

CENTRAL HEAT

by

David Dvorkin

2031

ONE

Holroyd watched in horror, unable to tear his eyes from the screen.

At first glance, the tiny figure struggling in the center of the screen might have been a fly caught upon some reddish-white, glowing, slightly flickering surface. Then the camera zoomed in and the figure resolved into a man, squirming desperately on the frictionless, bowl-shaped surface of the force screen that suspended him above the hellfire of the magma.

The image of Martinson expanded still more, and at the same time he looked up at the camera suspended above him, so that his face suddenly filled the screen. His eyes were wide, bulging, his face glistened with sweat. His lips moved, but whether with curses or pleas or recantations, Holroyd could not tell.

Alone in his small apartment, Holroyd said aloud, "For God's sake, get it over with!"

Martinson stopped moving, surrendering at last, and the camera drew back again to savor the image of the condemned man lying still in the very center of the force screen, its lowest point, his eyes closed, his shoulders heaving as he wept in despair. Only then did the executioner act.

A second force screen came into existence above the weeping man. It was invisible, ultimately transparent, but its presence was obvious from its effect. It was lowered until, as Holroyd and all his fellow Americans watched, Martinson was forced flat on his stomach, spread eagled, squeezed between the two screens. He stayed that way for only a moment, too tightly held to move with weeping, perhaps too tightly held to breathe.

With the upper screen now strong enough to hold the magma by itself, the executioner cut the flow of energy to the lower screen, and it vanished. Liberated by that tiny amount, the magma blossomed upward until it hit the upper force screen.

That small motion of the magma was invisible on the television screen. All Holroyd could see was how his cousin shriveled in an instant, vaporized, was gone. The picture of the now empty, glowing magma surface persisted for a few seconds, the calm sun at the heart of the world, and then the television screen went blank.

To Holroyd's astonishment, Cathy was at work the next day. White-faced and thin-lipped, she sat at her console next to his, making fine adjustments, recording changes in heat flow, saying nothing. After more than an hour of this tense silence, Andrew could bear it no more. Eyes still on his console, he said softly, "Cathy, I'm sorry."

"Killer!"

Holroyd looked at her in shock. Tears were rolling down her cheeks, and yet her tightly clenched jaw did not betray even a quiver. She looked at him at last. "You murdered him, not the government!"

"No," he gasped, shaking his head, "no, I just –"

But she was gone, running down the long, stone corridor.

He waited almost another hour, hoping she'd return, and then reluctantly he called in an Operator Missing alarm. The consoles must always be manned. He feared he might have endangered his own freedom by waiting so long to report Cathy's absence. Fear for himself warred with fear that by reporting her absence from her console he had condemned her.

Three days after her disappearance, as he was eating his supper and idly watching the evening newscast, Andrew was surprised into full attention when Cathy's face appeared suddenly on the screen. He recognized the shot. It had been cropped from a picture of the three of them taken during an outing in California a couple of years earlier, before Cathy and Henry had decided to get married. Andrew shook his head as if to clear it of the memory and tried to force his attention to the rich baritone of the newscaster.

"According to the announcement from the Acting Secretary of Security, Cathy Martinson, the widow of the traitor Henry Martinson, whose execution was broadcast earlier this week, was seen prying the cover off an old ventilation duct in Chicago. The police warrant who saw her tried to stop her, but she eluded him and escaped into the duct. A note was later found at her quarters stating that she intended to carry out the plot for which her husband was executed. She is of course presumed dead."

Both of them dead! It seemed impossible. They had been a major part of Holroyd's life ever since their childhood together, a part of his world, a constant part of the background. Now suddenly, violently, both had been snatched away.

The image of Henry's execution returned with frightful clarity, as it was to do again and again during the coming years. Another image came to him suddenly, this one purely imaginary – Cathy lying on the surface, on the frozen ground, her body permeated with ice, dead beneath the silent layers of snow. Pretty Cathy. Eternally unchanging Cathy.

It was the very next morning that Andrew Holroyd's patriotism received its reward.

The red light on the corner of his console blinked at him, signifying a message from his supervisor. When he acknowledged, Clayton's voice boomed out, causing operators' heads to turn throughout the cavern. "Holroyd! Good work on that traitor last week. I've just got the papers confirming your promotion. W01, Holroyd, and there'll be more to come, you can bet. You're Warrant class, now, boy. Congratulations!" The red light winked off.

“But that wasn’t what I wanted at all,” Andrew whispered. “I was just trying to save him.” But the thought intruded unpreventably that now, at last, he would be able to move from his cramped apartment, that he could afford and would be allowed something better.

2008 - 2009

Two

Well, what did they have to say?”

Horwith snorted. “They told me there’s a team of experts on the way from Mendeleev to have a look. We’re to cooperate fully.”

“So much for letting us handle it ourselves.”

“Yeah. We’re not real scientists. We don’t count.” Honesty forced him to add grudgingly, “Of course, Battani is at Mendeleev, and he’s part of the team that’s coming here. I suppose he knows a lot more about this junk than we do.” The long white arm of his surface suit gestured clumsily toward the stacks of electronic gear before which he and Glen Alenian were seated. He let his arm drift down again in the gentle gravity. It bounced slightly, slowly, off the side of the boulder he was leaning against.

Beneath their feet was the barren, beautiful surface of the moon. The helter-skelter piles of equipment – some of it in smooth metal casings, some exposed like jury-rigged laboratory equipment, and all bound together by a bewildering rat’s nest of wiring – was exposed to the vacuum. Its only protection came from the huge boulders which sheltered it on three sides, forming a cul-de-sac, and the flimsy metal roof fastened to the tops of the boulders. Sunlight was thus kept off the equipment, and it was adequately protected from meteorites, but since it required a very hard vacuum to operate, the enclosure was not sealed and pressurized. Horwith, used as he was to working in uncomfortable surroundings, nonetheless hated the necessity of spending all of his shift in his bulky, awkward, cramped surface suit.

