

SUNSPOT

Ron Sacco's hand reached gently toward his switch, and paused. He glanced over at the commander, saw the latter's eyes on him, and took a quick look at the clock. Welland turned his own face away—to hide a smile?—and Sacco almost angrily thumbed the switch.

Only one of the watchers could follow the consequences in real detail. To most, the closing of the circuit was marked a split second later by a meaningless pattern on an oscilloscope screen; to "Grumpy" Ries, who had built and installed the instrument, a great deal more occurred between the two events. His mind's eye could see the snapping of relays, the pulsing of electrical energy into the transducers in the ice outside and the hurrying sound waves radiating out through the frozen material; he could visualize their trip, and the equally hasty return as they echoed back from the vacuum that bounded the flying iceberg. He could follow them step-by-step back through the electronic gear, and interpret the oscilloscope picture almost as well as Sacco. He saw it, and turned away. The others kept their eyes on the physicist.

Sacco said nothing for a moment. He had moved several manual pointers to the limits of the weird shadow on the screen, and was using his slide rule on the resulting numbers. Several seconds passed before he nodded and put the instrument back in its case.

"Well?" sounded several voices at once.

"We're not boiling off uniformly. The maximum loss is at the south pole, as you'd expect; it's about sixty centimeters since the last reading. It decreases almost uniformly to zero at about fifteen degrees north; any loss north of that has been too small for this gear to measure. You'll have to go out and use one of Grumpy's stakes if you want a reading there."

No one answered this directly; the dozen scientists drifting in the air of the instrument room had already started arguments with each other. Most of them bristled with the phrase "I told you—" The commander was listening intently now; it was this sort of thing which had led him, days before, to schedule the radius measurements only once in twelve hours. He had been tempted to stop them altogether, but realized that it would be both impolite and impractical. Men riding a snowball into a blast furnace may not be any better off for knowing how fast the snowball is melting, but being men they *have to know*.

Sacco turned from his panel and called across the room.

"What are the odds now?"

"Just what they were before," snapped Ries. "How could they have changed? We've buried ourselves, changed the orbit of this overgrown ice cake until the astronomers were happy, and then spent our time shoveling snow until the exhaust tunnels were full so that we couldn't change course again if we wanted to. Our chances have been nailed down ever since the last second the motors operated, and you know it as well as I do."

"I stand... pardon me, float... corrected. May I ask what our *knowledge* of the odds is now?" Ries grimaced, and jerked his head toward the commander.

"Probably classified information. You'd better ask the chief executive of Earth's first manned comet how long he expects his command to last."

Welland managed to maintain his unperturbed expression, though this was as close to outright insolence as Ries had come yet. The instrument man was a malcontent by nature, at least as far as speech went; Welland, who was something of a psychologist, was fairly sure that the matter went no deeper. He was rather glad of Ries' presence, which served to bring into the open a lot of worrying which might otherwise have simmered under cover, but that didn't mean that he liked the fellow; few people, did. "Grumpy" Ries had earned his nickname well. Welland, on the present occasion, didn't wait for Sacco to repeat the question; he answered it as though Ries had asked him directly—and politely.

"We'll make it," he said calmly. "We knew that long ago, and none of the measures have changed the fact. This comet is over two miles in diameter, and even after our using a good deal of it for reaction mass it still contains over thirty billion tons of ice. I may be no physicist, but I can integrate, and I know how

much radiant heat this iceberg is going to intercept in the next week. It's not enough, by a good big factor, to boil off any thirty billion tons of the stuff around us. You all know that—you've been wasting time making a book on how much we'd still have around us after perihelion, and not one of you has figured that we lose more than three or four hundred meters from the outside. If that's not a safe margin, I don't know what is."

"You don't know, and neither do I," retorted Ries. "We're supposed to pass something like a hundred thousand miles from the photosphere. You know as well as I do that the only comet ever to do that came away from the sun as two comets. Nobody ever claimed that it *boiled* away."

"You knew that when you signed up. No one blackmailed you. No one would—at least, no one who's here now." The commander regretted that remark the instant he had made it, but saw no way to retract it. He was afraid for a moment that Ries might make a retort which he couldn't possibly ignore, and was relieved when the instrument man reached for a handhold and propelled himself out of the room. A moment later he forgot the whole incident as a physicist at one of the panels suddenly called out.

"On your toes, all of you! X-ray count is going up—maybe a flare. Anyone who cares, get his gear grinding!" For a moment there was a scene of confusion. Some of the men were drifting free, out of reach of handholds; it took these some seconds to get swimming. Others, more skilled in weightless maneuvering, had kicked off from the nearest wall in the direction of whatever piece of recording machinery they most cherished, but not all of these had made due allowance for the traffic. By the time everyone was strapped in his proper place, Ries was back in the room, his face as expressionless as though nothing had been said a few moments before. His eyes kept swiveling from one station to another; if anyone had been looking at him, they would have supposed he was just waiting for something to break down. He was.

