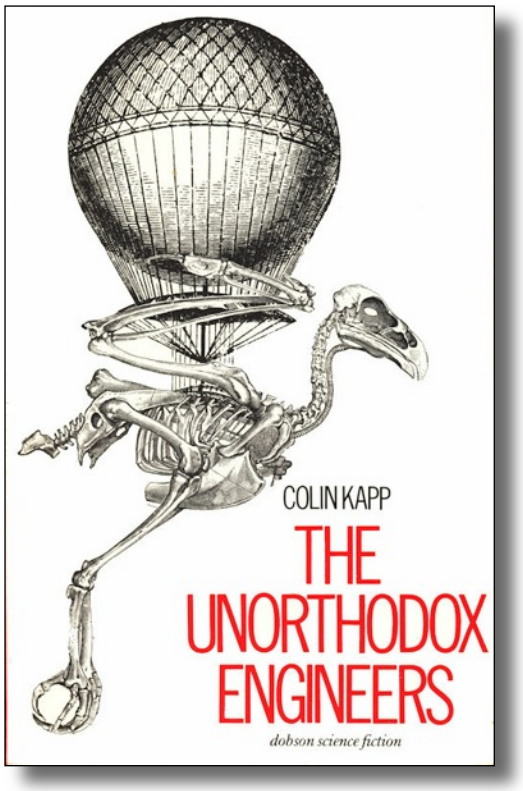

The Railways Up On Cannis

'Colonel Ivan Nash to see you, Sir.'

Colonel William Belling frowned. 'Ivan Nash? I thought he was on Cannis IV with the occupation force. Anyway, show him in.'

'Too late!' said Nash from the doorway. 'I'm already in. Can't wait on ceremony, you know, Bill. I've got an operation to run.'

`Good to see you, Ivan! What brings you to Terra?'

'Briefly,' said Nash, 'it's the railways up on Cannis.'

Belling waved his visitor into a chair and issued him with a drink. 'I fear I'm a little out of touch,' he said. 'I didn't think railways were quite in your line.'

`No?' Nash filled his pipe carefully. 'How much do you know about Cannis IV anyway?'

'Not much. Gravity, atmosphere and climate roughly earth-normal. Population rated human equivalent on the Manneschen scale. Oh yes—and volcanoes!'

'Precisely,' said Nash dryly. 'Let us not forget the volcanoes. Cannis IV is a young world with a very thin crust. Plate-tectonic movement is still pretty extreme and the resulting volcanic activity is widespread and generally severe. magma-blowholes about a dozen metres in diameter can force up anywhere at any time. They raise sharp-edged slag cases from ten to a hundred metres in height. That's why there are no roads on anywhere on Cannis.'

`Quite a place,' commented Belling, refilling the glasses.

`Quite a place and quite a people.' Nash studied the ceiling reflectively. 'Tough as nails and as perverse and changeable as the hell-hole that spawned them. Considering there's not a two-hundred metre diameter of flat space anywhere on the whole damned planet it's highly remarkable that any form of civilization ever managed to evolve, let alone one that managed to kick itself into space.'

'I had wondered about that.'

'Well you might. They're an extremely clever race. They're craftsmen, hobbyists and gadgeteers of the highest calibre. They built up a highly effective mechanical culture by trial and error and empirical method. But they have no true science as such.'

`So?'

Ivan Nash paused. `So Cannis IV took an accidental kinetic impactor during the war. One of the rebel asteroid-ships ended up there after we knocked out its drive. Now the locals don't have sufficient continuity

of technology to get back on their own feet. If you knock a cockeyed culture like that to pieces how, in hell do you get it together again?'

'I don't know,' said Belling, quite honestly.

`And neither do I. They're a heck of a nice people when you get to know them. That's why our presence on Cannis IV is more of a rehabilitation job. If we let them down we throw them back a thousand years.'

'As bad as that, eh?' Belling muttered morosely.

'Worse. With their present production and distributing capacity they'd have difficulty in maintaining more than twenty per cent of their population at a minimum survival level without our help. And help all the way from Terra is a mighty expensive item. We have to stand them on their own feet fast.'

'So you want reconstruction engineers?'

`No, I *already* have engineers. Unfortunately it doesn't work. Advanced technology is not very suited to patching up a string and hairpin culture. The gulf between our technology and their technique is too great. What I need are specialists with a peculiar kind of skill. That's why I came to you.'

'The entire engineering reserve is at your disposal,' said Belling. 'You name 'em, I've got 'em. What do you want?'

`My main concern is with the railways. With no roads or airstrips, the railways alone give cohesion and life to their scattered society. Without it they can't survive.'

`So you want railway engineers?'

'No,' said Nash sadly, 'they wouldn't be any use.'

'How come?'

'Man! ' said Nash in a voice of awe and wonder. 'Did you ever see the railways up on Cannis? It's a shunter's nightmare, a plate-layer's conception of hell. From an engineer's point of view it's a complete and utter impossibility.'

`Somebody must have constructed it originally.'

`Yes, a myriad crazy, bug-brained innovators, each working on a separate part to an entirely different specification and for conflicting reasons. It's a completely lunatic system which breaks every known law of elementary railway technique.'

'Then,' said Belling wearily, 'if you don't want engineers what *do* you want?'

'I want to borrow the UE squad,' said Nash grimly.

Belling winced. 'Are you serious?'

`Deadly.'

`You realize what the UE squad could do to a situation like this?'

'I realize it's a dangerous thing to try, but desperate ills need desperate remedies. It's the last chance we have to save the planet from barbarism.'

'If I were you,' said Belling sadly, 'I'd resign.'

Lieutenant Fritz van Noon of the Unorthodox Engineering squad faced his superior warily.

`I've got news for you,' said Colonel Belling. 'As you know I was against the formation of the UE squad right from the start. The whole subject of Unorthodox Engineering has never sat very easily on my conscience. However, I think you've won your point.'

'You mean that Operation *Hyperon* is going through?'

'Just that, but there is a proviso. You have to keep the squad in operational trim until *Hyperon* is ready by accepting assignments outside this reserve. Colonel Nash has already made a specific request for your services.'

`I'm grateful,' said Fritz warily, 'but there's a distinct odour of an ulterior motive here somewhere.'

Belling smiled wolfishly. 'There is indeed. Tell me, Fritz, do you know anything about railways?'

'No, sir, should I?'

'Then you'd better get yourself a book or something. You've just been appointed controller of public railways on Cannis IV. UE goes with you.'

`Cannis IV? Where the fuck is that?'

Belling winced. 'It's the only habitable planet in the Cannis sector. And it's the closest approximation to Hell I've come across so far.'

'I'm grateful you thought of me, sir," said van Noon sardonically.

`And I appreciate your tact, Fritz. You know, it's no easy task running a specialist engineering reserve. Always you get the one engineer in a thousand who should never have got out of playschool, let alone

graduated. With a reserve strength like ours it's inevitable that we should have collected more than our fair quota of screwballs. The problem has always been to place them in positions where they aren't actively dangerous. *Now* I don't have to worry. The UE squad is a natural home for these guys.'

'Which statement reveals a deplorable lack of insight,' said Fritz van Noon. 'I devised UE to provide an outlet for those engineers whose imagination carried them beyond the ordinary.'

'I know,' said Belling dryly. 'I've seen some of your extraordinary engineering. I can only assume that taking you to Cannis to rehabilitate an entire planet is some glorious form of poetic justice. And Fritz—'

`Sir?'

'Take it easy on Ivan Nash. He's a friend of mine, and he doesn't suffer fools gladly. Try pulling some of those stunts you've pulled on me and you'll probably spend the rest of your career in the deepest and darkest jail he can find.'

'You can trust me, sir. After all, UE has a reputation to maintain.'

'That's precisely what I'm afraid of. Now get the hell out of here. I have an army to run . . .'

The landing at Hellsport Base did nothing to endear Fritz to the planet. The transfer ferry entered the guiding radio-cage at a tangent, failed to equalize, and bucked and ricochetted from beam to beam until the crew abandoned the automatics and dropped her to the ground under manual control. The ferry touched down with the motors out of synchronization, spun crazily, and dug itself a trench in the sand before it finally swayed to rest. That meant two hours of waiting whilst water jets strove to cool the hull.

Jacko Hine, his second in command, met him at the space-port entrance. Jacko and a small contingent of UE had been sent ahead to make a preliminary survey of the situation. The summary of the reconnaissance was proclaimed by Jacko's crestfallen attitude and by the way his hair looked as if he'd been grabbing it by handfuls.

'How does it look?' asked Fritz suspiciously.

Jacko stared at him for a second or two. 'Grim,' he said. 'If I'd tried to figure out an assignment which would prove UE to be a bunch of useless, incompetent, layabouts I couldn't have made a better choice.'

'I *knew* there was a catch! ' said Fritz. 'Friend Belling was too polite on handing out this offering. Too polite by half. He's usually cussing as soon as he sees me coming through his office door.' Fritz grimaced. 'But this gives us a chance to prove the bastard wrong once and for all.'

'Does it? Open your pretty shell-like ear and I'll pour in a few home truths about Cannis railways. One: no part of the system has been in operation for at least five years. Those parts of the installation which survived the asteroid impact during the war have either fallen down of their own accord or else torn apart by mini-volcanoes.'

Fritz choked on his drink. 'Volcanoes?' he queried finally.

'Sure. Small ones. The thin crust is easily split by quakes, and magma squeezes through the cracks under pressure to form miniature volcanic eruptions. Even at the heyday of the Cannis railway approximately one fifth of the total rail length was always out of commission due to volcanic activity. After five years without maintenance or repair the damage and confusion is simply catastrophic. Nash's engineers rebuilt five kilometres of new track and suspension last year and two eruptions ruined it within a week.'

`Go on,' said Fritz grimly.

'Two:' said Jacko. 'All the new steel has to come from Terra. Delivery delay is a little under two years and a ship can't deliver more than a hundred tons at a time. There is some good malleable iron locally, but it's not durable enough for high-stress applications. It's all right for rails and short supports but the tensile strength is too low to allow its use for major engineering projects.'

'Enough!' said Fritz. 'The rest of the misery I'll discover for myself. I'm seeing Colonel Nash this afternoon, and after that I want to see some railway.'

'In that case,' said Jacko, 'let's go to the bar for a drink. We're going to need it . . .'

Colonel Nash was waiting for him in his office. There was a certain air of reserve between the two officers which Fritz found vaguely familiar. The reputation of the Unorthodox Engineers usually preceded them. Tales were legion, and some of them were even true.

'I take it you've read the dossier on Cannis IV.' said Nash. 'How does it strike you as a job?'

Fritz shrugged. 'That depends on the type of co-operation we get.'

`You get whatever you want. This is very much a last-stand project at this point. The Cannis rehabilitation is costing us more than did the war. We can't afford to mess around here for much longer.'

'What I *want*,' said Fritz, 'is simple. I just want that we should be left alone. We'll do our own thing, in our own way.'

'How do you mean? Discipline, administration, or what?'

'Everything. Just set us down at a rail point about fifty klicks out and then forget us.'

'This is bloody irregular,' said Nash. 'After all, you *are* an army unit. What about supplies, for instance?'

'We'll find our own.'

'And steel—you can't build a railway without steel.'

'Lack of essentials never yet troubled an unorthodox engineer.'

'But this is ridiculous!' said Nash. 'I didn't fetch you out from Terra just so you could go play cards in the wilderness.'

'Look,' said Fritz quietly, 'you want a railway. You've proven that ordinary methods can't provide it. Now do I get a crack at it the unorthodox way or do you return to Terra and admit the job has you beat?'

'Get out!' said Nash angrily. 'Get out of my sight before I have you cashiered for impersonating an army officer! I'll leave you alone, but I promise you one thing . . . the next time you enter Hellsport it had better be on a bloody train, else I'll nail you for insubordination and bust you so low you'll have to say "Sir" to the Padre's dog.'

'Thank you!' said Fritz van Noon. 'That's all I wanted to know.'

They came across the structure dully silhouetted against the overcast sky. It reminded Fritz of nothing so much as a rotting seaside pier propped awkwardly on random legs clear of the broken terrain below. Jacko had a rope ladder tied to the structure, since the original sling and hoist access had rotted beyond repair. The two climbed gingerly to the platform overhead, brushing the rusting piles and girders, and being showered with dirt from the gaps in the dark decking.

Above the decks the desolation grew. It was a crumbling, grotesque parody of a structure whose impotence in style and form was rendered more alien and yet artistic by the vagaries of slow corrosion. It was like a surrealistic film-set for a comedy of horrors which nobody dared to make. And on the far side, characteristically askew, was a sign board in local script, and after, scrawled in chalk in English, the legend : 'Hellsport Terminus. The end of the line.'

'It reminds me,' said Jacko, 'of a card house set in a sea of rusty spaghetti.'

Fritz frowned and mooched dismally through the festoons of rusty iron and threadbare cable. 'What hit it?' he asked at last.

'Nothing.' Jacko guided him away from a bed-plate which had rusted to an extent where an uncautious foot might easily penetrate into the depths below. He pointed to a slag cone, now cold, which had burst through the tracks at mid-point across the terminus, ruining two tracks completely and half filling the remainder of the terminus with light volcanic ash. 'Apart from the inquisitive volcano everything is just as it was when the last trains went north in the war. Believe me, they'd be using this installation now—only the trains never came back.'

`Can't say I blame the trains,' said Fritz moodily. 'You mean to tell me this rotting junk heap is still in functional order?'

`By local standards, yes.'

'Tell me,' said Fritz testily, 'did they have remarkably small trains or is this multiple-rail stuff some sort of gimmick?'

'I asked about that. Seems that each branch line had its own gauge and some had several according to who built them. At a terminus like this you have to accommodate anything which comes, so you run one track inside another nice and tidily. One snag though—you should see what it does to the points.'

Fritz shuddered visibly despite the warm afternoon air. `I'd better see the worst, I suppose.'

They walked out from the terminus to the huge switching grid which served to integrate the various branch lines entering the terminus. There was nearly a kilometre of patchwork mechanical desolation, liberally coated with rust and complex beyond belief. Gantries and galleries were solid with cranks and levers, bars and linkages, rods, and handwound helical springs. Cloth-covered cables and solenoids had dropped their sickly bitumen under the coercion of many summers' suns, and now lay bleached white and ugly across the rotting spans like the bones of some alien skeleton.

Fritz viewed the scene with increasing dismay. Jacko leaned heavily on a stanchion and eyed his discomfort with a perverse humour.

`We're doing fine,' said Fritz. 'We've got ourselves a station complete with a junior volcano, a marshalling yard which shouldn't exist outside of a bad dream, six branch lines which don't go anywhere, and no trains to try out anyway. Add the fact that we can't get any steel and the probability that anything we do build will be ruined by more eruptions within six months, and I surmise we are well and truly screwed. I don't know whether to blow the whole lot up and start again or to leave it as an object lesson on how *not* to build a railway.'

`Now who's being conventional?' grinned Jacko. 'I should have thought that this morass of mechanical ingenuity would have gladdened your heart no end.'

'No,' said Fritz, 'and I'll tell you why. You see, its builders paid no attention to basics. There is a certain idiot futility about building something destined for sure destruction. Even a bodger must work to the principle of the greatest return for the minimum of effort. That's why this damned railway is not only unsound but also needlessly complicated.

`Take this switching grid, for instance. It's not only vulnerable but it's largely unnecessary. It's designed to be completely automatic, self-routing, self-isolating, self-signalling and probably foolproof. Even Terran computer-controlled rail networks have nothing to match this except in theory. But the faults result from limited vision. We could have done the whole thing with about a tenth of the parts and ten times the reliability.'

'We may have to,' said Jacko. He pointed outwards across the tracks to where thick motes of dust and cinder were dancing in the sun. 'Unless I miss my guess there's magma pushing up from down there.'

'I want,' said Fritz van Noon, `to start at least fifty klicks out on something nice and simple. We should have worked out the necessary technique by the time we get back to Hellsport. What type of engines did they use, anyway?'

Jacko drew a deep breath. 'You're not going to believe this.' He sounded depressed, 'But the engines were even stranger than the tracks. A locomotive designed in the town of Juara, about a hundred klicks from here, was a steam-engine run on dried resins. Two locos from Manin, down by the coast, were sort of battery-electric jobs. One from a place called Nath came home on some kind of super gyroscope, and there was one using an internal-combustion engine run on alcohol made by fermenting bean husks. I've no idea who made that one. There are others so weird no-one has a clue how they operated at all.'

'Why doesn't that surprise me!' said Fritz dryly. 'These people may be able to beat us at our own game, Jacko. Talk about unorthodox engineering! We're a set of ruddy amateurs compared to them.'

'I doubt it,' said Jacko. 'In my youth I thought I was the world's worst crackpot screwball. Then I met up with you and found that, in comparison, I was merely a sane, sensible, hard-working engineer. I never got over the disappointment of that hour of realization. I have a feeling these people will find themselves in a similar predicament. Under the heavy hand of Fritz van Noon the Cannis railway will never be the same again.'

'Thank you for that sly vote of confidence,' said Fritz. 'Now this is what I propose to do. I want you to take a helicopter to the Callin area, find the loco and bring it back to there—' He stabbed his finger on the map. 'There's a two kilometre break in the track that will suit us just fine. I'm taking the rest of UE to that point and we'll repair the break – if we can. It will give us a workable area down as far as Juara. I want to complete that run before the Callin bean harvest is ripe. That gives us about two months.'

'Two kilometres of new track in two months? You're off your rocker!'

'Naturally,' said Fritz. 'Else I wouldn't be running UE . . .'

The town of Juara lay on a crest of sullen rock. The shelf of granite had reduced the volcanic activity of the region to a tolerable level, and made habitation possible at the expense of the fertility of the soil. The railhead was untouched, but as the line swung again north-west and then north of the plateau it entered a low basin where the slag-cases, dunned with vegetation, stood up thick and tall like armless trees in some fantastic petrified forest.

This was a bad point for the rail. From the air it was obvious by the tortuous twisting of the route that the line had been diverted from disaster and rebuilt at least a dozen times. Occasional sections were completely isolated from the remains of the existing track and lay as forlorn crescents of rotting railway awaiting trains that could never come.

Six kilometres out from Juara was the break. The railway had literally been shaken to pieces. For nearly two kilometres the remnants of twisted girderwork and trestles sprawled on the broken ground, tied together with the soft iron of the rails. North again by over forty kilometres lay Callin and the fertile mountains of Cansoun.

In the centre of the break, the cargo aero-sleds rendezvoused to drop the heavier equipment. The fragile, alloy Knudsen huts were hastily assembled and staggered, two by two, between the tall mini-volcano spires. Prefabricated workshops were completed in record time as soon as a bulldozer had cleared a sufficient site. The packaged forge and the rolling mill were moved on air cushions to key points on the site.

Working feverishly and without obvious direction, the engineers of UE carved themselves a base on the alien territory and settled themselves in. By nightfall a new functional township had arisen beneath the dark towers of Cannis.

Fritz was well pleased with the achievement: Its success was marked by a subtlety which would have passed all but the keenest of observers. For UE was not a team as such; it was a collection of individuals. Nobody planned or directed, except in the very broadest way, but each engineer was trained to analyse the salient points of an operation and to guide his own activities to achieve the maximum effect. It was the myth of anarchy on a practical, productive scale—and it worked! The patient genius of Fritz van Noon had wrought a philosophic miracle.

At the crack of dawn the following day, a skinny, brown-skinned humanoid walked in from the desert.

Fritz had heard that the local population was inquisitive to a fault, and a casual inspection of any work in progress was slways part of the scheme of things. After poking and probing into every conceivable crevice, the native he went from hut to hut harrying the occupants with atrocious pidgin English. He found nobody who could understand him until he came across Harris, who had a flair for languages. Harris realized the worth of the contact and hurried him off to meet Fritz van Noon.

'His name is Malu,' said Harris. 'I think he's local engineer. He seems to want to help with the railways.'

Fritz smiled quizzically. 'Can he find me any local labour?'

Heated discussion followed. Finally Harris turned back to Fritz. 'If I understand him correctly, there is plenty of local labour but they won't work in gangs under direction. They're strictly independent buggers, sir.'

'Well,' said Fritz. 'Point out that it's their harvest we're trying to get to Juara. It's no skin off our nose if it doesn't go through. Also they obviously don't have the skill or the ability to do the job themselves else they'd have done it already.'

'I think I already said that, but it's no dice. They won't play. I reckon they'd sooner starve than take orders from off-worlders.'

'Come to think of it,' said Fritz, meeting the native's frank stare, 'so would we I guess. Hell, I'll take a chance! Get as many as you can. It may never look like a railway but I guarantee it'll be a bloody lot of fun trying.'

By this time Malu had wandered off to examine, with great interest, one of the Knudsen huts. He was obviously worried by the alloy hulks, and came back for a long and excited argument with Harris.

'He doesn't like the huts, sir,' said Harris. 'Says we mustn't build directly on the ground.'

'Oh? Why not? There's no danger of flooding hereabouts and the site is reasonably level.'

More gabbling and arm-waving..

'No, sir. I think the lichen is temperature sensitive. It turns brown where a hot-spot is developing. It gives about a ten hour indication of when to move house. I suppose he means that the huts prevent us seeing the lichen underneath.'

Fritz relaxed. 'We already thought of that. Between each pair of huts we have a thermocouple buried. They'll wake the dead if the temperature rises too much. More reliable than any local plant, for sure. Anyway you can't put a Knudsen hut on stilts—it'd fall to bits.'

Harris spoke with Malu, who shrugged resignedly and walked away wagging his head from side to side.

'He says it won't work,' said Harris. 'He's not staying around to see the action."

`Bloody hell! That's all I need.' said Fritz van Noon.

Curiously enough the combination of local and UE personnel worked rather well. The natives knew their own limitations and did not attempt to handle unfamiliar tools until they were sure of their competence. The UE squad became the lead team, breaking new ground, and the local workforce seconded in careful emulation of their instructors. They proved to be even better at picking up languages than Harris, and communication improved rapidly.

By the end of the fourth day a huge stretch of track had been cleared, the rails returned to the rolling mill for straightening, and trestles and undamaged span girders stacked ready for reassembly. Ingots of malleable

iron were manhandled down the line from Juara, and the forge and rolling mill worked continuous shifts to shape the soft metal which had to serve instead of steel.

The UE metallurgist was going quietly nuts trying to figure out why the Cannis IV iron refused to harden. He finally decided it was due to the perverse allotropic form of the native carbon, and broke down an electrolytic refining cell of Terran origin to gain a less temperamental sample of the element. Two pounds of this steel prepared in the laboratory exhibited a cold-short brittleness of such degree that it could be broken apart by a few taps of a hammer. Increasing the silicon and carbon content he obtained a steel of similar tensile strength to lead. At this point he broke down and wept bitterly, then went out and got drunk. Fritz didn't have the heart to put him on a charge.

A week passed and Fritz was awakened by the babble of voices outside his door. He dragged himself from his bunk, opened the door and stepped out. He immediately fell over Jacko who was prostrate on his stomach in front of the threshold probing the ground with the aid of a spot lamp. Malu and two other natives were watching the proceedings from a discreet distance.

`Jacko! ' said Fritz. 'What the hell are you doing?'

Jacko rolled over and looked up at him. 'Hell,' he said, 'is an apt description of our destination if we don't leave this spot pronto. Your hut is nicely located on a hot-spot.'

'What?' Fritz felt a sudden tremor of the ground beneath his feet and caught a wisp of the sulphurous fumes issuing from widening fissures in the ground. He pulled Jacko to his feet and they backed off rapidly. They had scarcely covered twenty metres before the Knudsen disintegrated in a plume of gas and smoke, shot through with streaks of fire. At a safe distance they turned and watched the miniature volcano erupt at the very spot where Fritz had been sleeping barely four minutes earlier.

'One up to Cannis IV! ' said Fritz grimly.

Jacko surveyed the furious gout of fire before him. 'What happened to the thermocouple alarms?'

'Useless,' said Fritz. 'Platinum, platinum-rhodium couples at three metres depth. But the hot sulphur and silicates and god-knows-what-else are corroding them away at a ridiculous rate. It must have gone open-circuit before it could operate the alarm. Useless. The rest of the Knudsens will have to be jacked up somehow, so we can see what's happening underneath.'

'Can we afford the *time*?' asked Jacko. 'The bean harvest won't wait and you know the old saying: civilization is only ever three meals away from a revolution! Can't we simply use another type of thermocouple?'

'No, this damned soil is too corrosive, and a shielded couple isn't sufficiently sensitive. Either we find a way to raise the huts or we risk frying in our beds. I don't fancy waking in the morning and finding myself well done on both sides. And we're still putting this railway through to Juara on time even if it's over your dead body.'

'Thanks a lot, boss' muttered Jacko. 'By the way, I've got you an engine. As a locomotive it would make a very good potting-shed, but the fuel is simply superb.'

'I know,' said Fritz. 'I can smell it on your breath.'

Much of the track itself was recoverable since the low speeds and traffic density of the line would make no great demands on the quality of the rail. A great deal of the girderwork from the spans was likewise capable of reclamation. Only the trestles had suffered badly. Four out of five were a total write-off and, due to the great allowances needed by reason of the poor quality of the metal, rebuilding ate deeply into the available stocks of iron. As the work progressed it became painfully obvious that no more than half of the break could be completed because of the lack of trestles.

Fritz refused to be disheartened, and laid his advance plans with a quiet precision and a secrecy which involved the confidence only of Harris and Malu, who both disappeared on special missions Fritz wouldn't talk about. Everyone else grew despondent, and even Jacko's customary pessimism seemed justified when the next hot-spot appeared.

Where is it?' asked Fritz.

'Sod's law,' said Jacko, 'It's right where it will do the most damage. Under our new track and right in the centre of a span. Three days and the whole lot will be down again. How the hell can you build a railway under these terms?'

'You can't,' agreed Fritz. 'That's why we're going to alter the terms. Take my advice, Jacko, never try to buck the system. If it's big enough to break you, try helping it on its way.'

'Fine in theory,' said Jacko. 'But you can't stop a volcano.'

'Can't I? Cannis IV and I have a lot in common. We both think the same way—mean and underhand. It's a policy of kicking the enemy while he's down. That way you get the greatest results for the least effort. This is getting personal, and no bitch of a planet is going to put one over on Fritz van Noon.'

Jacko shook his head sadly. 'Let's face it, Fritz. We're licked. We can't go any further without Terran steel and we can't even hold on to what we've already *done*. There's no disgrace in folding up before a physical impossibility.'

'I've told you before,' said Fritz sternly, 'there's no such thing as a physical impossibility. A limitation is a state of mind not a question of fact. An aeroplane was a physical impossibility until men's minds learned how to tame the concept.'

'Is lack of steel and a surplus of volcanoes also a state of mind?'

'Certainly—if you regard them as limitations?

'Very well,' said Jacko, 'come and prove your point.'

By the time they arrived at the span the hot-spot was beginning to break. Even as they watched, the ground lurched and broke as the angry pressures blew the topsoil apart. Then came a heavier explosion, the ground cracked into a fissure and a column of fire spurted irregularly through a spray of liquid, incandescent magma, which congealed around the blowhole to form the foundations of the cone. About fifteen metres above, the span appeared to dance in the stream of heated gases, and was soon blackened and scorched . It's demise was inevitable.

Ensign Harris came over at a run, pulling and old-fashioned mortar on a trolley, and was followed by Malu and two engineers carrying a rack of mortar bombs. They set up the mortar at a reasonable distance and proceeded to prime the bombs.

'Are you crazy?' asked Jacko.

'Yes,' said Fritz. 'That's my forté. I want to see what happens if we put a mortar bomb smack inside that crater. You're the weapons expert. Can you do that without damage to the trestles?'

Jacko estimated the position silently. 'With a couple of ranging shots I can pin the hole all right, but the trestles will be in the hands of the gods.'

The result was even more spectacular than anticipated. The first shot fell short, and the mortar was adjusted slightly to lower the trajectory a fraction. The second bomb rose in a brief arc and fell with careful precision into the mouth of the flaming cone. A split second's pause and then Hell itself was unleashed. The pyramid of toffee magma split wide with a murderous roar; gouts of flame and incandescent lava boiled and foamed high into the air and collapsed into a storm of white-hot cinders and writhing jets of burning gas. At the base, where the cone had stood, the blowhole angrily vomited a widening pool of boiling lava like some grotesque festering sore.

'Another?' asked Jacko.

Fritz nodded. 'We might as well be fried sheep as roast lambs.'

The third bomb, too, was accurately placed. This time the lava rose like a living wall and plunged outward, splashing and streaming its magnificent debris up to thirty metres from the seething well. A sheet of roaring flame rose up with frenzied fingers and enveloped the protesting members of the rail-span overhead.

The blast of heat and awesome fury sent the watchers scurrying for shelter, with Harris fearing for the safety of his remaining munitions. Only Fritz stayed put, his clothes smouldering, shielding his eyes with his hands and overcome with the enormity of the havoc he had wrought. Then the flaming torches died and the white-hot spume grew less. The lava pool became a darkening puddle of red toffee, shot with occasional bursts of recalescent heat and overhung with the will-o'-the-wisp of burning sulphur.

'One up to me,' said Fritz van Noon.

By morning the remains of the volcano held no visible sign of life. The lava had spread into a vast rippled puddle of rock, still hot but solid enough to bear a man's weight. Already the lichen was beginning its assault on the cooler regions, eager to begin the symbiosis with the grass to follow.

Jacko had the calculations finished by the time that Fritz was ready to inspect.

'Fritz, you're a ruddy genius! There's enough material in this puddle to make two average-sized volcanoes in this district. That means we've cleared it out completely. With a bit of luck they won't have another volcano here for the next sixty years or so. Unless an eruption happens right under a trestle leg we can treat it the same as this one. That simplifies life no end.'

'Precisely,' said Fritz. 'But it's the trestle legs I'm worried about. Pile-driving those base supports makes the trestles rather vulnerable. What happens to your railway if your trestles suffer a high mortality rate?'

'I think we quit,' said Jacko candidly.

'Not on your life,' said Fritz. 'We've got enemies. If UE goes home with it's collective tail between it's legs they'll try and break us for sure. We've got the largest collection of screwballs and technical malcontents in the whole army. Not one of them would be happy about returning to honest engineering while they can stay with us and play forsaken children's games under the minimum of effectual supervision. As officers, we have a responsibility to these guys. We can't just let them be pissed on from a great height. Besides which, there's more than the Cannis railway at stake here.'

'I guess you're right,' said Jacko. 'But look at the problem. We can't put a straight track run on the ground because of the cones in the way. Even if we could it would take years to level up the site. Therefore we build on trestles and spans over the rocks and smaller cones. That makes sense even if it looks grotesque. But you can't stop a volcano which comes up under a trestle. That's what has been killing this railway since it was invented.'

'I can,' said Fritz slowly. 'But it's a dangerous thing to try. You see, there is one place on Cannis where a volcano never rises.'

'I doubt it.'

Fritz grinned. 'Oh ye of little faith.' He waved an arm in the general direction of the desert. 'An old and weathered volcano will eventually crumble and be replaced by another one, but a new eruption never rises where an previous one *still stands*. Pressure difference, I suppose.'

He broke off suddenly with a puzzled frown.

'I thought I heard a chopper. Are we expecting any visitors?'

Jacko found a pair of field glasses and studied the helicopter rapidly growing larger in the lens.

'Trouble!' he said. 'Looks like Admin has found out where we are. That's a deputation from Hellsport unless I'm very much mistaken.'

'Shit!' said Fritz. 'Can't you head them off. I've got work to do. I bet it's that lousy planning group come to foul things up.'

There were two Terran civilians in the helicopter. The taller of the two was clearly a classic, pompous pen-pusher, whilst his companion seemed to be some kind of technical consultant. On the way down from the landing raft they made a rather pointed inspection of the piles of girders and miscellaneous metalwork which littered the camp, and the short man took it upon himself to explain to his companion certain niceties of railway construction which Fritz appeared to have overlooked. By the time they reached the office they were clearly in the mood for business.

'I'm Eldrick, Planning and Co-ordination,' said the tall civilian. `I think you would be Mr Noon.'

'Lieutenant *van* Noon,' corrected Fritz wearily. He was proud of his Dutch heritage. 'I thought Colonel Nash agreed not to waste resources sending Admin out here to count the paperclips.'

Eldrick smiled tolerantly. `I think you misunderstand our purpose. We are the group which co-ordinates the efforts of all units on Cannis IV to ensure that the maximum effort is concentrated in the right direction. We are here to *help* you.'

'When UE needs help,' said Fritz, 'it helps itself. I haven't come across an administrator yet who even knows what a spanner is. We're independent, uncoordinated, unorthodox, and generally fireproof—and what's more I have a certificate to prove it.'

Eldrick was unmoved. `I still think you're making a mistake, Lieutenant . . .'

'Listen,' Fritz broke in. `The whole Cannis IV episode is a mistake. This misbegotten planet is some kind of cosmological joke. If you think you can create order out of chaos with a ruler and a pencil-sharpener then you have no idea of the complexities involved.'

`Have *you?'* asked Eldrick pointedly. 'What about steel! You're supposed to be recreating this railway system. But you can't build a railway without steel. There are priorities to be arranged, specifications to be agreed, orders to be placed on Terra. Delivery charges . . . *Organization* is essential to the well-being of any major endeavour.'

`Organization,' said Fritz, `is the last refuge of a tired mind. It's a bumbling, mechanical substitute for initiative. I can't wait twenty months for Terran steel even if it *is* cut to size and neatly drilled to specification. If I haven't got steel then I'll use something else, *anything* else.'

`I regard that as a very foolish and unnecessary attitude.'