Alenian said soothingly, “It’s probably a good idea, then. Battani more or less invented T-band, didn’t he?”

“Discovered.” Horwith made the correction automatically. “Oh, I guess I don’t mind too much. It gets boring sitting out here with nothing to do but monitor the equipment. The company’ll be welcome. But they’d better not get any ideas about moving the stuff over to Mendeleev and using their own people to run it.”

Alenian laughed at the idea. “NASA would fight that tooth and nail.”

“Also,” Horwith added thoughtfully, “we could make the argument that we don’t know how well it would operate that close to the big antennas at Mendeleev. We really don’t know enough yet about how prone T-band is to interference.” He pushed himself away from the boulder. “They should be here any minute. I’ll go look for them.”

He slid the dark, highly reflective sunscreen down over his visor and stepped from the shelter into the brilliant sunlight. He stood still and scanned the sky, but all he could see was the usual wild blaze of stars, unblinking and many colored. If anything was moving among them, it was invisible to him. Presumably, the vehicle bringing the team of experts from Mendeleev

would be flying low, in which case it would slip over the horizon only minutes before arriving.

Nearby stood the rover that had brought him and Alenian here from a nearby base at the beginning of their shift. Behind him was the sun, small and blindingly white, impossible to look at even through his sunscreen. It was low now, near the uneven horizon, casting his shadow long before him over the rolling, dipping, rising surface. Even further behind him, he knew, but beyond the horizon, was the lovely blue-white ball of Earth.

Horwith had been here for months on this tour of duty. It would be Paradise to get back to a place with an atmosphere, a place where he could go outside a building without first squeezing into a man-sized spaceship with arms and legs. He hated the moon.

The Mendeleev surface shuttle appeared suddenly over the lunar horizon, unsettling Horwith even though he had been expecting it to come into view in just that way. It arrowed toward him, no more than twenty meters above the surface, slowing as it passed over the rover.

The shuttle was a long, slender vehicle that flew with its long axis parallel to the ground. Small rocket nozzles were spaced evenly along the bottom, and small, round windows lined the side facing Horwith. He felt a surge of jealousy and resentment. Budget-conscious NASA restricted its personnel to the rovers, wire-frame vehicles descended with little change from the lunar rovers originally built for the Apollo missions of forty years earlier. The rovers were cramped and uncomfortable, notoriously short on springs or shock absorbers. If driven too fast, they showered their occupants with lunar dust. They were powered by banks of batteries that had to be regularly recharged from sunlight and which seemed to require such recharging at least twice as frequently as the manual claimed they did. Worse, the batteries often chose to die at exactly those times when their crews would be faced with long and exhausting walks back to base.

The Mendeleev shuttle stopped some distance away from Horwith. It hovered, sank toward the ground, then hovered again about three meters above it. Horwith could feel the vibration through his boots. A cloud of dust arose, completely obscuring the vehicle. Then the vibration coming to him through the ground stopped, and almost immediately the dust fell back down. In an instant, all was clear again. The shuttle rested upon four metal legs, one at each corner, each bent outward in the middle, so that it looked like a giant insect, some creature of the vacuum that had landed temporarily upon the moon for its own obscure purposes.

Beneath the shuttle, a cage appeared, descending slowly toward the surface. As the elevator reached the bottom and stopped, the four surface-suited figures in it shuffled about uncertainly and unhappily and at last plucked up their courage enough to leave it. They struggled across the surface toward the waiting figure of Horwith, who felt flushed with superiority at their clumsiness.

He knew the type. They might spend years working on the moon and yet never go outside a building, out to the true surface, except in an emergency. They might never put on a surface suit, spending their time in office buildings that, except for the gravity, might as well be on Earth. *They* might as well be on Earth, he thought scornfully, forgetting the hatred for the moon and the longing to be home on Earth that he had been dwelling on only minutes before.

Horwith tongued his suit radio on and uttered the appropriate greetings, then led the four newcomers back to the shelter where Alenian still sat monitoring the behavior of the T-band receiver.

The four from Mendeleev took over the pile of equipment immediately. They asked the two NASA men a few questions, but with so much open skepticism that Horwith could hardly

prevent himself from asking them why they'd bothered to come here from Mendeleev, if they doubted the existence of the signal he and his partner had picked up. He and Alenian stood back and watched in silence with the injured pride of the professional whose competence has been questioned.

Watching the four of them more closely, Horwith realized that only three of them were really dealing with the equipment. While his three companions examined the T-band receiver, their hands working with surgeon's skill even though encumbered by the gloves of their surface suits, virtually taking the equipment apart and putting it back together again without even disturbing its operation, making measurements with devices Horwith didn't even recognize, the fourth man ignored the equipment itself but pored with total absorption over the records of the signal.

There was much for him to look at. Even though the signal had only been coming in for about two hours now, there was a substantial pile of hardcopy output. When the signal first caught Horwith and Alenian's attention, they had examined it in various ways, including audio and graphic representations, before making a report. Neither had been anxious to overreact to what might be a peculiarity of the electronics rather than a genuine incoming Tband signal. If it were real, it might be a discovery of immense importance. If it were merely an artifact of their experimental equipment, they could ruin their careers by sounding the alarm prematurely. So they had taken their time, and now Battani – Horwith guessed that the fourth man was he, even though none of them had deigned to introduce himself – had the records of their preliminary investigation to look over.

