homberg booming away at his theory that no life was possible beyond the earth and that the flash we had just seen was nothing more than a natural phenomenon.

At breakfast the next morning the "big flash," as everyone had begun to call it, was the main topic of conversation. Tago, with whom I ate breakfast, was particularly interested. He questioned me, especially when I reported to him that I thought I had heard the distant sound of a plane.

"What did Homberg think?" he asked.

"An exploding meteorite," I said. "He seems to be afraid that we will attribute it to Martians, flying saucers, or worse."

Tago's dark eyes grew serious. "To the Martians?"

"Yes," I said. "Homberg's dead set against any theory based on the idea that there's any life on the planets or any life possible."

"I can't quite decide," Tago said thoughtfully, "whether it's a real conviction on his part, a real scientific conviction, or whether it's merely to persuade us that our main objective is not flight into outer space, but only to establish his satellite station a thousand miles above us."

I shrugged my shoulders. I didn't know myself and as we had both finished breakfast we went outside. For a while we stood talking in the brilliant sunshine, standing on the steps.

"By the way," Tago asked, "how do you and Homberg hit it off these days?"

"Oh, we have our arguments," I admitted, "but in the observatory, I must confess, it's a real pleasure to work with him. He's a highly competent astronomer."

"Friendly?"

"Quite," I said. "He's even asked me to attend a meeting of the Silent Chessmen. Understand that's a pretty exclusive bunch."

"They are," Tago said. "Are you accepting the invitation?"

"I thought I might," I said, "though I'm not what you'd call a brilliant chess player."

"I think you'd better go," Tago said. "I'm interested in what it's like."

"You've never been invited?"

"No," Tago admitted. "Though they must know I play the game. They've seen me. But I'd like to hear your impression of the group."

At this moment Spender trotted up the steps and put his hand on my shoulder. "They tell me," he said, "that you haven't seen the inside of our training ship yet."

I admitted that I had only seen it from the ground.

"I'm going there now," Spender explained. "We're trying out a new atmosphere inside it. Going to pump her full of a mixture of oxygen and helium gas. No nitrogen. Want to take a whiff?"

"Going to use me as a guinea pig?" I asked.

Spender laughed. "I'll be with you; besides, a half dozen jockeys are already inside it. Like to see how they're bearing up." He turned to Tago. "Want to come?"

Tago shook his head. "I want to find out more about the big flash last night."

"I'm afraid to," Spender said. "I only hope it was merely the big fire ball Homberg says it was. Understand some of the boys are going around saying someone was getting a snapshot of us. Hope it's not true."

"It's worth investigating," Tago said.

"You have my permission," Spender remarked as he took my arm. "Let's get going."

We left Tago, climbed into the jeep, and were soon bounding along toward the other side of the lake where the big aluminum sphere resting on its metal column stood gleaming in the sunlight. It was, Spender told me as we sped along, fifty feet high and, not counting the base, contained five stories.

"We've tried to make an exact reproduction of the inside of a ship," he said. "And though our actual space

ship won't be round unless we can build one above the limits of the atmosphere, a sphere is the shape best adapted to travel in true space."

"Looks as if it might be pretty hot inside," I said.

"It would be," Spender said, "if it didn't have an air-conditioning plant to keep it at an even temperature. Besides, it's painted white so there's as little absorption of heat as possible. Near the moon, Digits estimates, an unpainted aluminum ship in sunlight would produce an inside temperature of about 850° F., or more than 500° above the melting point of lead. It's funny that so many of the new men come here with the idea that space is freezing cold. That's one of the misconceptions so many of them have. I hope in one of your early lectures you'll clear up any illusions they have on that score."

"It's one of the things on my list," I said.

"Good enough." Spender pulled the jeep to a screaming stop at the foot of the training ship. "And here we are."

A number of space jockeys (you could always spot them by their size and the vizored hats they wore) hailed Spender from the door of the escape hatch where they were evidently waiting for a chance to get inside.

"Coming on in?" one of them called as we climbed out of the jeep. "Bends has just gone in."

To the right of the training ship stood an enormous Quonset-shaped building which housed, I imagined, a machine shop. From within I could hear the thin whine of a lathe as Spender and I dismounted from the jeep. Together we went toward the escape hatch.

"How're they taking it inside?" Spender asked as he approached the jockeys.

"Okay," one of them said. "I just came out. They're reducing the pressure and feeding in the helium. The pressure is seven."

Spender turned to me. "That's the air pressure at a bit above twenty thousand feet altitude. Think you can take it?"

"Nothing like trying," I said, though I did not look forward to the experience. However, I was eager to see the inside of the ship. I knew, too, that the experiment with as low a pressure as the human body could stand was an important one. The less air pressure within a space ship the less chance of leakage into the vacuum of outer space and the less heavy the structure of the ship would need to be.

Nevertheless, I could not understand why helium was being used until Spender, as we stood there, pointed out that it saved weight. Air is heavy, and though it is composed of 78 per cent nitrogen, the nitrogen is not necessary to human existence. Helium can be a substitute as a carrier for the oxygen, and helium is one of the lightest and least inflammable gases there is.

"Besides that," Spender added, "it's the nitrogen bubbles forming in the blood when the air pressure is lost suddenly that give people the 'bends.' "

At this moment a bell sounded above the door of the escape hatch and with a slight hissing sound the door opened. Spender and I crowded through. The door closed and another bell sounded inside the hatch. This, I imagined, was a signal for the air lock in the ceiling above our heads to open. I saw Spender start up the eight-foot duralumin ladder bolted to the wall. Then the air lock, something like the hinged cover of a man-

hole, swung back and we scrambled through onto the deck above.

This was the lowest of the five decks inside the ship and consequently the narrowest. It was used mainly as storage space, Spender told me, for oxygen and water to be used during a voyage. It also included the water recovery plant, a machine to remove the water from the air, for in the enclosed area of a space ship each member of the crew would discharge by perspiration and breathing about a quart of water every twenty-four hours.

"You see why we're in favor of the jockey-size man," Spender said. "He has every advantage."

"Is the water extracted from the air reused or discarded?" I asked.

"Reused, of course, for various utility purposes. But each man will be rationed two quarts of fresh water a day."

We climbed another duralumin ladder to the deck above. This again was used as storage space, mainly for equipment of various kinds. I noticed a couple of space suits hanging in an open locker. From this deck we climbed up the metal ladder and found ourselves on the central deck which, being the largest, was used as combination mess room and, as Spender informed me, sleeping quarters. Here a couple of space jockeys were busily preparing lunch for the crew. I watched them as they were pumping fruit juice into some plastic bottles from whose necks protruded plastic straws. I picked one up.

"You understand the reason for that?" Spender asked.

I did, for at zero gravity no liquid will stay in an open container. Its own inertia causes it to rise from the

glass or tumbler and float into space in the shape of tiny spheres. Liquid can be served only in enclosed plastic bottles whose liquid contents can be sucked or forced up through a straw. Solid food, too, must come in enclosed metal containers, so that the table, heavily magnetized, Spender told me, could keep them, along with forks and knives, from floating around the mess room.

I was amazed, not only at the thought that had gone into the planning, but at the extreme care with which the Astropolitans had reproduced every detail of actual space flight.

"But where are the bunks, the contour beds I always heard were necessary, particularly during the takeoff when the acceleration is producing six or seven gravities?"

Spender went to one side of the room and unhooked a hammock.

"We're using nylon hammocks instead. It saves not only room but weight. One of these closely woven things will support a pressure of 1,500 pounds. Even at ten G's one of our 125-pound jockeys wouldn't reach that."

Spender spread the hammock out so that I could look at it. I noticed a zipper ran most of its length.

"To keep them in it?" I asked.

"You wouldn't want a sleeping jockey to start floating around the room, would you?" Spender asked. "And here's the strap to hitch the hammock securely to the deck."

"And the crew," I asked, "how do you keep them from floating around when they're doing work? Use shoe magnets?"

"We tried that," Spender said. "Of course it's almost

impossible to reproduce zero gravity. The closest to it is to put a man in a diving suit and submerge him, but there the buoyancy of the water makes it quite different from what zero gravity actually is. Magnetized shoes might solve it, but it's like lifting your feet off sticky flypaper to break contact with the floor. So far, our best solution is a guide line, though some of us are in favor of small rubber vacuum cups embedded in the soles of the flight sneakers. The problem of weightlessness sure is a tough one."

I agreed, for my head was beginning to feel weightless itself. I wasn't used to low pressure or helium gas, for that matter, and though I had become more or less acclimatized to the height of Astropolis, I had become painfully aware that the pressure in the sphere was being slowly reduced to way below normal. My ears were roaring, and as we climbed the ladder to the next deck, my heart pounded and I began panting for breath.

"Getting woozy?" Spender asked as he helped me out onto the fourth deck.

I confessed that I was, but told him that I would keep on as I found my sightseeing trip fascinating.

"You've got farther than I ever dreamed," I told him.

"It's been hard work, I admit," Spender confessed. "But we're getting there fast now. Another year or so and we'll be ready to take off." He gestured toward a large aluminum table over which two jockeys were busily engaged plotting something on graph paper. "The navigation room," he explained. "The two lads there are using the dead-reckoning tracer in a set problem. Over there is a computer and position finder." Spender

paused and studied me for a moment. "Can you take another ladder to the control deck?"

I nodded my head. Talking requires breath and I was saving as much as I could. We climbed to the highest deck of the ship. The room, being at the top, was narrow and jammed with instruments. Three jockeys were there: skipper, radio operator and engineer. They glanced up as we crowded into the confined space, and the skipper, whom I had met at dinner the night before, gave me a broad grin. He was seated in a contour chair, swiveled so that he could watch the master controls or consult the battery of gauges that surrounded him. Behind him, immediately beneath the astrodome of tinted plastic which crowned the top of the ship, were mounted a small telescope and a small celestial camera.

On the side opposite the skipper sat the flight engineer and the radio operator, both with a dazzling array of dials and gauges in front of them. From his position in the top of the ship, Spender told me, the flight engineer controlled temperature, fuel, light and air pressure. Being curious about the pressure at the present moment, I went over and, using as few words as possible, asked the engineer what the pressure was.

He glanced at a dial. "Around six plus pounds," he said.

"Whew!" I exclaimed. "With so little oxygen no wonder I feel queer."

The engineer studied my face for a moment or two. "It's only the lack of pressure you're feeling, sir," he observed. "You're getting as much oxygen as you'd get at sea level. I'm feeding in plenty." He glanced at a gauge. "At present the air you're breathing is 40 per cent

oxygen and 60 per cent helium. You shouldn't be complaining. A mountain goat doesn't get half of what you're getting."

"Thanks," I said. "Glad to hear I'm better off than a goat, at least in one respect."

The engineer laughed and I returned to Spender who was deep in conversation with the radioman. He cut the conversation and turned to me. "Seen enough?" he asked.

I told him that I hadn't but that I was feeling a bit unsteady and felt that for the good of all concerned it might be wiser for me to leave.

We climbed down the ladders and went through the air lock into the world outside. I took a deep breath. It was a real pleasure to sniff natural air again with its smell of the sea intermingled with the scent of the orange groves which, I had been told, flourished on the fertile slopes of the crater.

"Well," Spender said as he stood waiting while I inhaled the delicious air. "What did you think of the joint?"

"Fantastic," I said. "Never expected to find it dressed up with such accurate detail."

Spender looked pleased. "Practically all the instruments and most of the equipment are the real McCoy. We'll use them in actual flight. As for the crew, each man is trained to take over any duty aboard—even navigation."

We walked to the jeep. Spender turned and gazed back with admiration at the great sphere. In the machine shop I could hear the hum and whirr of machinery.

"Wish we could take off with a sphere like that," Spender said. "But climbing up through the atmosphere would prevent it." He got into the jeep. "Coming?" he asked.

I told him that I thought I'd walk back if he didn't mind. "Suit yourself," Spender said and with a wave of his hand he was off.

Alone, I walked at a leisurely pace toward the main building. I halted for a while to watch the great 'copter land with its cargo of fresh supplies that it brought from the island's port a few miles east of Astropolis. I watched with admiration as the freight was hustled out of the hatches into waiting trucks. In ten minutes it was unloaded and rose slowly into the air for another trip.

Across the lake, which I had been told was a mile in width—though it seemed much wider, for distances are deceptive in clear air where no surrounding trees or cottages give scale—I could see a half dozen men in swimming. Their voices rang out as plainly as if I were swimming with them.

I proceeded along the gray basaltic shore. I was admiring the deep blue of the water and its breathless calm when the flash of something metallic, floating near the shore, caught my eye. Leaning out and supporting myself on one hand, I managed to capture it.

Putting on my glasses, I inspected the object. It was roughly cone-shaped, about three inches long, and except for the tip, made of some sort of plastic material. The tip itself was aluminum, but on its surface, I noticed, was a strange kind of writing which I could not identify. Considerably puzzled, but hoping that someone

would be able to explain what it was and where it came from, I wrapped it in my handkerchief and stuffed the thing in my pocket.

"Perhaps Homberg," I thought, "with his gift for languages can explain what it is."

A quarter of an hour later I reached my room. An envelope was waiting for me. Upon opening it, I found it was a letter from the Silent Chessmen inviting me, in the stiffest and most formal language, to join them Sunday evening at Dr. Homberg's apartment. R.S.V.P.

I tossed the invitation onto my desk. I would write them a polite note, I immediately decided, saying that I very much regretted but that I was otherwise occupied.

Then, dropping down into the chair before my desk, I went to work on my next lecture.

Chapter 8

I HAD NOT SEEN HOMBERG at the observatory for almost a week but I can't say that I regretted his absence much. My two young assistants, whom I called Castor and Pollux after the heavenly twins, were able and friendly co-workers. They had very quickly learned how to operate the celestial camera and worked with me until the small hours of morning. Neither of them liked Homberg, however, and when he appeared I found it difficult to keep them for more than an hour or so.

"We just can't make that Dr. Homberg out," they confessed to me one evening while they helped me develop some photographic plates of Mars. "He seems to have some sort of chip on his shoulder."

"How is he in the lecture room?" I asked.

"Oh, he evidently knows his stuff," they admitted. "But he keeps flying off on tangents."

"In what direction?" I asked.

"The space station, or the satellite station, as he calls it. He doesn't seem interested in space flight itself. Always sort of belittling it."

"In class?"

"All the time."

"Well," I said, for I didn't wish to appear like an out-and-out critic of Homberg's, "there are a good many

arguments for a space station, particularly from an astronomical point of view. A telescope mounted on a satellite a thousand miles above the earth would certainly bring the stars much closer, give us far better pictures of Mars, for example, than we could ever get here." I held up one of the plates to the light. "Almost impossible to get a clear picture through our turbulent atmosphere. Look at this one."

I showed them what I meant. The strange canal-like markings on the surface of Mars were there, but too vague for real study. I explained to them that the detail is so intricate that much of it is finer than the grain of the photographic plate required in a fast exposure. But if a finer grained plate is used for a time exposure, the restless atmosphere surrounding the earth blotches all the details.

"At a thousand miles there wouldn't be an atmospheric problem to contend with," I said. "Though I must say that a telescope moving around the earth at the speed of 17,500 miles an hour might add other difficulties."

"But is that the reason Dr. Homberg wants a space station?" one of the boys asked me. "For astronomical purposes?"

"I'm afraid not," I admitted.

"What then?"

"Doesn't he tell you in class?"

"In a sort of roundabout way, mostly, how it would be a perfect carrier for atomic bombs."

"Yes," I said. "That's part of his plan for what he calls 'satellite dictatorship.' "

"What does that mean?"

"Merely that a group of scientists and military men aboard a satellite station could rule the world."

"What's wrong with that idea?" the chap I called Pollux asked.

"Nothing," I said. "That is, if you believe one man or a small group can rule the world. But the trouble is that anyone who thinks he can rule the world is apt to be off his nut."

"Do you think Dr. Homberg is?"

"Hum," I said, not wishing to express any doubts about Homberg's sanity. "He's a brilliant astrophysicist. I can only judge him on those grounds. But how do the rest of the students take it when he mentions 'satellite dictatorship'?"

"Some of them seem to take the idea seriously. After class, that is. That's when we hear most about it."

"Some of the students defend the idea?"

"There's a small group that does," Pollux said. "They seem to think Homberg's a little tin god on wheels. It's always 'Homberg says this. Homberg says that.' Some of them are pests."

"Many of them?"

"Quite a number, but what's worrisome is that they seem to be gaining converts."

"Indeed!" I said, rather alarmed to hear this. But fearing that I might show too much concern, I changed the subject. For the rest of the evening we devoted our time strictly to Mars.

However, I felt that I should hand on to Spender the information my two young helpers had given me.

I didn't have an opportunity until the following

evening when, just before I was preparing to go over to the observatory, Tago dropped in to see me. I opened the subject by telling him that I had received a formal invitation from the Silent Chessmen to attend one of their meetings, but that I intended to refuse.

I explained my reasons to Tago. I told him that I was afraid I might get in an argument with Homberg, that if I did so I was likely to lose my temper and that I didn't want to have a fight with Homberg in front of a group of students.

"Any reason to think that the Silent Chessmen aren't mainly interested in chess as they pretend to be?" Tago asked.

I told him what my two helpers had reported. "And if he's carrying on his propaganda in his classes, there's little reason to believe that he doesn't among his Silent Chessmen."

"Spender and I have been wondering what's going on in that club," Tago said. "Also, we've learned recently that for some time Homberg has been in secret correspondence with some party on the outside."

"Any idea who?" I asked.

"Not yet. We don't even know how he manages to carry on his communications. I think you could help us. I advise you to accept the invitation."

"I'm afraid I wouldn't be much good as an undercover man," I confessed. "But what the devil are Homberg's plans? What's the reason he wants to stay here? A man with his training and knowhow could get a job practically anywhere in the world."

"I'm afraid he's after the plans for the photon reactor and the facilities we have here."

"But for what purpose?"

"A space station. Don't you realize he's hipped on that idea? It would give him power and that's evidently what the man wants."

"Terrifying idea," I said. "But madness."

"Madness, maybe, but dangerously possible. With the photon reactor a space station could be established before any nation, including the United States, could stop him."

"And you think that is Homberg's plan? His reason for staying on?"

"I'm beginning to believe so. I'm afraid we're going to have real trouble getting Homberg out."

"How soon is he supposed to leave?"

"By July first."

"Has he given any signs of leaving?"

