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LOST NEWTON

Stanley Schmidt

A black and white photograph of a forest. The trees are mostly bare, suggesting a winter or post-fire setting. A sign is attached to a tree trunk in the center. The sign lists various activities that are prohibited in the forest.

**NO CAMPING
NO SWIMMING
NO HIKING
NO RELAXING
NO FISHING
NO HUNTING
NO RIDING
NO SIGHTSEEING**



Only you can prevent forest fires.

SCIENCE FICTION SCIENCE FACT

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40TH YEAR ANNIVERSARY

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NEXT ISSUE ON SALE
September 10, 1970
\$6.00 per year
in the U.S.A.
60 cents per copy

Cover by
Kelly Freas

Vol. LXXXVI, No. 1 September 1970

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Editorial and Advertising
offices: 420 Lexington
Avenue, New York, N. Y.
10017.

Subscriptions: Analog
Science Fiction/Science
Fact, Box 2205, Boulder,
Colorado 80302

POSTMASTER: SEND FORM 3579 to ANALOG SCIENCE FICTION/SCIENCE FACT, BOX 2205, BOULDER, COLORADO 80302.

Some years ago, a Union Pacific section supervisor was out walking the tracks along one of the lines he was responsible for through the Rocky Mountains. He was out with notebook and pencil, noting the things that would need to be done to maintain the railroad right-of-way, when a grizzly bear came out of the woods—in a bad mood. Whether it had a toothache, or had just been shoved around by another grizzly no one knows—but some 1,500 pounds of angry grizzly started for the man.

The man wasn't hunting—he had no gun, or even a knife with him—but five minutes later the bear was dead, and the man had not been touched. He was standing on all that nice fist-size, sharp-edged track ballast, and baseball pitching was his hobby. The bear was blind in both eyes within fifteen seconds—and not even a grizzly's skull can stand up to a hard-thrown rock. A fact that Ugh, the caveman, learned a quarter of a megayear ago.

Now with this in mind, let's consider the matter of the Kent State students-Guardsmen clash, and ask who launched the first deadly missiles. The answer, of course, is perfectly clear—the students started the lethal bombardment.

I have seen a number of write-ups on that affair in the week or so between the time it happened and the time of this writing, but I have

THE NEW STONE AGE

*an editorial by
John W. Campbell*

yet to see what I can honestly consider a balanced presentation of the case.

For one thing, there's this standard-in-current-journalism-100%-liberal-viewpoint attitude that Students Can Do No Wrong. That They Are Our Children and that We Must Not Punish Them.

Dissent is something I, of all people, certainly favor. But dissent means with words—not with lethal weapons. When lethal weapons enter it's called "war" or, at least, "rebellion"—not dissent. The current generation of students, loudly damning their elders for hypocrisy, make noises about peace and love—and enforce their preachings with rocks, bottles, hunks of concrete and fire bombs.

Their dissent takes the form of massive destruction of things that

have taken centuries to build and accumulate. Because their ability to reason and express their ideas clearly is markedly deficient, they prefer to speak with dynamite.

If they make demands, and are not given exactly what they want, without discussion and argument, they say they are not being listened to.

They think "to hear" means "to heed," when it comes to what they arrogantly insist are the Great Truths They Have Conceived.

Now, inasmuch as I've been a dissenter, attacking the orthodox and the "establishment" for some forty years, it can hardly be said that I am a Reactionary, or Conservative, or even that I'm an Establishmentarianist. I believe very strongly indeed in the importance of raising dissenting voices.

But the student bums today think that a bomb is better than a voice because it's louder.

And there *are* student bums. Naturally, our coddled students get terribly upset when somebody calls them a name—name calling is a right reserved *exclusively* to their own foul-mouthed tribe.

And they call their elders hypocritical . . . ?

So let's try looking at that Kent State affair from the viewpoint of the young men who were on the receiving end of the joyously thrown rocks.

Now in the first place, they didn't see those students—who'd smashed up the town, burned a couple of buildings, and tried to destroy a local bank—as just some wild kids being mischievous. The Guardsmen saw them as a bunch of destructive, dangerous men their own age—you may think a twenty-year-old student raising some Cain is just a fool kid, but that's not the way it looks to another twenty-year-old who's been called on to accept the responsibility of protecting the property of the local citizens. To one twenty-year-old, another looks like a crazy vandal who needs to learn some sense; the Guardsmen were of the same age group as the students, and had an extremely low opinion of the behavior of those students.

There was a great difference of philosophy between the two peer-groups. The Guardsmen were citizens of nearby—but not the local—communities, who had taken on the responsibility of serving their State in maintaining civil peace. They were young working men who were the often-derided "weekend soldiers."

The difference of philosophy between a twenty-five-year-old graduate student and a twenty-five-year-old man who's working for his living and earning his own way is quite remarkable. The workman has learned the value of property, because he's had to earn it.

Generally, the college student values property in terms of how hard he has to work his parents to get what he wants. Sometimes it takes a lot of hard plotting before he can get Pop to break down and give him that set of wheels he needs. He might even be forced to have his hair cut before Pop yields.

But the fact that the student is in college means that somebody's supporting him.

The Guardsman, on the other hand, is supporting himself—and, quite likely, a wife and child, too. He works in a business somewhere, and has some idea of what it costs to maintain a business establishment.

The result is that the Guardsman doesn't tend to view the smashed business places in town as a "dis-sent to the Establishment"; he sees it as what it is—criminal vandalism. He doesn't look at it with the forgiving "Well, after all, they're just kids . . ." attitude possible to the over-thirty group. He's in the college-age group himself, and he damn well doesn't like what they've done to his neighborhood.

And "they," in any specific case, is *not* indefinite—in the case of Kent, Ohio, "they" were specifically the destructive mob of Kent State students. True, the Guardsmen were not drawn from Kent itself—the Ohio Guard avoids having local men involved in any such clash—but they were from other Ohio towns that look just as Kent did

before it was raped by the invading aliens.

For the students, remember, are largely aliens—they come from all over. It wasn't *their* home town they assaulted. It wasn't *their* families' businesses they put to the torch.

Of course, from the student's viewpoint, it was just end-of-the-semester high jinks, modern version.

There was something of the ancient, traditional town-vs.-gown tension in the situation. The students thought it was good fun—which it appears to have been for them. They, you see, knew they were immune to punishment. Nobody could do a thing to them.

And remember that *power* does not corrupt; *immunity* does.

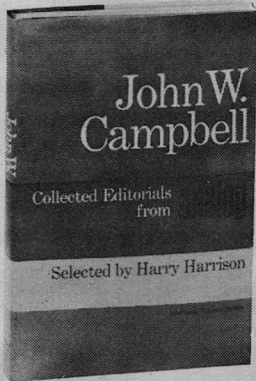
A baby can rule the family, because he can't be held responsible for anything he does. He can howl everybody in the house awake a dozen times a night, and never be punished for his inconsiderate demands.

A child is legally not responsible for his destructive actions—his parents may be, however.

The modern college students have, in effect, been declared by the society to have a total immunity to law; absolute immunity breeds absolute corruption. It takes a little while—but it's getting there.

The young workingman, however, is *not* granted immunity; he's held responsible for his acts, for his

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debts, and for making his way in the world.

This produces a curious bias; he doesn't see the destruction of a town as "just good fun" but takes a curiously puritanical view that the guys that did it were a bunch of vandals and arsonists.

In some ways, you can respect a looting thief more than a vandal; the thief takes something he wants because he plans to use it. The vandal simply destroys for the pleasure of destruction.

And do *not* talk about "dissent" in that connection; dissent is something done with words. Ask old Tom Paine, or Ben Franklin, or the men who wrote our Con-

stitution. They knew the difference; they dissented for years, with speeches and pamphlets, before they launched a violent revolution. And they were not as hypocritical as the college bums who say "peaceful demonstration" and *do* violent destruction.

Now as to that word "bums"—if the shoe fits, wear it; if it doesn't, then it isn't for you. A bum is someone who won't work for a living, drifts around amusing himself and benefitting no one. The other major type causing disruption in our colleges are not harmless, but useless, bums—they're criminal vandals and violent rebels.

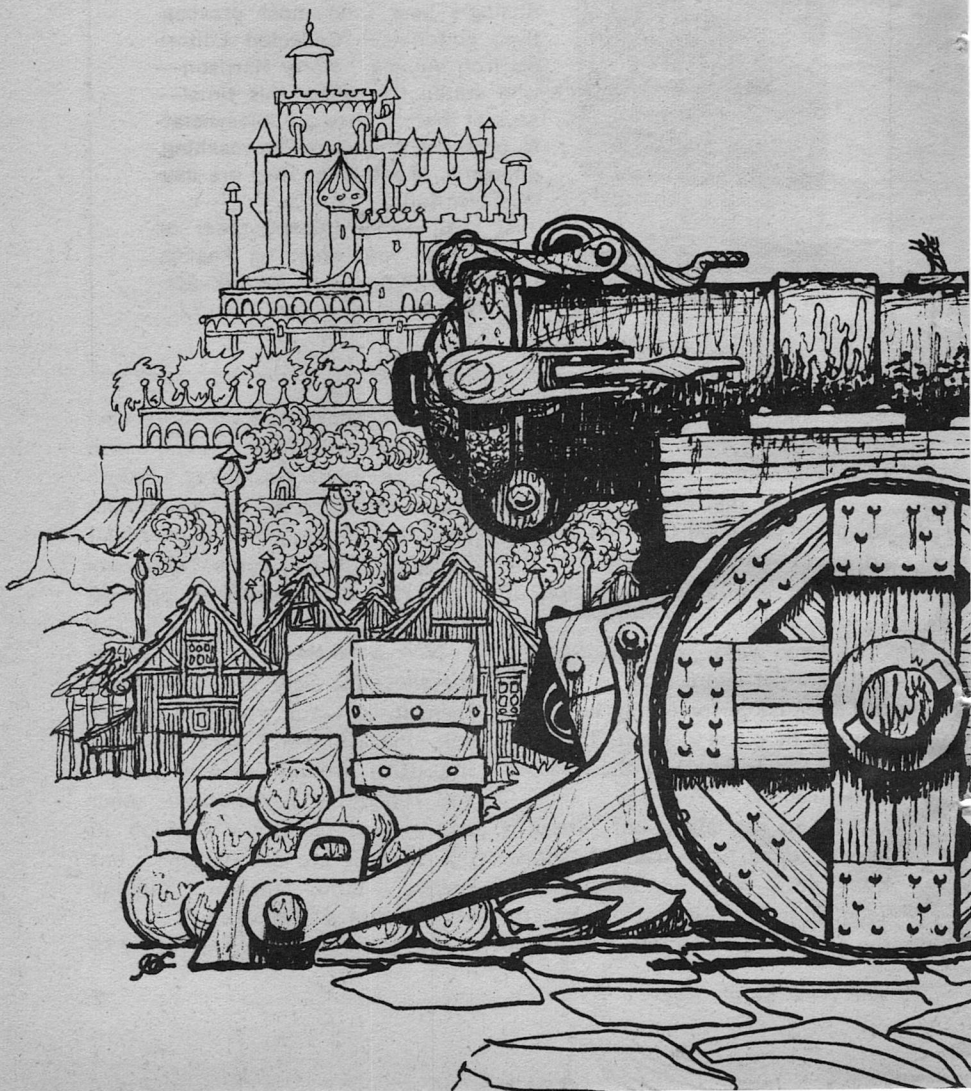
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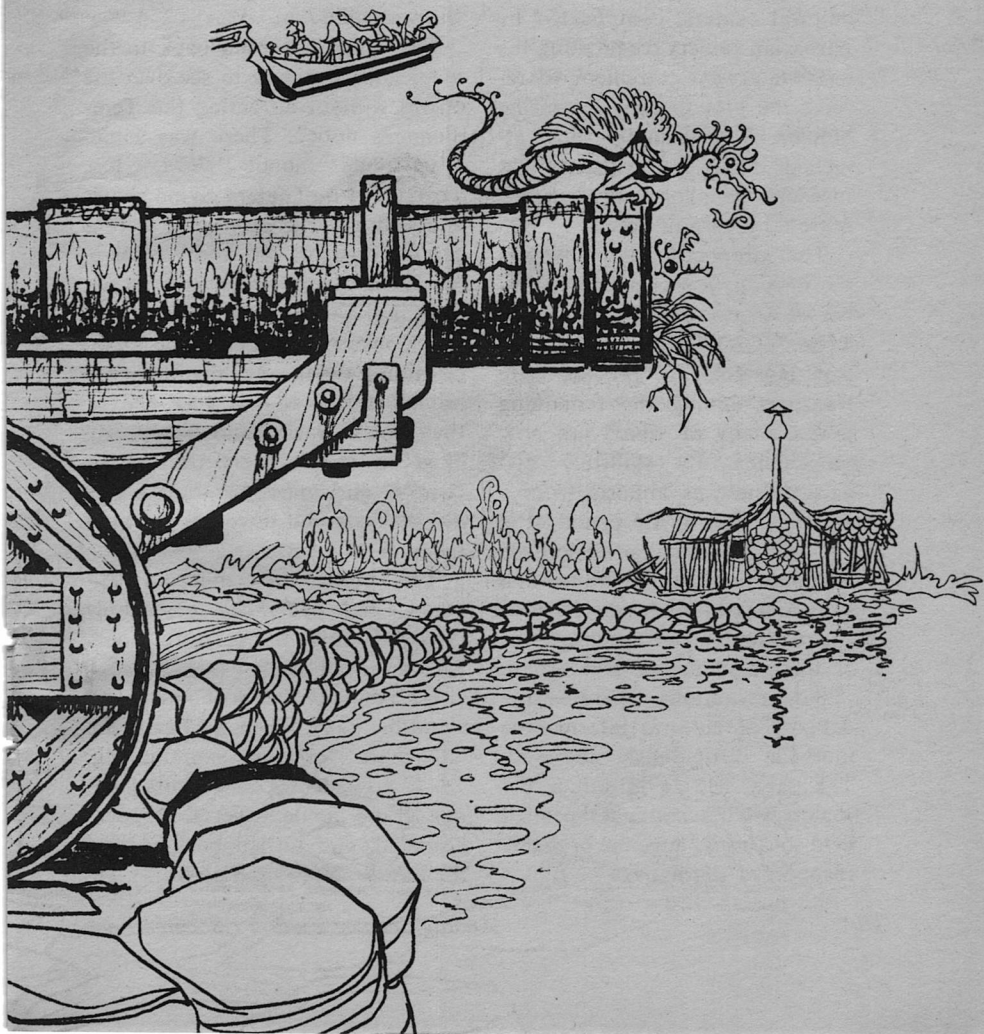
Lost Newton

Under just the wrong circumstances, the tiniest alien artifact could massively alter a people's development!

STANLEY SCHMIDT

Illustrated by Kelly Freas





. . . Have studied the attached documents summarizing the situation on Ymrek—native name—and recommend action as described herein. The essence of the problem is that recent seismic upheavals, resulting in drastic redistribution of land and water areas, have fragmented the budding civilization of Yngmor. Loss of communication among cultural centers, complicated by barbarian raiders frequenting the new waterways, threatens to reverse the growth of a promising humanoid civilization. The attached documents suggest that measures be taken to prevent this regrettable turn of events.

The proposed plan involves the introduction of a small number of Reynolds air-floaters using Type 76CB3 Quasimaterial control elements to provide safe transport among the remaining towns, many of which are now on islands. By skillfully disguising these as imports from a remote region of the planet, it is believed that they can restore an adequate level of communication with a minimum of disturbance and without arousing suspicions of their true nature and origin.

All precautions regarding the dangers of cultural interference must be scrupulously observed. The party sent to introduce the floaters will first conduct thorough field studies to gauge the probable reaction of the natives . . .

Terek uncomfortably eyed the Templeman slinking around the far side of the crowd and then sought a less conspicuous position. He wasn't sure exactly what was wrong, but he felt a vague gnawing of half-certainty that something was. It was not common for those of the Temple to waste their time on itinerant magic shows, and Terek kept imagining that this one was watching *him* . . .

He forced his mind back to the magicians, straining to see over the crowd without attracting the Templeman's notice. There was something odd about *them*, too. Troupes of outlanders giving shows and selling curios from afar were a common sight in the towns—though not as common now as before the Shakes—and Terek had never broken his childhood habit of joining the throngs that gathered around them. Magic was one of their main wares, and Terek still liked to watch their transparent "tricks" and marvel at how easily the peasants and townspeople were taken in by them.

This bunch was different. Already Terek had failed to see how three of their tricks were done. That annoyed him.

He was about to go home to resume his work when he heard the tall male foreigner announcing, "And now, ladies and gentlemen, our grand finale." Terek stopped, hesitated, and turned back toward the hastily improvised platform. He

tried again to place the tall foreigner's accent and failed. That bothered him, too.

"Before your very eyes, ladies and gentlemen," the outlander chanted, "this enchanted statue from a far corner of the world will vanish." The crowd—twenty or thirty shabbily clothed men, women, and children—pressed toward the platform for a closer look. Terek decided to stay it out and pressed forward with them, still careful to avoid the Templeman's direct view. Disappearing acts were popular, and he seriously doubted they could fool him on that one.

"On the count of three," the magician warned, "it will begin to vanish, and by ten it will be gone. One . . ." Terek frowned. The statue, a foot high and gleaming metallically, was standing in plain view on the edge of the table. Weren't they going to cover it with a cloth?

". . . two . . ."

Terek found himself staring with an intentness he had not known since his first magic show. Still the statue stood unprotected in the full light of the Day Star.

". . . three . . ."

Was it imagination, or did the metallic luster begin to dim?

". . . four . . . five . . ."

By six there was no doubt. The once-solid statue had acquired a ghostly pallor. Its form still shimmered unchanged, but was growing

harder to make out against the background.

". . . seven . . . eight . . ."

Now the background began to be visible *through* the statue. ". . . nine . . ." Only a mere suggestion, a faint, three-dimensional shadow, remained.

"Ten!" It was impossible to say exactly when the last remnant of shadow had passed away, but it was undeniably gone. The onlookers broke into ecstatic applause and even Terek shook with an excitement he had thought long outgrown. That was the most convincing bit of trickery he had ever seen, and he had to find out how it was done!

Muttering hasty apologies, forgetting his uneasiness about the Templeman, he began shoving toward the front of the crowd. On the platform, the performers, all smiles, acknowledged the applause. The smallest one, the only woman of the three, reached into a box and pulled out a double handful of trinkets. Laughing gaily, she threw them out to the crowd, the customary invitation to come and buy more after the show.

And Terek stopped in his tracks, momentarily dumbfounded. It wasn't the sight of the woman's spread hands, which he suddenly realized had only five fingers apiece, but the behavior of the things she had thrown. They flew out over the crowd and fell, but they fell at widely different rates!

One drifted slowly down near Terek; a small boy caught it and cried out at its impact. He dropped it—it fell slowly—and Terek picked it up. It felt strangely heavy. *More trickery*, he thought with a grin, recovering quickly from his surprise and moving forward again. *Really first-rate . . .*

Then he saw the Templeman looming in front of him and stopped again, and this time he did not recover. The Templeman threw a handful of the strange trinkets in his face, pointed, and roared with gloating laughter. Nearby heads turned toward Terek and more and more peasants joined the Templeman's coarse mockery. Some began to throw things . . .

And Terek filled with something like horror as he realized what was happening. *No!* he thought in amazement, not heeding the rain of trinkets. *I was so close! Can a few cheap tricks really kill an idea?*

As the derisive hoots closed in around him, he felt for the first time a sinking fear that they could—and a defiant will to prevent it.

He never reached the platform.

Tina led them into the clearing and the boat with her usual amazing confidence—amazing, at least to her husband Chet Barlin, because the boat happened to be invisible from outside. Chet always had to stop and think twice about whether he was following the right land-

marks. Tina didn't seem to have to think about it at all—she just pranced deftly through the shrubbery and at just the right moment sang out, "Open sesame!" By carefully following her steps, Chet and Jem Wadkinz, the man from Quasimaterials, Inc., managed to wind up safely inside the familiar cabin.

The inside of the landing boat, being visible, always seemed a good deal more homey than the outside. As soon as he heard the portal seal shut behind Wadkinz, Chet tossed aside the wig he wore to pass as a native and lit up his pipe. Then he noticed Stiv Sandor, copilot of the starship orbiting overhead and the landing party's chauffeur while they were down here in the boat, bending over the communicator with the panel off. "Trouble?"

"Nah." Sandor reached into the open unit and popped the top off a cylindrical chamber. "Routine overhaul. Have to refresh the vacuum in these things every now and then, and now seemed as good as any." He took a can of Instavac from a cabinet under the console, emptied it into the vacuum chamber so it overflowed, and set the empty can aside. "How'd it go with you? Ready to move on?"

Chet shrugged. "O.K., I guess. Same as everywhere else, anyway." He noticed that Wadkinz had vanished into the galley for his customary post-show beer, while Tina had just as predictably gone

straight to her beloved PFSU to read the reviews. The routine was getting a little tiresome. Chet was glad they only had to go through it a few more times before they could get down to their main job and then go home.

Sandor put the cap back on the vacuum chamber and pointed his damping trigger at it briefly. "You sound bored," he chuckled. "I thought you'd be a regular ham by now."

Chet grinned as he watched the quasimaterial liquid fade exponentially from the chamber, leaving an excellent vacuum and heating the surroundings only a few degrees in the process. "It gets to me once in a while," he confessed, "mainly at the end of a show." *Which*, he reflected, *amounts to nothing more than what you just did*. "But it's the same everywhere. They're impressed and intrigued, but not unduly. They've seen so little of the planet for themselves that nothing we claim to bring from another part of it really surprises them. I couldn't see any more evidence here than elsewhere that there's going to be any problem getting them to take a few quasimaterials in stride." He looked across the room. "Could you, Tina?"

Tina, uncharacteristically, was frowning. "Not out there," she said cryptically. "But, Chet, come here and take a look at this."

"Better go," Sandor said, turning

back to the communicator. "She sounds worried."

The PFSU—psychocultural field survey unit—was one of the main tools of the modern anthropologist, psychologist, or xenologist. But its use required a formidable complex of highly refined, subtle skills—akin to those demanded by the polygraph of centuries earlier, but orders of magnitude more difficult. Tina Barlin, educated and employed as a xenologist, had those skills. Chet, whose work as a comparative historian brought him into contact with dead cultures more often than living ones, didn't. Consequently his look at the crowded panel of meters, color bars, and chart recorders failed to tell him what had Tina so upset. He wound up staring blankly and asking, "Well, what's it say?"

"This place *isn't* like the others," she explained. "It seemed like it, out there, just watching the audience. But there's a lot we didn't see. Look here." She pointed at some multicolored wiggles and spikes on a roll chart. "This is the time of our show. I can't correlate it down to the minute, but it's in this neighborhood. All through it there's a pattern of unusual activity, highly localized and increasingly intense. I've never seen anything quite like it before, but it looks like a single highly intelligent mind in a state of great agitation. Look at this shock here."

"Can you tell any more?"

"General location—right around that farmyard where we gave our show. It could have been somebody in the audience."

Chet nodded, then brightened. "That little brawl we saw starting up in the audience after the show . . . could it have something to do with that?"

Tina shrugged. "I don't know. I didn't pay much attention at the time. It just looked like typical peasant rowdiness. Didn't seem to have much to do with us."

"That's what I thought, too. But now that I think back . . . Tina, did you notice that there was a Templeman in that brawl?" Unable to pursue the line of thought, Chet bit his lip and looked back at the PFSU traces. Now that they were pointed out to him, he could recognize the highly abnormal character of those patterns. And he could see, faintly, some of the possible implications. But he couldn't follow the interpretation into the present. "Then what?"

Tina motioned at some later charts, and then at screens showing live displays of current monitorings. "It continues. There are a couple more distinct jolts. Then a few other patterns become prominent, too. The locale changes—it seems to be in or near the castle now—but all the unusual activity remains clustered around the one we saw first."

Even with Tina's guidance, Chet

could follow only the barest outlines through the PFSU's maze of output. But he thoroughly trusted her interpretation, and it wasn't hard to see what the pattern she was describing might mean. "Some bright boy's onto us?"

Tina nodded. "That's my guess. Somebody who came to our show and recognized that we're not just another band of gypsies from over the hill. He has suspicions about us—powerful suspicions, and a powerful determination to do something about them." She waved a hand at the real-time displays. "Now this. Does this mean that not only does he suspect, but he's already gone straight to the local priest-king and got *him* scared of us?"

"It could," Chet said grimly. "Of course, it could mean something else. You still haven't taught that thing to read actual thought content, have you?"

"Not a chance. That's what's so maddening. All we can see are prevalent attitudes, emotions, mental tones. But when we see a pattern like this we can't resist guessing what's behind it. Our guesses may be all wet, but we worry about them anyway."

"True." Chet couldn't deny that he was worried by these. "It fits together too well, Tina. I don't like it."

"Neither do I. Where do we go from here, Chet?"

"Yjhavet's next on the list," Chet

said unnecessarily, "but I see what you mean. I think it's conference time."

Bydron Kel, the Republic's B.E.L. Field Agent who had the ultimate say on whether Project Airfloat would be carried through, chain-smoked. He puffed incessantly and nervously on long thin cigarette after long thin cigarette, and the parts of him that weren't busy smoking found other ways to fidget. He sat impatiently through Tina's exposition of what the PFSU had told her. When she finished, he cleared his throat and complained, "Really, Mrs. Barlin, I hardly see that there's any great problem. If there's a chance we've been discovered here, we move on to the next place without further ado. It's as simple as that. The bulk of the data was typical, wasn't it?"

"Yes," Tina granted, "but you underestimate the possible importance of a sufficiently atypical individual—not to mention the Temple of the Supreme Presence. In case you've been neglecting your brief, let me remind you that the Temple is behind this whole renaissance we're supposed to be protecting. Its *dixar*—priest-king, if you insist on a near translation—directly controls every town in Yngmor. If we get *them* down on us, the project has unequivocally had it. Very probably, so have we."

Kel said nothing. He seemed to ignore her sarcasm, and the face he

made seemed to say merely, *Why does life have to be so complicated?*

"Look at it this way," Chet suggested. "If there's a chance we've been discovered, it's especially important that we stay here long enough to make sure. If it *has* happened, we have to *know* about it and see if we can undo any damage the discovery's caused. That means no Project Airfloat—and who knows what else? This started out to be a very small, very cautious intervention justified by special circumstances. They're not special enough to justify any more than that, Agent Kel. You know that . . . don't you?"

Slowly, as if suddenly painfully aware that he didn't really want this responsibility, Kel nodded.

They set out for the monastery at dawn, armed with unusually few traces of their parent civilization and an unusually high level of caution and wariness. The landing boat was hidden a little over a mile from the outskirts of Yldac, isolated by a half-mile barrier of thickets into which natives seldom, if ever, ventured. Chet, Tina, and Jem threaded their way among the grasping thorns with delicate care to avoid damage to the colorful robes which advertised them as travelers from an unnamed far corner of Ymrek. Despite the careful attention to costuming, this morning they felt painfully conspicuous and vulnerable. The PFSU could

do little more than raise suspicions and doubts, but it had done that very effectively. And if any trouble arose, they would be able to do little more than contact Sandor and Kel aboard the landing boat.

They paused at the edge of the bush to survey the thousand yards of open plain between them and the town. Then, seeing no danger, they started across.

Yldac rose from the plain directly ahead. The nearest parts, the outermost rim of the town, consisted of low, dingy houses of rough-hewn wood, with thick smoke billowing from tall thin chimneys. Beyond them, surrounded by them, rose the expansive stone terraces of the monastery, surmounted finally by the spires and minarets of the dixer's central castle.

Tiny farmhouses sprinkled the surrounding plain. Far off to the left, one stood abandoned, half-collapsed and rotting, at the very edge of the water that had not been there a few years earlier. Next to it stood a cannon installation, one of many pointing out over the water to remind prowling Ketaxil that they were unwelcome. Chet looked at that and thought involuntarily of how much more complicated things could get before they left this town.

He hadn't wanted to mention it to Kel, but the orbiting starship had seen evidence of Ketaxil raiders approaching Yldac, and an-

other raid seemed imminently possible. So far the island towns had consistently succeeded in repelling the pirates from their shores, although boats sent out from the towns to face them on their own ground—the water—were rarely heard from again. But those cannons were old and primitive, and there was rumor in the towns that the Ketaxil were developing improved weapons and tactics.

If the next attack came today, Chet wondered, would the old defenses be adequate to repel it?

All the thousands of eyes along the narrow streets of the periphery and hidden behind chinks in shack walls seemed to be staring at them. Intellectually, Chet knew that was highly unlikely, but the awareness that suspicions had likely been aroused made him unusually wary. He could see something similar in Tina's face, although she hid it so well that anyone not married to her would have missed it. Wadkinz's anxiety, in contrast, was painfully obvious.

The feeling intensified when they reached the gray stone wall of the monastery. Nothing had happened yet, but there would be other eyes behind the small windows high in this wall, and some of those might represent real threats. Yet, precisely for that reason—because the PFSU had said that the recent unusual activity was centered here—this was where they had to come.

They didn't know what they were looking for, and the castle itself was inaccessible atop the sprawling monastery. So they simply started around the monastery, looking for any hint of the disturbance. They completely circled it once—a matter of almost a mile of broad cobblestone street separating the monastery from the town—without noticing anything.

The second time, they saw the Dunce.

Chet didn't recognize the grotesque figure's significance, but that in itself was cause for suspicion. "Look up there!" he whispered, stopping and pointing. "Up on the wall. What's with him?"

Tina and Jem looked. The wall was ten or twelve feet high, and now a native, barely recognizable in garish paint and clothes, stood at the edge some hundred feet ahead. He wore a huge, bizarre helmet and there were chains on his elbows and wrists, but he was standing very erect and looking this way.

"A Dunce," Tina explained. "A minor heretic. The Temple doesn't tolerate ideas too much unlike its own, of course. But the priests know better than to execute anybody, except as an extreme last resort. Martyrs are so awkward—if you kill somebody for his ideas, it strongly suggests you took them seriously. The Temple prefers to nip heresy in the bud by holding the troublemaker up to public ridicule.

So they stand him out on the monastery wall in a clown suit and—" She broke off suddenly and Chet could see her mind racing. "Chet!" she squealed. "Could he be it? If we have something to do with his heresy—"

Before Chet could answer, the Dunce called to them.

Startled, Tina looked at Chet. "Maybe I was right. He wants us to come. Should we?"

"Sounds dangerous to me," Wadkinz grunted.

"I think we'd better," Chet said, though he felt no more real enthusiasm than Jem. They went.

At close range, they saw that the Dunce was smiling with a surprising air of calm confidence. Looking down from his high perch, he gave an uncomfortable impression of considering himself in command of the situation. He stared at them silently for some seconds and then asked, "Where do you come from?"

Chet suddenly became very apprehensive. He gave the stock answer, but he had a feeling it wouldn't satisfy this customer. "We have traveled far, from a distant land where—"

"Where?" the Dunce interrupted bluntly.

Chet didn't bother to finish the rehearsed answer. And he knew that he was on much more treacherous ground ad-libbing. "You wouldn't know the place," he said.

"No one from Yngmor has ever been there."

"I can believe that," the Dunce said. He made it sound as if it had more than surface meaning. "Do you recognize me?"

Evidently Tina's guess had not been too far wrong. "I'm not sure," Chet said. "Should I?"

"I would hope so," the Dunce said wryly. "It's the least you could do after the way you wrecked my life."

Chet blinked. "Wrecked your life? Us? How's that?"

"I was at your show yesterday," the Dunce said. "It was the best I've ever seen. That's the trouble—it was too good. It destroyed everything I had done toward getting the blessing of the Temple for my work. But my work's *right*, your tricks notwithstanding! So I hoped to persuade you to help me unwreck my life—to placate the dixar Kangyr—"

Chet was beginning to see where the Dunce fitted into yesterday's incident—and implications of something possibly much bigger behind that. But before the Dunce finished explaining, they were interrupted by a clatter of rapidly approaching footsteps and a harsh voice. "Hey, you, there! What are you doing?"

Chet turned to see the Templeman running toward them with ceremonial lance raised and instantly recognized potential trouble. He turned quickly back to the

Dunce. "For future reference," he said, "what's your name?"

"Terek," said Terek.

The Templeman halted, puffing, a lance length away from Chet. "Why were you talking to the prisoner?" he demanded.

"What difference does it make?" Tina taunted. "He's just a Dunce." She glanced up at Terek and added, "No offense."

"None taken," Terek said. Then, to the Templeman, "These are the so-called magicians who got me in this mess, Xymrok."

Xymrok lifted his lance tip momentarily in a perfunctory threatening gesture. "You know better than to address a Templeman by name," he muttered. Then he looked puzzled—or so Chet thought, although there were enough differences between human and Kemrek facial expressions that he couldn't always be sure. "If that's true," he mused, "why should they be talking to you?"

"He called us," Chet said. "We didn't know—"

Xymrok looked up. "That so?"