The suited figure put down the papers at last and straightened up. He stood still as though lost in thought. After a few minutes, he walked over to the three men who were still examining the receiver and talked with them for a while. Horwith tongued his suit radio through the standard channels, trying to pick up their conversation, but all he could find was a meaningless gabble on one of the channels. Mendeleev had apparently added encoding/decoding equipment to its suits.

The fourth man left the group and came up to Horwith and Alenian. Still tuned to the same channel, Horwith now had no trouble understanding him. He had apparently turned off his encoder in order to speak to the *canaille*.

"You are Mr. Horwith and Mr. Alenian? Good day, gentlemen. My name is Battani."

Horwith tapped Alenian three times on the shoulder, quickly and lightly, to indicate the proper channel in case he hadn't already found it by himself. "I'm Horwith." He raised a hand to show it was he who had spoken.

Alenian mumbled something vague in greeting to their visitor, and Horwith could hear the suppressed laughter in Alenian's voice.

They all had their sunscreens up, of course, and in the low-power electric light under the canopy, Horwith could easily see through Battani's faceplate, so he understood why Alenian was amused.

Mendeleev bought its surface suits from NASA and was therefore stuck with two standard sizes, one designed for the average five-foot-ten-inch man, and the other for the average five-foot-five-inch woman. Battani must have been scarcely over five feet in height, and his eyes barely cleared the bottom of the faceplate. His was probably one of the suits designed for female surface workers, with minor modifications to the internal plumbing done by Mendeleev technicians. Perhaps they had also added height inside the boots for Battani's convenience, but if

so, it had not been enough to really help. Not that they could have done much for him without making the suit impossible to use. Wearing the suit and working inside it must be an endless misery for him, Horwith realized.

Horwith felt a rush of sympathy for the man. He was six and a half feet tall himself and extremely thin, and it was something like torture to squeeze himself into his suit before his shift – and almost worse torture to unfold himself from within it when his shift was over. A custom-made suit was supposedly on its way from Earth, but he'd been hearing that for months, and he suspected that his tour on the moon would be up well before it arrived. Men like him and Battani – too many *sigmas* away from *mu* – could expect no sympathy from Alenian, who was blessed with precisely average height and weight.

“Doctor Battani,” Horwith started to say.

Battani interrupted. “Please. Call me Al.”

“Okay, Al, then. Have you come to any conclusions about our signal?”

Battani laughed. “Obviously *you* think it's real. You should have called it ‘the anomaly,’ in the approved manner. However, I think you're right. I think it's a real signal and not just an electronic quirk.”

“You *think*?” from Alenian. “Hell, I thought you were the guy who was supposed to know everything about T-band. Don't you *know* whether or not it's a signal?”

Battani sighed. “I've run into this misconception before, Mr. Alenian. I'm an astrophysicist. I know virtually nothing about electronics. T-band was an accidental byproduct of something else, my work on a theoretical problem. The problem is still unsolved, by the way. But this,” he pointed at the receiver, “this electronic realization of the theory – no, I don't understand it at all. However, those men do, and they seem to think the equipment is working just as it should. What you've picked up must be a real signal, coming from outside your receiver. I've been looking at the excellent preparatory investigation you two performed, and it's clear there *is* a significant pattern.”

Alenian burst out, “A message, you mean! My God, it's a message from somewhere!”

“No, no, that's not what I said.”

But the other two men weren't listening.

“A message,” Horwith whispered. “Christ, I wish we had a transmitter working already! We've got to respond somehow.”

“You're being too hasty,” Battani insisted. “I'd like to explain what I mean, but I'm sure you're impatient for us to get out of your hair, and I simply can't spend much longer in this space suit.”

“Surface suit,” Alenian said.

Ignoring his partner, Horwith answered Battani's objections. “It's true we're supposed to do quite a few more hours of testing, but I think this takes precedence. Anyway, I was ordered to give you full cooperation, and if you think that includes giving us a lecture on Tband, how can NASA object?”

Battani laughed. “Jesuitical sophistry! I do have to get back, but you're welcome to come back to Mendeleev with us. We always have room for visitors there.”

“Hey, wait a minute,” Alenian said, his voice angry. “We can't just leave this equipment alone.”

“I can order a couple of my men to stay behind and guard it,” Battani said quickly.

“No, I don't think so.” Alenian's voice was cold. “I'm sure NASA wouldn't approve of

that at all.”

“Then *you* stay here with it,” Horwith snapped at him. “I’ll go to Mendeleev. Gladly.”

As he was gliding toward the Mendeleev shuttle with Battani and the three others a few minutes later, Horwith radioed, “So long, Glen. I’ll be back at base before our next shift.”

Alenian still sounded hostile. “See you later, Pole.”

Horwith checked his stride for the barest instant and then walked steadily toward the shuttle. Battani had caught his reaction, however. Once the elevator had carried them up into the body of the shuttle and the locks had been sealed, so that they could take off their helmets and talk directly rather than over radio, Battani said mildly, “Your friend called you ‘Pole.’ I was told your first name is Clemmons.”

“It is, but ‘Pole’ is what most people here call me.”

“Because they think your surname is Polish?”

“Partly.” He longed to drop the subject.

Battani looked up at the remarkably tall, thin engineer. “I see. If you don’t mind, I’d rather call you ‘Clemmons.’”

Horwith smiled down at him. “Great!”

