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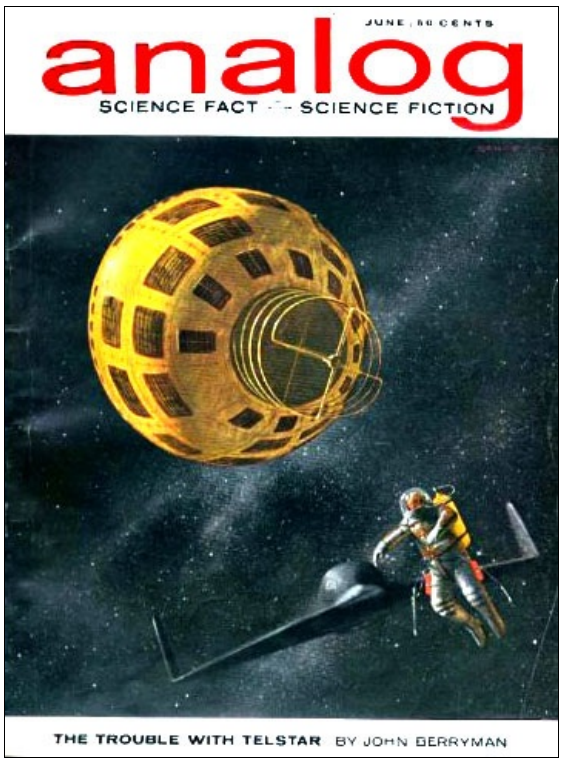
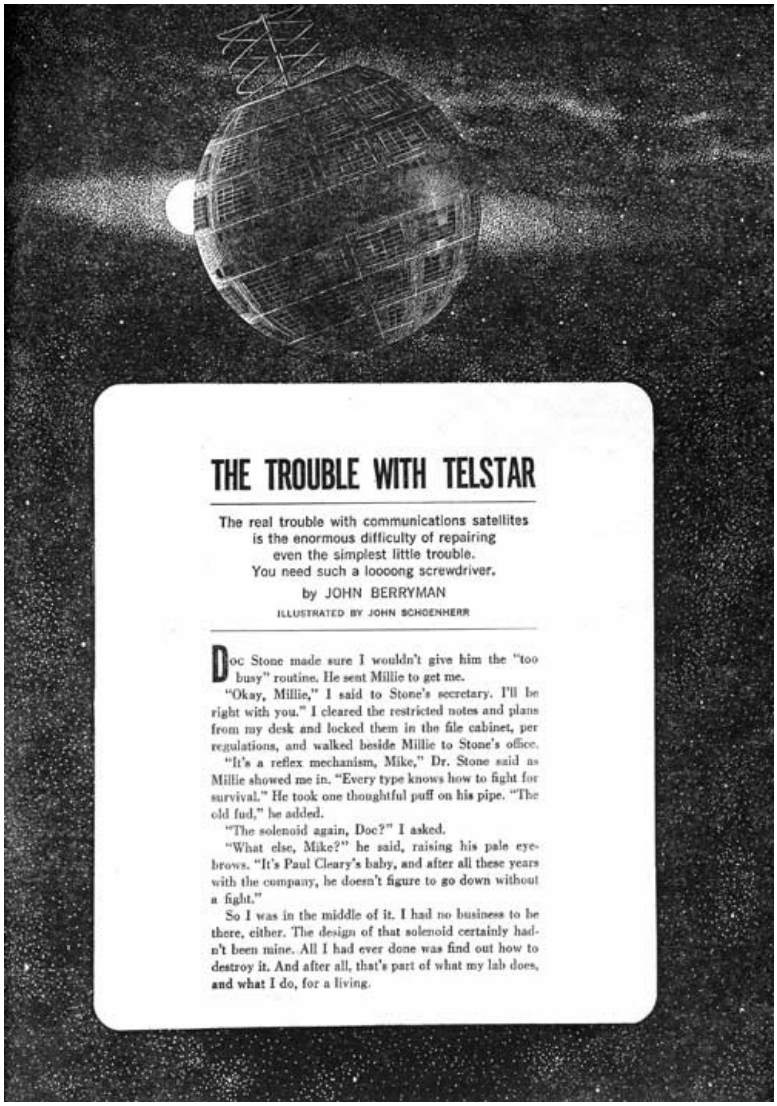




THE TROUBLE WITH TELSTAR

The real trouble with communications satellites
is the enormous difficulty of repairing
even the simplest little trouble.
You need such a looooong screwdriver.

by JOHN BERRYMAN

ILLUSTRATED BY JOHN SCHOENHERR

Doc Stone made sure I wouldn't give him the "too busy" routine. He sent Millie to get me.

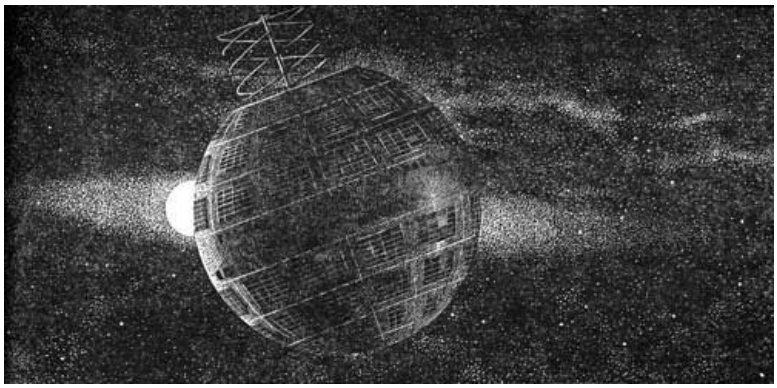
"Okay, Millie," I said to Stone's secretary. I'll be right with you." I cleared the restricted notes and plans from my desk and locked them in the file cabinet, per regulations, and walked beside Millie to Stone's office.

"It's a reflex mechanism, Mike," Dr. Stone said as Millie showed me in. "Every type knows how to fight for survival." He took one thoughtful puff on his pipe. "The old fud," he added.

"The solenoid again, Doc?" I asked.

"What else, Mike?" he said, raising his pale eyebrows. "It's Paul Cleary's baby, and after all these years with the company, he doesn't figure to go down without a fight."

So I was in the middle of it. I had no business to be there, either. The design of that solenoid certainly hadn't been mine. All I had ever done was find out how to destroy it. And after all, that's part of what my lab does, and what I do, for a living.



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"Quit staring out the window, Mike," Doc said behind me. "Here, sit down."

I took the chair beside the desk and watched him go through the business of unloading his pipe, taking the carefully air-tight top off the humidor we had machined for him down in the lab, and loading up with the cheapest Burley you can buy. So much for air-tight containers. Doc got it going, which took two wooden matches, because the stuff was wringing wet—thanks again to an air-tight container.

"I just left Cleary's office, Mike," he explained. "He won't admit that there's any significance to the failures you have introduced in his solenoid. He insists that your test procedures affected performance more than design did, and he wants to talk with you."

"Great," I said glumly. "Can I count on you to give me a good recommendation for my next employer?"

"Cut it out, Mike," he said, coming as near to a snap as his careful voice could manage. He blew smoke out around the stem of his pipe. I think sometimes it's a part of his act, like the slightly-out-of-press sports jacket and flannel trousers. It says he is a sure enough Ph.D. If you ask me, he's a comer. You can't rate him for lack of brains. He knows an awful lot about solid-state physics, and for a physicist, he sure learned enough about micro-assemblies of electronic components. I guess that's why he was in charge of final assembly of the Telstar satellites for COMCORP.

"Don't worry about what Paul Cleary can do *to* you, Mike," he suggested. "Think a little bit more about what Fred Stone can do *for* you. Cleary is only a year or so from retirement, and you know it."

"He could make that an awful tough year, Doc." I said. "You told me he won't hear of design bugs in that solenoid. He'll insist something went wrong in assembly."

Doc Stone smiled thinly at me and brushed at his blond crew cut. "It is a tough spot, Mike," he agreed. "Because I won't hear any talk of faulty assembly. You'll have to choose, I guess. If you think you can make your bed by playing footsie with an old fud who has only a year to go, try it. Just remember that I've got another thirty years to go, and I'll breathe down your neck every minute of them if you let me down!"

"Sure," I said. "When do I see him?"

"Now."

Doc Stone got someone named Sylvia on the phone and then told me to go right up. After I got there, I had to sit and wait in Cleary's outer office.

I shared it with a small, intense girl named Sylvia Shouff, if you believed the little plastic sign on her desk. There was barely room for it in the welter of paper, files, notebooks, phones, calendars and other junk she had squirreled. She was much too busy banging at a typewriter and handling the phone to pay any attention to me. Her pert, lively manner said she hadn't taken any wooden nickels lately.