To his surprise, nothing did. The flare ran its course, with instruments humming and clicking serenely and no word of complaint from their attendants. Ries seemed almost disappointed; at least Pawlak, the power plant engineer who was about the only man on board who really liked the instrument specialist, suspected that he was.

"C'mon, Grump," was this individual's remark when everything seemed to have settled down once more. "Let's go outside and bring in the magazine from the monitor camera. Maybe something will have gone wrong with *it*; you said you didn't trust that remote-control system."

Ries almost brightened.

"All right. These astronomers will probably be howling for pictures in five minutes anyway, so they can tell each other they predicted everything correctly. Suit up." They left the room together with no one but the commander noting their departure.

There was little space outside the ship's air lock. The rocket had been brought as close to the center of the comet as measurement would permit, through a tunnel just barely big enough for the purpose. Five more smaller tunnels had been drilled, along three mutually perpendicular axes, to let out the exhaust of the fusion-powered reaction motors which were to use the comet's own mass to change its course. One other passageway, deliberately and carefully zigzagged, had been cut for personnel. Once the sunward course had been established all the tunnels except the last had been filled with "snow"—crushed comet material from near the ship. The cavern left by the removal of this and the exhaust mass was the only open space near the vessel, and even that was not too near. No one had dared weaken the structure of the big iceberg *too* close to the rocket; after all, one comet *had* been seen to divide as it passed the sun.

The monitor camera was some distance from the mouth of the tunnel—necessarily; the passage had been located very carefully. It opened in the "northern" hemisphere, as determined by direction of rotation, so that the camera could be placed at its mouth during perihelion passage and get continuous coverage. This meant, however, that in the comet's present orbital position the sun did not rise at all at the tunnel mouth. Since pictures had to be taken anyway, the camera was at the moment in the southern hemisphere, about a mile from the tunnel mouth.

Some care was needed in reaching it. A space-suited man with a mass of two hundred fifty pounds weighed something like a quarter of an ounce at the comet's surface, and could step away at several times the local escape velocity if he wished—or, for that matter, if he merely forgot himself. A dropped

tool, given only the slightest accidental shove sideways, could easily go into orbit about the comet—or leave it permanently. That problem had been solved, though, after a fashion. Ries and Pawlak attached their suits together with a snap-ended coiled length of cable; then they picked up the end of something resembling a length of fine-linked chain which extended off to the southwest and disappeared quickly over the near horizon—or was it around the corner? Was the comet's surface below them, or beside or above? There was not enough weight to give a man the comforting sensation of a definite "up" and "down." The chain had a loop at the end, and both men put one arm through this. Then Ries waved his free arm three times as a signal, and they jumped straight up together on the third wave.

It was not such a ridiculous maneuver if one remembered the chain. This remained tight as the men rose, and pulled them gradually into an arc toward the southwest.

Partway up, they emerged from the comet's shadow, the metal suits glowing like miniature suns themselves. The great, gaseous envelope of a comet looks impressive from outside, seen against a background of black space; but it means exactly nothing as protection from sunlight even at Earth's distance from the sun. At twenty million miles it is much less, if such a thing is possible. The suits were excellent reflectors, but as a necessary consequence they were very poor radiators. Their temperature climbed more slowly than that of the proverbial black body, but it would climb much higher if given time. There would be perhaps thirty minutes before the suits would be too hot for life; and that, of course, was the reason for the leap.

A one-mile walk on the surface of the comet would take far more than half an hour if one intended to stay below circular velocity; swinging to their goal as the bobs on an inverted pendulum, speed limited only by the strength of their legs, should take between ten and twelve minutes. There were rockets on their suits which could have cut even that time down by quite a factor, but neither man thought of using them. They were for *emergency*; if the line holding them to the comet were to part, for example, the motors would come in handy. Not until.

* * *

They reached the peak of their arc, the chain pointing straight "down" toward the comet. Their goal had been visible for several minutes, and they had been trying to judge how close to it they would land. A direct hit was nearly impossible; even if they had been good enough to jump exactly straight up, the problem was complicated by the comet's rotation. As it turned out, the error was about two hundred yards, fairly small as such things went.

The landing maneuver was complicated-looking; but logical. Half a minute before touchdown, Ries braced his feet against Pawlak and pushed. The engineer kept his grip on the chain and stayed in "orbit" while his companion left him in an apparently straight line. About fifteen seconds sufficed to separate them by the full length of the connecting snap line; the elasticity of this promptly started them back together, though at a much lower speed than they had moved apart. Just before they touched the surface, Ries noted which side of the camera the snap line was about to land on, and deliberately whipped it so that it fell on the other side; then, when both men took up slack, it snubbed against the camera mounting. Even though both men bounced on landing—it was nearly impossible to take up exactly the right amount of energy by muscle control alone—they were secure. Ries sent a couple more loops rippling down the line and around the camera mount—a trick which had taken some practice to perfect, where there was no gravity to help—and the two men pulled themselves over to their goal. The tendency to whip around it like a mishandled yo-yo as they drew closer was a nuisance but not a catastrophe; both were perfectly familiar with the conservation of angular momentum.