The approach to the Mendeleev observatory was anticlimactic. Horwith had been fascinated by the great multinational observatory from the moment its construction was first seriously suggested, almost ten years earlier. The Eye at the Back of the Moon, the press had dubbed it. He had followed the press reports of its construction within the great farside crater with intense interest, hoping that some day he would be able to get one of the rare and coveted non-scientific jobs there. To an extent, that hope had led to his going to work for NASA – only to discover that no NASA personnel were stationed at Mendeleev, that in fact there was a growing animosity between the aging space agency management and the new and international upper echelon of the United Nations-sponsored organization formed solely to run the new observatory.

And he had discovered that he hated life on the moon.

Still, the old dream had never quite died. At the very least, Horwith hoped that he would now get a chance to see the ring of mighty radio and optical telescopes sited along Mendeleev’s rim, that the shuttle would pass close to at least one of them on its way in toward the administrative and residential buildings clustered together at the crater’s center. That hope, too, was destined to be dashed.

They approached the crater rim flying only meters above the lunar surface, and they grounded between two other shuttles on the outside surface of the crater wall, on a ledge, a terrace, cut into the wall. At the last moment, just before landing, Horwith looked up and caught a glimpse, far above on the very rim of the crater, of a spider web gleaming in the sunlight, a spider web on a vast scale. Then even that was hidden by the dirt and rock of the wall of Mendeleev.

The party left the shuttle through a flexible tube that had attached itself to the shuttle hatch. It was provided with Earth-normal air pressure, so that they were able to leave their

helmets off, which Horwith considered a blessing. The tube led them to a small building, the terminus of an elevator, which in turn took them down some distance into an underground tunnel. Here a railroad track stretched off into the well lit distance. A small subway car, with room for no more than ten people, waited for them. They climbed aboard and were taken the rest of the way to the headquarters of the observatory.

“Anticlimactic, I know,” Battani apologized. “A walk across the crater to the center is much more impressive. But this is much quicker, and for me it’s a lot more comfortable.”

“And for me,” Horwith told him. “Sometimes I really hate the moon. Walking outside here isn’t like walking outside on Earth. I long for a place where you can go outside without having to stuff yourself into a cramped surface suit, where you can breathe because there’s something there to breath. Breezes and flowers and people.”

One of the other men said, “And the girls in their summer dresses?”

Horwith grinned. “Yeah. That, too.”

Another man chimed in, “And breezes to lift up the dresses.”

Battani grimaced. “Some things never change,” he muttered, loud enough for only Horwith to hear him.

“Some things shouldn’t,” Horwith told him.

This leg of the trip ended at another elevator. They rose into sunshine, muted and pleasant. As he had imagined, the buildings at Mendeleev – all connected by surface tubes and underground tunnels – were as much like Earth-surface office buildings as possible. One could spend his entire tour of duty inside them, never stepping outside. Even the rare times an astronomer had to travel in person to one of the telescopes, Horwith was to learn, he could do so by subway and elevator, ending his trip in an airtight, sealed building at the telescope’s base. Only the gravity and one other thing reminded the personnel at Mendeleev that they were on the moon and not on Earth.

That other thing was the existence of windows. At the NASA Frontside base, almost everything was underground. Here at the observatory, that was also true of most of the buildings, but there were some that projected above ground, and in those buildings there were heavily tinted windows everywhere that gave a clear view of the silent, still, sterile landscape.

It was an extravagance that tortured Horwith’s somewhat Puritanical soul and his NASA training. NASA’s bases on the moon were uniformly buried for the sake of insulation against the fierce heat of the lunar day and the terrible cold of the lunar night. Mendeleev was so well funded that economically absurd variations in heat loss and gain were tolerated, were, in fact, not even noticed. Environment control equipment compensated. This profligacy shocked Horwith and angered him.

Mostly, though, he was angry with himself for being so fascinated with the view from the observatory’s windows, a view bought by that profligacy.

Something else that fascinated Horwith was the way the other workers at Mendeleev treated Alfredo Battani.

Alenian might have laughed at the astrophysicist because of his height, but here that height seemed not to matter. Neither did Battani's accent or dark coloring. A spectrum of skin colors and accents filled Mendeleev's halls. The observatory was a citadel of the intellect. Accidents of stature counted for nothing, brilliance counted for everything, and Battani was treated with a respect verging on reverence.

The discovery pleased Horwith. He told himself, though, that his attitude was paternalistic, and that he held that attitude precisely because of Battani's shortness, as though the man's small stature somehow meant he needed to be protected. That was the sort of stereotype that Horwith had always resented when he detected it in others. It galled him to discover it in himself.

I guess I'm not a saint quite yet, he told himself. Maybe next year.

Battani's shortness had one advantage, though, and he pointed it out to Horwith himself.

After introducing Horwith to those workers who happened to be in the area when the elevator arrived, he led the way down a maze of corridors to his office. This, too, was flooded with muted sunshine. A pleasant enough effect, but the office itself was minuscule, and it was crowded, a desk and a table covered with papers taking up most of the room. "Space is still at a premium here," Battani explained. "At least, until our new building is ready, which won't be until sometime next spring. In the meantime, it's a good thing I'm not your size, or this coffin would seem even worse than it already does. Here."

He pushed some of the papers on the table aside carefully, clearing a small space for himself. He pulled himself up easily to a seat on the table and gestured to Horwith to take the swivel chair by the desk.

"Now, then, Clemmons. The guru of the mountaintop will enlighten you."

THREE

What I was getting at back there is this,” Battani said. “It’s true that what you picked up seems to be a signal of some sort, not produced inside your receiver, and it’s also obviously not some sort of random stellar noise. The patterns you showed in those hardcopies simply can’t be denied – even if you’re the sort who tries to deny such things, as so many of my colleagues are. But that doesn’t mean it’s a message, a deliberate signal. Remember the pulsars.”