`That foolish attitude of creation out of necessity,' said Fritz heatedly, 'is the power and the reason that placed Mankind above the animals. Without it we'd still be scratching fleas off each other's backs. You're wasting your time here.'

`Very well,' said Eldrick, 'but if necessity is the mother of invention then you are in for a highly creative time. I've had a look at your constructions here, and if you think you can get a line through to Hellsport inside ten years you're either a genius or a fool.'

Was that wise,' asked Jacko, watching the helicopter lift off for Hellsport. 'I mean, throwing him out like that.'

'Maybe not,' said Fritz. 'But I can tell you it felt good! These damned pen-pushers make my blood boil. Civilization runs at a quarter pace because of the blind dictum that everything must be organized according to the book. Ticked off box by box.'

'I suppose it has its virtues, though.' Jacko was thoughtful. 'After all, look at these people,' he jerked a thumb towards the town. 'They can't muster a sufficiently collective effort to repair their own railways.'

Van Noon nodded absently. `And for why? Because they're running on the wrong philosophy. They can't do it because they're trying to reinstate the railways as they *used to be*. That's not the right attitude. There is no logic in believing a problem has to be solved in the same way now as it was done previously. This railway was a product of its own time—and times change. If you haven't the means to do what the other fellow did, then forget it and try something else.'

'That's what I like about you,' said Jacko. 'You consistently move in the opposite direction to everyone else. I seem to remember you were about to show us how to build a volcano-proof trestle without actually using any steel.'

Fritz smiled mischievously. 'Suppose we forget about trestles. Can you salvage enough scrap to manage the spans and the rails?'

'Sure. That I can find, but if it's not a rude question how do you figure to hold them up? Will power?'

'Not really. These miniature volcanoes all form cones of approximately the same height, and we can adjust that without too much hassle to even them out. So what does *that* leave us? Natural pillars of rock which will last a lifetime. Strap on a yoke, sling the spans between them and you have your railway.'

'Crazy like a fox!' said Jacko. 'It would work, of course —over a very short section, but I suppose that tired little brain of yours didn't also figure out how to manoeuvre a string of volcanoes into a straight line roughly approximating the way we want to go? Or do we build a crazy zig-zag track and use triangular trains?'

'No,' said Fritz, 'although the idea did occur to me. Also a proverb about Mohammed and the mountain.'

'Now I know you're nuts,' said Jacko. 'If you haven't got volcanoes then you haven't got any, and there's nothing you can do about it.'

'Is that so? Then I think you have something yet to learn. This may not be one of the most brilliant moments of my career but it may well prove to be the most spectacular.'

At the end of the line, where the next trestle ought to have been, Harris, and Fanning, the UE geologist, had the mobile drilling rig assembled. Fanning was taking core samples from the drill and shaking his head sadly.

'I don't like this, Fritz. We've penetrated to forty metres and the stuff is coming up hotter than hell. I should hate the drill to break into a high pressure region. We'd all be very dead, very quickly.'

'How near are we to a molten layer?'

'Can't tell exactly, but the ground-penetrating radar puts it at about seventy metres, plus or minus ten.'

'Near enough,' said Fritz. 'If the stuff the drill is picking up is fusible then I think we can stop right here.'

Fanning breathed a sigh of relief and began to withdraw the drill. When it was out they collapsed the drilling rig, and the bulldozer hauled it from the site.

Then Harris returned dragging a trolley bearing several metal cylinders. He looked a little nervous. Fritz waved everyone away from the drilling, pulled the pin from the safety-disarm and heaved one of the cylinders end-first down the well. Nothing happened except that after about a minute thick yellow smoke began to issue from the hole. Fritz cursed and, approaching warily, dropped another cylinder after the first.

He scarcely got away in time. There was a crack like the voice of thunder, and a ball of violent, sparking incandescence screamed into the sky. Then flames jetted up, a scorching burst of fire leaping from the soil

like some demented blow-torch. Molten magma, entrained in the superheated gases, was hurled high in the air and descended as a scatter of singeing hail driven on the light cross-winds.

The onlookers fled in confusion. By the time that Fritz reached shelter his uniform was smouldering in a dozen places and his face and hands were red from exposure to the heat and covered with superficial burns from the searing fall-out. Jacko had fared little better, having waited to make sure that Fritz was able to escape. They sat down on a broken slag-case, dabbing balm from a first-aid pack on their burns and watching the hectic blast as it roared into the sky.

Slowly the cone began to form as lava congealed around the flaming throat, and the fiery torch rode up with slow magnificence as the cone became a candle and then a tower with a bright and angry beacon at the top.

`Voila!' said Fritz. 'I give you a volcano.'

`Hell, I'll give you volcanoes! ' said Jacko, dabbing at his burns. 'Next time you try this Guy Fawkes stunt you're strictly on your own. What the heck did you drop down that hole?'

Fritz smiled. 'A thermite bomb—and a cylinder of oxygen for luck. The intense heat generated by the bomb just above a bed of active igneous magma was more than sufficient to trigger an eruption. This time the process was channelled by the bore-hole, so we got a cone instead of a puddle. We'll have to adjust the thermite charge to tailor the height of the resultant cone, but that's not difficult.'

`Per ardua ad asbestos!' said Jacko ruefully. 'Are you seriously suggesting we do this all the way to Hellsport?'

'Only where we have to,' said Fritz. 'And even that will take more thermite bombs than we can come by honestly. Fortunately there's a way round that. Up on the Juara shelf is the Command weapon stores. They've more munitions there than we're ever likely to need.'

'But will they let us have them?'

'No,' said Fritz, 'but that's never stopped Harris before.'

Several days later the new volcano was extinct. A crazy scaffold was set up round the cone and the top neatly truncated with power chisels and pneumatic drills. As a structure it stood supremely suited for its job. The siliceous rock had set like concrete, and had it been cast deliberately by hand it could not have stood more straight or firm. The yoke was placed around the cone top and secured by hooks into the narrow crater. Prefabricated spans were trimmed to length and joined up to the existing structure. The result was the finest trestle that Cannis IV had ever possessed.

For UE it was an hour of jubilation. The forgotten gimmicks and the half-formed innovations suddenly leaped to new promise now it was certain the line was going through. At the end of a three week burst of energy the last rail of the Juara line was bolted into place. The locomotive returned to Callin with improvised rolling-stock and two days later chugged triumphantly through to Juara with the first load of the finest bean harvest for years.

Then it blew itself to bits.

`And something else,' said Jacko. 'They've just arrested Harris at the Command weapons store. So we won't be using thermite bombs any more.'

It was summer in Hellsport. Flies and dust thickened the air, whilst the humid heat was relentless and intolerable. Even in the air-conditioned sanctuary of the Command HQ the fine dust crept through the filters and the humidity defied the monitors to hold the moisture content and the pressure down.

Sweltering in the heat, Colonel Ivan Nash was about ready to chew bricks anyway. So when the shouting began, he emerged from his office in a thoroughly bad mood. 'What the *fuck* is going on out here? He yelled at no-one in particular'

One of the native helpers said with sly humour, 'It is said that a train comes in from Juara bearing the greatest man on Cannis.'

'Nonsense!' said Nash irritably. 'There are no trains left on the Juara-Callin line.'

'That may be true,' the native answered smugly, 'but something is coming down the line. Look, you can see it for yourself.'

Nash fetched his field glasses and scanned the railway, which seemed to be dancing in the slow heat-haze. Something *was* coming down the Juara line, but the distance and the dust conspired to make identification impossible. Only when it grew nearer were the details of the vehicle displayed.

Nash choked and closed his eyes. 'That *bloody* man!'

The 'train' bore a curious resemblance to an army cargo helicopter, minus rotors, and slung on a low truck, the wheels of which were broad grooved rollers. Various items of machinery were slung about the outside of the strange assembly, and on the front, perched awkwardly and in imminent danger of falling off, was Malu. He was waving a large red flag . . .

The train entered the terminus, reversed to another rail, then shuttled back and forwards just to show the proficiency of its roller wheels in manoeuvring on any gauge of line. The local workers went wild with enthusiasm, and shouted and cheered until Nash thought his head was going to split. He was still staring from his office window when Fritz van Noon came into the room.

The Colonel weighed him up silently. 'All right, Fritz, you win—so far. I never thought you'd really make it. Too bad you had to step out of line to do it.'

'You didn't exactly help,' said Fritz. 'I thought we were finished when you had Ensign Harris arrested for stealing the thermite bombs. Fortunately Malu, our tame local genius, cooked us up a substitute using what I believe might be rocket fuel.'

'Well,' said Nash. 'A very worthy effort. Too bad I have to throw the book at you. Unorthodox engineering I could learn to stand, but stealing government property is a very different matter.'

'Is it?' asked Fritz. 'I have a warrant here authorizing the release of Ensign Harris. It's neatly signed, sealed and counter-signed by Terran GenCom.'

'No dice! ' said Nash. 'I mean to court-martial Harris good and proper. Even GenCom can't dictate to me on the internal administration of my own sector. With any luck Harris will still be in jail when the sun freezes over. And as soon as I can get evidence of complicity *you'll* be up beside him. Besides which—' he said accusingly, `—you haven't had time to get GenCom confirmation on a release warrant.'

'No need,' said Fritz complacently. 'I always have a release warrant for Ensign Harris filed away. We usually need it somewhere along the way.'

Nash stared at him grimly. 'You mean to say that this man's conduct is officially condoned?'

'Condoned?' Fritz chuckled. 'As far as I am aware the only crime Harris committed was to get caught. For that I will personally reprimand him.'

'But this is preposterous! ' said Nash. The man's a *thief*.'

'Well, yes. But that's his speciality. It took us a long time to find someone of his calibre. He's the man who obtained the suitcase nuke the navy used to end the rebel war. You wouldn't *believe* who's private arms cache it came from!'

'Jesus! This gets worse and worse,' said Nash, his voice rising with disbelief. `Do you mean to say you employ a known criminal because of his prowess at breaking and entering? What sort of trade classification do you call *that?'*

`Quartermaster,' said Fritz, with obvious enjoyment. 'We want equipment and supplies, and Ensign Harris gets them for us.' He shrugged. 'We don't ask too many questions, and anyway, it's a point of honour that he never comes by anything through the proper channels.'

`But . . . he . . . *why?*' Nash sensed he was losing ground.

`It's part of the fundamental philosophy behind Unorthodox Engineering.'

Nash chewed his moustache nervously. 'I've been warned about getting into an argument with you.' He returned to the desk and poured himself a drink. On second thoughts he offered it to Fritz and poured himself another.

`I don't doubt you can explain,' he said heavily. `I don't doubt your ability to talk your way out of anything. I'm just warning you it'd better be good. If I'm not convinced I'll have every man-jack of yours in irons before the morning.'

`I think not,' said Fritz. `I'm afraid you've been the victim of a slight deception. That crazy gang of bodgers of mine is not quite what it seems. This may be unethical, but if you attempted to take any action against us you'd be out of the army so fast you wouldn't have time to change your hat.'

'I warn you . . .' ground out Nash.

`Hear me out first,' said Fritz. 'Have you heard of Operation *Hyperon*.'

Nash nodded. `The deep-space penetration project. Exploring inward towards the galactic core.'

'Precisely. Well, UE is the lead team that's going.'

`I don't think I understand. Is this some sort of joke?'

`No, sir, very far from it. You see, in a deep-space expedition you can't afford to carry anything but men and the very minimum of equipment which will ensure survival. There are no supply ships, no machine shops, and no reference libraries in between the stars.

`So what type of men do you send? Physicists who are lost without a laboratory? Engineers who can't obtain any steel? No, you send the men who can make a plough out of a tree-trunk, a stone and a length of creeper. You send the men who have made a lifetime's habit of turning anything they could lay their hands on to their own peculiar advantage.'

`And that's the philosophical concept behind UE?'

`Just that,' said Fritz. `Ours is an age of highly complex technology. Specialization and standardization are the key-words of our civilization. But as the starships spread us further across space the strings which tie us to the centres of order and knowledge tend to become a bit tenuous. You can only take a certain amount of technology with you. Things come unknit.'

`A masterpiece of understatement,' said Nash. `Even on Cannis IV we created a technological monster. We tried to apply Terran know-how without having the facilities to back us. It didn't work.'

`Just so,' said Fritz, `hence UE. This is an experimental team chosen to a pattern decided after years of psycho-research. It's a completely flexible approach with no precepts sacred except that the *end justifies the means*. We have built a team which can construct the nucleus of a functional civilization out of bits of string and matchsticks if necessary. Our coming to Cannis IVwas simply an exercise.'

Nash picked up the phone and dialled a number.

'Bring Ensign Harris to my office immediately—and forget the guards. I'm ordering his immediate release. That's right, you idiot, I said "release"! '

He looked up at van Noon and slowly shook his head. From his desk drawer he extracted two glasses. 'You got any Scotch tucked away somewhere, Fritz?'

'Oh yes, I think I can manage that,' said Fritz van Noon with a straight face.

'I thought you might.'

The Subways Of Tazoo

One

"Lieutenant van Noon, report to Colonel Belling's office."

"Damn!" Fritz van Noon glared at the loudspeaker. "Sounds as though Belling's back and on the warpath again."

"Can you wonder?" Jacko Hine helped him out from under the tottering pile of half-assembled pieces. "Let's face it, Fritz, some of our recent projects have come unstuck in a rather spectacular manner."

"True," agreed Fritz, ruefully, "but never let it be said that the Unorthodox Engineers have produced a damp squib. Always our results have exceeded our wildest expectations."

"Or Belling's wildest fears," grinned Jacko.

As Fritz entered the office Colonel Belling looked up over the top of his old-fashioned half-moon spectacles. "Ah, van Noon! Just the fellow I wanted to see."

"Sir?" asked Fritz suspiciously. Colonel Belling was not a man given to cordiality towards his subordinates.

Belling smiled wolfishly. "I've just returned from the General Staff conference. Since you re-instated the railways on Cannis IV even the Old Man has been forced to admit that there may be occasions when unorthodox engineering has its virtues. For my part I felt impelled to point out that I'm trying to run a specialist engineering reserve, and that carrying the can for a complete squad of engineering illegitimates was not strictly within my terms of reference. As I explained, always I get stuck with the one engineer in a thousand who should never have left his mother's knee, let alone graduated from a university. The only repository I have for these mechanical misfits is the Unorthodox Engineering squad, where the damage they can do will at least be limited."

"That's a little unfair, sir . . ."

"I *know* what you're going to tell me! And I don't accept it. Engineering is a discipline, but the brand you people apply is strictly delinquent. Anyway, the outcome of the conference was that Colonel Nash, whom I'm beginning to suspect has masochistic tendencies, has volunteered to take the U.E. squad on the Tazoon expedition."

Fritz considered this for a moment. Tazoo was a recently-discovered planet orbiting Beta Centauri. Once home to a technologically advanced civilization, it was now a silent, abandoned world.

"Exactly what are they doing on Tazoo, sir?"

"Supporting the archaeological team. Life on Tazoo is now extinct, but we continue to find evidence that a well-developed civilization once existed there. In terms of knowledge to be gained it could be the most valuable opportunity ever presented to us."

He paused, and studied van Noon dispassionately. "It's doubtful if the Tazoons were human or even humanoid. The archaeologists tell me they became extinct around a hundred thousand years ago, and that creates certain complications. After that length of time there might not be much left for us to examine. Our problem is to pick up the remains of a complex mechanical culture as alien and as old as that and attempt to understand it for what it was."

"That shouldn't be impossible, sir."

"No, Fritz, not impossible, but definitely not easy. That's partly the reason I'm sending you. Your inverted-sideways approach is the nearest thing to an alien technology that we've got. That makes you a specialist."

"Thank you, sir," said Fritz warily. "And the other part of the reason we're going?"

"The climatic conditions on Tazoo are such hell that the average rugged ground-cat has a useful working life of about two weeks. That means the archaeologists can't explore far enough from base to expand their operations. Fritz, I want you to provide them with transport to where they'll be most use—and if you don't, you'd better find some other engineering reserve to come back to . . ."

"Yes, sir," said Fritz unhappily, "I get the point."

"You know, Fritz," said Colonel Belling, "I think we may finally have reached a point of real understanding!" He grinned wolfishly. "I'm going to rather enjoy the thoughts of you and the U.E. squad sweating it out in a hell-spot like Tazoo."

Touchdown on Tazoo. The transfer ferry had no viewports and afforded no opportunity for its passengers to receive a preview of their destination. Even the ground-cat which rendezvoused at the landing site close-coupled its hatches with the ferry's air lock before the transfer of passengers and goods began. In the cabin of the ground-cat, shutters likewise obscured the view and cheated Fritz of his moment of revelation.

"Allow me to introduce myself," said the cabin's occupant. "I'm Philip Nevill, Archaeologist in charge of this project."

"Van Noon," said Fritz. "Engineer extraordinary—and this is Jacko Hine, one of my staff."

Nevill grinned affably. "Your reputation preceded you, Lieutenant. Frankly, when I heard of you I persuaded Colonel Nash to get the U.E. squad here at any cost. There are things on Tazoo it'll take a very liberal mind indeed to understand."

The ground-cat struggled away from the ferry, its treads crunching through the sand and its engine coughing in asthmatic complaint.

"So I've heard," said Fritz. "Look, do you mind if I open the shutter for a second? I'd like to know the worst right from the start."

"Help yourself," said Nevill, "but I promise you it's a passion you'll soon lose."

Fritz fought the shutter from the window and peered out for his first glimpse of Tazoo. Heavy ochre-coloured cloudbanks filtered the furious sunlight to a baleful glare, and rendered all colours as murky shades of reds and browns. Black shadow cut the view into odd-shaped segments. The terrain itself was nothing but a lumpy, featureless waste as far as the eye could see.

"Satisfied?" asked Nevill.

Fritz dropped the shutter back and closed his eyes.

"Painful, isn't it?" asked Nevill. "Normal endurance is about forty minutes before red-blindness sets in. Very bad for the eyes, to say nothing of the psychological effects. And as if that were not bad enough; the planet has no ozone-layer, so ultraviolet radiation is extremely severe at all times."

At the blare of the ground-cat's horn Nevill opened the shutter again. "There's the base—way over yonder."

Fritz scowled at the deep-red panorama. Perhaps half a kilometre away was the base, like a cluster of cherries half-submerged in a basin of dirty pink icing.

"Underground, eh? A very sensible precaution."

"It isn't underground," said Nevill in a slightly aggrieved tone. "It's a surface installation."

"But I don't see anything but some almighty balls of mud."

"They're standard Knudsen huts with a protective skin on. There's a sandstorm that whips up every night which would sandblast an unprotected Knudsen to a skeleton before dawn. We spray each hut weekly with a highly plasticized poly-polymer which is reasonably abrasive resistant. The plastic traps some of the sand and this materially increases its resistance, but builds up and completely ruins the shape."

Abruptly the engine of the ground-cat coughed and died. Nevill held a rapid exchange over the intercom with the driver.

"Engine's gone," he said finally. "Either the carburettor's etched away or the damn sand has got into the cylinders— probably both. Anyway, this cat is a write-off for all practical purposes, so there's nothing for it but to walk—and it's too near evening for that to be funny."

They descended from the cabin, Fritz and Jacko choking quietly in the acrid air which caught at their noses and seared their lungs. Nevill, more acclimatized, was surveying the sky anxiously. Above them the swirling cloudbanks, smokey-red trailing into purple and black, plunged across the darkening sky so low that Fritz had an almost compulsive desire to put up his hands to see if he could touch them. There must have been a strong wind above, for the cloudrace was certainly moving at a significant clip, yet on the ground the warm humidity was almost deathly still, as though a sheet of glass insulated them from the driving turbulence above.

"Looks like a storm," Nevill muttered in a worried voice.

"Is that bad?" asked Fritz.

"Terminal if you're unlucky enough to be out in it. Let's hope it's a wet storm. They're decidedly uncomfortable, but not usually fatal if you can get to shelter quickly enough,"

"Why, what happens?"

"Nothing spectacular if you can find shelter from a hundred kilometre per hour damp sandstorm, and if you happen to have sufficient alkali available to neutralize the rain on your skin."

"Neutralize the rain?" said Fritz, his voice rising. "What the hell is *in* it?"

"Oh, about five per cent sulphuric acid plus a trace of hydrogen chloride with a little free ionized chlorine. Stings like crazy, I can assure you. But it's better than a dry storm."

"I'll buy it," Fritz said helplessly. "If a wet sandstorm is equal to an accelerated metal descaling process, what's a dry storm equal to?"

By now Nevill was deeply concerned, scanning the furious cloudrace with worried and experienced eyes. They were still three hundred metres from the nearest part of the base, with Jacko and the driver close behind.

"I think you're going to have a practical demonstration of a dry storm, Lieutenant. If the smell of ozone becomes intolerable or if you hear anything like a bee buzzing don't hesitate —just drop to the ground as fast as you are able. If you can find a hollow then roll into it, but whatever you do, be *quick."*

"A bee buzzing?"

"Air ionization path, the prelude to a lightning bolt. The cloudrace generates several megavolts, and it packs a current that can fuse you very neatly into the sand. The carbon from the body reduces a great many metal oxides in the ground so that the resultant slag forms a remarkable range of glasses." He looked round and Fritz saw the concern in his eyes. "I've seen it happen—not pretty!"

"Forget the chemistry lesson," Chimed in Jacko. "I never could see myself making a very convincing paperweight."

"Then *drop!*" said Nevill, suiting action to the words.

They all hit the ground. Fritz's nose didn't have time to detect the ozone, virtually paralysed as it was by the existing acridity, but his ears did register the sudden buzz which Nevill had anticipated by a half second. Then the lightning discharge, a *crack* of vivid energy a mere thirty metres distant. The noise and the shock-wave of its passing stunned them momentarily. By the time they had collected their wits only a generous patch of fused sand and a choking concentration of ozone marked the spot where the bolt had struck.

"Bad!" said Nevill, "Worst I've seen for some time. It's striking low ground, which means we have no possible cover out here. Best to crawl back nearer to the cat—-but for God's sake keep your heads low."

"But—" Fritz protested.

Another bolt of lightning, bigger and nearer than the first, stabbed into the sand behind them like the bursting of a shell, followed by three almost simultaneously in the near vicinity.

Desperately slowly the party crawled back towards the cat, which stood as the pitifully-low high-spot of this particular area of terrain. On all sides of them now the jagged lightning cut into the ground with burning shafts of vicious energy, like the arrows of retribution fired by some crazed electric god. Then a shaft burned down on the cat itself. The vehicle sagged in on itself and molten metal seeped down its flanks and dripped onto the red sand of Tazoo.

"Treads!" Shouted Fritz van Noon, spitting sand. "The bloody treads are *metal*!"

"Jesus!" muttered Jacko, "we've been travelling in a glorified lightning-conductor!"

Then mercifully it began to rain. Nevill turned his face to the stinging, acrid precipitation and let out a howl of relief. A few seconds later they were running like half-blinded madmen through the corrosive waters in the direction of the base camp, heedless now of the cracking lightning which had withdrawn to the edge of the rain belt. They were fortunately within a few steps of the base when the wall of sharp, abrasive sand, whipped to fury by a fantastic driving wind, bore down upon them out of the deep purples of the approaching night.

Two

"Welcome to Tazoo, Lieutenant!" Colonel Nash beckoned him into the office.

Fritz explored the still-smarting skin on his face and hands, and was still painfully aware of the puffiness around his eyes. "Thank you, Colonel. That was quite an initiation ceremony out there!"

Colonel Nash smiled fleetingly. "Unpremeditated, I assure you, but the weather is part of the reason you're here. A ground-cat is the toughest machine available, but as you saw for yourself, it's totally incapable of standing up to the environment. The low pH of the rain conspires with the sand to etch and tear the guts out of any transportation contrivance we've yet imported to Tazoo. When you consider atmospheric chlorine, hydrogen chloride, free sulphuric acid, plus high humidity and extreme ultraviolet radiation together with an additional nightly sandblast, you can guess that corrosion prevention isn't the least of our troubles."

Fritz shuddered involuntarily.

"I must admit," said Nash, "that I haven't always seen eye to eye with you before on the subject of unorthodox engineering, but if you can come up with a reliable way to transport the archaeological teams around this place I'll at least be open to persuasion. Certainly no orthodox methods can give us transport on Tazoo at a cost less than the total budget for the entire mission."

"What facilities have we?" asked Fritz.

"Anything you can find, basically. If you need anything shipped out from Terra you'll need a damn good case to get it because of shipping costs, not to mention the time-delays on freight movements. Certainly we can't afford to bring any more vehicles out here to be ripped apart. I'm relying on you to delve into your unorthodoxy and come up with something practical."

"What progress has been made here?" asked Fritz.

"A little, but slowly," said Nash, "largely because of the aforementioned transport limitations. Nevill's team have uncovered some real architectural monstrosities, but the real prize will be finding anything like technological artifacts. If they can do that, and if they're half as weird as the rest of this planet, it will require all of your peculiar genius to identify and interpret them. We're expecting to find some very unorthodox engineering from a culture which died around the time the last ice-age began on Terra."

"Have there been any signs of a highly scientific culture?" asked Fritz. "The reports I've read don't go into much detail on that."

"The preliminary survey party found signs that the Tazoons had visited both of the moons of this planet. And we're reasonably certain that they also reached the next planet sunward in this system and actually established a base there."

"All this sounds highly promising," said Fritz. "But a hundred thousand years is a long time. Would there be anything left of machines and mechanisms after such a period?"

"Normally no, of course, but Nevill theorizes that to develop a high-level functional civilization under these climatic conditions the Tazoons must have had some pretty sophisticated technology. Certainly, they knew well enough what they were up against."

Van Noon nodded. The trouble was that what was sophisticated technology to one culture, could be impenetrably obscure black magic to another. U.E. had come across one or two of those already . . .

"Furthermore," Nash continued, " the moist conditions don't penetrate very far down into the sand, so that the deeper an artifact is buried the greater are its chances of long-term survival. Deep exploration at a really promising site should give us a slice of Tazoon civilization in a very reasonable state of preservation. The bottom line is that we need only one good site to justify the whole Tazoon expedition." He glanced up at Fritz. "And that's precisely what I want *you* to help us achieve."

The next day Fritz found Philip Nevill in the Archaeological HQ, apparently none the worse for his previous day's exposure.

"Hullo, Lieutenant van Noon. What can we do for you?"

"Fritz. I hope you can answer a question. Do you know what happened to the Tazoons themselves—I mean, why did they become extinct so swiftly when they had achieved such an apparently high technological level?"

Nevill scowled. "You're equating technology with the ability to manipulate environment and thus ensure a higher survival potential." He shrugged. "I'm afraid I can't answer that. Indications are that they abandoned the populated areas *en-masse* and migrated towards the equatorial regions. From distribution figures it looks as though the entire population set out for the tropics and were decimated on the way."

He rubbed his hands over his eyes. "Fritz, this suggests they were fleeing from something biologically intolerable which claimed a great number in flight. That's our best guess"

"Drastic climatic change?" asked Fritz.

"Climatic, no—*environmental*, possibly. We looked for evidence of major climate changes, but there's nothing significant that we can trace. The only thing that is recent, geologically speaking anyway, is the sand."

"The sand?"

"Mmm. Probably the result of some ecological imbalance. The major plains appear to have once included prolific forests, such as are still to be found in places around the temperate belts. For some reason, drought or fire or blight perhaps, these forests died. The results were typically Terran in their inevitability."

"Soil erosion."

"Yes, exactly, and on a catastrophic scale. Once the sand got to work on the unprotected soil nothing thereafter got the chance to germinate. More soil dried up and blew away, hence more sand. We're still picking up viable seeds from the deep diggings, but all the shallow seeds are either dead or had started growth only to be uprooted."

"When did this happen—the erosion?"

"Can't tell with certainty, but it appears to slightly pre-date the extinction of the Tazoons themselves. Whether these two factors are related is something only further research can prove. But it seems likely. Does that answer your question?"

"Yes, but only to pose another," said Fritz. "I don't understand how any culture technically able to explore the neighbouring satellites could have been wiped out by anything as foreseeable and reversible as soil erosion. And why migrate to the tropics when the soil fertility remained in the temperate belts?"

"I don't know," said Nevill honestly. "It's a difficult problem. The Tazoons were not even humanoid, and the probability is that neither their physiology nor their culture had anything in common with our own. It could be very misleading if we attempted to interpret their actions by simple extrapolation of what *we* might have done in similar circumstances."

"A good point," agreed Fritz. "I don't necessarily *agree* with it, but I'll bear it in mind. Thanks, Philip, you've given me something to think about."

Having established that the U.E. squad was reasonably well quartered, Fritz turned his attention to the transport problem. This brought him back to Jacko who had compiled a transport survey which he presented with as much enthusiasm as if it had been his own death warrant.

"We're in trouble, Fritz. Of the thirty ground-cats originally provided for the enterprise only ten are still functioning. Two hundred hours operating life on Tazoo reduces a cat to a condition where you couldn't sell it for scrap. By sorting bits and pieces we could probably reconstruct another couple of cats, but no matter how you cut it, it's not going to be very long before we start walking."

Fritz stared disconsolately at a virgin notebook. "What about tractors and heavy equipment?"

"They're not too bad—but only by virtue of the fact that most of them are still in sealed crates. Once they're broken-out there's no reason to suppose they'll last any longer than the cats do. This combination of corrosion and abrasion is something to which I'd not cheerfully expose a clockwork mouse."

"All right," Fritz sighed. "What protection can we give to the cats to extend their working life?"

"A lot of the vehicle we can plastic coat, as they do with the Knudsens. The engines are a more difficult problem. Some genius thought of providing them with standard aluminium-alloy turbine housings, and what the Tazoon atmosphere does to the alloy makes my flesh creep. Even the vitreous liners *de*vitrify and release particles of silica into the bearings."

"Don't bother to describe," said Fritz, "what that does to the bearings. I think we have to face the fact that while we might save most of the cats themselves we aren't going to be able to save many of the engines. We could devise a system of enclosing the engines in an inert atmosphere— but I doubt if we have the facilities here to do a permanent job. We then also need a supply of controlled pH, moisture-free oxygen for the air intake. I think we could produce that by electrolysis, but I doubt if we can handle it in sufficient quantities to be of much value."

"And so on *ad-infinitum,"* said Jacko ruefully.

Fritz nodded. "Well, let's try it anyway. I want two cats modified. Plastic-coat them everywhere possible, seal the engine compartment and fill it with a nitrogen and hydrogen mixture of non-ignitable composition. Get our micro-Linde column working for the nitrogen and make an electrolysis plant for the hydrogen. You'll need both the Linde and the electrolytic plant to get enough oxygen for the air-supply for the engine intakes, and you'd better dilute the oxygen with any nitrogen you can spare, then adjust the turbines to run on that."

"And what do I keep the oxygen in?" asked Jacko.

"They've a fair supply of the plastic poly-polymer they use for spraying the huts. It shouldn't be beyond our capacity to blow a gasbag from that."

"It all sounds feasible," said Jacko after some thought, "but I doubt the capacity of the micro-Linde to give us all the nitrogen we need."

"So do I," nodded Fritz, "that's why I said to modify two cats only. There's plenty of other things to try, but this is the most obvious, and we've neither time nor the resources to start nitrogen fixation in a big way." He went to the window, opened the shutter and stared moodily out at the red and featureless wasteland.

"Sand," he said. "Nothing but *bloody* sand, fine-grained, abrasive and all-pervading. What we need, Jacko, is something completely new in the way of transport on Tazoo. I wonder what the Tazoons themselves employed."

Three days later and the modification of the cats was in full swing. Fritz had just returned from inspecting the work when the radio buzzed.

"Lieutenant Van Noon."

"Fritz, Nevill here. I've got some work for you."

"Bring it over," said Fritz. "A little more won't make much difference."

"Right. Be with you in about ten minutes. We've found what might be some sort of mechanism."

"Now you have me interested," said Fritz. "What is it?"

"That's what I want *you* to tell me."

Ten minutes later Nevill arrived and eyed the jury-rigged electrolysis plant. Then he signalled to his assistants who dragged a large object into the hut and dropped it on the floor. Fritz looked at it dubiously.

"I think you've come to the wrong department. It looks like the great grandaddy of an alien chicken wishbone once belonging to some grandaddy alien chicken. Why not present it to the biology department?"

"I did," said Nevill, "but they sent it right back with the message that you were responsible for investigating machinery."

"Machinery?" Fritz surveyed the acquisition moodily. "Have you tried it on the catering people? Perhaps they could turn it into some sort of soup."

"Machinery," said Nevill firmly. "And I'll tell you why. It isn't animal, it's vegetable—Tazoon ironwood to be precise. Also, it didn't *grow* that way. It was manufactured, or at least trimmed to shape, as witness the tooling marks. Furthermore, the Tazoons were plenty fond of them because the Southern plain out yonder has them at an estimated density of nearly fifty thousand to the square kilometre."

Fritz choked on his words. "*Thousand?*"

Nevill nodded. "And that plain is pretty big. If the sampling we have done is representative of the whole area there could be many millions of them on that one site alone. I know the Tazoons were alien beyond our conception of the word, but I just can't see them producing that many just for the hell of it. That would be an exercise akin to paving the Sahara desert with pencil sharpeners. It's my belief that the wishbones are something functional. I want you to tell me what they were and what their function was."

Fritz nodded. "I'll let you have a preliminary report in a day or so, but if that's a machine I should hate to see their idea of a great big alien chicken wishbone."

After Nevill had left, Fritz spent a quiet hour examining the thing from all angles and going all over the surface of it with a magnifying glass looking for clues as to its function. Then Jacko had it hauled to the workshop for a more thorough examination. He reported back when the work was completed.

"I think we have something here, Fritz. You know those nodules on the inner surfaces, well, the fluoroscope shows a dark mass of some foreign material in each. If you're agreeable we're proposing to cut one out and see what it is."