"You have the outlander's word," Terek said dryly. "Of course I did. I don't especially like it up here. I thought if they would talk to Kangyr—"

"*The dixar Kangyr!*" Xymrok corrected sharply. He frowned. "None of you are making any sense, but this all smells very funny. I've half a mind to haul you up to the dixar on suspicion, but

"I'm not sure it's worth his trouble."

"Look at their hands," Terek suggested.

Wadkinz turned white; Chet and Tina just quietly abandoned any remaining hope of evading discovery. The Templeman looked, at first uncomprehendingly, then with widening eyes as he counted only five fingers on hand after hand.

Then he looked up at Chet, all traces of indecision gone from his face. "Come along," he said.

Xymrok led them through musty-smelling torchlit corridors and up long winding staircases. Chet wondered briefly if now was the time to call Sandor with the rudimentary transceiver he carried in a second molar, and decided against it.

They arrived finally in a long room, high above ground level, in which a purple-robed native sat alone at the end of a long table. Alone, that is, except for highly stylized images of himself in niches above all the wall torches—for the dixar was, according to the teachings of the Temple, the literal incarnation of the Supreme Presence in this region. The humans echoed Xymrok's elaborate salute to him, and Kangyr, who looked a good deal like a beardless gnome, returned it.

"These are said to be the magicians whose performance led to Terek's disgrace yesterday, Your Holiness," Xymrok explained.

"They were found talking to Terek and could not explain themselves to my satisfaction. I suggest also that Your Holiness examine their hands."

The dixar Kangyr glanced quickly at their hands and his forehead wrinkled almost imperceptibly. "Magnificent and infinitely varied are the ways of the Supreme Presence," he recited indifferently. "Xymrok, you may leave the room."

Xymrok saluted and left, closing the big wood door quietly behind him. Kangyr affected something resembling a very relaxed smile. "I don't suppose you'd like to tell me where you're from?"

"It would be difficult, Your Holiness," Chet said. "It's a very distant land—"

Kangyr dismissed the thought with a wave of his hand before Chet finished. "No matter. There is surely room in the world for a land of people with five fingers, and surely the Supreme Presence would find it no great challenge to create such a people. Is it true that you were talking to Terek?"

"I suppose it is—if that's who the Dunce was."

"You don't know him?"

"No."

"Then why were you talking to him?"

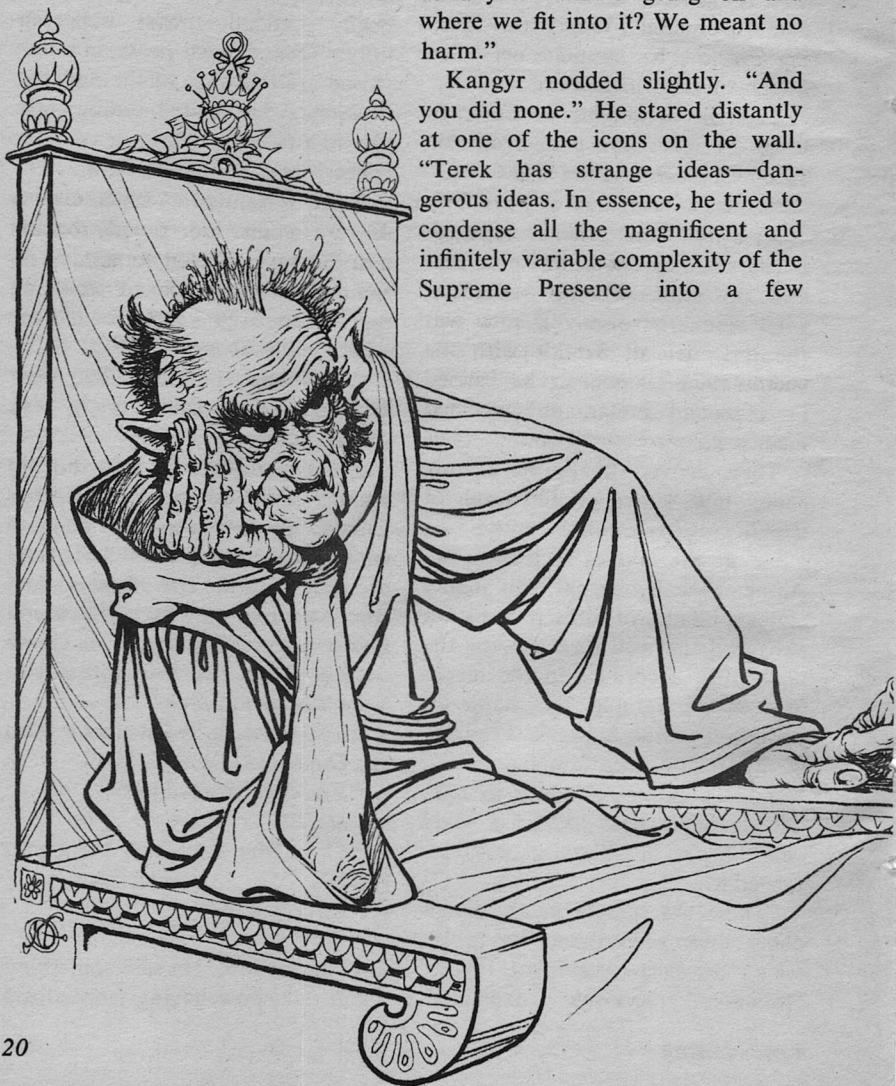
"He called us."

"Why?"

"I'm not sure. He said something about our show having jeopardized

hisstanding with the Temple, but we couldn't understand it. Your Holiness"—and Chet hoped as he said this that he wasn't going too far beyond the bounds of propriety—"could you explain to us any of what's going on and where we fit into it? We meant no harm."

Kangyr nodded slightly. "And you did none." He stared distantly at one of the icons on the wall. "Terek has strange ideas—dangerous ideas. In essence, he tried to condense all the magnificent and infinitely variable complexity of the Supreme Presence into a few



simple sayings—some of them clearly and flagrantly wrong, others simply claiming to impose restrictions on the Supreme Presence where there is clearly no need for the Supreme Presence to be restricted at all. There are . . . ah . . . those in the Temple who were tempted to grant some acceptance to his ideas, primarily because he claimed that with some of them he could greatly improve our defense capabilities. With the Ketaxil situation deteriorating as it has been . . . well, I can forgive temptation in the weaker elements of the Temple. Yet I always felt obliged to resist Terek's heresies altogether because of their terrific religious impact. Why, he wanted us to believe Ymrek revolves around the Day Star, when everybody knows that

the Day Star and everything else revolves around Ymrek!" He looked at Chet. "So I welcomed the opportunity your show gave to denounce Terek once and for all as a Dunce. After your show it was impossible for anyone to take seriously a madman who thinks all objects must fall at the same speed and—" He broke off. "But I'm boring you. Is there anything else you want to know?"

There was plenty, but Chet was so excited by what he had heard already that he didn't want to risk saying anything else to get them into trouble. The urgent thing now was to get back to the boat and decide what to do about it. "No, Your Holiness. Thank you for clarifying the situation."

"The least I could do," Kangyr said. "I apologize for your inconvenience, but you understand that Xymrok must be suspicious of anyone he finds talking to a dangerous prisoner. Since this wasn't your fault, you may go with my blessing whenever you like."

When they reached the door, Kangyr spoke again. There was a note of something like pleading in his voice now that sounded odd from one in his position. "Your magic," he said. "It is . . . real?"



Chet thought, startled by the question, then said cautiously, "We have learned control of some . . . er . . . spiritual phenomena which seem to be unfamiliar in this land."

"I was just thinking," Kangyr said. "If you have magic which might be effective against the Keta-xil, we could make it worth your while . . ."

"Uh," said Chet, increasingly anxious to get away, "I'd have to consult the spirits on that."

"Please do. And if you find a way, you will let me know?"

Chet nodded uncomfortably.

They returned to the boat as fast as they could.

". . . So it looks to me," Chet finished, "like we've just pulled off the most horrendous piece of cultural interference in history. Now it's up to us to stick around and see if we can undo any of the damage."

Kel, sitting on the far side of the main cabin, looked thoroughly miserable. "What are you talking about, Barlin? I don't see—"

"Don't you see what's happened? We've come at one of the big turning points in their history, and by introducing a few tentative samples of quasimaterials, we've frustrated it."

"We're not all historians, Chet," Wadkinz reminded. "You're not ringing many bells yet."

"Terek," Chet said earnestly, "is this culture's Newton . . . and

maybe Copernicus and Galileo, too, all rolled into one. I can't be positive yet, but from what he and Kangyr said I'm almost willing to bet that he's worked out a modern picture of the universe, together with universal gravitation and Newtonian mechanics to back it up. Now we come along and give them a look at some things that don't work that way, and the established church jumps at the chance to laugh his ideas into the ground!"

Kel frowned. "But is it all that important? Sure it is for him, but . . . well, if it doesn't catch on now, somebody else will think of it later."

"Probably," Chet granted, "but who knows when? There are some times in history when an individual mind *is* of great importance. Just because Newton's laws—Terek's laws?—are now taught in the first week of every kid's science course, we think they're trivial. It's very hard for a modern person to appreciate what a tremendous accomplishment it was to formulate them from scratch, when nobody knew them. It's a huge step which *can* happen when a certain point is reached—but it *doesn't* until some individual comes along capable of taking it. It still doesn't, unless the right things happen to suggest it and encourage him to follow through. That may take centuries.

"If Terek's done it and we let him be stopped, it may be centuries before it happens again. And so

much future science and technology depends on that . . . what we may have done to their history is absolutely appalling." He laughed sourly. "We thought quasimaterials were such a timely development—not only for our own use, but just what the doctor ordered for Yngmor's little communication setback. Well, it looks like we've come at just the right time to nip their science in the bud—by showing them just the wrong piece of advanced technology!"

Tina and Jem waited uncomfortably to see if he was going to say more. Then Tina asked softly, "What can we do about it?"

"I don't see that we can do anything," Kel interjected. "The damage is done. They've seen and touched quasimaterials, and we can't undo that. Maybe it'll even turn out better this way—"

"I think," Chet interrupted bluntly, "you're just looking for the easiest way out for yourself, without thinking about the consequences. There are several things we might do. We could remote-trigger all the quasimaterials on the planet to damp out and then hope the natives will forget about them. But there's no guarantee that they will, or that Terek will still be in the humor to push this when the climate improves. I'd write that approach off as too uncertain. There's another one that I'm pretty sure has a better chance. You won't like it."

Kel frowned and started a new cigarette. "Oh?"

"Once," Chet said slowly, "I saw a man poison himself accidentally on a small craft in space. I don't remember what it was, but I remember what the medic did about it. There was no antidote on board, but there was lots more of the poison. The doc poured a whole bottle of the stuff down the patient as fast as he could—and the poor guy reacted so violently that the whole mess came right back up. From that point on, saving him was easy. I think this is a case like that."

Chet saw Tina start to grin knowingly, but Kel just kept frowning and said, "I don't see what you're driving at."

"Simply this: our blunder was showing them quasimaterials that seemed to violate Terek's laws. Well, I think the clergy must have some prejudices of their own about what's reasonable. Let's try to violate a few of those. Let's give them a *real* magic show, on a grand scale!"

"You're crazy!" Kel gasped.

"For instance," said Chet, ignoring him, "I still think some Reynolds air-floaters, introduced to the right people with the right degree of flamboyancy, might shake them up a bit. Kangyr, anyway. And there's a growing market for them—Yldac could have another Ketaxil raid at any time, and they could use some souped-up defense

methods to counteract the souped-up offense the Ketaxil have."

"Out of the question," Kel snapped. "A few little quasimaterial trinkets are one thing and a full-scale floater is quite another—"

"Exactly," Chet nodded.

"—And the study is not complete."

"And it won't be! Can't you see yet that we've already messed things up in a big way and we have to try to fix them?"

"But," Kel spluttered, "you're talking about a large-scale cultural interference! Barlin, what are you trying to do to my career?"

Chet turned and stared at the B.E.L. agent with frank disgust for several seconds. "I could care less about your career," he said finally, evenly, "but it wouldn't be easy. I care very much, though, about the fact that we have *already* committed a large-scale cultural interference and it's going to take a comparable one to fix it. We can't guarantee the cure, but we can't leave knowing we've messed things up so thoroughly and made no attempt at one. So, Agent Kel, about your career—if you try to keep us from doing anything, when we get home I'll testify against you as strongly as I can. Think how you'll fare in that."

Kel did, and once more gave his most grudging consent. Chet turned to Jem with a grin. "O.K., quasimaterial man—we're ready to go into production!"

Five fingers, Kangyr thought after the magicians left. *I never met a man with only five fingers before.* The thought lingered all day—that thought and a feeling of almost-shame at the moment of weakness he had had as they left his chamber. It was far from fitting for a dixar to suggest the vulnerability of his own district to that extent. And yet, if it led to help in the form of magic comparable to that which had refuted Terek . . .

Maybe it would be worth it.

At Day's End he went down personally to take Terek off the wall. "I hope," he said as he freed Terek's chains, "that these days have been profitable ones for you. Having seen your error, are you ready to return to the Truth?"

Terek grinned impudently. "I'm not convinced I was wrong, but I won't be preaching any more for a while. But I think one of these days you'll see that you need at least some of what I offered you. And when you do, it's still available."

Kangyr shook his head sadly. "Such arrogance! But time will cure that." His voice dropped, became confidential. "Terek, what do you know about those outlanders? I believe you were the first to notice their hands."

"I know nothing about them," Terek said, "but I suspect there's a lot I'd like to know." He grinned again. "Dixar," he said, gently chiding, "you're not getting ideas about using their parlor tricks in-

stead of my new gunnery methods, are you?"

Kangyr looked away. That was exactly what he had in mind, although he didn't feel completely comfortable about it. From a theological viewpoint, he found the idea of dealing with the foreign magicians less disconcerting than dealing with Terek—at least they didn't try to clamp a tight harness of rules onto the Supreme Presence. Yet there was something which he couldn't quite place which bothered him about them, too . . .

"Because if you are," Terek finished, "I think you'll find you have the same objection to them that you do to me. Good night, Dixar."

Terek strolled off into the dusk toward his shack in the periphery, leaving Kangyr to puzzle over what his last remark meant.

What all quasimaterials have in common is that they are artificial standing wave structures qualitatively similar to ordinary matter—although in general their actual energy content is much lower. And, just as computer-generated sounds can have properties "natural" sounds can't, or hologram images can be made of objects which could never "really" exist, they can have properties wildly unlike those of ordinary matter. Some, like the outer hull of the landing boat, are totally invisible from at least one direction. Some, like some of the trinkets Tina peddled after their ex-

ploratory magic shows, have inequivalent gravitational and inertial masses. Most can be induced to damp out and vanish exponentially—like Instavac, or the statues Chet used to finish the magic shows.

The special qualities of the Type 76CB3 control elements used in Reynolds air-floaters are a little harder to describe.

Chet and Tina watched with interest as Jem put the finishing touches on their first floater early the next morning. Mostly it consisted of real matter, a cheap, easily-shaped synthetic that emerged ready-formed from an automatic fabricator. A casual observer would never have guessed that—the fabricator was programmed to imitate minutely skilled hand-crafting of wood, even to the extent of providing different minor flaws in each unit. It would have taken sophisticated chemical analysis to prove that the floater was not a boat hand-carved by barbarians in some far-distant region of Ymrek.

Even the control elements were made to resemble carved sticks mounted in crude swivels in the bottom of the boat. But Jem had to mount *them* by hand, and as he worked they often seemed to want to float, or occasionally jump, from his hands. The front one went in without much trouble; the one in back took a little longer. But finally the job was finished and Jem

stood up with a look of satisfaction.

"Finished?" Tina asked.

"Almost. But I thought since we're planning to play this magic bit to the hilt, one little finishing touch might be in order." He reached into the pouch of quasimaterials he carried inside his magician's robe and produced something which he attached to the prow of the floater. "Like it?"

Chet looked at the figurehead for a few seconds, then quickly away. It was one of those visual paradoxes that can be drawn in perspective but could never actually be built in three dimensions—with ordinary matter. It made him dizzy to look at it.

"Perfect!" he laughed.

Jem sat in the bow, Tina and Chet behind him in single file, as the landing boat's cargo hatch yawned open to bright clear morning before them. Jem took the front control element in his left hand and the long rod to the rear element in his right. He moved each lever the merest trifle—

And the floater lifted inches off the deck and floated silently out through the hatch. As they cleared, Chet glanced back just in time to see the hatch shut after them, leaving the boat again invisible. Looking over the side he saw the ground several yards below, then falling away as Jem pulled back sharply on his front stick to be sure they

would clear the highest parts of the barrier thicket. Tina grabbed Chet's hands tightly and asked, "How does it work, Jem?"

"You never rode one before?" Jem sounded surprised. "Gravity. The strength and direction of the force on each control element depends on its orientation relative to the gravitational field. It's a little like the way the force on an electron in a magnetic field depends on which way it's moving—but not very much. Anyway, I can make gravity move each end of the floater in any direction I like just by moving the control elements around. Like this." Without further warning, he suddenly made the floater twist wildly, stopping just short of pitching the crew overboard, then chuckled at Tina's reaction and settled back to a smooth glide.

He kept climbing as they crossed the barrier thicket, reaching a peak of over a thousand feet and starting downward only after they emerged over the open plain surrounding the town. As they went over the top the entire town came into view sprawled out before them.

The town—and the water around it.

"Look!" Tina gasped suddenly, pointing off to the left. "What are those?"

Chet looked, and didn't like what he saw on the water. "One, two, three, . . . seven," he

counted. "I guess today's the day."

"Ketaxil?" Tina asked.

"I'd say so. Wonder what they really do have in the way of weapons? And what kind of defense improvements Terek was trying to peddle to the Temple."

"I doubt that they have anti-aircraft guns," Jem said, looking curiously at the boats approaching Yldac. "Want to go over for a closer look?" He veered slightly to the left.

"No!" Tina said instantly. Jem unwevered.

"Probably not a good idea, Jem," Chet said. "They might surprise you, and we're not exactly armed to the teeth." They weren't completely unarmed this trip—along with all the other paraphernalia befitting powerful magicians from afar, each had allowed himself the luxury of a compact beamer, just in case. Effective, under the right conditions, but far from limitless in capability. Chet cast one more look at the boats. "This might not be the best possible day for this, but the show must go on. Let's get down to that castle as quick as we can."

As they descended steeply toward the center of town, a few people in the streets below looked up, saw them, and scattered into houses with considerable commotion. Jem ignored them and headed the boat faster and faster down toward the castle at the sum-

mit of the monastery. Then, in the last few yards, he slowed them to a gentle landing on the last terrace below the castle proper.

"This must be the place," he said. "Now what?"

"Have to get inside," Chet said. "I'm pretty sure the dixar's chamber is in the extreme top level—that little box right up there in the middle. But it doesn't seem to have any doors or windows on the outside."

"Sure doesn't. Seems odd, but we didn't notice any when they took us up there from inside . . . Hm-m-m. Hang on." He lifted off again, lowered the floater over the edge of the terrace and ran it methodically along the wall in search of an opening.

He found one at the first corner and hovered in front of it to size it up. Then he said, "Duck," and eased the floater through the window, barely clearing the sides. Inside, he hovered again to allow their eyes to adjust to torchlight, then headed along the empty hall until he found a stairway. He tilted the floater's nose upward to match the slope of the stairs and started up, never touching, but occasionally maneuvering delicately past an almost impossibly tight turn.

The stairs rose three levels and then leveled off into a familiar short corridor. At the other end was a big wooden door—and a Templeman. When he saw them float out of the stairwell he let out

a gasp clearly audible the length of the hall and then stood frozen—except for some protective religious gestures which he managed to get through in great haste. Jem pulled the floater almost to within a lance length of him and halted.

Chet grinned broadly at the Templeman. "Good morning," he said, his hand resting lightly on the beamer just inside his robe. "We've come to see Kangyr on business. You will please admit us—and I suggest you don't attempt to raise your lance. Right where it is will be fine."

Kangyr's eyebrows rose quite noticeably when they floated through the open door—much more so than when he had counted their fingers. "What," he demanded, staring at the bow of the floater, "is *that*?"

"Your Holiness wondered if our magic could help you," Chet said, "and I said I'd have to consult the spirits. This is their answer. And none too soon, I might add."

Kangyr looked at him sharply. "What do you mean by that?"

As if in answer, the faint sound of an explosion, muffled by distance and the indirectness of its path, reached them. Kangyr's expression changed abruptly. "The Ketaxil are back," Chet said quietly.

Kangyr nodded solemnly, then seemed to turn fiercely defiant. "We've stood them off before!" he

said hotly. "We can do it again, just as we've done in the past." His gaze returned to the floater suspended two feet above the floor, full of what Chet was pretty sure was suspicion.

"Are you sure you can?" Chet asked. "It is said that the Ketaxil have new weapons and plans of attack. Are you sure the ways you held them off before will work again?"

Kangyr started to say something, but broke the first word off to listen to a particularly violent and rapid volley of gunfire. "I think so," he said finally, but there was a lack of conviction in his voice. "With the Supreme Presence on our side—"

"It might not hurt to have some of our magic on your side, too," Chet suggested. The distant rumble of battle continued to underline their conversation. "Take this boat, for instance. With the spirit-sticks mounted in bow and stern, it can fly high over the enemy. If nothing else, it could carry a messenger to a neighboring island for help when all other routes are blocked. The mere surprise of seeing such craft could place the enemy off guard. No doubt Your Holiness could even find ways to use them in actual battle. Would you like to go for a ride and see how it works?"

"No," Kangyr replied at once, shrinking slightly away from the floater. "No, thank you. Perhaps later. I can see what it does. But

...” He stared distantly at an icon of himself, much as Chet had seen him do once before. “From all sides,” Kangyr said sullenly, “I’m besieged not only by Ketaxil but by people telling me I must adopt this or that new-fangled contraption to protect my town. First Terek, now you—”

“Might I ask,” Chet ventured cautiously, “just what Terek tried to get Your Holiness to adopt?”

“Guns,” Kangyr said with a shruglike gesture. “New kinds of guns firing more rapidly, and firing larger balls to larger distances . . . It would be impossible to aim such devices, of course, yet Terek claimed he could aim them better than our old guns—by doing mumbo jumbo with figures on paper!”

Hardly surprising, Chet thought, *that he’d spend some time on trajectory problems—probably complete with fudge factors for air resistance and such.* He asked Kangyr, “Did you ever try Terek’s methods?”

“Of course not! A dixar is no fool. And the ideas underlying Terek’s wild scheme were so terribly at odds with the Truth . . .” He broke off, and a flurry of cannon filled the pause. With an abrupt change of expression, Kangyr dropped the subject of Terek and looked with renewed interest at the air-floater’s figurehead. “These spirits of yours,” he said. “They are of the Supreme Presence?”

Chet wasn’t sure how to answer that and was relieved to hear Tina, who was somewhat more familiar with the Temple’s beliefs and practices, fill in for him. “Of course,” she said brightly. “Isn’t everything?”

For the moment Kangyr seemed almost satisfied. Then he sank back into his mood of doubt. “Actually,” he said slowly, “I hardly see the need of either. I know Terek’s a crackpot, and I don’t see that your flying boat is any panacea. If it’s true that the Ketaxil have better guns, flying boats will hardly counteract them.”

“Maybe not,” Chet said. “But if you change your mind, we can get you many more such boats on short notice—”

He didn’t finish the sentence because suddenly there was an insistent pounding on the door and then a Templeman ran in, panting from exertion. Chet recognized him as Xymrok, the one who had originally brought them before Kangyr.

“Your Holiness!” Xymrok said excitedly. “Our guns are failing to repel them. The periphery is feeling unprecedented destruction—” Then he noticed the floater and broke off in midsentence, staring wide-eyed. “Your Holiness, what *is* that?”

Xymrok’s report had had its effect. Kangyr’s decision had been made with obvious reluctance, but it had been made. “Salvation,” he said curtly, and then added under his breath, “I hope.”

Terek moved swiftly through the cobblestone street around the monastery, driven by the pounding of gunfire in his ears. He knew the street well, and he knew exactly what he was looking for.

And he found it.

Xymrok was pacing back and forth near the west entrance, and he was alone. That was good. Terek hurried up to him and slipped him a coin. "Any word?" he asked, glancing significantly up.

Xymrok pocketed the coin and looked around. "The dixar Kangyr has accepted aid from the foreign magicians," he whispered quickly. "They have a strange boat which flies, and say they will sell Kangyr a number of these—"

Terek didn't wait for all the details. He pounded the door until another Templeman opened it from inside, recognized him as one enjoying slight and variable favor with the dixar, and let him in.

Then he started at top speed up the long succession of corridors and stairs.

"Your Holiness," Terek insisted, even more exasperated than he dared show, "you're being taken in. The magicians' boats aren't going to save Yngmor, or even Yldac. Not by themselves, anyway. At best, they'll provide a way to carry word from one town to another. But what good's that if the Ketaxil have destroyed the towns? Face it, Your Holiness—we can't survive

without better defense. And no matter what else you use in addition, that means better coast guns. And I can tell you how to make them."

Kangyr stared at him for a long time, his face full of weariness and uncertainty Terek had never seen there until quite recently. "Terek," he said finally, "we've been through all this before. Do you want to spend all your time on the wall?"

"I'll risk it," Terek said tightly, "if the alternative is to watch you throw away a chance to salvage some of what we call civilization." He paused. Then, "Your Holiness, what makes you believe that these so-called magicians are infallible while everything I say is wrong?"

"Do I?" Kangyr snapped. "I don't think so. Why are *you* so suspicious of *them*? 'Magnificent and infinitely varied—'"

"—Are the ways of the Supreme Presence," Terek finished quickly. "Yes. I know. But how is it that with the Supreme Presence everything is possible but what *I* suggest?"

"You're verging on blasphemy," Kangyr warned. "And you miss the point. It's not that way at all. It's just that you try to impose artificial restrictions on—"

"Your Holiness misses *my* point," Terek interrupted. "O.K. Maybe the foreigners' magic is real—but *that doesn't prove my work is wrong!* You preach that the Supreme Presence can act in

any way it chooses—and I say that includes the ways I describe. But there's even more than that. Maybe nature can act any way it likes—but there are certain ways it seems to prefer most of the time, and there's strength in learning those. You believe that yourself."

"How dare you tell me what I believe—"

"It's implicit in all your actions. Your discomfort at the thought of the flying boats is obvious. Why do they make you uncomfortable? Because they clash with your built-in ideas of how things naturally act. And you're *very* sure that everything revolves around Ymrek?"

"Yes!"

"O.K., let's leave that to argue about later. But meanwhile, give my guns a try." His voice lowered. "As for your magicians—I don't know how their tricks work. It doesn't matter. But, as dixar, haven't you wondered about the possibility that you're being enticed into a trap?"

Kangyr looked at him sharply. "What do you mean?"

Terek paused, momentarily hesitant to attack a man with his own religion. Then he said it. "You never did find out where they come from, did you? Yet the Temple recognizes sources of power opposed to the Harmony of the Supreme Presence. And these people have hands like no others we've ever seen. I'd think you'd wait to deal with them until you knew . . ."

Kangyr looked startled, then pensive. For several seconds he was silent. Then he said grimly, "On *that* point, I'll have to agree with you. The question bears further examination."

The next time they descended toward the castle, the Barlins and Wadkinz had two more floaters in tow. They also had a considerable assortment of the most outlandishly "magical" objects Jem had been able to concoct. Chet felt that the first visit, in succeeding so easily, had failed in its real purpose. The object had been not to have Kangyr eagerly accept airfloaters, but to confront him with magic that defied his own intuitive ideas of natural law—which he must surely have—as thoroughly as the earlier examples defied Terek's laws.

With the result, hopefully, that he would decide the magic must not be taken too seriously and should be viewed as a thing apart from either the Temple's teachings or Terek's innovations, neither proving nor refuting either.

Unfortunately, it didn't seem to be working that way—anyway not as fast as hoped. Kangyr had balked noticeably at the floaters, but had given in far too easily. A stronger dosage was indicated.

Kangyr had appointed a spot on a lower terrace for delivery of the floaters. He was waiting as they approached, but he was not alone.

Chet frowned in puzzlement as they got close enough to recognize the other figures.

Two armed Templemen—and Terek.

Why?

Despite apprehension, they landed as scheduled. As soon as they were down, the armed Templemen flanked the floaters menacingly and Kangyr strode out to meet them. "For religious reasons," he said crisply, "I cannot conclude business with you until I have more definite knowledge of your origins. You will please answer the simple question: Where is your home?"

Chet knew it was up to him to answer, and he felt trapped. Somewhere along the line a new factor had entered the picture—and he wasn't sure what it was.

"*Quit stalling!*" a voice rasped. Chet looked up, surprised. It was Terek who had spoken, and there was an odd expression on his face. "Answer the question," he prodded. "You do have a home, don't you?" After a short pause, he turned to Kangyr. "He refuses to answer, Your Holiness. Our suspicions—"

Kangyr nodded gravely. Chet saw him give an almost imperceptible signal to the Templemen, and their free hands moved to their lances—

"I'll answer," Chet said.

Kangyr's eyebrows shot up, he glanced at the lancers, and they seemed to relax. Terek's expression

changed abruptly to a rather bewildered one. He and Kangyr stared attentively at Chet.

Chet's pulse raced. He knew that Bydron Kel would never forgive what he was about to do, but he suddenly thought he understood what was going on.

And that, at this stage, however drastic it might seem, the rest of an answer might be as simple as the truth.

"I'll tell you where we came from," he said evenly. "The place is called Larneg. It is a planet which revolves about a very distant star—much as Ymrek revolves around the Day Star."

He heard Tina and Jem gasp, shocked. Kangyr's face registered first confusion, then disbelief, then anger. Terek's reactions were the most complicated—first, very briefly, he was stunned and incredulous, but then he believed, and with belief came a flood of satisfaction and excitement and humility.

"You're lying!" Kangyr snarled.

"I'm not," Chet said simply. "Terek knows. And we know that Terek is right, because we've seen both your world and ours from outside. Can you think of a more believable way to account for us and the things we do?"

Terek said quietly, "Coming here must have been very difficult—"

"Not for us," Chet said, "but it took our ancestors many centuries to learn how—even after our Terek's work was accepted." He ad-

dressed Kangyr. "There's a lot of what you would call magic in it. We have a lot more 'magic' that you haven't seen, and some of it could help you. But those that can help you most are the same ones Terek can show you. *Let him.*"

Kangyr stared at Chet, hard to read, for a long time. During that pause, Chet moved his hand inconspicuously to his beamer. Finally Kangyr said, "You will not leave. You will stay and show us all this magic, and we will select what we want of it." He nodded to the lancers.

But before they could get their lances up, Chet had whipped his beamer out and they backed away from it. "Stay put," he said. "This little piece of magic can be deadly at a distance." They stayed put.

"We're going," Chet announced. "We'll leave these two boats here, but they're the last you'll get from us. Whatever else you want, you'll have to get for yourselves. Terek can get you started—and when we

go, he's your only chance. Make the most of him. There aren't many like him." Chet disconnected the two new floaters from the one they were riding. "Let's go, Jem."

Jem lifted their floater off the terrace and started it almost imperceptibly skyward. "And if I don't?" Kangyr asked sullenly.

Chet grinned at him. "I don't think you're that stupid, Kangyr. When you honestly ask yourself if you can afford not to try Terek's suggestions, you won't answer wrong. And one thing will lead to another—"

He waited. When Kangyr said nothing, he nodded to Jem.