"None. Just the other day Spender asked him what his plans for the future were and he merely said that he wasn't crossing any bridges until he reached them."

"You think that's a threat?"

"A warning, at least. I'm afraid that Homberg has not only crossed his bridges already but that he's burned them behind him." Tago went to my window and looked out. "Frankly, I'm afraid that Homberg is so deep in his plans to remove Spender and some of the rest of us that it's too late for him ever to back down."

"To replace Spender with himself!" I exclaimed. "But how could he do that?"

Tago turned from the window and stared into my eyes. "How do fanatics greedy for power usually remove men who stand in their way?"

"You mean . . . ?"

"Yes. . . . Violence." Tago came over to my desk. "You have only to read a little history to realize that. History ancient and modern."

"Then it evidently is important for me to visit the Silent Chessmen."

"It is," Tago said. "If it's only to find out how far Homberg has spread his poison among the other members of his club."

"I'll write them that I accept their invitation. But why did they invite me?"

"Maybe simply to prove to you, and to us, that we will not have only Homberg alone to . . ." Suddenly Tago stopped. He had caught sight of the strange object I had found floating on the surface of the lake. He picked it up and studied it for a moment or two. "Where in the world did this come from?" he asked.

I told him where and how I had found it.

"Recently?"

"A couple of days ago."

"After you and Homberg had seen that mysterious flash?"

"Yes. The following afternoon."

Tago took it over to my desk light and, using the reading glass I had there, studied it intently. "Most extraordinary," he said. "Looks as if it might be the tip of a shell."

"A flash bomb?"

"Maybe. Mind if I show this to Spender?"

"Go ahead," I said. "I was going to show it to him myself but forgot about it."

"Please be more careful from now on, will you?" Tago cautioned me. "Clues like this may be more impor-

tant than you think." He reached for his hat. "And tell the Silent Chessmen you're coming. Don't give them a chance to change their minds."

"Right!" I agreed. "I'll stick my acceptance in the mailbox on the way to the observatory."

"Thanks," Tago said, and hurried out.

All that evening and the next few days I found it difficult to get my thoughts in order. I felt that we were perched on top of a volcano that wasn't extinct like our own real one. I was afraid that things at any moment might start erupting and blow us and the training school of Astropolis into the middle of next week.

But one effective way of getting rid of anxiety and worry is work. So I put my nose to the grindstone and tackled my lectures. As I did I suddenly realized that I had not yet prepared a lecture on space itself. If the Astropolitans were to explore space, what would they find in space itself? What is outer space made of and what will it be like when we begin cruising through it?

To begin with, space is a difficult thing to understand, for the simple reason that it can hardly be said to exist. It's not like air or water, which we can feel and which resists us when we travel through them Space is hardly more than an idea, a concept, a nothing, an emptiness. Or to express it in another way, it's a vacuum so nearly perfect that it is impossible for us to produce anything like it even with the highly efficient instruments and machines that science has at hand today.

But, as I have said, the vacuum of outer space is not absolutely perfect. It contains wandering molecules of hydrogen, but not enough of them to say accurately that

space is composed of hydrogen gas. At least it could only be described as a very thin gas, a highly tenuous one, for its density is a thousand million million millionth of that of air at sea level. From the point of view of a space ship cruising through outer space, the existence of hydrogen can be totally disregarded.

But there are two other elements we find in space that may bring us trouble. One is the various rays—cosmic and ultraviolet—about which we know very little except that they are deadly and our atmosphere protects us from them. So little is still known about them that only space flight itself can reveal their secret.

The second danger that we will find in the vacuum of space is interstellar dust and debris. This, we know, may bring us real trouble.

It is not so much that this dust and debris is there; what makes it dangerous is the high speed at which every tiny bit travels. When a bit no bigger than a pea strikes our atmosphere fifty miles above sea level, it produces the flaming trail of light that we call a shooting star. Some of these tiny bits of matter, vaporized by contact with the atmosphere, have been clocked at unbelievable speeds. Three hundred sixty thousand miles an hour is not unusual—a hundred times faster than our swiftest rifle bullets.

At the speed of three hundred sixty thousand miles an hour, or a hundred miles a second, the tiniest bit of metal could pass through almost any protective armor. Even traveling at only twenty-five miles a second, a bullet no bigger than a pinhead could pierce an inch of armor plate. As for a space ship, it would go right through, and heaven help any member of the crew that

happened to be standing in its path. Fortunately it would make a clean hole that could be instantly patched before much of the life-protecting pressure in the ship would be lost. But if a ship were hit by anything much larger, a bit of metal, say, the size of a baseball traveling at one hundred miles a second, the ship might as well have been hit by an atomic bomb. The entire ship would be instantly vaporized.

Fortunately there is not much dust and debris, comparatively speaking, in outer space. It has been estimated that if a volume of outer space the size of our earth could be crushed together, it would produce only two or three ounces of hydrogen and only a quarter of an ounce of interstellar dust. So one can see that there is not much of it.

But what are the chances of a space ship or a space station being hit by a fragment of interstellar debris?

Astronomers don't all agree on this point.

Dr. Fred L. Whipple of Harvard estimates that a space station 250 feet in diameter revolving around the earth at a height of one thousand miles would be punctured by a small fragment at the rate of twice a month. But a space station offers a pretty broad target. The chances of a space ship being hit are much less. It has been estimated by one or two authorities that on a trip to the moon there is less than one chance in ten thousand of a ship being hit by a fragment large enough to penetrate armor plate one-eighth of an inch thick. The chance of a ship being hit by a fragment an inch or more in diameter is once in several million years.

To protect the space ship from high-speed debris, Dr. Whipple has devised what he calls a "meteor

bumper," a metal skin surrounding the space ship an inch or so above its surface. This skin, though it would not stop fragments entirely, would break their force so that there would be less likelihood of their entering the ship or passing through it.

The truth will not be known until actual space flight is made, and the action of interstellar debris on the ship can be studied at first hand.

But if we do not know what actual danger we face from dust and flying particles, we know what dangers we face from the extremes of temperature that we will have to reckon with.

To begin with, space, being a vacuum, can have no temperature itself. It can be neither hot nor cold. So the temperature of the space ship will depend entirely on its position in relation to the sun and on the ship's color.

We can find out what the temperature of a space ship would be on its surface by investigating the temperature of the moon. Unlike the earth, whose heavy atmosphere captures and retains the sun's warmth, the moon's atmosphere is so thin that almost as soon as the sun has set there the temperature drops 462°. When the sun is shining full upon the moon's surface, the temperature is that of boiling water—212° Fahrenheit. When the sun's rays disappear and the surface of the moon is plunged in darkness, the temperature drops, and with terrifying swiftness, to 250° below zero, or the temperature of liquid air.

The temperature on the outside of a space ship, as far away from the sun as is the moon, would be about the same—212 above on the sunny side, 250 below on the dark—unless the ship is painted white with magnesium

oxide. As we know, white does not absorb heat; it reflects it. Place a black and a white piece of cloth on snow, and the snow will melt faster under the black piece than it will under the white one. So it is estimated that by painting the space ship white the temperature of the surface can be reduced to something below zero. To vary the temperature, an ingenious device has been worked out. Shutters like those of a Venetian blind, painted black on one side and white on the other, and operated by a thermostat, will give the proper amount of black and white to keep the interior temperature at a normal level.

However, if we should start cruising in our space ship away from the sun, toward Jupiter, for example, we should run into real problems. Near Jupiter the dwindling sunlight would not warm our ship. The temperature of Jupiter, even with the sun full upon its surface, is 250° below zero. And if we should proceed even deeper into space and reach Uranus, one of the more distant planets, we would find the temperature there 324° below or only 135° above absolute zero, which is 459.6° below zero, Fahrenheit. And at the temperature of absolute zero, we would have something less simple than a heating problem to solve. For at absolute zero, matter—theoretically, at least—cannot exist.

If, on the other hand, we should travel toward the interior planets, Venus and Mars, the problem would become that of preventing the crew from being roasted alive. On the sunny side of Venus, however, the temperature has been estimated at around 108, for Venus, in respect to temperature as well as size, is very much like the earth. If we were to pass beyond Venus toward Mercury,

we would find the temperature on the sunny side of Mercury way up at 720° above. I doubt if even the bravest of our space jockeys would want to toast his toes there very long. Even a highly efficient cooling system could not protect a crew for long at that temperature. For at 185° a man collapses in one hour, while at 500° of heat he passes out for good in five minutes. . . .

I had hardly finished sketching out my lecture when the chambermaid came in to do my room. She was one of the group of native servants whom the 'copter brought in each morning from the village at the foot of the mountain. I had often talked with her in my poor Spanish, but never until that morning had I thought to ask her about the story I had heard that members of her race had in ancient times once lived in our crater.

She told me when I asked her that she had heard the story from her grandfather. A group of natives, hoping to escape the cruelty of Spanish rule, had once taken refuge in the volcano.

"But how did they get here?" I asked. "They didn't have airships in those days."

She gazed at me for several moments. "Oh, Señor," she said. "There was a tunnel. My grandfather knew where it was. When he was a little boy he climbed through it. But when he came here and saw the old building, he got scared and never came back."

"He saw the big building with the glass roof?"

"It didn't have a roof then. My grandfather said it was here even before my people came here."

"Does anyone know where the tunnel is now?"

She shrugged her shoulders. "I don't know."

I had a suspicion that she knew, or at least knew

someone who did, but she merely shook her head when I asked her again.

I gave up questioning her any further, but I was determined to find the tunnel and explore it. Along with tennis, which I had been playing on the fine hard courts with Tago, it would give me a chance for some strenuous exercise. And perhaps some excitement. That is, if I should need any excitement. Things around me seemed to be moving rapidly toward some sort of explosion.

Would it come from the Silent Chessmen?

Perhaps I could discover if I attended a meeting.

Pulling out a sheet of notepaper from my desk, I wrote a formal note to Homberg that I accepted with pleasure his kind invitation.

Chapter 9

On Sunday evening promptly at eight I knocked at Homberg's door.

I had gone there feeling uneasy about the whole business. If the Silent Chessmen were the underground organization Tago suspected that it was, I wanted to have as little to do with it as possible. Neither did I like my role of undercover investigator. However, I felt it was my duty to go, come hell or high water. But I couldn't help feeling that I was walking into a hornets' nest.

From what Tago had said and from what I had myself gathered, I knew pretty well what Homberg's main purpose was. Obsessed with the idea of establishing a space station, he had no interest at all in flight to outer space. I wondered if he had succeeded in persuading all of the Silent Chessmen that he was right. But I knew that it was quite likely that I would be dragged into an argument on the subject. I therefore went to Homberg's room well primed on the whole subject.

I knew just about what type of space station Homberg was eager to get into space. It was far from being a simple one. It was modeled after the plans that Wernher von Braun, one of the leading space engineers of the 1950's, had drawn up. It was to be a huge affair, 250 feet

in width and carrying a crew of eighty men. It was to be shaped like an enormous inner tube, and constructed of prefabricated material that would be shot up into space by a fleet of ships. At the height of one thousand miles, they would unload their cargo and set it traveling in an orbit around the earth at a speed of 17,500 miles an hour. Traveling at this speed, the parts would continue to orbit around the earth. As they would have no weight, the prefabricated sections could easily be assembled in space by astromechanics. The doughnut-shaped framework having been assembled, it would then be covered with a skin of airtight plastic and the whole thing inflated with a combination of oxygen and helium gas.

In its final form, it would resemble a gigantic wheel, held rigid by four hollow spokes which would act also as channels for communication. For reasons that I have already discussed in previous lectures, the station would require no energy to keep it revolving around the earth at a height of 1,037 miles.

The energy needed to operate the air-conditioning plant, water recovery plant and other units would be supplied by solar power. A condensing mirror in the shape of a trough would be constructed on the outer edge of the station. This mirror would concentrate the rays of the sun on a pipe running along the trough and containing liquid mercury under pressure. The heat from the sun would vaporize the mercury and the steam thus produced would operate a turbogenerator to produce about five hundred kilowatts of electricity.

Aside from the various units necessary to sustain life aboard, the space station would also carry a great variety of instruments. These would include bomb-sight-

ing apparatus, telescopic cameras, radar systems, radio transmitters, astronomical equipment, anti-spacecraft guns. In fact, the space station would be the largest and most deadly flying fortress the world has ever seen. Equipped with a few atomic bombs, it could pinpoint any city below into a mass of smoking rubble. And in a matter of seconds.

Why should anyone mad enough to want to rule the world pass up a chance to have a space station under his control? The cities and nations below would be so many sitting ducks.

However, if I planned to argue the question with Homberg, it certainly couldn't be on the military advantages of a space station. That would have to be admitted. My only chance of winning any argument would be that establishing a space station, even a smaller one than von Braun's, would leave no resources for flight into outer space.

Even back in 1954 when prices were lower than they are today, von Braun had estimated that the cost of his space station would come to six billion dollars. But the main cost would not be the space station itself; it would be the cost of getting its prefabricated parts up into space.

For this purpose fifteen cargo space ships would be necessary. Each one would be as large as a light navy cruiser. Each would stand 265 feet high and with its fuel and cargo would weigh seven thousand tons. Yet for all its great size and weight, the space ship would be able to carry a mere thirty-six tons of freight. That is a bit more than 5 per cent of the overall weight. Most of the overall weight would be liquid fuel, for in order to

reach one thousand miles and the speed of 17,500 miles per hour, about six thousand tons of fuel would be consumed. Fifteen times six thousand is ninety thousand tons of fuel and that is the minimum amount required to lift 540 tons of cargo into space.

Mulling over these figures, I realized now what Homberg was after. It was, indeed, the photon reactor. For without it the very task of getting enough liquid fuel to propel his fifteen cargo ships into space would make the whole job of establishing a space station almost impossible.

Would he manage to get hold of the plans for the photon reactor? That was something that Spender, Tago, I and all other loyal members of the Young Astropolitans would have to fight with our very lives to prevent.

Filled with fears and apprehensions, I knocked at the door of Homberg's apartment.

From the inside I could hear Homberg laying down the law to his little circle of admirers. It was what I expected to hear, though it made me wonder why the Chessmen should call themselves Silent.

At my knock Homberg stopped speaking suddenly, though not before I had picked up the words "satellite station" and "H-bomb." It was quite evident that he was holding forth on his pet idea of "orbital dictatorship."

Homberg himself opened the door and greeted me with loud exclamations of pleasure.

"Welcome! Welcome!" he shouted noisily, as if he were trying to drown out the remarks I had just heard him making. "So good of you to come! Welcome to the Silent Chessmen!"

He grasped my hand and almost yanked me into his apartment.

Twenty or so students were standing about the room, along with a couple of instructors whom I already knew. One instructor was an authority on atomic fission; the other was an expert in electronics. I was surprised to see only two chessboards in evidence with a pair of young chaps bending over one in the far corner. There was silence in the room when Homberg introduced me. I looked around his room.

He had managed, I observed, to get a very large room for himself. It was a good deal larger than that of Spender, who certainly could not have entertained a group of twenty men in his. On a large table at the end of the room were sandwiches, a coffee urn and cups and saucers. It was evident that Homberg went to some trouble to entertain the members of his club.

For half an hour or so I chatted with Homberg and other members of the group and was, to my surprise, enjoying myself when Homberg suddenly called for silence.

"I have an important announcement to make," he began, "and I want everyone to hear it." Then he paused and scowled across the room at the two students who had resumed their game of chess in a corner of the room. "You two over there," he snapped, "I want you to hear this."

Somewhat abashed, the two rose and stood sheepishly listening as Homberg, leaning back against the table, continued.

"What I am about to say may come as a shock to some people. I won't name them now. It may lead them

to believe that I am overstepping my rights, talking out of turn. But I am only working for the greater good of Astropolis. Let that be understood."

Homberg paused again. I lighted a cigarette and looked around me. Judging by the expressions on the faces of the men there, it was obvious that the announcement Homberg was about to make would not be news to anyone except myself. I realized that everyone there had already heard Homberg's announcement and that he was only repeating it now for my particular benefit. And for Spender's. But Homberg's slow delivery was giving me the fidgets. I nervously tapped the ashes of my cigarette into a tray.

"When I first arrived at Astropolis a year and a half ago," Homberg continued finally, "I believed with Spender that flight into deep space, the discovery and exploration of new worlds, was the solution to every problem. I was mistaken. Space flight is a dream of half-baked professors, frustrated engineers, eggheads and longhairs. No, the practical solution of the world's problems lies not in space flight, in dreams of escape. The practical solution of world problems lies within a thousand miles of the earth's surface—satellite dictatorship."

Homberg paused to let his words sink in. I was becoming increasingly nervous. For I, not Homberg, was now the center of attention as if everyone present was waiting to see my reaction. I felt a rising attitude of antagonism toward me.

"A satellite dictatorship!" Homberg began again. "There lies the solution. A satellite station circling the earth at bombing range and manned by a staff of scien-

tists who will rule the world. At the head of this staff one scientist will reign supreme. From him will come all orders and those on earth who dare disobey his commands will risk destruction."

"Wonder who that chief scientist will be?" I could not help thinking.

"Yes, my friends," Homberg went on, his eyes glowing, "all problems will be solved on this satellite island of brains. Peace, war, overpopulation, economic problems, will all be settled by this staff of scientists circling the globe every two hours. Yes! Toward the establishment of satellite dictatorship I have dedicated my life and all my powers. And these men around me," here Homberg with a lordly gesture included all the Silent Chessmen, "have dedicated their own lives to the same high purpose. Have we not, my friends?"

Murmurs of approval greeted Homberg's question. Homberg stared straight at me, and in the uproar I realized that he was throwing down the gauntlet, challenging Spender's leadership. But though I found the announcement startling, I was relieved that Homberg had at last come out into the open. I wondered what his next move would be.

"Satellite dictatorship," I said as I tried to collect my thoughts, for Homberg's sudden announcement had caught me unprepared. "Well, it's true that we need brains to run the world, but whose brains are we going to choose to do it?"

"That remains to be seen," Homberg said darkly.

"And it will be a rule of fear and terror," I said.

"Certainly," Homberg said. "That's the only effective way the world can be ruled."

"I'm afraid I can't agree with you," I said. Not wishing to argue on this point, I changed the subject. "But aside from that question, how are you going to establish a satellite station? That's a big engineering problem in itself."

Homberg smiled and made a gesture with his hand. "It will be a simple matter," he said. "We have all the facilities for constructing one right here."

"Here at Astropolis?" I exclaimed.