But I had. The last series of tests in my lab had put me in the middle of a hell of a scrap. It had all started a couple years back, when the final design had been approved for a whole sky-full of communications satellites. Well, eighteen, to be exact. One of the parts in the design had been a solenoid, part No. M1537, which handled a switching operation too potent for a solid-state switch. That solenoid was one of the few moving parts in the Telstars, and it had been designed for skeighty-eight million cycles before it got sloppy or quit.

In practice, out in space, the switching operation simply hadn't worked. After about a hundred hours of use in Telstar One, it failed. Unfortunately, this had not been discovered until the first six satellites had been launched. Further launchings were postponed while they ran accelerated switching tests on satellites Two through Six out in space. The same kind of failure took place on each bird.

There were two schools of thought on licking the bug. Doc Stone, of course, insisted that solenoid M1537 had failed, which was one possible interpretation of the telemetry. And Paul Cleary, who had been in charge of design, insisted that faulty assembly was to blame. Well, somebody would make up his mind pretty soon, and my evidence would have a lot to do with it. I had done the appraisal tests of the circuit in the test lab once the bug had been detected, and now Cleary was going to smoke it out of me.

"Mr. Seaman," Sylvia Shouff said to me, kind of waking me up. "Mr. Cleary will see you now. Have you ever met?" she added, as I came toward her desk.

I shook my head. "I'm a working stiff," I said, "I never get to meet the brass."

"You are also somewhat insolent," she said tartly. "Better wash out your mouth before you try that on Paul Cleary. He eats wise young laboratory technicians for breakfast."

"Yes, *mam*!" I said, feeling my ears burn. She led me to the door, opened it, and introduced me to Paul Cleary. He lumbered out around his desk and shook my hand with his rather gnarled and boney paw.

"Hello, Seaman. I'm glad to meet you, young man. Come in. We have a lot to talk about," he said.

Considering that Cleary was a wheel, and had thirty years of service with Western Electric behind him, his office wasn't especially large. Maybe that's because Communications Corporation is owned half by the government and half by AT&T. The government half makes us watch our pennies.

"Have a seat, Mike," Cleary said, going around to lower himself carefully into a tall swivel chair. He learned back and rocked slowly, like an old woman on the front porch of a resort hotel. His pipe was still smoking in a rather large ashtray. He picked it up, showing it to be a curve-stemmed old-man's style, and puffed contentedly at it. On him it didn't look like an act.

"Well," he said, pulling big shaggy eyebrows down so they shaded his pale blue eyes. "You've become something of a celebrity around here, Mike."

This was an unexpected approach. "Nobody told *me*," I complained. "Does this kind of fame show up in the paycheck?"

"Not always," Cleary said, scowling a little. "I just meant that your name gets bandied about. Every time I talk to Fred Stone he says, 'Dr. Seaman says this,' or 'Dr. Seaman says that.' I just had to see what this doctor looked like."

"You can forget the doctor part," I said uncomfortably. I had heard that Cleary was sensitive about having no advanced degree. When he went to work for the Western, college was plenty. You did your post-graduate work on the job. He sure had—and he had a string of patents as long as your arm to prove it.

"That's good," he said. "I'd hate to think I was competing with you in the field of knowledge where you are the world's specialist."

I grinned at him a little sickly. "COMCORP has never made any use of my specialty," I conceded. "You already had about ten guys around here who had learned twice as much as I had simply by doing it every day for a living. They could have written rings around my thesis."

"Sure," he said contentedly, puffing more smoke. "So we made a testing engineer out of you. And you may amount to something, to hear Fred Stone tell it."

"Thanks," I said.

"Now let me hear what you've been doing for Fred," Cleary suggested, in a sort of avuncular tone. "I'd like to measure you myself."

"You mean the tests I ran on the switching gate?" I asked.

"Why, yes, we can start there," he nodded, squinting his blue eyes more and blowing a real screen up between us.

"When Telstar One packed up, they sent me down the whole gate from that sector," I said. "Dr. Stone asked me to run destruct tests on the whole assembly, which I did. The only failures I have induced so far are failures in M1537, the solenoid that all the shouting is about."

"What kind of failures did you get?"

"Armature froze on the field," I said. "I guess the bearings really went. When there was enough load on them, they couldn't maintain concentricity."

"What kind of loads?" he growled, sinking down lower in his chair. He put his elbows on the arm and laced hairy-backed fingers together under his chin.

"I put the whole gate on the centrifuge and swung it up to twelve gees" I said. "Switching was normal there for the twenty thousand cycles I gave the gate. But when I added undamped vibration at twelve thousand to fifteen thousand cycles per second, I could induce failure pretty quickly. Say an hour or so."

"You had to apply the vibration throughout the whole test period to get these failures?"

"Yes, Mr. Cleary."

"Then how do you explain how vibration during no more than six or eight minutes of blast-off and launch could have the same effect on the actual installation on M1537 in a satellite, Mr. Seaman?" Smoke poured from the curve-stem.

"I don't have to explain it," I said, beginning to get a little hot. "All I have done is find a way to make one part quit. I haven't said it did quit in use, or that it could be made to quit in use."

"Then what the hell are you good for?" Cleary growled.

I didn't have any answer for that.

He repeated his question, blue eyes glittering. "I asked you what the hell you were good for, Seaman!" he said, much more loudly.

"For putting in the middle," I snapped back.

"That's how you interpret this affair, then?"

"Yes."

"All right," Cleary said, straightening up. "We'll stop talking about your work as if it were scientific study and talk about it as a play in office politics. Is that what you want?"

"I don't want any part of it," I said, hoping I wasn't plaintive. "I work under orders. The director of assembly asked me to test the part to destruction. I tested it. I'm sorry that it wasn't a soldered joint that failed. It wasn't. It was a solenoid. What has that got to do with me?"

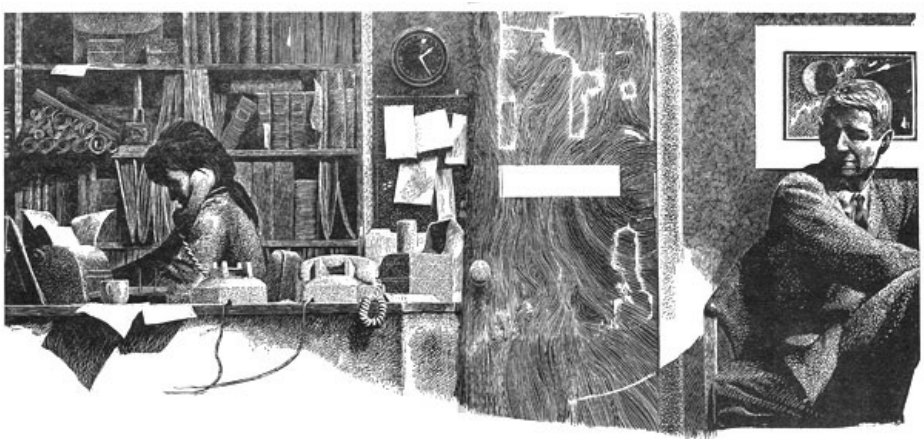
"Nothing, maybe," Cleary conceded, pushing himself up out of his chair. He went to his window to stare out at the parking lot. "You can be a test engineer all your life, if that's what you want."

"It isn't."

"And what do you want, Mike?" he said, turning back to face me.

"Your job," I said. "In time."

He nodded. "Well said," he decided. "But if you want it, you'll have to learn that business is about ninety per cent people and about ten per cent operations. You know, as you have clearly shown, that Fred Stone is pushing to get me out of here a little before my time, and pushing to make sure that he gets this spot, for which there are other claimants of equal rank in the organization. Oh no," he said, holding up his hand. "Don't tell me that is none of your affair. Right now you are in the unusual position of being able to cast a vote that will decide just how soon Fred Stone can make his move for the top spot. And as long as you sit there and try that smug line of 'I just test 'em and let the chips fall where they may,' you are really siding with Fred Stone. I need something else out of you, and you know it. What's it going to be? Are you a wise enough head at your years to pick a winner in this scrap? And what if it *isn't* Fred? I'll have your hide, young man."



"That's what your snippy little brunette said," I told him. "She told me that you'd eat me for breakfast, and she was right." I got to my feet.

"Where are you going," he growled. He was still standing behind his chair.

"To look for another job, Mr. Cleary. There must be some place where the honest result of a test

will be assessed as the honest result of a test rather than a move in a political fight."

"Honest result?" he echoed, and snorted. "*Was* your test honest? What *really* happened out there in space?"

"Nobody asked me," I said hotly. "My assignment was to test that gate until a part failed."

"A dishonest assignment," Cleary said. "Sit down a minute." We both calmed down and took our seats. I got a cigar out of my coat, peeled the wrapper and made counter-smoke. "Here, I'll give you an honest assignment, Seaman. You're a test engineer. Tell me what happened *out there in space*. Why did that switching operation fail?"

"I haven't the faintest idea," I said.

"Then find out!"

I chewed my cigar. "Without duplicating the conditions?" I protested. "And how can we? There's zero gravity—zero pressure—all sorts of things going on out there we can't duplicate in a lab."