This time they lifted off in earnest and rose skyward with appreciable speed. Chet looked back at the dwindling figures on the monastery terrace and tried to foresee the future. There could be no absolute certainties in such things, of course, but—

"I think they'll make it," he told Tina. ■

THE ANALYTICAL LABORATORY / MARCH 1970

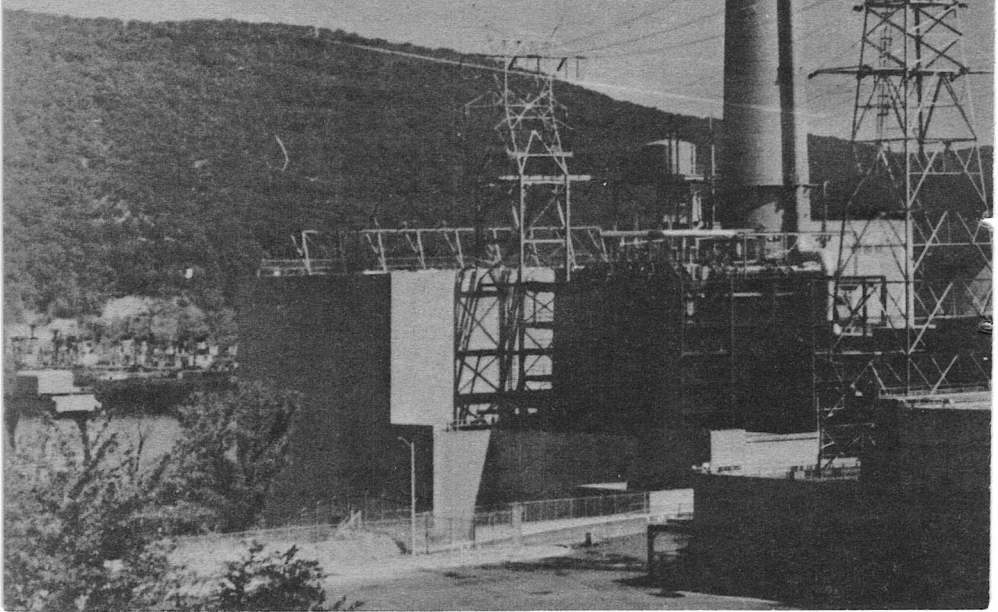
PLACE	TITLE	AUTHOR	POINTS
1. ..	The Siren Stars (Pt. 1 ..	<i>Richard and Nancy Carrigan</i>	2.33
2. ..	Revolutionaries	<i>M. R. Anver</i>	2.92
3. ..	Ravenshaw of WBY, Inc. ..	<i>W. Macfarlane</i>	3.00
4. ..	Wrong Rabbit	<i>Jack Wodhams</i>	3.77
5. ..	Protection	<i>Steven Shaw</i>	4.10
6. ..	One Step From Earth	<i>Hank Dempsey</i>	4.33

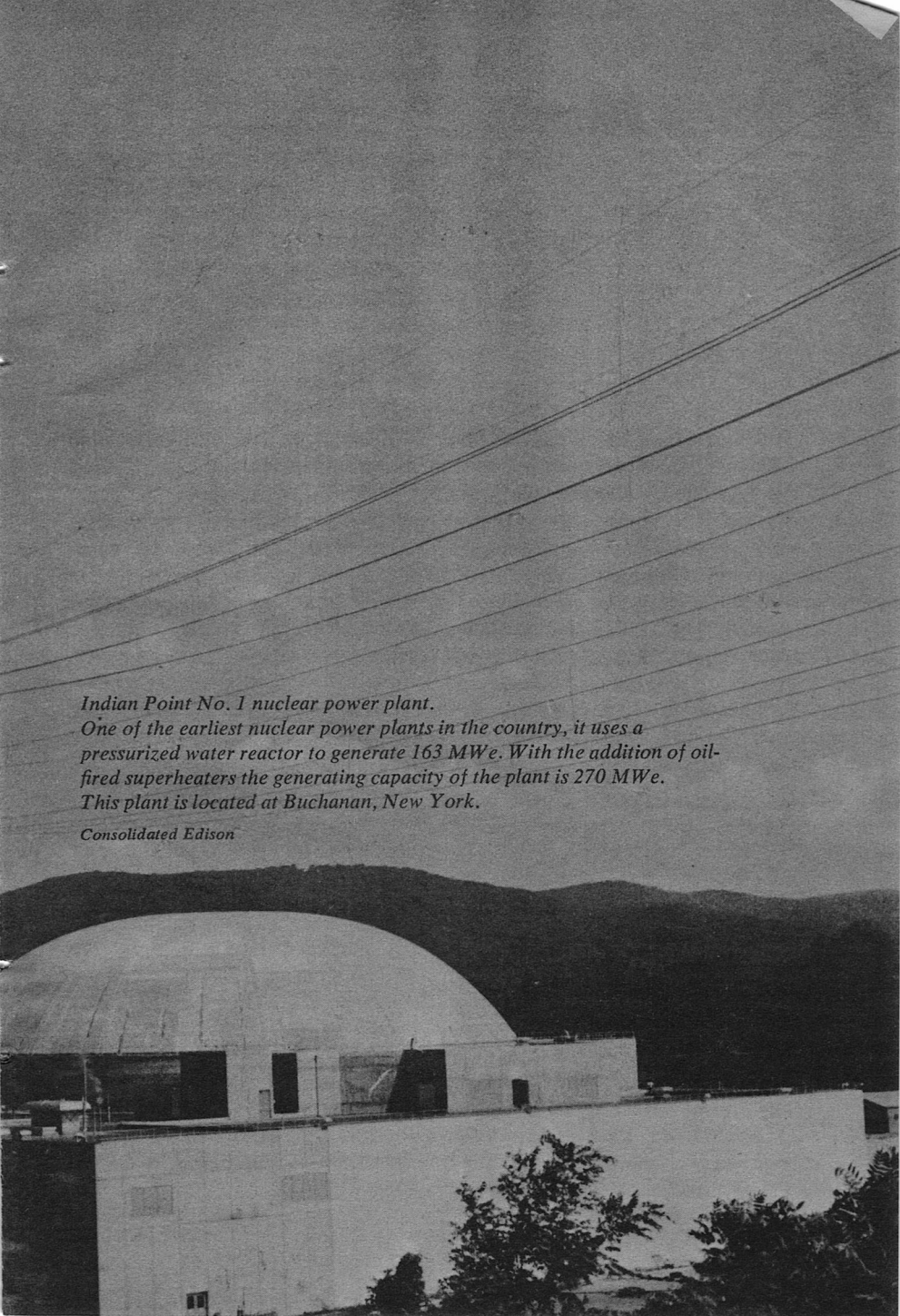
continued on page 111

NUCLEAR POWER

We are going to have to go to nuclear power plants, simply because there isn't enough fossile fuel—and the chemical substances are too valuable as chemicals to be wasted by burning! Moreover, nuclear power unlike chemical fuel power, does not have to pollute the biosphere! It's the only kind that doesn't automatically interfere with the life-support system aboard Spaceship Earth.

Edward C. Walterscheid



A black and white photograph of the Indian Point No. 1 nuclear power plant. The central feature is a large, white, dome-shaped containment structure. Below the dome is a long, rectangular building with several dark rectangular openings, likely doors or windows. In the foreground, there are some dark, leafy trees. The background shows a range of dark, forested hills under a light sky. Several power lines run diagonally across the upper portion of the image.

Indian Point No. 1 nuclear power plant.

One of the earliest nuclear power plants in the country, it uses a pressurized water reactor to generate 163 MWe. With the addition of oil-fired superheaters the generating capacity of the plant is 270 MWe. This plant is located at Buchanan, New York.

Consolidated Edison

NUCLEAR POWER

"Extension of electricity into individual households was perhaps the greatest blessing of the twentieth century. It powered washing machines, heated laundry irons, and illuminated rooms to diminish drudgery and gloom in millions of lives. With time, electricity invaded and intruded upon every aspect of household, office, and commercial life until it became pervasive, ubiquitous, and indispensable." WILLIAM RODGERS

Demand for electricity varies according to the season and the weather. In the United States it used to be that the peak demand came during the winter with the most electrical power being used the week before Christmas. Not so anymore. Now summer brings the greatest power demands with peak periods occurring during hot spells. The biggest culprit has become the air-conditioner. During the 1969 heat waves, some utilities found that as much as 35% of the power

demanded by their customers went into air-conditioning.

But can we continue to install more air-conditioning, heat swimming pools, and generally transform luxuries into necessities of life, without demanding more and more electrical power? Perhaps more to the point, is sufficient electricity going to be available without resorting to significant changes in our system of power production? The answer in both cases is no.

Consider the items tabulated in Table I. These and other items in the news within the last year indicate that production of electrical power in this country is barely keeping pace with the ever increasing demand. Unless a large number of new generating facilities are constructed—and soon—there is a fair possibility that voluntary, or perhaps even mandatory, rationing may be required. Whether we like it or not, we have indeed come to consider an adequate supply of electricity as indispensable to our way of life.

TABLE I.
RECENT SIGNIFICANT POWER PROBLEMS IN THE U.S.

The famous blackout of November 9, 1965, which left 30 million people without power for up to 12 hours, occurred not so much as a result of an overload—although that quickly became a factor—but rather because of equipment failure and instability in the transmission network. Illustrated the extreme reliance placed on having efficient and effective electrical power available.

Heat wave in summer of 1966 caused utility supplying power to St. Louis to ration it for days after numerous “brownouts” occurred due to insufficient power supply.

In 1967 large portions of the Pennsylvania-New Jersey-Maryland power grid blacked out, with some areas without power for as long as 10 hours.

During summer of 1968 and 1969, numerous power companies along eastern seaboard forced to appeal to their customers to turn off air-conditioning units, lights, appliances, and other “nonessential” equipment because generating capacity could not meet demand. Also reduced voltage. During July, August, and September, 1969, New York’s Con Edison used both tactics, trimming voltage by as much as 8%.

On August 4, 1969, equipment breakdown resulted in loss of 20% of power-producing capacity of New York’s Con Ed. Followed by another appeal that consumption of electricity be reduced.

Following day, August 5, 1969, two million people in Miami, Florida, without electricity because of power failure.

At the end of 1968 there was slightly less than 300,000 megawatts* of generating capacity available in the United States. Current projections indicate that by 1980 some 600,000 megawatts of electrical power will be required. By 1990 an installed generating capacity of a little over 1,000,000 megawatts is deemed necessary. Estimates conflict as to the need for electricity in the year 2000, with the lowest guess being about 1,350,000 megawatts and the higher ones ranging up to about 1,600,000 megawatts. It thus appears that the generating capacity required for entry into the twenty-first century is going to be somewhere between four and five times present capacity. Currently, it is no error to say that the need for electricity is doubling every nine or ten years.

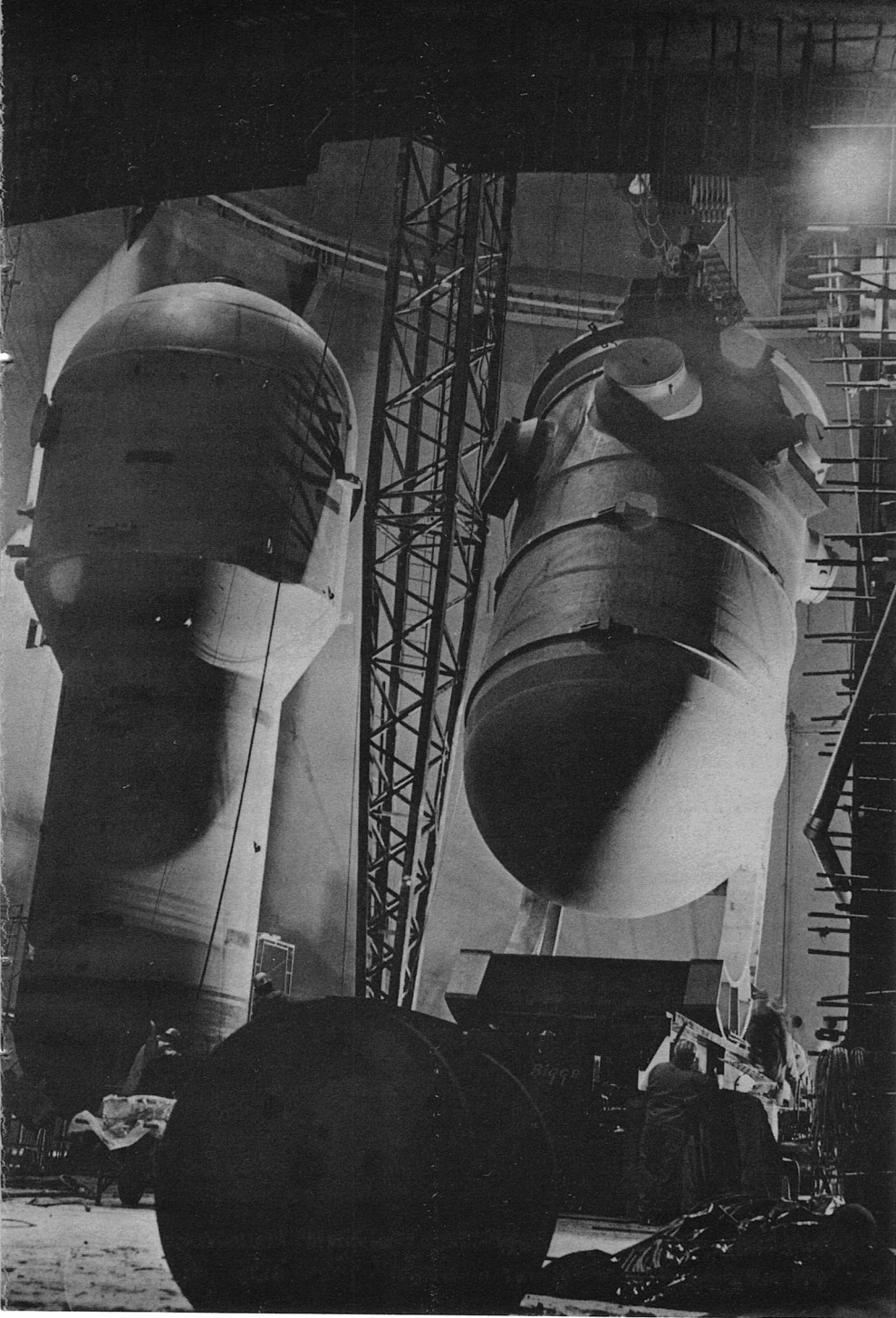
Another way of looking at this is in relation to the amount of electricity consumed on the average per person. Electrical usage per person has been increasing at a much faster rate than the population. Between 1950 and 1968 the requirements for electricity quadrupled while the population rose only by a third. In 1950 the average power consumption per person per year was 2000 kilowatt-hours. By 1968 it had risen to 6500 kilowatt-hours and when we finally reach the turn of the century it is projected to be about 25,000 kilowatt-hours.

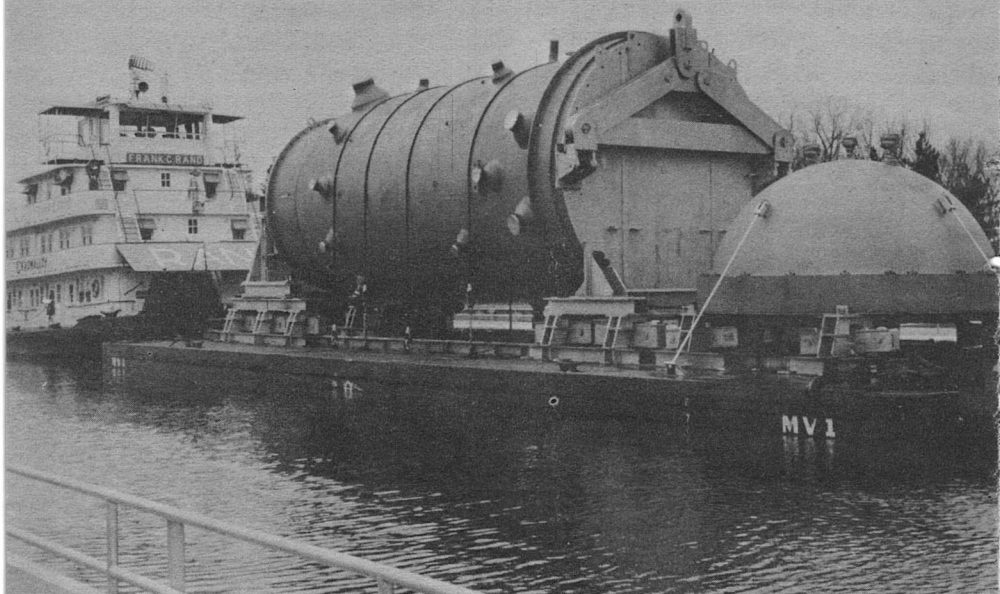
*A megawatt is 1,000,000 watts.

How does a country go about at least quadrupling its electrical power output? The answer requires a look at the manner in which electrical power is generated. Presently, more than 80% of the electrical energy produced in the United States is generated in steam-electric plants, while the remainder is almost totally produced from hydroelectric plants.

Hydroelectric power production depends not only on a generous supply of water but also on adequate sites where this water can be used to generate electricity. There are large sections of this country where the water supply is more than enough to produce vast additional amounts of electric power. The problem is that favorable sites for hydroelectric plants are not

The 320-ton pressure vessel for the pressurized water reactor for the Palisades nuclear power plant being lowered into place. The plant will generate 821 megawatts of electricity. To the left of pressure vessel is a 60-foot-long steam generator used in conjunction with the pressurized water reactor. A comparison of the Dresden No. 2 boiling-water reactor pressure vessel with this one will show the difference in size—the Dresden vessel weighs nearly 500 tons more. But the difference in sizes of the pressure vessels is rather quickly compensated for by the necessity of having that monstrous steam generator—in this case two of them are used—with a pressurized water reactor.





Commonwealth Edison Company

One of the largest reactor pressure vessels ever built is shown on its way toward the Dresden nuclear power plant near Morris, Illinois. The 72-foot-long pressure vessel, which weighs 800 tons, is to be used with Dresden nuclear power reactor No. 2, scheduled to begin operation this year. The vessel will enclose a 809MWe boiling water reactor.

very numerous, and many of the better sites are already used for this purpose. In some cases, reasons of aesthetics and conservation preclude use of sites that would otherwise be extremely desirable. But even should hydroelectric power be developed to its fullest potential, it is unlikely that it would be capable of producing more than 20% of the electricity needed by the end of this century.

This leaves the thermal power

plants in which heat to produce the steam necessary to drive the turbines is obtained from nuclear or fossil (coal, oil, and gas) fuels. An additional possibility is power production through the use of such advanced concepts as magnetohydrodynamics (MHD) and controlled thermonuclear reactions (CTR). The phrase "advanced concepts" is used advisedly because most planners in this area feel that neither concept will become a prac-

tical reality much before the end of the century.

Power production by MHD depends on the fact that passage of a highly ionized gas through a magnetic field can be made to produce an electrical current. The first economic application of this concept would probably be in conjunction with a steam-electric plant—either nuclear or fossil fueled—with MHD being used to increase the efficiency of the plant.

Much has been written about CTR since the concept was declassified in 1958. Research in this area is going on in many countries with the U.S. and Russia being the leaders in the field.* Papers on the actual engineering of generating plants operating on a CTR cycle are beginning to appear with considerable regularity. However, the viability of this method of producing power remains to be demonstrated. But should it become a reality, it will rather quickly make obsolete almost all other types of large central-station power plants.

If one is willing to discount the possibility of practical MHD and CTR power generation within the next decade or two—as the planners appear to have largely done—

*This is one area of research where the Russians can rightfully claim to be well ahead of the U.S. Whereas the U.S. Atomic Energy Commission has budgeted three to four times more money for the development of civilian power reactors than for CTR research, the Russian budget for this type of research is differently oriented, with twice the amount of financing for CTR work than now exists in the United States.

then this leaves nuclear and fossil fueled thermal power plants to take up the slack.

And that is the what and the wherefore of this article—to explore some of the similarities and differences between nuclear and fossil fueled plants and to describe in some small degree the various types of nuclear power plants that will increasingly dot the landscape.

Perhaps the chief similarity between fossil fired and nuclear power plants is their inefficiency. Regardless of the type of fuel used in present plants, the major part of the thermal energy produced is wasted, that is, dissipated to the environment without being converted to electricity or performing any sort of useful work. Currently, fossil fueled power plants can achieve net efficiencies of 38 to 40% in the conversion of thermal energy to electrical energy. This is somewhat better than the light-water*-reactor nuclear power plants now in use in this country which have a net plant efficiency of only 32%. It is believed that the efficiency of nuclear power plants employing high temperature gas-cooled reactors (HTGR) or liquid metal fast breeder reactors (LMFBR) can be raised to somewhere in the range 39 to 43%. However, these last two types of reactor are still largely

*As opposed to heavy water—i.e., deuterium oxide—used in some Canadian and European reactors.

in the developmental stage and should not see widespread use before 1980 or thereabouts.*

It is thus important to carefully distinguish between megawatts thermal (MWt) and megawatts electrical (MWe). The former refers to the thermal energy produced by a reactor while the latter refers to the electrical energy that can be produced using the same reactor. A fast breeder reactor—about which more will be said later—which has a power output of 2,500 MWt can produce only about 1,000 MWe. The difference between these two values is, of course, a measure of the efficiency of a power plant using the reactor as a source of energy.

Obviously power plants, whether fossil or nuclear fueled, must dissipate a tremendous amount of heat to their surrounding environment. In a fossil fueled plant about 15% of the heat input is lost through the stacks, boilers, turbines, and generators and for station use. There is no stack loss in a nuclear plant and other in-plant losses amount to 5% or less of the thermal input. The remainder of the heat present in the steam that has passed through the turbines is dissipated to the atmosphere through condensers which can re-

quire very large amounts of cooling water.

A quick correlation of heat losses other than through the condenser with the efficiencies noted above will show that the amount of waste heat discharged to the cooling water and thence to the environment may range from an amount equivalent to the electrical energy generated—in the most efficient fossil fuel plants—to about twice that amount—in certain nuclear fueled plants.

In passing through the condenser, the cooling water is heated 10° to 20°F and in some cases even more depending on the plant design. Because of the very large amounts of waste heat that must be dissipated from thermal power plants, almost one third of all water used in the United States for all purposes is used as cooling water for these plants. This, in a nutshell, is the origin of the so-called thermal pollution problem. Although this problem is common to both fossil and nuclear fueled power plants, the light water reactors now in use or planned require approximately 50% more cooling water through the condenser than large modern fossil fueled plants.

In addition to heat, both nuclear and fossil fueled plants produce certain waste products which must be dealt with in one fashion or another. The wastes from fossil fueled plants are generally considered as air pollutants and consist primarily

*One HTGR power plant is now under construction in Colorado. Although it will produce substantial amounts of electrical power—330 megawatts—it is perhaps more than anything else a demonstration plant intended to prove the viability of this type of reactor for power production.

of fly ash and the gaseous oxides of sulfur, nitrogen, and carbon. The pollution is most severe where coal is used—as it is in almost all fossil fueled plants having a generating capacity in excess of 100 megawatts.

Fly ash emission can be—and is—controlled to a considerable extent; however, it still remains a serious source of pollution in certain areas. Sulfur oxides present perhaps the most difficulties in controlling, and the best solution at the present time is to use only low-sulfur-content coal. Unfortunately, only a few percent of the known coal reserves are of this variety.

Until rather recently the carbon monoxide and carbon dioxide produced by the burning of fossil fuels were largely ignored as air pollutants. But carbon dioxide is being added to the atmosphere at a rate of more than six billion tons a year by the burning of fossil fuels. By the year 2000 the carbon dioxide content of the atmosphere will have increased by 25%. Since there is considerable evidence that carbon dioxide plays an important role in maintaining the atmospheric heat balance and thus directly affects climatic conditions, this outpouring of CO₂ is rapidly coming to be looked on as a major form of air polluting. While it should be emphasized that the primary use of fossil fuels today is not in power plants, nonetheless they do consume a significant amount—par-

ticularly of coal—each year.

The problems associated with the wastes from nuclear power plants can be summed up in one word: radioactivity. There are actually three types of radioactive waste produced by a nuclear power plant. First, there is a low-level release of radioactivity directly to the environment, primarily through the cooling water but some gaseous products are also evolved. Secondly, certain solid materials also achieve a low level of radioactivity during the operation of a nuclear power plant and hence are treated as waste. These include such things as filters, protective clothing, and tools. Finally, there is a highly radioactive waste product, namely, the spent fuel elements from the reactor.

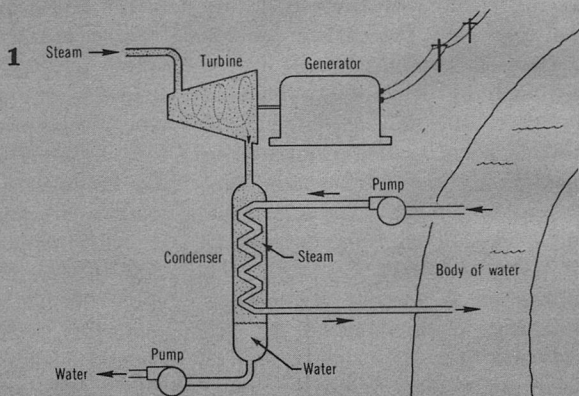
There has been a considerable amount of argument as to whether the low-level radioactivity present in the liquid and gaseous effluents from a nuclear power plant constitute a long-term health hazard. Releases of radioactivity of this type are governed by standards set forth by the AEC. These standards are designed to assure that all such releases of radiation, when added to other sources of exposure—including natural background radiation—do not exceed the radiation protection guides established by the Federal Radiation Council (FRC). The guides are set forth by the FRC after consultation with a great many scientific groups and

are approved by the President for the guidance of Federal agencies.

The argument usually concerns whether the FRC guidelines are good ones rather than whether the nuclear power plants are violating them. It would seem, however, that even should these standards be severely tightened—and the arguments for doing this are confused at the present time—there would still be almost no immediate effect on the release of radioactive effluents by these plants. This is because the effluents now being released by nuclear power plants generally contain radioactivity at a level of only a few percent of that permitted by the guidelines. Thus even should the present permissible

levels of radiation release be cut in half, almost all of the power plants would still be well within permissible levels.

Interestingly enough, it appears that from a biological point of view more radioactivity is released to the environment by operation of a large fossil fueled power plant than by the equivalent sized nuclear power plant. This release is in the form of several isotopes of radium present in coal and oil and which are emitted to the atmosphere in fly ash. While it should be noted that this does not constitute the formation of new radioactivity—the radium was always present in the fossil fuel—such as occurs in a nuclear power plant, it does nonethe-



less have a similar effect on the environment.

The low-level radioactivity associated with the various types of solid wastes from the nuclear plants is bothersome but not particularly troublesome. These wastes are sealed in drums and buried at commercial burial sites in New

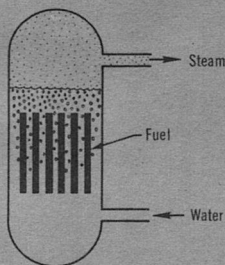
1. A nuclear reactor is only one part, albeit a major one, of a nuclear power plant. This is a sketch of the non-nuclear components of such a plant. Note the need for a sufficient body of water to condense the steam leaving the turbine. If a river—or lake—is not available for this purpose, the cost of the plant can rise significantly.

2. The simplest power reactor avail-

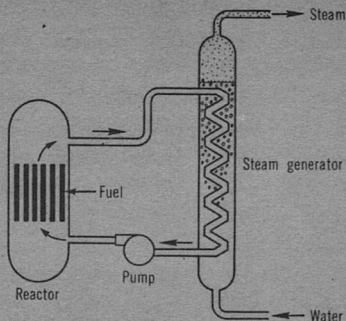
able is probably the boiling-water reactor. Water passing through the reactor at a pressure of about 1,000 psi is transformed to steam with a temperature of about 545°F. This steam is then used to drive generating turbines.

3. Steam production for power use by means of a pressurized water reactor. The water passing through the reactor is pressurized to about 2,250 psi. At this pressure it cannot boil but leaves the reactor as a liquid at a temperature of about 600°F. It is then used to produce steam from water kept at much lower pressure in another water system. A pressurized water reactor and its associated pressure vessel are considerably smaller than those of a boiling water reactor of similar generating capacity.

2



3



U.S. Atomic Energy Commission

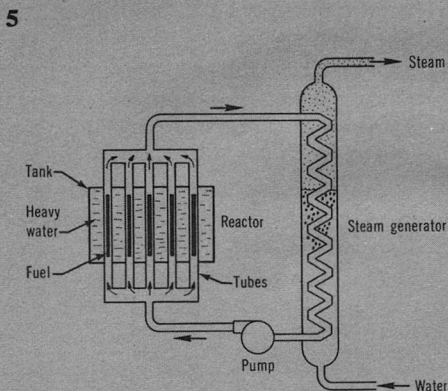
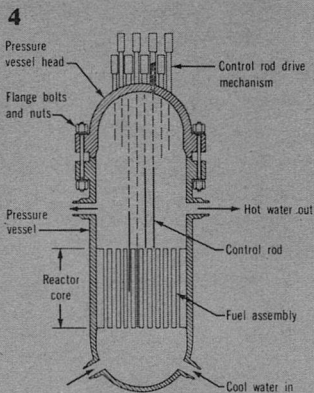
York, Kentucky, Nevada, Illinois, and Washington.

The spent fuel elements are much more difficult to deal with, however. Because they are extremely radioactive, they must be handled with special precautions. The first step is shipment to a special reprocessing plant where valuable fissionable material and certain other isotopes are reclaimed. Because the fuel elements are getting larger and the power of the reactors is going up—with resultant increases in radioactivity—transportation of these spent elements represents a considerable problem. The problem is compounded by the fact that some railroads refuse to accept irradiated fuel elements for shipment.

Currently one fuel reprocessing plant can handle the output of all nuclear power plants in the country, but by 1985 three to six will be required.

After the fuel is reprocessed, the radioactive wastes are present as very "hot" liquids. Because of the difficulties inherent in disposing of

4. *Additional details of a pressurized water power reactor. The walls of the pressure vessel are about a foot thick. For a plant generating about 800 MWe, the pressure vessel for the reactor would have to be about 40 feet high and have an outside diameter of some 16 feet. It would weigh about one million pounds empty. A serious problem now plaguing the nuclear power program is the difficulty in*



fabricating these pressure vessels.

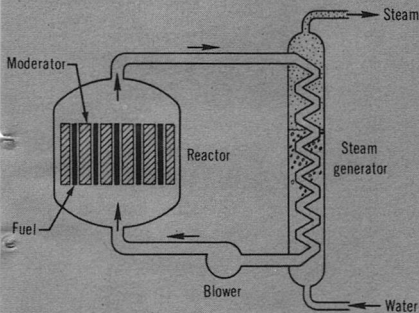
5. Heavy-water reactor gets its name from the fact that heavy water—deuterium oxide—is used as the moderator. Various coolant fluids, e.g., organic compounds, gas, light water, or heavy water can be used with this type of reactor. The Canadians are perhaps the foremost experts on the use of this type of reactor for power production.

6. Sketch of a gas-cooled reactor. Reactors of this type require use of a moderator—usually graphite—to slow the neutrons to an energy most suitable for inducing fissions in the fuel material. Temperatures of the coolant gas exiting from the reactor are normally much higher than that of the water used as coolant in light-water reactors. The gas temperature is usu-

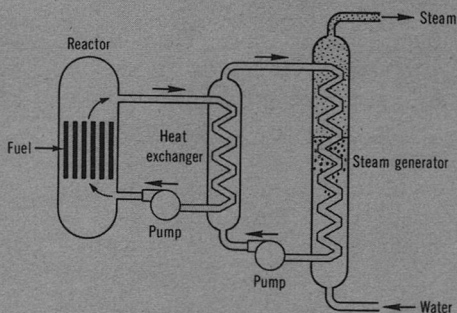
ally around 1,400°F, but unfortunately a gas cannot transfer heat very efficiently so that the system as a whole is rather large in comparison to light-water systems. In this country helium is the preferred coolant whereas in most European reactors of this type carbon dioxide is used.

7. This is the liquid metal cooled fast breeder reactor—the second generation of power reactors. The coolant will be liquid sodium. In addition to power, reactors of this type produce more fuel than they consume. Because sodium and water react explosively, two separate sodium coolant loops are used. The intermediate loop between the reactor and the steam generator is used to reduce the possibility of serious nuclear accident should sodium and water somehow come into contact.

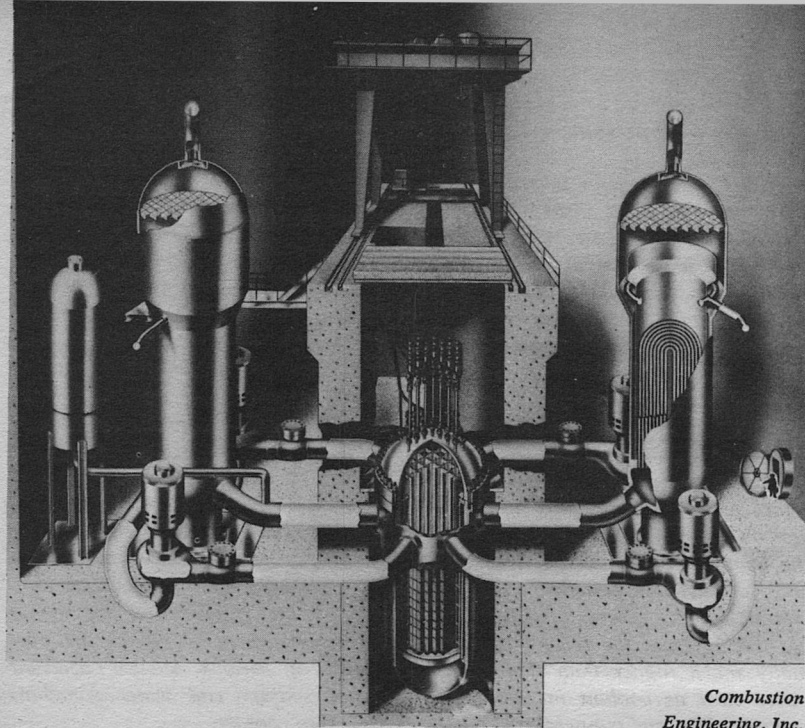
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7



U.S. Atomic Energy Commission



*Combustion
Engineering, Inc.*

Cutaway view of a nuclear steam-supply system based on a pressurized-water reactor. Note size of man entering door at right.

many millions of gallons of such liquids, steps are now being taken to further concentrate them and reduce them to solids. These solids, although much smaller in volume, are even more intensely radioactive.