"Start cutting," Fritz said, "because if this is a sample of Tazoon engineering then the sooner we get to grips with it the better."

Reluctantly the handsaw cut into the ancient ironwood. Halfway through, the blade screeched complainingly on some hard inclusion. Jacko made another cut at a tangent and suddenly the nodule became detached, and from inside it he shook a large, dusty crystal on to the table.

"Now *that's* interesting!" said Fritz. "There are metal fibres in the structure of the carcass and metallized facets on the crystal. On this evidence I'd say this was some form of piezo-electric device. And see how the crystal is drilled— do you suppose there could have been strings across this thing?"

Jacko counted the nodules—equal on both sides. "Lord, a harp!" he said in a voice heavy with incredulity.

Fritz stared at him dubiously. "Or a sound-transducer," he said. "There are common electrical paths through the ironwood, and connections to the crystals. If you applied an alternating current to those contacts, the crystals would excite the strings in sympathy according to the resonant frequency of the particular system. I wonder what on earth it would sound like?"

They looked at each other in silence for a time.

"Jacko, start re-stringing what's left of this thing while I sort out a power amplifier and a few bits and pieces. Together we can make some be-eautiful music."

"Right," said Jacko, "but if your conception of music is anything like your engineering I'm going to dig out some earplugs too."

Three

It took three hours to complete the assembly. Fritz disappeared to the communications hut and returned with an assortment of equipment which he appeared to assemble more by inspiration than by design. When everything was ready he switched on. The first results were shattering, and the electronics needed drastic revision before a reasonably tolerable result was obtained.

After some final adjustments Fritz pronounced himself satisfied with the results and dropped into a chair to listen attentively, his gaze wandering to the open shutter and the blood-red sunset trailing nakedly beyond.

"Listen to it, Jacko!" said Fritz happily. "Alien and beautiful beyond recall."

"I might just point out," said Jacko, "that if somebody attempted to re-string a hundred-thousand year old grand piano with random electrical cable and without any idea of the scale and pitch involved, the results would sound equally alien."

"I'm in no mood to quibble with one who possesses such a tiny soul," said Fritz. "To me this is music such as the ancient Tazoons knew it as they walked hand in hand in the eyeless evenings of old Tazoo. Can't you *imagine* it, Jacko, this incredible music voiced by a million harps in the blood-red twilight of this alien land?"

"It makes my head ache," said Jacko. "What are you feeding into the blasted thing, anyway?"

Fritz coughed. "Actually it's the telemetry signals from a weather satellite, but the harp contributes about five-hundred per cent distortion, so you'd never know it from music."

"You ought to be locked up! Isn't there something distinctly loony," said Jacko, "about the notion of anybody wanting thousands of crazy self-playing harps to the square kilometre. No culture could be *that* fond of music and survive."

"They *didn't* survive. And we can't yet hope to understand so alien a culture. If you want a parallel, think of all the millions of personal transistor radios taken to the beaches on Terra on a public holiday. Think how much simpler life would be if they erected loudspeakers at four-foot intervals on all beaches and made full-time listening compulsory instead of merely unavoidable."

Despite the warmth Jacko shuddered visibly and closed his eyes, while the complex tones of the harp sang strangely with unfathomable harmonies which did curious things to his stomach. "I'm beginning to get the idea," he said, "exactly why the Tazoons decided to migrate. Listening to this, I get precisely the same urge myself."

At that moment the door was flung open and Nevill, eyes aglow with jubilation, burst into the hut. "Fritz, we've *done* it! A real find at last. To judge from the extent of our soundings we seem to have hit upon the location of a whole damn Tazoon *city* under the sand."

Fritz raised a hand in salute. "Congratulations, Philip! This sounds like the breakthrough we've been waiting for. Exactly where is this place?"

"Under our very noses in fact—about twenty kilometres east of here. I tell you, Fritz, there could be a real *metropolis* down there."

He stopped, aware for the first time of the singing harp.

"What the *fuck* is that?"

"A genuine Tazoon harp in action," said Fritz modestly. "Don't you like it?"

"No," said Nevill, "because it isn't right. Nobody, however alien, would want more than one of anything that sounds like that. Besides"—he winced as the harp screeched into an entirely new scale—"the Tazoons had very small ear cavities. Their audible range was undoubtedly in the medium ultrasonic.

Frankly they could never have heard anything pitched as low as that. Sorry! Try and make it do something else like lighting fires or something."

And so saying, he was gone, leaving Fritz looking frustrated and trying to avoid Jacko's eyes. "All right," he said, "so even *I* can't always be right first time." He turned off the amplifier disconsolately. "I still think it was a good idea."

"That's the second of your good ideas that has run off the rails today," said Jacko, fingering his ears.

"Second?" Fritz looked mildly surprised.

"Yes, I forgot to tell you. Your idea for obtaining pure nitrogen for the cats by fractional distillation in the micro-Linde didn't solve the problem, it merely transferred it. The blasted Tazoon atmosphere's eaten the guts out of the Linde compressor."

"Damnation!" said Fritz. "You'd better get the boys together, Jacko. I want every repairable ground-cat and tractor prepared for operation, and as much heavy lifting and moving tackle as we can acquire."

"What are you planning, Fritz?"

"Let's face it, Jacko, we can't keep enough transport in service to do the daily forty-kilometre round-trips to the new site for very long. If that *is* a major site they've found, there won't be much point in having a base camp this far distant. The logical thing to do is expend all our resources, moving the whole base to the new site."

"Jeez," muttered Jacko. "It'd take months to dismantle this lot and transport it that far."

"I said nothing about dismantling. A Knudsen hut is a unit structure. It is capable of being moved as a whole with reasonable care. Can you think of any reason why we shouldn't just attach a cat or tractor to each hut and haul it bodily over the sand to the new site?"

"Yes, Colonel Nash and the base psychiatrist, to name only two. A Knudsen could never stand a belting like that and finish in one piece."

"Ordinarily, no, but these have been covered with alternate layers of resin and sand to a thickness which has become ridiculous. Dammit, Jacko, you've got a metal and sand-filled resin laminate there which must have all of a hundred and fifty times the strength of the original hut."

"You're dead right, of course," said Jacko. "But I'm going to love seeing you try to explain it to Colonel Nash."

"All right," said Nash, eventually. "You can start moving the base just as soon as the necessary cables and services have been laid. I don't need to remind you that everything has to be fully secured by sundown. And I warn you that if anything goes wrong . . . "

He leaned back speculatively for a moment.

"You know, Fritz, I must confess I'm disappointed. I'd expected great things from unorthodoxy, but when it comes to the point you can't even promise to keep a decent transport system in operation."

"A snowflake," Fritz protested, "wouldn't stand much chance in Hell unless you had a ton of refrigeration equipment alongside. The fault is not being in Hell, but in being a snowflake. You've got a roughly similar position with your cats on Tazoo. A suitable cat could easily be designed for these conditions, but it would need Terran resources to build it and a long haul to bring it out here. The cost would be astronomical. The limitation is in associating transport with the idea of a ground-cat."

"I'm perfectly aware of that," said Nash. "In fact it's the reason I sent for you. You have the reputation for producing the impossible at very short notice. All right—I challenge you to produce."

"Miracles we perform immediately," said Fritz morosely. "The impossible takes a little longer. After all, we've only been here a *week."*

Nash watched him narrowly for a moment. "Fritz, frankly I don't believe anybody has the remotest chance of doing what I ask, but I'm calling your bluff. If you have any sort of transport running on Tazoo in three months' time I'll be glad to take back all the harsh things I've ever said about U.E. If you don't I'll have to send you back to Terra. This expedition wasn't designed to carry any dead weight."

"It's a challenge I'll accept," said Fritz, "but don't expect to equate transportation with any vehicular form you're used to, because the chances are a million to one against it looking like anything you've ever seen before."

Jacko was waiting for him outside the office. "Bad?" he asked.

"Not good," said Fritz. "We've got three months to crack the transport problem or get kicked out as a bunch of no-good layabouts. The honour—even the continuance of U.E. —is very much at stake. Somehow

we've got to contrive some sort of vehicle, and this in the face of the fact that we have no source of constructional material capable of withstanding the Tazoon environment."

"So where do we go from here, Fritz?"

"Damned if I know. You go and check the arrangements for the big move. I'm going over to the site to see how friend Nevill is doing. He may have dug up a little inspiration out there—and Heaven knows I could use a little right now."

Nevill saw the cat drawing across the rouge desert, and came to the edge of the workings to await Fritz's arrival.

"How're things going, Philip?"

"Just great! We knew we had a major find, but this—this is paradise! We're going straight down on a major city by the look of it, and the stuff on the lower levels where the sand is dry is in a perfect state of preservation. Some of the three-storied buildings are so sound that we'll be able to use them for our own purposes. I tell you, Fritz, Tazoo looks like paying off about two million per cent interest. The complete analysis of the stuff found here will occupy generations."

Fritz gazed down into the broad quarry which was the site of the workings. On every hand the feverish activity of the archaeological teams pointed a measure of the excitement and enthusiasm which infected everyone concerned. The shifts had been voluntarily lengthened, but even so, the end of the shift period had to be declared a compulsory cessation of work. Even then it was difficult to actually get some folk off the site and into their beds.

Here and there alien towers were already exposed above the sand, unimaginable obelisks of incomprehensible architecture, curiously distorted and decayed by time and the ravages of wind and sand. Some, the sand shored back to greater depths, were firmer on the lower levels, and the architecture was even more marvellously apparent. Occasionally, vertical pits descended at points where logic had decreed there lay something more Intriguing or exciting or simply yielding greater bounty for the effort it entailed.

Fritz was fascinated beyond measure. The sheer otherworldliness drew his imagination on with an inescapable lure. As an engineer he fought to tame the logic of the structures which were being uncovered before him, but something in his soul trapped him in the wonder of the whole. He was the technologist who came for a dispassionate analysis and stayed to gawp.

Nevill watched him in amusement. "I know, it takes us *all* like that. It's both wonderful and sad to be uncovering the remains of so great a culture: wonderful because the culture was so great, and sad because we find their city empty of the creatures who created it."

"What the hell happened to them?" asked Fritz. "After they'd got all this way? They had mastered their environment to a degree comparable to ourselves, then in the space of a few short centuries they faded and died away––and then the sand moved in and covered all their marvels. But what *happened?* It's something we must discover in case one day we're faced with it ourselves."

Four

By sundown the last hut had been transferred to its new position near the workings. The day had been one of great activity intermixed with frustration. As Fritz had expected the huts had proved themselves capable of being moved bodily across the sand, but the condition of the cats and tractors was such that the path of the move was plainly marked with a trail of abandoned vehicles spread broadly across the sandy steppes. Indeed, by the end of the day only five cats remained in operation.

After organizing a team to recover any repairable machinery, Jacko went to look for Fritz and found him in the workshop idly strumming the Tazoon harp with the air of a man evoking the muses as an aid to inspiration.

"You know, Jacko, I wish I could work out what happened to the Tazoons. I simply can't understand why such a highly advanced and organized culture should suddenly fall to pieces. Planetary war—or assault from outside—would have left obvious traces, recognisable even after this long. It's a highly disturbing thought that a catastrophe which could destroy a race with significant levels of technology could leave so little trace. It's as though they suddenly closed the doors and walked out to die on a mass trek to the equator."

"What about famine?" asked Jacko.

"Possibly. That's virtually what Nevill suggested—widespread soil erosion. For some reason the major forests in this zone died suddenly. That rather suggests a prolonged drought—but you'd think a major technology fighting for survival could cope with that. The sea is an atrocious mineral stew, but I'm willing to bet you could desalinate enough water to maintain a pretty fair agricultural belt if the need arose."

"But without nuclear energy where would you get that sort of power?" asked Jacko. "Distillation of sea-water on that scale would take a great deal of energy. And we've seen nothing that might suggest the remains of fusion plants."

"Even the more primitive sort of fission reactor would have left pretty obvious traces. I know." Fritz sat up. "*That's* the crux of the problem! Come to think of it, where *did* they get their power from anyway? Let's put a few facts together. We know that at a certain stage in the history of Tazoo something happened—something which in the span of a couple of centuries destroyed the civilized inhabitants of the planet.

"Curiously, the wildlife forms survived for a considerable time afterwards, and some are still to be found in the forest belts. Now the basic difference between civilized and wild-life forms is that the former are power dependent animals while the latter are not. Jacko, you've hit upon the heart of the matter, and no mistake."

"It's just a gift," said Jacko modestly.

"Then seeing it didn't cost you anything, see if you can stretch it a little further. Let's play for a moment with the assumption that the Tazoons had become power-dependent creatures—as we have ourselves. What would their basic source of energy have been, and why did it fail so suddenly and disastrously?"

"Oil or natural gas, perhaps," said Jacko.

"Not very convincing. By all appearances the Tazoons were great power users. From what Nevill's uncovered recently I'd say the power consumption in this area alone must have been quite enormous even by Terran standards. Now, you don't develop a heavy power-consuming technology without creating the resources to maintain it. To do otherwise would be technological suicide."

"That's assuming they thought about the problem in the same way that a human being would."

"I wouldn't know about human beings," said Fritz drily, "but engineers I *do* know about, and their thought processes must be essentially similar whether they have one head or six. There are an infinite number of ways of solving any engineering problem, but the simpler answers will always look familiar. It's just the nature of the beast.

"Give a ten-armed Dingbat a head of steam and tell him to convert it into electrical energy. I don't care what the influence of his racial characteristics, training or personal geometry, he's going to produce something that any engineer would recognise as a turbine generator. So, I don't think we can go far wrong if we tackle this problem from our own standpoint, and currently we are assuming they had a power supply which appeared infallible yet failed. Now we need to know what was the *source* of that energy. If we knew that maybe we could work out why it stopped."

The portable radio squawked and Fritz picked it up.

Nevill. "I'd like to see you first thing in the morning, Fritz. There's something I want you to take a look at."

"Okay. Something promising?"

"Oh yes. The team has just uncovered something which looks like the entrance to a mine of some sort. Perhaps you'd like to look it over."

"We'll be there first thing," said Fritz, and dropped the handset back on the desk.

"What's up?" asked Jacko.

"Nevill's team have discovered what he thinks may be the entrance to a mine."

"In the centre of a city?"

"Yes, that's what I thought, too," said Fritz. "I don't think that a mine as such is particularly likely, though it might just be connected with our lost energy source—or he may have stumbled on something I've been looking for myself."

"What's that?"

"Jacko, in a city as large and as complex as this one appears to be, where's the logical place to put the bulk passenger transport system?"

"Underground," said Jacko, "same as always."

"Precisely, and that's what I'm hoping Nevill's hit upon."

"God!" said Jacko. "An alien subway scarcely bears thinking about."

Fritz van Noon stood in the glare of floodlights, watching Jacko Hines pack spare torch batteries into his belt pouches. Then they moved cautiously through the doorway.

Further in from the door they had to use the flashlights. Here the sand had not penetrated so deeply, and by the time they had reached the head of the shaft only a brief dusting covered the floor.

The shaft was equipped with the normal Tazoon-type stairway—a central pole with round horizontal bars set in a helix, but on a broader pattern than they had encountered hitherto and with a deeper pitch. Such a stairway was not adapted to human physiology, but it was traversable—just— by those with climbing experience or suicidal tendencies. Jacko had neither.

"Down?" he enquired, his torch failing to probe the darkness of the alien depths.

"Down," confirmed Fritz. "Where's your sense of adventure?"

"It remained firmly embedded in my childhood," said Jacko, "along with the sense necessary not to get into situations like this."

"Down!" said Fritz firmly, and led the way.

Together they climbed down perhaps one hundred metres. Since it was impossible both to climb and hold a flashlight, this was accomplished in total darkness, and the steady rhythm of the climb from bar to bar exercised its own almost hypnotic fascination. Both had to stand for many seconds at the bottom to re-orientate their senses.

The preservation of the passageways at that level was remarkable and probably complete, and the air was cooler and less aggressive than above. Remarkable also was the dryness of the connecting tunnels which had lain for so long at such a depth, indicating the complete lack of a water table above the level of the deep-welled seas of Tazoo. The walls here were of metal, curiously wrought in a manner which might have been functional or might have been symbolic; and the alien strangeness of a completely artificial Tazoon environment gripped at their hearts with a half fear which had nothing to do with self-preservation.

For the first time they felt the full impact of standing in the presence of the unimaginable achievements of a culture which had no common roots with their own. They could vaguely comprehend but never predict the unfolding of the unearthly technology which surrounded them.

Machine or effigies, they had no means of knowing which, stood like dark, mute sentries in the uncertain, shifting shadows of the torch's beam: the tortuous walls and fluted ceilings were channelled and moulded with a thousand metal mouths connected to unguessable throats for unfathomable reasons—only the floor approximated its Terran counterpart, having a common engineering function of providing an unimpeded pedestrian passageway.

They turned another corner and stopped abruptly when torchlight soared into empty darkness and encountered nothing. Their consternation was relieved by the realization that they were now looking along the length of a vastly greater tunnel. Vaguely they could trace the complex vaulted roof rising to its apex in a series of panels shaped more like sculpture than supporting structure. At their feet the floor continued unchanged as far as torchlight could reveal, while to their right the level dropped abruptly perhaps two metres to form a channel of about seven metres width. Beyond the channel the walls rose again, arching upwards.

"Are you thinking what I'm thinking?" asked Fritz.

"Uh!" said Jacko. "No matter how you build it, a subway station is a subway station is a subway station, and this is one such."

"I agree," said Fritz. "Let's have a look at the rails."

"No lines," said Jacko at last, his voice tinged with disappointment. "It could be that we're wrong about this place. Perhaps a sewer . . ."

"I'm not wrong," said Fritz. "I'd know a subway when I found one even if I was deaf, blind and locked in a box. It's part of the chemistry of whatever genes conspire to make an engineer. Here, help me down, I want to explore."

"Don't you think we'd better go back and get some reinforcements?" said Jacko. Fritz had started along the channel to where it entered a somewhat smaller tunnel undeniably reminiscent of a Terran subway. "For Heaven's sake, Fritz, you don't know what you might find in there!"

"What's eating you, Jacko? Not losing your nerve all of a sudden?"

"No, it's just that walking down a tunnel that *might* contain an emergent subway train goes against my finer sensibilities—even if it *is* thousands of years behind schedule."

Fritz took fifteen paces into the tunnel and let out a whoop which paralysed Jacko with fright.

"Jacko, get down here quick! I've found one."

"Found one what?" asked Jacko when he had regained control of his vocal cords.

"A train, you idiot. I've found a bloody *train!* Bring your torch in here."

Against his better judgment Jacko dropped into the channel and followed Fritz into the tunnel. Then with a churning stomach and racing brain he examined the artifact which barred their further entry.

"That," he asked finally, "is a train?"

"It can't be anything else," said Fritz, not very happily. "It doesn't appear to be a signal box and there's not much point in having a wrought-iron summer house this far underground. It appears to be the right shape to fit the tunnel so it's probably either a highly ornate tunnelling machine or else it's a train."

"Alien!" said Jacko in awe. "The connotations of that word get lost by common usage. It doesn't begin to convey the mind-twisting sense that everything you know and believe has been scrunched up and re-sorted by a different kind of logic. These beings had different values and different basics, and it makes the mind squirm even trying to re-adjust."

"They didn't have different basics," said Fritz, "they merely had a different emphasis on the relative values of the *same* old basics. We can't yet try to comprehend the culture, but when it comes to unravelling their engineering I think we'll find we have a great deal in common."

"Like an iron-lace potting-shed without wheels or tracks which we presume to be a train simply because it doesn't appear to be anything else?"

"Just so," said Fritz. "We have to separate the mechanics from the culture. So far we've found very few Tazoon applications of principles of which we were completely ignorant. Of course, they were streets ahead of us in some fields and curiously lacking in others—they had no organic chemistry, for instance. But failing the practical application of black magic, *that's* a train. And it's only a matter of time before we find out what made it go."

Cautiously they squeezed down between the curious vehicle and the tunnel wall, the better to examine the odd-looking thing.

"It's a crazy, twisted birdcage," said Jacko finally. "An appliance for containing crazy, twisted birds."

Fritz looked up from the complex of curiously wrought mechanisms. "We'd better get some more lights down here, and muster some of the squad. I want this insane tin can taken to pieces, and put together again when I've had a chance to examine the bits."

"Cannibalization I can understand," said Jacko, "but why the resurrection?"

"Because," said Fritz van Noon, "if it's the last thing I do I'm going to put the subways of Tazoo back in operation. We obviously can't build a transportation system on the surface, that's a lost cause. But here we have a ready-made nucleus which already goes halfway to meet the problem."

"I demand to be invalided out of the Service on the grounds of insanity," said Jacko, "*your* insanity. I thought we'd had enough of railways on Cannis IV."

"That was different," said Fritz. "There, we were merely up against physical obstacles such as errant volcanoes. This is specifically an exercise in matching technologies. All we have to do is to determine which part of the railway system moves and which part is intended to stay still. That shouldn't be too difficult, now should it?"

"Not when reduced to such basic terms," Jacko agreed dourly. "But I know you. You never know when you're beaten,"

"I've told you before," said Fritz sternly, "there's no such thing as a physical impossibility. A limitation is a state of mind, not a question of fact. Here we are faced with the work of a completely alien race who nevertheless had a technological and scientific level roughly comparable to our own. Providing we hold that one fact paramount we ought to be able to unscramble any device this planet has to offer— and make it function for our own service if we wish."

"Providing one thing holds good," said Jacko. "We have first to be able to recognize an artifact for what it actually is. It's no good dismantling a Tazoon milk-strainer if we're under the impression that it ought to be a microphone—or vice-versa, come to think of it."

Five

Fritz reported back to Philip Nevill. The latter listened to the details of the find with the air of suppressed jubilation which was rapidly becoming his permanent expression. Then he ran his fingers through his untidy hair and searched for his pipe with a distracted grin.

"Fritz, this is perfectly marvellous. What a day we've had! We've opened up so many promising new lines of research that the whole damned thing is getting out of hand. We could do with a hundred trained archaeologists to digest the meat in this lot, and even then we couldn't do more than scratch the surface. The impact of building techniques alone on Terra is going to be extensive.

"If you really want to make your mark on this project, then take over this subway completely, because I shan't be able to get round to it for five years at least. Do a complete technical run-down on it, as detailed as you like. Do anything you like with it which won't impair its archaeological value. All I ask is a comprehensive progress report in time for each data shipment to Terra."

"Fair enough." said Fritz. "Later, I want to open up the buildings directly above the station to look for ancillaries."

Nevill glanced at his sketch map and drew a line through two diagrammatical blocks. "It's all yours," he said, "but don't drive yourself twitchy trying to comprehend too much too fast. You have to *absorb* alien environments rather than understand them. Sooner or later the pieces fit themselves into place. And Heaven knows there's enough pieces available for fitting—a jigsaw embracing the life and work of a complete culture."

"Seems that we've just got ourselves a subway," said Fritz, as he rejoined Jacko at the workings. "We need to make some progress. Lets open up the building here and see what's inside."

"Who's we?" asked Jacko suspiciously.

"You," said Fritz. "I'm going below again to see if I can trace any control connections running up from below. I want you to go in there and see if you can find anything similar running down. We'll meet at the end of the shift and compare notes. You know what to look for—cable groupings or isolated wiring; anything which suggests that it might have a control or power function."

"You're really set on this idea?" Jacko said. "About using it, I mean."

"Certainly," said Fritz. "Let's face it, if Fritz van Noon can't restart an alien subway then who the blazes would you *expect* to do it?"

"That's what I've always respected about you, boss—your modesty," said Jacko.

An hour later they met again at the portals of the building.

"There's a sort of power and control complex which appears to come down somewhere near the further end here," said Fritz.

Jacko nodded. "I'm sure I came across the other end of that," he said. "There's a channel running through the basement of the building, and the complex rises into that, and is then split into sections which are fed to the floors above."

"What's it like in there?" asked Fritz.

"Weird," said Jacko. "There's no other word to describe it. It's like the epitaph to an insane, overgrown spider with compulsive delusional tendencies."

Fritz grinned. "I can imagine it all too clearly."

Jacko's description of the basement of the building was, if anything, an understatement. The ground floor proved inconceivably worse, and the situation deteriorated rapidly as they ascended to the higher floors. The subway had possessed the crude simplicity of a functional unit, but the detail and complexity of the levels in the building above defied analysis or description. For a long time no object which they examined provided any sort of clue as to its function, and they traversed the cluttered levels with an increasing sense of dismay and frustration. As with most of the larger buildings only the top storeys had suffered any considerable decay, and the sand and damp had not penetrated into the interiors to any great extent, so that the state of preservation on the levels in which they were interested was impressive.

However, Fritz's spirits were nearing their lowest ebb as he battled with an ocean of incomprehensibilities. When he wandered into the final gallery, he stopped, groping for form in the alien pattern, then seized a glimpse of illuminated understanding and fanned it into a flame.

"Jacko! Do you know what this *is?* Don't you see—electrical control gear."

Jacko was unimpressed. "If this is their idea of electrical control gear I should hate to see their version of a collection of crazy, twisted maypoles."

"It doesn't matter," said Fritz. "The approach may be alien, but the underlying logic is inescapable. Unless I miss my guess this is an automatic switching system, and from its complexity I should think it's pretty comprehensive. It may even be the only switching system for the whole of the Tazoon subways. You realize what that means?"

"About fifteen years' circuit analysis," said Jacko morosely.

"No—well, *yes*, but look at the condition of this stuff. The preservation is as good here as it is in the subway itself. The chances are it's still functional. We might only have to re-connect the power to get the whole thing back into operation."

"Perish the thought!" said Jacko. "I may be a bit naive, but assuming—just for the sake of argument—that what we've found *is* a subway, where would you get the energy to power it? Subways need a lot of power, and if the Tazoons ran out of it where are you going to get more?"

"We'll worry about that later. It may not be easy, but I have one advantage the Tazoons didn't have—access to the complete technologies and resources of a scientific culture. And one quite alien to anything here. We could possibly persuade Colonel Nash to bring an MHD oscillating-plasma generator out from Terra, but it would need a lot of shouting. As an unorthodox engineer I'd prefer to locate the original Tazoon power source and see if a completely fresh engineering approach could start it producing again."

"So what's the plan?" asked Jacko.

"Hmm, get Harris and a couple of the electrical boys to join me here to try and analyse the circuit logic. Meanwhile you take the rest of the squad below and start dismantling the train. Between us we should discover enough about the way the Tazoons handled electricity and mechanisms to have a fair idea of how to make things work."

"You think so?" asked Jacko. "I still haven't forgotten what you did to that damned harp."

Fritz's team did indeed manage to isolate a certain amount of circuit logic, and once a few principles were established the work progressed rapidly. They concentrated mainly on the huge switching columns, swiftly realizing that what at first sight could be mistaken for relative crudity was in fact a cunning and sophisticated short-cut technique to solve a highly complex sequence-switching problem. Among other things they discovered that the assembly was probably built to handle alternating current with an efficiency peaking at about ten kilocycles a second, although such periodicity seemed unlikely in practice.

The current handling capacity of the assembly was staggeringly high. Breakdown voltages too were significant, but afforded no real clues as to the normal operating potentials. Safety precautions against unshielded conductors were non-existent, and they were forced to the conclusion that either the equipment was designed to operate unattended or else the physiology of the Tazoons had rendered them immune to electric shocks which would prove lethal to their Terran counterparts.

The apparatus which logically should have been metering equipment, however, made no sense at all.

Somebody was soon at work rigging up a communicator to connect the switching gallery with the subway below. When the line was functional Jacko was the first to make a call.

"Fritz, we've run into a snag on this train dismantling project. We can't get the blasted thing apart. Tell me I'm crazy if you like, but I'd swear the train was cast as a whole and not fabricated—moving parts included."

"Cast in a pattern of that complexity, in steel?" asked Fritz incredulously.

"Not steel," said Jacko. "Titanium, unless I judge my metals wrong."

Fritz van Noon pressed his eyes tightly shut. Every time he thought he was making some progress, the planet whipped the legs from under him. "That only makes it worse," he said grimly. "Come to think of it, we were being a bit naive expecting a long-extinct culture to leave something which could be dismantled with a hammer and a pair of pliers. Is there no hope at all?"

"We could take a cutting laser and chop it into two-inch slices, but I doubt if Nevill would react favourably to the idea."

"Come to think of it," said Fritz, "neither would I. Better abandon the project, Jacko, and come back up here. I think I've got a better idea anyway."

"Is this a new plan, or just good, honest desperation?"

"I'm looking at it this way: there are two ways of making a piece of equipment yield the secret of its function—you can dismantle it and worry the principle out of its components, or you can simply set it operating."

"I hope I'm misunderstanding you," said Jacko. "For one ghastly moment I had the idea you were proposing to re-start the Tazoon subway without knowing how it worked."

"Can you think of a faster way of finding out how it works than by seeing it in action?"

"Is one allowed to resign from the project?" asked Jacko. "Or is suicide the only logical form of escape?"

"You can also be beaten to death by your superior officer. The boys claim they have unscrambled the power lines in the gallery here, and we've made a guess at what should prove to be the main input lines."

"So?"

"So I want to trace them back to source. Then we can start investigating whether or not we can re-start the native power producing plant. I want every man I can get employed on tracing those lines, Jacko, and I want you to supervise personally. Remember, we have to get the whole thing operational inside three months if we're to beat Nash's deadline."

"I still think it's a waste of time," said Jacko. "If we're right that the Tazoon civilization collapsed because of lack of power, what chance have we of finding it thousands of years later?"

"I suspect the answer is quantitative," said Fritz. "They were trying to run a *civilization*, we're trying only to run a subway. I'd estimate our requirements at perhaps one ten-millionth of theirs or less. Viewed in that light it doesn't seem too difficult a task, now does it?"

Six

Nevill's team had concentrated on clearing only the tops of the taller buildings. Generally the sand penetration into the interiors was not total, and thus they had access to large modules of Tazoon architectural environment without having to wait for the total clearance which ultimately would follow as resources became available. Once gaining the interior of a building they were relatively free to explore the entire contents of the lower levels. Archaeologically, the finds were so numerous that complete classification and analysis would take many decades.

So Nevill set up specialist study groups to make a complete analysis of certain typical areas as a guide to rapidly separating the unique from the mundane when new areas were opened up. Representative samples were carefully crated for transport to Terra, where a more exhaustive examination could be undertaken.

For the next two weeks Fritz himself was kept fully employed in his role as authority on alien science and technology, and the sheer mass of work confronting him could have kept him comfortably occupied for several years at least. It was now painfully obvious that the staff of the Tazoon expedition could have been increased a hundredfold and still the finds would have been more numerous than the researchers.

Fritz's own work in the field was hampered by the fact that he was working without assistance, the entire complement of the U.E. squad being devoted to locating the elusive power source for the subway.

On this latter point even Nevill had been unable to offer any help. Although detailed maps of the sectors of the buried city were beginning to be built up there was nothing in them which suggested any power generation or distribution facilities. This was not conclusive, because in very few areas had it yet been possible to excavate below the level of the basic terrain on which the city had been built, and what lay underneath was still a subject for conjecture, but the pattern of conductors disappearing into the depths was sufficient to convince Fritz that whatever the source it was probably not located within the city confines.

Jacko's report did not appear to illuminate the situation.

"I tell you, Fritz, that main power input cable you gave us was nothing of the sort. For fifteen blasted days we've traced that thing. A cable it may be, but it's a distribution circuit if it's anything at all."

Fritz scowled. "Are you sure you didn't lose it and pick up another cable in error?"

"Do me a favour!" said Jacko. "We were feeding a signal into the thing at the switching house and picking it up all the way down the cable. I tell you that thing is a distribution complex *originating*, not terminating, at the subway building."

Fritz sat up sharply. "Distributing power where?"

"Well—I hate to tell you this, but it covers a fair proportion of the Southern plain. The cable divides and sub-divides *ad-infinitum* as far as we can tell. We counted divisions into roughly forty thousand pairs and that still left a fair majority—but we gave up when we found what was at the end of a dozen or so of the minor pairs. I'll give you three guesses . . . "

Fritz saw what was coming. "I can imagine . . . those damned Tazoon harps."

"Harps, harps and nothing but harps, and never a string between them. Listening to music I could understand, but can you seriously maintain that they installed millions of loudspeakers across the plain just so that they could listen to the trains? Nobody could be *that* alien!"

Fritz thumped the table. "Jacko, you're a ruddy *genius!"*

"Am I?" Jacko blinked.

"Damn right. You've given me the clue I needed. Get the squad together, Jacko, we're going to re-start the subways of Tazoo."

Ten weeks of the precious three months of Colonel Nash's ultimatum had elapsed before they were in a position to make the preliminary tests. The intervening period had been one of furious activity for the U.E. personnel, and one over which Fritz had draped a veil of secrecy such that nobody outside of his group had any idea of the direction of his slowly unfolding plans. But on the final evening everything was ready. Fresh heavy-duty cables threaded their way out of the subway entrance. On the platform, two dozen floodlights illuminated the mechanical achievements of a culture which had passed many thousands of years before, and shone into the tunnel to light a vehicle which had stopped in that position while Neanderthals still walked the hills and plains of Terra.

Shortly before sunset Fritz and his team assembled at the subway building. Already the calm stasis of the day was beginning to tremble with unease as the riding cloudrace overhead broke lower, heralding the nightly windy torment of the land. This was no lull before the storm but an increasing tension, a tight coil being further tightened to the inevitable breaking point which was the lash of the sand-filled gale. As the storm broke they hastened inside.