“Sure. Who could forget them? A rock group, weren’t they?”

Battani smiled. “No, but they *were* stars. Neutron stars. We’re both too young to have been born when they were discovered and all the fuss started. That was . . .” He thought for a moment. “About forty years ago. Neutron stars had been predicted theoretically quite some time before, thirty years before, but no one had yet found one. Then radio astronomers in England found a radio source that was pulsing at them, throbbing, with a period, or cycle time, of about one and one-third seconds.

“At first, they thought they must be picking up some manmade signal from Earth, just as we first thought your signal must come from inside your receiver itself. They even thought they might be tuned in on a signal from some other observatory! Finally, they were able to convince themselves that the signal was truly extraterrestrial. But it was so fast, and so remarkably regular! How, they asked themselves, could it possibly be natural? Eventually the connection was made with neutron stars. But for a long time, there was a spate of articles in the popular press all over the world, speculating madly about what these strange objects must be. The most popular idea was that they were navigation beacons for some interstellar civilization. Other pulsars had been found after the initial discovery, with other cycle times. That led to speculation that you could determine your position during interstellar flight by identifying a few of the pulsars and determining the direction from you to them very accurately. Or you might be able to calculate your distance from them, based on signal strength, which would also give you your position in terms of a fixed coordinate system.”

“So you’re saying we shouldn’t get excited,” Horwith said, feeling a strong sense of disappointment. “Even though there is a pattern, and it’s so complex, it might just be a natural phenomenon like the pulsars, but maybe more complex.”

“Exactly. But don’t despair on that account. You may still have contributed to an astronomical discovery of incalculable importance. Remember the pulsars again. The astronomer who found the first one won a Nobel Prize for it, and, not coincidentally, what you’ve found may get me my Nobel. There’s bound to be some recognition in it for you, as well,” he added quickly.

Horwith sighed. “If it would persuade NASA to give me a promotion at last, I’d be happy. You know, when I was a kid, my greatest wish was to be an astronaut, but then someone

told me I'd have to cut off my legs to even fit into the interplanetary vehicles they were designing. And then I'd be disqualified because NASA doesn't want any legless astronauts."

Battani shook his head. "It's strange what can destroy a dream." He shrugged, as if to drive the mood away. "I was about to explain that what you've found could just possibly be developed into a new area of astronomy, an entirely new way of studying space. Conceivably, if that signal is being put out by a star, as pulsar signals are, we could now have the means of examining stars at the very edge of the Universe, a way of studying the deep interiors of stars, and even a view into a black hole. And I mean *into* it – to the singularity itself."

"It's exciting," Horwith admitted, his disappointment fading only slightly, "but not as exciting to me as it must be to you. And not as exciting as a message from an alien civilization."

"Bah!" Battani jumped down from the desk and tried to pace about in the tiny space, able to glide only one energetic step in each direction. He waved his hands. Words flooded from him. "Alien civilizations, Clemmons! Nonsense! Unimportant! Nothing Man can devise, and nothing any aliens could devise, no matter how evolved they might be, could ever compare to the amazing things Nature has already experimented with out there. Neutron stars and black holes are just the start. And now, with T-band astronomy, we can really find them, really know what they are, how they work. What can aliens offer us to compete with that?"

"How to make a better mousetrap, maybe."

Battani stopped, brought up short in his enthusiasm. For a moment, he seemed angry, and then he relaxed and burst out into laughter directed at himself. "You're quite right! And they might also know how to make a T-band telescope."

"Okay. Now, why would your T-band telescope be such a great thing?"

"Aah, good!" Battani rubbed his hands together. "Just what I wanted – an excuse to lecture. First, do you know what the tunneling effect is?"

"Vaguely. I know that tunnel junctions were very important in seventh-generation computer circuits."

Battani looked uneasy. "Let's stay away from that sort of thing. I have a mental block against it. I don't know a diode from a transistor."

"I guess not," Horwith laughed. "Okay, Professor. Treat me like I don't know anything at all, and you won't be far wrong."

"All right. First of all, you did have the right tunnel effect in mind. I know that much electronics, at least. That's electron tunneling. It's a quantum mechanical phenomenon whereby an electron can cross a potential barrier without actually having to get over or through it. One moment it's on one side, and then presto! it's on the other."

Now Horwith looked uneasy. "This sounds slightly familiar. I think I heard it in college, but *I* have a mental block against *this*."

"You're in good company, then. Even Einstein never accepted quantum theory. 'God doesn't play dice with the Universe,' he said. An unfortunate attempt at being poetic on his part. It led many people to the absurd conclude that he was a theist. We've made the dice a lot more complicated since his time. He'd probably dislike quantum mechanics even more now. Sometimes it seems like magic to me, even after all the years I've used it in my work. However, unlike magic, it works. It does what it's supposed to. It's an adequate description of the Universe. The computers you mentioned work because . . . They do work, don't they?"

"Generally speaking."

"Good. They work because electron tunneling exists and quantum mechanics gives us a

good enough description of how it works.”

“How about *why* it works?”

Battani waved his hand in dismissal. “Leave that to the philosophers and theologians. They’re paid to waste their time. Now, here’s how an electron can jump – or tunnel through – a barrier it doesn’t really have the energy to get over. Imagine this wall is a potential barrier, even though a potential barrier doesn’t really have to be something solid, a physical barrier. Oh, let’s forget that detail,” he said hastily, sensing confusion in his student. “My hand is the electron.” He slapped his palm against the wall. “Obviously, it can’t pass. I could make a hole in the wall, but the electron we’re talking about doesn’t have the energy to do that. In other words, my hand can’t break a hole in this wall by itself.