The problem of isolating these wastes from man and his environment is made even more severe by the fact that the isolation must be effective for hundreds of years.* Clearly, wastes of this type represent the most difficult pollution

*About 600 years must pass before the strontium 90 and cesium 137 present in these wastes lose enough of their radioactivity to be safe.

problem associated with nuclear power plants.

It now appears that the best place to store these highly radioactive solids is in salt mines. Salt is advantageous because salt formations are dry and impervious to water. They are not associated with usable ground water and, therefore, have no connection to the biosphere. In addition, salt is a very plastic material so that fractures in it seal or close very rapidly. Fortunately, the quantity of the high-level radioactive wastes is relatively small, and there are a number of

salt mines that can be used for storage purposes.

Although siting of any power plant depends to a considerable extent on the amount of cooling water required, the actual land needed varies according to the type of fuel used. Thus, assuming a 3,000-megawatt generating capacity, 900 to 1,200 acres of land are thought to be required for a coal fueled plant. This assumes on-site storage and ash removal. If no on-site coal storage is necessary, the site can be considerably smaller. Within the last few years several coal-fired plants have been located right at the coal mine. While this obviously cuts down on fuel transportation costs and negates any necessity for large fuel storage areas, it is impossible to locate more than a small number of fossil-fired power plants at mine sites.

The amount of land needed for a 3,000-megawatt nuclear power plant is estimated to be somewhere between 200 and 400 acres.

In addition to the problems of cooling water supply, aesthetic and environmental considerations are playing an ever increasing role in the siting of thermal power plants. It turns out that the most economically advantageous sites for such plants are often situated in areas that are also well suited to use for recreation, parks, or as historical sites. People somehow have a natural antipathy to having a power plant—of whatever sort—placed in

the middle of a bathing beach!

Although safety factors influence the siting of both nuclear and fossil-fueled plants, they are much more stringent with respect to the siting of nuclear power plants. Thus, while probabilities of flooding, or seismic activity, are taken into account in locating a fossil-fueled plant, the mere possibility, however remote, that such might occur is often sufficient to prevent the siting of a nuclear power plant in the same location.

It is convenient at this point to note that the Federal government does not directly regulate the construction and operation of fossil-fueled plants. This is somewhat strange when one realizes that the Federal Power Act provides for the licensing of hydroelectric plants and the Atomic Energy Act of 1954 requires that the AEC regulate nuclear power plants through construction permits and operating licenses.

The AEC's licensing authority with respect to nuclear power plant siting is essentially limited to protecting the health and safety of the general public. Rather early in the game a decision was made that the best method of achieving this goal was to keep nuclear reactors isolated as much as possible from the population. Therefore an applicant for a construction permit for such a reactor must identify:

- 1) An *exclusion area*, which is that area surrounding the reactor

in which the reactor licensee must have authority to determine all activities including exclusion or removal of personnel and property from the area.

2) A *low population zone*, immediately surrounding the exclusion area in which the total number of residents and the population density are small enough to provide a reasonable probability that appropriate protective measures could be taken in their behalf in the event of a serious accident.

3) A *population center distance*, which is the distance from the reactor to the nearest boundary of a densely populated center containing more than 25,000 residents.

There is a growing effort, however, to site large power reactors near metropolitan areas. The reasons for this effort are both economic and aesthetic. Metropolitan and urban areas require vast amounts of power. Nuclear power plant sites tend to be much smaller and look nicer than fossil-plant areas. They also do not pollute in the same way. There is some indication that as design criteria, inspection and operation techniques, and safety standards are improved and made more stringent the AEC will tend to relax the rather rigid distance and population exclusion criteria that now exist for the siting of nuclear power plants. Nonetheless, it is highly unlikely that the next few decades will see any large city drawing its power from a cen-

tral nuclear power plant such as has long been envisaged by science fiction.

The primary reason for not siting nuclear power plants within cities is, of course, the fear of nuclear accidents (or as they are more euphemistically known—nuclear excursions). Thus far, however, the safety record of civilian power reactor operations has been quite good. Since the advent of reactors, there have been seven persons killed in nuclear accidents. None of these fatalities were in any way connected with the operation of a nuclear power reactor. Indeed, there is no record of any person outside the confines of a nuclear power plant site receiving more than a permissible level of radiation as a result of an accident within the plant.

This does not mean that potentially serious accidents cannot occur around nuclear power reactors. It does mean that strong measures have been taken to reduce the probability of such accidents and to limit deleterious effects if such an accident should occur.

Nuclear fuels make use of either uranium or plutonium as the fissionable ingredient. Since uranium is presently the more important of the two insofar as power reactors are concerned, some mention of how it becomes a fuel is in order.

Uranium, as it is mined, is composed mostly of a mixture of two isotopes, U-238 and U-235. It is

the U-235 that is naturally fissionable,* but natural uranium contains only 0.71% of it. While natural uranium can be used as a reactor fuel—and has been so used in the French and British nuclear power programs—it is under many circumstances a marginal fuel.

As a consequence, in the United States enriched uranium is the fuel presently used in nuclear power reactors. Uranium is enriched by simply—although it is most certainly not a simple thing to do—increasing the percentage of the fissionable component within. Normally this means increasing the content of U-235, but it can also mean addition of another fissionable material such as U-233** or plutonium, e.g., Pu-239. The fuel used in power reactors generally contains 3 to 4% of U-235, but in certain specialized applications such as nuclear submarine propulsion, the uranium may be enriched to as much as 90% fissionable content. Use of a highly enriched fuel makes for a very compact reactor.

There are numerous advantages to using slightly enriched uranium as a fuel in power reactors. First of all, as inferred above, the size of the reactor is reduced. Secondly, the reactor can be operated longer without requiring replacement of fuel elements. In the reactors now

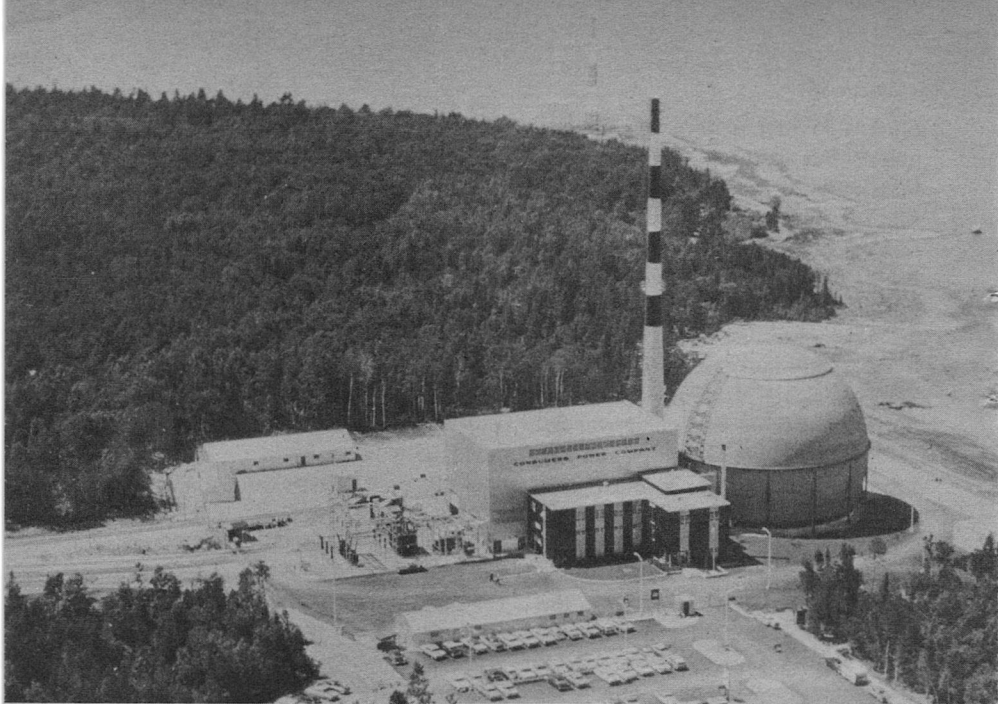
*Although U-238 can be made to fission, this requires neutrons of an energy not readily obtainable in a reactor environment.

**Present only in very small quantities in natural uranium.

in use, fuel replacement is usually necessary after three to four years of operation. Finally, and perhaps most importantly, the design constraints imposed by the use of natural uranium are largely removed. Thus, much wider choices as to coolant, moderator—used to control the velocity of neutrons and hence their ability to induce fissions—control rods, et cetera, can be made.

A distinct disadvantage is that producing even slightly enriched uranium in the quantities that are deemed necessary in the next quarter century is an extremely costly undertaking. It requires an industrial base and a technology such as are currently possessed by only a few countries.

Although uranium is frequently not present as the oxide in its ores, it is nonetheless the custom to express the uranium content of such ores in terms of a mixture of uranium oxides formulated as U_3O_8 . Uranium ores average only about 5 pounds of U_3O_8 per ton of ore. At uranium mills something known as "yellow cake," which usually assays between 70 and 80% U_3O_8 is produced from the ore. This yellow cake is then refined to form essentially pure uranium trioxide (UO_3) which is a bright orange in color. The trioxide is first converted to UO_2 and then to uranium tetrafluoride (UF_4) which is a nice green color. The final step is to convert the UF_4 to the hexafluoride



Consumers Power Company

Although this article has not concerned itself to any great degree with nuclear power plants producing less than 100 megawatts of electricity, there are several of them around. Most represent early efforts in the development of boiling water and pressurized water-power reactors. Shown here is the Big Rock Point nuclear power plant at Charlevoix, on Lake Michigan, at the northwest tip of Michigan's Lower Peninsula. The plant which uses a boiling-water reactor has a generating capacity of 75 MWe.

(UF₆). All these chemical conversions take place at several rather widely disparate locations within the country.

The importance of the UF₆ is that, although it is a solid at room temperature, it sublimates into a gas at slightly higher temperatures and thus becomes the raw material for the gaseous diffusion process for enriching uranium. This process is so complex and difficult to master

in practice that it is the primary reason why so few countries can produce the highly enriched uranium so necessary for either weapons or specialized reactor applications. And yet in theory it appears quite simple.

It depends on the fact that there is a small, but real, mass difference between U-238 and U-235. Because these isotopes behave identically chemically, any separation tech-

nique must rely on physical properties. The mass difference between U-238 and U-235 means that the molecules of gaseous $U^{235}F_6$ tend to travel somewhat faster than molecules of $U^{238}F_6$. If a mixture of the hexafluorides is present in a chamber separated from a lower-pressure chamber by a thin porous membrane, the portion of the gas that diffuses through the membrane will be found to be slightly enriched in U-235.* This result occurs because the $U^{235}F_6$ molecules, moving faster, strike the membrane more frequently and hence have a better statistical chance of finding their way through.

Because the mass difference is slight, the "separation factor" is only 1.0043. This means that many stages must be placed in series to form a "cascade" before any significant enrichment occurs. Because of the number of cascades and amount of auxiliary equipment required, a gaseous diffusion plant is quite literally huge, occupying hundreds of acres. The capital investment is also huge; the three existing U.S. diffusion plants cost \$2.4 billion. An additional \$2 billion is going to be required to expand plant capacity over the next ten to fifteen years.

The standard fuel material for U.S. power reactors is now enriched UO_2 . This material is used

*For maximum efficiency of separation only about half the gas is allowed to diffuse through the membrane in any one stage.

because, at present reactor temperatures, it gives the best combination of chemical and nuclear properties, ease of fabrication, and ability to withstand the effects—i.e., various forms of physical distortion—of irradiation. However, in the newer experimental reactors, which operate at much higher temperatures, uranium and plutonium carbides and also various alloys of uranium and plutonium are being considered as fuels.

It is also conceivable that pure uranium, or plutonium, might be used as well as the nitrides, sulfides, or even phosphides of these metals. The fuel could consist of mixed uranium and plutonium or mixed compounds of these metals. Finally, although unlikely, it could even be in a liquid form—e.g., molten metal, or a slurry.

The UO_2 now used in power reactors is loaded into thin walled tubes of stainless steel or zirconium alloy, called cladding. This cladding protects the fuel from erosion or corrosion by the reactor coolant and also prevents fission products from the fuel from entering the coolant. It may also serve a structural function.

A number of these fuel tubes are arranged in certain geometrical shapes to make up what is commonly known as a fuel element. The geometrical spacing within a fuel element depends on several factors such as the amount of coolant required to pass through the re-

actor and the neutronics—i.e., the manner in which neutrons are produced and interact with the fuel to produce fissions—desired. A fixed spacing of the fuel is essential for the reactor to function properly.

Thus, the core of a light-water reactor consists of fuel elements arranged in a carefully determined pattern, spacers and structural supports, and control rods which can be withdrawn or inserted as desired to control the number of fissions and hence the amount of energy produced by the reactor.

As mentioned earlier, regular light water is used in U.S. nuclear power reactors. There are only two types of light-water reactor—pressurized water and boiling water—currently in use. The essential difference between these two types of reactor is the pressure at which the coolant water circulates through the reactor. In the typical boiling water reactor (BWR), the water moving through the core is kept at a pressure of 1,000 pounds per square inch (psi), whereas in a pressurized water reactor (PWR), the pressure is about 2,250 psi.

The reason for the pressure in either type of reactor is to allow the water to accept more heat from the reactor before vaporizing and changing to steam. In fact, in a PWR the pressure is so high that the water never boils but stays constantly in the liquid state. At standard atmospheric pressure water

boils at 212°F, but the heat content of the resulting steam is so low as to make it worthless for driving a turbine. However, in a BWR operating at 1,000 psi, the steam temperature is about 545°F. At this temperature the steam contains a great deal of energy that can effectively be used to drive a generating turbine.

In a PWR the water passing through the reactor does not boil and hence cannot be used directly to drive a turbine. Instead it is made to circulate through an essentially closed loop from the reactor to a heat exchanger and back to the reactor. The water leaving the core of the PWR has a temperature of about 600°F. As it circulates through the heat exchanger it heats other water destined for the turbines but maintained at much lower pressure. As a result steam is produced with a temperature of about 500°F. This steam is used to drive the turbines.

Thus in a PWR two separate water systems are needed to produce power. The net result of this, however, is that the reactor vessel for a PWR system is considerably smaller than that required for a BWR system. In a 800 MWe nuclear power plant deriving its energy from a BWR, the reactor vessel must be about 70 feet high and 20 feet in diameter. A PWR plant with the same generating capacity requires a reactor vessel only about 40 feet high by 16 feet in

diameter. But the overall size of the plants are similar due to the additional components—e.g., the heat exchanger—required for a PWR.

There is nothing that inherently requires water to be used as the heat transfer agent from a power reactor. The working fluid can just as well be a gas such as helium or carbon dioxide. The nuclear power program of Great Britain, which is quite advanced, is based on the use of gas-cooled reactors in which the working fluid is CO_2 . These reactors are similar to PWR systems in that the CO_2 is circulated from the reactor in a closed loop to a heat exchanger where steam is generated to run the turbines.

Gas-cooled reactors operate at much higher temperatures than the light-water reactors. In some, the gas is heated to almost $1,400^\circ\text{F}$, and in one experimental reactor at the Los Alamos Scientific Laboratory, the operating temperature is $2,400^\circ\text{F}$. Using gas-cooled reactors, steam as hot as about $1,000^\circ\text{F}$ can be produced. This makes for an efficient turbine operation.

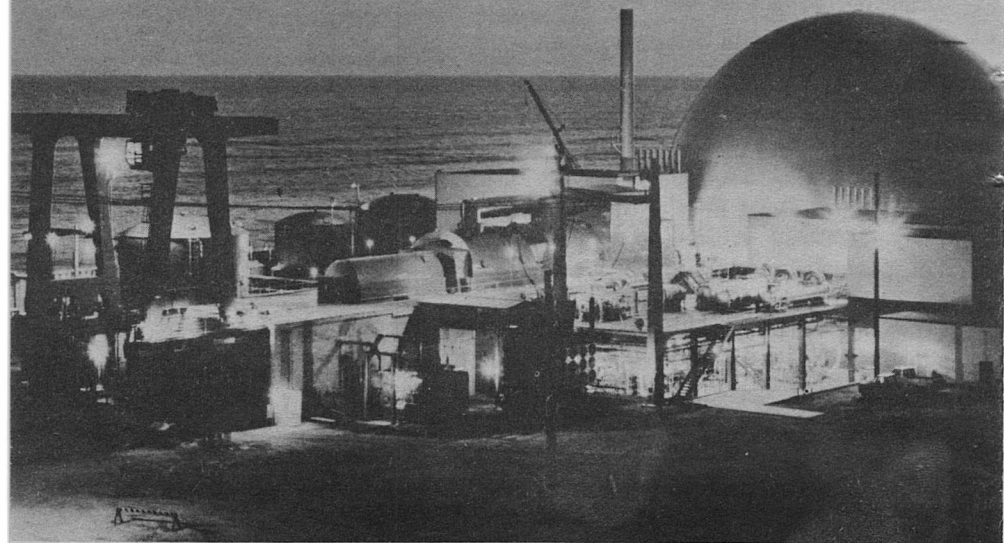
Unfortunately, the thermal conductivity of a gas is not very good so that the reactor size is rather large in comparison to the light-water reactors. In addition, a moderating material is required in the core to slow the neutrons to an energy more suitable for inducing fissions. The material usually used is graphite. No moderator is required in light-water reactors be-

cause the water itself, as it circulates through the reactor, effectively moderates the neutrons.

Although U.S. emphasis has been on light-water reactors, one high temperature gas-cooled power reactor is currently under construction in Colorado. The power plant using this reactor is designed to generate 330 MWe. This generating capacity is relatively low insofar as the newer nuclear power plants are concerned. However, the primary purpose of the plant is to demonstrate the viability of using gas-cooled reactors for power production on a significant scale. A prototype HTGR producing 40 MWe has been in commercial operation in Pennsylvania since 1967.

The U.S. HTGR's vary from their European counterparts in that helium rather than CO_2 is used as the coolant. The fuel is thorium and highly enriched uranium dicarbide particles interspersed in a graphite matrix. (The reason for the presence of the thorium will become clearer later in this article.) While the dicarbides presently are favored, it also appears feasible to use thorium and uranium dioxides in these reactors.

It is possible to fuel gas-cooled reactors with natural rather than enriched uranium. Indeed, both France and Great Britain have a number of power reactors of this type. Generally speaking, however, the efficiency of a natural uranium



Southern California Edison Company

This is the 429 MWe San Onofre nuclear power plant at Camp Pendleton, California. The pressurized water reactor is located under the hemispherical vapor containment shell. In the background is the Pacific Ocean.

fueled reactor is somewhat less than that of one using enriched uranium.

Still another type of power reactor in which natural uranium can be used is the so-called heavy water reactor. This reactor uses heavy water—deuterium oxide—as a moderator, much in the same manner as graphite is used in a gas-cooled reactor. The heavy water can be used both as a moderator and as a coolant; and the Canadians have designed a power reac-

tor of this type. But because heavy water is very expensive, the trend appears to be toward the use of light water, or organic compounds, as coolants.

Within the United States there is no active support for a heavy-water reactor using light water as the coolant, although the British, Italians, and Canadians have all built prototypes of this kind of reactor. Here organic coolants are regarded more favorably. They can operate at higher temperatures and lower

pressures and also permit a wider choice as to fuel materials. A mixture of ortho- and metaterphenyls is presently the preferred organic coolant.

The core of a heavy-water reactor is immersed, naturally enough, in a tank of heavy water, but the fuel elements are not actually in contact with the water. Rather they are in tubes running through the tank. The coolant—whatever it may be—is circulated through these tubes and by the fuel elements. Temperatures within a heavy-water reactor depend on the type of coolant used, but steam hotter than 700°F can be produced.

Although U-235 packs a very large amount of energy into a very small mass, there is simply not very much of it around. Indeed, it is possible that if the nuclear power plants destined to be built within the next several decades were to rely on U-235 exclusively as the fissile material in their fuel the supply of U-235 would be exhausted long before we actually deplete all of our reserves of fossil fuels. The dependency on U-235 becomes even more pronounced with the increasing likelihood that fossil fuels will be more and more used as a source of chemical raw materials rather than of energy.

If U-235 were the only fissile material available for use as a reactor fuel, the U.S.—and Russia for that matter—would be spending one heck of a lot more for CTR

research than is even contemplated now. But it is not. There are three other fissile isotopes which can effectively be used to fuel nuclear reactors, namely, U-233, Pu-239, and Pu-241. None of these occur in nature except in very minute quantities, but they can be made—and therein lies the future of nuclear power.

Consider a pressurized water reactor fueled with slightly enriched uranium. Most of the uranium consists of U-238. When U-235 fissions, on the average between two and three neutrons are produced per fission.* Several things can happen to these neutrons. Perhaps the worst from the reactor designer's point of view is that they can escape from the reactor entirely. A certain percentage will be absorbed by the structural material and coolant. Still more will be absorbed by the control rods; that's what they are there for. Hopefully enough will strike additional U-235 atoms to cause the chain reaction to continue efficiently. If not, the reactor will cease to function rather rapidly.

But there is yet something else that can happen to some of these neutrons—they can be absorbed by the U-238 present in the fuel. Technically, they can even cause the U-238 to fission, but as a prac-

*As few as none can be produced and in rare instances more than four can result from a single fission.

tical matter this does not happen except in rare instances.

The reason is as follows. Neutrons produced by the fissioning of U-235 nuclei are fast, that is, they have energies in excess of 1 MeV.* These fast neutrons are perfectly capable of causing U-238 to fission. They almost never do this, however, because there is a greater likelihood that instead they will merely collide inelastically with the U-238 nuclei and bounce off. In so doing, they lose energy. Through many such collisions, their energy level is very rapidly reduced below 1 MeV where they can no longer cause any significant number of fissions in U-238.

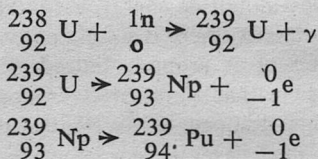
As a matter of fact, the neutron energy is quickly reduced to a point where the neutrons move so slowly that they come to have the same average energy as that of the atoms of the medium through which they are moving and colliding. Since the energy of these atoms is dependent on their temperature, it is not surprising that neutrons having an equivalent energy have come to be known as thermal neutrons.

It turns out that the chances of a thermal neutron causing fission in U-235 are much better than those of more energetic neutrons, even though neutrons of any and all energies can fission this isotope. This is the basic reason why mod-

erators are necessary for reactors fueled with natural, or slightly enriched, uranium. The moderator slows down or thermalizes the neutrons to the point where U-235 fissioning is greatly enhanced.

As neutrons approach the thermal energy region, however, they also become susceptible to capture by the U-238 nuclei. The probability that this will occur is not great but neither is it very remote. Over a sufficient length of time a small but significant number of captures do occur.

When a neutron is absorbed by a U-238 nucleus a physicist describes the resulting sequence of events as follows:



Although this looks like so much Greek, there is only one Greek letter in there and it represents the emission of gamma rays. Otherwise, all that are shown are nuclei, a neutron, and several electrons. This is actually the physicist's shorthand which tells him immediately what has occurred. You, too, can read it rather simply.

The first equation states that uranium, which has an atomic number of 92 and a mass of 238, absorbs a neutron, which has a mass of one but no atomic number,

*One MeV means one million electron volts.

to form a new isotope of uranium with mass 239. Gamma rays are also given off. This isotope is unstable, however, and decays by giving off an electron to form an isotope of a new element, neptunium, which has an atomic number of 93 and a mass of 239.

The way the electron is designated is of interest. While it obviously does not have a zero mass, its mass is very small in comparison to that of neutrons and protons, each of which has essentially unit mass. So for purposes of nomenclature it is designated as having no mass because, in relation to everything else, this is nearly true. But how can something have a negative atomic number? Easy. Think of the atomic number as the number of protons—which it is—that is, the number of positively charged particles, in the nucleus. Since an electron is, electrically at least, the opposite of a proton, it can figuratively be taken as the absence of a proton. Therefore, again for purposes of nomenclature, it is convenient to designate an electron as having an atomic number of -1 .

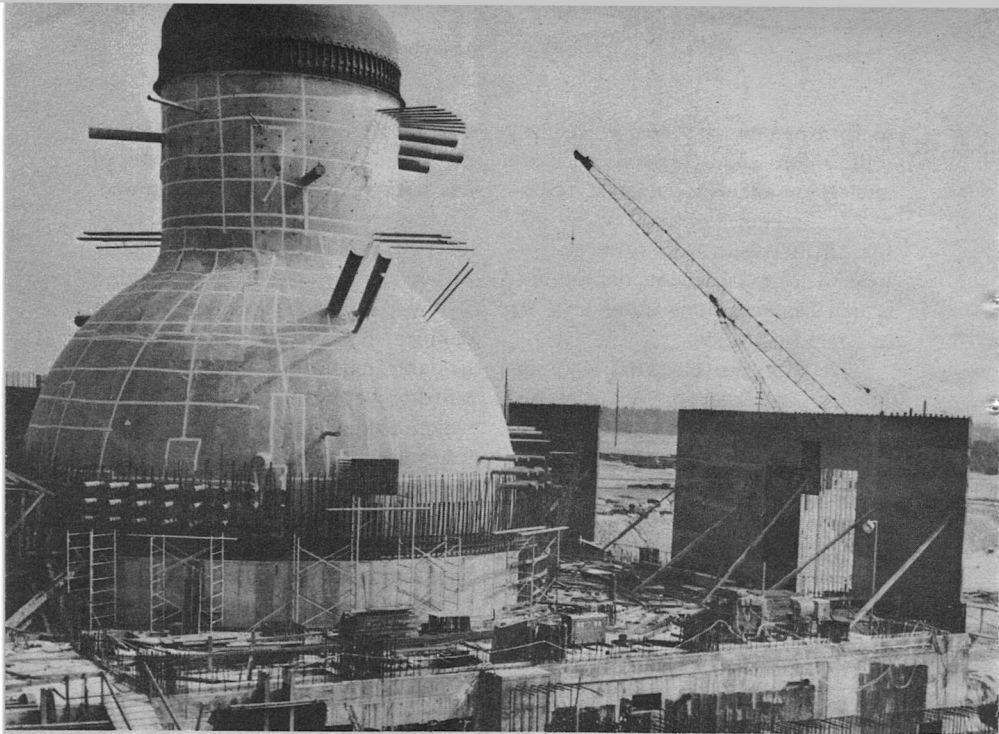
But to get back to the primary message carried by the shorthand. The neptunium is also unstable and emits an electron to form yet another element, namely, plutonium. The nice thing about this isotope, Pu-239, is that it is one of those fissile materials mentioned earlier as being useful as a fuel in a nuclear

reactor. What has happened is that an essentially nonfissile material has been converted to a fissile one. To be sure, there were several steps in the process, but they occur rather rapidly, taking place within a few days of the initial neutron capture. The Pu-239 formed is also unstable, but it has a much longer half-life—almost 25,000 years—which means that it sticks around long enough to be useful.

Remember now that this sequence of events took place in a pressurized-water reactor. Remember, too, that several years pass before the fuel elements of this type of reactor are reprocessed. Consequently, a fair amount of Pu-239 can be formed. When the spent fuel is reprocessed, it is this Pu-239—as well as remaining U-235—and certain other valuable isotopes—that is sought to be recovered.

Pressurized and boiling water reactors are known as converters, because they convert a portion of the nonfissile U-238 into fissile Pu-239. These reactors are not particularly designed to do this; it is rather more of a fortunate happenstance that it occurs. The conversion ratio, i.e., number of fissile atoms produced versus number of fissile atoms consumed, for a converter is of the order of 0.5 to 0.75.

Ordinary converters use significantly more fuel than they produce. It is possible, however, to design a converter such that the conversion ratio is much improved.



General Electric Company

In the event that the pressure vessel of a nuclear power reactor is somehow breached, AEC safety regulations require that vessel be enclosed in a structure that will effectively contain any radioactive vapor or particulate matter that might be released. Shown under construction is the vapor containment shell for the 640 MWe boiling water reactor for the Oyster Creek No. 1 nuclear power plant in New Jersey. The plant went into operation in 1969.

These so-called advanced converters have conversion ratios in the range of 0.75 to 1.0. The HTGR is an advanced converter as is the heavy water moderated, organic-cooled reactor. Various types of fuels are possible, including slightly enriched uranium carbide, natural uranium carbide, natural uranium metal, thorium-uranium oxide, and thorium-uranium metal.

Although research into advanced

converters continues, it now appears likely that the next generation of U.S. power reactors will be of the fast breeder variety. A breeder reactor produces more fissile material than it consumes. The conversion ratio can vary from 1.0 to as high as 1.4. It is readily apparent that breeder reactors greatly enlarge the amount of fuel available for reactors because they transform large quantities of heretofore

unusable U-238 into fuel. While theoretically 100% of all fertile material—i.e., U-238—could be transformed into fissile material by means of such reactors, a practical upper limit would seem to be around 80%. This limit is set by the fact that there are inevitably some losses during reprocessing of fuel.

While many types of breeder reactor can be envisaged, and a number of prototypes have been constructed, a decision has been made to have the AEC concentrate its developmental work on only one. The design given priority is the liquid metal fast breeder reactor (LMFBR).

The coolant selected for the LMFBR is liquid sodium. At first glance the choice may seem rather startling. If irradiated heavily, sodium becomes intensely radioactive. Also anyone who has taken high school chemistry knows that sodium reacts violently with water. Since steam is required to run the generating turbines, obviously at some point in a heat exchanger liquid sodium and water are going to be in close proximity. Should there be a leak of some kind so that these two come into contact, it is not difficult to visualize an explosive loss of sodium coolant from the reactor. This in turn could result in a possibly serious nuclear accident as the reactor rapidly heats up because of loss of coolant.

To greatly reduce the probability of this particular type of accident ever occurring, an intermediate heat transfer loop is incorporated into the system. Thus, the sodium coolant from the reactor transfers heat to the sodium in an intermediate loop which in turn transfers it to the water system. Hopefully, any problem resulting from sodium-water reaction would be confined to the intermediate loop and would not directly affect the primary coolant loop circulating sodium through the reactor. Since sodium has a large heat capacity, that is, ability to absorb heat, it would be possible to shut down the reactor without damage if the intermediate loop is put out of operation but the primary loop remains intact. This should also be possible if there is a relatively slow loss of sodium from the primary coolant loop.

In addition to high heat capacity, sodium has certain other advantageous characteristics. Its nuclear properties are such that it does not have advance effects on the breeding of new fuel. It has a high boiling point—1637°F—so that high-temperature operation is possible without high pressures.* No heavy pressure vessels are required. It also has excellent heat transfer characteristics, i.e., it can remove a great quantity of heat

*The light water reactors operate at coolant pressures of 1,000 psi and higher. This necessitates the use of reactor-pressure vessels with walls many inches thick.

from a reactor very efficiently. The advantage of this is that the reactor can be run at a much higher power density. One way of defining higher power density is to say that more fissions can occur within a limited area. More fissions produce more neutrons which in turn means better breeding. More fissions also mean more heat, which is why efficient heat transfer is so important. These are the chief reasons why sodium now appears to be the best available coolant for a fast breeder.

Nonetheless, there are those who are convinced that liquid sodium simply presents too many problems for use in a reactor. Great Britain has begun a breeder program based on the use of gas-cooled reactors. This approach is a natural one for the British since they have the most extensive operating experience with gas-cooled reactors.

But if the difficulties of using sodium are great, so are the advantages. The U.S. is now preparing to spend perhaps two billion dollars to overcome the difficulties and exploit the advantages. It will be 1980 before we know how successful the attempt has been.

The four fissile isotopes, U-233, U-235, Pu-239, and Pu-241, all produce more neutrons than are needed to maintain a chain reaction in power reactors, but only U-233, Pu-239, and Pu-241 produce sufficient neutrons so that in a practical power reactor more fissionable

material can be produced than is consumed. This means that U-235—the fuel of today's power reactors—will not be used in the breeders that are being developed.

Because the plutonium isotopes produce the most excess neutrons in a fast breeder reactor, cycles using U-238 as the fertile material and mixtures of Pu-239 and Pu-241 as the fissile material form the basis of the LMFBR program. It might well be asked where the Pu-241 comes from. The fact of the matter is that Pu-239, while fissile, is also fertile. In other words, a certain number of neutron interactions with Pu-239 produce absorptions rather than fissions. The resulting Pu-240 is fertile and can also absorb a neutron. If this happens Pu-241 is produced, and we are once again back to a fissile isotope. Because of the large amount of Pu-239 which comes to be present in the fuel elements and the surrounding U-238 blanket of a breeder reactor, Pu-241 can be produced in fairly significant amounts.

The LMFBR is a "fast" breeder. This means merely that the neutrons produced have a high kinetic energy and do not readily lose it. There can be other kinds of breeder reactor, however. It is also possible, for example, to have a thermal breeder operating on the thorium-uranium cycle.