"Yes, my friend, right here."

"But here our purpose is space flight. And besides I was led to understand that you . . ."

"That I was leaving here?" Homberg interrupted. "That is quite true. But is there any assurance that I will not return?" Homberg gave me one of his disagreeable smiles. "I have friends, you know, Stateside and elsewhere."

"I'm afraid that you might find a little difficulty in getting back," I suggested.

"You think so?" Homberg said, flushing slightly. He glanced around him. "I have some loyal friends here who may see that I do."

"Against the express orders of Spender?"

"Just a minute, Professor." Another voice rang out. A tall chap with yellow hair and a broad, freckled face pushed his way through the crowd toward me. "Mind if I say a few words, Doctor?" he asked.

"Go right ahead," Homberg said. "This is an open meeting."

"Thanks," said the tall blond. He looked down at me. "From what I hear," he began, "you're one of the

men here at Astropolis who's been largely responsible for getting the doctor out."

"Not at all," I said. "I've had nothing to do with it."

"Didn't you come here with the idea of replacing Dr. Homberg?"

"I was engaged by Spender," I began, "as an astrophysicist . . ."

"We know you were engaged by Spender," the big man cut in again. "But ever since you've arrived here you've been engaged in getting Dr. Homberg out."

"I deny that," I said. I looked at Homberg, alarmed at the turn things were taking. I had hardly expected such out-and-out antagonism. Homberg, however, continued placidly rolling a cigarette. "I deny that charge," I repeated. "And I resent the way you're making it."

"It hits home, doesn't it?" the big man said with an ugly grin. "The professor here is getting riled up."

"Dr. Homberg," I said, raising my voice. "May I remind you that I'm your guest here?"

"Quite true," Homberg said. "Grid, be a bit more careful of your manners."

"It's all right, Doctor," the big man growled over his shoulder. "I'm just talking." He turned back to me. "We have Astropolis as much at heart as you or anyone else has, understand that?" To emphasize his statement he poked me in the chest with his forefinger.

"I'd rather you wouldn't do that," I said as I pushed his hand aside.

"Oh, pardon me," Grid said with exaggerated politeness. "I just want to make sure you're listening to what I say. I want you to know that we're as loyal a

bunch of men as there is on the campus. The only difference is that we don't see eye to eye with your friend Spender. Do you get it?"

With these words he poked me again in the chest.

"Just a minute," I said, as my dander rose. "If you do that again, I'll be obliged to kick you in the shins."

"Forget it," Grid said and slapped me on the shoulder. "Just hear me out, will you?"

"Go ahead," I replied. "But take it easy."

"Now, we chaps in this group don't agree with Spender for two reasons. One, we don't want to see Homberg dropped, and two, we're all in favor of a satellite station in space."

"I'm afraid Astropolis is no place for you then," I said.

"You want to give us the gate, too?" Grid said. "Let me tell you, brother, you're going to run into opposition. We're here to stay and I don't mean maybe."

He poked me in the chest again with his finger.

It was too much. I hauled off with my foot and let him have it in the shins.

I suppose it was a hot-tempered thing to do, and ten minutes later I regretted my act for it made it impossible for me to stay in the room any longer. I should have taken the rough treatment quietly, for it was my duty to discover just how far Homberg had gone in whipping up his little group to open rebellion against Spender. However, it had become pretty obvious that the rebellion was taking a serious turn and that Spender would have to take some action to suppress it. But I shouldn't have kicked Grid in the shins.

"Why, you little . . . !" he bellowed and seemed

on the point of taking a swing at me when Homberg broke through the crowd that now swarmed around me.

"Gentlemen! Gentlemen!" he shouted. "The social amenities! Please!"

The social amenities! I couldn't help breaking into laughter at Homberg's insistence on good manners when he appeared to be guilty of breaking every other item in a code of honor.

Grid meanwhile had backed away and was ruefully rubbing his leg. Homberg glared at me for a moment. "Sorry," he said, "but I'm afraid I'll have to ask you to leave. I should have warned you that my boys here feel rather strongly about certain matters."

"So I see," I remarked. "I had no idea when I came here that I was stepping into a hornets' nest."

"Someone bring the professor his hat," Homberg said.

My hat was instantly produced. Taking my arm, Homberg escorted me to the door, the crowd giving way as he went across the room. I could see none but hostile faces watching me. At the door I turned and looked back.

"Good night, my friends," I said.

One only, a timid voice, bade me good night.

Homberg stepped out into the hall with me. He closed the door and held out his hand.

"I must apologize," he said. "But, as you see, feeling is running high. Perhaps you will come again, later."

I shook hands, without saying anything. I left him and walked across the campus toward my room. I felt upset, bewildered by the turn of events. If the Silent Chessmen were an underground organization, their activities were rising dangerously close to the surface. I

wondered how soon an actual outbreak would occur. And I wondered what form it would take—and how far it would spread.

Though it was still early, I decided that I would not tell Tago or Spender about the unpleasant episode until the next day. Perhaps if I slept on the business it might not seem so important as it did at the moment. Moreover, I hated to confess that I had lost my temper though I did not regret having kicked the young man in the shins.

I went into my room. Sitting down at my desk, I went over the whole recent episode again. It had been disagreeable enough, heaven knows, but I concluded that it was just as well it had occurred. For the episode brought things out into the light at least. We knew now where the Silent Chessmen stood and what they were after.

Later that night, sometime after I had gone to sleep, I was awakened by a light tapping at my door. I climbed out of bed and, half awake, looked out into the hall. A young man wearing a ski cap pulled low over his eyes stood there. I asked him abruptly what he wanted.

"I have something important to say to you, sir," he said.

I did not recognize him until he had come inside. When he had taken off his cap and stood in the light I saw that he was a young man I had met at the Silent Chessmen just that evening.

For a moment he stood nervously looking around my room until I realized that he wanted me to pull down the shades. I did so.

"Thanks," he said. "I had a feeling someone was following me but I guess it was my imagination." He held out his hand. "My name's Cipher," he said. "Tiny Cipher, one of the jockeys. I was glad to hear you stand up to Dr. Homberg the way you did."

I shook hands with him, wondering if he had awakened me at that hour of the night merely to compliment me on my hot temper. "Thank you," I said.

"Dr. Homberg made the air blue after you left," the young man said. "It was quite awful."

"What did he say?" I asked as I pulled up a chair. "I imagine he can lay it on when he's a mind to."

"It doesn't really matter, what he said, does it?"

"I suppose not. But what are you here to tell me?"

"It's a sort of warning," Cipher said.

"From you?" I asked, for if it were another warning from Homberg I wouldn't listen.

"It's strictly between you and me. I think my life would be in danger if they knew I'd come here."

"Oh, cheer up!" I said reassuringly, for the chap sounded a bit hysterical. "I think most of them are just full of hot air."

"Not at all, sir!" Cipher said positively. "When I first joined the Chessmen six months ago we really played chess. But we've slowly dropped that idea for other things."

"What other things?"

"All we do now is talk about the space station, just as you heard tonight."

"What's the harm in that?" I asked.

"Because it's getting dangerous. I think Homberg's planning to take this place over."

"Nonsense," I said. "How would he propose to do it? Do you know?"

"Not exactly," Cipher admitted. "But I'm afraid he'd stop at nothing."

"You mean he might use violence?"

"Exactly. I think, sir, that he's planning to kill Spender."

"Bosh!" I exclaimed, though I said it rather to quiet Cipher's fears than because I didn't believe such a thing was possible. "Have you any real basis for believing that?"

"Not any real proof," Cipher said dubiously. "It's just that I've a feeling he may do something rash and crazy."

"I guess you'll have to give us a better reason than that," I said. "Is this all you came here to tell me?"

"No. There's something else."

"What is it?"

Cipher then proceeded to tell me a strange story. It almost convinced me that the chap was suffering from delusions and was beginning to see things that weren't there.

Late one afternoon, he told me, he had taken a spin on his bicycle. He had ridden down to the south end of the crater and had reached the rim which at that end rises abruptly from the basin, when his bicycle chain came off. He had turned his bike upside down and was trying to fix it when for some reason he happened to glance up over his shoulder. As he did so, he saw two men appear.

"They seemed to have come right out of that crater wall," Cipher said, as he leaned forward and stared at

me through his glasses. "Just about twenty feet above me. For the life of me I couldn't see where they'd come from. They just sort of appeared. They stood there for a moment or two as I watched. Then they both climbed down and started walking at a rapid pace toward the campus."

I thought a minute. Had someone discovered the tunnel and been using it for secret purposes? I wondered, but kept my suspicions to myself.

"Did they see you?" I asked.

"I don't think so." Cipher shook his head. "And it was so dark by that time that I couldn't have recognized them, even if I'd known who they were."

"Do you suppose you could find the exact spot where they appeared?" I asked.

Cipher believed he could with a bit of searching.

"I'd like to find it," I said. "We can go down there some afternoon soon and look for the spot."

"I'd be glad to," Cipher said.

"But keep this under your hat," I advised him. "Told anyone else?"

Cipher said that he hadn't.

"Good," I said. "And please keep me informed how things are going. You'll be attending meetings, I suppose."

"I will if you say so, sir," Cipher agreed. "But as a matter of fact, I was thinking of resigning before the trouble starts. I'm afraid of Dr. Homberg."

"Take it easy," I said, as I patted him on the back. "Take it easy, and keep your mouth tight."

Cipher got up from his chair and pulled on his cap. "Hope you'll excuse me for getting you up at this hour,

but the whole business was beginning to prey on my mind. I feel better already."

"Tell me anything and at any time," I said. "And thanks for coming."

I took him down to the outside door and watched as he scurried across the campus in the darkness toward his dorm.

Chapter 10

On the following morning both Spender and Tago were too busy for me to tell them the strange story I had heard the night before from Cipher. A "shoot" of a sixty-foot rocket was to take place that afternoon and both men were busy all morning overseeing the preparations.

It was to be the first shoot since I had come to Astropolis. I could feel the excitement around me. Classes had been called off for the day and the whole atmosphere was like that in my own college before the big game.

However, I managed to get in some work for my classes had begun. I had already lectured on the theory of space flight, escape velocity and rocket motors, but now I had to lecture on a subject that wasn't exactly in my line. However, it was as important as any of the others.

What happens to the human body during flight in space?

First of all, what happens to the body during those brief moments when a space ship is gathering speed as it leaves the earth?

Now, there are two ways in which the weight of an object can be increased. One way is to move it to a planet

bigger than this one where the gravity is greater. Jupiter is one of these planets. Its radius is almost eleven times that of the earth and its gravity is 2.6 times greater. A space jockey who landed there would find that his legs would have to sustain a body weight of almost 350 pounds. A six-foot football player would have to carry almost a quarter of a ton as he charged down the field. That is, if they play football on Jupiter.

The other method of increasing weight is to increase the speed at which an object is moving. Just as we lose weight when an elevator starts down, so we gain weight as an elevator starts upward. And our weight is directly proportional to the increasing speed at which the elevator rises. This is because our body is obeying one of Newton's Four Laws. In this case it is the first; i.e., a body always tends to remain at rest.

It is an easy matter to discover what the relation between acceleration and weight is, for it is a simple mathematical problem. One-gravity, or 1-G, is what our weight is when we are standing still at sea level. But when we are shot into the air at the accelerating speed of a falling body—that is, at the rate of thirty-two feet per second every second—we double our normal weight. That is, we will weigh 2-G's.

Thus a space jockey weighing 130 pounds just before takeoff would weigh 260 pounds and exert that much pressure on the chair he sits in when a space ship begins to rise from the earth as fast as an object starts falling toward it. Double this speed and the weight of a space jockey would be tripled.

However, it must be remembered that the weight is increased only when the speed is increasing. As soon

as the motor is throttled down and the ship maintains an even speed, other interesting things happen which I will take up later.

For a long time it was believed that men would black out during violent increases of speed. For a while 4-G's was supposed to be the extreme limit of human endurance. But recent experiments have proved that men can take anywhere from 10- to 12-G's for three minutes and even 17-G's have been endured. In fact, one Lieutenant Colonel in the Air Force has, it is said, taken 35-G's in an experimental device called a G-sled. Even at less than 20-G's, a space jockey weighs more than a ton!

The human body always seems able to take much more punishment than scientists expect.

But if we can't knock a man out by increasing his weight to a ton or more, what happens to him when we remove all the weight he has?

As we have seen, the crew and everything inside a space ship lose all weight when the ship has reached a certain distance from the earth where the earth's gravity is practically nil. And we have also seen that things become weightless when the ship, having reached a certain speed, cuts off its power and begins to coast. This weightlessness is known technically as zero gravity.

Since it is almost impossible to reproduce this condition on the earth, no one yet knows how the inner organs of human beings will behave. However, there is little cause for worry.

For some strange reason none of our organs seem to depend on gravity to help out in its functions. The blood circulates, the stomach digests, the lungs breathe with no help from gravity at all. In fact some organs, like

the heart for example, work more freely when no gravity is involved. We can even swallow without the help of gravity and any student who doubts my statement can try eating a doughnut while he stands on his head. I have seen it done.

But under the condition of weightlessness, of zero gravity, there are many things that a space jockey will have to learn. He will have to learn how to get from one place to another for he will no longer be able to walk normally. On the earth's surface we push ourselves around on our feet by means of the friction between the soles of our shoes and the ground. But in a space ship we can't depend on friction for no gravity holds us down on the floor. We would float around and until we got used to it we would constantly be bumping our heads against the ceiling.

Sneezing, for example, would be a dangerous pleasure. The air jet escaping from our noses would send us sailing backward and upward across the cabin. Even blowing our noses would send us toward the roof. Asleep, we would have to be lashed or zippered into our hammocks, for no gravity would hold us in place and the jet effect of our breath would propel us slowly around the cabin.

There are other more serious dangers. If the air in a space ship is not kept in active circulation by means of blowers, a sleeping man will suffocate in the poisonous gases that he exhales from his own lungs. On the earth, gravity in a closed room itself provides circulation. It causes warm air to rise and cool air to fall and hydrogen and carbon dioxide gas to behave in the same way. But in a ship, at zero-G, no force except artificial circulation

can remove waste gases from the immediate vicinity of our faces. For the same reason, a lighted candle would soon be extinguished. Even the flame would not rise.

As for the materials around us, they will be a constant source of trouble. If we should uncork a bottle of ink and attempt to move the bottle, the ink will rise out of it. Forming rapidly into little black spheres, the ink will float around the cabin until the spheres break against the walls and become mist. As for our fountain pens, they will be totally useless as ink will not flow through the tip. Soup will not stay in our bowls or coffee in our cups. Both liquids will tend to form tiny globules which we would have to chase around the cabin if we served our dinner in this way.

To overcome these difficulties, would it be possible to produce gravity artificially in a space ship?

In a space ship it would be difficult indeed. To keep things down, magnets might be used. It has even been suggested that magnetized sneakers might be worn to keep the crew attached to the floor but, as Spender put it, that would make walking something like moving across a sheet of sticky flypaper.

However, on a large space station of the kind Dr. Homberg advocated, gravity could be produced artificially by revolving the station. Centrifugal force, then, would act very much like gravity. Thus if a 250-foot space station, shaped like a huge inner tube, should revolve once every 12.3 seconds, it could produce an artificial gravity at the circumference equal to that of the earth's at sea level. The crew could then walk about normally, though their heads would be pointing toward the axis or center where, of course, no gravity would exist.

But now what problems would the human body encounter *outside* a space ship during flight?

Before leaving a space ship through the airlock a jockey will have to put on his space suit. Some of you may still believe that a space suit is exactly like a diving suit; actually, they only look alike. Their purposes are the exact reverse of each other. A diving suit keeps the pressure out; a space suit keeps the pressure in. For in the vacuum of space, unless the body is fully protected it will blow up.

This is due to the fact that the pressure of fifteen pounds, which the atmosphere at sea level exerts on every inch of our bodies, compresses the gases in our blood. When this pressure is removed, these gases expand and our blood behaves just as a bottle of warm carbonated water behaves when we remove the cap. Without the pressure of the atmosphere, our blood would boil up into an explosive froth and we would die instantly.

Thus a space suit has to maintain within it a pressure of at least seven pounds per square inch. And that is not all. The suit has to be air-conditioned like the space ship itself. Its temperature must be controlled and excessive moisture removed. The jockey's hands must be protected by heavy gloves or mittens. Bottles strapped to his back must supply him with oxygen at the rate of two ounces an hour. He must also carry a walkie-talkie, for even if his voice could be heard outside his helmet, no atmosphere would carry the sound waves an inch beyond his face.

As one can see, a space suit will be nothing like those interesting fancy-dress costumes space cadets wear in the comic strips and the movies. It is quite likely that they

will have to be made of heavy metal and it is most unlikely that anyone will ever be able to walk around wearing one.

However, until he lands on the moon or some planet, the jockey will find little need for walking. In flight, he will be weightless, not only inside the ship, but outside it, too. When he climbs outside, there will be no danger of his losing the ship. He will travel right along with it and will have no sensation of motion except the motion he gives himself. So he can clamber around on the outside of the ship, pulling himself along by safety lines or ladders. His main source of motion will be a small jet gun of compressed air which will propel him in any direction in which he wishes to move.

Even though he is weightless, and all the materials he works with will be weightless too—moving a two-ton girder will be no problem for a space mechanic—still the inability to move his arms freely in his heavy suit will not make construction work easy. A satellite station in space, even though it is constructed of prefabricated parts, will be a colossal undertaking. So if we are mainly interested in flight into deep space, a simple fuel dump, circulating around the earth at the height of a thousand miles, would provide . . .

I broke off my lecture suddenly.

Did I dare take up with my class the arguments for and against a space station?

It would be difficult for me not to take sides. But I realized that now, more than ever, the whole question of space station versus space flight was getting dangerously close to dividing Astropolis into two warring camps. And I knew that if this ever happened, Spender's and our

hopes for the exploration of space would go up in smoke.

I decided, therefore, to stop where I was and leave the whys and wherefores until arguments over a space station had quieted down. Or until the increasing difficulties Homberg was making for us were somehow settled. But how could they be? It was obvious that something had to be done about him—and soon. I should see Spender at once. I could probably catch him now at the proving grounds.

Borrowing a bicycle from one of my students, I tooled across the field toward the big rocket that now stood on the firing table being fueled.

As I reached it, the great derrick was being moved away. Students in their blue coveralls were scurrying about like ants, while the fueling men, swaddled in white plastic togas and masks, were tossing empty nitric acid bottles into a truck.