"I really don't care how you do it," he said. "But if it were my job I'd just light my pipe and sit here and think for a week or so. Why don't *you* try it?"

I got up again. "Yes, sir," I said. "I suppose it would help to have the original telemetry data so that I could evaluate for myself what went wrong."

"I thought you'd get to that," he said, passing me a fat file-folder. "Here it is." He stood up, too, and led me to the door. "And other data you might want?" he asked, now a good deal more kindly. His hand was on my elbow.

I looked at him. "How about the phone number of the brunette out there?" I asked without taking the stogey from my teeth.

"Sylvia? That's pretty valuable information," he said, beginning to grin in a sleepy old fashion. "But she only dates astronauts. If you haven't made at least three orbits, she won't even have dinner with you."

I stopped at Sylvia's desk with half an idea of asking her for a date. "Well, Dr. Seaman," she demanded as I chewed on my pacifier. "What did you learn?"

I thought about it. "That a lot depends on knowing where to put your feet," I said, puffing smoke. "And my name is Mike."

She sniffed. "If you think Paul Cleary hasn't been around long enough to catch Fred Stone trying to fake him out of position with a meaningless test," she said, "you have another think coming!"

"He'd never have tried it," I told her, "if he'd known Cleary had you to look after him." That got me a much louder sniff and toss of the dark curly head, which broke up my plans to ask her to dinner.

The telemetry results had been decoded, of course, so that a mere mortal could read them. I didn't have a pipe, which probably meant I'd be a failure as a physicist, so I chewed cigars ragged for about three days and did some serious thinking. When I got a result, I looked up Shouff, Sylvia, Secy./Mgr./Dsgn., in the phone directory, and talked to my favorite brunette.

"Mr. Cleary's office," she said.

"When would he like to see Mike Seaman?" I tried.

"Probably never," she told me. "But I suppose he'll have to. Isn't Fred Stone going to run your errand for you?"

"I'm running Fred Stone's errands, isn't that what you really think, Sylvia?" I asked her.

Sniff! "He can see you at eleven." Click.

Paul Cleary had his coat off and was poring over a large black-on-white schematic when I was shown in by sniffin' Sylvia. "Hello, Mike," he growled. "Here, Sylvia. Mike's not supposed to see this stuff. Drag it away, honey. Drag it away!"

With quick motions she rolled up the drawings, snapped a rubber binder around them and went out. Cleary wagged his hairy old paw to the chair beside his desk.

"So you've been thinking?" he asked, reaching for his curve-stemmed pipe.

"How do you know?"

"My spies tell me you haven't been out in the lab since the other day. Certainly you were doing something besides sulk in your office."

"Yes."

"Well, what did you come up with? Why did that switching operation fail out in space."

"I don't know."

His shaggy eyebrows shot up. "You don't know? Is that all COMCORP got for three days' pay?"

"A confession of ignorance is a hell of a lot more revealing than a solid error," I snapped. "The honest answer that I get out of the telemetry data is that something in that gate broke the circuit and the switching operation failed. I think there are about seven thousand components in the gate. I don't know which one failed. A few I can rule out, because they would only cause part of the gate to fail. But a hundred different breaks could account for the data. So I don't know."

He lit his pipe and blew smoke around the curved stem before he made reply. "So we got a philosopher for our money," he said. "A confession of ignorance, eh? What are you going to do about it?"

"You tell me, Mr. Cleary. You're the old head around here."

"So I am," he said evenly. "So I am. Well, my advice to young pups is that they should not be ashamed when they don't know. They should say so. But they should have something else to say along with it."

"For example," I suggested grumpily.

"They should say, 'I don't know, but I know where to find out,'" he said. "Tell me, Dr. Seaman, do you know where to find out?"

He puffed at me for the two or three minutes I thought about it. Really, that's a very long time to think. Most ideas come to you the moment you identify the problem, which is the really hard part of thinking. But this problem took some thought, and I wanted him to think I was thinking.

"Yes," I said at last. "I know where to find out."

"Where?"

"Out in space."

This called for a lot more smoke. "You mean, go out there and look at the satellite, in space?"

"Yes, I can't imagine any other way really to figure it out."

He nodded. "You may be right, Mike. But do you know how much it costs to send a manned satellite aloft?"

"Oh," I agreed. "There are cheaper ways. We can beef up every part in that gate, test it much tougher than we already have, and when we get the gate to where all seven thousand components can stand any imaginable strain, we can rebuild the twelve Telstars we haven't launched yet and be pretty sure they won't have switching failures. But that isn't what you asked me."

"We'd have to fix eighteen of them," he said. "The first six are about sixty per cent useless. They'd have to be replaced."

"I still think you should consider sending a man to examine the Telstars in orbit," I suggested.

"Science demands it, eh" he growled.

"No, I was thinking that perhaps a simple repair could be made in space, and that you wouldn't have to launch six extra birds."

He got out of the chair and went to the clothes tree to put on his coat. The elbows were shiny from leaning on his desk. "It might be cheaper at that," he said. "The first six are launched in only two orbits. Three telstars in each orbit, separated by one hundred and twenty degrees. Two launches of a repair man might do it, with careful handling. Is that what you had in mind?"

"Something like that."

"We'd have to send a pretty rare kind of a repair man, Mike," he said, coming back to sit on the corner of his desk and glower down at me. That was about his kindest expression.

"Yes," I agreed. "You need somebody who can test and diagnose, and then make a repair."

"And who is an astronaut, too," he said. "I wonder if there is such a thing?"

"Make one," I suggested.

He scowled a little more fiercely. "Explain that," he ordered.

"I figure you could take one of our men from my laboratory, who knows how to test the gate, and a man who is handy enough with miniature components to cut out the one that failed and replace it, and teach him how to get around in a spacesuit. That would surer than hell be quicker than taking one of these hot-shot astronauts and teaching him solid-state physics."

"Yes," he agreed, looking down his fingers. "That was a pretty sneaky way to get out from between Fred Stone and me, young man."

I couldn't resist it: "That's what took most of the three days," I said, just a little too smugly.

"I liked you better in the middle," Cleary grumped. "Well, you have a thought, and it calls for a conference." He took his coat off again, hung it on the clothes tree, came back to his desk and got on the phone.

"Sylvia? Have Fred Stone come up, and you come in with him, eh? That's a dear."

He racked up the instrument and smiled at me as he stoked his pipe into more activity. "Relax," he advised me. "It always takes a while to round up Fred Stone."

He wanted no small talk, so I fidgeted in my chair while Cleary rocked gently in his. In about ten minutes, curly-headed Sylvia brought Dr. Stone in with her.

It was, "Hello, Fred," and "Hello there, Paul," when they came in. Sylvia didn't have anything to say, although she gave me a hot-eyed glance before pulling out the dictation board on Paul Cleary's desk and making herself comfortable with her notebook.

Cleary offered Doc Stone some of his tobacco, which was politely refused. The old man began it:

"Your Dr. Seaman has quite an idea, Fred," he said, in a mild, kindly voice, with a dumb, guileless look on his face.

"Good, Paul," Doc Stone smiled thinly. "I've told you he's a good boy."

"Hm-m-m," said Cleary. "He says his tests can't prove what went wrong with the switching gate on the satellites, and in effect that the telemetry doesn't make it plain whether we have design or assembly trouble."

"Well, *well*!" said Fred Stone. I decided to start shopping for a marker for my grave.

"Yes," Cleary said. "He made quite a suggestion, that we send a man out in space to look over the Telstars and find out what went wrong. Even better, he says it might be possible to make a repair at the same time and get the bird working. You can see the advantages of doing that, the way they are orbiting."

"Yes, indeed," Doc Stone said, looking at me with slitted eyes. "Quite a unique adventure for some technician."

"Just what I was thinking," Cleary said. "The problem resolves into: Who do we send? Now Mike, here, says we should take a man from his lab who knows the bird and its assembly and teach him how to get around in a spacesuit—that, he claims, would be quicker than taking one of these space jockeys and making a technician out of him."

"I think he's right."

"So—there we are. Who do we send?"

"There can hardly be any choice," Dr. Stone said, looking at me with eyes like granite.

"Hardly," Cleary agreed. "The head of the lab is the best man, beyond a doubt."

They were talking about me! Try to get out of taking sides, would I? Cleary wanted me back in the middle. Stone wanted me dead. They were both likely to get their way, unless I told them off.

I opened my mouth. Cleary cleared his throat loudly.

"Oh, Dr. Seaman!" Sylvia cut in, breaking her careful silence. "What a thrilling opportunity for you!"

I gaped at her. Well, Cleary had said it. She only went out with astronauts. She was space-happy.

"There are men in the shop who deserve the chance...." I started.

"Nonsense!" she said quickly. "It's your idea, doctor, and you deserve the fame!"

"And the promotion this will undoubtedly earn—if you can bring it off," Cleary added.