Recall that thorium was mentioned earlier in this article as a

constituent of the fuel for the HTGR. The thorium isotope Th-232 is a fertile material like U-238. It can absorb a neutron to form Th-233. This isotope has a half-life of 23.5 minutes and decays by giving off an electron to form an isotope of protactinium. This, too, is unstable with a 27.4 day half-life. It decays by emitting another electron to form the fissile U-233. The neutron capture by thorium occurs most efficiently with thermal or slow neutrons. This is why breeding of U-233 is done in so-called thermal reactors or in advanced converters such as the HTGR. At present there is no big push to produce large quantities of U-233, but thorium does represent an alternative source of fertile material should the supply of U-238 ever be largely exhausted.

So much for the breeders. It is time now to summarize.

For the next decade it appears that most of the new nuclear power plants constructed in the United States will make use of either pressurized, or boiling water, reactors. Sometime around 1980 the fast breeder should arrive on the scene. In this country that means use of liquid sodium as it has never been used before. While light water reactors will see considerable use around the world, Europe in particular will tend to emphasize construction of gas-cooled reactors. Outside the United States and perhaps Russia

natural uranium will continue to be used as a fuel in many power reactors. However, this could rapidly change if (1) a cheaper method of enriching uranium is found, or (2) the United States makes available large quantities of enriched uranium for foreign reactor use.

We in the United States tend to think of ourselves as the leaders in developing nuclear power. We think of this as being obviously true because we just naturally do things first and on a greater scale than just about anyone else. Not so in this case. In 1969 Great Britain produced 60% of the world's nuclear power. It would seem that—in relation to its size and power requirements—Britain is far ahead of us in its use of nuclear power.

This does not mean that there are that many nuclear power plants in existence. At the end of 1969 the International Atomic Energy Agency stated that it was aware of about 105 power reactors within its jurisdiction. Since this jurisdiction covers most of the noncommunist world, this statement can be taken as fairly conclusive as to the number of such reactors in that part of the world. If we add the communist world, it is probably safe to say that only about 125 power reactors were in operation at the start of 1970.

Within the United States the end of the '60s saw only nine completed nuclear power plants with a generating capacity in excess of

100 MWe. The largest, located in Illinois, has a capacity of 809 MWe. It is a BWR plant. The largest PWR plant now operating is capable of generating 562 MWe.

But things are destined to change in a hurry. It is estimated that between now and 1990 utilities in eleven northeastern states must build about four times as much electrical generating capacity as they have provided thus far in their 80-year history. By 1980 nuclear power will account for about 60% of the total generation in the Northeast. This will increase to more than 80% by 1990.

Reasons for the choice of nuclear power—particularly in the New England-New York areas—are the low fuel cost, the low fuel transportation cost, and the virtual absence of atmospheric pollutants.

Within the United States as a whole the AEC estimates that about 150,000 MWe of nuclear generating capacity will be installed by the end of 1980. Within the rest of the "free world" another 140,000 MWe of generating capacity will have been installed by that same year.

The President's Office of Science and Technology believes that by 1990 there will be a need for 164 U.S. nuclear power plants with generating capacities of 500 MWe or larger. The majority of these new plants are thought to be required in the 1,000 to 4,000 MWe range, with a significant number

bigger than 3,000 MWe. The largest should closely approach a generating capacity of 10,000 MWe.

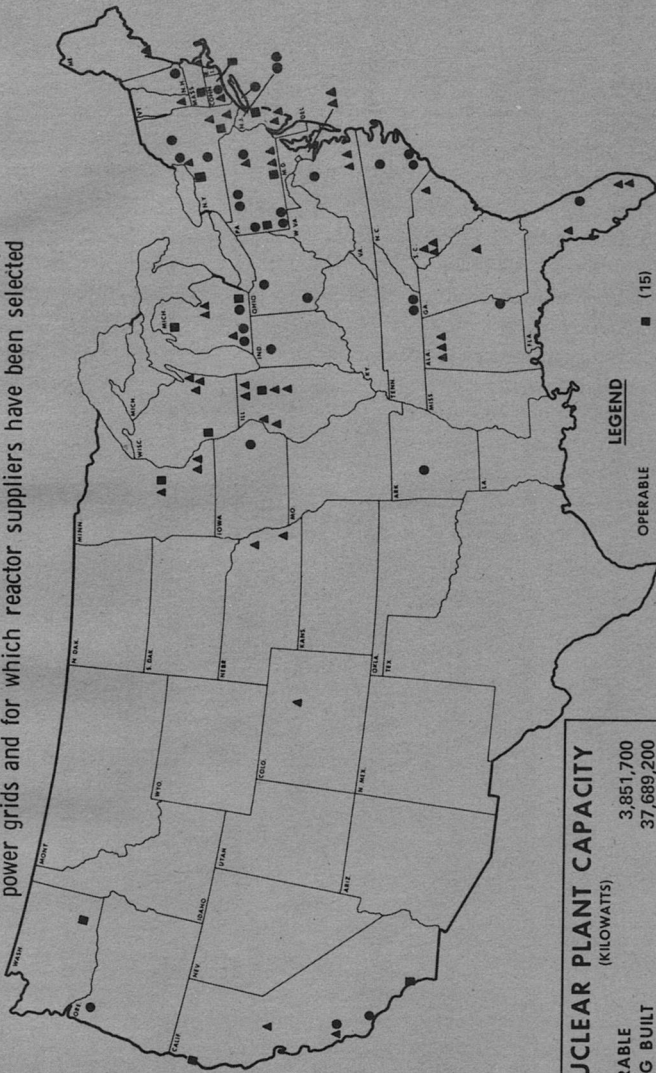
One obvious reason for going to much larger nuclear power plants is the "economy of scale" factor, that is, the decrease in unit electrical cost with increasing plant size. Presently a light-water reactor power plant of about 1,000 MWe generating capacity coming on line in 1973 has a capital cost about 30 to 50% higher than that of a comparable fossil fueled plant coming on line at the same time.

Nonetheless, numerous new nuclear power plants with capacities in the vicinity of 1,000 MWe are in the works. As of December 15, 1969, fifty-six new nuclear power plants, or additions to existing ones, were under construction, or on order. Many of the new plants will have more than one power reactor; at least one will have five. The largest power reactor now on order, for the Tennessee Valley Authority, will have a generating capacity of 1,175 MWe, while the smallest, the HTGR in Colorado, will generate 330 MWe.

We are still essentially in the first generation of nuclear-power reactors. Already, however, it is apparent that it is no longer a question of whether reactors should be used for the generation of electrical power, but rather one of to what extent we should—perhaps even can—control the nuclear power plant. ■

NUCLEAR POWER PLANTS IN THE UNITED STATES

The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected



NUCLEAR PLANT CAPACITY (KILOWATTS)	
OPERABLE	3,851,700
BEING BUILT	37,689,200
PLANNED	28,375,000
REACTORS ORDERED	8,455,000
REACTORS NOT ORDERED	8,455,000
TOTAL	78,370,900
ELECTRIC UTILITY CAPACITY BY CONVENTIONAL MEANS AS OF AS OF JUNE 30, 1969: 321,153,088 KILOWATTS	

LEGEND
 ■ (15) OPERABLE
 ▲ (48) BEING BUILT
 ● (32) *PLANNED (Reactors Ordered)

*9 more plants have been announced for which reactors have not yet been ordered.

TABLE II. NUCLEAR POWER PLANTS IN THE U.S.*

<i>Plant Name</i>	<i>Owner</i>	<i>Location</i>	<i>Startup Year</i>	<i>Reactor Type</i>	<i>Reactor Capacity (MWe)</i>
COMPLETED					
Dresden No 2	Commonwealth Edison	Morris, Ill.	1969	BWR	809
Oyster Creek No. 1	Jersey Central Power & Light	Toms River, N.J.	1969	BWR	640
Nine Mile Point	Niagara Mohawk Power	Oswego, N.Y.	1969	BWR	600
Connecticut Yankee	Connecticut Yankee Atomic Power	Haddam Neck, Conn.	1967	PWR	562
Robert E. Ginna	Rochester G. & E.	Rochester, N.Y.	1969	PWR	470
San Onofre	Southern California Edison —San Diego Gas & Electric	Camp Pendleton, Cal.	1967	PWR	429
Dresden No. 1	Commonwealth Edison	Morris, Ill.	1959	BWR	200
Indian Point No. 1	Consolidated Edison	Buchanan, N.Y.	1962	PWR	270 including oil-fired superheat
Yankee	Yankee Atomic Electric	Rowe, Mass.	1960	PWR	175
UNDER CONSTRUCTION OR ON ORDER					
Sequoyah Nos. 1,2	Tennessee Valley Authority	Daisy, Tenn.	1973, 1974	PWR	1175 each
Diablo Canyon No. 2	Pacific Gas & Electric	Diablo Canyon, Cal.	1974	PWR	1156
Enrico Fermi No. 2	Detroit Edison	Lagoona Beach, Mich.	1974	BWR	1127
Browns Ferry Nos. 1,2,3	Tennessee Valley Authority	Decatur, Ala.	1971, 1972	BWR	1118 each

Two units (unnamed)	N.J. Public Service Electric & Gas	Newbold Island, N.J.	1975, 1977	BWR	1115 each
Nuclear Units 4,5	Consolidated Edison	Verplanck, N.Y.	1976, 1978	BWR	1115 each
Salem No. 2	Public Service Electric & Gas (with Philadelphia Electric, Atlantic City Gas & Electric and Delmarva)	Salem, N.J.	1973	PWR	1112
Trojan	Portland General Electric	Rainier, Ore.	1974	PWR	1106
Oyster Creek No. 2	Jersey Central Power & Light	Toms River, N.J.	1976	PWR	1100
Two units (unnamed)	Duke Power	South Carolina	1977	PWR	1100 each
Two units (unnamed)	Philadelphia Electric	Not announced	1975, 1977	BWR	1100 each
Zion Nos. 1,2	Commonwealth Edison	Zion, Ill.	1972, 1973	PWR	1100 each
Donald C. Cook Nos. 1,2	Indiana & Michigan Electric	Bridgman, Mich.	1972, 1973	PWR	1100 each
Salem No. 1	Public Service Electric & Gas (with Philadelphia Electric, Atlantic City Gas & Electric and Delmarva)	Salem, N.J.	1972	PWR	1090
Peach Bottom Nos. 2,3	Philadelphia Electric (with Public Service Electric & Gas, Atlantic City Gas & Electric and Delmarva)	Peach Bottom, Pa.	1971, 1973	BWR	1065 each
Diablo Canyon No. 1	Pacific Gas & Electric	Diablo Canyon, Cal.	1972	PWR	1060
Indian Point Nos. 2,3	Consolidated Edison	Buchanan, N.Y.	1971, 1973	PWR	1033 each
North Anna Nos. 1,2	Virginia Electric & Power	Mineral, Va.	1974, 1975-6	PWR	927
Three Mile Island No. 2	Jersey Central Power & Light	Gouldsboro, Pa.	1973	PWR	900
Oconee Nos. 1,2,3	Duke Power	Seneca, S.C.	1971, 1972, 1973	PWR	874 each

TABLE II. NUCLEAR POWER PLANTS IN THE U.S.*

<i>Plant Name</i>	<i>Owner</i>	<i>Location</i>	<i>Startup Year</i>	<i>Reactor Type</i>	<i>Reactor Capacity (MWe)</i>
Davis-Besse	Toledo Edison, Cleveland Electric Illuminating Consumers Power	Oak Harbor, Ohio	1974	PWR	872
Midland No. 2	Florida Power & Light	Midland, Mich.	1975	PWR	855
Hutchinson Island	Arkansas Power & Light	Ft. Pierce, Fla.	1973	PWR	850
Arkansas Nuclear One	Florida Power	London, Ark.	1972	PWR	850
Crystal River	Duquesne Light	Red Level, Fla.	1972	PWR	850
Beaver Valley	Cincinnati Gas & Electric	Shippingport, Pa.	1973	PWR	847
William H. Zimmer	Metropolitan Edison	Claremont County, Ohio	1975	BWR	840
Three Mile Island No. 1	Northeast Utilities	Gouldsboro, Pa.	1971	PWR	830
Millstone Point No. 2	Alabama Power	Waterford, Conn.	1974	PWR	830
Joseph M. Farley No. 1	New York State Power Authority, Niagara Mohawk Power	Houston County, Ala.	1975	PWR	829
James A. FitzPatrick		Scriba, N.Y.	1973	BWR	825
Maine Yankee	Maine Yankee Atomic Power	Wiscasset, Me.	1972	PWR	823
Brunswick Nos. 1, 2	Carolina Power & Light	Southport, N.C.	1974, 1976	BWR	821 each
Unnamed	Carolina Power & Light	No site announced	Unknown	BWR	821
Palisades	Consumers Power (Mich.)	South Haven, Mich.	1970	PWR	821
Shoreham	Long Island Lighting	Shoreham, N.Y.	1975	BWR	820
Dresden Nos. 2, 3	Commonwealth Edison	Morris, Ill.	1970	BWR	809 each
Quad-Cities Nos. 1, 2	Commonwealth Edison, Iowa-Illinois Gas & Electric	Cordova, Ill.	1971, 1972	BWR	809 each

Surry Nos. 1,2	Virginia Electric & Power	Gravel Neck, Va.	1971, 1972	PWR	800 each
Rancho Seco	Sacramento Municipal Utility District	Clay Station, Cal.	1973	PWR	800
Cooper	Consumers Public Power District	Brownsville, Neb.	1972	BWR	800
Calvert Cliffs Nos. 1,2	Baltimore Gas & Electric	Lusby, Md.	1973, 1974	PWR	800 each
Edwin I. Hatch	Georgia Power	Baxley, Ga.	1973	BWR	786
Turkey Point Nos. 3,4	Florida Power & Light	Turkey Pt., Fla.	1970, 1971	PWR	721 each
H.B. Robinson No. 2	Carolina Power & Light	Hartsville, S.C.	1970	PWR	700
Pilgrim	Boston Edison	Plymouth, Mass.	1971	BWR	687
Millstone Point No. 1	Northeast Utilities	Waterford, Conn.	1970	BWR	650
Duane Arnold	Iowa Electric Light & Power	Cedar Rapids, Iowa	1973	BWR	550
Kewaunee	Wisconsin Public Service, Wisconsin Power & Light, Madison Gas & Electric	Carlton, Wis.	1972	PWR	550
Prairie Island Nos. 1,2	Northern States Power	Red Wing, Minn.	1972, 1974	PWR	550 each
Monticello	Northern States Power	Monticello, Minn.	1970	BWR	545
Vermont Yankee	Vermont Yankee Nuclear Power	Vernon, Vt.	1971	BWR	540
Midland No. 1	Consumers Power (Mich.)	Midland, Mich.	1974	PWR	527
Point Beach Nos. 1,2	Wisconsin Electric Power, Wisconsin Michigan Power	Two Creeks, Wis.	1970, 1971	PWR	497 each
Fort Calhoun	Omaha Public Power District	Ft. Calhoun, Neb.	1971	PWR	475
Fort St. Vrain	Public Service of Colorado	Platteville, Colo.	1972	HTGR	330

* Data provided by Atomic Industrial Forum. Covers all plants ordered as of December 15, 1969. Excludes the large N Reactor plant at Hanford, Washington, which is owned by the AEC and produces 776 MWe of power. The primary purpose of this reactor is the production of plutonium.



THE WANDERING BUOY

Actions—even enormously sophisticated actions—do not reveal the motivation that led to them.

And even actions can be hair-raisingly mysterious.

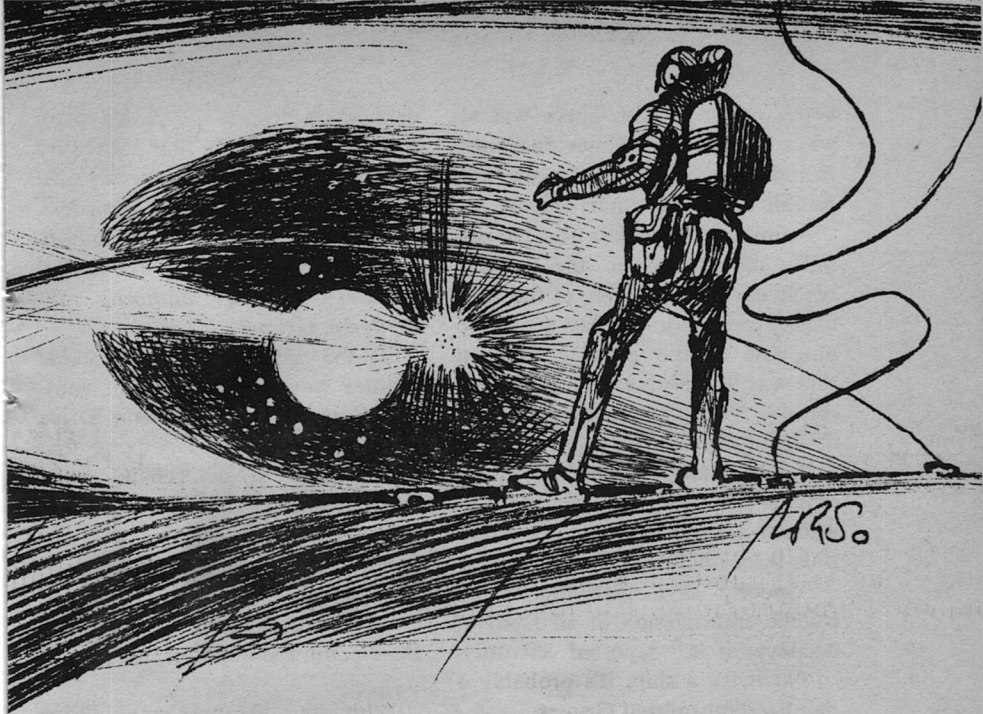
A. BERTRAM CHANDLER

Illustrated by Leo Summers

It really shouldn't have been there.

Nothing at all should have been there, save for the sparse drift of hydrogen atoms that did nothing at all to mitigate the hard vacuum of interstellar space, and save for the Courier *Adder*, proceeding on her lawful occasions.

It shouldn't have been there, but



it was, and Grimes and his officers were pleased, rather than otherwise, that something had happened to break the monotony of the long voyage.

"A definite contact, Captain," said von Tannenbaum, peering into the spherical screen of the mass proximity indicator.

"Hm-m-m . . ." grunted Captain Grimes. Then, to the electronic

communications officer, "You're quite sure that there's no traffic around, Sparks?"

"Quite sure, Captain," replied Slootny. "Nothing within a thousand light-years."

"Then get Spooky on the intercom, and ask him if *he's* been in touch with anybody . . . or anything."

"Very good, Captain," said Slo

votny rather sulkily. There was always rivalry, sometimes far from friendly, between electronic and psionic communications officers.

Grimes looked over the navigator's shoulder into the velvety blackness of the screen, at the tiny, blue-green spark that lay a little to one side of the glowing filament that was the ship's extrapolated trajectory. Von Tannenbaum had set up the range and bearing markers and was quietly reading aloud the figures. He said, "At our present velocity we shall be up to it in just over three hours."

"Spooky says that there's no psionic transmission at all from it, whatever it is," reported Slovtny.

"So if it's a ship, it's probably a derelict," murmured Grimes.

"Salvage . . ." muttered Beadle, looking almost happy.

"You've a low, commercial mind, Number One," Grimes told him. *As I have myself*, he thought. The captain's share of a fat salvage award would make a very nice addition to his far from generous pay. "Oh, well, since you've raised the point you can check towing gear, spacesuits and all the rest of it. And you, Sparks, can raise Lindisfarne Base on the Carlotti. I'll have the preliminary report ready in a couple of seconds . . ." He added, speaking as much to himself as to the others, "I suppose I'd better ask permission to deviate, although the galaxy won't grind to a halt if a dozen bags of mail are

delayed in transit . . ." He took the message pad that Slovtny handed him and wrote swiftly, *To Officer Commanding Couriers. Sighted unidentified object coordinates A1763.5 x ZU97.75 x J222.0 approx. Request authority investigate. Grimes.*

By the time that the reply came Grimes was on the point of shutting down his Mannschenn Drive and initiating the maneuvers that would match trajectory and speed with the drifting object.

It read, *Authority granted, but please try to keep your nose clean for a change. Damien.*

"Well, Captain, we can *try*," said Beadle, not too hopefully.

With the Mannschenn Drive shut down radar, which gave far more accurate readings than the mass proximity indicator, was operable. Von Tannenbaum was able to determine the elements of the object's trajectory relative to that of the ship, and after this had been done the task of closing it was easy.

At first it was no more than a brightening blip in the screen and then, at last, it could be seen visually as *Adder's* probing searchlight caught it and held it. To begin with it was no more than just another star among the stars, but as the ship gained on it an appreciable disk was visible through the binoculars, and then with the naked eye.

Grimes studied it carefully through his powerful glasses. It was spherical, and appeared to be metallic. There were no projections on it anywhere, although there were markings that looked like painted letters or numerals. It was rotating slowly.

"It could be a mine . . ." said Beadle, who was standing with Grimes at the viewport.

"It could be . . ." agreed Grimes. "And it could be fitted with some sort of proximity fuse . . ." He turned to address von Tannenbaum. "You'd better maintain our present distance off, Pilot, until we know better what it is." He stared out through the port again. Space mines are a defensive rather than offensive weapon, and *Adder* carried six of the things in her own magazine. They are a dreadfully effective weapon when the conditions for their use are ideal—which they rarely are. Dropped from a vessel being pursued by an enemy they are an excellent deterrent—provided that the pursuer is not proceeding under interstellar drive. Unless there is temporal synchronization there can be no physical contact.

Out here, thought Grimes, in a region of space where some sort of interstellar drive *must* be used, a mine just didn't make sense. On the other hand, it never hurt to be careful. He recalled the words of one of the instructors at the Academy. "There are old space-

men, and there are bold spacemen, but there aren't any old, bold spacemen."

"A sounding rocket . . ." he said.

"All ready, Captain," replied Beadle.

"Thank you, Number One. After you launch it, maintain full control throughout its flight. Bring it to the buoy, or the mine, or whatever it is, *very* gently—I don't want you punching holes in it. Circle the target a few times, if you can manage it, and then make careful contact." He paused. "Meanwhile, restart the Mannschenn Drive, but run it in neutral gear. If there *is* a big bang we might be able to start precessing before the shrapnel hits us." He paused again, then, "Have any of you gentlemen any bright ideas?"

"It might be an idea," contributed Slovtny, "to clear away the laser cannon. Just in case."

"Do so, Sparks. And you, Number One, don't launch your rocket until I give the word."

"Cannon trained on the target," announced Slovtny after only a few seconds.

"Good. All right, Number One. Now you can practice rocketship handling."

Beadle returned to the viewport, with binoculars strapped to his eyes and a portable control box in his hands. He pressed a button, and almost at once the sounding rocket swam into the field of view, a sleek, fishlike shape with a pale glimmer

of fire at its tail, a ring of bright red lights mounted around its mid-section to keep it visible at all times to the aimer. Slowly it drew away from the ship, heading towards the enigmatic ball that hung in the blaze of the searchlight. It veered to one side to pass the target at a respectable distance, circled it, went into orbit about it, a minuscule satellite about a tiny primary.

Grimes started to get impatient. He had learned that one of the hardest parts of a captain's job is to refrain from interfering—even so . . . “Number One,” he said at last, “don't you think you could edge the rocket in a little closer?”

“I'm trying, sir,” replied Beadle. “But the thing won't answer the controls.”

“Do you mind if I have a go?” asked Grimes.

“Of course not, Captain.” Implied but not spoken was, “And you're welcome!”

Grimes strapped a set of binoculars to his head, then took the control box. First of all he brought the sounding rocket back towards the ship, then put it in a tight turn to get the feel of it. Before long he was satisfied that he had it; it was as though a tiny extension of himself was sitting in a control room in the miniature spaceship. It wasn't so very different from a rocket-handling simulator.

He straightened out the trajectory of the sounding rocket, sent it back towards the mysterious

globe and then, as Beadle had done, put it in orbit. So far, so good. He cut the drive and the thing, of course, continued circling the metallic sphere. A brief blast from a braking jet—that should do the trick. With its velocity drastically reduced the missile should fall gently towards its target. But it did not—as von Tannenbaum, manning the radar, reported.

There was something wrong here, thought Grimes. The thing had considerable mass, otherwise it would never have shown so strongly in the screen of the MPI. The greater the mass, the greater the gravitational field. But, he told himself, there are more ways than one of skinning a cat. He actuated the steering jets, tried to nudge the rocket in towards its objective. “How am I doing, Pilot?” he asked.

“What are you trying to do, Captain?” countered von Tannenbaum. “The elements of the orbit are unchanged.”

“Hm-m-m.” Perhaps more than a gentle nudge was required. Grimes gave more than a gentle nudge—and with no result whatsoever. He did not need to look at Beadle to know that he was wearing his I-told-you-so expression.

So . . .

So the situation called for brute strength and ignorance, a combination that usually gets results.

Grimes pulled the rocket away from the sphere, almost back to the

ship. He turned it—and then, at full acceleration, sent it driving straight for the target. He hoped that he would be able to apply the braking jets before it came into damaging contact—but the main thing was to make contact, of any kind.

He need not have worried.

With its driving jet flaring ineffectually the rocket was streaking back towards *Adder*, tail first. The control box was useless. "Slovotny!" barked Grimes. "Fire!"

There was a blinding flare, and then only a cloud of incandescent, but harmless, gases still drifting towards the ship.

"And what do we do now, Captain?" asked Beadle. "Might I suggest that we make a full report to Base and resume our voyage?"

"You might, Number One. There's no law against it. But we continue our investigations."

Grimes was in a stubborn mood. He was glad that *Adder* was not engaged upon a mission of real urgency. Those bags of Fleet mail were not important—Revised Regulations, Promotion Lists, Appointments . . . It would not matter if they never reached their destination. But a drifting menace to navigation was important. Perhaps, he thought, it would be named after him. Grimes' Folly . . . He grinned at the thought. There were better ways of achieving immortality.

But what to do?

Adder hung there, and the *thing* hung there, rates and directions of drift nicely synchronized, and in one thousand seven hundred and fifty-three Standard years they would fall into, or around, Algol, assuming that Grimes was willing to wait that long—which, of course, he was not. He looked at the faces of his officers, who were strapped into their chairs around the wardroom table. They looked back at him.

Von Tannenbaum—the Blond Beast—grinned cheerfully. He remarked, "It's a tough nut to crack, Captain—but I'd just hate to shove off without cracking it."

Slovotny, darkly serious, said, "I concur. And I'd like to find out how that repulsor field works."

Vitelli, not quite yet a member of the family, said nothing.

Deane complained, "If the thing had a mind that I could read, it'd all be so much easier . . ."

"Perhaps it's allergic to metal," suggested von Tannenbaum. "We could try to bring the ship in towards it, to see what happens."

"Not likely, Pilot," growled Grimes. "Not yet, anyhow. Hm-mm . . . you might have something. It shouldn't be too hard to cook up, with our resources, a sounding rocket of all-plastic construction and . . ."

"There has to be metal in the guidance system . . ." objected Slovotny.

"There won't be any guidance

system, Sparks. It will be a solid fuel affair, and we just aim it, fire it, and when we see what happens . . .”

“Solid fuel?” demurred Beadle. “Even if we had the formula we’d never be able to cook up a batch of cordite or anything similar . . .”

“There’d be no need to, Number One. We should be able to get enough from the cartridges for our projectile small arms. But I don’t intend to do that.”

“Then what do you intend, Captain?”

“We have graphite—and that’s carbon. We’ve all sorts of fancy chemicals in our stores, especially those required for the maintenance of our hydroponics system. Charcoal, sulphur, saltpeter . . . Or we could use potassium chlorate instead of that . . .”

“It *could* work,” admitted the Beadle dubiously.

“Of course it will work,” Grimes assured him.

It did work—although mixing gunpowder, especially in free fall conditions, wasn’t as easy as Grimes had assumed that it would be. To begin with, graphite proved to be quite unsuitable, and the first small sample batch of powder burned slowly, with a vile sulfurous stench that lingered in spite of all the efforts of the air-conditioner. But there were carbon water filters, and one of these was broken up and then pulverized in the galley

food mixer—and when Grimes realized that the bulkheads of this compartment were rapidly acquiring a fine coating of soot he ordered that the inertial drive be restarted. With acceleration playing the part of gravity things were a little better.

Charcoal 13%, saltpeter 75%, sulphur 12% . . . That, thought Grimes, trying hard to remember the History of Gunnery lectures, *was about right*. They mixed a small amount dry, stirring it carefully with a wooden ladle. It was better than the first attempt, using graphite, had been—but not much. And it smelled as bad. Grimes concluded that there was insufficient space between the grains to allow the rapid passage of the flame.

“Spooky,” he said in desperation, “can you read my mind?”

“It’s against Regulations,” the telepath told him primly.

“Damn the Regulations. I sat through all those Gunnery Course lectures, and I’m sure that old Commander Dalquist went into the history of gunnery *very* thoroughly, but I never thought that the knowledge of how to make black powder would be of any use at all to a modern spaceman. But it’s all there in my memory—if I could only drag it out!”

“Relax, Captain,” Spooky Deane told him in a soothing voice. “Relax. Let your mind become a blank. You’re tired, Captain. You’re very tired. Don’t fight it. Yes, sit down.

Let every muscle go loose . . .”

Grimes lay back in the chair. Yes, he *was* very tired . . . He did not like the sensation of cold, clammy fingers probing about inside his brain. But he trusted Deane. He told himself very firmly that he *trusted* Deane . . .

“Let yourself go back in Time, Captain, to when you were a midshipman at the Academy . . . You’re sitting there, on a hard bench, with the other midshipmen around you . . . And there, on his platform before the class, is old Commander Dalquist . . . I can see him, with his white hair and his white beard, and his faded blue eyes looking enormous behind the spectacles . . . And I can see all those lovely little models on the table before him . . . The culverin, the falcon, the carronade . . . He is droning on, and you are thinking, *How can he make anything so interesting so boring?* You are wondering, *What’s on for dinner tonight?* You are hoping that it won’t be that beef stew *again* . . . Some of the other cadets are laughing. You half heard what the commander was saying. It was that the early cannoneers, who mixed their own powder, maintained that the only possible fluid was a wine drinker’s urine, their employer to supply the wine . . . And if the battle went badly, because of misfires, the gunners could always say that it was due to the poor quality of the booze . . . But you are wondering

now if you stand any chance with that pretty little nurse . . .”

Grimes felt his prominent ears turning hot and scarlet. He snapped into full wakefulness. He said firmly, “That will do, Spooky. You’ve jogged my memory sufficiently. And if any of you gentlemen think I’m going to order a free wine issue, you’re mistaken. We’ll use plain water, just enough to make a sort of mud, thoroughly mixed, and then we’ll dry it out. No, we’ll not use heat, not inside the ship. Too risky. But the vacuum chamber should do the job quite well . . .”

“And then?” asked Beadle, becoming interested in spite of himself.

“Then we crush it into grains.”

“Won’t that be risky?”

“Yes. But we’ll have a plastic bowl fitted to the food mixer, and the chief can make some strong, plastic paddles. As long as we avoid the use of metal we should be safe enough.”

They made a small batch of powder by the method that Grimes had outlined. Slovtorny fitted a remote-control switch to the food mixer in the galley, and they all retired from that compartment while the cake was being crushed and stirred. The bowlful of black, granular matter looked harmless enough—but a small portion of it transferred to a saucer—and taken well away from the larger amount remaining in the bowl—burned

with a satisfying *whoof!* when ignited.

"We're in business!" gloated Grimes. "*Adder* Pyrotechnics, Unlimited!"

They were in business, and while Grimes, Beadle and von Tannenbaum manufactured a large supply of gunpowder Slovoṭny and Vitelli set about converting a half dozen large, plastic bottles into rocket casings. They were made of thermoplastic, so it was easy enough to shape them as required, with throat and nozzle. To ensure that they would retain the shape after firing they were bound about with heavy insulating tape. After this was finished there was a rocket launcher to make—a tube of the correct diameter, with a blast shield and with the essential parts of a projectile pistol as the firing mechanism.

Then all hands joined forces in filling the rockets. Tubes of stiff paper, soaked in a saturated solution of saltpeter and allowed to dry, were inserted into the casing and centered as accurately as possible. The powder was poured around them, and well tamped home.

While this was being done Spooky Deane—who, until now, had played no part in the proceedings—made a suggestion. "Forgive me for butting in, Captain, but I remember—with *your* memory—the models and pictures that the instructor showed the class. Those old chemical rockets had sticks or

vanes to make them fly straight and . . ."

For a moment this had Grimes worried. Then he laughed. "Those rockets, Spooky, were used in the atmosphere. Sticks or vanes would be utterly useless in a vacuum." But he couldn't help wondering if vanes set actually in the exhaust would help to keep the missiles on a straight trajectory. But unless he used metal there was no suitable material aboard the ship—and metal was out.