I found Tago and Spender standing with a small group of instructors. I joined them just as Homberg came up. He gave me an icy greeting and stood staring at the rocket while he rolled a cigarette.

Spender turned to me. "It won't be long now," he said with a grin. "Going to try to reach the five-hundred-mile mark. Pretty, isn't it?"

I glanced toward the rocket. It was beautiful indeed. Slender, painted white with black stripes spiraling down its sleek sides, it looked like a toy for the gods. It was a double-stage booster job. Only the long, pencil-shaped rocket attached to the nose, like the spear of a swordfish, would reach the five-hundred-mile height. The big lower part would be automatically released and drop into the sea after it had boosted its little sister to a height of fifty

miles. From there on the smaller rocket, under its own power, would rise alone until its fuel and momentum were played out.

As I was standing there admiring the rocket and the efficiency with which the preparations were being made, I felt a touch on my arm. Digits was beside me, asking me if I cared to see the blockhouse.

I told him I'd like nothing better.

"Ever have a rocket go wild on you here?" I asked him as we started toward the big concrete igloo.

"We keep our fingers crossed," Digits said with a chuckle, "every time there's a shoot."

"I've heard of it happening," I said. "At White Sands once a big Viking got away and almost wrecked the place. Tore things up like a wild man."

"It hasn't happened here yet," Digits said. "Though we all take what precautions we can. We clear the place and stand way off at the other end of the crater. But it's like playing with dynamite."

We had reached the blockhouse and went inside. It was like entering the bridge of a battleship. A half dozen students, specialists in their own field, were standing in front of a long control panel, dotted with small red lights, dials and gauges of every description. Occasionally one of the men would peer through the narrow slits of a window to inspect the progress the technicians on the firing table were making.

"All the radio reports from the instruments in the nose of the rocket come in here," Digits explained. "Instruments to report on temperature and density of the air. Other instruments analyze the sunlight. Geiger tubes report on cosmic rays while the photon counters record

and transmit by radio the amount of X-rays up there."

"Are the instruments a total loss once they've done their bit?" I asked.

"Oh, they're expendable. A short life and a merry one. Ten minutes of flight and then the big drink. But in that time they've sent back enough data to keep us busy for weeks analyzing it. One more shoot, though, and I think we'll have all the data we need for a real flight into deep space."

Fascinated by the intricate gadgets that crowded the room, I was watching the bright green lines of the oscilloscope wriggling across the panel like a live thing, when suddenly I heard the loudspeaker in the place boom out: "Zero minus twenty minutes."

Digits grabbed my arm. "Time for us to clear out," he said, as he hurried me toward the door. "That's the second warning."

Outside everyone was hustling about like a disturbed colony of ants. Students were climbing into trucks, jeeps, stuffing themselves into cars. I saw Tago and Spender climb into the yellow jeep Spender always used.

"How'd you get here?" Digits asked me.

I pointed to my bike.

"Gosh, you better not trust that to get you across the crater in time," he exclaimed. Picking up the bike, he lifted it with some effort into a truck that stood nearby. "Climb in," he said.

With half a dozen students bouncing happily in the rear of the truck, we sped across the flats to the far end of the crater where groups were already forming near the lecture hall. In the distance, its white image reflected in the clear blue surface of Crater Lake, stood the rocket

gleaming in the sunlight. As we dismounted, the nearby loudspeaker chanted: "Zero minus ten minutes."

Five minutes later, by my watch, we saw the last jeep speed away from the launching table. We realized that now the entire control was in the hands of the men in the blockhouse.

"Zero minus thirty seconds," cried the loudspeaker. A hush fell on all of us. The speaker began counting: "Zero minus five seconds . . . four . . . three . . . two . . . one . . . zero!"

In the dead silence each one of us, I imagine, pictured the firing officer throwing the switch.

A brilliant dagger of green flame, like the sting of a wasp, shot from the rocket's tail. A burst of white smoke. Then the crater reverberated with a roar that sounded as if the old volcano itself had erupted.

Slowly, as if it were struggling free, the rocket began rising from the ground. It seemed to wobble a bit, then steadied itself as if it had found new strength. It was rising faster now as if feeling sure of its own power. It rose above the Gantry crane and in the brilliant jet stream of green fire we could see the "shock diamonds" of supersonic flow.

Faster, faster it rose, bellowing with power, now becoming smaller and smaller until suddenly it passed beyond the range of vision, leaving behind only a drifting scrawl of smoke against the blue sky.

"It's a keeper! It's a keeper!" Someone was screaming in my ear and slapping my back. I turned to find Digits there. But he was not the only one who was yelling like an Indian. The whole mob of students were behaving just like him.

It was soon over. Jeeps and trucks were already racing across the field toward the blockhouse. As I knew that Spender and Tago would be among them, I strolled back to my own room. I would have to wait until that evening after dinner to tell Spender Cipher's story.

As for the rocket, it was already on the bottom of the Atlantic. But it had told its brief story in a dozen different languages to a dozen instruments. . . .

As the shoot was followed by a celebration with speeches and a great deal of shouting, I did not manage to see Tago and Spender alone until quite late. I found them together in Spender's office, poring over the first reports on the rocket's performance.

"We broke five hundred!" Spender announced with glee as I came in. "The highest we've ever reached."

I was delighted to hear it but waited until his enthusiasm had subsided a little before I told him about the meeting and then Cipher's weird story.

Spender listened intently, occasionally exchanging glances with Tago.

"Cipher didn't recognize either of these men?"

I told him that he hadn't because it was too dark to see faces.

"And Cipher is a member of the Silent Chessmen?"

"He was there the night I attended."

Spender thought a moment. "Think he can be trusted?"

I told Spender that I thought he could, that though he was highly nervous when he talked to me, he seemed like an honest young man who was distressed at the way things were going with the Silent Chessmen. But I said

that he was young and too innocent to do much heavy undercover work.

"I told him to stick with the club and keep me posted. That's already asking quite a lot, for he wanted to get out before trouble broke."

"Good," Spender agreed. "And he better not be seen talking with us."

"Do you know where this tunnel is?" Tago put in.

"I'll try to find the opening," I said. "But I think it might be dangerous to look for it except at dark. I'll have Cipher point out where he saw them."

"I see where we've got to watch Homberg like a hawk from now on," Spender said. "I was afraid he had some secret contact with the outside world. But the only letters he ever sends out seem to be descriptions of chess games." He paused a moment. "For some time Tago has been urging me to get rid of him before his time's up. I've told you both the reasons I don't like to."

"This news puts a different light on the whole question," Tago said. "We have something definite now. Before we had only vague suspicions. I suggest that we watch Homberg, find out whom he meets and then confront him with our evidence. Know anyone here who could shadow him without arousing too much suspicion?"

Spender thought a moment. "Yes," he said finally. "I can think of one who could do the job."

"Who's that?" Tago asked.

"The man here with us. The professor."

For a moment I was too surprised to speak. The job of tailing Homberg was the last job in the world I wanted and one that I had no reason to believe that I could perform successfully. I had a real dislike of that sort of work,

even though in my youth my greatest hero had been Sherlock Holmes.

"Excuse me," I said when I had caught my breath. "It would be quite impossible for me to do it."

"Why couldn't you?" Spender asked.

I explained my reasons. One, my dislike of undercover work and second, the fact that Homberg and I, since our set-to at his club meeting, were hardly on speaking terms.

"That makes your position all the better," Spender said. "Besides, you're one of the few choice mortals around here who has been invited to his club. And you'll have Cipher, who evidently has confidence in you, to help you along. Moreover, as you and Homberg work together in the observatory, you'll have a better excuse than any one of us to watch him."

As I could understand the weight of Spender's arguments, I could only repeat the arguments I had already made. However, when Tago also urged me to take on the job, I finally, though unwillingly, agreed.

"Good enough!" Spender exclaimed as he seized my hand and shook it. Then he paused. "Got anything to protect yourself with?"

"Nothing except my two fists," I admitted.

Spender glanced at Tago. "We better give him something, don't you think?"

"By all means," Tago said. "If he knows how to use a gun."

"How about it, Professor?" Spender asked.

As I had done a brief hitch in the Army, I told them, I could handle almost any kind of sidearms.

"Good," Spender said. "Follow me."

With Tago beside me, I followed Spender across his office, down flights of circular stairs to the deep cellar of the building. There Spender opened a door with a small key that he took from his wallet. As he swung the door open, he looked back over his shoulder at me. "Don't be alarmed now," he said with a grin.

He switched on a light and we followed him into a large windowless vault. It was stacked with guns of every description. Boxes of ammunition were piled up on the floor.

"Our first line of defense," Spender said, as he waved his hand toward the astounding supply of arms.

Without further words, he pulled open a long shallow drawer and took out two objects wrapped carefully in oiled paper. He unwrapped one and handed it to me.

I looked down at it. A beautiful little Belgian automatic lay in my hand.

"And give this one to Cipher," Spender said as he handed me the other. "Hope neither of you has to use them, but it looks like there may be opportunities. And here are a couple of boxes of cartridges."

I shoved the two guns and the cartridges into my pocket. Still slightly dazed by the unexpected sight of enough weapons to equip a regiment, I glanced around the room. "Sure no one knows about all this stuff being here?" I asked, alarmed by the idea of anyone getting hold of that stock of high-powered artillery.

"Oh, I guess it's pretty safe," Spender said. "It's protected by a burglar alarm that sounds off in my apartment and a special magnetic key opens the door."

"We've got to take every precaution," Tago said

thoughtfully. "We may be in deeper water than we think."

We followed Spender out of the vault. He switched off the light and locked the door. "Don't jump hurdles until you come to them," he said. "But if you're worried, Tago, I'll have them run the alarm into your rooms, too."

"I wish you would," Tago said.

I left them there. Feeling the heavy weight of the two guns in my pocket, I went down the stairs to the first floor and out into the night. It was late and Mars hung red above the crater's rim.

Under the sky-bright stars, I hurried toward the observatory. Homberg was there waiting for me. He greeted me with much less coolness than he had that afternoon. Together, in the harmony which only a mutual interest can create, we forgot our differences as we studied the mysterious and rusty face of that planet named after the God of War.

Chapter 11

I DID NOT CARE MUCH for the undercover job I had taken. Though it is true that when I left my quiet campus I had realized I might run into something livelier than my own humdrum routine, I had not imagined that before a month was up I would be toting a gun and, as Spender believed, be in danger of my life.

But now I remembered the card with its warning in green ink that I was to keep "Hands Off," I remembered Homberg's interest in my mail when I had first arrived, and his eagerness to find out who I was and where I had come from.

Evidently he had become satisfied as to who I was. For, though neither of us had ever mentioned our meeting abroad, I had a feeling that he had finally placed me.

What was he up to now? Was Cipher right in believing that he planned to take over Astropolis? That he had been grooming his faithful little band of Silent Chessmen for that purpose?

Or was Homberg set only on getting hold of the plans of Spender's photon reactor? If this strange motor was all that Spender suggested, every nation on earth would be after it. I myself hadn't been shown the details of its construction, but perhaps Homberg in his own secret way had found out more about it than anyone except

Spender himself knew. With some more efficient means than chemicals to propel his cargo-carrying ships, Homberg could establish his space station with little difficulty.

But was Homberg interested in establishing one for himself? Or did he mean to work hand in glove with some foreign power?

Deciding that only time itself would tell us the secret plans that seemed to be stewing in Homberg's fertile brain, I walked back to my room.

There I drew the two revolvers from my pocket. Hoping that Homberg, while he was working with me that evening, hadn't noticed the bulge in my pocket and guessed that I was armed, I loaded both guns and placed them in a convenient drawer in my desk.

I wondered if I should give one of them to Cipher. I still wasn't entirely sure of him. It was still possible that he was acting as an agent for Homberg. But what I feared more was that in some sort of panic he might fly off the handle and betray us all. Besides, if they ever caught him packing a gun, it would be curtains for him.

The motion of the stars and the planets may be complicated, I thought to myself as I slowly undressed and donned my pajamas, but their motions are not half so complicated as the emotions of human beings.

With this solemn thought I drifted off to sleep.

On the following morning I left Cipher a brief note asking him to take a bicycle ride that afternoon, late. Having done this, I went over to Tago's room to discover if he and Spender had worked out any concrete plans.

I had never visited his room before and wasn't ready for the Oriental splendor with which his place was decorated. Silk tapestries hung on the walls and covered the

windows. Here and there were small statuettes, while shelves of books stood against the walls.

I found Tago himself seated on a low, red leather divan. He waved me to a chair and at once outlined what Spender and he had decided on as a course of action.

The plan was simple and, except for one item, I subscribed to it heartily.

"In the first place," Tago began as he clasped his delicate hands over his knees and leaned back, "Spender is wiring a New York agency for a couple of men to cover the harbor. That shouldn't be difficult. The harbor is a small one and the town is composed largely of natives. But we must find out at once where that entrance to the tunnel is so we can watch it. Are you ready to do a little exploring?"

I told Tago that I was arranging to explore the tunnel that evening.

"Good," Tago said. "Secondly, we are storing all papers, blueprints, and so forth concerning the photon reactor in the vault you saw last night. We plan to keep them there until this business is cleared up. And, thirdly, we plan to treat Homberg as if we still had confidence in him."

"Think that's a sound policy?" I asked.

"No," Tago said as he studied me with his black eyes. "Frankly, I don't think it's wise to keep Homberg here a moment longer than we have to. I was of the opinion that the man should be loaded into the 'copter and dumped back in the States. But Spender's the boss and my suggestion was overridden. He thinks we should keep him here until we find out what enemies we might

have to look out for when Homberg's gone. Perhaps he's right, but I don't think so."

"I agree with you," I said. "Though I must admit it may be because it would free me from my task of shadowing the chap."

"I'm afraid he's turned out to be a really dangerous menace. Have you your gun with you?"

I confessed that I hadn't.

"Spender wants you to carry it, says that from now on you shouldn't go unarmed."

I couldn't help smiling. "Why, is Homberg a killer?"

"I suppose you've heard that in Poland they once attempted to kidnap him."

"I've heard the story," I said.

"He killed the two men who tried to do it," Tago said.

"Killed them!" I exclaimed. "Homberg did?"

"They were found with their throats cut," Tago said. "They were both found in the room in Warsaw where Homberg was staying."

"Has Spender known this right along?" I asked.

"Homberg told Spender himself. I guess it's true." Tago paused a moment. "But you look as if you could take care of yourself, as you say you did a hitch in service. But Cipher worries me. Do you think the lad would stand up in an emergency?"

It was naturally impossible for me to say. Cipher was slight of build, but there was as yet no reason to believe that he lacked courage. The only question was whether or not he was telling me the truth.

"I'll know this evening," I said. "If he can show me the tunnel entrance, I'll know he hasn't just been seeing things, or lying."

"As for guns," Tago said, "personally, I've never carried a gun at any time. I prefer other methods, but you'd better stick to a gun." He paused a moment. "In India our weapons are sometimes invisible, but they have power."

Tago did not explain what he meant by this, but for half an hour or so we discussed his country—its ancient religion, its history, its wealth, and its vast poverty. Finally I brought up a question that had been troubling me.

"By the way," I said. "It's always bothered me, who is that super-wealthy Hindu who helps finance Astropolis? Who is this mysterious individual?"

Tago laughed. "Oh, he's not so mysterious, but quite a chap, all the same. Young, fairly intelligent, a good mathematician, pretty trustworthy. Likes Americans. I'll tell you his name some day."

I looked at Tago. "I'm beginning to have a vague suspicion that I've met the chap somewhere," I said. "Is his name Tago by any chance?"

"Maybe," Tago said with a smile. "Come to think of it, his name may be that. But keep it under your hat, will you?"

"Trust me," I said. I shook his hand and tried to think of something real to say to him. But I couldn't and soon after I left him, feeling as I always did when we had talked things over together, unworried, free from all anxiety.

Back in my room, I went to work with renewed zest.

Even if bullets started whining past my ears, I had my lectures to prepare. I still hadn't touched on a number of subjects and one of these was the actual handling of a space ship, particularly the problem of bringing it back safely to earth.

As we know, any astrocraft traveling from some distant point in space would approach the earth, even with its motors throttled way down, at the speed of something less than seven miles a second. This is the speed which the gravity of the earth would give it, for to all intents and purposes it would be a falling body. But long before we reach anywhere near the earth, this speed must be reduced. For if our ship should dive into our atmosphere traveling at that clip, it would instantly be transformed into a shooting star and that would be the end of us.

Now, how can we avoid this unpleasant way of ending our interplanetary career? How can we land safely on *terra firma?*

Before taking up this question, let us consider how we would land our ship on the moon. It is a simpler operation but in many respects like landing on the earth.

Unless the ship is traveling at a fantastic speed, the atmosphere surrounding the moon can be ignored. It is too thin to create a serious problem. Moreover, since the gravity exerted by the moon is only one-sixth that of the earth's, less power is needed to slow the ship down. For, since the escape velocity of the moon is 1.5 miles a second, a ship, its motors cut off, would gradually reach that speed as it fell.

Now, there is a point in space between the earth and the moon where gravity reaches a sort of dead cen-

ter. This dead center is 23,600 miles from the moon. It is the point where the gravity of earth and moon counterbalance each other. If neither the moon nor earth were in motion, an object caught in that Sargasso Sea would hang there forever. However, long before this point has been reached, our ship will be merely coasting, thus permitting the pull of earth's gravity itself to slow the ship up. After reaching this dead center, our ship will begin falling toward the moon.

How can this fall be checked?

A parachute is, of course, out of the question. There isn't enough atmosphere to open a 'chute. So the only method we can employ is to turn the ship around and approach the moon rearside foremost so the rocket motors can counteract the motion. Reversing the ship so that the stern points toward the moon will not be difficult. The dozen or so hinged rocket motors will do the work very nicely for us.

To prevent the ship from spinning head over heels, and otherwise to stabilize it, we must employ a set of flywheels mounted at the ship's center of gravity. There will be three of them and they will be placed at right angles to one another. When one of these wheels is spun around at a high rate it will gradually absorb the rotation of the ship and steady it just as a gyroscope steadies an ocean liner.

When the ship has come within a few thousand feet of the moon, the rocket motors will be turned on full blast. At the same time, the landing gear will be lowered. This consists of four long legs like those on a stool. Then a central landing leg will be put down. This is a

large, hydraulic shock absorber to cushion the jolt when the legs strike the solid rock of the moon's surface.