“However, this is a misleading analogy, because my hand is a definite object, with well defined boundaries. When you get down to the super small level of the electron, matters are no longer so simple. You can think of an electron as being smeared in space. Instead of describing its position by, say, giving three coordinates, you have to speak in terms of probabilities – the probability that it will be at a given point at any one time.”

“And that probability is derived from the wave function describing the electron,” Horwith said. “It begins to come back to me from out of the dim and dusty past. However, I for one still believe that electrons and all those other particles are really hard edged, definite, and solid. Like tiny ball bearings. Except duller. They’re a dull gray.”

“Philistine! Remember that your computers work, and that should count for something. You said they work generally speaking. Well, when you speak about the position of an electron, you’re also generally speaking, and speaking generally. Hmm, I may use that phrase in my Nobel acceptance speech. I’m sure it means something.

“Now, suppose my hand were like the electron, having a certain probability of being here, and a certain probability of being there, on the other side of the wall. A small probability, but greater than zero. So sometimes it’s here. Most of the time. But every so often, it’s there, on the other side. It has tunneled through.”

“Hot damn. I don’t believe a word of it, but at least I understand it. Years ago, I couldn’t get it at all. Now I see that it was just because my physics professor insisted on talking about electrons and potential barriers, instead of hands and walls.”

Battani grinned. “Some teachers just don’t know how to get things through the typical undergraduate’s thick skull.” His smile faded. “Now, T-band is an extrapolation of the tunneling concept. I was trying to explain some observational anomalies, readings that indicated that some black holes give off too much energy. There should be a great deal radiating from their vicinity, such as X-rays and gamma rays, given off by gas from their companion stars if they’re in a binary system, as the gas falls into the black hole. The gas forms what’s called an accretion disk, and there are many powerful radiation-producing effects going on in the disk. There are also quantum mechanical effects in which virtual particles and their antiparticles are produced at the black hole’s event horizon, and that’s equivalent to energy being given off. All of this energy is what we actually see. However, what was being observed couldn’t be accounted for by those processes. It was clear to most people, including me, that something else must be underway.

“I tried to extrapolate the idea of electron tunneling to come up with some way radiation trapped within the event horizon could appear outside it, purely by quantum mechanical means, in much the same way as an electron can suddenly appear on the far side of a potential barrier.” His voice trailed off and he stood staring into space.

“And you succeeded?” Horwith prompted, unsure where this lecture was leading.

Battani hit the table lightly with his fist. “No!” he shouted angrily. The mood passed away instantly. “I worked on it for almost five years, with absolutely no success. The anomaly is still just that, and,” he sighed, “I’m still as far as ever from fame and fortune.”

“Ah, Ambition,” Horwith said, “how many men have you gripped in your deadly embrace?”

“Me, for one,” Battani said with a smile. “One good thing came of it all, however. Much of my work was done on a NASA grant, so the results were published as a NASA document and circulated to the agency. Someone there saw the potential of part of it. Apparently, without at all realizing it, I had laid the foundations for T-band technology. All this, you see, was just at the time when NASA was starting work on its interstellar probe project, and they were worried about how to handle the transmission problem. In spite of modern computer technology, there are still some old-fashioned engineers in your agency who insist on full ground control of probes whenever possible, just in case the devices get ideas of their own or run into problems their onboard computers can’t handle.”

“It’s not just probes they treat that way,” Horwith muttered. “Employees, too.”

“Hmm. Well, the further the probe gets from Earth, the longer the delay in transmission time becomes, of course. Eventually, especially in the case of an interstellar probe, the time is too great for ground control from Earth to be practical. Unforeseen emergencies can always happen, so they want to be able to have engineers on the ground looking through the probe’s eyes through TV cameras and able to make it respond quickly.”

“And T-band is a form of instantaneous transmission. I’ve been told that, but not how it’s possible for radio waves to go faster than the speed of light.”

“They don’t,” said Battani, “not really. And they’re not really radio waves. They are electromagnetic, but the frequency is far below what’s usually considered the radio spectrum. Under the right conditions – which I thought should exist near a black hole’s event horizon, although I must have been wrong – energy of the right frequency and the proper probability function will tunnel from one point to another. Think of distance and the speed of light as the potential barrier in this case. Or time, rather, since that’s what really concerns us humans. In zero time, the energy front will tunnel from here to there, just as the electron tunnels through the barrier.”

“Shit. You pulled a magic trick on me again, just when I thought I was following you. No, wait.” He held up his hand. “Don’t go over it again. I followed the words all right. Just give my brain a few days to catch up.”

“I could show you the mathematics, but I’m not really sure that would help make it any clearer. We press on,” Battani said, pointing upward as if to some far frontier. “Some electronics whizzes at NASA devised a way of creating the tunneling effect at will. Tband, as they decided to call it.” He grimaced in distaste. “They didn’t ask my opinion on the name. Both transmitter and receiver have to operate in hard vacuum, so they set the receiver up here on the moon and set up the project you’re part of to make sure it could operate for hours at a time without trouble. Presumably there will be backup receivers emplaced before the probe is launched. The only transmitter in existence is a low-power, experimental version in Houston, a version of the one that will fly. That’s why we can be sure that what you received didn’t come from a transmitter on Earth. I’ve been assured that no one else in the world has the ability to build one yet. And anyway, without the quantity of hard vacuum we have here, there’s no practical way for anyone

to build a transmitter with significant power.”

“I think I see what you’re hoping for, at last,” Horwith said. “You think the signal Glen and I picked up might be the radiation from a black hole you were after before?”