Ries quickly opened the camera, removed the exposed part of the film in its take-up cartridge and replaced and re-threaded another, checked the mounting for several seconds, and the job was done. The trip back was like that out, except for the complication that their landing spot was not in sunlight and control was harder. Five minutes after getting their rope around the pole at the tunnel mouth, they were in the ship. There was no speed limit *inside* the comet.

Once they were inside the air lock, Ries' prophecy was promptly fulfilled. Someone called for

pictures before his suit had been off for two minutes. Pawlak watched his friend's blood pressure start up, and after a moment's calculation decided that intervention was in order—Grumpy couldn't be allowed *too* many fights.

"Go develop the stuff," he said. "I'll calm this idiot down."

For a moment it looked as though Ries would rather do his own arguing; then he relaxed, and vanished toward the instrument shop. Pawlak homed on the voice of the complaining astrophysicist, and in the three minutes it took Ries to process the film managed to make the fellow feel properly apologetic. This state of affairs lasted for about ten seconds after the film was delivered.

A group of six or seven scientists were waiting eagerly and had it in a projector almost instantly. For a few seconds after the run started there was silence; then a babble of expostulating voices arose. The general theme seemed to be, "Where's that instrument maker?"

Ries had not gone far, and when he appeared did not seem surprised. He didn't wait to be asked any questions, but took advantage of the instant silence which greeted his entrance.

"Didn't get your flare, did you? I didn't think so. That camera has a half-degree field, and the sun is over two degrees wide seen from here—"

"We know that!" Sacco and two or three others spoke almost together. "But the camera was supposed to scan the whole sun automatically whenever it was turned on from here, and keep doing it until we turned it off!"

"I know. And it didn't scan. I thought it hadn't when I was getting the film—"

"How could you tell? Why didn't you fix it? Or did you? What was wrong, anyway? Why didn't you set it up right in the first place?"

"I could tell that there hadn't been enough film exposed for the time it was supposed to be on. As for fixing it out there, or even finding out what was wrong—don't sound any more idiotic than you can help. It'll have to be brought into the shop. I can't promise how long it'll take to fix it until I know what's wrong."

The expostulation rose almost to a roar at this last remark. The commander, who alone of the group had been silent until now, made a gesture which stilled the others.

"I know it's hard to promise, but please remember one thing," he said. "We're twenty million miles from the sun; we'll be at perihelion in sixty-seven hours. If we pass it without that camera, we'll be missing our principal means of correlating any new observations with the old ones. I don't say that without the camera we might as well not be here, but—"

"I know it," growled Ries. "All right. I knew we should have laid down a walk cable between here and the blasted thing when we first set it up, but with people talking about time and shortage of anchoring pins and all that tripe—"

"I think that last was one of your own points," interjected the commander. "However, we have better things to do than fix blame. Tell us what help you need in getting the camera back to the ship."

An hour later, the device came in through the air lock. Its mass had demanded a slight modification in travel technique; if the chain had broken during a "swing" the rockets would not have been able to return men and camera both to the comet, in all likelihood. Instead of swinging, therefore, the workers had pulled straight along the chain, building up speed until they reached its anchorage and then slowing down on the other side by applying friction to the chain as it unwound behind them. An extra man with a line at the tunnel mouth had simplified the stopping problem on the return trip with the camera.

Four hours later still, Ries had taken the camera completely apart and put it together again, and was in a position to say that there had been nothing wrong with it. He was not happy about this discovery, and the scientists who heard his report were less so. They were rather abusive about it; and that, of course, detonated the instrument man's temper.

"All right, *you tell me* what's wrong!" he snapped at last. "I can say flatly that nothing is broken or out of adjustment, and it works perfectly in here. Any genius who's about to tell me that *in here* isn't *out there* can save his breath. I know it, and I know that the next thing to do is take it back out and see if it still works. That's what I'm doing, if I can spare the time from listening to your helpful comments." He departed abruptly, donned his suit, and went outside with the instrument but without Pawlak. He had no

intention of returning to the original camera site, and needed no help. The tunnel mouth was "outside" enough, he felt.

It took several more hours to prove that he was right. At first, the trouble refused to show itself. The camera tracked beautifully over any sized square of sky that Ries chose to set into its control. Then after half an hour or more, the size of the square began to grow smaller no matter what he did with the controls. Eventually it reached zero. This led him into its interior, as well as he could penetrate it in a spacesuit, but no information was forthcoming. Then, just to be tantalizing, the thing started to work again. On its own, as far as Ries could tell. He was some time longer in figuring out why.

Eventually he came storming back into the ship, fulminating against anyone who had had anything to do either with designing or selecting the device. He was a little happier, since the trouble was demonstrably not his own fault, but not much. He made this very clear to the waiting group as soon as his helmet was off.