"Yes!" Dr. Stone said with relish. He didn't think I could, either. Well, that made three of us, unless Sylvia made four.

"Thank you very much," I started, as a prelude to backing out.

"Good, that's settled," Cleary said. "That's all, Sylvia."

She got up and left. She had done her dirty work. If I hadn't been so sick at my stomach, I would have had to admire really great teamwork.

Stone shook my hand with an evil kind of relish and followed her out.

That left Paul Cleary and me alone. "This is a great thing, young man," he said.

I couldn't stand him any longer. "You are a worm!" I told him.

"You're probably right, Mike," he agreed, without any particular heat. "But a rather just one. I

think you'll admit you've been paid off in your own coin. All you had to do was beg off."

"In front of her? You knew I wouldn't."

"I *figured* you wouldn't. That's one of the advantages of being older. You know more about how the young will behave. Come on," he said, getting up to put on his coat again. "We have to see a man."

"One thing," I said, as I got up, "while we're being so just."

"Yes?"

"I had thought of asking your Sylvia for a date. But she was so snippy the other night I decided to forget it. Now, she got me into this, and she'll have to pay and pay! How do I get to her? It'll be quite a while before I'm an astronaut."

He took his pipe from between his teeth. "This calls for the wisdom of a Solomon," he decided. "But you might try oysters."

It was pretty good advice. I hung behind him long enough to tell Sylvia about the Chincoteague oysters they put in the stew at Grand Central Terminal, and got a dinner date. That was all, just the date, because Cleary was itching to take me to see a man.

Politics must be an awfully large part of business. The man we went to see was the government side of COMCORP, and I guess he had had to do as much explaining about Telstar failures to a Senate Committee as Paul Cleary had had to do to the Western. He wanted an out just as bad as Paul did.

There were a good many conferences before a sufficient number of people decided the cheapest way out was to send a man to fix the Telstars that had broken down. The question was whether it was possible.

We went at it from two directions. They got a team assigned to figuring out if the Dyna-Soar rocket could be modified to make the three contacts around the orbit, carry two men and enough air and fuel for the job, and at COMCORP we appointed a crew to figure out what it meant to make the repair in orbit.

Cleary put me in charge of our crew. They gave me a full-size Telstar satellite for my lab, and I went to work.

Fancy electronic equipment consists of millions of parts, and Telstar is no exception. One of the bonuses America got from its poor rocket booster performance, as compared with the Russians, was a forced-draft course in miniaturization. Our engineers have learned how to make almost anything about one-tenth the size you'd think it ought to be, and still work. To get all these tiny parts into a total system, they are assembled in racks. In the Telstar each of these long skinny sticks of perforated magnesium alloy is hinged to the main framework so that it can be swung out for testing or for replacement of parts, which is why the engineers call each component a "gate."

I spent several weeks learning how to take each suspected component out of the gate. Most of the time I needed a screwdriver. Sometimes I had to drill out a soft aluminium rivet. The hard part was that some of the components were so deep inside, even with a couple gates swung out the way, that I needed all kinds of extension tools.

Of course, I had to visualize what it would be like doing all this out in space. I'd be in a spacesuit, wearing thick gloves, and when I removed a screw that would have looked good in a Swiss watch, there'd be no work bench on which to place it while I took out the next one. Worse yet, I would have to put it back in.

The longer I worked with the parts, the harder it looked. There wouldn't be a prayer of just turning the parts loose in space. In theory they'd follow along in orbit. In practice you can't bring your hand to a halt and release a tiny part without imparting a small proper motion to it. And even worse, you couldn't handle the little wretches when you tried to put them back in. With a solid floor to lie on, with gravity to give things a position orientation, I kept losing tiny screws. Magnets didn't help, because the screws were nonmagnetic for what seemed pretty good reasons. Some were made of dural for lightness. Some were silicon bronze. None of them was steel.

That put us back in the lab to find out what would happen if we used steel screws. The answer was, surprisingly, nothing important. So there was one solid achievement. I had a few thousand of each of the thirty-four different sizes of fasteners machined from steel, and magnetized a fly-tier's tweezers. The result was that I could get screws back into their holes without dropping them, especially when I put little pads of Alnico on the point of each tweezer to give me a really potent magnet. Then we had to cook up an offset screwdriver with a ratchet that would let me reach in about a yard and still run a number 0-80 machine screw up tight. That called for a kind of torque-limit clutch and other snivies.

It was the fanciest and most expensive screwdriver you ever saw. The handle was a good two feet long. The problem then became that of seeing what you were doing, and one of the boys faked up

a kind of binocular jeweler's loupe with long focus, so that I could lie back a yard from the screw and focus on it with about ten diameters magnification. The trouble was that the long focal length gave a field of vision about six times the diameter of the screw-head, which meant that every time my heart beat my head moved enough to throw the field of vision off the work.

By that time I was working in a simulated spacesuit—the actual number was still being made to fit an accurate plaster cast of my body. So the boys figured out a clamp that would hold my helmet firmly to the gate, and a chin rack inside the helmet against which I could press and hold my head steady enough to keep my binoculars focused where they had to be focused. At a certain point I went back to Paul Cleary and said I thought I could make the necessary tests, dismount what I had to dismount, and replace any affected part.

"All worked out, eh?" he said, reaching for his pipe.

"Not by a county mile, Mr. Cleary. But I know what the problems are, and the shop can figure out sensible answers. Some of the hardest parts turned out to be the easiest."

"Name any three," he suggested.

"Well, the screws. As I take them out, I'll discard them into space. I have to use magnetic screws on reassembly, so there is no point saving what I take out. Doug Folley has doped out something like a motorman's change-dispenser that will dispense one screw at a time into my tweezers, and I'll carry a supply of all thirty-four kinds at my waist."

"That's one," he counted on a hairy forefinger.

"We can use something like a double-faced pressure-sensitive tape to hold other parts," I said. "We'll draw a diagram on it, stick it to some unopened part of the satellite near where I'm working, and as I pull pieces out, I'll just press them against the other sticky face, in the correct place in the diagram, and they'll be there to pull loose when I want them."

"At absolute zero?" he scoffed. "That sticky face will be hard as glass."

"We'll face the bird around to the sun," I said. "And warm it up. If we have to, we'll put wiring in the tape, connect it to Telstar's battery supply, and keep it warm."

"Might work," he grumped. "That's two. How about the spacesuit part?"

That had been tougher. Some forty or fifty men had made the ride into space and back from Cape Canaveral by this time, and there had been rendezvous in space in preparation for flights to the moon. But so far no one had done any free maneuvering in space in a suit.

They had put me in a swimming pool in a concentrated salt solution that gave me just zero buoyancy, and I had practiced a kind of skin-diving in a spacesuit. The problem was one of mobility, and the one thing we could not reproduce, of course, was frictionless motion. No matter how I moved, the viscosity of the solution quickly slowed me down. Out in space I'd have to learn on the first try how to get around where every force imparted a motion that would continue indefinitely until an equal and opposite force had been applied.

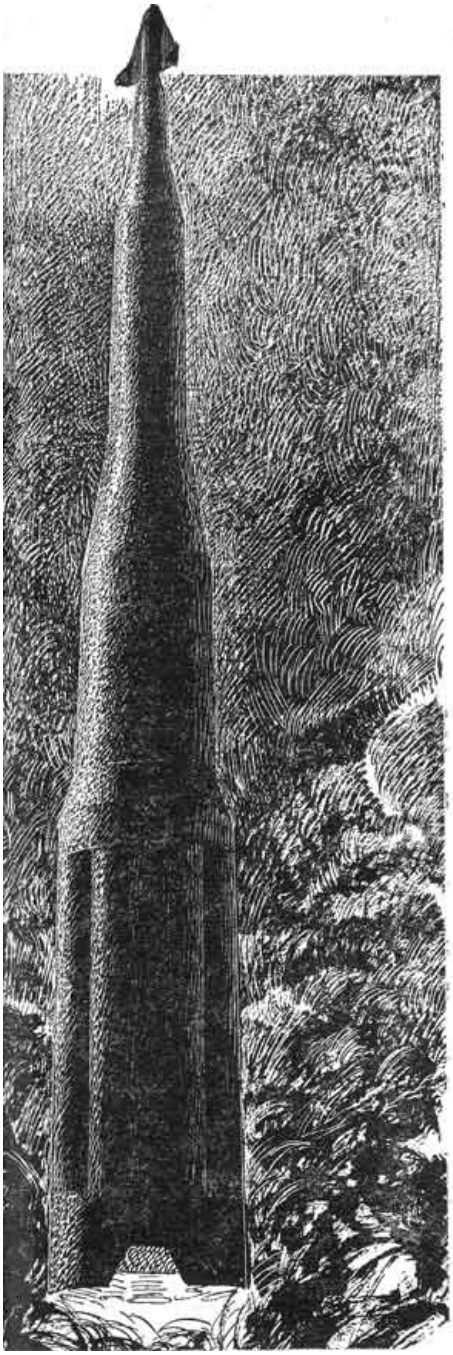
The force part had been worked out in theory long before. To my spacesuit they had fixed two tiny rockets. One aimed out from the small of my back, the other straight out from my belly. Two pressurized containers contained hydrazine and nitric acid, which could be released in tiny streams into peanut rocket chambers by a single valve-release. They were self-igniting, and spurted out a needle-fine jet of fire that imparted a few dynes of force as long as the valve was held open. It only had two positions—full open, or closed, so that navigation would consist of triggering the valve briefly open until a little push had been imparted, and drifting until you triggered the opposite rocket for braking.