“Precisely! But there’s a barrier standing in the way of proving that, or even of building a T-band telescope. The method doesn’t provide a direction, a line of sight. The radiation tunnels from the transmitter across a desired distance. The distance is proportional to the cube of the energy being emitted. So if you increase the power enough, the signal could show up at the end of the Universe, but it would be in the shape of a sphere. We can control that in the case of our probe, but a natural event, such as a black hole, would be putting out T-band signals over a vast range of intensities, so that the signals would tunnel to various distances in all directions, making the geometry problem intractable.”

Horwith thought for a moment. “At any one intensity, it would show up as a sphere, you said. It seems to me that all you’d need would be three points on the surface of the sphere. Non-collinear points, I mean. Draw the chords, the line segments connecting the points. You’d only need two of the chords. Then the perpendicular bisectors of those chords would intersect at the center of the sphere, giving you the location of the transmitter.”

“Quite right,” Battani nodded. “But practically speaking, it’s much harder than that. First of all, given a signal, we have no way of deriving the intensity of the source signal from it, so we can’t know if our three points are on the surface of the same sphere. Even if we do find a way of doing that, getting the three points will be difficult. We’re talking about a very large sphere, because the black holes in question are on the order of a thousand light years away, at least. That means the three points have to be very non-collinear indeed to do the trick. Points along the Earth’s orbit wouldn’t work. I think we’d have to send a receiver well out above the ecliptic to get the third point. You might try asking your superiors for money for a mission like that. I don’t think relations between Mendeleev and NASA are warm enough right now for me to make such a suggestion through my channels. But you sound interested in the theoretical problem.”

“I am,” Horwith admitted. “I’d still prefer aliens, and maybe some sort of tunneling method of transporting mass. I mean real mass, not just electrons, so that we could have instantaneous interstellar travel. But as second best, this sounds very interesting. I wish I had the brains to contribute something.”

Battani hesitated, then said, “You underestimate yourself. Not all the work will be theoretical, and Mendeleev does lack practical engineers. This is a wonderful place to work. I don’t normally offer jobs on such short acquaintance, but my intuition tells me that you could make a significant contribution. Would you like me to speak to Professor Larrieux? He’s LOAM Director. He might be able to arrange something with NASA. Perhaps we can get you loaned to us or assigned here on an open-ended basis.”

Horwith needed no time to think about it. “I’d love that, Al. I’d love to work here. That way, if there are aliens, I’ll be the first to know, right?”

Battani chuckled. “Hope springs eternal in the human beast. I hope you aren’t disappointed with what you find out.”

Battani's influence, or perhaps that of Professor Larrieux, must have been of large caliber. Late the next morning, Horwith received word from his superiors at NASA Frontside that, while the T-band receiver would stay where it was and the test program would continue as before, he was being transferred to Mendeleev for an indefinite period, assigned to work under Battani.

He was ordered to report back to Frontside first, however. He asked Battani if he could arrange for him to be taken by shuttle, since he had no other transportation.

"I'll see what I can do," Battani said. "It does work out most inopportune, though. When you arrived at the crater rim, did you happen to notice a large radio telescope just above us?"

"I did."

"Well, it just so happens that there's a brilliant young astronomer on the staff here, a Dr. Thabanchu, who's been trying for months to get observing time for a pet project of hers, and the only time available started just before we got to Mendeleev Rim in the shuttle."

"So?" Horwith asked, puzzled.

"So our arrival and then the elevator and then the subway starting off produced enough vibration to ruin all the work she was doing. Or so she says. She now hates both my guts and yours. Why yours, I don't know, but Moira has a habit of blaming whoever's available when things go wrong. Anyway, last night she caught me in my office without warning. If I'd had warning, I'd have been sure not to be there. She bullied me into giving her another time slot, and I managed to squeeze her in today for a couple of hours. She's out there now, preparing, at Radio Three, which is the instrument she was using yesterday. In other words, it's the one directly above the elevator and shuttle terminal we used yesterday. That's also where the only available shuttle is right now. If I do it to her again . . ."

"So why not have the shuttle take off right now, before she begins her observations, and fly around the perimeter of the crater and land at some other terminal point, and then I'll go out to that one? You'll disturb someone else's observations, I suppose, but I gather that this Thabanchu woman is the one you're afraid of."

Battani stared at him for a moment in open admiration. "Brilliant! Of course! Trust an engineer, a man of action, to see the solution." His admiration gave way immediately to annoyance. "I am *not* afraid of Moira Thabanchu, Clemmons. It's just that she's considerably larger and stronger and shorter-tempered than I am, and I'm a sensible fellow."

"Sounds like an interesting woman. I'll get back as soon as I can, Al, so you'll have someone here to protect you."

It was better than a nine-hour trip back to the NASA base, even by shuttle, since the base was almost in the center of the moon's frontside, fully halfway around the moon from Mendeleev. Clemmons spent part of the time napping, part of it watching hills, rilles, and craters slide by below, and part of it chatting with the two-man crew. They were basically glorified truck drivers, and he found them unintimidating compared to the self-aware geniuses he had already encountered at Mendeleev.

"Tell me something," he asked them. "Al Battani was explaining to me that the shuttles and the elevators and the subway cause vibrations that can ruin telescope observation. Didn't anyone foresee that when the base was being designed?"

The less intelligent of the two pilots shrugged. "Beats me. So long as they pay me, I don't give a shit what they do over there."

His companion said, "You're right. They should have mounted the telescopes somehow so that didn't happen."