Fritz found himself more than slightly in awe of what he contemplated doing. Immaculate as was the preservation of these Tazoon artifacts he could not help remembering, as an engineer, the patterns of low temperature creep, the grain growth, the diffusion—all the degradation of properties which fabricated metals might be heir to after a hundred thousand years of rest. Fortunately the Tazoons had understood their materials and their atmosphere well, and apparently had built to last, with a success which was staggering.

In any case, Fritz was now committed. Sentiment and curiosity apart, the very continuance of the U.E. depended on his ability to re-activate the subway. He could not draw back now even though the whole place threaten to crumble about his head in a welter of dust and thunder.

As was his custom when there were unavoidable risks to be taken, Fritz alone attended the array of instruments set up in the subway proper. Jacko was in the switching gallery on the other end of the communicator, in a hastily conceived control set-up which included the rest of the relevant monitoring instruments they had been able to piece together.

Jacko, uncomfortably aware of the danger of Fritz's position, had sought to dissuade his boss from being present for the actual test run. But Fritz, foreseeing the cataclysmic damage to the installation which might result from the experiment, had decided to be present to gain first-hand experience of the principles of operation—which might by their own employment become hopelessly obscured.

Five minutes to zero hour, and Fritz took a last check on his instruments. He had already signalled Jacko to begin preliminary switching when he heard footsteps and voices echoing in the corridors leading to the platform. He snatched up the communicator.

"Hold it, Jacko. I think I've got company. Do nothing until you hear from me."

"Right," said Jacko. "But it's none of *our* boys down there, I promise you."

"No," said Fritz, "unless I mistake the gruff undertones it's Colonel Nash and his aides. I'll have to get rid of them, of course. We'd get ourselves a bad name if we knocked off all of the top brass in one go." He slammed down the handset and marched up the platform just as Nash and his retinue arrived.

"Lieutenant van Noon," said Nash icily, "I have just been informed of your intention of trying to re-start the Tazoon subway this evening. As this is a project of the first magnitude I think I should have been more directly informed."

"You will be, sir, as soon as we have anything to report."

"I don't think you quite appreciate my point," said Nash. "If you succeed in this it will be the very first Tazoon mechanical artifact of any moment to have been re-started. As such it is a rather—er—*historical* occasion. Naturally I'd have liked to have been asked to be present."

"And I don't think you quite appreciate *my* point," said Fritz. "There comes a stage in the progress of any project which is usually obscured by a notice reading: *Danger, Engineers Testing.* As far as we *know* the

Tazoon subway is intact and perfectly preserved. From an engineering point of view there is no reason why we can't switch on the current and have it back in operation as it last was."

"Well?" asked Nash ominously. "What's the problem then?"

Fritz shrugged. "How do we know that what was normal for the Tazoons is even remotely tolerable for us? The power input for this one sector of the line is quite fantastic by Terran standards. The Tazoons don't appear to have been fools about the efficiency of power conversion, so I can only conclude that Tazoon subway operation was a pretty hectic procedure. When they throw the master switch upstairs we shall have a sample of Tazoon mechanical environment in the raw. I don't want anybody down here at that moment who isn't absolutely essential to the success of the operation."

Colonel Nash snorted with irritation. "The best available information to date indicates that the Tazoons were small-boned, avian and somewhat fragile creatures. I am perfectly certain that officers of the Terran Exploratory task force are able to tolerate the conditions in a deserted subway every bit as well as its former occupants. But if you happen to be so unsure of your mechanical aptitude why don't you switch things on a piece at a time?"

"Because," said Fritz, "as far as we can tell the whole system is interlocked back to a master computing house of such complexity that it will likely take years to unravel the individual controls. For reasons best known to themselves the Tazoons did not appear to have been in favour of local circuit isolators, so we have to accept the whole––or nothing at all. I'm making a formal request, sir, for you to leave. If you remain I can't be responsible for the consequences."

"Are you staying, Lieutenant?"

"Yes, sir."

"Then we stay too. I appreciate it's your show, but I think you're over-stressing the danger angle."

"Very well," said Fritz. "But remember it was your decision." He returned wearily to his communication point. "Jacko, prepare to switch on."

"Have they gone?"

"No, they insist on staying to see the fireworks."

"Ouch! I hope you know what you're doing."

"If I did," said Fritz, "the chances are that nothing would persuade me to stay on this platform while you throw that switch. Bring the current up to a maximum over thirty seconds and hold it there for three minutes. If you can't contact me on the communicator immediately you've switched off again then get down here fast with all the emergency equipment you've got."

"Right," said Jacko. "And good luck! I'm giving you a count-down of ten . . . "

Seven

If Fritz van Noon was prepared for the worst experience of his life he was still unprepared for the sheer intensity and quality of the impressions which assaulted him. The whole tunnel cavity lit up in a kaleidoscope of lights of unbelievable colour-range and brilliance. The air grew rapidly and uncomfortably hot and choking with acrid vapours which his lungs could not accept and which burned his skin like the breath of a playful blowlamp.

But it was the *noise* that dug furrows in his soul. A series of rising screams from a dozen mechanical throats passed up through the audible range and into the low ultrasonic, causing dust fires to break out at intervals along the platform. Devices hammered and clattered and chattered in a cacophony which clawed at his eardrums with red-hot needles. Literally every fragment of the installation vibrated or resonated or contributed in some way to the atmosphere of screaming, explosive thunder. Ominously, the train which Fritz had stationed himself to watch, held motionless for a full minute then discharged itself in a rumbling, grinding ricochet into the station and down the further tunnel, accompanied by a cataclysmic roar which contained all the acoustic qualities of a continuous collision with an unending series of cheap tin tea-trays.

Scarcely had the first train disappeared from view than another skeleton juggernaut hurled itself upon the station and drove a hectic and furious path straight down the line and was gone before his senses could properly interpret its arrival. Fritz cringed before the shock-wave of its passing and watched his precious monitoring instruments scatter in all directions. He ground his teeth in mental pain at the

sound of the mechanical anguish of tortured metal biting into tortured metal. Sparks and white-hot fragments showered the platform and peppered his clothing with a pattern of small singed holes.

Colonel Nash and his entourage were now crouched against the wall further down the platform, white-faced and with their hands over their ears, while some noise-making instrument above aimed horrific noises at their heads. Under their feet the dust smouldered with a repulsive miasmatic odour which seemed to hit them in waves.

Fritz flinched as yet another train entered the station, this one fighting to halt itself with a spine-chilling screech of unseen brakes which fought valiantly to kill the considerable momentum. He gritted his teeth and watched its progress until it finally shuddered to a halt. With his monitoring equipment out of action he was forced to estimate the vehicle's speed mentally and make a rough guess at the G-forces which would act on the passengers of a vehicle involved in such a drastic reduction of speed. The answer told him more about the physiology of the Tazoons than Nevill had deduced in the previous twelve months.

Abruptly the power died and his eyes were forced to adapt to the relative dimness of the Terran floodlights. His ears still whistled and ached from their recent battering, and the intolerable heat and humidity made him feel like the occupant of some outlandish turkish bath. Nash climbed unsteadily to his feet, and picked his way carefully around the untidy layers of dust on the platform. His aides, displaying classic pen-pusher courage, made straight for the exit.

Nash headed towards Fritz.

"Van Noon!"

"Sir?" Fritz saluted briefly while trying to balance an audio-frequency spectrum analyser which was in danger of falling off the platform into the channel.

"I owe you an apology," said Nash. "Lord, that was ruddy awful! I'm not saying you didn't warn me—but where in *hell* did you get all that power?"

"I'll be reporting on that, sir, as soon as I've tidied a few details."

"Very well," said Nash. "There'll be a Staff conference at three o'clock tomorrow in my office. I'd appreciate your answer then."

He turned and strode off, while Fritz became aware of the communicator buzzing urgently.

"Fritz, *Fritz*! Are you all right?"

"Only just," said Fritz. "It was grim. Everything was at least five times as fast as its Terran counterpart and about twenty times as noisy, to say nothing of the heat. If that's a sample of a deserted Tazoon subway in operation I hope I never have to suffer one during the rush hour."

"I've got news for you," said Jacko. "We had switching trouble up here on the temporary lines we rigged. According to our calculations we were only able to supply forty-three percent of the total estimated loading. If you'll hang on for a moment I'll give you a test run at a hundred percent loading."

"Don't bother," said Fritz hastily. "For that I'd need some repeaters and telemetry equipment plus a few unattended TV cameras. I'm not staying here for a hundred percent loading run."

"Did you discover anything?"

"Enough. Initially the potential weakness of this system will be confined mainly to its passengers. It's a Mag-Lev system. The Tazoons were apparently using an adaptation of an A.C. linear motor for traction, with the bottom of the channel as the reactive element. Magnetic repulsion lifts the train clear of the track so that they're hovering on a magnetic levitation field. I suspect the same principle should be operating on each side to centre the train with respect to the tunnel walls.

"Only we didn't have enough current to make it fully effective. The trains were grinding on the track and the walls—hence the appalling noise. With the train held in a mechanically frictionless supporting field the only losses to be overcome are inertia, air-resistance and eddy-currents. No wonder this subway is capable of silly speeds!"

Fritz looked about him. "I can't yet see how the current pickup is arranged, but that's probably inductive too. Suffice it to say we can soon adapt it to our own purposes."

"Good." said Jacko, "But how is this going to produce what we set out to achieve. They asked for a transport system and we're offering a subway with all that connotes in the way of limited routes and limited points of access. How long do you think that is going to satisfy Nevill?"

"The rest of his career, I should think," said Fritz. "The building of a subway is a climactic achievement in the history of any culture, requiring, as it does, the co-ordination of a considerable

quantity of technological resources. Therefore you only build subways to connect points which are sufficiently important to warrant such endeavour. Give Nevill a functional subway under this city and he will have immediate and convenient access to all those points of the city which the Tazoons *themselves* thought worth while making accessible. You not only have a transport system but a considerable pointer to the psychology and cultural habits of the indigenous civilization."

When Fritz arrived at the Staff conference he had the feeling that the rest of the meeting must have been convened about an hour earlier, for the assembly was already engaged in earnest discussion at the time of his arrival. Nevill was leafing forlornly through a formidable pile of notes, reading abstracts, and Colonel Nash was in the chair.

"Ah, Lieutenant, take a seat. We hope you are going to tell us how you came by that impressive source of energy which enabled you to put on that display last evening in the subway."

"I can do more than that," said Fritz. "I think I can add considerably to our knowledge of the Tazoons themselves. But let's start with what were referring to as 'Harps'. I suddenly realized what they really were."

"And what was that?"

"Mechano-electric energy converters—piezo-electric generators, if you like. The harps are merely assemblies of high-efficiency piezo-electric crystals operated by the vibrating strings of the harp. The strings are made to vibrate by the passage of those vicious night winds."

"I'm no scientist," said Nash, "but I would have thought that piezo-electric effects were scarcely of sufficient magnitude to be useful for energy conversion on that scale."

"A common misconception," said Fritz. "Even our relatively undeveloped Terran ferroelectric ceramics are capable of something better than a power generating density of sixteen watts per square centimetre, which has solar cells beaten hollow. The Tazoon crystals are capable of an output of around eighty watts per square centimetre and a conversion efficiency of better than ninety-five percent. An efficiency markedly better than even the most advanced Terran M.H.D. oscillating-plasma reactors, Mechano-electric conversion has always been a highly promising line of development, but hampered by the fact that on Terra there was a scarcity of large-scale sources of mechanical energy of useful frequency.

"The Tazoons made ultra large scale use of medium-level energy by utilizing the winds to activate the harp strings. A Tazoon 'harp' in a typical night wind is capable of an output approaching two kilowatts. This comes out to around a megawatt of power for each square kilometre of plain equipped with 'harps'."

"Are you sure of this, Fritz?" asked Nevill.

"Perfectly sure. We powered the subway by re-stringing some of the 'harps' out on the plains there."

"But doesn't the output vary with the force of the wind?"

"Oh yes, but with the harps ranged over a wide area the variations average out fairly well."

"But how did they obtain their power when there was no wind?"

"They didn't," said Fritz. "We've found nothing which would indicate any attempt to store the power nor any suggestion of an alternative supply. When the wind stopped, everything stopped. Thus by habit if not by nature the Tazoons were probably nocturnal."

"But this is ridiculous," said Nevill. "I still can't conceive that they would fill whole plains with electrical generating transducers."

"Why not? They had no particular use for the great outdoors. By and large their native environment was intolerable to them."

Nevill sat up sharply. "That's a highly speculative statement to make. How do you arrive at that conclusion?"

"Simple," said Fritz. "Firstly, they were nearly blind, hence the need for such inordinately intense lighting such as we found on the subway. If my calculation is correct even Tazoo at mid-day was a pretty dull affair to their eyes. Secondly, the temperature the subway reached was so far above ambient that it's a reasonable guess that they couldn't tolerate outside temperatures for very long. They had a very low body mass and presumably chilled rapidly."

"Incredible!" said Nevill. "I knew they were small-boned, but body mass . . ."

"If you'd seen the rates of acceleration and deceleration of a Tazoon subway train you'd soon see that only creatures of small body mass wouldn't be injured by it."

"All right," said Nash, "you seem to have all the answers. Perhaps you also know why the Tazoons become extinct?"

"I could make a good guess. Even more than ourselves the Tazoons were power dependent animals, for the aforementioned reasons. They had reached a point where they couldn't exist without power for light and heat, having presumably reached an evolutionary dead-end which had put them out of phase, so to speak, with their native environment. Now remember that they depended on power from the 'harps', not having any great resources of alternative fuels, either fossil or nuclear. Remember also that the device frames were made of ironwood from the trees of the forests which used to adorn the plains. I suggest they increased their power generating areas at the expense of the trees until at some point they encountered soil erosion. Normally soil erosion is reversible if the right steps are taken to combat it, but . . ."

"Well?" said Nash.

"Soil erosion led to sand and the sand and wind conspired to form a sandblast which abraded and destroyed the strings of the harps. The failure of the harps meant loss of power— the very power essential to bring in the desalinated sea-water necessary to help combat the soil erosion. The process developed into a vicious circle—more sand, less 'harps'; less 'harps', more sand, and so on *ad-infinitum,* every day the situation worsening as the sand robbed them of the power they needed to combat its formation.

"When the sand grew deep enough it even prevented ironwood seeds from rooting, so the rest of the forests gradually died also. The Tazoons, faced with a gradual but unalterable loss of power, took the only course open to them—they tried to migrate to the tropical regions where the climate was life-supporting without the need for power. History seems to record that very few of them ever got there, which is not surprising when you consider that the night-wind was certainly capable of blowing a Tazoon clean into the air."

There was several moments' silence. "And the 'harps'?" asked Nash. "That was their *sole* means of power generation?"

"We've found nothing which would indicate otherwise."

"What a pity! Philip Nevill had just succeeded in persuading me to lend support for a rather ambitious project. Consequent upon your demonstration of both power production and a potential source of transport, Philip was proposing to re-establish the Tazoon city, initially to cater for archaeologists interested in extra-terrestrial work, but later as a permanent colony and as a supply base for ships moving out to the Rim."

"You mean to re-populate the place—turn it back into a living city?"

"Given time, yes. If possible also irrigate the deserts and reclaim some of the wasteland. It's a great pity you have such admirable reasons why it can't be done."

"But it *can* be done," said Fritz. "Given time and sufficient labour to repair the 'harps' there's enough energy out there to power the whole city and a dozen others."

"But I thought the sandblast. . ."

". . . ruined the strings. Yes, it did —but that was before the advent of Fritz van Noon. The Tazoons probably used a plain metal wire, possibly titanium, which was susceptible to abrasion. Remember they had no organic chemistry to speak of, hence no plastics. We can use a high tensile and extremely tough steel wire with a polysilicone elastomer coating over it, which is a highly abrasion-resistant combination and should give many years' service without trouble. Unfortunately it will damp the vibrations considerably—but then, we don't need the degree of either heat or light which the Tazoons found necessary."

"And you really believe the Tazoons became extinct because of the lack of a suitably coated wire?"

"Yes," said Fritz, "just that. And let it be a lesson to ourselves. We don't know what factors in our own technology may be lacking when it comes to meeting some new and unexpected crisis. Our development is probably as one-sided as the Tazoons, but in another direction. Therefore nothing but benefit can come from the complete assimilation of every phase of Tazoon science and technology into our own. If colonization can do that, then I'll see you have the power to colonize."

"For the want of a nail . . ." said Nevill speculatively.

"Fritz," said Nash. "I've been meaning to speak to you about the possibility of permanently establishing U.E. as a branch of the Terran Exploratory task force instead of merely a section of the Engineering Reserve. How would you react to that? Of course, it would mean promotion. . . ."

"I should personally welcome the idea, sir," said Fritz, "but I fear I've already accepted another assignment on Tiberius Two. They're trying to establish a mono-rail system there."

"I see," said Nash. "And just what is there about a monorail system on Tiberius Two that requires your peculiar talents?"

Fritz coughed discreetly. "I understand it's something to do with their gravity. Apparently it changes direction by seventy degrees every Tuesday and Thursday morning . . . "

The Pen And The Dark

The scudder slid through candy-floss clouds of cirrus and strato-cumulus so extremely Earthlike in formation that even the scudder's well-travelled occupants felt a twinge of nostalgia for home. Far below, the green and gilded fields proudly displayed the rich bust of the planet Ithica ripening in the rays of the G-type primary. The occasional sprawl of town or metropolis betrayed the Terran origin of Ithica's inhabitants and the results of their desire to re-create the image of a far-off homeworld. With a little imagination this could easily have been mistaken for one of the rarer spots on Earth.

But when the scudder cleared the haze of the cloud formation, the black and fearsome thing which reared above them was decidedly not of Earth.

Caught on a sudden and curious downdraught, the scudder dived steeply and then went into a mammoth power-climb that took it soaring into a wide and safe helical orbit around and finally above the livid patch of darkness.

`So that's it!' said Lieutenant Fritz van Noon.

Dr Maxwell Courtney nodded. 'That's it. That's what we call the Dark. What you see now is the mushroom dome. It's all of twenty-five kilometres across, and as near indestructible as anything we've ever encountered. We've tried everything short of nukes and nothing happened at all.'

Van Noon raised an eyebrow. 'Nothing?'

'The Dark absorbs every erg of energy released. It swallows the whole damn lot without as much as a flicker.'

`And you say that aliens put it there?'

`So the records read. About two hundred Terra-years ago—long before we re-established contact with Ithica. It would seem some sort of alien vessel orbited the planet, stayed just over a day and then vanished as abruptly as it had come. It wasn't tracked in or out. Just appeared and disappeared.

'But it left behind this pillar of darkness, and nobody has ever found out what it's for—or what it's supposed to do. There's a great many theories about it, but none which completely explains the facts. Some think that it soaks up energy and transmits it elsewhere. Some think it's antimatter. It's even suggested that an alien colony lives inside it.'

`It can't be antimatter,' Fritz pointed out. 'It's in contact with the ground, not to mention air molecules, dust etc.' He looked across and grinned. 'There would have been a hell of a bang!'

Courtney nodded acknowledgment. Fritz asked: 'And what's your own opinion?'

Courtney shrugged. 'After three years of scientific examination I still don't know what to think. At some time or another I've held most of the current physical theories only to discard them for another.'

'Is it uniform right the way down?'

`It's really shaped something like a bolt,' said Courtney. 'The shaft proper is about seven kilometres in diameter and about thirty kilometres high. It's capped by the mushroom head here which extends out to about twenty-five kilometres in diameter and apparently defines the region of the Pen.'

`The Pen?' van Noon looked up from his notes. 'What's that?'

Courtney smiled fleetingly. `Sorry! That's local terminology. I mean the apparent penumbral shadow of reduced effects which surrounds the pillar of Dark. It's a twilight region about nine kilometres average depth, the outer reaches of which are easily penetrable, and the inner regions connect with the Dark. It has an interesting sub-climate too—but you'll see that for yourself later.'

Van Noon scowled. 'And you have no idea at all what the Dark is made of?'

Courtney spread his hands. 'God-alone knows what it really is. Even the Pen raises some nice problems in physics which don't have answers in any of the textbooks.'

`All right,' said van Noon. `I'd like to take a closer look at it first and come back to you when I've some idea of what questions to ask.'

'Good idea,' Courtney said. 'We've assembled such a mass of data on the Dark that we don't know if we've lost our way in our own erudition. That's why we asked for some of you Unorthodox Engineering chaps to come out to Ithica to supply a fresh approach. The answer may be so damned obvious that we can't see it for the weight of the maths intervening.'

`And the primary object of the exercise is what?'

Courtney glanced from the window at the monstrous column of darkness which reared its head high over the landscape. `I don't know. Study it, use it, get rid of it—it's an alien paradox, Fritz, and I don't think anyone with an ounce of science in his makeup can let it rest there doing nothing but soaking up the sun.'

`What's the general topography of the Dark area, Jacko?'

Jacko Hine of the Unorthodox Engineers unrolled his sheaf of maps. 'This is the position of the Dark, and the area I've coloured shows the extent of the Pen. As you can see, the whole is centred on the edge of what used to be the city of Bedlam.'

`Nice name, the original colonists had a sense of humour! Is it still there?'

`Its ruins are. The present city of New Bedlam has moved southwards, but in and around the Pen the remains of the old city still exist. Nobody lives there now. If you'd been into the Pen you'd understand why.'

`You've been in, then? What's it like?'

'Weird,' said Jacko. 'It's cold and oppressive, but the sensations aren't the usual ones of coldness and oppression. This is a different feeling entirely. I can't quite explain it, but there's something wrong with the physics of the place.'

'Then I think I'd better start there. Where's the rest of the UE squad?'

`Doing some preliminary fact-finding at the edge of the Pen. I suggest we contact them as we go in, and see what they've found.'

'No,' said van Noon. `I'd sooner contact them on the way out. I want my first impressions of the Pen to be a direct personal experience. I need to get the "feel" of the thing—because I have a suspicion that this problem is going to be cracked by intuition rather than by observation. Maxwell Courtney's no fool, and he and his team have been gathering facts for three years now. There's no sense in repeating what they've already done, so I'm going to play it my way.'

'I was rather afraid of that,' said Jacko, following in his wake.

The edgeland was an area dominated by the ruins of the old city. The transport took them to the very perimeter of the Pen, and here they dismounted. van Noon surveyed the phenomenon thoughtfully.

The termination of the Pen was sharp, precise, and unwavering. At one point the bright sunshine of Ithica baked the dust golden and ripened dark berries on the hanks of hackberry-like scrub. A centimetre away the summer changed abruptly to a dark winter, shadowed and uninviting, and such scrub as grew within its bounds was thin and gnarled and bore no fruit at all.

Above them the wall of shade rose vertically until it disappeared into the cloud-ring which clung stubbornly round the sombre column. Looking into the Pen, van Noon gained the impression of gradually increasing coldness and bleakness and gloom until, in the centre, he could just detect the absolute blackness of the great pillar of the Dark. Cautiously he extended a hand into the boundary of the Pen and withdrew it, experiencing the strange chill on his skin.

`Very curious,' he said. 'What strikes you most about this, Jacko?'

`Lack of interaction between the warmth outside and the cold inside. There shouldn't be a sharp boundary like this.'

`Precisely. At a guess there's a temperature fall of fifteen degrees centigrade over a distance of one centimetre. Now there's plenty of heat available out here, so why doesn't the warmth penetrate farther into the Pen?'

'There's only one answer. The heat is being removed. Transferred elsewhere?'

'Hmm, but I don't see how. Even if you postulate that in the centre of the Pen is an area of absolute zero temperature you would still expect to get a graduated temperature rise at the boundary and not a sharp transition.'

'So?' Jacko looked at him expectantly.

'So I can see how to achieve the inverse of this situation using, for instance, a collimated beam of infra-red heat. But a collimated shaft of coldness is something very new indeed. As you remarked, Jacko, there's something wrong with the physics of this place.'

With swift resolution van Noon stepped through the perimeter and into the Pen. Jacko pulled up his collar and followed him in. The contrast was staggering. Whereas a few seconds previously the warm sunshine had been sufficient to bring them to a gentle sweat, they now stood shivering with the curious chill which inhabited the Pen. Van Noon was looking with amazement at the dreary landscape and sub-climate of the Pen interior.

No sunshine penetrated here. The internal winter continued sheer up to the outer wall, and such light as there was filtered downwards from a dirty, leaden cloudbase trapped within the Pen itself. Even looking sunward, no sign of the Ithican primary could be seen, though it should have been clearly visible, and its apparent loss was not explicable in terms of haze or diffraction.

The sun-toasted ruins which stood outside the Pen continued inside as a depressing waste of rotting bricks and slimed timbers, forming forgotten streets on which even the sparse and miserable vegetation had not much cared to grow. A few furred rodents scattered at their approach, with an attitude of resignation, as if self-preservation here was a matter about which one thought twice.

Van Noon was sampling his surroundings with the detachment of a scientist, yet using his own body in lieu of instrumentation. The process went on for several minutes before he came to a conclusion.

'What do you feel, Jacko?'

'Bloody cold.'

'Anything else?'

'Yes, almost a sense of *depression*. I don't know if it's physical or psychological, but every action seems to demand too much effort.'

Fritz nodded. 'I agree. I don't think it's psychological. It's almost as if every form of energy here was negated or opposed.'

He picked up a stone. 'See the window in the old wall over there? He threw the stone with practised ease, having judged its weight to a nicety. But the stone lost speed rapidly and fell in a limp trajectory to the muddied soil several metres short of its intended target.

'See what I mean?' said van Noon. 'That stone, accelerated to the velocity at which I released it, should at least have hit the wall. But it didn't. It acted as a lighter body might have done on travelling through these conditions—or as a body of its actual weight might have done had it somehow lost kinetic energy during flight. How do you lose kinetic energy from a body in flight, Jacko?'

'You can't *lose* it,' said Jacko. 'You can only react it against something—friction, air-resistance, and so on—in which case the energy leaves the system in some other form, usually heat. The energy itself is never lost, only converted.'

'Conservation of energy, right. But not *here*,' said van Noon. 'I wasn't throwing against a headwind, and the air is no more dense than outside after allowing for temperature and humidity differences. So whatever stopped that stone wasn't a normal reaction to flight. And I can find no evidence of abnormal gravity or coriolis effects. That stone just progressively lost energy. Mass times velocity doesn't seem to equal momentum in the Pen—and that's a hell of a smack at the textbooks you and I were raised on.'

'Working outside the textbooks never worried you before,' said Jacko. 'Let's get out of this place, Fritz. Its giving me the creeps.'

'In a minute, Jacko. I'd like to explore a bit farther in first.'

They walked together down the remains of a long-forgotten road, treading wearily on the slimed cobbles of the surface. The environment was desolate and forlorn, with an air of perpetual dampness and slow rot and reluctant fungus. As they penetrated to greater depths the gloom grew perceptibly greater, and the cold chill reached a degree where it would have been unwise to remain too long without the protection of additional clothing. Vegetable and animal life were here almost completely absent, and the slime and fungus showed plainly that even the lower life-forms were maintaining their hold only with the greatest difficulty. Even organic decay had not progressed far after two centuries of perpetual winter.

'What are we looking for, Fritz?'

'I don't know. It's the *feel* of this cold that has me puzzled. I don't feel I'm cold just because the environment is cold. I feel I'm cold because my body is radiating more heat than it should at these temperatures. To judge from the feel of my skin it's about five degrees below freezing point here.'

'Agreed,' said Jacko.

'Then just an observation,' said van Noon. 'Why aren't the puddles of water frozen? It's my guess that a thermometer wouldn't give much below ten centigrade. It's the same effect that we encountered at the perimeter of the Pen—radiant heat being opposed by something only explicable as radiant cold.'

'I don't understand that, Fritz. After all, cold is only the absence of heat.'

'I wonder,' said van Noon, 'if that isn't a limitation to thinking which we've imposed upon ourselves. What happens if we postulate a phenomenon called negative-heat, which we treat as the conventional electromagnetic heat radiation but with the signs reversed?'

'There can't be any such animal,' objected Jacko.

'No? Fetch some equipment in here and compare the radiant heat loss against temperature and I think you'll find there is. There has to be. There's nothing else you could set up in an equation which would go half way to meeting all the facts.'

Something crackled and spat unexpectedly behind them with a sound like a multiple pistol shot. They whirled round and stopped in their tracks. Between them and their path out of the Pen was quite the smallest and darkest and lowest thundercloud they had ever seen. The bottom of the cloud hung probably not more than thirty metres above the ground, and its inky-black consistency made it all the more threatening, though this was probably a trick of light and circumstance.

But it was the lightning which gave them pause to think: vicious arcs between ground and cloud which started to stab with all the anticipated brilliance and fire but which were curiously extinguished by some constrictive phenomenon which pinched the plasma and quenched the arc. The result was a staccato 'pop' instead of a thunderclap, and a rate of lightning repetition which occasionally generated a continuous tearing noise rather than the usual sounds of storm. But there was no doubting the destructive potential of the lightning bolts.

Moved by unfelt winds, the thundercloud was drawing rapidly nearer, and van Noon was more than a little apprehensive. 'Better find some shelter, Jacko. This could be dangerous.'

They looked about them. The ruins of a hovel, partly roofed with sloped and perilous slates, provided the nearest offer of sanctuary. They squatted within the miserable, damp, boxlike walls while the cloud moved overhead. Lightning stabbed at the path outside with a viciousness which seemed to contain some element of personal malice, but finally it passed. The cloud went spitting and snarling on towards the pillar of the Dark, and van Noon and Jacko emerged to watch its progress.

'I'll teach Maxwell Courtney to speak of "interesting sub-climate," ' said van Noon ominously. 'Let's get out of here, Jacko.'

'That was what the locals call a rogue storm,' said Courtney. 'In the Pen you meet them quite a lot. They seem to form and disperse almost spontaneously, but while they last they can be very dangerous. They always travel fast, and always in straight lines. If caught in the open we avoid them by simply moving sideways out of the way.'

They were seated in Courtney's office in New Bedlam, and the broad windows of the room opened to a distant view of the Pen and its core of Dark. Courtney's desk faced the window as if to give him a constant reminder of the broad enigma to which his life was currently dedicated. The attitude of his visitors' chairs showed that they were no less aware of the dominating influence of the looming column of shadow.

'Well,' said van Noon. 'We've gathered a little data of our own on a preliminary survey, and I'm told you have acquired data by the ton. That puts you in a good position for answering questions, and me for asking them.'

'Ask away,' said Courtney. 'I don't pretend to have all the answers, but I can do you a nice line in inexplicable facts.'

'What can you tell me about anti-energy or negative-energy effects?'

Courtney whistled softly. 'That's a piece of fast thinking, Fritz. It took us nearly a year before we could bring ourselves to consider the hypothesis seriously. But I know what you're thinking. Most of the physical effects observed in the Pen can be satisfactorily explained only by thinking in terms of polar opposition—negation by precisely defined effects of exactly opposite character. The fact that these opposite effects are completely unknown to nature outside the Pen doesn't necessarily invalidate the case for their existence *inside* the Pen. The very nature of the Pen and the Dark is obviously extra-physical, or we'd not have a problem in the first place.'

'Precisely!' said van Noon. 'But you do agree the possibility of negative-energy?'

Courtney spread his hands. 'I admit it as a *possibility*. It's certainly a basic premise which fits all the observed facts in the Pen. But it's only one premise among many, and it doesn't have much to commend it when you consider it a little deeper.'

`Go on,' said van Noon.

'Let's take an extreme case,' said Courtney. 'You can prove it for yourself if necessary, that the difference between the Pen and the Dark is purely one of degree. Whereas energy negation in the Pen is only partial, that of the Dark is absolute.'

'I'll take your word for it. I'd guessed it anyway.'

`Good. Now consider this: no matter what intensity, character, or type of energy we have applied to the Dark, we have had no discernible effect upon it, nor have we been able to pass any energy through even a thin sector of it. We have encountered absolute negation, Fritz, of any energy applied in any way. If you stick to your negative-energy theory the implications are too complex to be true, and rather frightening.'

'I think I understand you,' said van Noon, 'but I'd rather hear it your way.'

`I'll put it as simply as I can. If we fire a projectile at it, according to your theory that projectile needs to be met precisely at the perimeter of the Dark by what is effectively a counter projectile of identical mass travelling at an identical velocity to a precisely identical point. That makes too many coincidences for my orthodox-type stomach. And again, suppose we use X-ray bombardment or any other form of radiation. For precise negation this would need to be met at the identical point by anti-radiation of the same intensity, wavelength, and phase as that which we apply. Either the Dark is an extremely broadband transmitter capable of producing any type of force, energy, intensity, and phase of radiation at any point on its perimeter at any instant without prior notice —accurately and instantaneously—or else the Dark is full of little green men with an uncanny knack of anticipating our test programme and arranging their opposing facilities to suit.'

'I get the point,' said Fritz. 'How do you arrange to fire a projectile to meet an unexpected projectile head-on with precisely matched mass and velocity and to an impact position pre-determined to an accuracy of plus or minus a few microns? It can't be done. You've shaken some of my confidence, but you still haven't encompassed the impossible.'

'No? Then I'll do so right away. For your negative-energy theory to be true, the Dark would need to be a dynamic entity. It must necessarily give out exactly as much energy as it receives, for the negation to be complete. It's been here for two hundred years, Fritz. Now calculate two hundred years of radiant energy from the sun alone and then add what we've flung at it in the last three years of experiment. You'll see that it would need the energy resources of a small star in order to have the reserves to meet any demand."

'I don't know,' said van Noon, 'but we can't yet claim to know the ultimate in power sources. But very soon I intend to find a way into the Dark, and then perhaps we'll find out.'

'You can't do it, Fritz. There isn't a ghost of a chance of penetrating into the Dark.'