For landing on the earth's surface, this same technique will be employed. But the real difficulty will not be landing; it will be entering the earth's atmosphere. To reverse the ship and back down as we did on the moon would require far too much fuel to make that possible. It would require as much fuel to descend to earth, using the rocket motors as brakes, as it had to launch the ship into space. So we must slow down the motion of the ship in some other way. How can we do it?

As we know, a ship plunging vertically into the earth's atmosphere at seven miles a second would vaporize instantly. So the ship must enter the atmosphere at an oblique angle. However, even the rarefied air at a height of fifty miles would melt the ship if we stayed in it for more than a few seconds. So we must dive in and out like a porpoise. But each time we dive in, the atmosphere slows us up a little, just as water slows up a hydroplane when it lands at sea. Of course, during this in-and-out process, we may have to circle the earth several times until our speed has been reduced sufficiently to make a landing possible, as we did on the moon.

This method of using the atmosphere as a brake is officially known as the "supersonic glide" or "entry by braking ellipses." It will also be possible to use it in landing on Venus or Mars, for both these planets have atmosphere. The atmosphere on Mars is much thinner than our own but, like the moon, its gravity is considerably less than that of the earth—two-fifths of ours, in fact. So its escape velocity is only 3.2 miles a second,

which would be the speed we would have to counteract.

Landing on Venus, however, would offer many other problems. For though the atmosphere is heavy, we would have violent gales to contend with. Frightful dust storms, some astronomers believe, prevail there and the winds howl across the planet with hurricane violence. However, as no one has ever seen the surface of Venus, this is mere surmise.

Having worked out a method of landing, we must now consider the course a ship must follow to reach our neighboring planets.

Navigation during space flight will be a much more difficult operation than navigation on sea or air, for one's port of departure and one's port of call will be moving. And moving very rapidly.

Let us consider the earth's motion, for example. The earth rotates at the equator at the speed of 4.943 miles a second. That is one motion. The second is the earth's orbital motion around the sun. This is at the speed of 18.5 miles a second.

Now, when the space ship takes off it will be necessary to take advantage of these two motions. As the earth rotates from west to east, our ship must take off in an easterly direction to use the five miles a second the earth lends us. We must also arrange matters so that when we leave for our objective we will be traveling in the same direction the earth is traveling around the sun. This will add 18.5 miles a second to our speed. That is, if we want to use it.

Meanwhile our objective, let us say Mars, is moving around the sun, too, at a speed somewhat similar to our

own. At a certain point in its orbit it will be at its closest to the earth—thirty-five million miles away. It will be to our advantage to reach Mars at the very moment it comes closest to us. This timing will require some pretty fancy calculation, but we have electronic computers now that will do the trick for us.

But, to reach Mars, will we follow a straight course so that the distance traveled will only be thirty-five million miles?

No. Our course, unless we have so much power that we don't care how we waste it, will follow a long sweeping ellipse. It will cover much more than the thirty-five million miles that light, traveling in a straight line, covers in reaching us from Mars. But it will be our most efficient way of reaching the planet.

The next time you are in a moving car, toss an apple at a telegraph pole and see what course the apple follows. You will notice that the apple follows a curved line. It curves out and assumes the direction of the car itself because the moving car has given it that tendency. So to hit the pole you start throwing the apple well before you come abreast of it. That is the easiest way. Another way is to throw the apple so hard that, from the point of view of the car, it travels in a straight line. But this would take an exhausting amount of strength, the pitching arm of an Allie Reynolds.

But suppose that not only are you moving but the telegraph pole is moving, too. Or to make it easier to imagine, suppose you are in one car and want to toss an apple to a friend who is in another. Moreover, both cars are moving in the same direction, though your

friend's car is behind and moving at a faster clip. You will then time the throw of the apple exactly so that it will reach him when he is abreast. But if you want to toss the apple to him with as little energy as possible, you will do it so the apple describes a wide, sweeping curve.

In the main, interplanetary flight will proceed along the same lines. Fortunately, the planets not only travel pretty much in the same plane, on the same level in space, but they all travel in the same direction. And as their motion is always uniform, the timing can be worked out to the fraction of a second. And it will have to be. For if your space ship arrives at its destination a second late, the planet it hopes to land on will have shot past. Then you will either have to chase it or wait a year or so for the planet to return. If you missed Mars, you would have a wait of 687 days, which is the time Mars takes to circle the sun.

For this reason, it will certainly be advisable to have a competent navigator aboard who can plot the ship's position in space at any given moment. However, it will not be a difficult matter, for since the motors of the ship are throttled down as soon as the ship has reached a certain speed, the ship will necessarily continue at the same speed. And once the skipper has estimated the speed, he will not have to bother much about it again.

Finding his position in space will be a more difficult problem for a navigator than finding a position at sea. For at sea one travels on a flat plane of two dimensions, while in space a ship moves in all three. A space ship not only can move in all the directions of the compass, but it can move up and down as well. . . .

It was now afternoon. I glanced over the pages of my lecture, added a few notes and changes, and then stepped to my window. It was beginning to grow dark. The towering rim of the crater was already casting its jagged shadow on the crater's floor.

Cipher was due to meet me in my apartment at four o'clock, and it was now quarter past. I went to my desk and took out my revolver. I was admiring its beautiful workmanship when there came a rap at my door. It was Cipher.

"Are you ready, sir?" he asked.

I told him to come in. He did so and then stood staring at me until I realized that I still held the revolver in my hand.

"Oh, yes," I said, as I held it out. "There's one here for you, too. Want it now?"

Cipher looked worried. "Will I need one?" he asked.

"Probably not," I said. "But there's one here if you do."

"Thanks," Cipher said. "But I'm afraid I'd have no place to keep it. You see, I share my room with two other students."

I was glad to hear Cipher refuse the revolver for this reason. It proved that he had his wits about him. I slipped my own gun into my pocket and put on my hat. "Got a bicycle for me?" I inquired.

Cipher said that he had borrowed one. Five minutes later we were spinning side by side along the path that led to the south end of the *caldera*.

"Things are tightening up," I said to him. "It's

more important than ever to keep track of Homberg. Seen him today?"

Cipher shook his head. "Not this afternoon at any rate."

"I should have made certain," I said, inwardly hoping that he was busy in his room or in the observatory.

Cipher wheeled on. As he knew which direction to take, I dropped behind. Ten minutes later, he halted. Straddling his bicycle, he looked around him.

"It's somewhere near here," he said when I came up to him. "I think I was over near that rock when I was fixing my chain."

We pushed our bikes over to a jagged splinter and started searching for the path down which Cipher had seen the men descend. We scrambled over the dusty and weather-bitten pile until suddenly Cipher stopped and pointed to a large upright fragment that stood darkly against the evening sky.

"It was near that bird-shaped rock," he murmured. "They seemed to come from behind it."

We climbed toward it, pulling ourselves up on jagged splinters that tore my hands, until we came to a sort of landing place. Cipher pulled a flashlight from his pocket and beamed it about him.

"Careful of that light," I cautioned him, for I knew it could be seen from across the crater.

I had hardly spoken when Cipher's flash spotted the opening. It was oval in shape, about six feet high and, because it was not on the crater's face but at right angles to it, invisible from the ground below.

"There it is!" Cipher whispered as he touched my arm.

We went toward the opening, and cautiously entered it.

For the first two or three yards the tunnel ran at only a slight incline. It was a narrow tunnel, only wide enough for one man to walk in. Briefly inspecting the sides, I could not determine whether it was manmade or was the product of some natural force.

We had not gone far, feeling our way along, and had come to a bend in the tunnel when Cipher halted. He snapped off his flashlight.

"Listen!" he whispered.

Stock still, we stood. Then in the distance I heard someone cough, the sound of a stone rattling, the scuff of feet. Someone was coming toward us, but so close that there was no time to escape.

We both turned and in the utter darkness felt our way back toward the entrance.

I felt wildly around me for a place to hide. Before Cipher had snapped off the light I had noticed a sort of hollow place at a bend in the tunnel. I found it and, grabbing Cipher's arm, drew him back toward me.

The footsteps were drawing closer. We could hear distinctly now the panting of someone struggling up the steep incline. Closer it came and then suddenly a beam of light flashed on the tunnel's roof above our heads.

We flattened ourselves against the wall and held our breath. The panting of whoever was coming toward us was now so close that it seemed almost like our own. I tightened my hand on Cipher's wrist, for he had begun to tremble from the effort of keeping himself flattened against the wall. Then suddenly the beam of the flashlight showed around the bend. For a moment it played

around the entrance as if the person directing it wished to make sure that the coast was clear. The light flashed off. There was absolute darkness for a moment. Then I felt a body brush past mine. I gripped the gun in my pocket.

The figure did not stop. He continued along the tunnel until his body blotted out the tunnel opening. For a moment he stood there inspecting the land below. Then he turned his head and I saw, plainly revealed against the darkening sky, the profile of Dr. Homberg.

His flashlight played on the ground below for a time, and I wondered if its rays would pick up our bicycles. But then he disappeared and we could hear him slowly making his way down to the crater's floor.

"Who was that?" Cipher whispered as we stood there motionless. "What was he doing here?"

"I don't know," I said, avoiding Cipher's question. "I don't know why he's here."

I didn't tell Cipher who it had been. But as the two of us rode slowly back to the campus, I wondered with a deepening sense of fear what Homberg had been up to.

Was he planning now to take matters into his own hands? And soon?

Chapter 12

At the faculty table that night, Homberg seemed in the best of spirits. He laughed and chatted with those next to him. If he had any suspicion that Cipher and I had seen him, that he had passed so close that his sleeve had brushed my arm, he gave no sign of it.

Though I was sitting next to Spender, I did not tell him then what we had seen. In fact I had made up my mind not to be seen talking publicly with either Tago or Spender except briefly and casually. But I could not help casting a furtive glance at Homberg. Perhaps a little too often. For when I had finished my meal and was starting toward the door, he came over to me and took my arm.

"Will I see you at the observatory tonight?" he asked.

I told him that I intended to be there.

"Thought you might be a bit tired," Homberg said. "Out cycling again?"

Startled by this question, I was about to deny it when I caught myself. "Why, yes," I admitted. "How did you guess?"

Homberg laughed and raised a finger to his eye.

"Nothing escapes the sharp eye of an astronomer,' he said. "You're still wearing your clip."

I glanced down. Homberg's eyes were sharp indeed. I realized, then, if I hadn't before, that I must be on my guard.

"Yes," I said. "I took a little spin just before dinner." Then I stared at his shoulder. It was perhaps rash of me to have done so, but I could not forbear taking Homberg down a peg too. I brushed some dust off his shoulder with my hand.

"It seems, Doctor," I said, "that you've been out browsing somewhere yourself."

Homberg gave me a sharp look which he immediately covered up.

"Dust on my shoulder, eh?" he said. "Celestial dust, no doubt. Are you coming over to the dome now?"

I told him that I couldn't do so right away. I had to return, I said, to my room. I left him at the door of the dining hall.

I had no reason to go to my room, for I was planning to drop in on Tago and tell him what Cipher and I had seen that evening. I found him just returned from dinner.

"What can he be up to out there?" Tago said thoughtfully when I had told him. "But it does seem as if things were rapidly coming to a head. Was he alone?"

"When we saw him."

"I'll tell Spender this evening. You didn't have a chance to go through the length of the tunnel?"

I told him how far we had gone.

"I'll go through it myself tomorrow," Tago said, "if you can keep an eye on Homberg. Think I can find it?"

I gave him directions as accurately as I could and then hurried off to the observatory. I did not wish to arouse Homberg's suspicions by staying away too long.

I found Homberg fiddling around with the celestial camera when I got there. After we had discussed some technical details of the mechanism, Homberg suddenly asked me if I had found time to do a little exploring around the crater.

"Some very interesting geological formations," he said. "And a few lava caves that would bear investigation. Like to show you some of them myself."

"Didn't know you were a cave man," I remarked. "Done any exploring recently?"

"Whenever I have a chance," Homberg said. "Besides chess, it's my only recreation here."

Well covered up, I thought to myself. But he's evidently aware that someone may have seen him. I changed the subject, or rather attempted to, for Homberg returned to it.

"Yes, chess and caves," he continued as he leaned back in his chair and started rolling a cigarette. "My only recreations, and pretty innocent ones at that. Yes, my friend, I'll be rather glad when I leave the tedium of this place."

"This is news to me," I said, completely taken aback by the announcement. "Are you planning to leave soon?"

"In a few days," Homberg calmly replied. "I guess my work has about ended here. A year or more in this crater is a long time for a man who still has plenty of work to do in his own field."

"Where will you go?" I asked. "Europe?"

"Not there. I've had several flattering offers from

American universities. I'll probably start teaching in the States."

"This is all rather sudden," I said. "When did you come to this decision?"

"Only this afternoon," Homberg said. "It all seems pretty hopeless for me here, and I doubt if anyone will miss me except a few chessmen. Some of them, as you know, feel pretty strongly that I should stay on and battle for our ideas. For a time I considered it. But outside of that, I haven't made many friends, more enemies, I imagine. I suppose I've been a bit too bullheaded."

"You mean about your space station?" I asked with a smile.

"Ah, yes. The space station. That was my dream and dreams are hard things to give up. I tried to interest the Astropolitans. But I'm afraid my dream must end. Here, at least."

I had never seen Homberg in this mood before, and I must confess I found it disarming. I even wondered for a moment if I had misjudged him. As I gazed at him sitting there beside the telescope, fumbling with his cigarette, he seemed like an old, defeated man. In spite of myself a wave of pity went over me.

"Oh, you may find someone else to interest in your space station," I suggested. "There are many who believe that it's the thing to work for."

Homberg shrugged his shoulders. "But who?" he asked. He paused a moment and then suddenly rose. "But this is getting no closer to Mars and time is short. Let's to work." He laid his hand on my shoulder. "I'll miss you and this good tube when I'm gone," he said.

We went to work then. Seldom in my experience collaborating with other astronomers have I worked more profitably than I did with Homberg that night.

On the following morning I ran into Tago at breakfast. I could not help repeating what Homberg had told me about his plans to leave. Tago was obviously puzzled.

"Rather unusual procedure for Homberg to take," he said. "But maybe he's begun to realize that a space station could never be our main interest."

"It sounded as if he were throwing in the sponge," I said.

But I couldn't discuss it any further for I had to hurry to my class. As a matter of fact, I was lecturing that day on space stations.

In my prepared lecture I had handled the problem as diplomatically as I could, for I did not wish to involve myself or my students in any quarrel over that ticklish subject. I was sorry now that I had pussyfooted the issue. For if Homberg were leaving, the main supporter of the space station would go with him.

However, I managed to get in a few of my own opinions on the matter and when some questions were raised at the end of class I gave some pretty straightforward answers.

My class done, I returned to my rooms. My lecture for the following day was to be on the moon and the planets and I had to prepare it. I sat down and started to work, feeling more lighthearted than I had for days.

I tried to compose a brief lecture, relying largely

on questions my students would raise when I had finished. I knew that they would have many, for my subject was: "Is the moon or any of the planets habitable?"

I started off with the moon. It is, of course, the nearest celestial body, two hundred twenty-six thousand miles away at its closest, and it will naturally be our first stopping place. But what will we find there?

In the first place, we will find there nothing that could be described as visible forms of life. There are many reasons why there can't be, but I need to go into only a few.

Life, as we know it, is mainly dependent on three things: temperature, the presence of oxygen and the presence of water. Let me begin with the temperature.

When milk is pasteurized, all the living germs are killed and the milk is sterilized by keeping it at a temperature between 145 and 150° F. for thirty minutes. We also know, as I have mentioned before, that a human being, a much tougher species than a germ, can last barely an hour at a temperature of 185. But what is the temperature of the moon?

Well, when the sun has been shining upon the moon, the surface temperature rises, as we have seen, to that of boiling water, that is, 212° F. at sea level. Moreover, when the moon is dark the temperature plunges to 250° below zero. This is far below any temperature the earth ever drops to, for 94 below is the lowest that has ever been recorded here. No, life could never exist in these wide ranges of temperature.

But if a living organism should manage to develop some way of resisting these wide ranges of temperature, is there any oxygen for it to breathe? No, there is no oxy-

gen on the moon. It has all escaped for the simple reason that the gravity of the moon is not powerful enough to hold its oxygen. Or to express it in a mechanical way, the velocity of a molecule of oxygen is so close to the escape velocity of the moon that it can fly off into space. And that is where most of the oxygen that existed on the moon has gone—it has escaped into space.

But what is the atmosphere on the moon made of? It has been proved that an atmosphere surrounds the moon, though it is an extremely thin one. Its rarity is made evident by the fact that when a star passes behind the moon it disappears immediately. If there were a moderately dense atmosphere on the moon, the light rays of the star would be refracted and we would see it for an instant or two before it actually faded from view. Recent investigations prove that our atmosphere at sea level is ten thousand times as heavy as the moon's. However, at the height of fifty miles, the density of the moon's atmosphere and our own are about the same.

This is an interesting point, for it is at the height of fifty miles that small meteors striking our atmosphere disappear and there is every reason to believe that meteors striking the moon's atmosphere disappear at that distance too. If they weren't disintegrated by the atmosphere, they would shoot down to the moon's surface and explode. Dr. La Paz of the University of New Mexico has calculated that a meteor weighing ten pounds would make a flash bright enough to be seen with the naked eye and that by the law of averages there should be one hundred flashes on the moon every year. But though astronomers have watched carefully, hardly half a dozen of these flashes have ever been seen.

During its long history, the earth has used up an enormous amount of oxygen in the process of weathering or, in technical terms, the oxidization of its minerals. It is estimated that during the millions of years that this process has been going on, it has exhausted twice as much oxygen as now exists in our atmosphere. How has this oxygen been replenished?

The oxygen in the earth's atmosphere has been replenished by the vegetation on the earth. Plants absorb carbon dioxide. They then decompose it by means of the green coloring matter, the chlorophyll, present in their cells. Oxygen is the result, a sort of byproduct, and plants breathe this out into the air. If the plants, through the power the sun gives them, did not produce oxygen in vast quantities, we would soon have none to breathe ourselves and the earth would find itself in the same sad shape as the moon and Mars are in.