The airtanks on my back were right off a scuba outfit.

Really, they spent more time on the gloves than anything else. At first we thought of the problem as a heat problem, but it was tougher than that. Heat loss was not much, out there in a vacuum, and they made arrangements to warm the handles of my tools so that I wouldn't bleed heat through my gloves to them and thus freeze my fingers. No, the problem was to get a glove that stood up to a pressure difference of three or four pounds per square inch and could still be flexed with any accuracy by my fingers. We could make a glove that was pretty thin, but it stiffened out under pressure and made delicate work really tough. It was a lot like trying to do brain surgery in mittens.

They eventually gave me a porous glove that leaked air when you flexed your fingers. Air, they said, could always be gotten from the Dyna-Soar rocket that would be hanging close at hand in space. Well, we hoped it would work. I could do pretty fair work with the leaky gloves, and all we could hope was that the vapor would be dry enough as it seeped out through the gloves to prevent formation of a foggy cloud all around me, or the formation of frost on the gloves. That we could not test under any conditions easy to simulate.

Each team spent ninety days. They tell me that's right quick work for pointing up a launch. But at the end of three months I had assembled enough stuff to do the job, and still well within the



weight limit they had to set. I wasn't a walking machine shop, but there was a lot I could do if I had to.

Ninety days had been enough for several dates with Sylvia. Out of the office she wasn't quite the protective harpy about Paul Cleary that she had been in the office, although the thought was never far from her mind.

We spent my final night in New York before leaving for the Cape at Sweets, a real old fashioned seafood house down on Fulton street. After the obligatory oysters, we had broiled bluefish, and otherwise lived it up. They serve a good piece of apple pie, and we had that with our coffee.

"Are you scared?" Sylvia asked me.

"Of what?" I lied innocently.

"Of being out in space—just floating around?"

"Yes," I told her honestly. "I'm scared to death. What if I have a queasy stomach? They say a good half of the men who have been in orbit have chucked up or gotten dizzy or something. What if they go to all this trouble and I get spacesick?"

"What if you drift away and can't get back?" she said. "It isn't like swimming back to shore."

"There's always a way," I said, my stomach tightening as I thought of what she said.

That was the night she kissed me good night. It wasn't much of a kiss, because we were standing in the lobby of her apartment house, and she wasn't going to invite me up, because she never did. But she said: "Hurry back."

"Just you know it, Shouff," I said, bitter inside.

I'd have been a lot more bitter if I had known what was in store for me at the Cape. COMCORP flew me down in one of our private prop-jets, with only Paul Cleary for company. He introduced me to the brass, and we sat through a couple conferences while the idea was spelled out to a group of sure-enough spacemen. Then they turned that mob loose on me.

I was emotionally unprepared. First off, Cleary and Fred had been building me up all through the three months, and I had actually gotten to the point where I thought I knew what I was doing. These space-jockeys spent most of their time deflating my ego.

My tormentor-in-chief was a wise punk from Brooklyn named Sid Stein. "How have you made out in your centrifuge tests?" he asked me at breakfast the first morning after I had reached the Cape.

"I have never done any of that stuff, Mr. Stein," I said.

"Well, how many gees can you pull?"

I shrugged. "Same as you, I suppose. How many is that?"

"Brot*her*!"

The space medic wasn't any better. The mission chief insisted that it wasn't safe to put anybody in a satellite who couldn't pass the physical. I guess you know that about one man in a thousand can qualify. This was supposed to wash me out.

"Remarkable shape." The space medic kept saying. "You must take considerable exercise, doctor."

"Oh, no," I said. "Just jog a mile or so before breakfast. Nothing spectacular."

"No other formal activity?"

"Well," I snarled, "just swimming, fencing and weight lifting. I've given up the boxing and handball."

"Kept in excellent shape, nevertheless," he said. "You'll be a disappointment to them."

"Look," Stein said to me after a week of tests and countertests. "Don't be deceived by these tests. All they show is that your heart is still beating. The big thing is emotional. Doc, I think you should

reconsider this idea of flopping around out there in the void. We've got experienced men here, and none of them is ready to try it."

"Fools rush in, eh, Mr. Stein."

"Precisely."

In the meantime I got a daily phone call from Paul Cleary. That I could have snarled off, but Sylvia always came on the line first, and there was a minute or so of chit-chat before she cut her boss in on the line. I'm sure she listened to all the calls. But her first words were deadly. For example:

"Mike! Hi, Mike. Mr. Cleary wants to see how you're doing."

"Good. Put him on."

"In a minute. I think it's so wonderful you passed the final physical, Mike. You're really so deceptive. I never had imagined you had such a steely physique."

"Clean living," I said. "No girls."

"There'd better not be!"

"Don't worry. How could I get to see any girls down here? Every time I look away from my work all I can see is Bikini swim suits."

"Cut that out!" she snickered, and put Cleary on the line.

There came a final day when the mission chief called me in to his office.

"Come in, Mike. Come in," he said shortly. "Sit down." He leaned back against his desk and started talking to me, like they say, straight from the shoulder:

"I'll give it to you straight, Mike. We've tried every legal way to wash you out of this mission. There isn't a one of us here at the Cape that wants any part of taking an armchair theorist and slapping him into space—into the kind of a mission you've cooked up. Somebody's going to get hurt out there, because you aren't fit for the job. Now, physically, yes, you have the capacity. But emotionally and environmentally, you simply don't add up. You're looking at this thing as an extension of your laboratory, and instead it is an enormous physical and mental hazard that you are undertaking. This country has never lost a man in space—and you'll be the cause of our first casualty, as well as being one yourself. I'm asking you man to man to disqualify yourself."

"And put an end to this mission?"

"We'll train one of our men," he said.

"In two or three years your best man might be barely capable," I said. "I don't think COMCORP is prepared to waste that much time. After all," I said ingratiatingly, "all you have to do is refuse the mission. Say I'm a built-in hazard and let it go at that." I grinned at him. I was learning from Paul Cleary. I *figured* how space-jockeys would react to that.

He told me: "Do you think any of these men would admit they are not up to a mission a mere technician is ready to try? No! I can't get them to beg off, either!"

"When do we go?" I asked.

Sid Stein was assigned as my pilot. He had made the trip into orbit and back four times with the Dyna-Soar rocket, and was considered the best risk to get me there and get me back. He was also the least convinced I had any right to sit beside him in the cabin.

His final briefing was a beaut: "This is a spaceship, doctor," he said frigidly. "And I want you to remember the 'ship' part of it. I'm in command, and my every word, my every *belch*, has got to be law. Do you understand that? This is my mission, and I'll tell you where to put your feet."

"Sure," I said. "Who wants it?"

"Can't figure out why you do!"

"I'm just paying somebody back," I said. "Is it tomorrow?"

The start was a drag. Eighteen hours before blast-off Sid and I went into a tank so that we would get rid of our nitrogen. We breathed the standard helium-oxygen mix at normal pressure until about four hours before H-hour. They wouldn't even let me smoke. Then we suited up and were lifted by a crane and stuck in the control room of *Nelly Bly*, as I had named our Dyna-Soar rocket-glider. The hatch stayed open, but we were buttoned up tight in our suits. They had a couple of mods that were supposed to fit them better for the mission. Instead of the usual metal helmet with face plate, we had full-vision bubble helmets of clear plastic. The necks were large enough so that we could, in theory, drag our arms out of our suits and clean the inside of the bubbles.

That was in case I sicked up out in space, which all experience said was a real enough hazard. They figured that filling me full of motion sickness pills was partial prevention.

These space-jockeys have their own vocabulary, and their own oh, so cool way of playing it during the countdown. I'm pretty familiar with complex components, but they were checking off equipment I never heard of. We had gyros—hell, our *gyros* had gyros. And we had tanks, and pressures and temperatures and voltages and who-stuck-John. It was all very impressive.

There were suited men up on the gantry unplugging our air feed and closing our hatch. Sid was straining up from where he lay on his back to dog it down tight.

"Roger," Sid was saying to somebody, as he had been all morning.

The white vapor from our umbilical stopped, which let me know our tanks had been topped off and sealed, and that we were about to blast off.

"This is it, Seaman," Sid Stein said. "Now for Pete's sake don't move, don't speak, just lie there. I've got the con."