Grimes went outside, with von Tannenbaum, to do the actual firing. They stood there on the curved shell plating, held in place by the magnetic soles of their boots. Each of them, too, was secured by lifelines. Neither needed to be told that to every action there is an equal and opposite reaction. The backblast of the homemade rockets would be liable to sweep them from their footing.

Grimes held the clumsy bazooka while the navigator loaded it, then he raised it slowly. A cartwheel sight had been etched into the transparent shield. Even though the weapon had no weight in free fall it still had inertia, and it was clumsy. By the time that he had the target, gleaming brightly in the beam of *Adder's* searchlight, in the center of the cartwheel he was sweating copiously. He said into his helmet microphone, "Captain to *Adder*. I am about to open fire."

"*Adder* to Captain. Acknowledged," came Beadle's voice in reply

Grimes's right thumb found the firing stud of the pistol. He recoiled involuntarily from the wash of orange flame that swept over the blast shield—and then he was torn from his hold on the hull plating, slammed back to the full extent of the lifeline. He lost his grip on the rocket launcher, but it was secured to his body by stout, fireproof cords. Somehow he managed to keep his attention on the fiery flight of the rocket. It missed the target, but by a very little. To judge by the straight wake of it, it had not been deflected by any sort of repulsor field.

"It throws high . . ." commented Grimes.

He pulled himself back along the line to exactly where he had been standing before. Von Tannenbaum inserted another missile into the tube. This time, when he aimed, Grimes intended to bring the target to just above the center of the cartwheel. But there was more delay; the blast shield was befogged by smoke. Luckily this eventuality had been foreseen, and von Tannenbaum cleaned it off with a rag.

Grimes aimed, and fired.

Again the blast caught him—but this time he hung in an untidy tangle facing the wrong way, looking at nothingness. He heard somebody inside the ship say, "It's blown up!"

Blown up? What had blown up?

Hastily Grimes got himself turned around. The mysterious globe was still there, but between it and *Adder* was an expanding cloud of smoke, a scatter of fragments, luminous in the searchlight's glare. So perhaps the nonmetallic missiles weren't going to work after all—or perhaps this missile would have blown up by itself, anyhow.

The third rocket was loaded into the bazooka. For the third time Grimes fired—and actually managed to stay on his feet. Straight and true streaked the missile. It hit, and exploded in an orange flare, a cloud of white smoke which slowly dissipated.

"Is there any damage?" asked Grimes at last. He could see none with his unaided vision, but those on the control room had powerful binoculars to hand.

"No," replied Beadle at last. "It doesn't seem to be scratched."

"Then stand by to let the pilot and myself back into the ship. We have to decide what we do next."

What they did next was a matter of tailoring rather than engineering. *Adder* carried a couple of what were called "skin-divers' suits". These were, essentially, elasticized leotards, skin-tight but porous, maintaining the necessary pressure on the body without the need for cumbersome armor. They were ideal for working in outside the ship, allowing absolute freedom

of movement—but very few spacemen liked them. A man feels that he should be armored, well armored, against an absolutely hostile environment. Too, the conventional spacesuit has built-in facilities for the excretion of body wastes, has its little tank of water and its drinking tube, has its container of food and stimulant pellets. (Grimes, of course, always maintained that the ideal suit should make provision for the pipe smoker . . .) A conventional spacesuit is, in fact, a spaceship in miniature.

Now these two suits had to be modified. The radio transceivers, with their metallic parts, were removed from the helmets. Plastic air bottles were substituted for the original metal ones. Jointures and seals between helmet and shoulder pieces were removed, and replaced by plastic.

While this was going on Beadle asked, "Who are you sending, Captain?"

"I'm sending nobody, Number One. I shall be going myself, and if any one of you gentlemen cares to volunteer . . . No, not you. You're second in command. You must stay with the ship."

Surprisingly it was Deane who stepped forward. "I'll come with you, Captain."

"You, Spooky?" asked Grimes, not unkindly.

The telepath flushed. "I . . . I feel that I should. That . . . That *thing* out there is awakening. It

was as though that rocket was a knock on the door . . ."

"Why didn't you tell us?"

"I . . . I wasn't sure. But the feeling's getting stronger. There's something there. Some sort of intelligence."

"Can't you get in touch with it?"

"I've been trying. But it's too vague, too weak. And I've the feeling that there has to be actual contact. Physical contact, I mean."

"Hm-m-m."

"In any case, Captain, you *need* me with you."

"Why, Spooky?"

Deane jerked his head towards the watch on Grimes's wrist. "We'll not be allowed to take any metal with us. How shall we know when we've been away long enough, that we have to get back before our air runs out?"

"How shall we know if you're along?"

"Easy. Somebody will have to sit with Fido, and clock-watch all the time, really concentrating on it. At that short range Fido will pick up the thoughts even of a nontelepath quite clearly. I shall remain *en rapport* with Fido, of course."

"Hm-m-m," grunted Grimes. Yes, he admitted to himself, *the idea had its merits*. He wondered whom he should tell for the clock-watching detail. All spacemen, except psionic radio officers, hate the organic amplifiers, the so-called "dogs' brains in aspic," the obscenely naked masses of canine

thinking apparatus floating in their spherical containers of circulating nutrient fluid.

Slovotny liked dogs. He'd be best for the job.

Slovotny was far from enthusiastic, but was told firmly that communications are communications, no matter how performed.

The inertial drive was restarted to make it easier for Grimes and Deane to get into their suits. Each, stripped to brief, supporting underwear, lay supine on his spread-out garment. Carefully they wriggled their hands into the tight-fitting gloves—the gloves that became tighter still once the fabric was in contact with the skin. They worked their feet into the bootees, aided by Beadle and von Tannenbaum, acting as dressers. Then, slowly and carefully, the lieutenant and the navigator drew the fabric up and over arms and legs and bodies, smoothing it, pressing out the least wrinkle, trying to maintain an even, all-over pressure. To complete the job the seams were welded. Grimes wondered, as he had wondered before, what would happen if that efficient adhesive came unstuck when the wearer of the suit was cavorting around in hard vacuum. It hadn't happened yet—as far as he knew—but there is always a first time.

"She'll do," said Beadle at last.

"She'd better do," said Grimes.

Grimes got to his feet, scowling. If one is engaged upon what might

be a perilous emprise, armor is so much more appropriate than long underwear. He said, "All right. Shut down inertial drive as soon as we've got our helmets on. Then we'll be on our way."

They were on their way.

Each man carried, slung to his belt, a supply of little rockets—Roman candles, rather—insulated cardboard cylinders with friction fuses. They had flares, too, the chemical composition of such making them combustible even in a vacuum.

The Roman candles functioned quite efficiently, driving them across the gap between ship and sphere. Grimes handled himself well, Deane not so well. It was awkward having no suit radio; it was impossible to give the telepath any instructions. At the finish Grimes came into a perfect landing, using a retro blast at the exact split second. Deane came in hard and clumsily. There was no air to transmit the *clang*, but Grimes felt the vibration all along and through his body.

He touched helmets. "Are you all right, Spooky?"

"Just . . . winded, Captain."

Grimes leading, the two men crawled over the surface of the sphere, the adhesive pads on gloves, knees, elbows and feet functioning quite well—rather too well, in fact. But it was essential that they maintain contact with the smooth metal.

Close inspection confirmed distant observation. The one-hundred foot diameter globe was utterly devoid of protuberances. The markings—they were no letters or numerals known to the Earthmen—could have been painted on, but Grimes decided that they were probably something along the lines of an integrated circuit. He stopped crawling, carefully made contact between his helmet and the seamless, rivetless plating. He listened. Yes, there was the faintest humming noise. Machinery?

He beckoned Deane to him, touched helmets. He said, "There's something working inside this thing, Spooky."

"I know, Captain. And there's something alive in there. A machine intelligence, I think. It's aware of us."

"How much time have we?"

Deane was silent for a few seconds, reaching out with his mind to his psionic amplifier aboard *Adder*. "Two hours and forty-five minutes."

"Good. If we could only find a way to get into this oversized beach ball . . ."

Deane jerked his head away from Grimes. He was pointing with a rigid right arm. Grimes turned and looked. Coming into view in the glare of the searchlight, as the ball rotated, was a round hole, an aperture that expanded as they watched it. Then they were in shadow, but they crawled towards

the opening. When they were in the light again they were almost on top of it. They touched helmets again. "Will you come into my parlor . . .?" whispered Grimes.

"I . . . I feel that it's safe . . ." Deane told him.

"Good. Then we'll carry on. Is that an air lock, I wonder? There's only one way to find out . . ."

It was not an air lock. It was a doorway into cavernous blackness, in which loomed great, vague shapes, dimly visible in the reflected beam of *Adder's* searchlight—then invisible as this hemisphere of the little, artificial world was swept into night. Grimes was falling; his gloves could get no grip on the smooth, slippery rim of the hole. He was falling, and cried out in alarm as something brushed against him. But it was only Deane. The telepath clutched him in an embrace that, had Deane been of the opposite sex, might have been enjoyable.

"Keep your paws off me, Spooky!" ordered Grimes irritably. Yet he, too, was afraid of the dark, was suffering the primordial fear. The door through which they had entered must be closed now, otherwise they would be getting some illumination from *Adder's* searchlight. The dense blackness was stifling. Grimes fumbled at his belt, trying to find a flare by touch. The use of one of the little rockets in this confined space could be disastrous. But there had to be light.

Grimes was not a religious man, otherwise he would have prayed.

Then, suddenly, there was light.

It was a soft, diffused illumination, emanating from no discernible source. It did not, at first, show much. The inner surface of the sphere was smooth, glassy, translucent rather than transparent. Behind it hulked the vague shapes that they had glimpsed before their entry. Some were moving slowly, some were stationary. None of them was like any machine or living being that either of the two men had ever seen.

Helmets touched.

"It's aware of us. It knows that we need light . . ." whispered Deane.

"What is it?"

"I . . . I dare not ask. It is too . . . big?"

And Grimes, although no telepath, was feeling it too, awe rather than fear, although he admitted to himself that he was dreadfully afraid. It was like his first space walk, the first time that he had been out from the frail bubble of light and warmth, one little man in the vastness of the emptiness between the worlds. He tried to take his mind off it by staring at the strange machinery—if it was machinery—beyond that glassy inner shell, tried to make out what these devices were, what they were doing. He focused his attention on what seemed to be a spinning wheel of rainbow luminescence. It was a mistake.

He felt himself being drawn into that radiant eddy—not physically, but psychically. He tried to resist. It was useless.

Then the pictures came—vivid, simple.

There was a naked, manlike being hunkered down in a sandy hollow among rocks. Manlike? It was Grimes himself. A flattish slab of wood was held firmly between his horny heels, projecting out and forward, away from him. In his two hands he gripped a stick, was sawing away with it, to and fro on the surface of the slab, in which the pointed end of it had already worn a groove. (Grimes could *feel* that stick in his hands, could feel the vibration as he worked it backwards and forwards.) There was a wisp of blue smoke from the groove, almost invisible at first, but becoming denser. There was a tiny red spark that brightened, expanded. Hastily Grimes let go of the fire stick, grabbed a handful of dried leaves and twigs, dropped them on top of the smolder. Carefully he brought his head down, began to blow gently, fanning the beginnings of the fire with his breath. There was flame now—feeble, hesitant. There was flame, and a faintly heard crackle as the kindling caught. There was flame—and Grimes had to pull his head back hastily to avoid being scorched.

The picture changed.

It was night now—and Grimes

and his family were squatting around the cheerful blaze. One part of his mind that had not succumbed to the hypnosis wondered who that woman was. He decided wryly that she was not his cup of tea at all. But he *knew* that she was his mate, just as he *knew* that those almost simian brats were his children.

It was night, and from the darkness around the camp came the roars and snarls of the nocturnal predators. But they were afraid of fire. He, Grimes, had made fire. Therefore those beasts of prey should be afraid of him. He toyed with the glimmerings of an idea. He picked up a well-gnawed femur—that day he had been lucky enough to find a not-too-rotten carcass that had been abandoned by the original killer and not yet discovered by the other scavengers—and hefted it experimentally in his hand. It seemed to belong there. From curiosity rather than viciousness he brought it swinging around, so that the end of it struck the skull of the woman with a sharp *crack*. She squealed pitiously. Grimes had no language with which to think, but he knew that a harder blow could have killed her. Dimly he realized that a hard blow could kill a tiger . . .

He . . .

He was outside the sphere, and Deane was with him. Coming towards him was a construction of

blazing lights. He was afraid—and then he snapped back into the here-and-now. He was John Grimes, Federation Survey Service, captain of the courier *Adder*. That was his ship. His home. He must return to his home, followed by this Agent of the Old Ones, so that observation and assessment could be made, and plans for the further advancement of the race.

The ship was no longer approaching.

Grimes pulled a Roman candle from his belt, motioned to Deane to do likewise. He lit it, jettied swiftly towards *Adder*. He knew, without looking around, that the sphere was following.

Although blinded by the searchlight he managed to bring himself to the main air lock without mishap, followed by Deane. The two men pulled themselves into the little compartment. The outer door shut. Atmospheric pressure built up. Grimes removed the telepath's helmet, waited for Deane to perform a like service for him.

Deane's face was, if possible, even paler than usual. "Captain," he said, "we got back just in time. We've no more than a few minutes' air in our bottles . . ."

"Why didn't you tell me?"

Deane laughed shakily. "How could I? I was being . . . educated. If it's any use to me or to anybody else, I know how to make wheels out of sections of tree trunk . . ."

Beadle's voice crackled from an

intercom bulkhead speaker. "Captain! Captain! Come up to Control! It's . . . vanished!"

"What's vanished?" demanded Grimes into the nearest pickup.

"That . . . that sphere . . ."

"We're on our way," said Grimes.

Yes, the sphere had vanished. It had not flickered out like a snuffed candle; it had seemed to recede at a speed approaching that of light. It

was gone, and no further investigation of its potentialities and capabilities would be possible.

It was Deane who was able to give an explanation of sorts. He said, "It was an emissary of the Old Ones. All intelligent races in this galaxy share the legends—the gods who came down from the sky, bearing gifts of fire and weaponry, setting Man, or his local equivalent, on the upward path . . ."

"I played God myself once," said

IN TIMES TO COME

Next month we start a long—four-part—novel by Gordon Dickson. In a way, you might call it a flashback novel—because it's the story of the founding of the culture of the Dorsai. What led to the development of that world of poor resources, and terrific men, the world that made its living fighting other people's battles?

This one—"The Tactics of Mistake"—will, I'm sure, be a classic of science fiction a few years hence.

It's been said that that side wins in a war which makes mistakes—but fewer of them than the enemy. But here the first of the true Dorsai generals shows another possibility—that side will win which formulates the best tactics for *inducing* mistakes!

After all, you don't have to be powerful if you can keep the other guy stumbling over his own feet, and hitting himself in the back of the head with his missed roundhouse swing!

THE EDITOR

Grimes. "I wasn't very popular. But go on, Spooky."

"These Old Ones . . . Who were they? We shall never know. What were their motivations? Missionary zeal? Altruism? The long-term development of planets, by the indigenes, so that the Old Ones could, at some future date, take over?"

"Anyhow, I wasn't entirely under Its control. I was seeing the things that It meant me to see, feeling the things that It meant me to feel—but, at the same time, I was picking up all sorts of outside impressions. It was one of many of Its kind, sent out—how long ago?—on a missionary voyage. It was a machine, and—as machines do—it malfunctioned. Its job was to make a landing on some likely world and to make contact with the primitive natives, and to initiate their education. It was programmed, too, to get the hell out if It landed on a planet whose natives already used fire, who were already metal workers. That was why It, although not yet awakened from Its long sleep, repelled our metallic sounding rocket. That was why you, Captain, got this odd hunch about a nonmetallic approach.

"Your plastic rocket woke It up properly. It assumed that we, with no metal about us, were not yet fire-making, tool-using animals. It did what It was built to do—taught us how to make fire, and tools and weapons. And then It followed us

home. It was going to keep watch over us, from generation to generation, was going to give us an occasional nudge in the right direction. Possibly It had another function—to act as a sort of marker buoy for Its builders, so that They, in Their own good time, could find us, to take over.

"But even It, with Its limited intelligence, must have realized, at the finish, that we and It were in airless space and not on a planetary surface. It must have seen that we, using little rocket-propulsion units, were already sophisticated fire-users. And then, when we entered an obviously metallic spaceship, the penny must finally have dropped, with a loud clang.

"Do you want to know what my last impression was, before It shoved off?"

"Of course I want to know," said Grimes.

"It was one of hurt, of disillusion, of bewilderment. It was the realization that It was at the receiving end of a joke. The thing was utterly humorless, of course—but It could still hate being laughed at."

There was a silence, broken by Beadle. "And Somewhere," he said piously, "at Some Time, Somebody must have asked, 'Where is my wandering buoy tonight?'"

"I sincerely hope," Grimes told him, "that this Somebody is not still around, and that He or It never tries to find out." ■

“talk with the animals—”



*Considering the variants on intelligence Out There,
maybe Earth's been invaded, studied, spied on
and recorded in great detail—and we'd never know . . .*

STEPHAN TALL

Illustrated by Leo Summers

I suppose you might call me a fairly ordinary guy. Well, maybe typical would be better. Not the all-American boy exactly, but close.

I work for a living. I'm in a nice little partnership business, with a partner I can stand even if his politics are asinine.

When I see a curvy girl I suppose I respond pretty much like any other normal male. And, if she runs and looks back, I'm not above doing a little chasing. So far I still recommend a bachelor's life.

I have a degree from a respectable college—biology major. I didn't follow it up, but it adds a little to the hunting and fishing I like to do. Sometimes I hunt and don't shoot. Often I fish and throw 'em back. But I like to be out where they are.

Maybe that's why what happened to me last spring happened. And then again, maybe it had nothing to do with it. I can't figure it. But happen it did. Have a listen:

The turtle started it.

I sat on a log and watched him lumber toward me over the leaves. He was mottled orange and black, bright like they are in spring, and his glowing red eye told me he was an old male, who would welcome a lady friend if he could find one. He detoured a few steps to take a bite of a mushroom that looked juicy, but he didn't stop. He came right up to my boot.

I bent down to look at him and he stared right back.

"I see," the turtle said, "that I have your attention."

Just like that.

Well, what would you have done? I looked closely, but couldn't see that I had missed anything. He was just a plain wood tortoise. My country friends would call him a terrapin. His red eyes glittered. There was no mistaking that he was consciously turning those eyes on me—as a person!

At least I didn't answer him. I was alone, and that helped, but I didn't even want to catch myself engaging in repartee with a turtle.

What anybody else would have thought about it if he'd heard me, you know as well as I do.

"I suppose this isn't usual," the turtle said after a moment. "You appear disturbed. I have selected you at random, mainly because you are obviously a dominant form. I require some assistance.

Not only talk, but English. Not only English, but that kind of English. The voice was rough, rasping, hoarse. It was so weak it barely stirred my eardrums. Come to think of it, I don't believe I ever heard a terrapin make any kind of noise before.

"I have probably selected the wrong vehicle," the turtle continued. "This being is ill equipped for vocalizing. I picked it because it was handy—that is, adjacent to you."

My resolution broke down. True, I'd never talked to a turtle before, but I did now. I spoke good and loud.

"Look," I said, "I know I'm being diddled. The question is, how? Radio? Ventriloquism? Fun's fun, and this is a good trick, but you can come out now."

The turtle started to wander away, then jerked back like somebody had pulled on his choke collar.

"Can't relax for a minute," the turtle rasped. "This is truly a stupid form. It is impervious to ideas or suggestions."

"Sounds like my partner." I

went along with the gag. "Tell me, why do you refer to yourself as 'it'? You sound like a distinterested third person."

"You're not so sharp yourself, are you?" the turtle said impatiently. "Surely you must see that that is exactly what I am. I can't communicate with you without a physical vehicle. This being is serving that purpose. Serving it poorly, I might add."

"I understand perfectly," I said. "You're a leprechaun."

"Negative," the turtle said. "I'm a Libidian. The name is doubtless meaningless to you."

"I know a variation of it," I said. "See your Funk & Wagnalls. And I know enough about male terrapins to know just what your interest is on this bright spring day. Libidian! You're not only a good technician, you've got a sense of humor, haven't you?"

I was keeping up the pretense, but I wasn't that sure. I had watched carefully when the turtle spoke. His beak opened and closed slightly, his throat throbbed. No ventriloquism. The reptile was actually forming the words. That turtle was talking!

"I suppose I should have anticipated this," the turtle said. "It is evident that your species has had no experience with this sort of thing. It's not unknown, but I do admit that we Libidians are good at it."

"You are, you are!" I agreed. "Look, Dr. Dolittle, I'm not, and talking with the animals isn't exactly my thing. Suppose you develop this plot. Why me? What do you want?"

The turtle cocked his head.

"You happen to be alone," the turtle said. "That's why you. It is very difficult to communicate with aware beings in groups. They do not believe, especially as I must use an unaware form as a vehicle. My corporeal being cannot be brought to your planet, since that already is occupied by life. We cannot physically visit occupied space."

"You can't," I said, "but here you are. You're contradicting yourself."

"Negative." It seemed to be a word the turtle liked. "My corporeal being is in our spacecraft on your nearby satellite. I have projected myself here as an intangible. This is permitted."

"From the Moon?" I looked around carefully. There wasn't a clue as to how the turtle was being put through his paces. So I just reached over and picked him up. He struggled and twisted and waved his legs as I held him upside down.

"I hope you don't mind," I told him. "I'm just making sure you're not wired for sound."

As far as I could tell, he wasn't. There wasn't a darn thing distinctive or different about him—except his conversation. I set him

back on his blunt-clawed feet. He eyed me with what could have been disgust.

"This being is becoming confused and weary," he husked. "It is not equipped for making sounds. I will release it, and find a more suitable vehicle. I will communicate with you again shortly."

I could sense when it happened. The turtle's head dropped, and he began to crawl away as fast as I ever saw one go. He acted like he was in a sort of reptilian panic. And I knew that he had said his last word. I didn't believe any of it, but I knew, just the same.

As far as I was concerned, the day had reached its peak and passed it. I picked up my fishing tackle, capped my binoculars and started back to where I'd parked my car. I needed to think, to check back and see if I had been feeling a little queer lately. I figured I could do it better if I wasn't interrupted by any more conversationally inclined turtles. I got as far as the end of the jeep trail into the woods.

A red bird flew past my nose and perched on a little sassafras six feet away. It fluttered its wings uncertainly, flared and flattened its crest.

"This is better," the cardinal said. "This being is vocal."

The voice was high, whistled rather than spoken. I could understand the words, though.

I hesitated for only a minute.

"Let me guess," I said finally. "You're no longer a turtle."

The cardinal snapped his heavy beak.

"I was never a turtle," he said. He seemed exasperated at my denseness. "I am not this thing either. They are vehicles. My analysis of you indicates that you can comprehend this. Therefore, you are being difficult."

It was the first time I'd ever had my wrist slapped by a bird.

"Oh, I dig it," I said. "I'm just having trouble believing it. Anything with the wit to call itself a Libidian can probably understand that."

The cardinal tilted on his twig and rolled his eyes; dark brown eyes this time.

"I suppose so." It was a whistled sigh. "At least, we will make no progress impugning each other's intelligence. I agree that you did not ask for this contact. The responsibility is, therefore, mine."

I studied the bird, just as I had recently critically examined the turtle. I had plenty like him on my sunflower feeders every winter. A pair was at the moment nesting in a climbing rose in my back yard.

"I've given up the idea of a trick," I said finally. "I'll allow that you actually are something intangible, and temporarily inhabiting that cardinal. You speak to me in English. It is good English, with a wide vocabulary. You

have used several words most of my friends wouldn't use, probably don't know. Will you explain that?"

The bird considered.

"I will try. Actually, I do not speak to you in English, which I comprehend to be the vocal pattern you utilize. The sounds this being makes are drawn from your own vocabulary. I simply project orderly meanings. You yourself convert them to speech, because only thus can you complete the contact."

"Clear as mud," I said. "I won't quibble, though. What's one detail of an entire unbelievable situation? Let's get to the point. What do you want?"

If the bird could have smiled, I think he would have.

"You would call that ungracious," he said. "Still, it is your right to be reassured. I will cause you no harm. It is not my purpose, and would not be allowed in any case. Beyond that, I am achieving my objective. I have established contact with an aware being—you. I propose to maintain this contact while I gather data on levels of development on your planet."

"Now wait a minute! People think I'm odd enough already. If I go around chattering to the wild-life, it isn't going to improve my image a bit."

The bird flared his crest and nodded.

"I am aware of this. I will be

discreet. Further, my sojourn here will be brief. I can maintain myself remote from my corporeal being for a limited time only."

A thought occurred to me.

"If you think you're going to learn much about this world by haunting my town and, specifically, me, think again. We'd be a pointlessly narrow cross-section. Earth is a varied planet. How big it is, compared to worlds you're familiar with, I wouldn't know, but to get an idea of its population you'll have to travel."

The cardinal looked smug, and a little disdainful.

"We are many," he said. "All over your planet intangible projections are seeking aware contacts. We expect a high percentage of success. We are skilled. We have done this many times before."

"Well, I'll be—. So the Air Force doesn't have the right dope. There are UFOs after all."

"Negative!" The bird was emphatic. "Material invasion of the living space of other life forms is not permitted. By Galactic agreement, achieved millennia ago, there will be no interference with the evolution of life complexes. Observation is allowed. Since we Libidians have perfected projection we have forged forward in knowledge. We are recognized authorities on Galactic life. We are of the few who can observe close at hand."

"It seems like a dodge to me," I said. "The idea of disembodied

keyhole peekers interferes with *my* evolution, I can tell you that. When I get home and think about this, I'm not going to believe it, anyway."

"So," the bird said, "I won't have affected you. In point of fact, you *will* believe for a brief while longer. I will be present and I will remind you."

He twitched, twisted, flared his crest, stretched one wing and then the other. Then suddenly he flew, darting away through the understory of the woods. He had been released.

I didn't feel much easier as I drove home. I tried to sift out what I had been told both by the turtle and the bird. The procedure seemed ponderous to me. And roundabout. Why not the more efficient way of just occupying *me*? Then I remembered. Only an *unaware* form could be used as a tangible. Galactic agreement! Sounded like complete nonsense. Still, I had talked with a bird and a turtle—I thought.

What I dreamed about that night has no place in this telling. It had no place in dreams either, but that's beside the point. I did sleep, and slept late. I woke when the family cat jumped on the bed. It's a habit he has. Pretty often his day is ending when mine is just beginning, and he doesn't like the bed to get cold.

I petted him a minute, then

rolled out. He looked pooped. I felt pretty sure it had been one of those nights. He was a big old gray, long-coated from a renegade Persian father, self-sufficient and arrogant from his mother's long line of alley-cat ancestors. If I ever lose my job, or get to where I can't provide him with warmth, food and comfort, he'll leave me without a backward look. He's a good actor, but he's completely practical.

"O.K., Tom, it's all yours," I said. "You look like you could use it."

The cat yawned and settled down.

"Can I ever!" He fixed his slitted yellow eyes on my face. "This being is far superior to the other two. At times it seems almost aware." The voice was rich and clear, as you'd expect from good vocal cords and a flexible tongue. The tone, though, was familiar.

I had been only half awake, but that snapped me out of it. The cat on the bed was just old Tom, wearily trying to close his eyes, but being prodded awake by his occupier.

"So now you're my cat." I said it maliciously.

Tom took it tranquilly.

"You cannot offend me," he said. "I recognize this as your purpose. I have occupied this being through the hours of darkness, knowing its relationship to you. What activity it enjoys! I have learned much."

The utter absurdity of the whole thing hit me suddenly and I began to laugh.

"You'd better stick with him," I chuckled. "He can show you more than I ever could. He already has. You've had something no man can possibly have—a night on the town *with* a tomcat!"

Tom stretched, kneaded the blanket with his forepaws, settled down again.

"Combat, females, food—" He spoke drowsily, but in that fine rich voice. "This being is a mass of sensation."

"Throw in a little shut-eye, and what else is there? The whole story of life—in a capsule. Explore all you want to. You won't find much more."

"You oversimplify," the cat said. "These are survival basics, I grant you. They are achieved in a variety of ways, and the details are of interest. But there is more. There must be more in forms that are aware. I search for these extensions."

"Have you found them?" I inquired. "In all the Galactic life forms you say you have observed, have you found them?"

"Not yet," the cat admitted. "But there must be a reason for all this. How does an unaware being become aware? In the final analysis, that is doubtless what we search for."

Tom's yellow eyes closed. He purred faintly.

"It can wait," I said. "Let Tom get his rest. He's had it."

My Uncle Jim was in the breakfast nook, having a late cup of coffee. Uncle Jim is retired. He gets up early so he can put in a long day of loafing and meddling in other people's businesses. He goes to bed at dusk.

"Sounded like you was havin' a regular argument with yourself upstairs," he said, when I came in with my eggs. He's got ears like an elephant.

"I was talking to the cat."

Uncle Jim cackled.

"Answered ye back, did he? Always thought that old devil could talk if he put his mind to it."

"Go upstairs," I suggested. "If you find anybody up there but the cat, let me know. He'll be trespassing."

Uncle Jim swilled coffee.

"Don't git huffy," he said. "You wouldn't git huffy if you got up earlier. It's stayin' in bed does it." He wiped his moustache, eyed me thoughtfully. "When you going to settle down, quit running around half the night? Ought to be somebody up there for you to talk to beside the cat. Ever think about that?"

"Frequently," I said. "You mention it once a week, on an average. Look, I run around a little and Tom runs around a lot. So go up and lecture him. He needs it worse than I do."

I was hoping he'd do it, and that the cat would set him straight. Naturally I knew it wouldn't happen, but hoping's no crime. It would have been just what Uncle Jim had needed for twenty years.

"Can't talk to you when you're in a temper." Uncle Jim left his coffee cup for somebody else to take out. "Got to git to work now, anyhow. Jest come in fer a blow. That's what's wrong with the world nowadays. People waste too much time settin' around talkin'."

Since that was his main occupation, I saw no point in disputing it. He does do a little yard work, but he spends more time admiring what he's done. He puts the hammock out in April.

I also had a job to do, so I went to it. Being part owner, I have a flexible schedule. I got home in late afternoon.

Uncle Jim was nowhere about, but the cat was roosting in the front yard maple. A retriever pup from down the street was seeing to it that he stayed there. The din was considerable. The pup was enjoying himself.

It seemed probable that the cat had lost his companion, but when I passed by the tree, he spoke.

"These forms are highly antagonistic," Tom said. "This one is less disposed to combat than it was last night. It seems quite content to remain out of reach."

The pup had stopped barking to

wag his tail at me. He stared with puzzlement at the rich voice coming out of the tree.

"Tom's an old hand," I explained. "He doesn't waste his energies. If the chips were down, he could take that pup's hide off and hang it on the fence."

"Interesting," the cat said.

The pup began to back away, growling. Then suddenly his mood changed. He sat down and regarded me fixedly. His eyes were as yellow as the cat's.

"Interesting." It was the same tone, but a different, more yappy voice. The pup was speaking. He couldn't enunciate as well as the cat.

I was surprised, and still am when I think about it, at how matter-of-factly I took this whole business. It almost seemed normal.

"Well!" I said. The pup now ignored the cat. "You do have a knack for getting into both sides of a situation."

I regarded the dog carefully. He simply sat and stared back at me. He seemed to have nothing else to say.

"With your abilities," I said finally, "I'd think you'd be doing some really significant research. If my job is interpretation, I can tell you now that you aren't learning anything important about this planet. You are wasting your time with small doings of unimportant animals. You're not learning about Earth."

The pup stood up, wagged his tail a couple of times, and sat down again.

"I disagree," he said. "It is simple to observe the accomplishments of aware beings. As I have said, we are more concerned with how they came to be aware. This, we feel, is a critical point. These small activities in this limited area are most informative. I shall have much to report."

"I almost wish," I said, "that I could introduce you about. Naturally, I can't just tell about you. My standing in the community is shaky enough as it is. But you're breaking all the rules. You're spoiling the extraterrestrial image. And you say UFOs are against the law. You'd hurt a lot of feelings if that got about."

"Beliefs, even invalid ones, are stabilizers," the dog observed tranquilly. "Let the believers in invasion and aggression from space have their beliefs. They are harmless, and add an interest to the lives of beings which probably have not many. It is not their descendants who will reach the stars from this planet."

The dog watched me solemnly.

"You know, I suppose, that you're a snob. An intellectual snob. Coming from that friendly pup, it seems particularly out of place."

"I speak what I know," the dog said. "Progress does not come from the dullards of a species. This is not snobbery. It is only fact."

I started to answer, then remembered where I was. I glanced hastily up and down the street, but nobody seemed to have noticed that I wasn't behaving quite normally. I'd been gossiping with the cat and then the dog for several minutes. I bent over to rub the dog's ears.

"Why don't you change back to the cat?" I suggested. "Then I'll hold the dog, and Tom can go into the house with dignity. I can't be seen talking to myself out here on the sidewalk."