'I think there is. And I think I know the very way in which it might be done.'

'Whatever made you say that?' asked Jacko anxiously, as they left the room.

'It's a feeling I have,' said van Noon. 'I said I was going to play this by intuition, and right now my intuition tells me that the Pen and the Dark *are* negative-energy effects.'

'In spite of what Courtney said?'

'Certainly. I must admit he had a nice point about the projectile needing to be met effectively by a anti-projectile if the negative-energy theory was to be maintained. It wouldn't actually need to be met by a anti-projectile as such, but merely by an opposing *force* of the right sort applied in the right place at the right time. I don't doubt that Courtney's correct that such a negation is necessary to substantiate the negative-energy theory. But I do suspect that his data on absolute negation is not quite as complete as he imagines.'

'In what way, Fritz?'

'Well, I can't conceive of a continuous pattern of negative energy which could deal with *any* sort of force or radiation applied at *any* point at *any* time. I can, however, conceive of a pattern of negative radiation or effect which is selectively produced in response to a particular stimulus at a particular point. But you see what this involves?'

'No,' said Jacko.

'It involves detection, analysis, and synthesis of the opposing effect. Three steps—which must necessitate some sort of time-lag. Courtney has established that any applied energy is negated—but I doubt if it can be cancelled instantaneously. The three steps may be completed in nano-seconds, but I'm quite sure that a time-lag must exist. Now I want to go into the Pen, right up to the Dark perimeter, and see if we can prove or disprove this.'

'And if we prove it?'

'Then I think we'll have a way to drive a tunnel into the Dark and see what's inside.'

Jacko lost his power of speech as his mind strove to contain the enormity of the project. Fritz shot him an amused glance.

'There's a particular reason I want to go in, Jacko. There's a second principle involved in this detection, analysis, opposing-synthesis set-up which you might not have thought of. Something else is implied . . . and that is some form of guiding *intelligence.'*

They had chosen heavy caterpillar crawlers for their transport into the Pen. The choice was determined not only by the fact that a tracked vehicle was an advantage over the broken terrain but also for the reason that the vehicles possessed powerful engines and an ample reserve of power. Three crawlers were obtained for the expedition; one to run well ahead, one to act as reserve, and one to stay well in the rear with sufficient rescue equipment to recover either of the leading crawlers should the deeper Pen effects exceed the capacity of the engines to keep the vehicles in motion.

Clothing for the party had been chosen for a simple property—thermal insulation. Although the actual temperature of the deep Pen probably did not reach freezing point it was essential to insulate the radiant heat of a man's body against the negative-heat effect which would otherwise have striven to reduce his temperature to the ambient point, with lethal effect. In this way the cold of the Pen differed from normal cold, and the expeditionary figures were clad as though for a journey to the arctic.

Once clear into the outer perimeter of the Pen and out of the strong Ithican sunshine, the expedition began to appreciate the clothing which up to that point had caused them a barely tolerable condition of overheating. Now, as the light faded and the chill of the perpetual winter closed around them, they grew more comfortable. But the underlying seriousness of the venture was pointed-up by a change in the engine note to a more laboured level as both the functioning of the engine and the momentum of the vehicle were affected by the negative elements of the Pen.

The leading crawler carried the bulk of the equipment, especially the precious lasers with which it was hoped to establish the existence of a time-lag in the Dark phenomena. Van Noon was captaining the vehicle. Jacko was driving, and Pederson, an observer sent by Courtney, completed the party. van Noon had intended their route to follow a road indicated on the old maps as running for nearly two kilometres straight in the direction of the axis of the Dark. The intention was abandoned quickly on finding that a building of considerable proportions had collapsed, turning part of the road into an unnavigable pile of masonry. The maps were forgotten and a new route was improvised as the situation demanded, having regard to the abilities of the crawler and taking advantage of the opportunities presented by the slow erosion of the Pen environment on the fabric of the old town.

The light from the trapped cloudbase became increasingly leaden and dull until, at about five kilometres in from the perimeter of the Pen, Jacko was forced to switch on the headlamps. Their effect was negligible. Such light as they produced was robbed by some negative effect in the Pen environment and did little to disperse the muddy gloom. Fritz had anticipated this and had a searchlight mounted on the roof of the crawler. The intensity of light from this was sufficient to permit their passage through the damp, dilapidated, ghost-like streets of Bedlam to within two kilometres of the Dark itself. Then that illumination too became inadequate.

`Better get out, Jacko, and let's estimate the situation,' said Fritz.

They descended, conscious of the acute negative-heat coldness which searched at their shrouded faces and probed at their wrists and ankles. They were conscious too, now, of anti-momentum, which gave an entirely false impression of the density of the air, since the effect was remarkably like trying to move under water.

Pederson joined them, and they made a brief survey of the situation. Whereas from a greater distance the column of the Dark had been clearly visible, it was now merged into the claylike blankness of scene which made it scarcely distinguishable as a separate entity. Jacko tried the radio communicator, but the instrument was dead save for some rare static from a distant rogue storm. The magnetic compass also had become non-functional much earlier, and though the gyro-compass still worked its readings were questionable in view of the conditions under which it was operating.

The quality of light from the cloudbase was curious and unreal. Effectively the light from above should have given them far greater incident and reflected illumination than they actually experienced. This drastic attenuation of the light should have been explicable in terms of fog or haze, but nothing such existed, and their inexpressibly dreary state of near-night had no explanation save for that of an alien opposition to the fundamental laws of physics.

`What are we going to do, Fritz?' Jacko's own attempt to resolve the situation had reached an impasse.

Van Noon looked back, hoping for an indication as to whether or not the second crawler had been able to follow their tortuous route to the spot. No evidence was forthcoming, so he shrugged his shoulders.

`You two can vote me down if you want to, but I propose that we choose the most likely direction for the Dark and just drive blind until we hit it or stop.'

`I'm with you,' said Jacko. 'What about you, Pederson?'

`Count me in. I've no ambition to walk back on my own.'

They re-entered the crawler. Having decided on the most probable direction of the Dark, Jacko orientated the vehicle, locked the tracks on synchronization, and proceeded to drive straight into the unknown.

The journey was a driver's conception of Hell, a nightmare route across unfamiliar territory, effectively blind, and with no warning of what obstacle might halt or jolt them. Added to this was the rising resistance to movement, both on the part of the vehicle and of its occupants. Inside the driving cab even the instrument lights had become impossible to see, and the penetrating coldness finalized the depression which was settling over the spearhead of the expedition. Once or twice Jacko questioned whether they ought to attempt to turn back. Van Noon chided him gently and looked only ahead to the point where the darkness ought to terminate in a meeting with the absolute of the Dark.

Constantly the vehicle rolled and bucked, and canted at dangerous angles as it encountered broken walls or piles of debris in its path. Sometimes it stopped with a bruising shock against some obstacle beyond its power to move. Jacko was skilful in such emergencies and withdrew the vehicle from each such predicament without stalling the engine, knowing that a stopped engine this far into the Pen would never be restarted. Bruised, and in constant danger of masonry from grazed walls crushing the cab, they endured the journey patiently; although with various deviations from the course which the presence of unsurmountable obstacles forced on Jacko, they had no certain idea if they were still headed towards the Dark at all.

Then came the moment they had been dreading. In pitch darkness now, the crawler came to a sudden halt against something immovable. The tracks churned the soft floor uselessly for a half second, and then the engine stalled before Jacko could throw the vehicle in reverse. He tried the ignition cycle in vain, but the negative effects were too powerful to permit the heavy engine to be restarted. The silence grew absolute save for the tick-tick of metal cooling rapidly and Fritz's voice cursing in a strangely muted way.

'End of the line,' said Jacko finally.

Van Noon opened the door. 'As we've managed to get here we may as well see where we are,' he said.

They climbed out. Their powerful torches were little use, and permitted an examination of no object more distant than about a quarter of a metre.

Beyond this was darkness in all directions except directly vertical, where a muddied stain across the sky mocked them with its inability to provide any useful illumination on the ground. Fritz searched around him and picked up a short length of rotting timber with which he cast about in the darkness on all sides. Then he called urgently: 'Jacko, are you near the crawler?'

'I am,' said Pederson. Just by the cab door.' He banged the metal, which returned a dull and unrewarding thud. Like their voices, the sound was strangely attenuated.

'Good! Now, Jacko, can you place yourself by sound in a line between our two voices?'

Jacko moved somewhere in the darkness. 'I think I'm there.'

`Right. Now we're three in a line, with Pederson on the right, you central, and myself on the left. As far as I can make out, about three paces ahead of us is the Dark. Find something to probe it with, and don't touch it even with your gloves. Maintain your orientation carefully so that you don't lose direction and walk into it. It could be very dangerous to touch.'

They advanced slowly, Pederson tapping the side of the crawler for identification, and Fritz and Jacko talking so that the sound of voices gave their relative positions. Even so, Jacko got there first. His probe was a shard of splintered ceramic with which he was striking before him as though at some anticipated enemy. Anti-momentum made this a difficult movement to achieve, and the darkness added to the soup-like resistance to movement, giving the whole situation a dream-like character without the visual qualities of the conventional nightmare.

Then Jacko hit the Dark. It was detectable by its complete negation of the force with which he struck it. And it returned no sound, and in this way was distinguishable from any ordinary obstacle struck with force.

`Got it,' said Jacko. 'But that knocking sound you hear is my knees. I admit I'm frightened of this thing, Fritz.'

'I'm not exactly keen on it, either,' said van Noon. `But this is what we came to see. It's a pity we can't see it now we've got here. Have you any suggestions, Pederson?'

'I've just discovered the Dark is what we ran the crawler into. No wonder it didn't move.'

An ominous and familiar staccato rattle made them turn. A rogue storm, travelling towards them and parallel to the wall of the Dark, was making its passage known by its peculiarly pinched lightning. Because of attenuation, the lightning and thunder had been undetectable even from a short distance, and the storm

was almost upon them before they were aware it existed. There was no time to seek shelter. They flung themselves down on the damp earth at the foot of the Dark and waited for it to pass. It sprayed the area with quenched fire as it went, doing no damage to them, but the intensity of the arcs was such that momentarily they had a clear picture of their situation.

The Dark was just in front of them, a sheer wall of unblemished black-velvet nothingness, impossibly perfect. The crawler had nosed head-on up to the black wall, and its tracks were pressed hard against the exterior. On all other sides of them lay the ghost-suburb of desolate ruins, the reflecting white teeth of broken masonry contrasting with the wet, black soil of the earth.

As soon as the worst of the storm was over, they climbed back to their feet.

'What are you going to do, Fritz? Try the lasers?'

'I don't know.' Fritz had moved back to the crawler and was examining the tracks in contact with the Dark by the spasmodic light of the rapidly waning storm. 'I don't think we need to. I think I've got my answer. You see, it did take time for the Dark to analyse and apply a counterforce to stop the crawler. But that fraction of a second was sufficient for something significant to happen. The crawler tracks have penetrated very slightly into the Dark.'

It was impossible for the others to verify van Noon's statement since the light from the storm had rapidly become eclipsed by the strength of the negative effects. The combined output of searchlight and torches failed to re-establish the point, and the lasers refused to function from the crawler's emergency power supply. But van Noon was sufficiently convinced of what he had seen to regard the expedition as a success.

`All we have to do now is to get back to tell the tale,' said Jacko, unhappily.

They started back by the only means available—they walked. For the first half kilometre they stumbled blindly through the darkness and the nightmare of anti-momentum. The coldness, too, was becoming serious now that they were exposed for a long period without the protection of the crawler cab. But gradually their eyes, accustomed to complete darkness began to discern light like the first touch of dawn, and with the returning ability to see, they no longer blundered into blind paths in the ruins from which they had to retreat by sense of touch alone. And the negative effects grew slightly less, so that their pace progressively improved as they made their way out of the deep Pen regions.

Two kilometres away from the Dark they came across the crushed path that their own crawler had made on its way in, and this they followed gratefully. Shortly they found the second crawler, abandoned, and with its engine stalled and cold. The third crawler was patrolling a broad front along a road about three kilometres radius from the Dark perimeter. They were hailed and taken aboard for the last part of the journey through the growing light and finally out into the unbearably bright gold sunset of an Ithican evening.

Courtney was there to greet them. His team had spent the day re-running exploratory tests, but this time with particular reference to the onset-time of negation. His results amply confirmed van Noon's experience. There was a time-lag on the introduction of any energy phenomenon to the Dark or the Pen before negative effects set in. The exact period of the lag varied with the type of phenomenon, but was greatest for applied physical force.

The party rode with raised spirits back to New Bedlam where work on the next phase of Fritz's plans against the Dark were just about to begin.

'A tunnel?' said Jacko.

'Strictly speaking,' said van Noon, 'I had in mind something more in the nature of a horizontal well, but I think a tunnel is a fair description.'

`And just how do you propose to sink a horizontal well into the Dark?'

`Frankly, I don't see much difficulty. We take an ordinary iron pipe of sufficient dimension to permit the passage of a man—and just knock it in.'

`Crazy like a fox!' said Jacko. 'We're talking about the *Dark*—the great energy negator. In the name of Moses, how do you just knock a pipe into that?'

'I thought I'd already demonstrated that,' said Fritz. 'There's a time-lag before the onset of negation. Apply a pile driver or something to your pipe and hit it once and it will penetrate the Dark just a little before the detection, analysis, and opposite synthesis has a chance to stop it. Then the negation will be applied and stop the tube going in any farther, and the system will reach stasis. The anti-force obviously cannot continue to be applied after the original force has ceased to operate, so the force anti-force balance will then relax.'

`So?'

'So then you hit your pipe again and drive it in a little more. And so on. And providing you work on a completely random and non-predictable basis there's no chance of the anti-force being applied in anticipation. I suspect that only if we set up a standard repetition rate will we meet with complete and instantaneous negation of the force that we apply.'

`So we knock in our tube. Then what?'

'It depends on what we find. The Dark may be a solid or it may be a thin-wall phenomenon. If it's a solid we shall not gain much except for a little knowledge. But if it's thin-wall, then we might have a chance to look inside.'

`From which you're assuming that the Dark effect won't penetrate inside the pipe.'

`I think it may to some extent, but take any physical phenomenon and place an inch of steel in front of it and you always get *some* modification or attenuation, if not a complete shutoff. I don't see that the situation should be materially different for anti-physical phenomena. With a bit of luck we should be able to get through.'

'What do you think's inside there, Fritz?'

'As I see it, Jacko, some form of intelligence, but I wouldn't like to guess any closer than that. Whether the Dark is some cosmic amoeba or has inside it a complex of little green men is something I intend to find out. Are you with me?'

'I'm right behind you,' said Jacko. 'But don't ask me to be the first man through that damned pipe.'

By the time that Courtney returned to the base camp a few days later van Noon's plans were fairly well advanced. Fritz described the scheme briefly. Courtney was intrigued but doubtful.

'I don't see,' he said, 'how you're going to drive a pipe of that diameter into the Dark—remembering that the driving has to be done in the deep Pen area where the anti-momentum is killing. You'd never get a horizontal pile-driver to work under those conditions.'

'No. We've already taken care of that point by taking a new line entirely. We're going to fire it in.'

'Fire it?'

'Yes. Attach the free end of the pipe to what is effectively a large-bore gun or reaction chamber with an open muzzle pointing away from the Dark. In the gun we fire a high-explosive charge and let the recoil of the apparatus drive the pipe against the Dark. According to my calculations, a series of explosive shocks should have the right sort of driving characteristics for the job. How does it sound as an idea?'

'It could work,' admitted Courtney. 'Unless we're up against something we don't know about yet. How far have you got with the project.'

'We've managed to get the lengths of pipe into the Dark area, and the gun chamber is there also. There's trouble keeping handling equipment working so far into the Pen, but we've managed somehow. We should be ready to start firing sometime tomorrow. Have you been able to get the extra stuff I asked for?'

'Most of it's outside on the carriers, and the generators will arrive in the morning. Here's the wide-band radiation monitor, trolley-mounted as specified. I only hope it fits into the pipe.'

'I'll try it out,' said van Noon. 'I can run it through our test length and if it doesn't fit we can modify it before it goes into the Pen.'

He wheeled the small apparatus-laden trolley to the length of pipe that ran down the workshop where they had been fabricating the gun chamber. The trolley fitted easily into the interior of the pipe and, to give himself a little practice, he crawled in after it and pushed it before him. The iron confines of the pipe returned the sound of the small rollers with a noise like a train speeding through a tunnel. When van Noon reached the far end he found that Jacko had returned and was peering anxiously down the pipe.

'Why the sound effects, Fritz?'

'Eh? Oh, this? It's the radiation detector. It's obvious that even the iron of the pipe can't do more than attenuate some wave lengths of the electromagnetic spectrum—and the same presumably applies to the negative spectrum. So just to be on the safe side Courtney has knocked up a combined range monitor which should cover anything likely to be dangerous but not detectable by our own senses. I don't expect that we'll encounter any such radiation, but it's better to be safe than sterile.'

'Agreed,' said Jacko. 'We're taking enough chances with the unknown already. I've just come back out of the Pen, and we're right on schedule. The first firing can take place at mid-day tomorrow.'

`I'll be there,' said Fritz. `I'm particularly interested in knowing what happens to the core which we leave in the pipe. If the Dark is true radiation-type phenomena, there won't be any core material. But if it's something else, we may have to think again.'

The null-pressure suits obtained from Space Command were far more suitable for working under deep Pen conditions than the expeditionary clothing had been. Specifically designed for work on asteroids and similar bodies under a pressure dome but exposed to extremes of stellar heat and cold, the suits were the finest flexible radiation foils that had yet been devised. In the Pen, of course, no pressurized dome was needed, but the suits ensured that the searching fingers of negative-heat were no longer a danger or of major discomfort to the UE squad.

But the drag of the anti-momentum was not so easily avoided. Close to the wall of the Dark it exhibited an almost treacle-like resistance to movement which was common to both men and machines alike. The adaptations of technique needed for working in an environment possessing such a high quasi-viscosity were numerous, but the combined ingenuity of the Unorthodox Engineering squad was equal to the challenge. Somehow the impossible had been accomplished, and the structural components of van Noon's tunnel had been patiently swung into place ready for the projected penetration of the Dark.

`Ready to fire?'

Jacko nodded. 'First shot in thirty seconds.'

They were watching the scene by the light of two large continuously operating lasers which Courtney had managed to obtain. These were directed on the point where the leading end of the pipe was pressed hard against the Dark perimeter. The illumination, spread slightly by deliberate diffusion with mesh screens, was adequate despite the negative-radiation loss. The backscatter illumination was also quite useful around the working area, but was attenuated sharply and unnaturally with distance. The power for the lasers had to be derived from outside the Pen via cable, and the negative-electrical loss was such that two large generators were needed to drive sufficient energy in to keep the lasers in operation.

The first shot was fired. The sound of the explosion was incredibly muted, and the tongue of flame from the reaction chamber was quickly quenched and drained. Van Noon examined the junction between the pipe and the Dark.

`I think it's working, Jacko. Only millimetres so far, but it's definitely going in. Keep firing rapidly but erratically. Let me know when you're in about a metre. Then I want to go down inside the pipe and see if any sort of core is left.'

By reason of good organization on Jacko's part they had penetrated a metre by late afternoon. Then the gun chamber was removed to allow access to the free end of the pipe. Van Noon had a line measured to a pipe's length minus one metre, and one end he left clamped to the free end of the pipe while he took the rest of the line inside to give him an indication of his position. Ten minutes later he came out jubilant.

'No core material, Jacko. The pipe is clear to the very end, and then the Dark begins again. That means we've got a metre of clear tunnel already and no complications so far. Now I want firings to continue right round the clock, as close-spaced as possible without setting up a standard repetition rate. If you scatter the charges round the area a bit so that each has to be fetched from a slightly different distance, that should be sufficient. But I want the depth of penetration per shot carefully watched, and if it varies very much from the existing rate, cease firing and let me know.'

It took forty hours to drive the first length of pipe into the Dark. By this time a second length had been added to the first and there were indications that the depth of penetration per shot was increasing. The second was driven home in twenty-five hours, partly due to the decreasing resistance it encountered, and partly due to the increasing proficiency of the shot-firers.

The third pipe was inserted in seventeen hours, and the fourth, in twelve. The time for subsequent pipes decreased in rough proportion. The tenth went half way, and then the indications were that no great resistance was being offered to it by the Dark since the assembly of pipes now moved forward the full theoretical distance per shot that they would have moved in the Pen itself. Jacko brought his charts to van Noon.

`I think we're through, Fritz. These seem to show that the Dark is a relatively thin-wall phenomenon with its effects decreasing with depth of penetration and reaching virtually zero at about ninety-five metres. God alone knows what's at the other end.'

'Take the gun chamber off, Jacko, but be careful in case something unexpected comes out of the pipe. If nothing happens in half an hour then I'm going through to have a look.'

Nothing did happen. The end of the pipe protruding from the Dark remained empty, silent and cold; and there was no way of telling what lay at the far end. A laser directed down the pipe returned nothing but light-scatter from walls and motes of dust. The only factor of note was a strong current of air entering the pipe as though to equalize some unexplained deficiency in pressure.

Finally van Noon hoisted the radiation trolley into the pipe and followed it in.

`I'm going down a bit, Jacko, for a preliminary survey. Stand by with some weapons in case I come out fast with something after me.'

`Nothing doing!' said Jacko. `If you're going down that pipe, then I'm coming too.'

Fritz nodded. 'All right, let's get on with it. The situation won't improve itself by waiting.'

He crawled into the pipe. With some misgivings, Jacko followed him in. Ahead of Fritz the radiation trolley clattered on the metal and raised a multitude of clamorous echoes which engulfed them in a tide of sound. Inside the pipe the negative-sound attenuation apparently did not operate to anything like the same degree as that encountered in the Pen. The radiation monitor gave no indication of any increase in rate above the slow background count, and they considered it safe to continue.

Occasionally van Noon stopped and let the echoes die, but nothing else disturbed the silence except their own breathing and their own awkward movements in the confines of the pipe. Then after what seemed an eternity of crawling the clatter of the trolley ceased again and van Noon stopped and half twisted himself to look back.

`Jacko,' he said urgently, 'think very carefully. Are you absolutely sure how many lengths of pipe we drove into the Dark?'

`A bloody fine time to be concerned about the economics of the project.'

`Stuff the economics! Are you *sure?'*

'Certainly. Ten in all. Why?'

`I've been counting the joins. I'm now in the twelfth pipe, that's why.'

`Don't make jokes like that, Fritz. You'll give me heart failure.'

`I wasn't joking. The rollers on the trolley drop into the flange gap at every join, and I have to ease them over. That's what made me start counting how many joins I'd passed.'

`So you're now in the twelfth pipe out of the original ten,' said Jacko, still not fully convinced. 'That's quite a trick! I think I'd like to go home now.'

'Opposing steel pipe,' said van Noon. 'Lord! I thought it was a joke when Courtney suggested that they stopped a projectile with an anti-projectile. But it appears it wasn't. They do just that. They tried to stop our pipe with a length of opposing pipe so precisely similar that I'd not have noticed the difference had I not been counting. What type of creatures could do that, Jacko—almost instantaneously?'

`I don't know,' said Jacko. 'But I'm afraid of them.'

'You and me both. To work a trick like that must demand a technology centuries ahead of ours. But even so, I've a feeling we've got them worried.'

`Why's that?'

`Because if they were still operating at full efficiency there's something we'd logically have met in this pipe before now—a anti-radiation monitoring trolley pushed by an anti-Fritz van Noon.'

`We're way out of our depth, Fritz,' said Jacko finally. 'Are you still going on?'

'If you're still following.'

`I'm still behind you, but I'm damned if I know why. I've followed you into some crazy situations before, but this has the lot beaten.'

They moved on, the roar of the trolley echoing and reverberating around them and occasionally stopping as Fritz eased the little wheels over a flange gap.

Just entering pipe nineteen,' said van Noon finally. `If they provided as many as we did then there's only one to go.'

`See anything yet?'

'Nothing.'

'I was just thinking, Fritz. It'd be a neat trick if they'd connected an infinity of pipes together. We could go on crawling through here till Judgment Day.'

`Good point, Jacko. We'll reconsider the position when we get to the end of number twenty.'

Again the trolley jerked and stopped.

'Just entering pipe twenty,' said van Noon.

'Let's get it over with,' said Jacko. 'It can't get any worse, surely.'

'Right. This is it! '

The trolley was moving slowly now, with Fritz concentrating on every centimetre of its progress, using the feel of the iron instead of eyes. There was no way to measure distance in the darkness. The only way was

to crawl and to hope that one remembered the feeling of crawling a length of pipe. Then a sudden cessation of noise, with the echoes slowly sinking around them.

'End of pipe,' said van Noon. 'But no resistance. The trolley is half way out of the end but I still can't see a thing. I'm going to let the trolley go and see what happens.'

There was a brief scrape of metal on metal, and the thump of something on the pipe.

'It fell down,' said van Noon, 'but not very far. I can still feel it with my hand. And something else . . . There's no anti-momentum out here. I can move quite freely. It isn't even very cold. It must mean we're well inside the wall of the Dark. I wonder if the torch will work.'

The torch did work. In the darkness the light touched the interior of the pipe with an intensity that was momentarily dazzling. Projected outwards, the beam was clearly visible but it contacted nothing that reflected except the wet, brown stones of the earth, and the equipment trolley fallen on its side. Ostensibly they were looking into night, bare and empty, but Fritz was not convinced.

'This isn't darkness,' said van Noon. 'It's more like veils of darkness . . . thin layers of negative-light. See how the torch beam falls off in discrete quanta. I'm going out there, Jacko, to see if I can make head or tail of this. You stay by the pipe with a torch ready to guide me back. I'd very much like to find out who or what it was that put ten pipes on the end of ours.'

'And I'm going to wish you luck,' Jacko said. 'But I'm not at all sure I want to know.'

Van Noon dropped to the ground. The soil underfoot was an obvious continuation of the old town terrain. His torch illuminated the stony earth for many metres in front of him, but it was useless when directed horizontally in any direction because of the apparent lack of anything to reflect the light.

But he was right in his observation that the intensity of the light was stepped-down by curtaining veils of something. As he approached a veil he could see a distinct drop in the brightness of the beam as it was intercepted by something dark and nebulous. He reached the veil and touched it, curiously. His fingers encountered nothing, and he walked through it without sensation. Looking back, he was glad still to be able to see the light from Jacko's torch, but he knew that if he passed through many veils even that would be lost to him.

But the situation changed without warning. The fifth veil was not insubstantial at all. It was a film of something like dark, thin-blown glass, and he shattered it with his torch because he had not known of its solidity. And as it shattered, light from beyond spilled out through the broken edges and he had the briefest glimpse of the scene of gold-hazed wonder . . . and then the air exploded in his face.

But even the explosion was unreal. The blast caught him not from in front but from behind and above, moving towards the explosion rather than from it. It tumbled him forward and pinned his body to the ground with a great pressure. Desperately he fought to raise his neck and shoulders for a further glimpse of the creatures who lived in their sanctuary deep inside the hollow Dark. He wanted a better look at the godlike machines they controlled, now rising high like gossamer and congregating in the golden light as they swept magnificently upwards almost faster than the eye could follow. But a sheet of flame crackled and tore across the vastness of the area and whipped high in an angry, explosive tide.

A shockfront of pressure tore him from the ground, then dropped him cruelly. Despite the hurt he fought to retain consciousness and turn and watch the exodus of the gods. But the forces acting on him were too great. Instead he was swamped by darkness.

His next impression was that of Courtney's face and the sense of lapsed hours. He felt bruised and shaken, but not seriously hurt. He was lying in the open, and the Ithican sky above was broadly trailed with the colours of the sunset.

Courtney came up and put a folded coat beneath his head and a blanket over him.

'Take it easy, Fritz. There's a doctor on his way.'

Van Noon smiled wanly. He tried to sit up, then thought better of it. 'Is this where the Dark was, or did you get me out.'

Courtney sat down beside him. 'The Dark's gone, Fritz. I don't know what you did, but you certainly made a good job of it. The whole darn thing imploded. It was a fantastic sight. The Dark and the Pen drew up together, then spiralized like a whirlwind. There was a blast which broke every window in New Bedlam . . . and then the whole complex just disappeared.'

'I know what did it,' said van Noon. 'Our universe reacted with theirs violently. Their laws of physics must have been very different! It was our tunnel that punctured the protective barrier, and I broke the last seal by accident. Once the reaction started, nothing could stop it.'

`So it *was* antimatter!' said Courtney.

'I think it was another universe, a parallel dimension. Another membrane interacting with ours. It's possible it was an antimatter universe, I suppose. I'd give anything to know how they managed to connect the two!'

Courtney whistled. 'What was that you said about the laws of physics?'

Fritz heaved a sigh. 'It's been suggested that other membranes in the multiverse would almost certainly have physics different from ours. Maybe only slightly—but maybe drastically different. Theirs must have been *very* odd for them to achieve what we've seen here! The Dark was some sort of barrier, a shield if you like, between their world and ours.'

'So who were they, and what happened?'

'Don't know. Maybe they were scientists, or explorers—they could even have been refugees from God-knows-what. When the two universes came into contact, the bridge between was destroyed.'

'The doorway slammed shut! Courtney muttered.

'Yes, quite,' agreed Fritz. 'As to what happened to them . . . who knows. We could have learnt an awful lot from them, if only there had been a means of contact.'

'Had they been inclined to teach,' said Courtney, 'but in two hundred years they never attempted even to make any contact. I think that they were so far ahead of us that we were merely as ants to them.'

Van Noon sat up painfully. 'I'm not sure that two hundred years passed for *them*—laws of physics, remember?' He looked around. By the way, what happened to Jacko?'

'He's a little bruised and dazed, but nothing serious. Apparently the implosive blast shot him out of the pipe like a cork out of a bottle. He swears you did it on purpose.'

Fritz rubbed his hands over his eyes. 'Do you suppose we'll ever know why they were here?'

'I doubt it,' said Courtney. 'And even if they'd tried to tell us, we may not have been capable of understanding. Try explaining the uses and construction of a starship to an ant . . .'

Getaway From Getawehi

One

`Colonel Nash has just checked out of the spaceport, sir. Says he'll be with you in about half an hour. He's bringing a Commander Brumas with him.'

'Coming to see me?' Colonel Belling cast a thoughtful glance at the wall clock. 'He didn't happen to say what he wanted?'

'No, sir.' The Port Liaison Officer was apologetic. 'But he was in one hell of a hurry. The Navy virtually commandeered the field to give the ship priority clearance to land. Looks like some sort of emergency. It's not often they risk landing a heavy cruiser at a metropolitan spaceport.'

`A heavy cruiser?'

'Navy craft. The Labship *Tycho Brahe,* no less.'

Was it in trouble?'

`Not apparently. But I think Colonel Nash was. When . the Port Marshal went out to meet him off the tender the Colonel shouted 'Get away!', or something like that, and ran up the walkway like he was jet assisted.'

`Thanks for calling.' Belling cut the connection to the spaceport and turned back to the wall clock speculatively. Then he picked up the handset again.

'Duty room . . . Is Lieutenant Van Noon still in the depot?'

'Yes, sir. But he's due to check out in a few minutes on twenty-one days' leave.'

`Stop him. He's not to leave without my personal authority. Put him under arrest if necessary, but don't let him go.'

'Understood, Colonel. What's the charge this time?'

`No charge. Just hold him until I send for him. I have a feeling that Colonel Nash isn't the only one who's going to be in trouble.'

'Glad to see you, Ivan! ' Belling held out his hand. 'You know, I haven't seen you since you went to Tazoo.'

`Tazoo?' Nash mopped his perspiring brow. 'I wish to hell I was still on Tazoo.'

'Oh? I gathered it was a bit of a hell-hole.'

'The galaxy's worst—or so. I thought at the time. But that was before I came across Getawehi.'

`Getawehi? What's wrong with Getawehi?'

'That's just the problem,' said Nash, with a look of resignation. 'I'm damned if I *know* what's wrong with Getawehi. I can't even talk about it without sounding irrational. That's why I asked Commander Brumas along. He's handling the Navy's side of the Getawehi project and a saner man you couldn't wish to meet. He doesn't find it easy to talk about Getawehi either. For that reason he's come armed with a video record which shows some of his peculiar problems. I think he'd better state his case first.'

'You have me intrigued,' said Belling. 'The entire resources of the General Engineering Reserve are at your service. If you can broadly define your problem, I'll call up one of our specialists who may be able to assist.'

`Forget your specialists,' said Nash heavily. 'Get that nutter Van Noon up here. This is the type of outwards-facing-interior problem that only he knows how to handle.'

'You know,' said Belling, 'I had the feeling this was going to be one of those days as soon as I heard you were coming.' He reached for the handset again.

'Duty room . . . Is Van Noon available?'

`Yes, sir. Under close arrest. He had to be restrained from leaving. Do you wish to enter a charge sheet?'

`No, no. Just get him up here fast. And while you're at it, drop a noose over Sergeant Hine .and the rest of the UE squad. I have a feeling we may be lucky enough to be rid of the whole damn lot by morning.'

'You sent for me, sir?' Lieutenant Fritz Van Noon entered the office cautiously.

'Yes, Fritz.' Colonel Belling motioned Van Noon towards a chair. 'Sorry to have to cancel your leave, but something very important has come up. Colonel Nash you already know, but I want you to meet

Commander Brumas, currently heading the Navy's Space-Engineering Research team. He has an emergency on his hands.' He turned to his visitor. 'Commander, this is Fritz Van Noon, who runs our Unorthodox Engineering group.'

Despite his obvious agitation, the naval officer relaxed somewhat at Fritz's entry. He had evidently found Colonel Belling's approach to his problems no more comforting than those of his own Service authorities.