That was a bunch of baloney. He really had nothing to do until we were in orbit. The delicate accelerometers and inertial guidance components did all the piloting until the second stage kicked us loose. But I kept my mouth shut. He'd have some work to do before the ride was over, and I might need him.

When the lift-off came, it was gentle as a dove's wing. But as we burned off fuel, the twenty-million pound thrust of our Apollo booster began to tell, and my vision started to go black. The gee-meter said we were pulling about ten gees when I could no longer read it, and I learned later we peaked out at eleven gees in the final seconds before first-stage burn-out. I didn't like it a little bit.

The liquid hydrogen second stage kicked in like a hopped up mule, and we pulled ten gees, right at the limit of my vision, for its whole four minutes of burning. My earphones were talking now as Sid gave it the A-OK and Roger bit all the way. This was the stuff, kid!

Our Dyna-Soar had been modified to some degree for this mission. It's essentially a big delta-winged glider with a squarish fuselage in the center. The mods had consisted of tying a third rocket stage out behind, so that Sid could move us around the orbit from one Telstar to the next if my work on the first one proved out. The retro-rockets had several times their normal complement of fuel, so that he could stop after he got started. The same was true of our steering jets.

The ship was not pressurized on the lift off. Cabin pressure fell rather quickly, as we could feel from the inflation of our suits, to their three and a half-pound pressure. No bends for either of us, because of the helium substitution for nitrogen. Because there were two of us, we could chuck and unchuck airtanks for each other as we needed fresh supplies. We had enough air and water for forty-eight hours. Together with our low-residue diet for the final week, they figured we could sweat it out in our suits for two days. We had suit radios, of course, and could talk with each other for a distance of a mile or so.

Burnout of the second stage came suddenly, and we heaved slightly against our belts as the springs in our seats pushed back out. And then I got my first taste of free fall. Each veteran astronaut I had talked to at the Cape had a different way of trying to scare me with the idea of falling endlessly, and each had different ideas about how to lick it. In spite of all the talk, I grabbed the arms of my seat to keep from falling. I turned my head and in the glow from our instruments could see Sid sneering across at me through his transparent bubble helmet.

"How you like them apples?" his voice came from my earphone.

"That first step is a killer, Sid," I said, trying to sound chipper. I felt horrible.

"Let me know when you've had enough," he suggested. "I've got things to do."

I knew he did. We had dry-run it a hundred times. If we had been inserted correctly in orbit, the *Nelly Bly* was right in the path that three of the Telstars were now following, and catching up with Number One at several hundred miles an hour. On the ground, radars all around the world were taking fixes on us, and Sid was talking shop over his long-range radio with the radar crews.

By the time my stomach had made up its mind that it would stick with me, he had a report.

"It could be worse," he said. "We've got a lot more velocity than I'd like, but we're on course. Our orbit would differ quite some, Seaman. Because of this speed we'd be somewhat more eccentric—maybe swing out a hundred miles beyond the birds we're chasing. Are you making it?"

"Easy, Sid. Do we slow down yet?"

"I'll fire the retros and retard us to the speed of what we're chasing," he said. "That will equalize our orbits very nearly. Get busy on that scope if you're up to it. I'll compute my retro."

They had made an amateur radar operator out of me, because it was easy to do, and gave Sid more time for actual rocket valving. My belt cut me hard as he braked for several seconds.

"There," Sid's voice said in my ear. "We should still be catching up about fifty miles an hour. Let's not ram that thing. See any blip?"

"Not yet. How close are we supposed to be?"

He lit the cabin light and tapped at the calculator that he swung out from its rack. "Still got a hundred miles to go, I'd judge." He moved awkwardly in his suit to finger a switch on his neck and I heard him speaking to the ground again, and heard in my earphones the answer that came up from Woomera. We had eighty miles to go, and were now a little below the orbit of the bird we were chasing.

"Can't have both ends of the stick, Mike," Sid explained, calling me by name for the first time. "As soon as we slowed down we had to drop lower." He fooled around with the steering jets, which were hydrazine-nitric acid rockets much like the tiny motors on my suit, and re-oriented *Nelly Bly*. A little burst from the nose, and I got my first blip.

"There!" I said, putting a finger on the PPI. "Turn out the light, Sid, so I can see the 'scope'."

He switched off the cabin light and followed my directions with tiny shoves, sometimes from the rockets, sometimes from the steering jets, while I conned us closer.

Our radar would only read within about half a mile. When we got that close I got the searchlight going and took my first real look through the forward port out into space.

It's black. Nothing—nothing you have ever seen will persuade you how dark it is out there. That was my first big shock. Oh, I had practiced in the dark, with only my helmet light to guide my tests and assemblies, but this was a different kind of dark. Our light had no visible beam—you couldn't even tell it was working. At first I had the idea we'd see the satellite occulting some stars, but a little mental arithmetic told me that an object six or eight feet in section would not subtend much of an angle of vision at half a mile.

We had chosen, I decided, much too narrow a beam of light for the searchlight, but just at that moment I got a flash from out in space, and worked the light back on to our objective.

"Got it," I said.

"Yoicks!" Sid said, and went back to the fine controls. After a long time, and lots of patience, we were hanging about fifty feet out from our bird. We were farther out in space so that the dark bulk of the satellite was silhouetted against the crescent light of Earth. I turned off the spot and switched on the floodlight.

"Here goes nothing, Sid," I said, and undid the dogs that held the canopy above our heads.

My earphone spoke to me: "This is Cleary. Do you read me, Mike?"

I fumbled around to find the right jack and plugged myself into the radio. "Yes, Paul. Loud and clear."

"Watch yourself. Think first. You've got all the time in the world."

"Sure."

"Sylvia would miss you," he added.

I hoped he was right.

Clinging carefully to the handholds that had been specially provided on the outside of *Nelly Bly*, I clambered through the hatch and hung in the darkness, looking down at South America. The world was turning visibly under me, although I knew that in fact we were skimming rapidly about three thousand miles over its surface. I got myself lined up nice and straight with the bird and did my first bit of non-thinking. I pushed off good and proper with my feet, the way you'd dive into a swimming pool. It was a fool stunt for my first act. I was doing a good five or six feet a second. You may not think that is very fast, but before I could gulp twice I had zipped past that bird and was headed for Buenos Aires.

I know I screamed. That was the first time I realized I really was falling. Earth looked awfully close, and seemed to be rushing up to meet me.

My orientation was all wrong for stopping. By diving head first I had neither my back nor my belly rocket lined up to stop me.

My training failed completely. I tried to squirm straight, and by proper swinging of my arms out to full length, and kicking the same way with my feet, I got turned around to where my belly was facing the floodlight on *Nelly Bly*. That's not how I was supposed to do it.

The glider had disappeared—all I could see was the floodlight. It was still by far the brightest thing in the sky, but if I drifted much longer, I would have to use radio direction-finding to get

back. I triggered the motor on my back and felt its gentle push against my spine.

"Sid!" I called.

"Roger, Mike!"

"Light the tip lights. I've got to get a fix on my velocity. I went way past and I'm trying to get back."

Two new stars winked into being, on either side of the floodlight. This had been some bright guy's idea, and it was paying off. I kept watching the apparent distance between them shrink as I continued my trip toward Earth. Memory and a little calculating told me that my acceleration of three inches per second per second would take twenty seconds of blast to slow me to a stop. I counted them off, aloud: "Mississippi one, Mississippi two, Mississippi three," as I had been taught to measure seconds. When I got to Mississippi twenty my visual measurement said I was about stationary with regard to *Nelly Bly*.

I used a little more blast and let a couple minutes go by while I drifted closer to the Telstar. I started squirming again, until I remembered to use the deflection plate they had given me to hold in my belly blast, and that got me lined up. But finally I was within touching distance of the bird, which was rotating with a certain slow majesty on its long axis.

The leisurely spin was there to make sure one side didn't face the sun too long and heat up. My plan called for stopping the bird's spin so that I could get reasonable solar heating of the part I was working on. The trouble was there was nothing to grab as the satellite turned. But we had worked on that part, too, and I went into my act of backing off the right distance, accelerating with my back rocket until I drifted close by the bird at its translational speed. I got one end of my sticky webbing stuck to it by pressure and decelerated so that the bird turned under me while I paid off the web. In a moment I had it girdled, and snapped the nifty sort of buckle they had made for me. Then drawing the webbing tight was no trouble, and I was spinning with the bird. My added weight slowed its spin down some.

Next came the trick of getting some special equipment loose from my right leg. This was a little rocket canister which had just enough poof, the slide-rule boys had said, to stop the rotation of the bird. I fastened the canister to the webbing, pushed softly with one finger to get me a few feet away, and drifted while waiting for the delayed fuse to fire the antispin rocket. It lanced out a flame for a few seconds, and sputtered dead. The bird hung virtually motionless beneath me—or above me—or beside me—or whatever you want to call it when there is no up or down.