My fingers closed on the dog's collar. Almost instantly Tom started to back down the tree trunk.

"A reasonable suggestion," he remarked. "This being still wishes rest, but I find it a suitable vehicle."

Tom ambled without haste across the lawn, pushed through the swinging door of his special entrance cut into the big door. I turned loose the pup. I expected him to chase, but he had lost interest in cats. He remembered that he had a home. I didn't blame him. What it was like to be occupied I hope I never find out.

Well, that's it. Or almost it. Earth was invaded from outer space, and scarcely anybody even looked up. I did, of course. And presumably so did those other "aware beings" all

over the planet, contacted in solitude and gently heckled for a week or so. The whole episode was so matter-of-fact, so painless, that it didn't occur to me to make a big thing of it. I couldn't have, anyhow. I wouldn't have been able to demonstrate. I was the only contact hereabouts—so far as I'll ever know.

In spite of his occupier's last remark, Tom never said another word. When I got inside the house Uncle Jim was there, I had phone calls, then got an invitation out for the evening. I didn't see Tom alone until the next day, and by then he wasn't talking.

There was a final touch, though. Two weeks later, at a cattle show, it was. I dig fine cattle. I was with a crowd around a champion bull, and we were going over him point by point with a thoroughness that was a plain invasion of privacy. There was considerable discussion, anatomical and to the point.

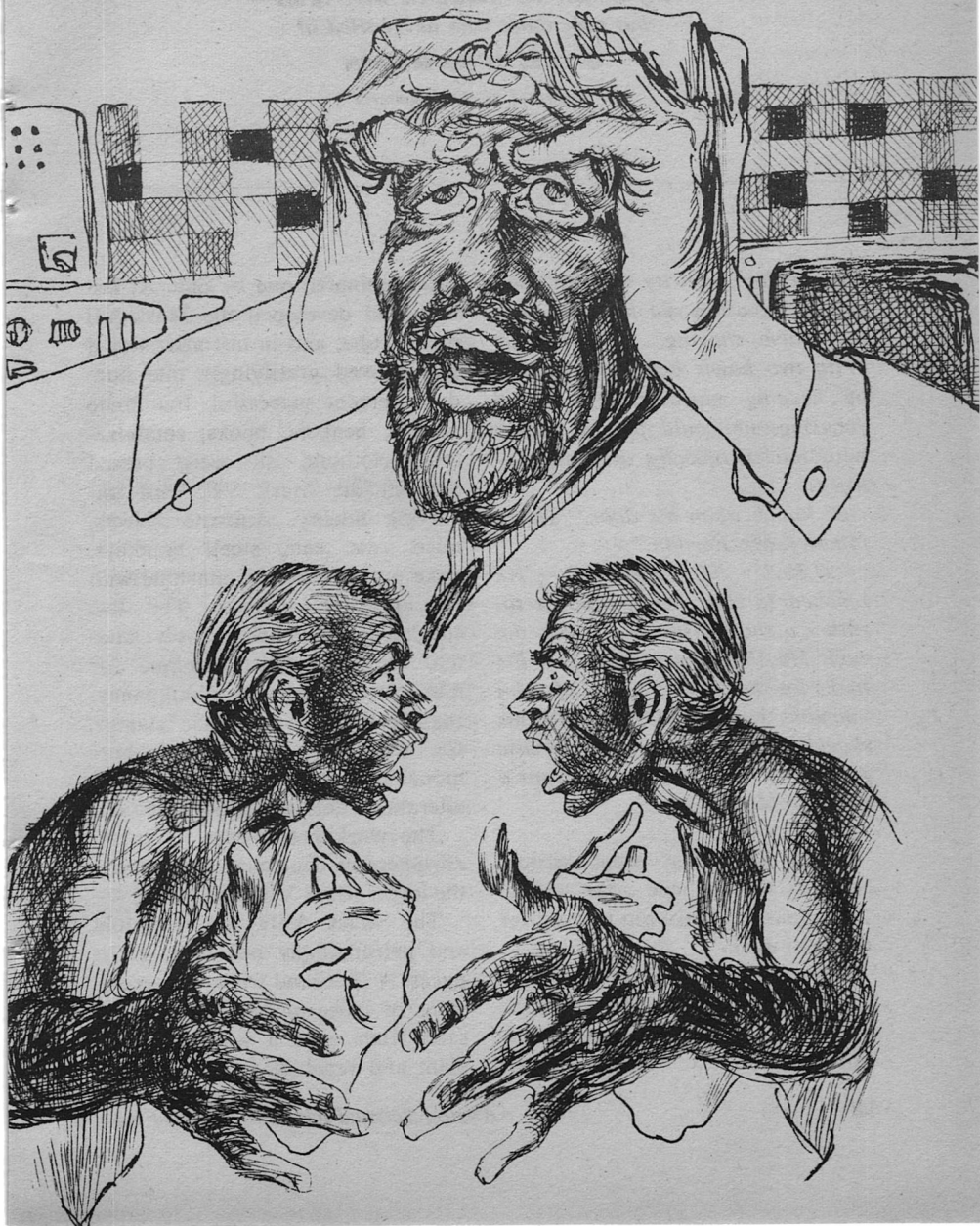
"If I were this fellow, I'd take exception to some of this," I said. "Lucky he can't talk back."

The bull turned his heavy head and looked at me. The big dark eyes glowed with intelligence.

"I wouldn't depend on that," he rumbled.

Naturally nobody thought it was the bull, but I knew. What a vehicle for a Libidian! ■

top billing



*Many a man has wished he were twins—
but only those who never tried it!*

JACK WODHAMS

Illustrated by Leo Summers

His peculiar capacity to mirror-image on occasion did have its uses. As when shaving, for example: With two bowls between him, and by keeping unwaveringly careful focusing, he could ply his razors with microscopically accurate delicacy.

A knock upon his door. "Thirty minutes, Mr. Farthin."

"O.K.," he answered. He reached to slide the two bowls together a short distance towards the wall. He then reached to pull his make-up boxes in front of him upon his special table. As with his shaving, the application of grease paint to his faces did not present a great problem.

Don't ask what went wrong. Nothing *should* have gone wrong. The apparatus had been tested over and over again.

Early faults in prototype machines had caused deformations and some weird disorganizations. But these troubles had been traced

and eliminated one by one. At last they had developed the Mark VII meter cube, and in test after test it had proved gratifyingly one hundred percent successful. Inanimate objects, beakers, books, small radios, clothing, all were passed through the Mark VII with unvarying fidelity. Animate objects, mice, rats, cats, small monkeys, were put through the machine with no apparent ill-effect. The live specimens were exhaustively studied, were minutely examined for the least anatomical discrepancy, the most minor metabolic change, for even the faintest of hormonal/chromosomal damage. No alteration could be found.

The work progressed. In an atmosphere of controlled enthusiasm, the larger Mark VIII was built.

The Mark VIII was lengthily and painstakingly put through its paces. A thousand trials with specimens of inorganic matter. A thousand trials with a wide range of plant and vegetable material. Two-

and-a-half thousand trials with mixtures, combinations and patterns. And finally, over four thousand experiments with a wide variety of animals, dogs, sheep, pigs, sometimes two or three together, sometimes with articles of cloth and wood and metal.

The process was perfect. No failure in any particular could be detected. The device was foolproof. The laws of correlation governed the order; selection out of natural sequence was impossible; misplacement, derangement, were impossible; to jumble the sequence was impossible.

At last there was only one crucial test to be made. The only danger that could exist, it seemed, was an abstract danger. If a man was to be subjected to the process, was it possible that a measure of harm, from a fractional to a total extent, would be done to his psyche? Was it possible that he might lose his sense of identity, be to a degree deprived in his mental awareness, his knowledge of being? Yes, there was that small possibility. That animals after could still perform the tricks that they had been taught before, did not necessarily imply that a higher order would suffer no impairment. However, it did suggest that the risk would be negligible. The only way to find out, of course, was for a man to replace the specimens and himself undergo a test series.

The general confidence of those

involved in the project assured that there was no lack of volunteers and, indeed, there was some competition for the prospective honor of being the first man ever to be conveyed ethereally from one point to another. In the event of so much willingness, lots were good-naturedly drawn to determine which of four specialists should have the considered privilege of historical mention.

The prize, if such it may be termed, was won by Professor Ian Allpenny.

Professor Ian Allpenny, with some difficulty, and in some confusion, struggled nudely out of the receiving congregator and, with that mirror-image facility that was to afford a crumb of utility at a later date, gazed at himself in shock. "Great Sassenach haggis," he chorused in consternation. "What in hell's happened here?"

He turned stunned faces to his colleagues and walked forward. "I can't see properly," he said, his steps and movements matching identically, "and I seem to be hearing an echo effect." He stood shoulder to shoulder and looked up at an amazed Professor Blumgaltz. "And," he added horrified, "I've shrunk!"

Blumgaltz looked from one to the other of him and could only murmur, "My God!"

"What's happened?" Ian asked again. "Your eyes are flickering in

a funny way and . . . you look . . . I've got double vision!"

"Ian, I . . ." Blumgaltz didn't know what to say.

Ian looked at himself again, reverse-switching his movements to uncannily exactly oppositely imitate each other. "Who's this? Look . . . I'm . . . This is crazy, I'm looking at myself! I'm looking at myself talking! I'm looking at myself like it was . . . Hey!" he wailed, "am I disembodied?" He turned back to Blumgaltz. "You *can* see me, can't you, Ernie? I haven't gone invisible, have I?" he pleaded, his four hands out in duplicate supplication. "Ernie, you do see me?"

"Yes. Yes. Oh, yes. I can see both of you quite well."

"Both of us?" An outstretched left hand touched an outstretched right. Ian gazed in unbelief. The fingers spread out against each other under even pressure, to be thumb to thumb, palm to palm. Then Ian snatched his hand back as though stung. He stared at himself, his jaws slack. "I've been divided." He shook his heads. "I've been turned into two me's."

"Yes, ah . . ." Blumgaltz flustered, recovering himself. "Yes, Ian, you . . . you . . . Huh-huh, quite remarkable. Yes, well, er . . . don't you worry. Um . . . probably just a . . . a . . . technical, ah . . ."

"Two of me." Ian could not take it in. "Two. But I'm me. I'm

still me. So how can . . .? Ernie? Frank?" His eyes bewilderedly sought elucidation from his friends. "What's going on?"

Frank stepped forward. His chin on his chest, his eyes dark behind his glasses, he looked very much the sober pragmatist that he was. "A fault, Ian, obviously. But it is a matter of interest and not, I should say, something to cause too much alarm. Doubtless we shall be able to correct the error, and I should say that you have no need to panic. If you keep calm, we shall try to discover the element that has been introduced."

"Keep calm?" Ian said. His two pairs of hands fluttered with mimical fidelity. "Oh yes, keep calm. It's all right for you. Two of me! How can there be two of me at once?" He looked about him fretfully. "Where's my dressing gown?"

Gregory, a junior assistant whose duty it had been to hold that garment ready, along with a pair of slippers, made haste to tender the covering.

Professor Ian Allpenny grabbed at the raiment—and in two seconds was yelling his heads off.

Ian's friends stood for a moment gaping in startlement at the writhing, kicking, struggling tangle that seemed almost instantly to develop at their feet. The overlarge dressing gown seemed in a jiff to wrap itself around Ian's bodies, tripping him,

tumbling him to the floor to frantically squirm in wild and total unco-ordination—or rather, in the negative co-ordination of competitive parity.

In snapping hurry they bent to aid and extricate Ian from his entanglement. It was no simple task. Ian flailed and gasped and hooted with all the strength of his dual vocal system.

At last they managed to unravel him, to persuade him to let go, to separate the tenacious interlocking clutch he had upon himself, and to draw him apart.

Ian shivered and babbled for a while, with his eyes squeezed shut. They hung on to him. Gradually he quietened, and tension eased from his limbs to leave him limp with fatigue.

Ian opened his eyes again—and yelped. “Oh, my God!” His eyes went glassy and he blinked, his faces stretching to maximally unplug his eyeballs in an effort to make sense of the jumble before him. “Yik!” He squeezed his eyes shut again. “Put me back! Put me back together!”

“We will, Ian, we will, just as soon as we can,” Blumgaltz soothed desperately. “Just try to keep calm, Ian.”

“No, no, put me back now!” Ian cried. “Put me back like I was!”

Blumgaltz was lost. “We will, Ian, just as soon as we’ve found what went wrong. We . . .”

“No, no, no,” Ian almost wept.

“Don’t keep me apart. I can’t make sense out of what I see. At least if I’m close and looking in the same direction . . .”

Frank Handie caught on. “He wants his bodies closer together. He’s doing everything double and doesn’t seem to know which one he is. Come on, let’s put them shoulder to shoulder like they were.”

This was done. Ian could not help whimpering involuntarily at the sensational discordance in balance and limb disposition as he was re-positioned once more alongside himself.

Blumgaltz fussed and was reluctant to release the hold that he had on his half. But Frank Handie took over. “Ian stand quietly now. Ernie, let go. Look, now, Ian, we have to evaluate this thing, right? We have to find out why this occurred, and see about setting up a reverse procedure. But we won’t be able to do that in two minutes, you can appreciate that, Ian?”

Ian was breathing hard. He still had his eyes shut. His heads nodded.

“Good. Now the thing is, not to get excited. It’s been a shock. It’s been a shock to all of us. And it has, of course, been a very great shock to you. Now let us take time out to cool down and make a practical assessment of the situation.”

Frank’s suggestion was a clinical one governed by a quickly aroused

scientific curiosity. However, it was a well-timed appeal to rationality that restored the research team to equilibrium, and earned a respite that happily prolonged into a probingly fruitful analysis of the phenomenon that had taken place.

Frank conducted the preliminary investigation. There was that in his matter-of-fact querying that did much for the moment to lessen the unreality of the scene. "Open your eyes and look at me, can you?"

Ian opened his eyes and looked at Frank.

"You see two of me?" Frank inquired.

"Yes. Like you're out of focus. Yet you're not."

"Hm-m-m. Will you raise your right hand?"

Ian raised his right hands.

"Uh huh. Will you count the fingers on your left hand?"

Ian counted the fingers on his left hands.

"How many fingers do you count on your left hand?"

"With thumb, five of course," Ian said.

"Good. Now, can you take a step forward? And now a step back? O.K." And Frank mused and squinted. "Can you move one left arm without moving the other one?"

"Uh?" Ian was nonplussed. "What are you talking about? If I move my left arm I move my left arm, don't I?"

"Uh, yes." Frank held his chin and peered. "But you can look at yourself, can't you?"

"Well, yes. Well, that's what it seems like." And Ian demonstrated promptly by inverting his reactions to turn and face himself.

"Intriguing," Frank said. "Now use your right arm."

Ian stood looking at himself and rapidly began to slide into paralysis. "I can't!" he said. "I can't! I . . . I . . . I don't know which one is my . . . my right . . . It's . . . It's . . ."

"Forget it," Frank said sharply, detecting a note of hysteria creeping back into Ian's voices. "Now, while you are facing yourself, move your arms about, just how you like. That's it."

As long as he did not have to *define* which side was which, Ian's desire for placement was automatic. His mind went from dizzy to blank as he tried to comprehend his incredible state of being. He looked and knew that he was seeing his counterpart, yet he *was* the counterpart, and the other was . . . It was so foolish, so ridiculous. As a reflection he copied himself, this arm, that arm, not knowing really which arm, stepping sideways, stepping back. Ian shrugged hopelessly and spread emulating arms. "It's . . . It's just crazy."

"It's fascinating," Frank commented, fascinated. "The sympathetic relationship that exists be-

tween left and right hemispheres, something allied to the observation that scratching the right wrist soothes an itch on the left. Ian, can you face front again? What I propose, and I think you will agree, Ernie, is that we get seating for Ian and go into this thing thoroughly. It might be a little while before we discover the means whereby Ian may be, ah, re-processed into singularity, and it would be well, I think, that he be given the opportunity to familiarize himself with his condition under circumstances that provide the least stress. What do you think, Ian?"

"I don't know," Ian said numbly. "I think you should get started and trace the fault as soon as possible. This . . . well, this is simply unnatural."

"Of course," Frank reassured. "We'll go through the equipment with a fine comb without delay, you know that. But it would be unwise to rush, wouldn't it? Temporarily you have no option but to stay as you are, you can realize that?"

"Yes, I think Frank's right," Blumgaltz said in a come-back attempt to re-assert his seniority. "You know that we'll do all we can. We'll get Roberts and his team to give us priority assistance. We'll go through the whole thing."

"And in the meantime you must have patience, Ian, eh?" Frank said. "After all, you're not in phys-

ical pain. It's strange, yes, but hardly likely to be irrevocable. Ha! It's just one of those things. You just have to be philosophical about it, try to reconcile yourself to it for a day or two."

"Yes," Blumgaltz put in. "Make the best of it, Ian, if you can. It's a novel experience. Yes indeed, most novel. We'll do everything we can for you, Ian, you can depend on that."

"Yes." Ian did not appear to be particularly cheered. "What I would like right now," he said, returning, as a human mind tends to, to essentials, "is clothes of some sort . . ."

"Five minutes, Mr. Farthin, Miss Nancy is here."

"Very good." He readied himself. He closed his eyes and shuffled closer to himself. "Come in."

Nancy entered. All was ready. Carefully she removed the center table top and contents, sorted out, tidied and stacked the various items. The Fabulous Farthin kept his eyes shut.

Nancy with a light touch re-arranged his bodies a little, set the seat belts precisely. "Now."

The Fabulous Farthin fastened the straps.

Nancy then depressed with her foot a lever that brought four wheels down to take the weight of the seated figures. "All right, Ian?" Nancy asked.

"O.K. Let's ah . . . what do they say . . . get this show on the road, huh?" Ian's tongues replied. And in stiff, self-imposed darkness he felt Nancy start the trolley into motion.

Sweat. Professor Ian Allpenny had never had cause to sweat so much and for so long—confusion, misjudgment, trial and error.

Some of the simpler things were learned the first day, but frustration, fatigue and mounting tension had brought him to the point of breakdown and nervous collapse. His state was one of vast immediate interest, but wise heads fortunately prevailed and prevented inundation by other members of the establishment as the word spread. It was in time that a sedative was prescribed and Professor Allpenny induced into a long recuperative slumber.

In the night that followed, the agitation and wonder of those associated in the matter diminished somewhat to permit them to make orderly and sensible assessment. Thus, while starting diligently to seek the original defect in the machine that had brought about the duplication, arrangements were made that on the morrow transferred Ian into the tightly secluded care of two of the firm's psychologists.

Ian became protected and guarded, and to Frank Handie was given the task of liaison between

the pursuers of cause and the students of effect.

Ian was weighed: 205 pounds—each part of him turning the scales at 102½ pounds. Ian was measured: 4 feet 0½ inches tall—1 foot 10¼ inches down from his singular 5 feet 10¾ inches. Comparable data for variation in his organs and bone structure involved intricate calculations that would take time to verify, but there was every indication that his volumetric proportion had been shared without disparity.

The prime and absorbing feature of his duality remained his inseparable motivational co-ordination. He thought, spoke and acted as one. His right little fingers curled together; his heads inclined together. In every gesture, in every twitch, the correspondence in movement was faithful beyond differentiation. His voices articulated in indivisible unison, his faces grimaced in indistinguishably matching concert. Except when, bafflingly, paradoxically, he chose to perfectly mime himself in reverse.

It was found that the position that caused Ian the least distress was one where he literally sat or stood beside himself. This oddly made him feel that he was a filling sandwiched between two invisible people. Of all his senses, vision occasioned him the greatest concern, and involuntarily he kept trying to adjust his focus. He rested his eyes whenever he could. The second

most unhappy consequence of his condition was his sense of balance, which could signal divergent responses if he found himself spongily traversing an uneven surface.

The third perplexing handicap, perhaps the most important but the first to be recognized to be a degree overcome, rested in his total inability to persuade one or other of him to perform independent action. Thus it was learned that for him to meet with any measure of success in attempting to clothe himself, twin garments had to be laid out as nearly as possible in identical order, upon identical benches, with foreground details and measurements coinciding as nearly as could be achieved. By such means Ian was able to dress and undress himself with seventy percent efficiency. He complained of fuzzy edges and, not being as intrinsically mated as himself, the folds in two like items of apparel did not always fall with convenient enough imitative accuracy.

Another large problem was eating. The most trouble-free way for Ian to be fed was intravenously, by tube. Ian, understandably, did not much care for taking nourishment in this manner. Spoonfeeding did not meet with his approval, either, and was not a markedly successful mode for him to imbibe victuals—two dissimilar servers of capricious approach and timing created a state of all-round hesitant ex-

pectancy that led to a mess that an eighteen-month-old babe would have been pressed to rival. The best partial solution was obtained by providing meals as squarely twin in design and placement as could be managed. Set before Ian upon a plain table, he would concentrate upon the components and give instructions for lateral movement and for circular motion, and his waiter would adjust the one plate to and fro and around until the best “focus” was achieved. The same would be done with the knife and fork. In this fashion Ian was able to take sustenance, and he could cope reasonably well with the minor discrepancies in size and consistency. He even learned how to pick up the “ghost” morsels that might have fallen off one fork but not from the other—it was rather peculiar having one of two mouths chewing vacantly, but then, what was there not peculiar about this business?

On his second night at the Center, after having spent a very trying day, Ian was able to sleep without the need for soporifics. However, jointly turning over in the bed that the company had made up for him, one of him overbalanced on the edge of the mattress and fell out. In no time his struggle to recover his position turned into a nightmare.

He tried to scramble up the side of the bed, clawed blankets, clawed nothing, reached, pushed with his

legs and thrashed, lunged, and fell back into the bed and at the same time fell out the other side.

Bruised, dizzy, a dim light affording cancelling superimposition, he tried to get to his feet, tottered on the soft mattress and flung himself backwards, to crash and send flying a side table and chair and a litter of oddments, to crash mostly on mattress and bounce all twisted.

Ian howled. He rolled on to hands and knees, weaved forward a little way across the floor—and fell off the bed again.

This was all extremely upsetting and Ian classically embraced the firmness of the floor and, eyes squeezed shut, yelled and yelled for help.

Due to the noise, aid was already well on its way.

It was after this contretemps that they hit upon the notion to set up two small identically furnished "rooms." Ian liked it, and didn't like it. To him it hinted strongly that a protracted stay was being contemplated.

Nancy was dismayed. Although forewarned and prepared by what would seem to be adequately detailed description, the actual sight of the change in her husband still came as a severe shock.

"Oh, Ian," she said, her eyes roving widely back and forth between the two Ians presented. "Oh, Ian, what have they done to you?"

"Nance, darling." Ian looked at his loved one with yearning. "I'm so glad you came." His impulse was natural; he stepped to take her into his arms.

"No, Ian!" Frank called.

Frank was too late. On opposite track, Ian converged with himself, pressed elbow to elbow, hip to hip, lurched and staggered.

Ian whirled on himself. "Will you leave me alone? Why don't you go away?" he shouted. His jaws belligerently thrust, he crouched angrily eyeball-to-eyeball with himself. "Why don't you go to hell!"

"Ian!" Frank protested, coming forward. "Take it easy, Ian."

"He's a menace." Ian turned to face him. "It's all right for you," he snarled, "but I've had enough. I can't even kiss my own wife. Do you know what that means?"

Frank had not thought it a good idea to introduce Nancy to the facts. He had preferred to ascribe Ian's absence from home to his deep involvement in the continuity of an important experiment. But Ian had been insistent. As Frank had foreseen, the occasion was less palliating than aggravating.

"Ian, it takes time. You must be patient. We're on the track of the breakdown. I'm sure that it won't be long before we can reconstitute you back into one again."

"Hah!" Ian stamped. "Can't even help myself. Yes. Yes, all right, I know. O.K., I know that."

But it's so restrictive all the time. I can't go out; I have to be nurse-maided." He stuck his hands into his pockets. "On the other hand, I'm getting used to it and it frightens me."

"We are aware of the terrific strain you're under, Ian, believe me. We . . ."

"Nuts," Ian said. "Sure there's stress, but if a man doesn't go insane he gets bludgeoned into accepting the reality and he adapts, even against his will. A man can't help thinking out the problems that have to be solved if he is to survive in any comfort. Look." He walked, left-right, right-left, between two chairs. An open left palm caught the back of a chair. The palm tilted the chair slightly till an open right palm contacted the back of the second chair. Ian then shoved, overturning both chairs onto their sides.

Ian squinted down at the upset seats. "Now watch this," he said. "It's an example of human resilience and how we learn to overcome." He bent. "I see two chairs at different angles, so"—one hand reached wrong, one hand reached right—"I grip one and stand it up. See?" He performed dual actions to raise one chair. "It's damned queer picking up a chair and seeing a chair still there. But one set of eyes must go out of focus a bit, and already I'm getting the knack of what allowance to make and what to reject."

Carefully moving to avoid both chairs, he bent again doubly to pick up and place the second chair. "It's an adjustment of images," he said. "Perhaps it's like the guy who wore inverting glasses—after a few days his brain turned the picture right-side up. I can see better now, especially if I concentrate on a fixed object."

"But Ian, you're not going to stay like that, are you?" Nancy appealed. "I mean . . . Oh Ian, what did you do it for?"

"I didn't do it on purpose, did I? It was an accident. Nance, try and understand. I don't *want* to be like this, and the sooner I can get back to normal the better I'll be pleased."

"When will that be, Ian?"

"As soon as we've pinpointed the trouble and have devised a way to reverse it," Frank said. "We are hopeful that it won't be long now."

Nancy gazed at Ian. "Oh Ian, what can I do?" Pygmy twins, absurd and tragic, she felt tears pricking her eyes and she wanted to gather him to her but did not know how. "Is there anything I can do?"

"Don't cry, Nance, please don't cry," Ian pleaded. "But if . . . if you could just stay around, be with me, be near. I . . . I've missed you. The setup here is O.K. but, well . . . it's not like home."

"Of course." Hurt, compassion, timidity, all were in her tremulous smile. "I'll do anything I can."

"Great," Ian said. And added with overly cheerful confidence, "It won't be for very long . . ."

They waited in the wings for his cue. The Fabulous Farthin, Ian thought, and pinched his underlips in musing amusement. So it wouldn't last forever. Sooner or later they would strike the combination, find a means of blending his consistency in sequence and so get Humpty back singularly and complete into his full-scale shell. In the meantime, an offer was an offer, and an opportunity was an opportunity. It was best to grab it while he could. His choice was limited and a bawbee was a bawbee. He could make more in ten minutes as the Fabulous Farthin than Professor Ian Allpenny could make in ten years . . .

"After eliminating everything else, it just *had* to be in the transfer relay." Frank spoke from a two-way closed circuit TV console. He looked pleased with himself.

Ian stared back into the sets. "And was at a high-frequency short circuit like I said?"

"Yes and no," Frank answered. "What we have found is the presence of air in the scanfix recorder tubing. It must be leaking, but damned if we can find where. Anyway, it's caused an oxidizing film to form the faintest insulation on a polar alignment across the center of the recorder contact. It appears

that the information current has been infinitesimally separated at the node to jointly impinge a double impression on the reading sensor. From there it's been picked up by the checking system, and it seems that our own precautions against such a mishap have inadvertently assured that rectification from then on is impossible."

Ian brightened. "A deliberately arranged synchronized feedback, then, should give us a mated code that could be fed straight through for reconstitution in the secondary receiver?"

"We're working on it, Ian, we're working on it," Frank said genially. "We didn't want to raise your hopes without some warranty, but I can tell you now that the results we've been getting are very promising."

"You've run tests?"

"A few. Of course, we'll have to run a lot more before we can be absolutely certain that the technique is one hundred percent safe, but I'm sure that before long we'll be able to reassemble you into your one proper being."

"How long?"

"A couple more weeks or so, that's all."

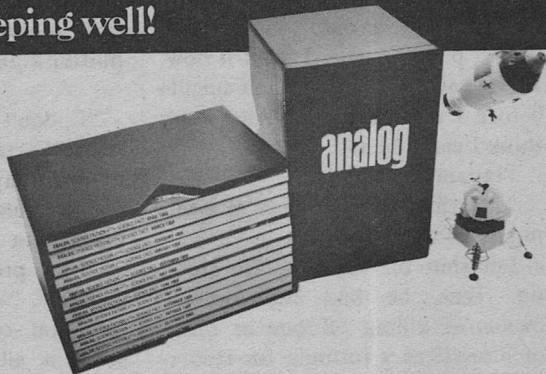
"That's all!" Ian echoed. "Look, Frank, if it works it works. If it works now, I want it now. If it works now, the risk has to be negligible, and it's a risk I'm prepared to take."

Frank's affability faded some-

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what. "You must be patient, Ian. We must make certain that we can control and achieve exactly the effect we require."

"To hell with that," Ian snorted. "I'm virtually a prisoner, a blasted freak. I'm tired of it. And I want my wife. What kind of life is it for Nance? We've got to think of her, too, remember. Oh sure, she says she doesn't mind and seems to be accustomed to it—she's great."

"Ian, be reasonable. You know very well that it is unwise to try and rush these things. Some of the animals we have twinned have died, and others have gone mad. Those live ones we have been able to pull through have yet to be be-

haviorally evaluated and thoroughly assessed constitutionally."

"That's so much crud and you know it," Ian declared. "If you've got them back together and there's something wrong with them, it may be years or never before you can eliminate the discrepancies. Frank, I've had enough. Noel and Bret are too damned interested in me. They're treating me like a pet project. They're on a telekinesis kick now and they've had me picking up weights all day. I tell you, they're too enthusiastic. I want out. I've had enough. If the thing works, it works, and I want to be the very next subject."

"Now, Ian, don't be precipitate,"

Frank said solemnly. "We can't allow . . ."

"I want to be one!" Ian bawled. "If it's possible now, I want it now. Do I have to commit half-suicide before I can be alone? And don't think I can't do it!"

"Ian, now wait . . ."

"I'm tired of waiting. I'm coming down there now."

Ian shut off the sets. He stood up. True, he had contemplated means of killing off one or other of himself as a formula for resolving his difficulty, but only as a scientist considering all angles. The thought of actually attempting such a thing he found to be repugnant in the extreme, plus there was the legal aspect to reflect upon in the aftermath, a formidable poser indeed. But Ian felt justified in employing the threat as a lever to gain what he wanted. His training and experience argued small odds against the benefits likely to be won by dilatoriness.

Ian walked to the doors of his rooms; opened them; stepped out. He turned to face himself. He strode towards himself. It was always easier to move when he had himself as a focal point. He matched himself shoulder to shoulder.

He walked down the middle of the passageway, down the middle of the steps, across a hallway. His right hands reached for a doorknob—one twisted emptily, the other opened the door. He

stepped through and out, and with precision marched over to the lab that housed the research transmitting equipment.

"I don't like this," Blumgalt said. "Certainly it works, but two or three days experimentation does not warrant direct human application. Ian . . ."

"I am prepared," Ian replied obstinately. "Your diffidence and observation of the professional niceties is all very well. But this is *my* life. I volunteered in the first place, with consequences only too apparent. You were exonerated from all blame and I solely bore responsibility in the event of disaster. Now I volunteer again on the same understanding, that the damage might be repaired."

Frank interposed, "But Ian you . . ."

"No," Ian said firmly. "We calculated the danger in the first exchange. I was the candidate chosen to make the venture; I was fully aware that I could claim no redress in the face of unexpected contingencies." He tilted his chin and challenged them aggressively. "I assumed my right then to permit my body to be used in a necessary step to advance knowledge. And I assume and demand such a right now, that an attempt be made at my complete restoration—for science, for our company, for"—he was not above stretching the truth—"the important, personal

well-being of myself. I," his faces revealed poignant agonized determination, "just can't go on like this. I . . . I'm at the end. You must revert me. As friends, as colleagues, for my sanity. Can you force me to wait an age, a day, an hour? Can you watch me break down into a wreck while you painstakingly double check every sample corpuscle and molecule? You know that the element you fear is indeterminable without a human volunteer. With myself as I am, in the name of humanity you cannot refuse the patent need of a man you have worked with, shared with, known and, I hope, respected."

Ian's passion would have touched harder and less curious minds than those he debated in this matter.

They conferred. They expressed doubt, they quoted precedence and rules. They raised half-hearted excuses, gave unwanted counsel and, inevitably, at last acceded to Professor Ian Allpenny's demands.

Ian was, as it turned out, somewhat hasty.

way, Ian thought, and now he would have patience, even if it killed him.

He got his cue and out he started before an audience and cameras, a trouper, dancing and singing. With all the drawbacks of his condition he did not lack the perception to find ironic humor in the thought of himself, a professor, clumsily footing the boards with impromptu steps of dubious aesthetic value, and singing with vocal chords that in the past had oft invited sarcasm. But now he was more than one and, no matter what his spontaneously unorthodox step or his spur-of-the-moment change of word or pitch, what he did was done unitedly, meticulously self-mimed to the last trip and quaver. He had an astonishingly faultless co-ordination that was simply marvelous to see and hear.