But even if there is carbon dioxide present on the moon, plants cannot live there for the same reason that other forms of life can't—there is no water. Years ago, when the telescope was first being used, astronomers thought that they saw great seas and lakes on the moon. They went so far as to name them. Even today we still call great dark patches seen on the moon such names as Sea of Clouds, Sea of Nectar, the Ocean of Storms, or Bay of Rainbows, Lake of the Sleepers. The names, however, are discreetly veiled in Latin. Perhaps millions of years ago these "lakes" and "seas" were made of lava, but liquid stone was the only liquid they have ever seen.

No, there is not a drop of water on the moon, nor ice, nor vapor. In fact, the moon is covered by something quite different. It is covered by a dry volcanic ash through

which our hardy spacemen would have to wade, like snow.

On the other hand, some astronomers think it is not volcanic dust but the powdered remains of meteors, for there is still disagreement as to what formed the craters that cover the moon's surface. Many of these craters are enormous, and there are hundreds of them. Our own crater here at Astropolis is a pigmy compared with some of them. The crater named Clavius is large enough to contain all of Switzerland and its rim towers seventeen thousand feet. Copernicus is fifty-six miles across, while one crater is so wide and deep that you could drop Mt. Everest into it and only the peak would show above the rim.

I will not go into my own theories as to how these craters were formed. Argument still rages, and it doesn't matter to us now. All we are interested in is what will we find when we get there. But whatever we may find there, it will be nothing that can be described as life. We couldn't even stop there to catch our breath, for there would be nothing to breathe except carbon dioxide gas, and dust.

What would we find if we proceeded to Mars?

Mars, which is farther away from the sun than we are, at times comes close to the earth, though never so close as Venus. A ray of light from the earth takes only a few minutes to reach Mars; a space ship traveling at the earth's escape velocity would require fifty-eight days. But, as we have seen, the journey must follow an elliptical path so the trip would actually require about two hundred and fifty days.

As we approach Mars, we will see its two tiny moons, only ten miles in diameter, while below will lie

the mother planet, orange-red, half the size of the earth, without mountains or craters, lakes or oceans, but criss-crossed with strange-looking lines. Are they canals? Or are they merely the volcanic fissures my colleague Homberg and some others believe they are?

Perhaps no one will know for sure, until someone gets there, what these mysterious lines are. There is a theory that they are canals dug there by the Martians to utilize the melted snow at the poles, for during their wintry season snow caps both poles. But even though they may not be canals, Mars is one of the few planets that could sustain a living population which could dig them.

Let us take up the three requisites for life, one at a time. Temperature, the presence of oxygen and the presence of water.

Temperature on Mars? Good to middling. In the Martian tropics it rises to well above freezing point at noon and may reach 50° or more. Quite enough to sustain life. Water? Water vapor at least is certainly present in the atmosphere, and as the planet shows seasonal changes visible from the earth, it is believed by many astronomers that these changes are caused by a heavy growth of vegetation. If there is vegetation, there must be water present, and if there is vegetation, there must be free oxygen in the atmosphere too. For unless the vegetation is totally unlike our own, it will produce free oxygen just as ours does.

So with all the elements necessary for life present on Mars—a degree of warmth, oxygen and water—it would be possible for human beings to exist there even though they might have to supplement the oxygen with

their own supply, or introduce new plant forms from the earth's own stock to supply it. There is no reason to believe that some of our desert plants might not grow on Mars, perhaps more readily than they do here. Plants introduced into new areas often flourish more profusely than they do in their own native climes; rose bushes in Australia are an example. It is quite possible that Mars could be transformed from a wasteland to a jungle if the proper vegetation were planted. Then we would see the rusty red of Mars turn to a brilliant blue-green.

In many ways Venus is more like our own earth than is Mars. It is about the same size, and many astronomers believe that at present it may be passing through the same process of development as our own earth did millions of years ago when life was just beginning to appear here. For like the earth at that period, Venus is veiled in clouds, impenetrable to all our instruments.

We can only guess what Venus is like on its surface. In fact we are not even certain what its atmosphere contains. So far, no oxygen or water vapor has been detected in it, but this does not necessarily mean that it isn't present there or at the surface. But we do know that if oxygen were present on Venus it would not drift off into space as it has from the moon or to a certain extent from Mars. For Venus, being the same size as the earth, has the same escape velocity. As we have seen, the speed of the oxygen molecules is not high enough to escape from the earth's gravity.

As for the temperature on Venus, we can only guess at that too. When statements rely on guesswork, there is apt to be disagreement, not only among different astronomers but among different statements of one astron-

omer himself. The atmosphere surrounding Venus is supposed to have a temperature that runs all the way from 90 to 120° Fahrenheit in the shade. As the atmosphere is supposed to have a sort of hothouse effect on the surface, some astronomers believe that the temperature there reaches that of boiling water. But, again, that is a guess.

Venus is the planet of mystery. We will only know her when we have pierced the pretty veil that covers her face and can see with our own eyes whether she is fair or ugly. Next to Mars, she will be high on our itinerary.

As for the other planets, it is hardly worthwhile to study them if we are doing so with any idea of colonization. Mercury is too hot; lead would melt on its sunlit surface. Jupiter, the largest of the planets and faroff in space, is too cold. It lies under an impenetrable blanket of ice sixteen thousand miles thick, while its atmosphere of marsh gas is heavy enough to compress hydrogen. No, the trip to Jupiter, requiring nearly three years, would hardly be worth our trouble. And even if we landed there, we would have quite a time leaving, for the escape velocity of Jupiter is more than five times that of the earth.

Because they are so far away from the sun, Saturn, Uranus, Neptune, and Pluto are too cold and too distant to make a visit worthwhile, unless they were found interesting enough to be investigated for purely scientific reasons. . . .

My lecture finished, I put on my coat and hurried over to see Spender. Fortunately I met him as he was hurrying out of the main building. He told me that,

though it was almost dinnertime, he was on his way to the training ship and he asked me to come along.

"You can tell me what you have to say on the way over," he said. "I've got a new hygrometer here I'd like to test. Climb into the jeep."

I went toward the jeep but as I started to climb in, I saw that Homberg, hurrying across the square, had hailed Spender and was now talking to him. His message evidently was a brief one, for a moment later Spender joined me.

"What's Homberg got on his mind?" I asked.

"Nothing important, I guess," Spender said as he leaned forward and snapped on the ignition. "I told him I had some business at the training ship. I'll see him later."

"I had a talk with him last night," I said. "He told me that he's leaving here in less than a week."

Spender, who had already set the jeep roaring across the square, looked at me in surprise. "When did he decide that?" he asked.

"Evidently he's just changed his mind," I said. "At least since I heard him sounding off at the Silent Chessmen that night."

"Has he packed up?" Spender asked.

I told Spender that I didn't know.

"Sort of funny way to announce it."

"Oh, I don't know. He seemed to be in a depressed mood last night and began confiding in me. To tell the truth, I began to feel sorry for the old duffer. He seems to think he's made no friends here."

"Guess he's right in that," Spender remarked, "though I understand he's got a number of loyal adher-

ents in his chess club. From what I gather, some of them think he's the last word. Would go the limit if he asked them."

I agreed that some of them might, at least what little I'd seen of them. "I'll find out from Cipher if he says anything tonight about leaving. There's a regular meeting of the Chessmen."

"Wish you would," Spender said. "But the whole thing sounds just too good to be true."

We had now reached the training ship. No one seemed to be around. Even the machine shop next to it gave no evidence of activity. We climbed out of the jeep and went at once to the airlock.

"The skipper is waiting for me here," Spender explained as he pulled down the release valve. "I think the rest of the boys have knocked off work."

I followed Spender inside the hatch and we climbed up the ladder onto the deck where the helium and oxygen tanks were stored next to the water recovery plant. Far above us we could hear distant metallic sounds of someone at work. Spender called and I heard the skipper shout for us to come up.

We climbed the ladder to the top and found the skipper dismantling an old hygrometer which was to be replaced by the new one Spender carried.

"Smells pretty good here today," Spender observed as he started to unwrap the package. "Not so humid as it generally is."

"Good reason," the skipper said. "Get twenty men in here working and it doesn't take long for it to begin smelling like a zoo."

Spender laughed. "We've got to work out some-

thing a bit more efficient for removing the excess moisture." He lifted the new instrument out of its box and held it up. "But this is one step in the right direction."

"Glad you got it," the skipper said. "Did it just arrive?"

"Half an hour ago," Spender said. "I was going to send it down by the Wrench, but he was busy and I wanted to see how this works. What's the mixture today?"

"The usual, 40 per cent helium to 60 oxygen. I've got so I don't like real air any more."

While Spender and the skipper were fussing with the new hygrometer, I wandered over to the celestial telescope, mounted at the center under the astrodome. When I had visited the ship before, my head had been in such a befogged state from the low pressure that I hadn't been able to look over the instruments as I should have liked.

I had been studying them for fifteen minutes or so, admiring the way each ounce of material had been spared to cut down the weight, when I thought I heard someone stirring below. I waited for a moment or two, expecting to see someone's head come bobbing up the companionway. As no one appeared, I laid the sound to a motor automatically starting and thought no more about it.

Spender and the skipper were meanwhile intent on their task and I continued inspecting the celestial camera when I began to realize that I was feeling queer. It wasn't the same kind of feeling I had experienced before, for I had not then felt nauseated, whereas now I was beginning to feel positively ill. I glanced toward the

two other men. They seemed to show no signs of discomfort and I was beginning to curse myself for my own feeble constitution when I heard a wrench clatter to the floor.

I looked toward the skipper. He was standing facing me now and sniffing the air.

"Seems like we're getting too heavy a flow of helium," he said. He glanced at Spender. "Feel anything?"

"I was going to mention it myself," Spender said. "What's wrong?"

The skipper glanced at the control board. "My God!" he exclaimed. "Look at it!"

Startled by the skipper's exclamation, I hurried over. I looked down at the gauge Spender and the skipper were staring at. The needle of the oxygen gauge, even as I watched, fluttered to zero.

Whether it was merely seeing the fact recorded on the gauge or that the lack of oxygen was beginning to strike home, I can't say for certain. But at any rate I felt myself slipping. Through a sort of fog I heard Spender snap: "Quick! Let's get out of here."

We hurried toward the communicating ladder. Spender went first and I followed. It was all I could do to hang on. By the time I had reached the deck below, my breath was coming in quick gasps and my heart was roaring in my ears. I noticed vaguely that Spender was having difficulty too. I felt him take my arm.

Three decks below was the airlock. Twenty more feet to climb. I began wondering if I could make it. Above me I could hear the skipper. "Take it easy," I heard him saying. "Save all the energy you can."

I looked below me. Far down the curving ladder—

it seemed then to extend a thousand feet into an abyss —I could dimly see Spender's figure rapidly moving down. I wondered if he were falling.

"Think you can make it?" I heard the skipper ask as we reached the midship deck.

I nodded, tried to grin. From below we heard a crash. Had Spender collapsed? I clung on with all my might.

"All right down there?" I heard the skipper call.

A muffled voice from below answered.

When I reached deck four the skipper pushed past and started scrambling down the ladder ahead of me. Panting now in quick gasps through my mouth, I descended the ladder alone.

I don't remember reaching the lowest deck. I remember vaguely seeing the skipper fumbling with the airlock, seeing Spender lying in a heap across it, and I passed out cold. . . .

I came to, I don't know how long afterward, lying on the ground staring at the star Antares in the constellation of Scorpio. Spender was bending over me, while Scorpio was swimming just above his head as if we were among the stars themselves.

"Where am I?" I asked.

"He's come round!" I heard Spender say. "He'll be all right in five minutes."

In less than five minutes I was able to walk without help toward the jeep. I climbed in. Spender, who seemed to have recovered completely, drove the skipper and me through the wonderfully fresh evening air back to the campus.

"What happened?" I asked as we sped along.

Spender's face was grim, his jaw set. "It was a close squeak for us all," he said.

"A faulty oxygen tank?" I asked.

"Guess again," Spender said.

"You know?"

"Sure do." Spender's eyes were fixed straight ahead of him. "Someone closed the oxygen valve," he said. "Someone closed it while we were working topside."

Chapter 13

By the time I reached my room, I was feeling almost myself again. The good evening air had cleared my head, but the shock of having so close a brush with death is something you don't recover from in a matter of minutes.

On the way back, I had not asked Spender for all the details. He told me only that the skipper had dragged us both out into open air and had a narrow squeak himself while doing it. He had dumped Spender's dead weight into the airlock and Spender was beginning to feel it in his shoulder. Fortunately he must have handled me more gently, for I had not yet developed any serious pains.

As I have said, I didn't ask many questions, but when Spender had taken me up to my room, he waited there a moment while I dashed some cold water on my face.

"I'll send the doc over here," he said.

"Thanks," I replied. "But I don't think I need one."

There was a pause while Spender lighted a cigarette. "I imagine you can guess who cut off the oxygen," he said.

"Homberg?"

"I was afraid when you told me that he was planning to leave that he was trying to put us off our guard. He must have hotfooted it down to the training ship as soon as we left him."

"A desperate chance," I said, "that he lost."

"He hasn't lost yet," Spender said. He took a deep puff and blew the smoke out into the room. "I'm calling an emergency meeting at eight in my quarters. Feel well enough to be there?"

I told him that I would. "Inviting Homberg?" I asked.

"No," Spender said. "But I'm afraid there's going to be fireworks tonight. Got that gun I gave you?"

I tapped my right side. "Right here," I said.

"Good enough. I'll send over the doc now and have them bring you some dinner."

Before I could repeat that I was all right and could get my own dinner, Spender was down the stairs.

Five minutes later the young doctor appeared and gave me a thorough examination. He was evidently under the impression that the whole thing was an accident. I did not tell him what our suspicions were. I could not help asking him if he had noticed if Homberg had appeared for dinner.

The doctor thought a moment. "Yes, I believe he was. Yes, he must have been because I remember seeing him leave with two or three young students."

"How long ago?"

The doctor glanced at his watch. "More than half an hour ago. It was just before I left myself."

A half hour ago. I did a little calculation. A half

hour ago Spender, the skipper and I had been fighting our way out of the ship. If Homberg had shut off the oxygen, he still might be unaware that we had safely escaped. Not seeing us at dinner would have convinced him that, dead from helium poisoning, we still lay in the ship.

"Funny you didn't smell the helium," the doctor observed.

"It's odorless," I told him. "It was the oxygen tank that went on the blink."

"I guess that's all you're suffering from—lack of oxygen. Lucky for you the skipper didn't pass out too."

I lay down on my bed and had been there only a few moments when there was a tap at my door. Tiny Cipher came in. His hair was on end and he looked excited.

"Professor!" he burst out as soon as he was inside. "What's going on?"

"Oh, just a slight accident," I said, thinking that he was inquiring about me. "I'll be all right in half an hour."

He stared at me with a puzzled look on his face. "I mean," he blurted out, "what's Dr. Homberg up to?"

"What do you mean?" I asked, startled.

"Right after dinner tonight he called the Silent Chessmen to his room. I passed a couple of them hurrying there just now."

"He didn't ask you to come?"

"Yes, at dinner. But I'm scared to go. I think he's beginning to suspect me. He asked me if I'd seen either you or Spender this evening."

"Did you tell him you hadn't?"

"Sure. He said that no one had and it looked mysterious. Then he asked me to meet him in his room."

"How long ago was that?"

"Half an hour ago. But I waited until the doctor had left. I was afraid of coming in while he was here."

"I think you'd better go and find out what's going on," I said.

"I will, sir, if you think I should."

"Yes," I said. "It's important."

I got up from my bed and yanked open my desk drawer. I took out the little revolver and handed it to Cipher. "You better take this along."

Cipher's eyes widened as he stared at the weapon. "Think I may need it?"

"You may," I said. "Know how to use one?"

Cipher admitted that he didn't, but that he thought he could use one in a pinch.

"Take it," I said. "Hurry over to Homberg's apartment. Find out what's doing and report to Tago. I'll be in his room."

"I'll do my best," Cipher said.

"If Homberg or anyone else asks you if you've seen me or Spender, tell them that you haven't. Tell them that several people were looking for us, but that no one seems to know where we are."

"I'll do that, sir," Cipher agreed. Slipping the revolver into the hip pocket of his blue coveralls, he left.

As soon as he had gone, I put on my coat and without waiting for my dinner to arrive I left the dormitory by a rear door. Taking a wide turn past the main build-

ing, I hurried over to Tago's room. I found him alone and immediately told him the whole story.

"I was wondering at dinner where Spender was," Tago said. "Then I got a message to meet him at his room. Where's he now?"

"Probably in his room. The doctor was going there to check up on him."

"We'd better see him as soon as the doctor's left. This news about Homberg scares me. What time is it?"

"Seven," I said. "The doctor may be through by this time."

Together we went downstairs. We reached Spender's door just as the doctor was leaving. Tago and I went in. Spender, seated in a chair, looked up as we came in. Digits and the skipper were with him.

"You shouldn't be running around like this," Spender said. "Didn't Doc tell you to stay put for a while?"

"I have some news for you," I said. "Cipher was just in to tell me that Homberg has called his clan together. I'm afraid there's going to be trouble."

"Does Homberg know we're safe?"

"Cipher thinks not. Homberg asked him if he'd seen either of us."

"Good," Spender said. "We'll play low and see what's in the cards."

"Don't you think we better find out what's going on?" Tago suggested.

"Take your time," Spender said. "I'm sure Homberg was behind this attempt but we don't have any proof that he's guilty."

"You think somebody from outside could have done it?" Tago asked.

"Could be," Spender said. "As you know, that tunnel the professor discovered leaves this place wide open. Anyone could have shut off that oxygen."

"Have you asked Homberg to come?" Tago inquired.

"Not yet. I'll leave that up to a vote when the committee meets."

"Time's running short," the skipper said. "We don't know what the Silent Chessmen are up to. Who we waiting for now?"

"The three men on the student council," Spender said. "Don't get jumpy. They'll be here."

For a moment there was silence. I nervously lighted a cigarette. Outside on the campus somewhere a jeep's starter whined and the motor sputtered into action. I wondered anxiously how Tiny Cipher was making out. The skipper, humming to himself, paced up and down the room.

The sound of feet in the hall outside brought us all to attention. There was a knock at the door. The skipper went over and opened it.

I drew a sigh of relief as the three council members walked in. Evidently puzzled as to why they should have been called, they greeted us and waited while Digits brought in chairs from the bedroom. When they had seated themselves, Spender got up from his chair.

"All here?" he asked. He counted us off—Tago, the skipper, myself, Digits and the three councilmen. Eight in all.