Our light was dimming as we passed the terminator and pulled over Earth's dark side. The sun was still visible, however, although soon to be eclipsed by Earth. I jetted softly back to the bird and lit my helmet light. I had to find the right face of the twelve-sided thing so that I could open the right gate. The markings were there. They were just hard to read from inside a helmet. Then the sun was eclipsed, and my headlamp gave me the kind of light I was used to working with. The sector I wanted was on the satellite's dark side. I had to clamp on to the girdle and jet quite a while to turn it halfway round, and then decelerate just as long to bring it to a stop. I fooled around several minutes getting the sector to face where the sun would soon rise.

My earphone spoke.

"Mike!"

"Roger, Sid. What's up."

"Take it easy on your steering fuel. You're getting low."

"Roger."

I had to wait for the sun before I could start work. When it came up, heating seemed quick. First a test with a thermocouple showed that Telstar's surface was warming nicely and would soon support the pressure-sensitive mat I was going to stick to some of her solar generators. When the 'couple said Telstar had reached zero centigrade, I pulled the mat loose from where it was stuck to my left leg and plastered it above the gate I was going to open. I say above, because it was closer to one pole—the "North" pole of the satellite—than the gate.

It was time to go to work on my first screw. And there I got my next lesson. It was a real big screw, as they go, a 4-40 flat head machine screw with a length of about three-quarters of an inch. I would have to give it thirty turns to back it out. I never gave it the first turn. The head snapped off as soon as I applied a few inch-pounds of torque.

Yes, the surface had heated up nicely, but the shank of the screw was about two hundred below zero centigrade, and far brittler than glass.

I cussed some and reported to Sid what had happened.

"Have to drill it out," I said.

My drill was a cutie. It was a modified dentists' drill, the kind that's run by a little air turbine at about two hundred thousand r.p.m.'s. I really mean that. They turn like mad.

I'd been taught to use it with care. When a dentist drills your teeth, he blows olive oil and water through the turbine, and the mixture cools the tooth—and the drill—while the cutting is going on. We couldn't afford any cloud of vapor—or the shorting out that ice would cause—so I had only the pressurized mixture of oxygen and helium in the tanks on my back to run the drill. And that meant light and intermittent pressures on the number 43 wire gauge drill—the one that's the right size to drill out a 4-40. It took me about fifteen minutes and I was down to my last number 43 drill bit when she broke free.

From then on I had to heat each screw before I went to work on it. I had something like a soldering iron that I could press against the screw-head. Heat would flow through the highly conductive alloy and make it less brittle. I flicked each screw I removed out into space and at last carefully hinged the gate wide open.

The gate was the length of the sector—about two feet. It was four inches wide and about an inch thick and had parts strung along it like kernels on an ear of corn.

At this stage I readjusted the position of my webbing girdle until I could clamp my head in position and begin the testing. It was slow work. The first sad thing was to learn that the solenoid M1537 was as good as new. When I put enough voltage across its terminals, the actuator clicked down through the core.

I swore a blue streak.

"What is it Mike?" Sid's voice came in my ear.

"Trouble," I said. "What did we expect?"

"Roger," he said in that toneless unexcited astronauts' voice. "Return to ship, Mike."

"Not now," I said. "I've just got the oyster opened."

His voice cut like my drill-bit. "I ordered you to return to ship. Your air supply is about shot."

"I haven't been out that long," I protested, not feeling too sure about the lapse of time.

"Your drill chewed it up pretty fast. Quit talking and start moving."

I was thankful for the experience of moving in close to the bird. The same tricks worked much more smoothly as I used my deflection plate in front of my belly blast to turn me to face the floodlight, and then followed up with a light shove or two in the spine to start me drifting toward *Nelly Bly*. There didn't seem any rush, and I drifted slowly over, using only a couple triggered bursts of deceleration to slow me down as I approached the open hatch.

Inside we went through the drill. My ears popped a little as Sid unchucked my spent tanks, and popped again as the new ones came on with a hiss.

"Take it easy on that steering fuel, Mike," he said again. "You're getting awfully low."

"Sure," I said and let myself drift out the hatch. I had enough sense to twist so that my back jet wouldn't hit the ship. Then I took a zig-zag course through the darkness to my bird, got oriented at the open gate and went back to work. Before I could get started, my earphones spoke.

"Mike, Cleary here."

"Roger, Paul. What is it?"

"Have you gotten to that solenoid yet?"

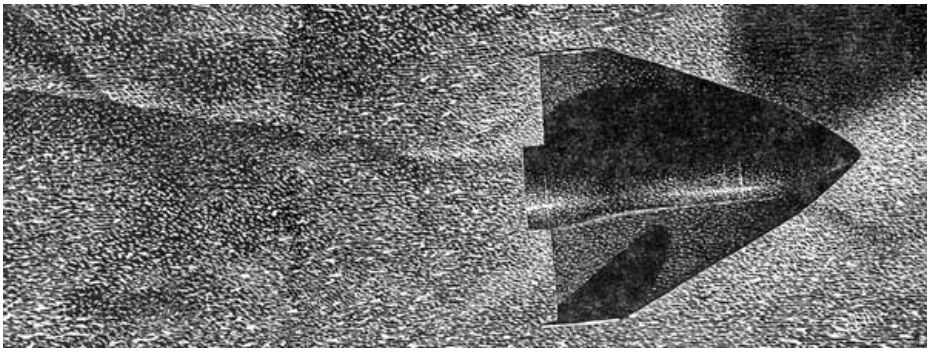
"Yes."

"What can you tell me?"

"That you're a fathead. Now shut up. I'm busy."

"Roger, Mike," Paul Cleary acknowledged quite meekly.

So I started again, reaching with my leads from point to point. After a certain number of tests, I had the area isolated, but not the part. From here on it would have to be disassembly. Every tiny screw had to be heated, then teased out with a jeweler's screwdriver. Some took my patented ratchet extension. The big miracle was that I didn't break anything.



When I got to it, it was ridiculous. A small length of wire connected one component to another. Space was lacking, and the wire was tight against the metal of the gate. Its insulation was one of these space-age wonders, a form of clear plastic that would remain ductile under zero temperature and pressure. Only it didn't. It had shrunk and cracked, and there was a simple short against the metal of the gate. There were so many forms of circuit-breakers and self-protectors in the machine that the whole gate had been switched off as long as the short was in existence. No wonder telemetry hadn't told us anything.

As I prepared to fix the trouble, I switched on my radio and had Sid connect me with the ground. "Canaveral Control," one of those emotionless voices said. He could afford to be. He was on the ground.

"Get me Cleary," I ordered.

"Cleary here, Mike. What have you found, boy?" He sure was anxious about that solenoid.

"Not much, Paul. Just that Fred Stone is a fathead, too. Over and out, like they say." I switched off and went back to my work.

The one thing I had nothing of was any kind of insulating material. With my screwdriver I hacked a piece loose from the double-faced sticky-tape I had used to keep loose parts from flying around, and teased it under the wire with my tweezers. Perhaps I could have done as well by heating the wire and bending it straight, but there was little room, and I was afraid of melting a solder joint. So I took my time teasing the tape through and finally got it to act as an insulator without breaking the wire. How long it would stay there was anybody's guess. It was held mechanically as well as by its sticky action, but when the bird cooled off enough, the sticky effect would lessen. I hoped the pressure between the wire and the gate could be enough to keep it in place. Certainly no forces would be acting to move it.

Just as I had figured, the reassembly was the tedious part. I had to move around into about sixteen screwy positions to do all the fixing. Finally it was back in one piece and I swung the gate closed.

When the final 4-40's were run up as tight as they were supposed to be run, I reported to Paul Cleary. "Try her," I suggested. "I think I found the trouble. No point my coming back down if it doesn't work."

They made me sweat it out for about ten minutes before Paul said, "Runs like a watch, Mike. Put the spin back on her, boy." At least he was quiet about his solenoid.

This called for the second rocket canister, which I hooked on to the girdle and, after thinking it out carefully, got headed in the right direction. I eased away with finger pressure, and let the delayed fuse do the firing. Telstar started her slow spin again.

Getting the girdle off was a lot harder than getting it on, something we hadn't figured on, and in the final stages of the job I found that my steering motors no longer fired.

"Sid!"

"Roger, Mike."

"How much fuel do you read in my steering jets?"

"You've been out of fuel for about five minutes, by my gauge. But don't worry about it," Sid said. "I'll nurse *Nelly* over there with my steering jets and pick you up."

"O.K.," I said doubtfully. "But watch it. Bump this bird and we'll have it all to do over again."

Sid had more trouble than he had figured. He had steering jets to run him in every direction except fore and aft. For that motion the retro-rockets were considered enough. But one belch out of them was enough to get me screaming into the mike: "Cut those retros!" I yelled, the volume making my earphones crack, as it undoubtedly did his.

"Roger. What's wrong?"