"I don't know what genius indulged his yen for subminiaturization," he began, "but he carried it too far. I suppose using a balanced resistance circuit in a control is sensible enough; it'll work at regular temperatures, and it'll work at comet temperatures. The trouble is it won't work unless the different segments are near the *same* temperature; otherwise the resistors can't possibly balance. When I first took the thing outside, it worked fine; it was at ship's temperature. Then it began to leak heat into the comet, and went crazy. Later on, with the whole thing cooled down to comet temperature, it worked again. Nice design!"

"But it had been outside for days before—" began someone, and stopped as he realized what had happened. Ries pounced on him just the same.

"Sure—outside *in the sunlight*. Picking up radiant heat on one side, doing its best to get to equilibrium at a couple of hundred degrees. Conducting heat out into the ice four or five hundred degrees colder on the other side. Nice, uniform—*aach!*"

"Can't a substitute control be devised?" cut in the commander mildly. "That's your field, after all. Surely you can put something together—"

"Oh, sure. In a minute. We're just loaded with spare parts and gear; rockets always are. While I'm at it I'll try to make the thing wristwatch size so it will fit in the available space— all we need is a research lab's machine shop. I'll do what I can, but you won't like it. Neither will I." He stormed out to his own shop.

"I'll buy his last remark, anyway," muttered someone. Agreement was general but not too loud.

At fifteen million miles from the sun, with another meter or so boiled off the comet's sunlit surface, Ries emerged with his makeshift. He was plainly in need of sleep, and in even worse temper than usual. He had only one question to ask before getting into his suit.

"Shouldn't the sun be starting to show near the tunnel mouth by now?"

"One of the astronomers did a little mental arithmetic.

"Yes," he answered. "You won't need to travel anywhere to test the thing. Do you need any help?"

"What for?" growled Ries in his usual pleasant fashion, and disappeared again. The astronomer shrugged. By the time conversation had gotten back to normal the instrument specialist and his camera were in the air lock.

Taking the heavy device out through the tunnel offered only one danger, and that only in the last section—the usual one of going too fast and leaving the comet permanently. To forestall the risk of forcing people to pay final respects to him and regret the camera, he made full use of the loops of safety cable which had been anchored in the tunnel wall. He propped the instrument at the tunnel mouth facing roughly north, and waited for sunrise. This came soon enough. It was the display characteristic of an airless world, since the coma was not dense enough to scatter any light to speak of. The zodiacal light brightened near the horizon; then it merged into pearly corona; then a brilliant crimson eruptive arch prominence appeared, which seemed worth a picture or two to the nonprofessional; and finally came the glaring photosphere on which the test had to be made. It was here that another minor problem developed.

The photosphere, area for angular area, was of course no brighter than when seen from just above

Earth's atmosphere; but it was no fainter either, and Ries could not look at it to aim his camera. The only finder on the latter was a direct-view collimating sight, since it was designed for automatic control. After a moment's thought, Ries decided that he could handle this situation too, but, since his solution would probably take longer than the sun would be above the horizon, he simply ran the camera through a few scanning cycles, aiming it by the shape of its own shadow. Then he anchored the machine in the tunnel mouth and made his way back to the ship.

Here he found what he wanted with little difficulty—a three-inch-square interference filter. It was not of the tunable sort, though of course its transmission depended on the angle of incidence of the light striking it, but it was designed for sixty-five hundred Angstroms and would do perfectly well for what he had in mind.

Before he could use it, though, another problem had to be solved. Almost certainly the lining up of the camera and its new control—that is, making sure that the center of its sweep field agreed with the line laid down by the collimator sight—would take quite a while. At fifteen million miles from the sun, one simply doesn't work for long with only a spacesuit as protection. The expedition had, of course, been carefully planned so that no one would have to do any such thing; but the plans had just graduated from history to mythology. Grumpy Ries was either going to work undisturbed in full sunlight, probably for one or two whole hours, or spend twenty minutes cooling off in the tunnel for every ten he spent warming up outside it; and that last would add hours and hours to the job time—with the heating period growing shorter with each hour that passed. A parabolic orbit has one very marked feature; its downhill half is very *steeply* downhill, and speed builds up far too quickly for comfort. It seemed that some means of working outside, if one could be found, would pay for itself. Ries thought he could find one.

He was an artisan rather than a scientist, but he was a good artisan. A painter knows pigments and surfaces, a sculptor knows metal and stone; Ries knew basic physics. He used his knowledge.

Limited as the spare supplies were, they included a number of large rolls of aluminum foil and many spools of wire. He put these to use, and in an hour was ready with a six-foot-square shield of foil, made in two layers a couple of inches apart, the space between them stuffed with pulverized ice from the cavern. In its center was mounted the filter, and beside this a hole big enough to take the camera barrel. The distance between the two openings had been measured carefully; the filter would be in front of the camera sight.