"Shouldn't there be nine?" one of the councilmen asked.

"Dr. Homberg is missing," Spender said. "We may

ask him to come here later. But before we do, I'd like to give everyone a briefing on what's been happening around here in Astropolis."

I don't need to give the details of the briefing here. It concerned the growing apprehension Spender and others had begun to feel about the Silent Chessmen, their fanatic devotion to Homberg and to his crackbrained notion that the world should be ruled by a satellite space station. Spender then described what had happened in the training ship that afternoon.

"Mind you," he said, as he brought his speech to an end, "we haven't any proof as yet that Homberg is guilty. But we have good reason to suspect him. With the board of directors' approval, I'm asking him to come here for some questioning."

As there were no objections, two of the councilmen were appointed to see Homberg and bring him over at once.

"Supposing he refuses," one of the men asked.

"We'll put him under arrest," Spender said. "But if he asks who's here, don't mention the professor and me. Just say Tago wants to see him."

"That all?"

"Yes," Spender said, "and make it fast."

When the two had gone, Spender turned to us. "Any of you men armed?" he asked.

There were only two revolvers among us, Spender's and mine. Tago, as he had stated, never carried one.

"Expecting trouble?" the skipper asked.

Spender shrugged his shoulders. "There's no telling what a crackpot like Homberg will do when he's cornered."

It was the first time I had actually heard Spender refer to Homberg as cracked, though I had been convinced of the fact for some time. But what made Homberg's insanity more dangerous than most was that he had communicated his disease to others. The germs of hatred, suspicion, fear and lust for power can spread fast and breed more rapidly than a virus. As I sat there with the others waiting for Homberg, I wondered how many of the Silent Chessmen had caught their master's virus, and how badly.

After ten minutes of waiting Spender, who usually was as cool as a cucumber under every circumstance, began drumming on the arm of his chair. Then we heard the sound of a jeep outside. The next moment came sounds of footsteps in the hall.

"They're back!" Spender jumped up and yanked the door open. In the doorway stood the two councilmen supporting Cipher between them.

Cipher seemed hardly conscious. His face was bloody. He managed to raise his head and gazed blinking at us.

"Quick! Bring him in," Spender said.

They brought him in and laid him on Spender's couch. While Tago bathed the little jockey's face, one of the councilmen told us briefly what had happened.

They had gone directly to Homberg's rooms but had received no answer when they knocked. They tried several times and were just leaving when one of them heard moans from the inside. Thinking, of course, that something had happened to Homberg, they forced open the door. They had found Cipher locked in a closet, bound, gagged and only half alive. Luckily they had got

hold of a jeep and had driven him immediately to us.

"We wanted to take him to the doctor's," one of the councilmen said, "but he wouldn't go. Said he must come here to see Spender."

Some cold water on his face brought Cipher around. He stared at me for a moment. Then suddenly, as if everything had come back to him in a rush, he began talking.

"The gun," he said. "They found the gun on me."

"Take it easy now," Spender said. "Take it easy, and just tell us what they're up to."

Cipher shook the fog out of his head. "There was a crowd of them there. The Silent Chessmen in Homberg's room. Homberg was telling them that he'd got Spender and the professor out of harm's way. He said now was the time to take over."

"Take over what?" Spender asked.

"The whole works. Anyway, they seemed to know what he meant, as if they'd all been briefed before I arrived. Then Homberg handed around some masks. That's when I got caught with the gun in my pocket."

"They beat you up?" Spender asked.

"I'll say so. Then they dumped me in the closet."

"How long ago?"

"It must have been just five minutes or so before these two guys found me."

"Know where they went?" Spender asked.

Cipher nodded. "They were going to raid some place for guns and ammunition."

Spender jumped to his feet. "They're after the guns now!" he burst out. "We've got to stop 'em. If none of you guys has a gun, pick up anything and . . ."

Spender's voice was cut short at that instant by the rasping sound of a buzzer over his desk.

"What's that?" the skipper asked, swinging around toward it.

"The vault alarm," Spender said. "They're raiding the vault. They've got the jump on us."

"And the photon reactor plans," Tago said. Spender stood biting his lip. The rest of us waited for orders.

"As soon as they get guns," he began, "they'll take over the intercom. And if they still think I'm a goner they'll try to grab Tago." He looked at me. "You ready to shoot it out with them?"

"I'm with you," I said.

Spender turned to the others. "Get Cipher over to the infirmary," he snapped. "And the rest of you go through the dorms. Get everyone down in the mess hall, armed with anything they can pick up—baseball bats, clubs, guns if they have them. Tell 'em to wait there until I come. Tell 'em to pay no attention to the intercom speakers until they hear my voice. Now scram!"

The boys had hustled Cipher out to the jeep, and the rest were on their way to the dormitories, leaving Spender, Tago and me.

"They've got the jump on us all right," Spender said as he jabbed a cartridge clip into his automatic. "Our main object now is to capture Homberg. Once we've got him, the whole thing will collapse."

"Think we can find him?" I asked.

"He'll be after the reactor plans," Spender said. He turned to Tago. "Mind waiting here? As bait? They'll be after you. It will keep some of them busy."

"Okay, sahib," Tago said with a grin that showed all his white teeth. "I'll try to keep at least two of them busy."

"Good!" Spender said. "Off we go!"

Spender went out and I followed him. We hadn't taken more than three steps when we heard the front door bang open. Footsteps came at a run up the stairs. We jumped back into a doorway, just as two masked men came down the hall. One of them kicked Spender's door open; with drawn guns they went inside.

"They've got the guns all right," Spender said.

We hurried down the stairs. As we crossed the campus, a loudspeaker started booming. We stopped in our tracks to listen. It was Homberg's voice over the intercom.

"Attention! Attention! All Astropolitans!" he was shouting. "We ask you to stay in your rooms to await further orders. Your leader Spender is dead under suspicious circumstances. As next in rank I'm taking over and placing Tago under arrest. This is Dr. Homberg speaking. Stand by for further orders."

"At least we know where he is," Spender said.

"Where?" I asked.

"At the mike in my office. Quick now, follow me."

At a run we crossed the campus toward the main building. Spender pulled open the door and we went inside. In the vault below we could hear the sound of boxes being ripped open. We started up the stairs. Spender had his revolver in his hand. I took mine out and snapped off the safety. We crept up slowly, quietly.

Above us we could hear a mumble of voices. As we

reached the circular stairs leading to Spender's office just above, Spender grabbed my arm. "Listen," he whispered. "He's at my two-way radio."

We both halted and listened.

Spender was right. It was Homberg trying to contact someone at a distance. He was telling someone that all was working out as per schedule. "I've got the reactor plans," he was saying. "I'm in complete control. Please contact me. This is Homberg. Homberg."

"We've got to cut him off," Spender said. "Quick now."

We started up the stairs, holding our breath as we climbed. I wondered how good I'd be when the shooting started. Already sweat was gathering on the palm of my hand as I gripped my little Belgian automatic.

As we rounded a turn in the stairs, I caught sight of someone on guard at the head of the steps. It was the big, yellow-haired man who had pushed me around in Homberg's room. He had his back toward us, evidently listening to what Homberg was saying.

Spender made a quick gesture to me that he would take him over. He tore up the remaining steps and made a flying jump. I barged into the office.

It is difficult for me to tell what happened next. I heard the thud of Spender's revolver as he brought it down on the yellow head in front of him. A bullet pinged past me. A big chap standing next to Homberg was taking aim. I fired, hardly taking aim myself. The big chap's revolver crashed from his hand onto the desk. I covered Homberg.

He was standing as if rooted to the ground. Beside him on the desk was the strongbox. His face was ashen,

his mouth open as he clutched the mike. It was evident that he was seeing two dead men who had come to life. All too obviously it was an unpleasant surprise.

"Up with your hands!" I shouted. "Stick 'em up!"

Homberg did not respond. He began screaming over the radio something about holding off. In his excitement he was using five or six different languages, but in English I heard him say that his plans had gone haywire, that things were in a mess, that he'd radio instructions later. . . .

I didn't let him go on talking. I squeezed the trigger and shot the mike out of his fist.

As I did so I heard the clatter of feet coming up the stairs.

"Keep 'em covered!" I heard Spender yell. "I'll take care of these boys."

I took a quick glance around. Spender had moved to the head of the stairs. He had guns now in both hands. The sound of clattering feet abruptly halted. I heard a shot from below and then Spender began blazing down the stairwell with both guns. There was a yell and the noise of steps hastily retreating down the stairs.

Spender came over to me.

"Hit any of them?" I asked.

"Just put the fear of God into them," Spender said. "I guess the shock of seeing a dead man scared 'em too. Keep these men covered while I search them."

Homberg stood beside the desk, his hands up now, his face white with rage as Spender went through his pockets. Spender pulled out a notebook and a small revolver. He looked at Homberg.

"Who the hell was that you had on the short wave?" he asked.

Homberg, his eyes blazing, stared back. He said nothing.

"Speak up!" Spender snapped. "Or I'll ram this mike down your throat. Was it a Sinasian plane with paratroopers?"

"Yes . . ." Homberg burst out. At the same moment he swung. Not at Spender, but at the standing lamp between them. It went over with a crash. Darkness.

"Catch him!" Spender yelled.

I made a lunge for him, tripped over the shattered lamp and fell heavily against the desk.

By the time I had got to my feet and Spender had managed to find the switch for the overhead light, Homberg was gone. I tore after him down the stairs. But when I reached the outdoors, he was nowhere in sight.

Chapter 14

ASHAMED OF MYSELF for letting Homberg escape so easily, wondering where he had disappeared to, I started back up the stairs to Spender's office. However, I was only halfway up when I heard footsteps coming toward me. To my relief, Homberg's two brave bodyguards appeared with Spender herding them down in front of him.

They were a sorry-looking pair, but Spender evidently wasn't taking any chances. He had the strongbox under his arm and his revolver was ready.

"What happened to Homberg?" Spender called as soon as he caught sight of me. "Get away?"

I confessed that he had. "Melted into the night," I said. "Couldn't find hide nor hair of him."

"We'll make a search later," Spender said, looking angry. "Sure is a slippery article."

"He may even be in this building," I said.

Spender tapped the strongbox with the muzzle of his revolver. "Not much he can get now. But I've got to put these two under guard. Hustle over and see how Tago made out."

I left Spender herding his two prisoners. As I started through the door, I bumped into Digits with one of the councilmen.

"We've got the men assembled in the mess hall," he said. "Where's Spender?"

I told him that Spender was on the way down and might need help. Then I ran across the campus toward Spender's room. I entered the building cautiously and climbed the stairs. As I could hear no sound from inside the room, I pushed the door open, my gun ready for any emergency. However, I wasn't ready for what I saw.

As I swung the door open, I found Tago untying some rope from his wrists.

"Where are the two Chessmen?" I asked.

"They took off when the shooting started," Tago said.

"And just left you here?"

"I was tied up," Tago said as he tossed the rope onto a chair. "Granny knots, nothing but granny knots. Did you get Homberg?"

"Homberg got away," I confessed. "Slipped through our hands. Spender's got the other two ringleaders. I guess Homberg's little revolt is ended."

"But Homberg isn't. Any idea where he might be?"

"Heaven knows where he is," I said.

"He'll be a menace as long as he's at large," Tago said, looking worried. "How about the rest of them?"

I told him what had happened, and that Spender was on his way to address the students assembled in the mess hall.

Tago stood up. "I must see him." He started toward the door.

We hurried toward the mess hall. Students were still gathering, coming from the dorms in excited groups.

We followed a group into the hall. One of the students, recognizing me, turned to ask what it was all about.

"Will Dr. Homberg speak?" he asked.

"I'm afraid he's not around at the present moment," I said.

As we entered, Spender had just mounted one of the tables. I noticed as I looked around me that most of the students were carrying clubs and baseball bats. They started cheering as Spender stood up. As Tago and I entered, he saw us and called out that he wanted both of us up there with him. Tago and I climbed up on the table.

"I want you boys to see that none of us is dead," Spender shouted. "Look us over carefully."

We were all cheered again. Then Spender started speaking. He explained briefly what had happened.

"I'm only sorry for the deluded fools who came under Homberg's influence," he said at one point. "I suppose they acted according to their consciences. I suppose they thought they were doing what is right. But a twisted conscience is often more dangerous than no conscience at all. I don't know how many men were involved. Twelve maybe, perhaps twenty, and some of them may be here in this room now.

"Homberg is still at large. I'm making every one of you here a deputy with powers of arrest. We'll search every square inch of Astropolis as soon as this meeting ends. If anyone finds Dr. Homberg, bring him in—alive. That's all, my fellow Astropolitans, and God bless you all."

Having finished his speech, Spender started to climb

down when he thought of something else. He waved for silence.

"As a celebration, my friends, we'll have our last big rocket firing, sooner than we planned it. Our last shoot reached five hundred miles. Let's try to make this one a thousand!"

More cheers and the meeting ended. When I got outside, students were already being arranged in squads. The search for Homberg began. I myself was too weary to take part in it. All night I could hear the sound of voices and from my window see the flashing of lights. I had little hope that they would ever find my recent colleague. Like a rat, I imagined, he had long ago slunk through the tunnel.

As I had expected, no trace of Homberg was found and he was soon forgotten. Spender had been wise indeed to order another shoot, even so soon after the previous one. It centered everyone's activity and instantly restored a feeling of unity and strength. Even the half dozen Silent Chessmen who were allowed to stay at Astropolis were soon treated as if they had never taken part in the attempt to wreck the organization.

However, it was less easy for Spender, Tago and me to forget Homberg. For the sheaf of papers Spender had taken from Homberg's pocket just before he smashed the light and escaped showed him to be a darker liar and adversary than we had imagined. Certain that his revolt would be successful, he had carried in his pocket not only the detailed plan of the rebellion which had misfired, thanks to the skipper's remarkable endurance

and his rescue of Spender, but also a detailed report of his activities in the past.

It was evident that he had been in constant communication with the Sinasians. It was evident that he had managed to carry on a correspondence with little chance of being found out. He had used an ingenious code which on the surface looked as if he were carrying on a chess game by mail. But what was more important to us was the knowledge that he had expected outside aid.

"It was a close squeak for us," Spender admitted when he showed the papers to Tago and me. "There evidently was a plane almost above us, ready to drop parachuters as soon as word came from Homberg. Tubes here shot the mike out of his hand just in time."

"But what I'd like to know," I said, "is, where's the plane now? And the crew? Aren't they still a danger?"

"Doubt if they'll try it again," Spender said, "now that we've been alerted. At least not for a while."

"The tunnel is still open," I observed.

"I've given orders to block the entrance," Spender said. "They're starting work on it as soon as we've had the shoot."

"Why delay?" Tago asked. "Even if his fellow conspirators don't strike, Homberg may."

"Wish he'd show up," Spender said, with a grin. "Nothing I'd like better."

"I doubt if you would," Tago said. "When men like Homberg go down, they try to drag the whole world with them."

"No sign of him anywhere," Spender said. "The

detectives down at the port haven't seen him. But anyhow, I've got the shoot on the schedule now. After that, we'll go about our plans for greater security. I've already ordered some anti-aircraft guns."

"I still have misgivings," Tago said.

So had I, but I soon forgot them in the general excitement and preparations for the rocket's takeoff. Classes had been called off as usual and the rocket, smaller but more highly powered than the previous one, now stood on its firing table. It was planned to shoot it at exactly noon on the Fourth of July. After that, there would be a swimming meet and a ball game.

I was glad of the opportunity for a brief rest. After all, I had already finished a tough year at Nutter, and though the courses at Astropolis were fun and I had enjoyed them, the extracurricular activities had become a little more arduous than I could easily take. At Nutter my life had never been threatened, nor had I been almost asphyxiated by helium gas, or been obliged to shoot it out with a fellow professor.

So on the day before the Fourth I took it easy. I visited Cipher in the infirmary, where he was rapidly recovering from the brutal beating he had received. I straightened out my papers in the observatory, wrote some letters and then spent the afternoon with Tago.

As I have mentioned, I had become fond of him. On that afternoon we took a long walk together around Crater Lake. The lake itself was the clearest blue, under the tropical blue sky. Reflected in the water lay the shimmering images of the buildings—the dorms, the great central building with its dome of glass, the observatory.

I had already come to love them. For a moment or two Tago and I stood enjoying the peaceful scene.

"The work of young men," Tago said as he waved his hand toward the campus. "It's good to see them building their own world."

"Let us hope it has a bright future," I said.

"It will," Tago said. "But there are dark clouds still. We must remember that Astropolis is founded upon a volcano."

I glanced around the ancient crater with its grim and jagged walls. "You don't think there's danger of an eruption, I hope."

"Not an actual one," Tago said with a smile. "But wherever there's power, there will always be men who wish to steal it. And Homberg is still alive."

"You think he's still a menace?"

"He's full of hatred," Tago said. "I'm afraid he'll return."

"With the Sinasians?" I asked.

"If he can persuade them. But I rather imagine that his failure to capture power here has discouraged them. He may come alone."

"I doubt it," I said. "He's shot his bolt. But tell me this. Suppose his plan had been successful and he'd wiped us out. I understand that his plan was to hold you as a sort of hostage."

"As hostage to myself?" Tago asked with a faint smile.

"Yes. To that mysterious Hindu in the Far East."

"He's a queer fellow," Tago said.

"I wish there were more like that queer Hindu," I

said. "But tell me, Tago, why does he hide his identity?"

Tago paused and thoughtfully dipped the tip of his cane into the waters of the lake. "What is it some old Chinese philosopher once said? Something like this: 'When one rules by love it is possible to remain unknown.' "

"You're a good man, Tago," I said.

By agreement I met Tago before noon on the following day, the Fourth of July, to see the rocket firing together. With Spender, we drove to the far end of the flying field where the rocket stood. It had already been mounted on the firing table, fueled, and its graphite vanes properly adjusted in the tail pipe to keep it on its course. This course would carry it slightly toward the east so that it could fall into the open sea.

When we arrived, students were scurrying about in their light blue coveralls, making the last-minute preparations. Everyone seemed in high spirits—gay, energetic and full of confidence that this would be the biggest shoot of all. When we had climbed out of the jeep, Spender turned to me.

"I'm nipping into the blockhouse to take a peek at the boys there," he said. "Want to come along?"

As I had already seen the place in operation and Tago didn't seem interested, we decided to watch the final preparations and then stroll back to the campus on foot.

Spender glanced at his watch. "Thirty-five minutes before firing time," he said. "I advise you two not to dawdle."