`What's on your mind, Commander?' asked Van Noon.

`Getawehi.' Brumas said it with the air of a man who has repeated a story so many times that he is sure that by now the whole world must be familiar with its details.

`Getawehi? Sounds like an insect repellent.'

'No such luck. It's a planet and one of the most Godlost territories in space. We've a twenty-man construction team trapped down there, and we can't lift them off.'

`And you think the Engineering Reserve might be able to help you?' Van Noon shot a quick look at Colonel Belling—who was apparently finding some innocent amusement in the ceiling to judge from the expression on his face and the elevation of his eyeballs.

`Not the Engineering Reserve,' corrected Brumas sharply. 'Specifically the Unorthodox Engineers. The other kind we already have, but after exposure to Getawehi problems they tend to go down with nervous breakdowns like they were infectious. No, this is a far-out situation, and it's going to take some intensely screwball ideas to solve it.'

'Then you're on to the right person,' said Belling maliciously.

'Exactly what's so special about Getawehi?' asked Fritz.

Brumas sat forward in his chair. 'Let me give you the background first. There's a big joint-service science project called Ixion on at the moment. The Navy's part was to land and assemble an equipment project on Getawehi. Superficially it seemed a simple job. It proved to be the biggest balls-up in Naval history. Not only have we been unable to complete the assignment, but we've also lost most of our equipment and left our construction team stranded on Getawehi. If we can do nothing else, we have at least to find a way to get the team off.'

`I don't quite see what the UE group can do that Space Rescue can't.'

No—but then you haven't been to Getawehi. The whole planet's a rotten cosmological joke. Everything about Getawehi is sideways-up. From its orbital velocity and apparent mass it has no business even being in its present orbit around its primary, Geta. And not content with being a complete mathematical absurdity, its own rotation is subject to such peculiar perturbations and variations that its progress can only be described as lolloping. It doesn't even have a stable period of rotation.'

'You must appreciate I'm supposed to be on leave,' said Van Noon warily.

Brumas was unswerving. 'But it's only when you take a closer look at Getawehi that the real peculiarities of the planet begin to emerge. Take, for instance, the dance of the drunken lander.'

Van Noon looked appealingly towards Colonel Belling, but the latter avoided meeting his eyes and busied himself with loading the video projector.

The screen brightened to show a stereo close-up of the planet's surface, a view obviously taken from a spacecraft in a precarious synchronous orbit. Under the cameras the terrain of Getawehi was nothing remarkable. On the screen an ashen-grey soil, spotted with wisps of heather-purple fern and tall grasses, gave way reluctantly to the edge of a grey, rock-strewn steppe—a typical patch of ecological poverty in the cosmological scheme.

`This is the spot,' said Brumas, 'where the first team made touchdown. The prognosis was favourable. Getawehi has a breathable atmosphere at tolerable pressure, no predatory animals above the size of a mouse, and temperatures well within the range of working suits.'

`I've still got twenty-one days due to me,' said Van Noon plaintively.

Brumas ignored the interruption. `I'm replaying the recording at ten times its actual speed, so that the effect will appear exaggerated. What you will see is only one example of the kind of tricks that Getawehi has up its sleeve. In a few moments you will see the landing of the ferry. At this playback speed the actual transit time will appear quite brief, but we are mainly interested in what happened *after* it landed.'

The actual moment of touchdown was obscured by a swiftly-subsiding dustcloud, which cleared to show the egg-shaped lander standing firmly on its tripod legs but leaning at a decided angle from the vertical.

For the first time, Van Noon began to take an active interest.

`Odd!' he said.

`It gets more odd the farther it goes,' Brumas assured him. 'As a matter of interest, it's the only ship we've been able to put down without it toppling. Not that *that* did very much good.'

From the vantage point of the camera almost vertically overhead in space, the legs of the lander could be seen to be firm, but the angle at which the nose-cone faced the sky changed direction and deviated in angle in the most alarming way.

`At this point we assumed,' said Brumas, 'that what we were observing was the failure of one or more shock-absorbers on the legs, and a hunting pneumatic servo trying to compensate. But it isn't true.'

'No,' said Van Noon. 'I didn't think it would be.'

'What makes you say that?'

'The lander's centre of gravity. Even with a weighted base—which you haven't got on a ferry—you couldn't lean it at *that* angle to the vertical without it falling over.'

'Very good! ' approved Brumas. `So what's your reaction to that little paradox?'

'I feel sick.'

'I can seriously . . .?'

'I *was* being serious. If the lander hasn't toppled it can only be because its centre of gravity hasn't been greatly displaced by the angle at which it's leaning. There's only one set of conditions where that would be possible.'

'Which is?'

'That the gravitational attraction of Getawehi is not perpendicular to the surface of the planet. On Getawehi, "up" is not only angled from the geocentric vertical, but it's even subject to short-period changes of direction.'

'This boy's brilliant!' said Brumas, glancing at Belling. `Now, Fritz, leaving aside the fact that gravity variations on that scale are a physical impossibility, let's see how you do on the next bit.'

'You mean there's more?'

`I haven't started yet. This is only by way of introduction. You name the impossible, and Getawehi has it.'

The nose-cone of the lander swung to encompass three hundred degrees of arc in as many seconds, then the whole space vehicle gave a skip and a stagger, spun completely about on one landing leg, then re-established itself about a ship's diameter away from its original position.

'Ingenious! ' said Fritz Van Noon.

'Isn't it? I thought you'd be intrigued. But the worst is yet to come.'

Having found its legs, so to speak, the lander adopted a fairly rapid series of gyratory steps while miraculously remaining approximately vertical. Its path was increasingly haloed by a ring of escaping crewmen, like frenzied ants encircling a honeypot. Each step the ship took was preceded by the curious hop-skip motion with which it had preluded its new mode of transport. Its continuing drunken dance through the fern banks soon carried it out on to the edge of the steppe. There it abruptly disappeared from view except for an unmoving brown stain.

Brumas swore and stopped the projector. 'Sorry about that! I'll give you that last sequence again at true speed.'

'It might help,' said Van Noon morosely. 'An inebriated lander I could learn to live with, but I know from bitter experience that the abrupt removal of several million credits of Government money invariably needs a good explanation.'

After a brief interval the lander re-appeared, moving now at its actual speed and engaged in the last of its strides through the fern and out on to the plain. The extreme angle of its tilt was clearly visible, and its last swivel-round was remarkably controlled considering the vehicle's four-hundred-ton Terran deadweight.

As the landing carriage touched the plain's edge, one leg folded beneath its burden. The lander tipped sideways and began to fall. But more than falling, the whole ship appeared to dissolve as it toppled, the debris melting like candlewax dropped on a hot stove. There was a brief flare, scarcely visible in Geta's strong sunlight, then there was nothing left of the vessel save for a large area of brown metallic stain on the sand-ash and a few chunky ceramic components which survived the remarkable fate of the rest of the ship.

For a long time Van Noon was silent. Then finally he spoke.

'That was quite some trick,' he said. 'How's it done?'

'I'll go into that later,' said Brumas. 'Right now the point at issue is that we've a job to do on Getawehi—a job we started but can't finish. We've three supply ships orbiting the planet which we daren't instruct to make planetfall for obvious reasons. And we've a twenty-man construction team stranded on Getawehi which we can't lift off. We've had a hundred per cent mortality rate on transfer ferries attempting touchdown, and we

can't even communicate with the ground force except by line-of-sight laser channel, due to radio interference.'

'All of which adds up to one heck of a problem,' said Van Noon.

'Precisely! ' Brumas and Colonel Nash exchanged glances. 'But as I said, this is only the introduction. Colonel Nash is the one who has the real problems.'

Two

The thunder of fusing hydrogen died as the Labship *Tycho Brahe,* having cleared the necessary seventeen thousand astronomical units, transmuted easily into its hyperspace analogue and fled through the weird corridors of the dimensionless continua. Aboard, it was time for relaxation. Geta lay far out on the edge of the local spiral arm of the Milky Way galaxy. Indeed, Geta and its single planet hovered right on the border of the vast ocean of interstellar space. The farther galaxies hung like incredibly distant islands in an ocean of darkness, with Andromeda dominating.

A five-day trip. And as the vibration of the planetary drive faded from the fabric of the ship, Van Noon forsook the computer and traced his second in command to the radio room.

`Colonel Nash wants to see us, Jacko. At last we're going to get a briefing on Project Ixion.'

Jacko Hine was not impressed. `If it's all the same to you, Fritz, I'd rather get off here and start walking home. The more I learn about Getawehi the crazier it all becomes.'

`Why? What's the matter now?'

`I've been checking the recordings to see why Brumas thought it necessary to use a laser channel to communicate with the ground force. I found the answer. In addition to an enormous magnetic field, Getawehi has an output of radio mush which exceeds that from Terra by about nineteen hundred to one.'

Van Noon stopped abruptly. 'Synchrotron emission or static?'

Jacko dropped the memory chips on the table. 'Neither. Modulated carrier waves. There's no doubt of it. Long waves, short waves, vhf, uhf, and damn nigh into the X-ray band. You name it, and Getawehi has it. And some of those transmitters pack a punch which would make a Terran megacast station look like a spark transmitter.'

Van Noon began to look rather grey. 'But there can't be any such transmitters on Getawehi. Hell, Jacko, it's uninhabited. There's no life form on Getawehi with an intelligence much above a jack-rabbit. So who's doing the broadcasting—ants?'

'I wouldn't know. But I can say that the radio output from the surface, mainly broadband carriers modulated by random noise, constitutes an almost perfect radio blanket.'

'But it's damn ridiculous! Radio galaxies I *have* heard of, but what the heck am I supposed to make of a radio planet? It can't be a case of synchrotron emission, because you don't get that sort of electron energy on a habitable planet. Anyway, it wouldn't give you a modulated carrier. But what's left? Nothing much less than an array of conventional transmitting equipments—which is impossible—and even if it weren't, you'd still need power to get that sort of output. You can't get that by rubbing two blades of grass together.'

Jacko smiled ruefully. 'It makes a change to hear *you* condemn something as impossible. What's happened to the spirit of sweet unorthodoxy this morning?'

'It's gone a trifle sour on me. Hell, Jacko, Brumas has a ground crew down there. If there were big radio transmitters on Getawehi they'd surely have investigated them by now. So where's their report?'

'There wouldn't necessarily be a report. Communications between ground and the spacewatch have been rather sparse.'

'But why? With a laser channel in operation they could have a thousand-way circuit in operation if they chose.'

'Except for one thing. A reliable line-of-sight channel presupposes the space end of the transmission to be in a synchronous orbit. But you can't establish a synchronous orbit around something which lollops about in space like Getawehi does.'

'I take your point,' said Van Noon wearily. 'We've just been trying to get some sense out of Getawehi's peculiar rotation scheme. The computer keeps throwing it back requesting further information. We can't find any set of postulates which goes halfway towards meeting the facts.'

Jacko stood up. 'You know, Fritz, We've seen some pretty crazy situations in the past few years. But from the way things are stacking up I have the premonition that Getawehi's going to be the craziest yet.'

'And I've a nasty suspicion you're right. No planet is entitled to be as crazy mixed-up as this. Even that self-disposing lander was a highly unusual bit of do-it-yourself. Let's go see what gives with Project Ixion. If it's half as mad as Nash is suggesting, you're going to have company on that long walk home.'

Colonel Nash looked up from a report-strewn table as Fritz and Jacko entered. He was obviously not looking forward to the interview.

'Sit down, gentlemen. You've no doubt wondered why I've left it this late to introduce you to Project Ixion. Frankly, it's because we've all been hoping that somewhere down the line there's been a ridiculous mistake. But I'm afraid our last analysis leaves us no such get-out. The improbable is absolutely true.'

'Exactly what is Project Ixion?' asked Fritz.

'I'm only an engineer,' said Nash. 'I don't pretend to understand the theoretical work behind it. It has something to do with determining the possibility of borrowing entropy levels from other parts of the universe. If it could be done, it would place at our disposal almost limitless sources of power.'

`That I can see,' said Fritz. But why do it on Getawehi?'

`Theory suggested Getawehi as an ideal testbed for the experiment. Geta and its planetary satellite are ideally placed—right out on the edge of nowhere. Freedom from massed stars was something which the experiment demanded. From the theoretical standpoint there's no better place that we know of than Getawehi.'

'So what's the problem?' asked Van Noon.

'The Ixion Project consisted of assembling two substantial prefabricated structures on Getawehi. One was a large turntable, and the second was a cantilever dish, which should have mounted on the turntable roughly after the manner of a steerable-dish radio telescope.'

'So?'

'So this . . .' Nash threw a clip of message forms across the desk. Fritz picked it up and read speculatively.

Getawehi ground force, to Nash, Tycho Brahe
You old idiot. Quite apart from our ridiculous confinement, I must inform you in no uncertain terms that no repeat no part of Ixion turntable can be assembled from the parts you provided. You must be mad!
Wooley, Commanding.

Van Noon turned to the next one and read on.

Wooley, Commanding ground force, Getawehi
I assure you all parts of Ixion were assembled and tested on Terra before transhipment. Try holding plans right way up.
Nash, Tycho Brahe.

Colonel Nash shifted his chair uncomfortably.

Getawehi ground force, to Nash, Tycho Brahe
No part of the turntable fits even with plans held sideways!. It is impossible these parts ever assembled into anything anywhere. You must be joking. Why don't you resign?
Wooley, Commanding.

Van Noon passed the first sheets to Jacko and continued reading.

Wooley, Commanding ground force, Getawehi
Sorry to learn of your nervous condition. I am acquiring a competent engineer as replacement soonest. Suggest you avoid alcohol if you cant handle that either.
Nash, Tycho Brahe.

There was one final sheet, which read :

Getawehi ground force, to Nash, Tycho Brahe
I'll give you alcohol you bl . . .

The rest of the signal was certified as corrupt by the Signals Officer, but he omitted to indicate whether the corruption was semantic or technical. Van Noon looked up.

`So who was wrong?' he said.

`Nobody,' said Nash. 'I saw the completed Ixion structure on Terra and it checked out to specification. It was dismantled and crated by Wooley's own team. The parts space-delivered to Getawehi were one hundred per cent accurate.'

'But he says—'

`I know what he says—and this is the paradox—I happen to believe him. Wooley's a hell of a good engineer. If he says the parts don't fit, then they don't fit. It's not a question of personalities or expertise. It's simply the fact that something built on Terra will not re-assemble on Getawehi. Don't ask me why.'

Fritz considered this in silence for a while. 'That takes a bit of swallowing.'

`I know. That's why I asked you to come. You specialize in impossibilities—well here's another one for you.'

'What do you want me to do?'

`Do? Brumas wants the construction team rescued from Getawehi. Naturally that's the first priority. But knowing the way you do things, I want you to go one step further. I want you to go down there and finish Ixion itself.'

Van Noon examined his knuckles. 'That may not be easy. This is a joint Service exercise with divided responsibilities. What sort of backing and resources can I count on?'

'Commander Brumas and I took the precaution of clarifying the position with GenCom. You must have friends up there, because their answer was unequivocal. As from the moment of this interview you are appointed Senior Adviser for the whole Getawehi–Ixion project. All units involved will take their instructions from you. Nice work, Lieutenant! As from this instant it's all *your* show.'

With a thunderstruck expression, Van Noon shook the offered hand.

`Seriously?'

`Seriously. There's far too much money invested in this enterprise and far too much to gain to let it fail now. Frankly, this is a vote of confidence in unorthodoxy.'

'Very well!' Van Noon turned to Sergeant Hine. `If you can manage to get your mouth closed, Jacko, we've got work to do.'

'Like what, Fritz?'

`Like beating the daylights out of the computer, for a start. There must be some reason why that damn planet lollops all over space like that. And unless we can come to grips with the problem I'd guess we're in for a pretty rough landing.'

Two days later, standard shipboard time, the *Tycho Brahe* quit hyperspace with a delicious quiver and proceeded on planetary drive to the rendezvous. In high orbit three supply ships circled the innocuous-looking mudball of Getawehi, while far below the solitary pinnace rode the lower circuit making a precariously bad job of maintaining a synchronized station above the ground base. Around them the fiery orb of Geta seemed to trace her possessive path as if guarding her solitary ugly-duckling of a planet.

When the rendezvous was complete, Van Noon abandoned the computer for a telescope and found the results equally uninformative. From any angle of off-world approach, Getawehi refused to deliver up its secrets. Superficially it was a sparsely vegetated, rather uninviting ball of rock and earth. It had never achieved a life-form capable of developing any degree of civilization and seemed content to go rolling perversely through space until the stars grew cold. Its only claim to activity was on the radio-frequency bands, where its output, inexplicably, was both prodigious and impenetrable.

Jacko watched the pencil being fractured by Fritz's powerful fingers. `So how're we going to play it, Fritz?'

`I'm not sure yet. We don't seem able to gain any meaningful information from up here, so we'll have to go to where it's all happening.'

'Well, so far the planet has wrecked every ferry they've sent. Were you thinking of taking the whole UE group?'

'Not initially. Just the two of us, if you're game. I need to get down there to get the feel of the place.'

Jacko shrugged. 'I've got a pilot's licence, but in the circumstances I make no guarantee about the quality of touchdown.'

`That's understood, Jacko. If you can get us down without any broken bones, it'll be the best we can expect.'

'Brumas isn't going to be very happy. He's lost too many ferries already.'

`He'll be a lot less happy if he goes back to Terra minus his ground crew. Frankly I don't see any alternative. Down there we stand a chance of doing something constructive. With the rest of the UE group still spaceborne we've at least hedged our bets.'

`What sort of equipment do you want to take?'

'Just light-engineering kit. If we need anything special they can do a spacedrop.'

`Assuming we can get into contact.'

'Wooley has his laser link down there, but the thought comes to me that if we can get control of one of those super-power transmitters down there, the communications problem should be over.'

'That's the bit that has me worried, Fritz. Where the hell are these transmitters? There's not a sign of them in the telescopes.'

`I scarcely expected to find equipment shacks and antennae laid out in a row. Let's face it, Jacko, we're playing in a pretty weird sector of the universe. We're up against so many unknowns that we'd be lucky to recognize a dog before it bit us.'

Three

`Can't you hold her, Jacko?' Van Noon was watching anxiously through the ferry viewpoints as the ground details of Getawehi grew more specific and less stable with their continued descent.

'The automatic control system is fighting me. The inertial guidance platform says that Getawehi is directly under, while Getawehi's gravitation says that it's sideways.'

`So who's right?'

`Both and neither. It's all relative, but it does raise complications. To exaggerate slightly, imagine trying to land a ship on a ramp angled at forty-five degrees from the horizontal. Do you approach at a true right-angle to the surface of the ramp, or do you follow the geocentric vertical?'

'Which way's softest?'

'Either way you're in trouble. If you choose the first, you're liable to topple. If you choose the second you're liable to skid down a one-in-one slope on one landing pad. Throw in the fact that your ramp is not only inconstant in angle but also varies in direction, and you have a rough idea of the dilemma facing both myself and the ship's computer at this moment.'

'What will be the result if we remain controlled by the inertial platform?'

'We crash.'

'What if we cut the automatics and try to achieve Getawehi's conception of the vertical?'

'We *might* just make it, if we conserve fuel and don't apply the corrections until the final moment. Only one problem—we don't know what Getawehi's conception of the vertical *is*. Even with the best of luck we're bound to come down askew on some parameter or other.'

'Gyp the automatics and fall by line-of-sight for a while.'

Jacko looked at him grimly. 'Right. I'm cutting all automatics except the stabilization gyro. We'd have had to do that sooner or later anyway. A small craft like this doesn't have enough fuel to make course corrections on a continuous oscillatory basis.'

Van Noon took up station by a viewpoint and watched the wildly plunging horizon with some dismay. 'How far are we aiming to land from the base camp?'

'Under these conditions I couldn't guarantee any position within a twenty kilometre radius. I'm heading far out so that we don't risk putting a jet burn across the camp. The camp's at the foot of the valley, and I'm aiming to come in between those two mountain ranges, about halfway up the pass.'

The rising scream from the ferry's outer skin told them of their entry into Getawehi's atmosphere. The laser altimeter raced suddenly alive and began to count down the distance to the surface, acknowledging Jacko's gentle manipulation of the thrusters .

Through the viewport the horizon spun wildly and disappeared from view. Fritz took one look through the opposite port at the alarming prospect of Getawehi approaching sideways-on, then ducked back to Jacko at the controls.

'If you call that a line-of-sight approach, we'd best go back for an optician.'

Jacko took his hands from the controls momentarily. 'If you think you can hold this she-devil in control any better, you're perfectly at liberty to try.'

The success of this impromptu manoeuvre was dramatic. The ferry immediately ceased its wild swinging and settled into a more restricted pattern of deviation from the geocentric vertical. Jacko looked at the controls in considerable amazement.

'I don't get it! '

Van Noon thought for a moment, then his lips twisted into a grin of amusement. 'I think I do. Both line-of-sight and inertial guidance are related to the geocentric vertical. All we did was substitute your reactions for those of the automatics. But we were wrong. All we have operating now is a simple stabilization gyroscope. Don't you see what that means?'

'No.'

'Where does the axis of a gyroscope point?'

'Near a planetary mass? Towards the centre of gravity if it's halfways orientated from the start.'

'Precisely! And since Getawehi's gravitational centre is not a fixed point, the gyroscope is swinging the ship to follow the gravitational drift. That was the tendency the inertial guidance system was fighting. But we don't *have* to fight it—the gyroscope is already giving us the factor we need. It's automatically correcting us to Getawehi's concept of the vertical.'

Jacko wasn't convinced. He concentrated on the task of matching their deceleration to altitude, seldom allowing his hands to move more than a hairsbreadth away from the guidance controls. His caution was proved unnecessary. With a reserve of power still to spare, they continued safely to the point where they were ready to make a soft landing.

But the actual moment of touchdown brought disaster. By virtue of being orientated to Getawehi's gravitational direction, the ferry hit the ground at an angle. The landing mechanisms refused to accept the situation, and the leg servos tried to force the ship to adopt a station at right-angles to the terrain. Such a stance was inconsistent with their centre of gravity. The whole structure staggered alarmingly and seemed likely to topple.

'Bail out, Jacko! If this thing goes over it's going to do some damage.'

Jacko needed no prompting. He hit the emergency release, and jumped as the hatch fell open. Within seconds they scrambled clear of the great egg-shaped bulk of the swaying ferry, and scarcely had they paused to gain breath when the vessel gave a skip and a grunt and toppled disastrously behind them.

Shorn suddenly of the ship walls, they looked at each other in amazement as the full experience of Getawehi's peculiar gravity became a physical reality for them. The first sensation was vertigo, the second, nausea. What had been uphill when they first made touchdown was perceptibly shifting until it became across-the-hill, and, even as they watched, became downhill. Fritz's natural body orientation changed with the shifting direction of "up", and the heavens swung around him in a great arc as he moved into equilibrium with the changing conditions.

'Interesting!' gasped Fritz at last, desperately trying not to throw up.

'I hope it's not going to do that often. I expect it when I'm drunk, but cold sober it comes as a bit of a shock to the system.'

'I know what you mean, Jacko. On Terra "up" is up, and it's inclined to remain that way. On Getawehi "up" not only varies in direction but also in slope according to what angle to the geocentric its gravity is pulling.'

`But how in hell does *that* work?'

'I don't know, but I'll figure an answer to it soon. Of course, even on Terra there's a slight distortion of gravitational direction due to the pull of the moon—hence the tides. But it's so slight it can't normally be noticed. If Getawehi had some extremely massive satellites, that could be a possible answer.'

'Except that Getawehi hasn't *got* any satellites. With the mass they'd need to produce an effect like that it would scarcely be possible to miss them.'

`Hmm. We'll come back to that problem when we've had a chance to talk to Wooley's crew. In the meantime, consider the potential uses of a variable-direction gravity. Given a soapbox on wheels and decent set of brakes, you have all you need in the way of low-cost transport. You wait until your destination lies downhill, release the brakes and coast towards it. When your destination shifts uphill you drop anchor and wait.'

'You couldn't run wheels over this stuff.' Jacko kicked the soft ashy soil moodily.

'I wasn't thinking of it,' said Van Noon. 'That was purely by way of illustration. Something more in the nature of a sledge . . . to get us to the base camp.'

'Moses! ' Jacko turned back towards the fallen ferry. It was now a stiff uphill climb, and the ferry approached from the side, looked precariously unsafe. 'I've just the thing, Fritz. The plastic cabin liners. Six sections meeting to form a dome. You couldn't have a better shape.'

As he spoke the world seemed to rear perilously upwards, ship uppermost, as some new component of Getawehian gravity roughly doubled its field and threw the gravitational angle to something approaching

forty-five degrees from the geocentric vertical. Standing now on a hillside plain which fell away below them in a one-in-one slope as far as the eye could see, they stopped in horror. The huge ferry vehicle, its weight now twice that on landing, crushed the soft ash-soil at the edge of the depression it had made for itself on falling, and began to roll murderously down upon them.

Their instinctive reaction was to turn and run down the monstrous incline in front of them. With rare presence of mind Van Noon caught Jacko's arm and forced him to run a diagonal path which took them barely clear of the rolling bulk as the rogue spacecraft rolled a deep trail in the ash-soil. The wisdom of Van Noon's diagonal path of escape was soon apparent. The rolling ship rapidly achieved a velocity which would have fatally outstripped a running man.

Then the angle of the terrain began to flatten again and the intolerable gravity lessened. The ferry rolled to a cumbersome halt as the incline down which it was moving became insufficient to support its motion. Finally the two unorthodox engineers trudged ironically up a slight incline after their errant vessel, approaching it from tail-on in case it took it upon itself to roll again.

'Lesson one,' said Jacko. 'First catch your spaceship.'

'We seem to be luckier than Wooley's ground crew. At least it hasn't dissolved on us.'

'There's still time,' said Jacko miserably. 'The hatch is on the side. Dare we go in?'

Van Noon cast a wary look at the unstable skyline. 'Not for very long. We don't know how often Getawehi goes in for a big pull like that. It'd be fatal to be trapped inside if it rolled again. What we really need is explosives to dig a real big ditch alongside. Once we got her into that we could work inside fairly safely.'

'There's explosives in the tool hold.'

'Do you know exactly where?'

'I stowed them there myself.'

Fritz had been attempting to time the apparent rotation of the highest point of the skyline. Its movement was highly erratic, but there was a certain degree of progression. The coming angle was one soon to place the ship in a position to slip only noseward if it moved at all.

'When I give the word, you try to get in there and out again with the explosives in about seven minutes flat. If you hit trouble, get out without the explosives. But whatever you do, keep inside seven minutes.'

Jacko nodded. When Fritz gave the signal he climbed swiftly to the hatch, fought the cover open, and disappeared inside. Van Noon spent an agonizing few minutes which lengthened into eight before a flurry of activity in the hatchway deposited a dozen packets of plastic mining explosive at his feet, followed by a box of detonators. It was ten minutes before Jacko himself got clear, having miscalculated the intricacies of manoeuvring in a space cabin with the gravitational attraction sideways on.

Van Noon was watching the shifting angle cautiously. He waved Jacko away urgently, but although the terrain began to slope in a direction which could have set the ferry rolling again, the angle did not become acute enough to bring the vessel into motion. Fritz was quick to seize the opportunity. Mentally estimating the circumference of the vessel, he paced out the distance through which the hull needed to rotate in order to leave the hatch at the top.

They placed a chain of explosives across this distance line, with a one-minute detonator at the end. Priming the detonator, they ran across-hill to a safe distance and waited. The explosion ripped a long, deep trough in the soft ash, the edge of which reached almost to the ferry's hull. The shock of the explosion was just sufficient to overcome the forces which kept the great vessel from moving down the incline. Ponderously it rolled into the crater and settled, almost a third of its bulk below ground level.

Now they were able to work on the ferry with the minimum of risk, although the uncertainties of exactly what was "up" were peculiarly unsettling within the confines of the fallen ship. Time and again they were disturbed by the sudden fear that the hull was beginning to roll again, as some sudden change in gravitic direction or intensity made the "floor" apparently shift under them.

It took two hours to cut the cabin liners into sections suitable for two sleds. The shapes they obtained could scarcely have been more suitable for the purpose had they been custom designed. The only brake they could devise was a crude foot-operated device like a ploughshare bolted on to angle brackets at the rear of the sections. On test the brakes proved savagely effective, but the failing light made them put away thoughts of starting their journey before morning.

Very few of the services in the ferry still worked. From the growing acridness of the atmosphere inside, it was obvious that the chemical powerplant had been damaged. For this reason Van Noon decided they would

be safer sleeping in the open. They spent the remaining time before darkness removing from the ship various tools and such few items of provisions as could be carried on the sleds.

Night came with explosive suddenness. The night sky was the first tangible reminder of their peculiar extragalactic location. Part of the sky was strangely dark and lacking in stars, while the rest was aglow with the enormous spread of the Milky Way.

They scuffed shallow grooves in the ash-soil in which to settle their sleeping pods, then climbed in, anxious to get some rest to meet the demands of the coming day. Such was their trust in the ecological and atmospheric climate of Getawehi that neither thought to place their face visors over their pods to ward off precipitation or biological attack. Their only inconvenience seemed to be the shifting gravity, which imparted to the pods the feeling of movement, as if lodged in the branches of a vast and slowly-swaying tree.

It was two hours after Geta had set that Van Noon was awakened by a startled cry from Jacko.

`Fritz!'

`What the devil's the matter?'

'Look at the mountains—they're *burning! '*

Van Noon roused himself and followed the indicated line. Surely enough, whole sections of the ranks of distant hills were lit with a red glow of such intensity that the sky was saturated with a blood-red cast.

'What the hell is it?'

`Damned if I know, Jacko. That range is best part of thirty kilometres away. It would need to be one heck of a fire to be clearly visible from here.'

As they watched, the burning mountains seemed to shift and change with running patterns and pulsations, forming a spectacle more absorbing than the species-long pastime of watching the flickering heart of a home-fire.

`It doesn't look right,' said Van Noon after a while. `Those currents in the flame are moving too fast and too regularly to be true. A fire is a set of small burning nuclei—individual conflagrations. But the way the flame out there flickers, it looks as if the mountain is burning *en masse.'*

'Could it be volcanic?'

`Not the kind of volcanism we're familiar with. Anyway, there was nothing in the reports about any sort of volcanic action.'

`So what's happening over there, then? Don't tell me the whole mountain is made up of paraffin wax?'

`Nothing about this place would surprise me,' said Van Noon moodily. 'But there's one thing that worries me.'

`What's that?'

`There's too much power about. Those burning mountains are a pretty powerful display of *something*—so is the radio output and the mixed-up gravity. They're all power manifestations of considerable magnitude. But it's always output, with never a sign of the origin. It's as if there's a very much larger force at work—a force so large that it can afford to spill over a few billion kilowatts as side effects and never notice the loss.'

`I had the same idea. None of the demonstrations we've seen so far seem lacking for a few billion ergs. I'm not keen on the implications. If there is a large power source around, I like to know where it is and *what* it is. It helps to know if you have to get out from under in a hurry.'

Getawehi swung "up" sideways, momentarily exerted a gravitational pull which almost broke their backs, then reduced its attraction to such an extent that their pods almost left the surface. There was another twist in gravitational angle, then the burning mountains, which had so far seemed to be up a slight gradient, slipped to the bottom of a racing slope of one-in-two. Then, as if to complete the performance, the burning mountains went out—like the turning-off of a lamp.

`You know, Fritz,' said Jacko as he sank back into his pod, 'Colonel Nash was right. There is no place in space quite like Getawehi.'

Four

At first light the next morning they had a trial run of the sleds. By reasonable guesswork their present position from the base camp was about fifty kilometres—an uncomfortable journey if made on foot over the soft ash. For direction they had only to follow the valley floor between the two mountain shoulders to a point where the mountains succumbed to the broad and rocky steppe, the edge of which had been the scene of the disastrous first landing by the construction crew.

To their delight the sleds ran easily over the ashy soil, even when presented with only slight gravitational gradients. The vehicles were prone, however, to come to an unexpected halt on meeting patches of the purple fern which clustered the landscape. A few outcropping rocks were an additional hazard which required careful negotiation. There was no way of steering the flat-bottomed sleds. Wherever obstacles were encountered, it was necessary to halt and manually drag the sled to a new position. Occasionally the gravitational angle produced slopes insufficient to support their motion, and these had to be borne in patient immobility, as did the passing of all slopes other than the one leading in the required direction.

After a survival-ration breakfast they secured to the sleds such items of tools and provisions as they were able to make fast. Then, waiting for the terrain to slope in a suitable direction, they set off. The air was crystal clear and inhabited with a crisp coolness and a heather-honeyed perfume which was decidedly pleasant. Far to their right the burning mountains, now quiescent, stood up glassy and apparently untouched by the conflagration of the night. Nearer and to their left, a vast outcropping of grey-white striated rock formed, with the burning mountains, the shoulders of the valley, some forty kilometres across, through which lay their route.

Their mode of transport proved both exhilarating and predictably hazardous. Swooping down an apparent slope of one-in-three, the ground reared suddenly upwards before them. Fritz managed to drive to a halt, but the momentum of Jacko's sled ploughed it a metre depth into the ash soil before it came to rest. Climbing out from the ditch which he had dug, Jacko's look of murderous reproach threw Fritz into fits of laughter.

However, it was Van Noon who nearly became the first casualty. Driving down a deep slope, where the sled velocity must have been nearing fifty kilometres an hour, the progress of Fritz's sled was suddenly arrested by a patch of fern. Fritz parted company with the sled and proceeded without visible means of support for a considerable distance before he made a spread-eagled landing. He got up, shaken, but miraculously unhurt. Nevertheless much of the equipment he had been carrying on the sled was lost in the ash and could not be recovered.