Characteristically, he showed the device to no one. He made most of it outside the ship, as a matter of fact; and when it was done he towed it rather awkwardly up the tunnel to the place where the camera was stored. Incredibly, twenty minutes later the new control was aligned, the camera mounted firmly on its planned second base at the tunnel mouth, and a control line was being run down the tunnel to the ship. With his usual curtness he reported completion of the job; when the control system had been tested from inside, and the method Ries had used to accomplish the task wormed out of him, the reaction of the scientists almost had him smiling.

Almost; but a hardened grouch doesn't change all at once—if ever.

Ten million miles from Sol's center. Twenty-one hours to go—people were not yet counting minutes. The sun was climbing a little higher above the northern horizon as seen from the tunnel mouth, and remaining correspondingly longer in view each time it rose. Some really good pictures were being obtained; nothing yet which couldn't have been taken from one of the orbital stations near Earth.

Five million miles. Ten hours and fifty minutes. Ries stayed inside, now, and tried to sleep. No one else had time to. Going outside, even to the mouth of the tunnel, was presumed impossible, though the instrument maker had made several more shields. Technically, they were within the corona of the sun, though only of its most tenuous outlying zones—there is, of course, a school of thought that considers the corona as extending well past the earth's orbit. None of the physicists were wasting time trying to decide what was essentially a matter of definition; they were simply reading and recording every instrument whose field of sensitivity seemed to have the slightest bearing on their current environment, and a good many which seemed unlikely to be useful, but who could tell?

Ries was awake again when they reached the ninety degree point—one quarter of the way around the sun from perihelion. The angular distance the earth travels in three months. Slightly over one million

miles from the sun's center. Six hundred thousand miles from the photosphere. Well within *anyone's* definition of the corona; within reach of a really healthy eruptive prominence, had any been in the way. One hour and eighteen minutes from their closest approach—or deepest penetration, if one preferred to put it that way. Few did.

They were hurtling, at some three hundred ten miles per second, into a region where the spectroscope claimed temperatures above two million degrees to exist, where ions of iron and nickel and calcium wandered about with a dozen and more of their electrons stripped away, and where the electrons themselves formed almost a gas in their own right, albeit a highly tenuous one.

It was that lack of density on which the men were counting. A single ion at a "temperature" of two million degrees means nothing; there isn't a human being alive who hasn't been struck by vast numbers of far more energetic particles. No one expected to pick up any serious amount of heat from the corona itself.

The photosphere was another matter. It was an opaque, if still gaseous, "surface" which they would approach within one hundred fifty thousand miles—less than its own diameter by a healthy factor. It had a radiation equilibrium temperature of some six thousand degrees, and would fill a large solid angle of sky; this meant that black-body equilibrium temperature at their location would not be much below the same value. The comet, of course, was not a black body—and did not retain even the heat which it failed to reflect. The moment a portion of its surface was warmed seriously, that portion evaporated, taking the newly acquired heat energy with it. A new layer, still only a few degrees above absolute zero, was exposed in its turn to the flood of radiation.

That flood was inconceivably intense, of course; careless, nonquantitative thought could picture the comet's vanishing under that bombardment like a snowball in a blast furnace—but the flood wasn't infinite. A definite, measurable amount of energy struck the giant snowball; a definite amount was reflected; a definite, measurable amount was absorbed and warmed up and boiled away the ices of water and ammonia and methane that made it up.

And there was a lot to boil away. Thrust-acceleration ratios had long ago given the scientists the mass of their shelter, and even at a hundred and fifty thousand miles a two-and-a-half-mile-thick bar of sunlight will take some time to evaporate thirty-five billion tons of ice. The comet would spend only a little over twenty-one hours within five million miles of the sun, and unless several physicists had misplaced the same decimal point, it should last with plenty to spare. The twelve-hour rule on Sacco's echo sounder had been canceled now, and its readings were common knowledge; but none of them caused anxiety.

In they drove. No one could see out, of course; there was nothing like the awed watching of an approaching prominence or gazing into the deceptively pitlike area of a sunspot of which many of them had unthinkingly dreamed. If they could have seen a sunspot at all, it would have been as blinding as the rest of the photosphere—human eyes couldn't discriminate between the two orders of overload. For all any of them knew, they might be going through a prominence at any given second; they wouldn't be able to tell until the instrument records were developed and reduced. The only people who could "see" in any sense at all were the ones whose instruments gave visible as well as recorded readings. Photometers and radiometers did convey a picture to those who understood them; magnetometers and ionization gauges and particle counters meant almost as much; but spectrographs and interferometers and cameras hummed and clicked and whirred without giving any clues to the nature of the meals they were digesting. The accelerometers claimed their share of watchful eyes—if there were any noticeable drag to the medium outside, all bets on the comet's future and their own were off—but nothing had shown so far.