"We'll be out of harm's way," I assured him. "We'll see you back on the campus."

"Let's hope so," Spender said as he hurried off.

After watching the preparations for a while, Tago and I started toward the campus. We took the route that led us past the tunnel entrance. For some reason I conceived the bright idea of showing it to Tago. I could not find it immediately but finally spotted it and we both clambered up. We inspected the entrance, did a bit of exploring inside and were climbing down when Tago touched my arm.

"They're starting to leave!" he exclaimed. "Look!"

I glanced toward the rocket. It was all too true. Trucks and jeeps, loaded with blue-clad students, were already taking off. Suddenly as we stood listening, I heard a distant loudspeaker bark out the time.

"Minus five minutes," it boomed. In the distance the echoing walls of the crater repeated it. "Minus five minutes."

Instinctively, we both started running, but stopped, out of breath, after a few hundred yards. It was useless to try to get back to the safe side of the campus now. Across the crater we saw the students gathering in the protective shadow of the lecture hall.

"Guess we better duck behind a rock," I suggested.

We looked around us. Tago's keen eye spotted a wedge-shaped rock and we dashed toward it. Though it was not much of a protection, still it might do. We settled behind it and I looked toward the rocket. I studied it for a moment and then for some reason, why I do not know, I looked toward the tunnel entrance. A startled cry, quickly muffled, left my lips.

There alone, ominous as the silent rocket itself, stood a figure I instantly recognized.

"Tago!" I exclaimed. "Look! Toward the tunnel!"

Tago turned his head. "Homberg!" he said in a startled whisper. "Back again!"

"Is it too late to grab him?" I asked.

Tago didn't need to answer. The loudspeaker answered the question for him. Zero minus one minute.

Again I stared at the rocket, and then back at Homberg. He had caught sight of us and was now looking straight at me. I thought I could detect a smile, at once evil and triumphant, upon his face. Then he slowly drew a revolver from his pocket. For an instant I thought he was planning to make us the target. But then I saw he was using it as a warning for us to keep our distance.

The loudspeaker began tolling off the seconds. Homberg lighted a cigarette with his free hand.

"He's already done his dirty work," Tago murmured. "We're in for it now."

"But how could he?" I asked.

"Watch!" Tago said.

He could say no more. With a roar, a tongue of green flame spurted down from the tail pipe. A burst of white smoke, steam, and the rocket began slowly to rise. I held my breath.

Bellowing, the rocket rose, straight up with slowly gathering power. "A keeper!" I thought, using the students' word, and was just about to say so when the rocket, as if obeying some inner, mysterious command, slowly began to turn.

It had reached a hundred feet or so above the firing table when it began turning. It turned slowly, as I say,

deliberately, veering from its perpendicular flight as if the black chemistry of its heart had spontaneously evolved a plan.

"The graphite vanes," I heard Tago say. "Someone has tampered . . ."

The roar, the bellowing of the rocket, drowned out the rest of his words. Spurting its poisonous green flame, the rocket suddenly described a complete circle above the flying field. Then, as if it had got its bearings, it dove toward the campus.

I saw the crowd of students scatter and run, wildly, without direction. Yelling in terror, I jumped to my feet, but Tago pulled me back. At the same moment the rocket struck the glass dome of the central building. For an instant a burst of smoke hid the raging thing. But in a split second we saw it lunge through the smoke and with gathering speed and a thundering roar that seemed to shake the crater to its very roots, it swaggered on toward the north rim.

For a moment I held my breath, hoping against hope that it would crash into that great gray wall of solid rock. But as if some evil genius were guiding its course, it veered upward and clearing the jagged rim by hardly fifty feet, swept around in a wide circle and came charging back.

I gripped the rock in front of me and started yelling. Across the crater it came, at about treetop level, the green flame of its exhaust reflected on the placid surface of Crater Lake. Again it made for the wall, the southern wall now, but again it veered up and this time swung into a long parabola.

For a moment it seemed as if it were making for the

sea, but this was only to torment our hopes. Swinging far around to the north, it came back toward us.

By this time I was too panicstricken to watch. It was beyond my strength, and I turned my head away. As I did so I caught sight of Homberg.

He had moved now to a position a few feet east of the tunnel entrance. He was calmly smoking a cigarette, watching the wild rocket as one might watch a caged beast at the zoo, his revolver still in hand and held pointed in our general direction.

Suddenly I saw his expression change. He flung his cigarette aside and started scrambling across the rocks toward the tunnel entrance.

At the same moment Tago gripped my arm and yelled. The rocket had passed through the smoke above the central building and was now swooping downward at an angle that headed it straight toward us! But suddenly it swerved, as if we were not its prey, and made straight for the tunnel entrance. I looked there. I saw Homberg's mouth open as he yelled in terror. Frantically he tried to pull himself up on a jagged crag of rock at the tunnel entrance.

But then, with a deafening roar, the rocket flashed past us and struck. A spew of flame, a cataract of purple fire, poured over me and I passed out. . . .

A couple of days later I came to in the infirmary, my head swathed in bandages that left only small loopholes for my mouth and eyes. I had been badly scorched, if not thoroughly broiled. A nurse who had evidently been brought in from the outside was standing over me with a tumbler of milk and a glass straw. Seeing me blink my

eyes, she told me that a friend in the next bed wanted to say hello.

I rolled my aching and unwieldy head on the pillow and, through my peepholes, saw Tago's smiling face. I was glad to see that he hadn't been burned so badly as I had, for his face was practically free of the bandages that covered mine. I managed to ask him how everything was.

"Not too bad," he said. "I guess your body sort of protected mine when that rocket blew."

"We were lucky," I said. "How about the rest?"

"All okay. Everyone's hard at work picking up the pieces. The central building is mostly rubbish."

"And Homberg?"

"A grease spot on the crater wall. They found his wrist watch stopped at 12:05. The tunnel entrance, it seems, is blocked forever."

"Spender going to rebuild?" I asked.

Tago smiled. "He has the money for it. An old friend of the Astropolitans just came through with enough to do it."

"Same old friend from India?"

Tago smiled again. "I imagine so. I hear he kicked in again."

"Bless you, Tago!" I murmured. "What's the new building to be called? The Homberg Memorial?"

Tago laughed outright. "Poor old Homberg and his orbital dictatorship. Just one more grease spot on the page of history."

"And long live the Young Astropolitans!" I tried to add, but my voice ended in a croak.

The nurse bent over me.

"Here, dear," she said. "Take this milk and try to be quiet. You'll begin thinking the world is coming to an end again."

"And it isn't?"

"No, dear," she said, as she inserted the glass tube into my mouth. "Just take this warm milk and everything will turn out all right."

Glossary

Aerodynamics — The branch of physics treating the forces acting upon bodies in motion in air.

Air drag — Forces created by the lift-producing surfaces of the wings which impede the forward movement of a plane.

Air resistance — Resistance of the atmosphere to an airplane or rocket moving through it.

Asteroids — Small planetary bodies, sometimes called minor planets. Hundreds of them have their orbit around the sun. Also known as planetoids.

Astro– — A prefix from the Greek word *astron* meaning star and denoting of or pertaining to the stars.

Astropolitan — Citizen of the Stars.

Atmosphere — The whole mass of air surrounding the earth. Its limits are, to all practical purposes, at 150 miles above the earth.

Atomic fission — The splitting of an atom, thereby changing it into energy.

Bends — Divers' paralysis. Pains in the joints and paralysis, occurring in workers in compressed air who are too suddenly introduced into the atmosphere. It is due to bubbles of nitrogen in the nervous system.

Centrifugal force — The reaction of a body forced to move along a curved path against the constraint, with a force directed away from the center of curvature of its path.

Centrifuge — An apparatus which spins a subject rapidly at the end of a long arm, thus testing its resistance to centrifugal force and rapid acceleration.

Cosmic rays — Mysterious radiation of an extremely low wave length thought to enter the earth's atmosphere from interstellar space.

Duralumin — An alloy of aluminum, copper, magnesium and silicon.

Formaldehyde — A gas of pungent odor (H·CHO), readily soluble in water, and usually used in aqueous solutions. It is a disinfectant, used by embalmers.

Gantry crane — A framed structure raised on side supports so as to span over something, such as a space ship or rocket.

Geiger tube — An instrument for counting radiations from radioactive substances.

Gravitation — The name given to that force of nature which manifests itself as a mutual attraction between masses.

Gyroscope — A small heavy wheel or top rotated at high speed and used as a controlling device in aircraft and torpedoes. Large sized ones are used to stabilize ships.

Hydrazine — Properly hydrazine hydrate ($N_2H_4 \cdot H_2O$). A colorless fluid used as an oxidizer in rockets as it has the advantage of being spontaneously combustible.

Hygrometer — An apparatus for measuring atmospheric humidity, either absolute or relative.

Interstellar dust — Minute fragments of matter occupying the empty space between the stars.

Meteor — A shooting star.

Meteorite — Small fragments of matter existing in interplanetary space which become incandescent by friction upon entering the earth's atmosphere.

Methane — A light, odorless and inflammable gas occurring in marshes and mines. Also called marsh gas.

Molecule — The smallest particle of a substance that is capable of independent existence while still retaining its chemical properties.

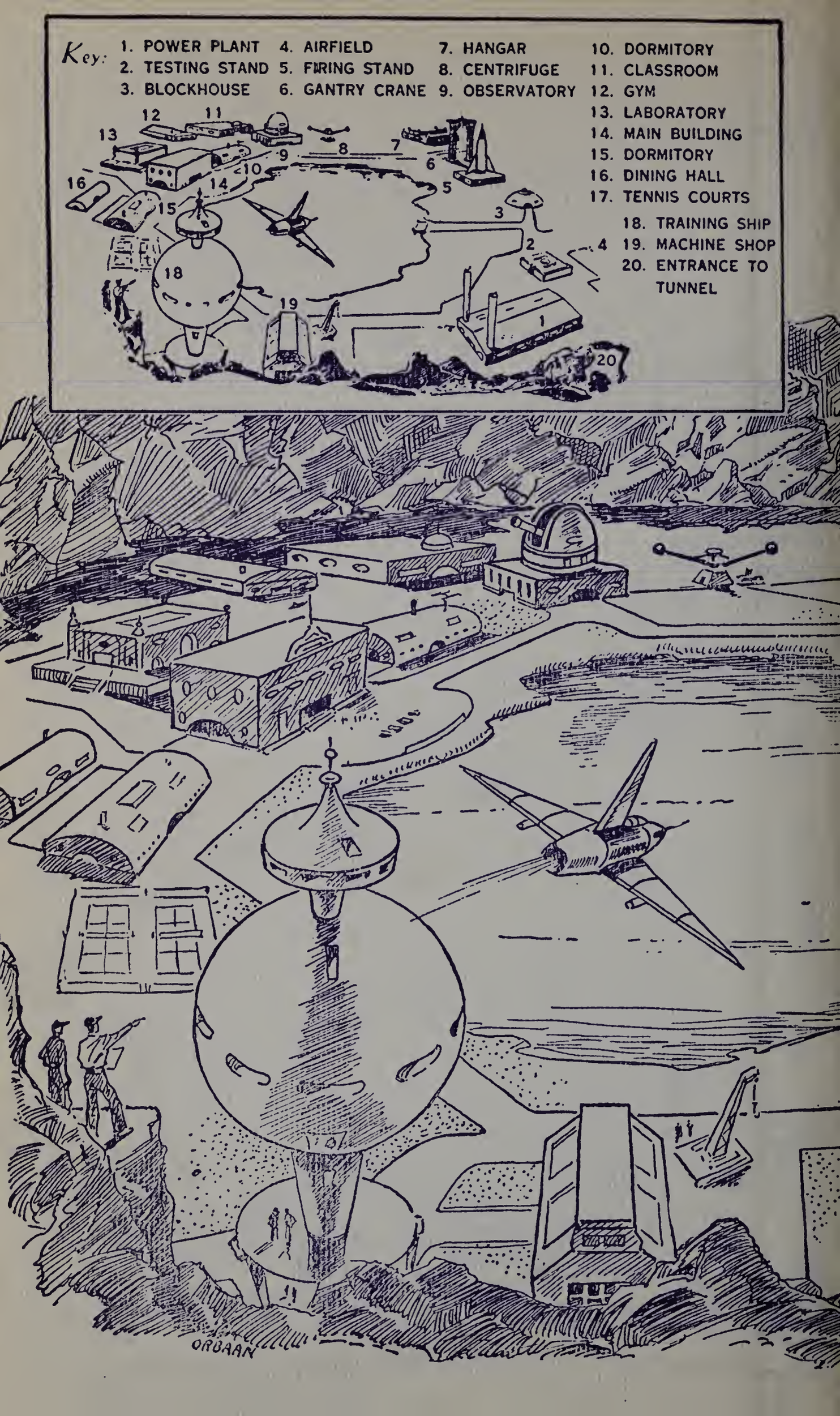
Orbital motion	The motion of a celestial body in its revolution around another body.
Oscilloscope	Instrument which records waves on a film or makes it possible to see waves on a screen.
Ozone	A concentrated oxygen (O_3) used as an oxidizer for combustion as it produces a higher exhaust velocity than simple oxygen.
Perigee	That point in the orbit of the moon, and occasionally of other celestial bodies, nearest to the earth.
Photon reactor	A jet engine using particles of light (photons) to propel it.
Reactor	A motor using Newton's Third Law of Motion as its basic principle.
Sargasso Sea	A large tract of comparatively still water in the North Atlantic, filled with floating seaweed.
Satellite	The name given to a smaller body revolving around another, like the moon which is the earth's satellite.
Sine, cosine	Mathematical relationships used in trigonometry.
Supersonic flight	Flight of aircraft that exceeds the speed of sound—1,087 feet a second.
Thermodynamic reactor	A jet engine using liquids in combustion as the propellant.

Turbogenerator A generator operated by a turbine.

Turbojet A jet engine in which turbines are used to suck in air to increase combustion.

Ultraviolet rays Invisible radiations of wave length less than the limit of visibility at the violet end of the spectrum.

Vacuum A region in which the gas pressure is much lower than the atmospheric pressure. A "perfect" vacuum, i.e., one which contains no gas, is unobtainable.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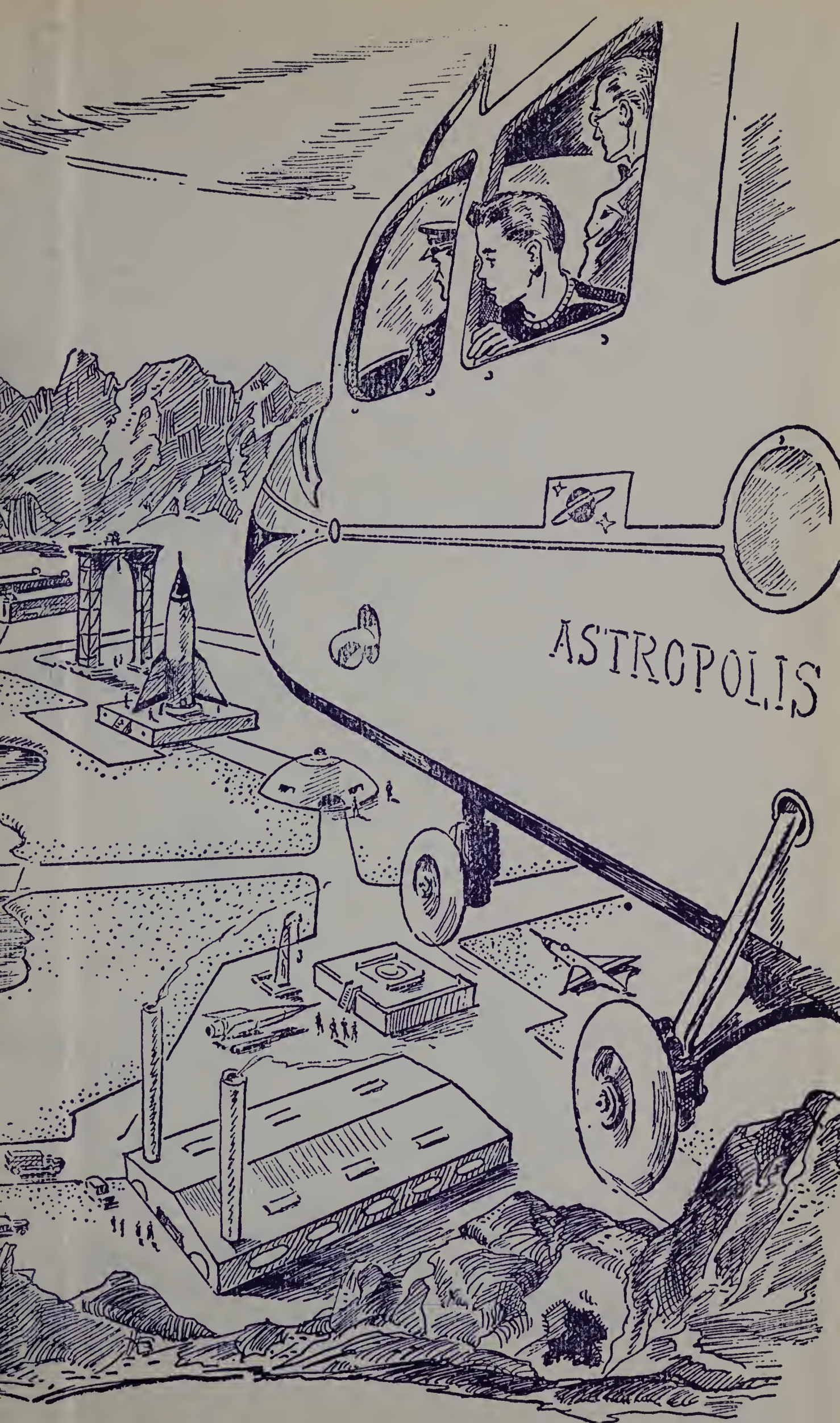
2. TESTING STAND
3. BLOCKHOUSE
4. AIRFIELD
5. FIRING STAND
6. GANTRY CRANE
7. HANGAR
8. CENTRIFUGE
9. OBSERVATORY
10. DORMITORY
11. CLASSROOM
12. GYM
13. LABORATORY
14. MAIN BUILDING
15. DORMITORY
16. DINING HALL
17. TENNIS COURTS
18. TRAINING SHIP
19. MACHINE SHOP
20. ENTRANCE TO TUNNEL
ORBAAN


ASTROPOLIS