Despite these and similar incidents and frequent halts while their intended direction lay sullenly uphill or across, they made very good progress. By tacking across their general course they found they could make use of nearly half of the available angles. The mountain shoulders gave them an easy sense of direction without reckoning and at last they reached the end of the broad valley. Before them now began one of the great steppes of Getawehi, a spotted, rock-strewn desert, completely without vegetation. It continued as far as the eye could see—monotonous and inhospitable.

Jacko viewed the prospect critically.

'We could never cross that on the sleds, Fritz. Too many rocks. There's less than a hundred metre straight run anywhere.'

'It's fortunate that we don't have to. By my calculation the construction team ditched somewhere between the steppe and the end of the grey-white mountain. If so, we should be nearly within sighting range by now.'

They scanned the area anxiously, but found no sign of the base camp.

'Have you got any distress rockets or anything similar in those bits and pieces of yours, Jacko?'

'No. But I've got some plastic explosive left, and a few detonators. We could at least make a big bang.'

'That should do the trick. If we can only get some sort of answering signal to guide us we should be able to locate them fairly easily from here. They should be on the lookout anyway, because they must have seen our ferry fall.'

They arranged three explosions, separated by a one minute and then a thirty-second interval. After what seemed like a ten minute wait a slight column of smoke rose up near the grey-white mountain's end at about five kilometres distance.

'That appears to be them,' said Van Noon. 'Let's go over and meet the troops.'

By a fortunate coincidence of angle and direction they covered the distance in record time. Swooping from the heights of a big slope they came suddenly across a string of a dozen men labouring on foot up an ashen trail. The party was encumbered with axes, ropes, and miscellaneous rescue equipment. As Van Noon and Jacko braked to a halt, the file of men dropped their loads, and, with a loud cheer, came dashing to greet them.

The teamleader was the first to arrive.

'My name's Wooley. We saw your fire-bucket come down behind the mountains somewhere, but nightfall beat us to it. We were just on our way to find you. Frankly we didn't expect any survivors, from the angle she was making when she hit.'

'We were lucky,' said Van Noon. 'We managed to get out before she toppled.' He had the distinct impression that Wooley was not too enthusiastic about their arrival.

'Just the two of you aboard?'

'Yes, but I'm afraid we lost the ship. She'll never make space again. But there's a lot of useful stores and equipment in her if you can get them out.'

'We'll get them out somehow,' said Wooley. 'As for losing the ship, that was a foregone conclusion. The spacecraft isn't yet made which can land undamaged on Getawehi. I don't wish to seem critical, but just what did you hope to achieve by joining the suicide club?'

'I'm Van Noon,' said Fritz. 'By some mischance I seem to have finished up with the responsibility for this little lot.'

'Van Noon?' Wooley screwed up his face. 'Weren't you mixed up in that affair on Tazoo?'

'For my sins, yes,' said Fritz ruefully. 'But by all accounts Getawehi has Tazoo beaten by several orders of magnitude. Jacko and I decided that if we didn't want to spend the next five years driving computers neurotic we'd better get down here and get the feel of it ourselves.'

'Then welcome to Getawehi!' said Wooley sadly. 'But believe me, you're in for a whole lot more surprises yet.'

In the meantime, a few of the construction team had borrowed Jacko's sled and had been making short experimental trips across the terrain whenever the opportunity presented itself. Wooley had watched these antics without much enthusiasm, but one particularly successful run captured his interest. He examined Fritz's sled more closely.

'Did you come all the way on this?'

'About fifty kilometres since sunrise.'

Wooley turned and clasped Fritz's hand in a sudden handshake. 'Sorry, Fritz! I knew I was being replaced as head of team, but I thought we'd merely get a new boy who'd be making all the same mistakes until he wound up six weeks later in the same situation as I'm in. I hadn't stopped to think of the unorthodox angle. You know, if we'd been at the wreck and wanted cabin liners back at the base camp . . . Dammit, we'd have *carried* the bloody things! '

'Forget it! ' said Fritz. 'You're not being replaced. It's simply that the overall control for the entire project has transferred itself from its lofty orbital heights to the place where things actually happen.'

'You mean they've given you control of the whole lot?' Wooley was incredulous.

'Just that. The veritable hot potato.'

'No potato that,' said Wooley sadly shaking his head. 'What they dumped on you was a small mountain. Come back to base and I'll try to explain.'

'I'd appreciate that,' said Fritz. 'It's about time somebody gave me a rational explanation of why a group of experienced engineers can't assemble a kit of prefabricated parts.'

For a moment Wooley's eyes looked haunted. 'I didn't say I'd give you a *rational* explanation . . . I only said I'd try to explain.'

The base camp was a camp in little more than name only. Originally the site of a single space-drop of heavy equipment, it had become the focal point of the endeavours of the construction team solely because there was no incentive to go elsewhere. Behind the site lay the grey-white mountain chain. In front lay the vast mottled steppe. On the ashy no-man's-land between the two, were gathered various space-drop capsules, some of which had obviously contained parts for the Ixion project. Also there were capsules from later drops, clearly marked as having contained emergency survival supplies.

Living quarters, such as there were, had been constructed from well-entrenched girderwork "borrowed" from the abandoned assembly project, overtopped by parachute material from the space-drop canopies. All the men seemed fit, but it was obvious that the prolonged period of enforced grounding on Getawehi, coupled with strict rationing, was beginning to have its effect. The most disquieting aspect was the look of resignation which rested in their eyes.

Fritz looked out over the broad steppe, something about the configuration of ferns and rocks stirring a thread of memory.

'Isn't this the place where your first ferry sank?'

'Sank!' Wooley was incensed. 'It didn't sink . . . it was *melted.'*

'You have to be joking! '

'Do I just! You watch this!'

Wooley turned, seized a crowbar from an abandoned tool-kit, and tossed it out on to the rock-strewn desert. One end struck the grey sand, while the other touched a protruding rock. There was a blue spark as it touched. For seconds it seemed as if nothing was going to happen. Then to Fritz and Jacko's astonishment the tool began to glow a visible cherry red. Its temperature continued to increase through white heat to a point where the iron bent and fused into a pool of molten iron. The incandescent metal dribbled into a thread and ran apart. The arc which struck as the curious circuit broke was more in the nature of an explosion, and the watching trio ran for their lives as the area was deluged with droplets of red-hot iron and warm sand.

'Convinced?' asked Wooley, when they had retreated to a safe distance.

'Convinced,' agreed Van Noon weakly. 'It must have taken a couple of thousand amps to melt a bar like that.'

'It must have taken many millions of amps to melt our ship,' said Wooley gloomily, 'but it did it somehow.'

'But this is ridiculous, Fritz! ' said Jacko. 'How can you have an electrified desert?'

'Not too ridiculous really. Even on Terra you can find a surprising amount of electrical currents in the earth if you go looking for them. On Terra the source is usually electro-chemical—minute differences in electrode potential between regions containing different concentrations of mineral substances. But I don't know of any natural source capable of producing some dozens of volts at many millions of amps—or why the system doesn't discharge itself.'

'We've done some investigating,' said Wooley. 'The grey rocks you can ignore, but we call the black rocks "terminals". Actually they aren't simple rocks at all, but columnar graphite structures presumably reaching down to the bedrock. They have an insulating sheath, a sort of lacerated asbestos, which we theorize came to be deposited by electrophoresis of the soil silicates. But however it came about, it's damned effective in insulating the columns from the rest of the plain.

'The remaining bulk of the desert is merely a minerised silicate-base earth, not unlike Terran clay. Average potential difference between the terminal columns and the base land is about twenty-seven volts. But it varies pretty widely and can touch a couple of hundred volts in the high season.'

'AC or DC?' asked Jacko.

Wooley began to look rather haggard and turned away for a moment.

'You aren't going to believe this,' he said. 'Generally it's DC with the terminals positive with respect to the base-land. But sometimes you get AC—especially on Tuesday and Sunday mornings.'

Five

'And if you think *that's* mad,' said Wooley, 'wait until you start on the Ixion project.'

'You know, Fritz, I'm beginning to get sorry I came.' Jacko looked at Van Noon appealingly. 'Can't I just go home and sleep it off?'

'Try closing your eyes, Jacko. Maybe it'll go away.'

'I tried that,' said Wooley. 'But it comes back every morning, large as sunrise.'

'Well, what *is* the Ixion problem?' Van Noon asked. 'The one thing I haven't been able to do is get anyone to talk about it.'

'Wait till you've seen it for yourself. I don't think *you'll* want to talk about it either.'

They were approaching a stockpile of carefully classified girderwork, part of the Ixion turntable structure recovered from spacedrop capsules. Wooley consulted a parts list, then drew a few sections from the stockpile and dropped them on the ground.

'A simple demonstration. Girder A measures two metres exactly between hole centres. Don't take my word for it—check it out.'

Jacko produced a steel tape from the recesses of one of his pockets and made the necessary measurement.

'Two metres—check!'

'Girders B and C each measure one metre between hole centres, yes?'

'Check! ' Jacko looked at Fritz as if seeking release from the infantile nature of what was being demanded.

'Very well! ' Wooley was unperturbed. 'If you assemble girder B to girder C, end to end with a suitable rivet, the total length between extreme hole centres should be two metres. Right?'

'Right.'

'Wrong,' said Wooley sadly. He dropped a rivet on to the ground and waited while Jacko moved the components into line and fitted the fastening loosely into the holes. 'If you don't believe me, measure it yourself.'

There was no need for measurement. Even viewed from a standing position the combined length of the two half girders was obviously much less than that of the whole one. Refusing to believe the evidence of his eyes, Jacko knelt and carefully measured the combined length of girders B and C.

'One point five seven,' he said hopelessly. Again refusing to accept the sum, he kicked the girders apart and checked each carefully before re-assembly. Fritz, who had watched the whole performance with detailed interest, seemed to have withdrawn into a state of deep concentration. At last he took the offered measuring tape from Jacko and repeated the whole ritual for himself. Intrigued by the situation, he found several other objects and measured them individually and together. Then he straightened.

'Incredible,' he said, 'but very definitely true.'

'Then explain it to me,' said Jacko. 'In all my books twice one is two—and it's never before been in dispute.'

'But your books were written on Terra, not Getawehi. On Getawehi they don't apply.'

'But that's insane!' Jacko was adamant. 'Mathematics is merely a system for expressing the properties and relations of quantities. It's universal, not a local phenomenon. Once one is one, twice one is two . .

Van Noon rapidly reviewed his previous calculations.

'Not on Getawehi. It seems to be different here. Once one is one . . . but twice one is only a bit over one and a half—one point five seven zero eight, to be more exact. And three times one is about two point three six.'

'Wooley, you don't agree . . .?' Jacko was still fighting. The look on Wooley's face, however, convinced him that the battle was lost. 'I still don't see how it's possible,' he finished lamely.

'It's long been suspected that our mathematics may not be universal,' said Fritz. 'Dimensionless numbers, for instance, although having an accepted value in the part of the universe where we customarily use them, are more likely to be local coincidences than physical absolutes. But on Getawehi we seem to have hit on something even more fundamental.'

'Such as?'

'I'm not sure yet, but for my money it's something to do with unity.'

'Unity?'

'Yes. Unity . . . one . . . a whole. I'm no mathematician, but it seems to me there's a darn great hole in our idea of the structure of numbers. We've explored number structure up to infinity and several orders beyond—but something we've always taken for granted is the constant mathematical value of unity.'

`But it has to have a constant mathematical value.' Jacko's voice was ragged. 'Once one is one . . . It can't be otherwise by its very definition.'

`So we've always assumed. But what if we happened to be wrong? What if there's a difference between the value of one as representing a whole thing—and the value of one as a mathematical factor. They seem both to be the same in the corner of the universe where our books were written—but one used as a factor on Getawehi is demonstrably only point seven eight five of what it was on Terra.'

'You're not right, you know, Fritz. I'll prove it to you.'

'How?'

'Take a metre length of iron, cut it in half and then join it together again. By your reasoning we should finish up with a total length only a little above three-quarters of what we started with.'

`Let's try it,' said Van Noon. 'We have to settle this one way or the other before we all go merrily insane.'

Wooley provided welding equipment, and they tried it. The final measurement was a little over point seven eight of a metre.

'But I still don't see how you can reconcile it with the law of conservation of matter,' said Jacko.

'Where do you keep the Scotch?' asked Fritz Van Noon.

'So what are we going to do with Project Ixion?' asked Jacko the next day.

'I've been thinking,' said Fritz. 'It's not going to be easy even if it proves possible. The Ixion assembly is a pretty complex girderwork construction. Every part has to be accurate if it's going to fit. My first thoughts are to take every girder, cut it in half, and re-join. In that way we might be able to construct what is, in effect, a scaled-down version of the original design.'

'Is that acceptable?' asked Jacko. 'Surely some of the parts have a critical size.'

'I don't know. I tried to put this question to the *Tycho Brahe,* but I don't think my message was received. Apparently the pinnace can hold our position by line of sight, but it's not easy for us to track the pinnace because of its unstable orbit. Anyway, I suspect this is a problem for the design team on Terra rather than something which can be settled on the *Tycho.'*

'Then you want me to try cutting and joining the girders?'

'We'd better have a go. We certainly can't make matters any worse than they are. I've a suspicion, however, that the problem isn't going to be solved that simply.'

'You're the boss! ' said Jacko. 'I still can't convince myself that it happens at all, but at least we'll go through the motions.'

Six hours later Jacko found Van Noon crouching at the laser terminal trying to maintain sighting on the pinnace. Such was the relative crudity of the ground terminal that sighting on a small and erratic spaceborne target such as the pinnace was so precarious as to be nearly impossible.

Jacko shook his head wearily. 'Project Ixion's no go, Fritz. We've tried cutting and joining the girders, but it doesn't help. Where the assembly calls for a total span to be formed of thirty components along one edge and only five in another, the whole scheme falls down. Short of cutting every girder into the total number of parts required to form the entire project—and then re-joining them—we don't stand a chance of getting anything to fit.'

Van Noon stood up. 'I was rather afraid of that. We'd need God-knows how much computer down here to calculate the operations needed to resurrect the original design, and even *then* we've no guarantee that the final de-scaled assembly would do the job it was designed to do.'

'Is it worth continuing with the work?'

'No. Abandon the whole thing. There has to be a more rational way out of this. As far as I can see, Ixion in its present form is destined to be a dead duck. I wonder where the heck they found a name like that for it anyway?'

`Mythology—rather symbolic as it turns out,' said Jacko mournfully. `Ixion was a character who killed his father-in-law and then tried to make love to Jupiter's wife. As punishment, Jupiter ordered him to be tied to a fiery wheel and rolled for ever throughout Hades. Right now I know exactly how Ixion felt.'

Van Noon was suddenly alert. 'Say that again, Jacko.'

'Right now I know exactly how Ixion felt . . .'

'Not that! About the wheel?'

`Tied to a fiery wheel and rolled for ever throughout Hades . . .'

'That could be it!'

`What's on your mind, Fritz?'

'I've just realized how it's done. Why didn't I think of it before?'

'You're way ahead of me. How *what* is done?'

`The gravity, of course. And the burning mountains, the radio output, and the self-consuming spaceship—they're all part of the same scheme.'

'Can we just go back to the start?'

Van Noon was jubilant. 'That *has* to be the answer! Wheels within wheels . . . the fiery wheel of Ixion . . . rolling forever throughout Hades . . . suddenly the pieces all fit together. All we have to do is prove it.'

'I'll get them to spacedrop a good psychiatrist.'

'Not for me, Jacko. I never use 'em. But get me a good computer and a hyper-radio link with Terra, I think I've just made the Ixion project obsolete.'

Six

'Radio Officer presents his compliments, sir. Requests yourself and Commander Brumas to come to the radio room immediately.'

Nash returned the salute and shot a quizzical look at Brumas, who was sitting near him at the conference table. Then he looked back to the courier.

`Is it important?'

'Radio messages loud and clear from Lieutenant Van Noon on Getawehi, sir.'

'Radio messages? I thought radio was impossible under these conditions? Dammit!' He looked round at the expectant faces of the officers present at the conference. 'In the circumstances, gentlemen, I'm afraid I

must call this meeting to a close. It would seem Van Noon has already achieved something of the impossible. There'll be a progress report at twenty-hundred hours ship's standard time. Until then, all sections are to stand in readiness. This may be the break we're looking for.'

With Brumas at his heels, Nash reached the radio room in record time. The Radio Officer was supervising a narrow-band lock on the big receiver, which appeared to be tuned to a slowly drifting signal.

'Van Noon to *Tycho Brahe.* Are you receiving me? I say again . . .'

'Can we answer?' asked Nash.

'Not by radio. We haven't anything available with the sort of power that Van Noon's using. All our transmissions would get lost in the mush. We're just linking a relay so that we can answer via the laser circuit on the pinnace. It's easier for us to get messages in that way than it is for Van Noon to get messages out.'

'Fine, do it! ' Nash waited impatiently for the hookup to be completed.

'Hullo, Fritz! We are receiving you perfectly. How the Devil did you come by a high-power transmitter like that?'

Van Noon's voice came over the noise with rare fidelity. 'If I told you, Colonel, you wouldn't believe me. Anyway, thank heavens I've managed to raise you. I've been calling for nearly two hours.'

'We weren't watching for you on the radio bands because we didn't think it possible for you to use them.'

'Anything's possible once you know how.'

'I'm glad to hear you say it. How're you making out with the Ixion project?'

'I agree with Wooley that we might as well sell the existing parts for scrap. No one could ever assemble them on Getawehi.'

'That wasn't the answer I wanted to hear.' Nash was disappointed. 'Is there no hope at all?'

'Not for the Ixion structure. But the Ixion *principle* might be a different matter. Unless I miss my guess, we can duplicate the function of the Ixion project without actually building it. But I'm going to need help.'

'You name it, and you've got it, Fritz. By the way, Commander Brumas is anxious to speak to you, so I'm handing over for a moment.'

'Hullo, Commander! You'll be pleased to know the whole team down here is fit and well.'

'I suppose that's some consolation.' Brumas was grave. 'Did you get around to having any ideas as to how we can get them off Getawehi?'

'Get them off?' Van Noon sounded surprised, then the humour came through in his voice. 'I don't think that'll be much of a problem. When the *Tycho Brahe* makes planetfall they can wander aboard just like anybody else.'

There was silence for a long moment, broken only by the hiss of white noise on the radio link and the muted hum of the radio room equipment.

Finally Brumas spoke. 'I don't think I quite understood you there, Fritz. For a moment I thought you were suggesting that the *Tycho Brahe* make planetfall on Getawehi!'

'That's exactly what I *did* say, Commander, I need the *Tycho Brahe* down here. I need the hyper-radio link, I need the ship's computers, and I need a mass of manpower.'

'But you can't jeopardize the *Tycho Brahe.* For pity's sake, Fritz! You know what happens to a ship attempting to land on that damned planet!'

'I know what *used* to happen, but we've got ourselves a few answers since then.'

'You can't be serious, Fritz?' Colonel Nash was back on the circuit. 'There's no point in writing off the Labship as well.'

'I don't intend to write it off. All I need is a direct two-way speech link with the senior pilot during the talk-down. Given that, I'll guarantee a safe touch down and that the ship will remain intact after landing.'

'I can't permit it,' said Brumas. 'The risk is far too great.'

'Are your recorders on, Commander?' asked Van Noon.

'Certainly. Standard procedure—why do you ask?'

'Because I want this firmly placed on record. I was appointed Senior Adviser for the whole exploit. My considered senior advice is that you should bring the *Tycho Brahe* down to Getawehi. If you should ignore this advice, I demand that this recording be placed in evidence at any court martial which may subsequently transpire. If you don't do as I ask you have no chance at all of recovering the team on Getawehi.'

'Damn you, Fritz!' said Brumas. 'Let me speak to Wooley. I want evidence as to the unsoundness of your state of mind.'

'You already have evidence. Look through your telescopes. Wooley's out in the valley with his crew, laying out landing markers to guide your descent.'

'Very well, Fritz . . . you win! ' Nash's voice carried begrudged acquiescence. 'It'll take about an hour to put the ship in a state of readiness. After that you can begin talk-down. But I hope you know how much responsibility you're taking on yourself. There's two hundred men aboard the *Tycho Brahe.'*

'I know it, Colonel. But I wouldn't put a mouse down on Getawehi unless I was absolutely sure.'

'I still don't see how the hell you can be so certain. Every other ship that has touched the planet has come to a sticky end.'

'It's just that I'm beginning to gain an understanding of Getawehi. It seems that she and I both have the same sort of outwards-facing-interior approach.'

High above them in the uncertain heavens a tiny fire-point denoted the position of the descending *Tycho Brahe*. Its visual distance belied the muted thunder of its thrusters. Even from the extreme altitude the sound carpeted the land with a pattern of sound which were reflected and amplified by the valley's throat. With sweat on his brow, and a shielded microphone pressed at his throat, Van Noon was making the critical talkdown. At his side, Jacko, operating both rangefinder and telescope, recited a constant steam of information which served as an informative background to Fritz's constant monologue.

The Labship, thrusters balancing its fall through the stratosphere, was weaving an erratic course into thicker air. Its point of destination was a mere approximation due to its curious deviations from the geocentric vertical. Everything now depended on the smooth continuance of the radio link with the *Tycho Brahe's* pilot, and upon the pilot's ready acceptance of Fritz's instructions. In such a manoeuvre the pilot's word was law. It was his decision to accept or reject advice affecting the safety of his ship, and his replies were routed via a laser link from the ship to the ground.

'Make ready for touchdown. Central thruster to maximum . . .' Van Noon's voice continued precisely above the wave of sound as the mammoth ship loomed in the air above them. 'Gently cut back . . . try for a very soft landing . . . don't worry about the angle you're making . . . Doing nicely now . . . only metres to go . . . Make sure the leg servos are off, and as soon as you feel the ground, cut thrusters.'

'Are you *mad?* With the terrain sloping at this angle?' The pilot's voice came back with swift dissension.

Van Noon was firm. `Do as I say, or you've no chance whatever.'

`Check! I can feel the ground. What about the gyro?'

'Leave it running.'

'Are you sure?'

'I'm sure about nothing on Getawehi. But leave it running. Oh, and one thing more . . . for Pete's sake don't let your engineers dismantle anything. If they do, they'll never get it re-assembled.'

A blinding hailstorm of dislodged ash soil settled in a broad area to reveal the *Tycho Brahe* safely planetbound but leaning at a decided angle to the vertical. Open mouthed, everyone waited for her to topple.

Those of Wooley's team who were able to manoeuvre sleds 'downhill' came shooting across the valley, convinced they were on their way to a major catastrophe. Van Noon only smiled slightly to himself and directed Jacko to watch the stability of the Labship's landing pads, which were buried deeply in the loose Getawehian soil.

As the uncertain gravity altered its angle and continued its slow rotary progress it became apparent that the towering mass of the ship was not going to topple. Jacko reported that the landing assemblies were firmly planted and showed no sign of wanting to tear out and wander, as had those of the first ferry on Getawehi. With an air of uncertainty the great craft moved in a broad arc as the angle at which the ship was leaning followed the migrating highest point of the horizon. Even so, it was nearly half an hour before the shipboard establishment cancelled the state of emergency and could be encouraged to open the hatches and leave the ship.

Characteristically, once the decision had been made, Colonel Nash was first out. He moved thirty paces from the ship, turned and looked dubiously at the huge bulk leaning above him. He winced and then set off downhill at a steady run until he was sure he had put more than a ship's length between himself and the metal Nemesis. During the course of the run, what had been downhill became across-the-hill and finally began to curve upwards. He stopped then, shaking his head sadly, and walked the rest of the way to Fritz's control point.

Van Noon wearily laid down the microphone and saluted. 'Welcome to Getawehi, Colonel!"

'It's an experience I could well have done without,' said Nash. 'I must congratulate you on safely conducting our touchdown, but it does raise a few interesting questions.'

'Like what, sir?'

'Like how the hell did you do it? Every other craft has either toppled or walked its way to destruction.'

'Simple,' said Fritz. 'I played Getawehi at its own game. If Getawehi wants it that "up" is angled umpteen degrees from the geocentric vertical, then so be it. Let the ship come down out of vertical, and let it stay that way when it's landed. The thing you *mustn't* do is try to fight it. It's axiomatic that Getawehi is going to have a last word.'

'But won't the *Tycho Brahe* walk?'

'No, and for the same reason. The leg servos, which are responsive to the geocentric vertical, have been cut out. We're not trying to use a stiff leg where a bent one is needed.'

'I'll take your word for it,' said Nash heavily. His eyes were still nervously watching the trials of the leaning spaceship. Then he shrugged resignedly. 'Very well, Fritz! You've got the *Tycho Brahe* down here, hyper-radio transmitters, computers, and all. You've demonstrated that the Ixion structure cannot be built—so now let's hear your plans for an alternative.'

'First,' said Fritz, 'I have to prove a theory. For that I need the computers and a lot of manpower. If I can prove what I suspect is true, I shall then need contact with Terra to verify that Getawehi itself can supply the information that Ixion was intended to collect.'

'The entire ship's facilities and the manpower's yours. All I ask is that we can make a getaway from Getawehi in a reasonably short period of time. Which reminds me, you haven't yet explained how you managed to acquire such a powerful radio transmitter.'

'I left the details of that to Jacko Hine. But I don't think he much likes talking about it either.'

Seven

It took three weeks. Teams ranged over a several hundred mile radius before Fritz could collect and collate the necessary information. For most of this time the shipboard computers on the *Tycho Brahe* worked continuously, sifting the data from the on-line transducers and from recorders which the sled teams kept bringing in. Piece by piece the pattern which Van Noon had intuitively deduced was verified and described in the mathematical detail which only a high-power computing complex has the ability to construct. From this Van Noon re-drew his simplified models more suited for communication between humans. When he was satisfied, he established a hyper-radio link with Terra. For three days more the ship's computers chattered to and were interrogated by their counterparts back home, while Van Noon himself argued on a more prosaic level with the Ixion Project design team.

On the last day he gained the point he had been seeking, and called an immediate conference of all senior personnel concerned. When they were seated, he rose and passed the message transcript round the table.

> *Van noon, Tycho Brahe*
> *We agree all points. The information supplied proves the Ixion entropy concept valid and viable. The project has now been drawn to a successful conclusion. This is a historic moment. Congratulations to all concerned*
> *Ixion control.*

After a few minutes Colonel Nash rose uncertainly to his feet.

`Gentlemen . . . I'm sure we're all glad to know that the Ixion concept is viable. And I'm sure we're all delighted to share in the congratulations for the successful conclusion of the project—especially after it was so nearly a disaster. But I have one important question to ask. Fritz . . . what the hell is going on?'

Van Noon stood up, grinning broadly. 'I must apologize, gentlemen, if the last phases of the operation seemed something of a mystery. The trouble was that I leaped to a conclusion about Getawehi which was so unorthodox that I doubt if you'd have given me a second hearing had I attempted to explain. Fortunately, events have proven me right. In case any of you haven't already reasoned the position for yourselves, I shall now be happy to explain. Of course, the whole key lies in the peculiar nature of Getawehi's gravity.'

'You have an idea of what causes the variations?' Brumas was sharply attentive.

`Yes. I theorized that the effect was consistent with the presence of orbiting satellites of very considerable mass. In point of fact, what we were experiencing was the result of several interacting gravitational attractions rather than the single one to which we are accustomed on Terra.'

'Ingenious! ' said Brumas. 'But not very convincing. To take the main point—Getawehi *has* no satellites.'

'I'm afraid you're wrong,' said Van Noon. 'We have orbital plottings of three major satellites and the reasonable suspicion that at least another twenty minor ones exist.'

'Rubbish! I tell you there are no such things.' Brumas was becoming annoyed. 'Dammit, we've been observing the planet from space for over six months now.'

'From space you wouldn't see them. You see, Commander, they happen to be *internal* satellites—orbiting beneath the planetary surface.'

`Nonsense?' Brumas flared with anger. `If this is some sort of a joke . . . !'

Colonel Nash rose and calmed the sudden uproar. 'Gentlemen, I think you now see why Lieutenant Van Noon didn't attempt to discuss the matter before. Very few of you have been exposed, as I have, to Van Noon's contempt for orthodoxy. At first sight it always hits below the belt. But somehow the damned idiot always makes it so plausible that I can assure you it's futile to get into an argument with him.' He turned back to Van Noon. 'I assume, Fritz, that you do have some justification for this amazing statement?'

'Certainly! ' Fritz was unruffled. 'By the use of weight-loaded strain gauges distributed over a wide area, we have been able to plot the mass, size, and orbits of the three major satellites. The orbital information is precise and all orbits fall well within the mantle of Getawehi. The mass and size figures are enough to make your hair curl.'

'Why so?'

'Because the only material known in the universe which could possibly have that mass and density is material which has itself suffered gravitational collapse—degenerate star-matter. Matter so far collapsed on itself that its atoms are virtually in contact with each other.'

'As would be material from completely exhausted dwarf-stars?'

'Yes. Factually, these small satellite bodies constitute over two-thirds of Getawehi's actual mass. Their orbital speed is low, and the planet is virtually an envelope which lollops around the variable centre of gravity of the satellite group. Getawehi's surface gravity is a compromise between its own weak attraction and the higher, yet mobile, attraction of the hyper-dense orbiting nuclei.'

'Are we to understand, then, that Getawehi is hollow?' Nash was puzzled.

'Far from it. Its internal structure is probably not too dissimilar from that of Terra, except that the crust and solid mantle of Getawehi must be many times thinner. Also the whole inner core must be in a molten state—probably molten nickel-iron. It's within this core of liquid metal that the satellites orbit.'

'If you say so.' Nash settled back and chewed his moustache. 'Very well, Fritz! I'll accept that, because I've no doubt that you have it well documented. Now tell us what you used as a substitute for the Ixion assembly?'

'In a moment,' said Fritz. 'First let me deal with the electrified desert, since it's all part of the same story. There just *had* to be some natural mechanism available capable of producing substantial voltages at an almost limitless current. I approached the problem by considering what type of generator could produce this order of electrical output. The only reqasonable answer was a homopolar generator.'

'A what?'

'A homopolar generator—the simplest electrical generator ever devised. It consists essentially of a large conducting disc or rotor, spinning in a magnetic field. Once I had hit on the idea of satellites orbiting in a molten metal core, the answer was obvious. Gatewehi has a strong magnetic field, and nine-tenths of her volume is a rotating ball of conductive, liquid metal. Getawehi *is* a homopolar generator, and one of no mean proportions. The black rod-like terminals apparently project through the solid mantle and act as current pickoffs. I suspect that variations in output are somehow associated with satellite turbulence and to the fact that frequently the whole system gets its axis out of line with the planetary magnetic field.'

'But you still haven't built another Ixion,' argued Nash.

'I didn't need to. As I thought, the Ixion structure was a massive but fairly simple device, intended to detect some of the oddities of entropy distribution in the continuum by measurement of fairly simple parameters. It was obvious that it was going to work because all the dimensionless numbers relating to entropy calculations are different on Getawehi—and even the dimensional numbers have adapted to follow suit.'

'But the hardware?'

'It wasn't needed. The criterion of Ixion was not its complexity, but its *size*. When I offered Terra not a large turntable but a planet-sized ball of rotating metal complete with current pickoffs, they were overjoyed.

They had to re-calculate their parameters, but we were able to feed them in a few days of the type of data that the Ixion structure might have taken centuries to produce.'

'Hmm! ' Nash was thoughtful. 'As usual, Fritz, you seem to have all the answers. But I can see some of the technical boys have their toes curling up. I suggest we adjourn for a while to allow them to catch up on the figurework. As for you, Fritz, you're coming with me.'

'Where to, Colonel?'

'To show me what the hell Getawehi uses as a high-power radio transmitter. I swear I've examined every square inch of this planet by telescope without detecting even so much as a banana plug.'

Van Noon shrugged. 'I suppose you won't be satisfied until you've seen it for yourself . . . and you may not believe it even then.'

As the sleds neared the range it was possible to see the light from the burning mountains even in broad daylight. Despite a favourable angle of slope, Colonel Nash halted his sled at a distance and took out his field glasses to study the phenomenon. Van Noon drew up alongside.

'How does it work?' asked Nash at last.

Fritz waved his hand. 'As with the steppe, the whole ground-mass is electrified. The mountain itself is a great mineral outcrop which consists largely of conductive silicates and laminated strata of various metals including gallium and its compound arsenide.'

'So?'

`So the whole mountain is electrically alive, with random electrical potentials everywhere. In the high voltage periods the great mountain currents surge through the partially conducting, partially semi-conducting layers, inducing all manner of curious effects. One of these effects is to cause some of the gallium arsenide layer to convert the current flow direct into light.'

'Of course—electroluminescence!'

'It doesn't stop there,' said Fritz. 'None of the metalloid layers are particularly pure, and all of them contain numerous slip-faults. In these circumstances it is inevitable that you find a profusion of naturally formed *p* and *n* junctions which would drive a solid-state physicist psychotic. As the potentials vary you get huge transistor switching actions with thousands of amps being diverted up and down the mountainside like the great grand-daddy of all thyristors gone crazy. That's why you get the glow running and shimmering through the mountain like that.'

`Fantastic! If I hadn't seen it myself I'd never have believed it.'

'You haven't seen anything yet,' said Van Noon.

By the time they reached the foot of the mountain itself the glow had died as abruptly as on the occasion when Fritz and Jacko had first seen it. Now the fissured and laminated glassy blocks of the mountain lay apparently lifeless and inert, and only the instrumented probes which Fritz applied to the surface showed the drift and drain of the electrical currents still surging in the mountain.