They were nineteen minutes from perihelion when a growing sense of complacency was rudely shattered. There was no warning—one could hardly be expected at three hundred twenty-five miles a second.

One instant they were floating at their instruments, doing their allotted work, at peace with the universe; the next there was a violent jolt, sparks flew from exposed metal terminals, and every remote indicator in the vessel went dead.

For a moment there was silence; the phenomenon ended as abruptly as it had started. Then there was a mixed chorus of yells, mostly of surprise and dismay, a few of pain. Some of the men had been

burned by spark discharges. One had also been knocked out by an electric shock, and it was fortunate that the emergency lights had not been affected; they sprang automatically to life as the main ones failed, and order was quickly restored. One of the engineers applied mouth-to-mouth respiration to the shock victim—aesthetic or not, it is the only sort practical in the weightless condition—and each of the scientists began trouble shooting.

None of the remote gear registered in any way, but much of the apparatus inside the ship was still functioning, and a tentative explanation was quickly reached.

"Magnetic field," was Mallion's terse comment, "size impossible to tell, just as impossible to tell what formed or maintained it. We went through it at three hundred twenty miles a second, plus. If this ship had been metal, it would probably have exploded; as it was, this general sort of thing was a considered possibility and there are no long conducting paths anywhere in the ship—except the instrument controls. The field intensity was between ten and a hundred Gauss. We've taken all the outside readings we're going to, I'm afraid."

"But we can't stop now!" howled Donegan. "We need pictures—hundreds more of them. How do we correlate all the stuff we have, and the things that will still show on the inside instruments we can still use, unless there are pictures—it's fine to say that this or that or the other thing comes from a prominence, or a flare, or what have you, but we won't *know* it does, or anything about the size of the flare..."

"I understand, sympathize, and agree; but what do you propose to do about it? I'd bet a small but significant sum that the cable coming in through the access tunnel *did* explode. Something certainly stopped the current surge before all the instruments here burned up."

"Come on, Dr. Donegan. Get your suit." It was Ries, of course. The physicist looked at him, must have read his mind, and leaped toward his locker.

"What are you madmen up to?" shouted Mallion. "You can't go out to that camera—you'd be a couple of moths in a candle flame, to put it mildly!"

"Use your brain, not your thalamus, Doc," Ries called over his shoulder. Welland said nothing. Two minutes later the pair of madmen were in the air lock, and sixty seconds after that were floating as rapidly as they dared out the tunnel.

The lights were out, but seeing was easy. There was plenty of illumination from the mouth of the tunnel, crooked as the passage was; and the two had to use the filters on their face plates long before they reached the opening. By that time, the very snow around them seemed to be glowing—and may very well have been doing just that, since light must have filtered for some distance in through the packed crystalloids as well as bounced its way around the tunnel bends.

Ries had left his foil shelters at the first bend. There was some loose snow still on hand from his earlier experiments, and they stuffed as much of this as they could between the thin metal layers, and took several of the sandwiched slabs with them as they gingerly approached the opening. They held one of the larger of these—about four feet square—ahead of them as they went; but it proved insufficient when they got within a few yards of the mouth. The trouble was not that the shield failed, but that it wasn't big enough; no matter how close to the opening they came, the entire sky remained a sea of flame. They retreated a little way and Ries rapidly altered the foil armor, bending the sheets and wiring them together until he had a beehive-shaped affair large enough to shield a man. He used the last of then-snow in this assembly.

Covered almost completely, he went alone to the tunnel mouth, and this time he had no trouble. He was able to use a loop of control wire as a safety, and by hooking his toes under this reached the instrument. It had settled quite a bit—its case and mounting had transmitted heat as planned to the broad silver feet, and these had maintained good surface contact. Naturally a good deal of comet material had boiled away from under them, and the whole installation was in a pit over two feet deep and eight in width. The general lowering of the comet's surface was less obvious.

The vanes of the legs were faintly well sunk into the surface, but with gravity as it was, the only difficulty in freeing them was the perennial one—the risk of giving too much upward momentum. Ries avoided this, got camera and mounting loose, and as quickly as possible brought them back into the

tunnel. There was no need to disconnect the control wire from the main cable; as Mallion had predicted, both had disappeared. Their explosion had scarred a deep groove along the tunnel wall at several points where they had been close to the side. Ries regretted their loss; without them he had some difficulty getting himself and his burden started downward, and he wanted the camera into the tunnel's relative shelter as quickly as possible. With its heat-shedding "feet" out of contact with the ground, it would not take long to heat up dangerously. Also, with the comet now whipping closer and closer to perihelion, there was already an annoyingly large gap in the photographic record.

Back in the tunnel, Ries improvised another set of shields for the camera and its operator, and checked the one he had used to see how much snow remained in it. There was some, but discouragingly little. He placed his helmet against that of Donegan and spoke—the radios were useless in the Sun's static.