"You'll burn the solar generators right off the bird, you fool! Steering jets, do you hear, steering jets!"

"Roger."

But it was not that easy. Finally Sid got *Nelly* within about twenty feet, and pretty near at zero relative velocity.

"All right, Sid," I said. "Hold it there. I'll push over."

A gentle shove against the side of Telstar was all it took. I got it straight, which was all that counted. My drift was slow, and I was a good five minutes making the twenty-foot crossing. But a handhold came within reach, and I worked my way back into the cabin and climbed in without shutting the hatch.

"Don't try that again," I cautioned him. "This thing weighs ten thousand pounds, and that bird half as much. Even at a couple feet a second, you can crush me to jelly between them, even if you don't burn one or the other of us to a crisp."

"Roger," Sid said, not quite so emotionlessly. "Are we ready to move?"

"What for?" I asked him. "Until we get me some steering fuel, I'm useless."

"I thought we'd abort this mission before we were through," he sneered.

"Not so fast. You've got the same rig on your suit. All we have to do is put your fuel tanks on my suit."

"Are you nuts?" he demanded.

"What's the matter with it? Those tanks aren't welded to you, and I've got tools."

I could see him shake his head in the dim light from the instrument panel. "You know those fuels ignite on contact with each other," he pointed out. "If we spill a couple drops of each in here, and they vaporize, we'll blow this kite to pieces!"

"Then we'll get outside to make the switch," I insisted. "It won't hurt anything if a few grams burn up out there, will it, with nothing to confine the expansion."

"But then I won't be able to come after you if anything goes wrong," he pointed out. "No dice."

"You're grasping, Stein," I growled. "At this stage I'm in charge around here. I'll take my chances on getting back."

With the cabin light on I went as far as possible in dismounting both our tanks. After a couple rehearsals to make sure that at least one of us would always have a glove on a handhold, we both climbed out the hatch and I made the switch. Just as Sid suspected, we spilled a few drops. They vaporized, and again as we had feared, combined in what would have been an explosion in a confined space. The soundless flash, dim but real, said we had released quite a little energy uniformly all around us. I never felt a thing except a faint warmth from infrared through my helmet.

Best of all, my jets worked. We both climbed back aboard *Nelly*, dogged the hatch, and started after Telstar Two.

The second bird was about fifteen thousand miles ahead of us. I slept most of the time, for after Sid gave us a jolt of added velocity, we had to settle down to about six hours of drifting. I woke up as the belt cut me when he fired the retros. We went through the radar and searchlight bit, and had the devil's own time finding our bird. But at last I got the flash of reflection and went to work.

I won't say the second job was any easier, except for the fact that I removed only one part to make room to do my bit with the insulation, and thus had very few screws to replace. My navigating in space was a lot better, and I didn't use steering fuel as wastefully as the first time. Still, when we dogged down to chase after the final bird, the cabin gauge said that I had less than half my load of steering fuel left. Equally glum, *Nelly* herself was even lower on steering fuel. Neither Sid nor I had been as expert as we were supposed to be.

Nevertheless, we took off after the third bird, and found it glistening in bright sunlight without the help of the searchlight. I thought that was a good omen. But from there on nothing seemed to work right.

We had been aloft about thirty-six hours, and fatigue was setting in. I was clumsy on the steering and had quite a time making contact.

The repair went according to Hoyle, but after I had put the spin back on the bird I found that I had no more steering fuel. I hung about ten or fifteen feet from Telstar Three and maybe eighty feet from *Nelly*, drifting slowly from both.

"Sid!"

"Roger, Mike."

"This one will have to make it with the girdle on."

"Can't you get it off?"

"I can't get back to it. Steering fuel gone."

"Oh, no!"

"No sweat, Sid. It occludes a small share of the solar generators, but not enough to hurt anything."

"That's not what I meant," he said quietly into my ear. "*Nelly's* out of steering fuel, too. I can't pick you up!"

I gulped on that one.

"Canaveral Control!" I heard him call.

"Cut that out," I said. "They can't help. Shut up and let me think."

But he didn't, and I couldn't. I had no fuel with which to move. Sid had only the retros and stern rockets, no good for swinging or turning. I was out of touching range of the bird, and couldn't shove against it to build up a little drift. Just as Sylvia said, it's not like swimming back to shore.

There was a lot of excited chatter in my earphones, in which I did not participate. Nobody made any sense, and Sid shut the thing down.

"Mike!"

"Yeah." Disgusted.

"Whatever you dope out, make it quick. You don't have all the air in the world." Sid warned me.

"How much?"

"Ten minutes or so."

"All right," I said. "It ought to be enough. Keep your eye on me. You may have to reach out an arm or leg for me to grab as I go by."

"How are you going to move?"

"I've got a lifesaver," I said.

I writhed and squirmed and made every use of the law of conservation of angular momentum until I had my back to *Nelly*. Then I wound up and threw my fancy screwdriver as hard as I could heave it away from me. I didn't get the zip on it I would have liked, but because it was sort of like a throwing stick, I got a little more on it than you might expect, maybe fifty or sixty feet a second. And the thing weighed about four pounds, with its fancy ratchet and torque clutch. Since in my suit I weighed just about a hundred times as much, I started toward *Nelly* at just one-one-hundredth of the velocity I had imparted to the screwdriver. In a couple minutes I was drifting pretty close, but tumbling. I had forgotten that part.

Throwing the screwdriver had given my body the correct vector and some velocity, but I had set up quite a tumbling moment, since I had thrown from the shoulder and not from my center of gravity.

I chucked a couple lighter tools away to correct my drift, and Sid snagged me as I drifted by the hatch.

"Come to Papa," he said, and drew me inside. We didn't horse around congratulating ourselves. My air tanks were no longer hissing, and we made a quick swap.

Sid let me dog down the hatch while he figured position. He used the iron compass method, just taking a close look at Earth, which was more or less dead ahead of us. That was a good place for it, because we had no steering fuel.

The re-entry was a mess, from Sid's point of view. We came in at a weird angle and heated up to beat hell before there was enough atmosphere for our rudder to swing us around straight. He bounced us off twice after that as we slowed down, but the creak of heating metal was all about us each time we dropped in. He cussed me plenty all the way.

The trick, of course, was to slow down to the point where he could spiral us down to Muroc Dry Lake. *Nelly* was a sort of glider. Her performance at about Mach 10 and two hundred thousand feet was quite respectable, but the lower and slower we went, the more she flew like the proverbial kitchen sink. Sid only had one bright spot: Our big fuel supply gave him plenty of rocket and retro when he wanted it, and allowed him to get us back over Muroc.

I can't say he made the landing look easy, because he didn't. It looked like plain hell to me, for we scorched in at something over four hundred miles an hour.

When *Nelly* screeched to a stop, we just sat there. There was none of this romantic business about snapping open face plates and exchanging witty remarks. Bubble helmets don't have face plates, and besides, I didn't have anything I wanted to say to Sid. I was as tired of him as he was of me. I was just plain tired, if you want to know the truth.

They didn't let us alone, of course. While the crash trucks were still kicking up a dust trail tearing out to get us, there were guys on the radio with those cool voices, and Sid was tiredly saying "Roger," to all their questions. And we didn't do any moving about. You'd be surprised how weighing four hundred pounds makes you willing to wait for the crane to lift you from your seat. All at once I almost wanted to be back in space again, where I didn't weigh anything at all. Almost.

They flew us back to Canaveral for the de-briefing, both asleep. The whole mob was there to greet us, Paul Cleary, Fred Stone, and even Sylvia. They met us at the plane and Sylvia was the first to grab me as I came down the steps.

"Mike!" she squealed. "Are you all right?"

"Better now," I said, kind of untangling from her. "How did you manage this?" I looked up. "Hi, Paul," I said to his sleepy old grin, and knew how.

"Dinner tonight?" she insisted.

"I don't know," I said, looking over at Paul. "I think there's a de-briefing or something before they turn me loose."

"Don't be silly," Sylvia said. "It's not as if you were an astronaut or something."

I was back on the ground, all right.

Well, there was sort of a de-briefing. Cleary and Stone got me alone for a moment in somebody's office.

"Well, Mike," Paul said, "that was a great performance. What was the trouble up there?"

I laughed at both of them. "Go jump in the lake," I said. "I'm out of the middle."

"What do you mean, Mike?" Doc Stone asked, holding his young-man's pipe at arm's length.

"It wasn't design—because the solenoid worked. And it wasn't installation. It was materials." I told them about the no-good insulation.

"Lucky it's only used in a couple points," Paul said, scowling. "I guess any other point where it broke up wasn't as critical in dimension and no short resulted."

"Not yet," I grinned. "It may. And I couldn't care less."

"You're a big winner, then, Mike," Paul grinned. "Fred and I have kind of made up anyway, and you're in solid with Sylvia."

"Not with that noise," I said. "No dame was worth that ride. Let Sid have her."

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forth in paragraph 1.E.8.

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