'Look to the end there,' said Van Noon. 'Where the mountain reaches down to the steppe there's a silvery outcropping containing a series of thrust faults. That's a typical formation distributed widely over the surface of Getawehi. Like the burning mountain, the lamellar layers show marked transistor action. The outcrop is predominantly laminated silicon semiconductor layers. Subjected to the terrain currents, almost every similar outcrop is a radio transmitter at some state of the current flow.'

Nash stopped and wiped his brow. 'I won't buy that one, Fritz. I grant you that you have the current and you appear to have the semiconductor material. But even I know that you don't get a radio transmitter by throwing random transistors into a box.'

`No,' said Fritz, 'but there is a logical explanation. In these fractured semiconductor masses you have potentially every aspect of transmitter function: capacitance, resistance, inductance, switching, amplification, and even piezo-electric oscillation. And you have *time.'*

'I don't see what time has to do with it?'

'Evolution takes time, Colonel. Pass too much current through a transistor junction and you destroy it. Start with an infinity of potential transistor circuit paths and destroy and modify them slowly, and one day you'll strike a circuit which will function—it will dissipate current rather than be destroyed by it. Continue the process for long enough and the only circuits which survive will be those capable of dissipating energy. Thus active circuits will become the rule rather than the exception—by a process analogous to natural selection on a biological level. The burning mountain survives by dissipating the electrical energy in the form of light. The small outcrops predominantly dissipate in the radio frequencies.'

'I still find it hard to believe,' said Nash.

'When you consider the capabilities of natural selection processes, a radio transmitter is a far less unlikely product than is a human being,' said Fritz quietly.

Nash looked at his hands reflectively, then nodded. 'And you used one of these outcrops as a transmitter to contact the *Tycho Brahe?'*

'We had to—er—modify it to suit our needs. But yes—that's basically what we did do.'

`I see,' said Nash. 'Your ingenuity does you credit, Fritz . . . but then I suppose that's what we employ unorthodox engineers for.'

'In this case,' said Fritz, 'I can't help feeling that Jacko surpassed himself. He can claim to be the first man—and I suspect also the last—ever to add an audio modulator to a solid state transmitter . . . with a pickaxe!'

The Black Hole of Negrav

'The basic philosophy behind the Unorthodox Engineers is simple,' said Fritz Van Noon. 'As our penetration of deep space continues, so communications and supply lines grow longer, finally impossibly long. And the transport costs of even simple items become disproportionately high.

'For instance, the price-penalties of space-freight are such that a simple spanner required on Aldebaran-seven costs sixteen times its weight of platinum on Terra. Assuming you can afford it, delivery time by hyper-ship can be anything up to three years.'

He waited until the buzz of conversation in the audience had died again. Then he continued. At his side, he was aware of Colonel Belling's dark scowl of disapproval, but decided to ignore it.

'If we're to take advantage of the new space-territories the hyper-ships are opening up to us, if we're to build out on the Rim something men can use as the foundations of a colony, we need engineering—and we need plenty of it.

'So who should we send? Mechanics who can't obtain any steel? Engineers whose nearest machine shop is fifty light years away? Or should we send the men who can make a plough out of a stick, a stone, and a length of creeper? The answer's obvious. You can send a few tools, but the thing that counts most at the edge of the galaxy is man's own unparalleled ingenuity—the ability to use anything available to your own peculiar advantage.

`And *that*, Gentlemen, is the function of unorthodox engineering. It's the habit of breaking with the traditional disciplines and learning how to construct the nucleus of a functional civilization out of bits of string and matchsticks, if necessary. To hell with what it says in the book. It may not even *look* like engineering—but if it works, it's justified.'

Shortly the chairman brought the assembly back to order.

`Well, now we've heard both sides of the argument—orthodoxy versus unorthodoxy in space engineering. I'm sure we've all been greatly enlightened, not to mention amused by Lieutenant Van Noon's account of railways built over small volcanoes, and the use of harps as electrical power generators. While Van Noon's approach may not seem as elegant as some of the precise and mathematical approaches we've heard his afternoon, it's brought some very practical solutions to some very intractable problems. I therefore suggest we conclude this session with an opportunity for questions from the floor. Of particular interest would be a problem which orthodoxy has failed to solve.'

At his side on the speakers' platform Van Noon felt Colonel Belling stiffen with anticipation, and knew that his worst fears were about to be confirmed. Belling's consummate hatred of unorthodoxy was almost a legend, and a public showdown before such an influential audience was too good a chance for the Colonel to have missed.

The next question would be a loaded impossibility. Regardless of who delivered it, Belling would have had a hand in the draft.

A young officer in the uniform of the Space Territories Administration rose to his feet. He was obviously one of the new breed of academic officers not long from space college. He began with his own introduction.

`Captain-Administrator Wilson, Rim Territories Survey. I've been fascinated by Van Noon's treatise on the uses of unorthodoxy. It so happens that out on the Rim we have a good example of one of these intractable problems. We've known for some time that the star Springer 218G has a complex binary-planet system. But closer inspection revealed that the two bodies were of disparate size and we couldn't understand how this orbit could be stable. That's because the smaller one is really just a large asteroid we've called Negrav.'

Van Noon stole a sly look at Colonel Belling, whose expression of smug innocence confirmed his worst suspicions. This problem had been hand-picked by a master.

`Perhaps I should explain,' continued Wilson, 'that the companion planet in the binary, it's been named Leda, is a body of considerable interest to us because of its mineral resources. However, because of the rather odd complications of this system, we want to put an observation platform on the asteroid to let us study the situation before we commit expensive resources to the planet.'

Fritz Van Noon listened to this with a patient frown. So far nothing unusual had emerged. Therefore, whatever the problem was, it had to be a honey.

Wilson was deliberately avoiding looking at Belling. 'I said the asteroid was called Negrav. The reason for the name is that the centrifugal force of its rotation at the equator exceeds the gravitational attraction of its mass. Thus except at the poles it has a negative gravity averaging about point seven Terrestrial. Unfortunately, because of its spin alignment, it's a point on the equator we need for a base.'

'If I understand you rightly,' said Van Noon, 'yours is a simple problem of securing buildings on to a surface which exhibits an effective negative gravity. This is slightly more difficult than free-fall work, but not much. Any good adhesive can get you started, and once you've obtained a reasonable foothold, you can anchor into the surface by any of a great number of standard methods?'

Wilson took the point sedately, but caught Colonel Belling's eye and was hard-put to restrain the amusement which welled suddenly inside him.

'It's not quite as easy as that,' he said, striving to retain his academic pose. 'I said that Leda was one of an odd binary pair. It's always been a puzzle how this could be stable—but now we know for sure that Negrav is not large enough to substantially affect the gravitational balance. Rather, it functions as a satellite to the *real* companion of Leda—which is a small black hole.'

'A what?' said Van Noon, sitting down weakly.

'A black hole,' said Wilson happily, under the approving eyes of his triumphant mentor. 'The second component of the binary is a small black hole of roughly Terran mass, which has an event horizon of about one centimetre.'

'And Negrav is in orbit about this?'

'A very close elliptical orbit.'

'How close?' asked Fritz suspiciously.

'It actually shaves the surface on its closest approach. Our problem on Negrav isn't getting an observatory to adhere, it's how to stop it being eaten by the black hole in grazing orbit—no pun intended. Orthodoxy doesn't have any good answers. I'd be interested in hearing the unorthodox approach.'

Colonel Belling was still laughing the next morning. When Van Noon received a summons to report to his superior's office at the Engineering Reserve he sensed it was only so that salt could be rubbed into an already smarting wound. It made a change, however, to find his commanding officer in a congenial mood so early in the morning. This was a situation Van Noon had plans to rectify.

'Ah, Fritz! Sit down! I've to congratulate you. Your reputation for unorthodoxy is unimpaired. Nobody ever gave such an unorthodox reply to a question at a Space Engineering Symposium. I was particularly intrigued by what you told him to do with his black hole.'

'It was deliberate provocation,' said Van Noon. 'A put-up job designed to discredit unorthodox engineering.'

'Which it did beautifully,' said Belling happily. 'I always said I'd show you crackpots up for what you are.'

'Then you haven't heard yet?' asked Fritz carefully.

'Heard what?' Belling's suspicion was palpable.

'General Nash was in the assembly representing Space Engineering Command.'

'Of course. What of it?'

'Well, the Unorthodox Engineers have pulled him out of several holes in the past. I think he saw the chance to return the favour.'

'What chance?'

'That building an observatory on Negrav wasn't entirely a leg-pull. With respects, Colonel, you were so busy looking at the absurdity of it, that you overlooked the possibility there might be a genuine need. It so happens there *is* a need. The Negrav-Leda complex promises to provide easily-won mineral resources for a large sector of the Rim, avoiding the long hauls from Terra.'

`Go on!' said Belling grimly.

'Well, General Nash got together with the Director of the Space Territories Administration and offered to build the Negrav observatory for him. The Director was delighted, and an inter-Service contract was drawn up on the spot.'

`And?' asked Belling. He had the look of a man who knew what the answer must be, but hoped against hope that the truth could not be as bad as he imagined.

'The contract makes this Engineering Reserve responsible for building the observatory,' said Fritz, with an evil smile. 'That means it'll be your pigeon.'

'I'll never forgive you for this, Fritz.'

'But I did nothing. It was you who had the matter raised.'

'I still shan't forgive you. It has all the hallmarks of your devious organization.'

'And it raises a good question, Colonel. Who're you going to send to Negrav? An orthodox engineering team —or a bunch of unorthodox crackpots?'

'I still think it was a heck of a tough way of proving your point,' said Sergeant Jacko Hine.

Van Noon scowled at his second in command. 'Not even Colonel Belling believes me, but I had nothing to do with us being sent to Negrav. The construction orders came down from General Nash, and Belling had to recant on his orthodox approach because there wasn't an orthodox way to do it.'

'My understanding is that everybody else refused point-blank to go! I suppose it never occurred to you that there might not be an unorthodox way to do it, either?'

'The thought did strike me, but I dismissed it as unlikely. Just how the heck we're going to do it, I don't have a clue at the moment. But at least it puts us marginally up on Belling's approach.'

'How do you figure that?' asked Jacko dubiously.

'Belling's certain it can't be done. I'm certain that it can. So all *we* have to figure out is how. That simplifies the problem no end.'

'Ri-i-ight,' said Jacko Hine slowly. 'You'd better clue me up on black holes. If we're to tangle with one, I'd like to know something of the enemy.'

`The classical theory's that of the collapse of a burned-out star. Once a star's used up its nuclear fuel the radiation pressures holding it up fall right away. It begins to contract under its own gravity. The size of the star controls how far the collapse can go—the larger the star, the smaller it will become. If the start is large *enough* then nothing can prevent it continuing indefinitely. The whole thing collapses down to an infinitely small point called a singularity. Around the singularity is a region of space where the gravitational field is so strong that not even light can escape from it—this is what's known as the "event horizon".'

'Since nothing that happens beyond that can ever be seen.'

'Sure. Light—or anything else for that matter—can be drawn into a black hole by the intense gravity, but nothing, nothing at all, can ever get out again. It's a one-way hole in space.'

'What happens to the things it swallows?' asked Jacko uneasily.

`Ripped apart to atoms, and then those are ripped apart until all that's left is randomised radiation. As to what lies on the far side—there are plenty of theories, but nobody actually knows.'

`So how big is it?'

'We can never know the radius of the singularity, but the size of the event horizon is determined by the mass of the black hole. Sol is too small to make a black hole, but if it *could*, the event horizon would be about three kilometres.'

'But Wilson was speaking of one about a centimetre in size.'

'There's another possible way by which black holes could have been formed. In the big bang which kicked off the expansion of the universe. Theory has it that baby black holes of a mass around ten to the minus five grammes and ten to the minus thirty-three centimetres in diameter could have been formed then and would have been wandering space ever since, consuming whatever mass they chanced to find in their travels. It's entirely possible for one of these mini black holes to be able to eat an entire planet and still not finish up much larger than a marble. It's likely that's what we're dealing with at Negrav.'

'It gives me a very curious feeling,' said Jacko, to think of a little black hole which could eat a planet. The more I hear of this expedition, the less I begin to like it. As I said just now, I think you've chosen a heck of a tough way to prove your point.'

The great hyper-ship of the STA had carried them out to Chronos, on the Rim. From there another Navy vessel had taken them on to the STA base on New Australia. Here, a smaller vessel took them on the three week sub-light trip to Springer 218G, with its curious binary satellites and the asteroid Negrav. Two days from arrival, Van Noon called a conference of his five-man team.

'Now you've all read the preliminary STA survey report on Negrav. When we get within telescope range, we'll be able to supplement what we know with our own observations. I hope to be able to discover a few items which the STA observers haven't mentioned because they weren't looking specifically for them. It's

highly unlikely that Negrav is totally composed of nickel-iron alloy, or that its entire surface is as smooth and unbroken as the STA report suggests. Initially we'll need to establish a foothold, and this'll have to be well below the orbital path of the black hole, so what we want particularly is a deep fissure or crack which we can hook into and work safely below the black hole's grazing orbit.'

'Check!' said Jim Fanning, the UE geologist. 'But if the STA photographs are to be believed, you'd stand more chance of hatching ball-bearings than you do of finding fissures in the surface of Negrav.'

'I'm aware of that,' said Fritz. 'The theory's that Negrav was once a full-sized planet, and all we see now is a remnant of the core. The rest of it's been eaten by that darned black hole. But I'm hoping at least for a blowhole or some form of depression. The frequency with which the black hole sweeps the surface gives us less than thirty-six hours between touching the surface and getting safely tucked down underground out of its way.'

`If I judge you right,' said Jacko, 'you're thinking of building the observatory beneath the surface?'

'We obviously can't build *on* the surface, because anything there gets eaten by the black hole. Besides which, it makes sense in other ways. Below the surface you don't have to bring in construction materials. You simply carve out the shape of cavity you want. Also you can make use of the negative gravity, because the centrifugal force'll drift you towards the roof of the cavity, thus producing a semblance of positive gravity. Once the observers get used to making their observations by peering down through windows below their feet, it should be a fairly effective working situation.'

'All of which sounds very nice,' said Fanning. 'But I foresee a couple of practical snags. Like how do we get in deep enough quick enough to avoid being eaten by the black hole? And having got into the surface, how do we carve an observatory-sized cavity in what promises to be a very strong nickel-iron alloy?'

'I admit it may be tough,' said Van Noon.

'Tough! ' Fanning was aghast. 'Blasting won't do much more than deform the surface, and oxy-acetylene cutting would take a lifetime—assuming you could get the supplies. So you're largely back to processes like laser drills and the occasional hand file. At a rough guess, Colonel Belling was damned right when he said it couldn't be done.'

'I've told you all before,' said Van Noon sternly. 'Physical limitations aren't absolutes. They're a state of mind. They said iron ships wouldn't float. They reached that conclusion because they hadn't taken all the facts into account. From this distance I can't see the answer to the Negrav problem either. But I'm sure as hell there *is* one: All we have to do is find it.'

Once they were orbit around Negrav subsequent observations did nothing to support Van Noon's optimism. Negrav *was* a ball of solid nickel iron, and its surface was flawless and honed to a micro-finish which would have done credit to a precision ball-bearing. Because of its small size, the black hole remained invisible. Its relentless orbit around Negrav—or rather the orbit of the asteroid around it, which came to the same thing relatively speaking—had for some millions of years ceased to take more than microns of further material from the surface.

Now the black hole's path hovered millimetres above the surface of Negrav and pursued a progressive rotation which effectively swept the entire sphere over a period of thirty-six hours. The position of the black hole was known with mathematical certainty at any time, but libration and other effects of the binary on the orbit of Negrav introduced an uncertainty factor. The black hole's progress across the surface had to be described in terms of statistical paths rather than positional lines. In practice this meant that thirty-six hours was the longest period any point on the surface of Negrav could be guaranteed safe from the marauding black hole.

'Which isn't long enough,' said Jacko Hine. 'Working under space conditions and negative gravity, we wouldn't have time to cut far enough into the surface to be any significant use. We've not only got to get into the hole, but around some considerable corner to prevent being drawn out by the black hole's gravity.'

'How far d'you estimate we could penetrate in thirty-six hours?' asked Van Noon.

'Judging by spectro-analysis of the surface material, we'd be hard-put to remove more than a cubic metre with the tools available. And once we get deeper, the work would slow considerably because we could only keep one man at the face.'

`That's not good enough,' said Van Noon. `I'm going down to Negrav myself to study the problem from the surface.'

'If it's not a rude question, how do you intend to hold to the unbroken surface against negative gravity? Chewing gum?'

'No, permanent magnets. Nickel iron of that structure ought to be highly magnetic. If the negative gravity's only point seven I should get all the attraction I need from a fairly small magnet pack.'

'It'll be a right game if you end up orbiting the black hole as well!'

If he was being strictly honest, even Van Noon would have admitted his confidence had fled as the little scudder dropped him towards Negrav's implacable surface. The nearer they approached, the more smooth and polished the asteroid's surface appeared, until from twenty metres up he could see the perfect reflection of the scudder mirrored in the giant metal ball.

The first problem was to secure a contact with the surface. Whilst the power manoeuvrings of the scudder could keep station over a particular point on the asteroid, the problem of trying to attach an assembled magnet package to the surface was akin to trying to throw it twenty metres vertically above his head. It was not until he had experienced the situation that he began to appreciate the reasonings behind Jacko's pessimism. What he had failed to accept subconsciously was that any work in negative gravity was akin to working on the ceiling, and that any drilling would have to take place in a "hands down, feet out" position, which was both unnerving and extremely tiring.

Jacko's estimate of a cubic metre of material removed in thirty-six hours began to look wildly optimistic.

After a series of hair-raising manoeuvres by the scudder, the pilot managed to bring Van Noon within striking distance of the nickel-iron "ceiling". After a few breathless moments, the magnet package stuck and the long cable trailed outwards with Fritz swinging uncertainly on the end of it. Thereafter he had to climb up the cable to reach his destination, which was no mean feat despite the lightweight flexibility of his spacesuit. This did not accord at all with his ideas on how a conquering hero, even an unorthodox one, should reach the planetary body of his choice.

Having secured himself on the cable, he then began to probe the surface above him. A small drill bit cleanly but slowly into the metal surface, though he was afraid to exert too much pressure lest he should lever away the magnets which held him there. He dutifully collected samples of the swarf which came away, tapped the hole, and screwed in a prepared eyebolt to which he attached a second line. More secure now, he brought up a large drill and drilled a hole sufficiently large for a second eyebolt to be inserted completely recessed below the surface.

This was the first permanent foothold secured on Negrav.

`Getting any ideas, Fritz?' Jacko's voice came over the headphones.

'It strikes me that with the small size of the black hole, the chances of any particular attachment to the surface being eaten in any one orbit are negligible. If we were to suspend a stand-off platform from the surface and attach it by more than an adequate number of cables, we could give ourselves a relatively safe work stage. Furthermore, it would be more comfortable than this fly on the ceiling approach.'

'Do you want me to organize a platform?' asked Jacko.

'Not yet, because the chances of cutting our way in seem quite as remote as Jim Fanning predicted. There has to be an easier method. Before I leave, I want to see what the explosive charge will do. But I don't really have much hopes unless the stuff is a lot more friable than it seems.'

'Right. When you get those swarf samples back we'll have some idea of the answers anyway.'

Van Noon attached his explosive package to his first eyebolt, carefully levered free his precious magnet pack, then dropped down the cable from the second eyebolt to make the precarious rendezvous with the scudder. When it had stood off to a safe distance, he fired the explosive charge remotely.

The flash was impressive because of the highly reflective surface, but the destructive effect was negligible. A further close pass in the scudder revealed only the barest depression in the solid metal surface. A slight element of plastic flow had taken place, producing an extremely shallow crater, but there was no evidence that any material had actually been removed.

Van Noon returned thoughtfully to the ship. On the face of it his exploratory trip to the surface of Negrav had been a failure. They had learnt nothing they did not already know, and the few straws at which he had clutched had disappeared like vapour in a vacuum. The problem of building an observatory on Negrav appeared as intractable as ever. As the hours wore on, however, he developed the curious quizzical look at the corners of his eyes which signalled he was far from being beaten.

He spent hours viewing the surface of Negrav with the ship's video facilities, imagining he could see the small black hole as it sped hungrily across the surface. The optical detection of such a small object from this distance was an impossibility, and his patient perusal of the scene began to worry Jacko Hine.

What's the score, Fritz?'

'One up to Negrav. Our turn to play.'

'Are we still in the game?'

'Very much so. Negrav's going to have its observatory, and we're going to build it.'

'Crazy like a fox!' said Jacko.

'Am I? You remember my theme at the symposium. The ability of the unorthodox engineer is to do the job with anything he can lay his hands on. Well, Negrav's a classic set-piece—the problem and the answer bound together in a single cosmological package.'

'You need to be joking!'

'Think about it. Ours is a problem of method. Cutting's too slow, and blasting's ineffective. But suppose I gave you a tool that'll not only cut nickel iron without effort, but will also consume the detritus? Suppose this tool needs no external power supply, and the tool wear is so low that it even finishes up marginally larger than it started. And all for no transport costs. Couldn't you do the job with that?'

'Yes—but—,' spluttered Jacko, and then realization dawned. 'You've lost your mind!'

'Our cutting tool's right down there, Jacko. And for a bonus we get an eternally spinning workpiece to go with it. No lathe required. All we need to arrange is the traverse mechanism. With the black hole we can cut a toroidal cavity right around Negrav's equator, and they can build a hundred observatories inside there if they like.'

'Fritz,' said Jacko, 'this time you've surpassed even your own idiot genius. But there's one tiny point you've overlooked. You can't pick up a black hole and use it as a tool. You can't hold it. You can't even *approach* it. It'll utterly absorb anything you can fling at it.'

'All that's accepted,' said Van Noon. 'But when you've a job to do and there's no conceivable way to do it, there's only one approach left open to you. You have to exercise some good old human ingenuity.'

The work-vessel took them back to the STA base on New Australia. This was the nearest point on the Rim where Fritz could find anything like the computer capacity he needed. He would have preferred to have gone back to Chronos, but was unwilling to waste the time whilst his enthusiasm was still at fever pitch. Once they had become convinced that Van Noon was intent on going through with the scheme, his team, too, had become infected with his eagerness, and their deliberations had considerably refined and improved Fritz's initial ideas.

The STA technicians on New Australia listened to Van Noon's proposals with critical alarm, and sent a message by subspace radio to Terra for confirmation that the project could proceed. In the meantime, Fritz got on with his computations.

The message which came back from Terra read :

'If van Noon wants to stick out his fool neck on a scheme like that, don't stop him. We might get lucky!

Belling, Commanding engineering reserve.'

Van Noon could almost picture the gleam in the colonel's eye as he penned the message. Nevertheless, he received all the help he needed from the STA staff on New Australia. With his precious calculations complete, and sufficient supplies for the job, he returned with his team to the keep-station around Negrav to begin the careful observations on which the success of the operation would depend. It was fairly obvious that the rest of the ship's crew regarded the project as insane. There were moments when Van Noon was not too sure himself. Nevertheless, the future of unorthodox engineering was riding on his back, and having declared his intention, he was unable to retract.

Above all else, *timing* was critical. The accurate gauging of Negrav's rotation was aided considerably by a huge dyespot which Jacko managed to produce on the surface. This was achieved in the course of a hair-raising approach to the asteroid in a scudder which was carefully manoeuvred while the dye was sprayed from pressurized canisters. With the spot in place, the rotational speed of Negrav was determined with an accuracy previously unobtainable, and Van Noon's calculations were complete.

By far the hardest part of the operation was to give the order to proceed. Not only were the dangers considerable, but the timing needed to be immaculate and the positional accuracies held within very small limits. Additionally, there were still a few unknowns which added not only to the hazards but also to the virtual certainty of unorthodox engineering becoming a standard joke throughout the Service if things went wrong.

Having rehearsed and re-rehearsed his team, Van Noon finally reached the critical point, and gave the fateful order. Once the first scudder had left the ship and headed towards the surface, there was no turning

back. It was only when he had passed this point that he began to appreciate the immensity of the forces with which he played.

Once started, there was no leisure for further thought. Jacko Hine went down with the first scudder and attached his package as specified. The second scudder was on its way before he returned. The third and most critical package, Van Noon took down himself.

There being no natural features on the surface of Negrav, he could only judge his position from the radioed instructions from observers on the ship and the relative movement of Jacko's dye marker. This made easy sense during the long space descent but when the orb of the asteroid began to dominate the sky he lost orientation. In sudden panic he had the scudder halted until he could recalculate his bearings. It was this hesitation that probably saved his life.

As he directed the scudder to continue the descent, a sudden warning was issued by the observers on the work vessel. *'Look out below!* You're off course and running right into the path of the black hole.'

The pilot reacted before Fritz had time to formulate his instruction. Veering crazily away in a tight arc, the little spacecraft struggled to escape from the gravitational well of the black hole which was overtaking it from the rear. Unless they could build up to escape velocity they were liable to be dragged irrevocably down into this hole to end all holes.

For a short time it looked as though they might escape completely. Then the full power of the scudder's tiny motors became insufficient to move them any farther against the intense gravitational attraction which now arrested and began to drag them back towards the surface. There was nothing the occupants could do except sit helpless as they were seized as if by a giant hand and thrown back on to the asteroid.

The touchdown, when it came, was unexpectedly mild. Fortunately their descent had been delayed by the scudder's motors just long enough for the black hole to have sped on its uncaring way. The friction of the craft against the asteroid's surface was sufficient to prevent them being drawn in the black hole's wake. Almost immediately the gravitational spasm was over, and Negrav's own negative gravity spun them crazily back into space.

Dazed and shaken, Van Noon checked his equipment, whilst the scudder pilot tested his craft. Miraculously there had been very little damage. The scudder, though dented, was still spaceworthy even though much of its instrumentation had failed. Van Noon's precious package, which had been the reason for the descent, likewise appeared to have suffered no permanent harm.

His timing, however, had been completely destroyed. This was a factor beyond recovery. Because of the orbiting black hole, the packages which had already been placed on Negrav had only a limited life expectancy. If his own package was not now put in place, the existing ones would all be destroyed before any new calculations could be made.

Van Noon shrugged his shoulders and took a chance. He placed the package with its magnet pack on the nearest part of the surface, knowing that its position was far from being where he had originally intended. The results would be in the lap of the gods, but it was either this or make the long haul back to New Australia for a fresh set of supplies. Then tired and disconcerted, he ordered the scudder back to the ship.

Compared to this first trip, the rest of the journeys to Negrav seemed uneventful. No less than seven other trips followed some achieving the desired accuracy, others varying. There was no time left, however, to make any corrections. Fritz had to suffer the errors and hope against hope that some overseeing deity would bring the project through. Otherwise he shuddered to think of the final results.

Then came the final phase. One after another in controlled sequence great explosions flared upon the surface of Negrav; appearing as little more than pinpoints of light to the distant observers, yet in reality being ample charges of super-high explosive. The timing was accurate according to the original schedule, but because of misplacement of several of the charges, the net effect would be anything but optimum. There followed a long period of waiting, after which the remaining charges were fired.

As Van Noon read the final collation of results, his heart sank like a stone. He had arranged to check the orbital velocity of Negrav so that it fell into a lower orbit around the black hole. In effect this meant that for a number of rotations the black hole would actually orbit inside the surface of Negrav. Then he had planned to correct Negrav's velocity so that the black hole would return to the surface leaving a toroidal cavity inside the asteroid's equator. Probably due to misplacement of the charges, the scheme had gone disastrously wrong. The black hole had remained inside Negrav . . .

Stupefied, he read the figures, but they no longer registered in his brain. Instead he saw the asteroid of Negrav being progressively eaten from inside by a small black hole so voracious that it could consume its entire host without particularly noticing the meal. Worse, if it remained inside Negrav, the asteroid would

disappear entirely. Van Noon did not much fancy being known for the rest of his career as the man who lost a whole asteroid.

In an agony of indecision, he called for the orbit of the asteroid to be monitored continuously, while he searched through the ship's stocks hoping to find sufficient explosive to kick the asteroid's velocity up and bring the black hole again to the outside. A trip to New Australia for fresh supplies was out of the question because of the time involved. By the time they returned, Negrav would have been swallowed whole.

He was unlucky. The explosives he had brought from New Australia had been carefully calculated for the job, and the entire stock had been used. Nor did the ship carry any stocks of its own. He briefly thought of trying to nudge the asteroid with the ship itself, but concluded that the vessel was unlikely to survive the ordeal.

Disconsolate, he sat down again to check the results of the orbital monitoring. As he did so, he began to brighten considerably. When Jacko found him, he was chuckling uncontrollably, and tears of laughter were streaming down his face.

`You're the first person I ever saw get a belly-laugh out of a computer printout,' said Jacko warily. 'We don't have a strait-jacket, so I'd better give you a shot of tranquillizer. I'd advise you not to struggle.'

`Knock it off, Jacko! I've just received proof of the theorem that the deserving don't always get what they deserve. Alternatively, the unorthodox looks after its own.'

`Crazy like two foxes!'

`Look at these orbital figures, Jacko. And tell me what it was about the original problem we forgot.'

Jacko took the sheets of printout and looked through them wonderingly. Then he, too, began to smile.

`Negrav's speeding up. If it continues to do that, the black hole'll come outside again of its own accord—and soon.'

`Right! We forgot about conservation of momentum. As the black hole removes some of Negrav's mass, the asteroid gets lighter but its initial momentum remains. Therefore it has to go faster, and climb into a higher orbit. It's a self-stabilizing system because whenever the black hole removes some mass from the asteroid, Negrav itself automatically retreats from the attack.'

`So what're we left with? The same problem only with a slightly smaller Negrav?'

'No. Unless my figures are wrong, the black hole's been in there long enough to give us a concentric ball and shell effect—like a marble in a table-tennis ball. The increase in Negrav's speed is running up an exponential curve, so that when the black hole does come out it should do so at some considerable angle. With luck it'll only puncture the shell as it comes, not eat it away. And do you realize the implications of *that,* my boy?'

'We were lucky?' asked Jacko uncertainly.

'Yes, but not only that. It means that Negrav will be safer from attack by the black hole than ever before. And if that cavity's the size I think it is, they'll be able to build a major base in there, not just an observatory. They can mine Leda at their leisure, and use Negrav as an on the spot refinery and transfer station from which they can load hyper ships direct. It'll be the most valuable space facility on the Rim.'

As the figures had predicted, the black hole did come out of Negrav. It reappeared some thirty-two hours later and finally stabilized with an orbital separation of eleven kilometres. This new orbital distance was a measure of the amount of mass which had been removed from Negrav.

The next part of the exercise was to explore the cavity itself. This was aided by the fact that they could now anchor a structure permanently on to the surface to give them safe working conditions without fear of being eaten by the black hole. With this new facility, the work progressed rapidly. Twenty metres in, they broke into free space inside the asteroid. Van Noon was first through, followed by Jacko and an assemblage of powerful lamps. Once inside, they gazed into the vastness with amazement.

Fritz's ball and shell concept was substantially true, but random deviations in the rotation of Negrav had not produced a completely clean cavity, but rather one populated here and there with crazy spires and towers and bridges, and many vast columns which rose up to support the central core nearly a kilometre above the inner surface. Every line was curved in representation of some complex mathematical equation, as though designed by a mammoth computer programmed to seek out the ultimate in form and shape; and everything was cleanly cut and polished in flawless nickel iron alloy.

They made a tour of inspection which lasted nearly twelve hours, and came out so impressed with the wonder of it all that it was difficult to believe that these fantasies had been the results of interference with their own hands. As an STA base, the situation was, and would be always, without parallel. Had it not been

situated on the Rim, it would have been a tourist attraction with no conceivable opposition. They had juggled precariously with Nature, and been rewarded with a marvellous demonstration of natural design that made them feel humbled and just a little bit afraid.

They found the points by which the black hole had entered and left the cavity, and had these sealed. Over their original entry point they built a docking hatch and an airlock. They then radioed New Australia for the STA to come and take possession of the prize. Captain-Administrator Wilson was the first STA man to arrive. He went in with a disbelieving sneer, and came out so passionately impressed that he couldn't speak.

From then on, the more orthodox engineers took charge, ferrying gases to provide a breathable atmosphere in the cavity, bringing in power plants and treatment plants and all the paraphernalia necessary to support existence in the far reaches of space. Their task done, the unorthodox engineers returned in triumph back to Terra.

'You don't have to rub it in, Fritz,' said Colonel Belling, when next they met. 'I admit I was wrong and you were right. Unorthodoxy *does* have a use in unorthodox situations.'

'Actually we're only arguing about definitions,' said Van Noon. 'Orthodoxy for us is the tools and techniques which have been evolved for dealing with our local Terran situation. We can't expect these to be the optimum for a completely altered set of conditions. What's orthodox in one part of the galaxy may be unorthodox in another. All that I'm saying is that the most useful thing we can take to any problem is an open mind.'

'Well you've certainly proved your point. The STA are so delighted with their acquisition that they've asked permission to call their Negrav installation Base Van Noon. I thought it only fair to let you make your own refusal.'

'Refusal?'

'That's what I said, Fritz. While you've been journeying back, I've been analysing your figures. As I read it, this was a battle you actually lost, but were saved by a most fantastic stroke of luck. D'you really mean to claim it as a victory?'

'In the circumstances, I take your point. But I claim the right to nominate my own alternative.'

'Which is?' asked Belling ominously.

'How about Serendipity?'

The Colonel's face broke into a smile. 'I'll go along with that, Fritz. I'll even buy you a drink on it. And while you're here, there's another matter I want to discuss. It concerns the tunnelling problem on Eggar III. Now I've been thinking that if you can find another black hole . . .'

The End