"You can't go out until we get more snow for this thing, and you'll have to come back every few minutes for a refill. I'd do the photography, but you know better than I what has to be taken. I hope you can make out what you need to see through the sixty-five hundred filter in the shield I made for the finder. I'll be back."

He started back down the tunnel, but at the second turn met another suited figure coming out—with a large bag of snow. He recognized Pawlak by the number on the suit, since the face of the occupant was invisible behind the filter. Ries took the bag and gestured his thanks; Pawlak indicated that he would go back and bring more, and started on this errand. Ries reappeared at the camera soon enough to surprise his companion, but the physicist wasted no time in questions. The two men restuffed the shields with snow, and Donegan went back to the tunnel mouth to do his job.

Through the filter, the angry surface of the sun blazed a fiery orange. Features were clear enough, though not always easy to interpret. Individual "rice grains" were clearly visible; a small spot, badly foreshortened, showed far to one side. By moving his head as far as the shield allowed, the observer could see well away from the camera's line of sight; doing this, of course, blued the sun as the ray path difference between the reflecting layers in the filter was shortened. He could not tell exactly what wavelength he was using at any given angle, but he quickly learned to make use of the rather crude "tuning" that angle change afforded. He began shooting, first the spot and its neighborhood, altering the camera filter wavelength regularly as he did so. Then he found something that might have been a calcium flocculus and took a series around it; then feature after feature caught his eye, and he shot and shot, trying to get each field through the full wavelength range of the camera at about fifty Angstrom intervals plus definite lengths which he knew should be there—the various series lines of hydrogen and of neutral and ionized helium particularly, though he did not neglect such metals as calcium and sodium.

He was distracted by a pull on his armored foot; Ries had come up, inadequately protected by the single remaining sheet of "parasol," to warn him to recharge his own shield. Reluctantly he did so, grudging the time. Ries packed snow against the feet of the camera mounting while Donegan stuffed it between the foil layers of his shield as rapidly as his space-suited hands could work. The moment this was done he headed back to the tunnel mouth, now not so far away as it had been, and resumed operations.

They must have been almost exactly at perihelion then. Donegan neither knew nor cared. He knew that the camera held film enough to let him take one picture a second for about ninety minutes, and he intended to use all of it if he could. He simply scanned the sun as completely as his eyesight, the protecting filter, and his own knowledge permitted, and recorded as completely as possible everything even slightly out of the ordinary that he saw. He knew that many instruments were still at work in the ship, even though many were not, and he knew that some of the devices on the comet's surface would function—or should function—automatically even though remote control was gone; and he intended that there should be a complete record in pictures of everything which might be responsible for whatever those machines recorded. He did a good job.

Not too many—in fact, as time went on, too few—yards below him Ries also worked. If being an instrument maintenance specialist involved moving snow, and in this part of the universe it seemed to involve little else, then he would move snow. He had plenty of it; Pawlak kept bringing more and more

bags of the stuff. Also, on his second trip, the engineer produced a lengthy coil of wire; and at the first opportunity Ries fastened one end of this to Donegan's ankle. It served two purposes—it was no longer necessary to go out to let the fellow know by physical contact that his time was getting short, and it let the observer get back to work more quickly. Since he was belayed to Ries, who could brace himself against the tunnel walls beyond the bend, there was no worry of going back to the surface too rapidly and being unable to stop.

Ries kept busy. No one ever knew whether he did it silently or not, since the radios were unavailable. It was generally taken for granted that he grumbled as usual, and he may very well have done just that, or even surpassed himself. Hanging weightless in a white-glowing tunnel, trying to read a watch through the heaviest solar filter made for space helmets, holding one end of a line whose other end was keeping a man and a fantastically valuable camera from drifting away and becoming part of the solar corona, all the while trying to organize a number of large plastic sacks of pulverized frozen water, ammonia, and methane which persistently gathered around him would have driven a more self-controlled man than Ries to bad language.

Of course, Donegan didn't map the whole surface. This would take quite a while, using a camera with a half-degree field on a surface over ninety-five degrees across, even when the surface in question is partly hidden by the local horizon. It was made even more impossible by their rate of motion; parabolic velocity at a distance of five hundred eighty thousand miles from Sol's center is just about three hundred thirty miles per second, and that produced noticeable relative motion even against a background a hundred and fifty thousand miles away. Features were disappearing below the solar horizon, sometimes, before Donegan could get around to them. Even Ries could think of no solution to this difficulty, when the physicist complained of it on one of his trips for more snow.

At this point, the sun's apparent motion in latitude was more rapid than that in longitude—the comet was changing its direction from the sun more rapidly than it was rotating. The resultant motion across the sky was a little hard to predict, but the physicist knew that the center of the solar disk would set permanently at the latitude of the tunnel mouth an hour and three-quarters after perihelion. The angular size of the disk being what it was, there would be *some* observing after that, but how much depended on what might be called the local time of day, and he had not attempted to figure that out. He simply observed and photographed, except when Ries dragged him forcibly back to get his shield recharged.