"They should have done that because of moonquakes, anyway," Horwith said. "The moon's in a quiet phase right now, but that's only supposed to last another five or ten years, and then they'll really have problems with the telescopes."

"I remember when they were building the observatory," the pilot said. "I thought they should have put it all in space instead of on the moon. They wouldn't have the vibration problem, and Chuck and I could be real astronauts instead of doing this kind of driving."

"I remember when they were arguing about where to put it," Horwith said. "NASA wanted control of the whole thing. But so did the Russians and the Japanese and the European Space Agency. There was a lot of compromise." But one of the decisions, he remembered, had involved a dispute between professions, rather than between nations. NASA had been run by engineers since its inception, rather than scientists. Mendeleev was the opposite. What he took to be the unimaginative, nuts-and-bolts attitude at NASA often grated on him, but he had to admit that NASA's engineers would never have neglected to include safeguards against telescope vibration, had they been given the task of designing and operating the Mendeleev observatory. He felt an unaccustomed moment of pride in his agency, the professional equivalent of patriotism.

Or chauvinism or jingoism, he warned himself. Still, maybe all those practical men aren't so bad, after all.

Or perhaps they were. At least, perhaps Jim Dysan was.

Dysan was Horwith's immediate superior, a section chief with delusions of grandeur, despised by those beneath him and barely tolerated by those above. It was he who had insisted that Horwith return to base for instructions. Dysan might have to buckle down to direct orders from above to assign Horwith to Mendeleev, but at least he could assert his power and authority this one last time. In fact, he had nothing to say to Horwith that he couldn't have radioed to him. Dysan specialized in such petty displays.

"So you're going to be working for that spick at Mendeleev, eh?"

Horwith knew better than to take the bait. "Looks like it, Jim." You prick, he thought. Dick. Hick. He couldn't think of any more pejoratives that rhymed with "spick."

Dysan leaned back in his chair, a very large, very plush executive swivel model that bore a non-accidental similarity to a throne. He was a grotesquely fat man. Even in one-sixth Earth gravity, his chair creaked and groaned in protest. He had added at least fifty kilograms since coming to the moon two years earlier. By now, it might be physically impossible for him to go back to Earth and endure full gravity again. "Yep, Horwith. A nice, soft assignment for you. Nothing to do but eat all that expensive food those guys can afford to bring up from Earth and grow fat and lazy. Right?"

Asshole. "I'll be working on a project over there, Jim."

"In charge of it?"

“That’s how I understand it.”

“Shee-it. So that explains why you’re so eager for this. You’d never get to head a project here, not as long as I’m in charge. All right, get the Hell out of here, you opportunist. You wanna know somethin’? At least I’m glad you won’t have the garden to waste your time in any more.”

The garden was a huge underground vault where a team of botanists conducted experiments in growing a variety of Earth plants in lunar soil and under lunar gravity, using sunlight piped down from the surface through an optical fiber. It was supposed to be carefully isolated and controlled, but within the last year or so it had become common for the experimenters to allow favored NASA personnel to stroll about in it. It was a highly valued privilege, of great psychological value to men and women stationed for long periods on the sterile moon, and indeed it was one thing Horwith would miss while at Mendeleev.

On the other hand, there was another, similar vault where a team of zoologists played their own scientific games with various animals. That area was theoretically completely isolated from the rest of Frontside, but at least once a month the smell from it managed to circulate through the base airconditioning system to every nook and cranny. That smell was something Horwith would not miss at all.

Horwith rose to his feet. “Don’t you have some instructions for me?” he asked mildly. “I thought that’s why I had to come back right away.”

Dysan grunted. “You had to come back right away because I said you had to, that’s why. Your instructions are to remember who you’re working for. Don’t switch sides.”

Horwith returned a mock salute and left. He went to his quarters for a shower and short nap and then packed a few belongings and solid-state book modules in his one small suitcase. There was little more in his one-room apartment. He had brought up from Earth only what NASA would transport for free. Anything beyond the weight limit, he would have had to pay for himself, at very high rates, and that had been beyond his financial reach. What little more was in his closet and chest of drawers could stay there until he returned from Mendeleev. He was sure his time would be more than occupied, and so would his interest.

The shuttle from Mendeleev had left as soon as it had dropped him off and refueled. Belying Battani’s words about the pragmatism of the engineer, Horwith hadn’t planned ahead this far and so he had to contact Dysan yet again to ask for help.

Dysan’s face on the television screen sneered. “You could walk, you know.”

“Six thousand kilometers?”

Dysan frowned. “You know we don’t have money running out our ears like those guys do. We don’t have shuttles like theirs just lying around, waiting to give some guy like you a joyride.”

Horwith controlled his temper and thought for a moment. “Jim, I’m on an official assignment to Mendeleev now. It came down to you through NASA channels. I’ve got to get back there, and this base has to provide me with transportation. Otherwise, someone will be in trouble with the folks in Washington. Someone might even be disciplined. Someone might even have to go back to Earth to defend himself. Day after day after week in one-g.”

Dysan glared at him. “I’ll get you a rover. Bring it back when your assignment’s up.”

A rover! It would take him days. He’d encounter both lunar day and night. He’d be in his suit all the time, eating liquid through tubes and eliminating wastes the same way. The only respites would be short ones, at small NASA outposts along the way. And there was a more than negligible chance that he wouldn’t make it – this his suit or his rover or both would malfunction,

leaving him to freeze or burn up or starve or suffocate alone, far from help, on the moon's barren surface. Perhaps that was what Dysan hoped would happen.

Horwith said, "Want to come along for the ride, Jim?"

Dysan cut the connection with a triumphant look. Horwith headed for the garage feeling grim and fatalistic.