Gradually the gigantic disk shrank. It never was far above the local horizon, so there was always something with which to compare it, and the shrinking could be noticed. Also, Ries could tell as time went on that there was a little more snow left in Donegan's shield each time it came back for refilling. Evidently they were past the worst.

But the sun had taken its toll. The mouth of the tunnel was much closer to the ship than it had been; several times Ries had been forced back to another section of tunnel with his snow bags, and each resumption of observation by Donegan had involved a shorter trip than before to the surface. Ries, Donegan, and Pawlak were the only members of the expedition to know just how far the evaporation was progressing, since the echo-sounder had been wrecked by the magnetic field; they were never sure afterward whether this was good or not. Those inside were sustained, presumably, by their faith in mathematics. For the physicists this was adequate, but it might not have been for Ries if he had been with them. In any case, he didn't worry much about the fate of the comet after perihelion had been passed; he had too many other troubles, even though his activity had quickly become routine. This left him free to complain—strictly to himself.

Donegan was furious when he finally realized that the sun was going to set at his observing station while it was still close enough to photograph. Like Ries, however, he had no way of expressing his annoyance so that anyone could hear him; and as it turned out, it would have been wasted breath. Observation was cut even shorter by something else.

They had been driven down to what had been originally the third bend in the tunnel, and at this point the passage ran horizontally for a time. Pawlak had just come to the other end of this straight stretch with what he hoped would be his last load of snow when something settled gently through its roof between him and Ries. He leaped toward it, dropping his burden, and discovered that it was one of the

instruments which had been on the surface. Its silver cover was slightly corroded, and the feet of its mounting badly so. Apparently its reflecting powers had been lowered by the surface change, and it was absorbing more energy than an equivalent area of comet; so its temperature had gone up accordingly, and it had melted its way below the rest of the surface.

Low as the sun was, it was shining into the hole left by the instrument; evidently the pit it had made was very broad and shallow. Pawlak made his way around the piece of gear and up to Ries, whose attention was directed elsewhere, and reported what had happened. The instrument man looked back down the tunnel and began to haul in on the line attached to Donegan. The physicist was furious when he arrived, and the fact became evident when the three helmets were brought together.

"What in blazes is going on here?" he fulminated. "You can't make me believe my shield had boiled dry again—I haven't been out five minutes, and the loads are lasting longer now. We're losing the sun, you idiot; I can't come back because someone has a brainstorm or can't read a watch—"

Pawlak interrupted by repeating his report. It did not affect Donegan.

"So what?" he blazed. "We expected that. All the gear around the tunnel mouth has sunk—we're in a big pit now anyway. That's making things still worse—we'll lose sight of the sun that much sooner. Now let me get back and work!"

"Go back and work if you want, provided you can do anything with the naked eye," retorted Ries, "but the camera's going back to the ship pronto. That's one thing we forgot—or maybe it was just assumed that gaseous ammonia in this concentration and at this temperature wouldn't do anything to silver. Maybe it isn't the ammonia, for all I know; maybe it's something we've been picking up from the corona; but look at that camera of yours! The polish is gone; it's picking up heat much faster than it was expected to, and not getting rid of it any quicker. If that magazine of exposed film you have in there gets too hot, you'll have wasted a lot of work. Now come on, or else let me take the camera back." Ries started along the tunnel without further words, and the physicist followed reluctantly.

Inside, Donegan disappeared with his precious film magazine, without taking time to thank Ries.

"Self-centered character," Pawlak muttered. "Not a word to anyone—just off to develop his film before somebody opens the cartridge, I suppose."

"You can't blame him," Ries said mildly. "He did a lot of work for it."

"He did a lot of work? How about us? How about you; it was all your idea in the first place—"

"Careful, Joe, or they'll be taking my nickname away from me and giving it to you. Come on; I want to see Doc Sonne. My feet hurt." He made his way to the main deck, and Pawlak drifted after him, grumbling. By the time the engineer arrived, the rest of the group was overwhelming Ries with compliments, and the fellow was grinning broadly. It began to look as though the name "Grumpy" *would* have to find a new owner.

But habit is hard to break. The doctor approached, and without removing his patient's shoes dredged a tube of ointment out of his equipment bag.

"Burn ointment," the doctor replied. "It'll probably be enough; you shouldn't have taken too bad a dose. I'll have you patched up in a minute. Let's get those shoes off."

"Now wouldn't you know it," said Ries aloud. "Not even the doctor around here can do the right thing at the right time. Physicists who want A's gear fixed on B's time—won't let a man go out to do a job in the only way it can be done—won't give a person time to rest—and now," it was the old Grumpy back again, "a man spends two hours or so swimming around among sacks of frozen methane, which melts at about a hundred and eighty-five degrees Centigrade below zero—that's about two hundred and ninety below Fahrenheit, doctor—and the doctor wants to use *burn ointment*. Break out the frostbite remedy, will you, please? My feet hurt."