Out he went onto the stage, a one-man chorus.

"And here they are!" the announcer cried, giving him to the world. "Thirty-three inches high and brought live to you in TeeVe-Vaudville—ladies and gentlemen—The Fabulous Farthin Quartet!" ■

We learn our lessons the hard

APRIL 1970 *continued from page 33*

1. . . . Quiet Village	David McDaniel	3.08
2. . . . Here, There Be Witches	Everett B. Cole	3.13
3. . . . The Siren Stars (Pt. 2)	Richard and Nancy Carrigan	3.16
4. . . . The Life Preservers	Hank Dempsey	3.43
5. . . . Seed Stock	Frank Herbert	3.48
6. . . . Come You Nigh: Kay Shuns	Lawrence A. Perkins	4.36



Star Light

Conclusion. Exploration of a strange world, like Science, depends for success on free interchange of all available information. When one group starts trying to hold out information—things can get very sticky indeed!

HAL CLEMENT

Illustrated by Kelly Freas



Dhrawn is the star/planet companion of Lalande 21185, a red dwarf sun half a dozen light-years from the solar system. It has been bothering the cosmologists and planetologists. In terms of mass, it is on the borderline between typical Jovian planet and extreme dwarf star; in terms of composition, it seems to be as nearly destitute of light elements as Earth, or Venus. It is generating internal energy; its sun could not warm it above a few tens of degrees Kelvin, but there are local regions as hot as 1200° K. The atmosphere contains free oxygen, although the oceans (?) contain not only water but ammonia—a chemically unstable situation leading to the presumption that Dhrawn has active life.

Direct exploration is impossible for human beings because of the forty-Earth surface gravity. It has been decided to hire natives of Mesklin, the variable-G planet of 61 Cygni A, to do the work. BARLENNAN, the Mesklinite sea captain who had worked with non-Mesklinite researchers on his own world fifty Earth years before, jumps at the offer—with unmentioned ideas of his own in connection with the deal. A Mesklin-conditioned settlement is established on Dhrawn, and a dozen exploring vehicles to be manned by the Mesklinites are designed and built.

One of these, the Kwembly, is commanded by DONDRAGMER, Barlennan's first officer in the old

days when they were carrying alien instruments around their own planet. One of the Kwembly's helmsmen is a young sailor named BEETCHERMARLF.

The surface work is being monitored from a station manned principally by human beings, in synchronous orbit six million miles from the planet. Its chief administrator is ALAN AUCOIN, who has a basic, though fairly well hidden, distrust of nonhuman beings. His staff includes ELISE RICH HOFFMAN—"EASY"—who functions as interpreter with the Mesklinites, and general spreader of oil on troubled waters; and her husband IB HOFFMAN. Their seventeen-year-old son BENJ is also at the station, serving an apprenticeship in the aerology laboratory. Like his mother, Benj is an excellent natural linguist and can talk directly with the Mesklinites.

A distrust has been developing between human and Mesklinite leaders, partly because of Aucoin's attitude and partly from Barlennan's underhanded activities. Even though field communication between the settlement on Dhrawn and the land-cruisers has to be relayed through the human station, Barlennan has been working to establish another settlement independent of, and unknown to, the human beings. Toward this end he has arranged the "loss" of the land-cruiser Esket and the disappearance of her crew. The Esket is being

used as the nucleus of the new settlement, at which mining and other activities leading toward local self-sufficiency are being carried on.

Now, however, genuine troubles are developing. The complex phase relationships between water and ammonia have been outwitting the human aerologists and their computers, and Dondragmer's Kwembly has been washed down a river formed by a suddenly melting "snow" field, grounded, damaged, partly repaired, and finally frozen in. Beetchermarlf and a companion have been trapped under the cruiser by the ice; another officer, KERVENSER, has disappeared in one of the tiny scout helicopters carried by the Kwembly.

The human beings get into a sharp disagreement because of the Kwembly situation. Aucoin, as in the Esket incident previously, is reluctant to authorize a rescue trip by one of the other cruisers—though he realized that if Barlennan wants to do this there is no way to stop him. The elder Hoffmans want the whole decision left up to Barlennan, with any help whatever which he may ask—including rescue from space—to be furnished from the station. They resent Aucoin's policy of editing, or actually censoring, the reports between Dondragmer and Barlennan. Benj, who has formed a close radio friendship with Beetchermarlf, considers only the personal aspects of the problem, but is

deeply upset by these. A staff discussion, kept from becoming a major brawl by Easy's professional tact, leads to only one result: Ib Hoffman, hearing for the first time a real summary of the relevant facts, begins to realize that Barlennan really is up to something on his own.

Beetchermarlf and his companion, caught in the shrinking volume of free liquid under the Kwembly's hull, spend hours in futile efforts to dig, scrape, and melt themselves free. They finally take refuge in one of the air cells forming the "mattress" underpinning between the hull and the driving trucks—incidentally concealing themselves very effectively from possible rescuers. Their own supply of breathing hydrogen, while not yet critically low, is causing them and the distant Benj more and more concern.

The human assistance to the Kwembly finally concentrates on technical advice, and some of the cruiser's equipment is dismantled to improvise a heater. Dondragmer is reluctant to take this step, fully aware of the Mesklinite position with regard to replacing or repairing, the equipment—but it seems the least of a host of evils.

At the Settlement, Barlennan and his staff have come to suspect that the human beings have not been entirely frank with their Mesklinite agents. Barlennan does not resent this, since he has been ex-

tremely deceitful himself and regards such things as matters of business acumen; but he decides that he should set up a test situation to find out how truthful the men are being, using the Esket as bait. He is about to send a message containing the arrangements by one of the dirigibles which the Mesklinites have improvised from homemade balloons and human-supplied power units. At this point, however, a message arrives from the orbiting station reporting a disturbance at the site where the Esket was lost. Barlennan is left wondering whether something is really happening at his secret base there, or whether the human beings are testing him.

At the Kwembly, Dondragmer is growing more and more concerned about the possibility of another flood, and keeps asking for risk estimates from the human scientists. If such a thing happens, his command is likely to be a total loss. He is considering moving the trapped vessel's life-support equipment to high ground, to insure his crew's survival. He also has his other helicopter out, carrying one of the television sets which transmit to the human station. The pilot is looking for Kervenser as well as for signs of another flood.

When the human watchers report that this set has also ceased sending, it does not occur to Dondragmer that the report might be false; but he is annoyed. He sup-

poses that the pilot shuttered the set to keep the human beings from seeing something which would betray Barlennan's machinations, such as a wandering dirigible; and unlike most of the Mesklinite staff, he has never been in very close sympathy with Barlennan's policy of trickery.

Dondragmer sends out a ground party to check the situation and restore his flood-guard, neither knowing nor greatly caring what Barlennan may know or think about the matter. This group is also carrying a vision set; and a short distance upstream it meets a Mesklinite on foot. Easy, watching the screen, assumes at first that it is either the missing Kervenser or the second pilot; but then she recognizes KABREMM, whom she knew well—and had assumed lost with the crew of the Esket.

At this point Barlennan, Dondragmer, the human watchers, and the ground search party—including Kabremm—have incomplete and conflicting pictures of the situation. Only the human beings are in direct touch with any of the other groups. Kabremm is horrified at having allowed himself to be recognized and thereby compromising Barlennan's plan; the human beings are theorizing about possible natives of Dhrawn who must have captured the Esket's crew months before; Barlennan is trying to decide how much to believe of what he hears from the human station;

XIII

and Dondragmer, mainly concerned with his vehicle and crew, is more annoyed at the confusion caused, he feels, by his commander's trickery, than anything else. He has now melted his way under the Kwembly's hull and is about to search for the missing Beetchermarlf when he is interrupted by sounds coming from across the ice. Benj, watching on one of the vision sets, knows only that the captain has been distracted; he cannot tell what is going on.

The result is that considerable communication back and forth from the human station to Dondragmer at the Kwembly and from humans to Barlennan at the Settlement has managed to confuse issues quite thoroughly. Barlennan is now trying to explain Kabremm's appearance on the basis of a possible Dhrawn native tribe, capture and escape. Dondragmer prefers to talk about anything else, and work at getting the Kwembly in action, while Aucoin wants to keep Barlennan from deciding to send another cruiser to the Kwembly's rescue.

Clarification of the situation is progressing at a very high negative rate.

Dondragmer, inherently the most straightforward of the group, has the best understanding of what's going on—but out of loyalty to Barlennan and the necessity of relaying through the human station, can't explain.

Barlennan was quite pleased with his speech. He had not told a single actual falsehood—the worst he could be accused of was fuzzy thinking. Unless some human beings were already actively suspicious, there would be no reason for them not to pass on the “theory” to the Kwembly's captain, thus telling him the line that Barlennan proposed to follow. Dondragmer could be trusted to play up properly, especially if the hint that Kabremm might not be available for further questioning were transmitted to him. It was too bad, in a way, to spring the “native menace” so long before he had meant to—it would have been much nicer to let the human beings invent it for themselves; but any plan which couldn't be modified to suit new circumstances was a poor plan, Barlennan told himself.

Aucoin was taken very much aback. He had personally had no doubt whatever that Easy was mistaken, since he had long ago written the *Esket* completely off in his own mind, and Barlennan's taking her opinion seriously had been a bad jolt. The administrator knew that Easy was by far the best qualified person in the station to make such a recognition; he had not, however, expected the Mesklinites themselves to be aware of this. He

blamed himself for not paying much more attention to the casual conversation between human observers, especially Easy, and the Mesklinites over the past few months. He had let himself get out of touch, a cardinal administrative sin.

He could see no reason for denying Barlennan's request, however. He glanced at the others. Easy and Mersereau were looking expectantly at him, the woman with her hand on the microphone selector in her chair arm as though about to call Dondragmer. Her husband had a half-smile on his face which puzzled Aucoin slightly for a moment, but as their eyes met Hoffman nodded as though he had been analyzing the Mesklinite's theory and found it reasonable. The planner hesitated a moment longer, then spoke into his microphone.

"We'll do that right away, Commander." He nodded to Easy, who promptly changed her selector switch and began talking. Benj returned just as she started, obviously bursting with information, but he restrained himself when he saw that a conversation with the *Kwembly* was already in progress. His father watched the boy as Easy relayed the Barlennan theory, and had some difficulty in concealing his amusement. It was so obvious that Benj was swallowing the idea whole. Well, he was young, and several of his elders seemed a bit uncritical, too.

"Barlennan wants your thoughts on this possibility, and especially any more information you may have obtained from Kabremm," concluded Easy. "That's all . . . no, wait." Benj had caught her attention. "My son has come back from the aerology lab, and seems to have something for you."

"Mr. McDevitt has made one run with the new measures added to the earlier data, and is making a second now," Benj said without preamble. "According to the first, he was right about the reason for the melting and freezing of your lake, and the nature of the clouds which Stakendee has encountered. The chances are better than even that condensation from these will increase, and make the stream near you bigger. He suggests that you check very carefully, as he mentioned before, the time the clouds reach the *Kwembly*. As he guessed, they are evaporating from adiabatic heating as the air carrying them comes down the ground slope. He says that the later they are in getting to you, the worse the flood will be when *it* does. I don't see why myself, but that's what the computer implies. He said to be sure to remind you that this was just another tentative calculation, just as likely to be wrong as any of the earlier ones. He went into a long speech about all the reasons he couldn't be sure, but you've heard them already."

Dondragmer's answer com-

menced almost on the light-echo; he could not have spent more than a second or two after the end of Benj's report in deciding what to say.

"Very well, Benj. Please tell Barlennan that his idea sounds reasonable, and at least fits in with the disappearance of my two fliers. I have had no opportunity to get information from Kabremm, if it really was he; I haven't seen him. He hasn't come back to the *Kwembly*. You could tell better than I whether he's still with Stakeendee and those who went upstream. I will take precautions on the assumption that the commander is right. If the idea had occurred to me earlier, I certainly would not have sent out practically my entire crew to set up the safety base at the side of the valley.

"However, it may be just as well I did. I see no possibility of freeing the cruiser in any reasonable time, and if Mr. McDevitt is even moderately sure that another flood is on the way we'll have to finish moving out shortly. If a current anything like the one that brought us here hits the *Kwembly* while she's fastened down like this, there'll be pieces of hull scattered for a million cables downstream. When my men come back we'll take one more load of necessary equipment and abandon the ship for the time being. We'll set up on the valley rim, and, as soon as life-support equipment is running adequately

there, I'll start sending crews back here to work on freeing the *Kwembly*—provided the flood isn't obviously on the way. That's a firm basic plan; I'll work out details for covering the work crews with your assistance, and if Barlennan's theory calls for special action I'll take it, but I haven't time to argue the basic decision. I can see moving lights to the north; I assume it's my crew on the way back. I'll turn the set so that you can see them."

The view on the screen wavered, then panned jerkily as the captain nudged the transmitter box through a third of a circle. The result was no improvement, from the human viewpoint; the lighted region around the *Kwembly* where details could not only be seen but compared and interpreted, was replaced by almost total darkness relieved by a few specks of light. It took close, careful watching to confirm Dondragmer's claim that they were moving. Easy was about to ask that the lens be returned to its former position when Benj began talking.

"You mean you've given up all hope of finding Beetchermarlf and Takoorch and the others, and are just going off and leaving them there? I know you have nearly a hundred other people to worry about, but there are times when that seems a pretty thin excuse for not even trying to rescue someone!"

Easy was startled and rather dismayed at her son's choice of words, and almost cut in with a combined rebuke to the boy and apology to Dondragmer. She hesitated, however, in the effort to find words which would do this without doing violence to her own feelings; these bore a strong resemblance to Benj's.

Aucoin and Mersereau had not followed the exchange at all closely, since both were concentrating on Barlennan on the other screen and Benj had uttered his tirade in Stennish. Ib Hoffman showed no expression which the casual observer could have translated, though Easy might have detected traces of amusement if she had been looking at him. McDevitt had just come in, but was too late to catch anything except Easy's facial expression.

The pause went overtime, so they waited for Dondragmer's answer. This revealed no annoyance in tone or choice of words; Easy wished she could see him to judge his body attitude.

"I haven't given them up, Benj. The equipment we plan to take includes as many power units as possible, which means that men will have to go under the hull with lights to get as many of them as they can from the unfrozen trucks. Those men will also have orders to search the ice walls carefully for traces of the helmsmen. If they are found, men will be assigned to chip

them out, and I will leave those men on the job until the last possible instant. However, I can't justify putting the entire crew to work breaking ice until there is nothing else to be done to get the cruiser free. After all, it is perfectly possible that they discovered what was going on before the pond froze to the bottom, and were trapped while looking for a hole in the ice somewhere else in the pond."

Benj nodded, his face somewhat red; Easy spared him the need of composing a verbal apology.

"Thanks, Captain," she said. "We understand. We weren't seriously accusing you of desertion; it was an unfortunate choice of words. Do you suppose you could aim the communicator back at the lighted space? We really can't see anything recognizable the way it's pointed now."

"Also," McDevitt cut in without allowing a pause to develop at the end of Easy's request, "even though you are planning to leave the *Kwembly*, do you suppose you could leave a power unit on board to run the lights, and lash the bridge communicator about where it is so we can see the hull? That would not only let us observe the flood if it comes, which I'm almost certain it will in the next three to fifteen hours, but would also give us a chance to tell you whether there was any use looking for the cruiser afterward—and possibly even *where* to look for it. I know

that will leave you with only two communicators, but it seems to me that this would be worth it."

Again, Dondragmer appeared to make up his mind on the spot; his answer emerged from the speaker almost with the sixty-four second bell.

"Yes, we'll do it that way. I would have had to leave light power anyway, since I wanted crews to come back for work; and as I said, I wanted some sort of safety communication with them. Your suggestion fits that perfectly. I've turned the set back to cover the starboard side, as you no doubt see. I must leave the bridge now; the crew will be back in a minute or two, and I want to assign duties to them as they arrive."

Again, Benj began talking without checking with anyone else.

"Captain, if you're still in hearing when this gets to you, will you wave or signal some way, or have Beetch do it, if you find him alive? I won't ask you to make a special trip back to the bridge to give details."

There was no answer. Presumably Dondragmer had suited up and gone outside the moment he finished speaking. There was nothing for the human beings to do but wait.

Aucoin, with Easy's assistance, had relayed Dondragmer's answer to the Settlement, and received Barlennan's acknowledgment. The

commander asked that he be kept up to date as completely as possible on *Kwembly* matters, and especially on any ideas which Dondragmer might have. Aucoin agreed, asked Easy to relay the request to the captain, and was told that this would be done as soon as the latter reestablished contact.

"All right," nodded the planner. "At least, there's been no mention so far of sending a rescue vehicle. We'll leave well enough alone."

"Personally," retorted Easy, "I'd have dispatched the *Kaliff* or the *Hoorsh* hours ago, when they first froze in."

"I know you would. I'm very thankful that your particular brand of ethics won't let you suggest it to Barlennan over my objections. My only hope is that he won't decide to suggest it himself, because every time I've had both of you really against me I've been talked down." Easy looked at Aucoin, and then at the microphone, speculatively. Her husband decided that distraction was in order, and cut into the thickening silence with a question.

"Alan, what do you think of that theory of Barlennan's?"

Aucoin frowned. He and Easy both knew perfectly well why Ib had interrupted, but the question itself was hard to ignore; and Easy, at least, recognized that the interruption itself was a good idea.

"It's a fascinating idea," the planner said slowly, "but I can't say that I think it very probable.

Dhrawn is a huge planet, if it can be called a planet, and it seems funny . . . well, I don't know whether it seems funnier that we'd have met intelligence so quickly, or that only one of the cruisers has done so. There certainly isn't a culture using electromagnetic energy—we'd have detected it when we first approached the place. A much lower one . . . well, how could they have done what seems to have been done to the *Esket's* crew?"

"Not knowing their physical and mental capabilities, quite aside from their cultural level, I couldn't even guess," replied Hoffman. "Didn't some of the first Indians Columbus met wind up in Spain?"

"I think you're stretching resemblances, to put it mildly. There's a practical infinity of things which could have happened to the *Esket* without her running into intelligent opposition. You know that as well as I do; you helped make up some of the lists, until you decided it was pointless speculation. I grant that Barlennan's theory is a little bit more believable than it was, but only a very little."

"You still think I was wrong in my identification of Kabremm, don't you?" said Easy.

"Yes, I'm afraid I do. Furthermore, I just don't believe that we've run into another intelligent species—and don't compare me with the people who refused to believe that dePerthe's rocks were man-

made tools. Some things are just intrinsically improbable."

Hoffman chuckled. "Human ability to judge likelihood—you might call it statistical insight—has always been pretty shaky," he pointed out, "even if you skip purely classical examples like Lois Lane. Actually, the chances don't seem to be that low. You know as well as I do that in the very small volume of space within five parsecs of Sol, with only seventy-four known stars and about two hundred sunless planets, what we have found in the way of intelligence. Twenty races at about our own stage of development, safely past their Energy Crisis; eight, including Tenebra and Mesklin, which haven't met it yet; eight which failed to pass it and are extinct, and three which failed but have some hope of recovery—every one of them, remember, within a hundred thousand years of that key point in their history, one way or the other! That's in spite of the fact that the planets range in age from Panesh's nine billion years or so to Tenebra's maybe a tenth of that. There's more than coincidence there, Alan."

"Maybe Panesh and Earth and the older planets have had other cultures in the past—maybe it happens to any world every few tens of millions of years."

"It hasn't happened before unless the earlier intelligent races were so intelligent from the beginning that

they never tapped their planet's fossil fuels. Do you think man's presence on Earth won't be geologically obvious a billion years from now, with looted coal seams and the beer bottle as an index fossil? I can't buy that one, Alan."

"Maybe not, but I'm not mystical enough to believe that some super-species is herding the races of this part of space toward one big climax."

"Whether you like that Demon Hypothesis, or prefer the Esfa Theory, doesn't matter. There's certainly more than chance involved, and, therefore, you can't use the laws of chance alone to criticize what Barlennan has suggested. You don't have to assume he's right, but I strongly urge you to take him seriously. I do."

Dondragmer would have been interested in hearing this discussion, just as he would have appreciated attending the staff meeting of some hours before. However, he would have been too busy for either, even if attendance had been physically possible. With the return of most of his crew—some, of course, had stayed behind to continue setting up the life-support equipment—there was much to oversee and quite a lot to do himself. Twenty of his men were set to helping the trio already chipping ice from the main lock. As many more went under the hull with lights and tools to find and

secure any power units not too solidly frozen in.

The captain kept his promise to Benj, ordering this group to check most carefully for signs of Beetchermarlf and Takoorch. However, he emphasized the importance of examining the ice walls closely, and as a natural result the group found nothing. Its members emerged in a few minutes with the two power boxes from the trucks which the helmsmen had used, and two more which had been freed by the action of the heater. The rest, which according to Dondragmer's recollection and the laws of arithmetic must number six, were unapproachable, even though the sailors could make a reasonably well founded guess as to which trucks they were on.

Meantime, the rest of the crew had been entering the cruiser by the available locks—the small one at the bridge, the larger ones through which the fliers were launched, and the pairs of one-man-at-a-time emergency traps at the sides near bow and stern. Once inside, each crewman set about an assigned job; Dondragmer had been thinking as well as talking to human beings during their absence. Some packed food to last until the life-support equipment resumed cycling normally; others readied coils of rope, lights, power units, and other equipment for transportation.

Many were at work improvising

carrying devices; one awkward result of the *Kwembly's* being fusion-powered was a great shortage of wheels aboard. There were tiny pulleys carrying the control cables around corners, but not only were these too small for wheelbarrows, or similar devices, but Dondragmer had firmly forbidden anything resembling dismantling of the vehicle. There was nothing resembling a fork-lift or even a dolly aboard. Such devices—the former variety muscle-powered, of course—were known and used on Mesklin for medium-to-long-distance carrying; but there was literally nothing on the *Kwembly* which could be moved at all which a Mesklinite could not easily carry to any part of the vehicle without such assistance. Now, with a distance of miles facing them and the necessity of moving many items complete rather than in pieces, improvisation was in order. Litters and travois were making their appearance. The corridors leading to the main lock were rapidly being stacked with supplies and equipment awaiting the freeing of the exit.

None of the bustle and thumping, however, penetrated the mattress where Beetchermarlf and Takoorch still lay concealed. As nearly as could be judged later, they must have sought this shelter within a very few minutes of the time the resistance heater went into action. The thick, rubbery material of the mattress itself, which had

been so difficult for even a Mesklinite-wielded knife to penetrate, resisted even better the sounds made by the crackling steam-bubbles around the hot metal and the calls of the workers who entered later. Had these last been forced to communicate with anyone at a distance, their resonant hooting might well have made its way even through that tough material; but there was little for them to say even to each other; they all knew their jobs perfectly well. The slit through which the helmsmen had found their entrance was held tightly enough closed by the elasticity of the fabric so that no light reached them.

Finally, the Mesklinite personality trait most nearly described as a combination of patience and fatalism assured that neither Beetchermarlf nor his companion was likely to check outside their refuge until the breathing hydrogen in their suits became a serious problem.

As a result, even if Dondragmer had heard Benj's appeal, there would have been nothing for him to signal. The helmsmen, little over three feet above some of their companions and a similar distance below many others, were not found.

Not quite all the *Kwembly's* crew were engaged in preparation for the move. When the most necessary aspects of that operation had been arranged, Dondragmer called two of his sailors for a special detail.

"Go over to the stream—head northwest and you can't miss it—and follow it up until you find Kabremm and the *Gwelf*," he ordered. "Tell him what we are doing. We will set up a livable site as quickly as we can—you tell him where; you've been there and I haven't—and we will set up the human machines so they are looking into the lighted, active portion of that area. That will make it safe for him to bring the *Gwelf* down and land her anywhere outside that area, with no risk of being seen by the human beings. Tell him that the commander seems to be starting the native-life part of the play early, apparently to account for Kabremm's being seen in this neighborhood. He's suggested no details, and will probably stick to the original idea of letting the human beings invent their own.

"When you have seen Kabremm, go on upstream until you find Stakendee, and give him the same information. Be careful about getting into the view field of his communicator—when you think you may be getting near him, shut off your lights every little while and look for his. I'll be in touch with him through the human beings, of course, but not with *that* message. You understand."

"Yes, sir," the two replied in unison, and were gone.

The hours passed. The main lock was freed and opened, and nearly

all the material to be taken was outside when a call came from above. The communicator which had been in the laboratory was now outside, so Dondragmer could be reached directly. Benj was still the speaker.

"Captain, Stakendee reports that the stream he is following is getting noticeably broader and swifter, and that the clouds are becoming rain. I've told him to start back, on my own responsibility." The captain looked up at the still cloudless sky, and westward toward the place where Stakendee's fog might have shown if it had been daylight.

"Thanks, Benj. That's what I would have ordered. We're leaving the *Kwembly* right now, in that case, before the stream gets too big to cross with the equipment. I have lashed down the communicator on the bridge, and will leave the lights on as Mr. McDevitt requested. We'll hope you can tell us that it's safe to come back, before too long. Please report this to Barlennan, and tell him that we will watch as carefully as possible for the natives; if, as he seems to be suggesting, they are using Kabremm as a means of getting in touch with us, I will do my best to set up cooperative relations with them. Remember, I haven't seen Kabremm myself yet, and you haven't mentioned him since the first time, so I'm entirely in the dark about his status so far.

"Be sure to keep me informed of

Barlennan's thoughts and plans, as far as you can; I'll do the same from here, but things may happen too quickly for any possible advance warning. Watch your screens. That's all for now; we're starting."

The captain uttered a resonant hoot which, fortunately for human ears, was not faithfully reproduced in volume by the set. The Mesklinites fell into rough line, and within two minutes were gone from the field of view of the bridge communicator.

The other set was being borne near the tail of the line, so the screen far above showed the string of lights bobbing in front of it. Little else, however, could be seen. The nearest sailors, those within two or three yards of the lens, could be made out in reasonable detail as they wound among the boulders with their burdens, but that was all. The line could have been flanked on both sides twenty feet away by a legion of natives, without any human being the wiser. Aucoin was neither the first, nor the last, to curse Dhrawn's 1,500-hour rotation period; there were still over six hundred hours to go before the feeble daylight from Lalande 21185 would return.

The stream was still small when the group splashed through it, though Stakendee's set a few miles west had confirmed the report that it was growing. Benj, noticing this, suggested that the small party also

cross so that its members could meet the main body on the other side of the valley. Fortunately he made this suggestion to Dondragmer before acting on his own; the captain, remembering the two messengers he had sent upstream, hastily advised that the crossing be postponed as long as possible so that Stakendee and his men could compare more accurately the size of the stream with what it had been when they had passed the same area earlier.

Benj and Easy accepted this excuse; Ib Hoffman, quite aware that the foot party was carrying no time measuring devices and could give no meaningful report on the rate of change, was startled for a few seconds. Then he smiled, privately.

For many minutes, which stretched into one hour and then another, there was little to watch. The crew reached and climbed the bare rock sides of the valley at the spot where the first load of equipment had been left, and set about constructing something which might have been called either a camp or a town. Life-support equipment had first priority, of course. It would be many hours yet before any air-suits would need recharging, but the time would come; and for organisms as profligate of energy as the Mesklinites food was also a matter of immediate concern. They set about it quickly and efficiently; Dondragmer, like the rest of the cruiser cap-

tains, had given plenty of advance thought to the problem of abandoning ship.

Stakendee's group finally crossed the river and, somewhat later, reached the encampment. The crossing had been approved by Dondragmer after he had received through Benj a message which contained, quite incidentally, the name of one of the messengers the captain had sent from the *Kwembly*.

Consequently no one, either member of the *Kwembly* crew or human being, was able to watch the growth of the ammonia-water stream. It would have been an interesting sight. At first, as the witnesses had reported, it was little more than a trickle running from hollow to hollow on the bare rock in the higher reaches of the riverbed, and winding among the boulders lower down. As the drops of liquid in the fog coalesced and settled out more rapidly, tiny new tributaries began to feed into the main stream from the sides, and the stream itself grew deeper and faster. On the bare rock it meandered more violently, overflowing the basins which had originally contained it. Here and there it froze temporarily, as the proportions of water supplied by the frozen puddles upstream and of ammonia from the fog shifted one way or the other from the eutectic which was liquid at the local temperature—about 174 degrees on

the human Kelvin scale, roughly 71 on that used by the Mesklinite scientists.

Among the boulders, as it neared the *Kwembly*, it found more and more water-ice, and the progress grew more complicated. The ammonia would dissolve water for a time, the mixture flowing away as the composition entered the liquid range. Then it would stop and build up—as Benj had pictured, like wax flowing from a candle—as it solidified temporarily from an addition of ammonia. Then it would slump away again as underlying ice reacted with the mixture.

It finally reached the hole which had been melted along the *Kwembly*'s starboard side, where the human beings could watch once more. By this time the "stream" was a complex network of alternate liquid, solid, and slush perhaps two miles across. The solid, however, was losing out. While there were still no clouds this far downstream, the air was nearly saturated with ammonia—saturated, that is, with respect to a pure liquid-ammonia surface. Naturally, the ammonia vapor pressure needed for equilibrium over an ammonia-water mixture would be lower; so condensation was taking place on the mostly-water and low-ammonia ice. As it reached the appropriate composition for liquefaction its surface flowed away and exposed more solid to the vapor. Of course, the liquid tended to so-

lidify again as it absorbed still more ammonia vapor, but its freedom to move also gave it access to more water-ice.

The situation was a little different in the space under the *Kwembly's* hull, but not greatly so. Where liquid touched ice the latter dissolved and slush appeared; but more ammonia diffusing from the free surface at the side melted it again. Slowly—slowly—minute after minute—the grip of the ice on the huge vehicle relaxed; so gently that neither the human beings watching with fascination from above, nor the two Mesklinites waiting in their dark refuge, could detect the change, the hull floated free.

By now the entire riverbed was liquid, with a few surviving patches of slush. Gently, very unlike the flood of a hundred hours or so before when three million square miles of water-snow had been touched by the first ammonia-fog of the advancing season, a current began to develop. Imperceptibly to all concerned, the *Kwembly* moved with that current—imperceptibly, because there was no relative motion to catch the eyes of the human beings, and no rocking, or pitching, to be felt by the hidden Mesklinites.

The seasonal river which drains the great plateau where the *Kwembly* had been caught slices through a range of hills—for

Dhrawn, respectable mountains—which extends for some four thousand miles northwest-southeast. The *Kwembly* had paralleled this range for most of its length before the flood. Dondragmer, his helmsmen, his air scouts, and indeed most of the crew had been quite aware of the gentle elevation to their left, sometimes near enough to be seen from the bridge and sometimes only a pilot's report.

The flood had carried the cruiser through a pass near the southeastern end of this range to the somewhat lower and rougher regions close to the edge of Low Alpha before she had grounded. Now she followed the pass which shaped the river once more; first almost eastward, then more and more to the north. She was backtracking on the path which Kabremm had followed in his dirigible from the *Es- ket* area some six thousand miles away, but she did not make the whole distance.

Low Alpha is an active tectonic region. Its energy, as men had guessed and were still trying to prove, is radioactive. Selection reactions which produce subcrustal effects analogous to zone melting—as they do at greater depths in Earth's crust—have concentrated unstable isotopes such as potassium 40 into definite, comparatively limited areas, so that Dhrawn's climate is internally controlled. This is not quite as completely true as for a typical sunless planet, of course;

Lalande 21185 by itself would warm Dhrawn when at its closest to about fifty degrees Kelvin. Low Alpha is over two hundred degrees hotter, averaging somewhere around the melting temperature of water-ice. In this range, of course, the sun adds less than one degree to the thermometer reading.

Low Beta, some forty thousand miles away around the planet's north pole, is actively volcanic. It is the major source of energy for Dhrawn's air circulation, and hence the key controlling area for its climate. The Mesklinites would have been landed there if anyone could have thought of a practical way to keep them alive.

The *Kwembly's* northward drift was carrying it into regions of higher temperature which kept the river fluid, even though it was now losing ammonia by evaporation. The course of the stream was almost entirely controlled by the topography, rather than the other way around; the river was geologically too young to have altered the landscape greatly by its own action. Also, much of the exposed surface of the planet in this area was bedrock, igneous and hard, rather than a covering of loose sediment in which a stream could have its own way.

About three hundred miles from the point at which she had been abandoned, the *Kwembly* was borne into a broad, shallow lake. She promptly, but gently, ran

aground on the soft mud delta where the river fed into it. The great hull naturally deflected the currents around it, and set them to digging a new channel alongside. After about half an hour she tilted sideways and slid off into the new channel, righting herself as she floated free. It was the rocking associated with this last liberation which caught the attention of the helmsmen and induced them to come out for a look around.

XIV

It would be untrue to say that Benj recognized Beetchermarlf at first glance. As a matter of fact, the first of the caterpillarlike figures to emerge from the river and clamber up the hull was Takoorch. However, it was the younger helmsman's name which echoed from four speakers on Dhrawn.

One of these was on the *Kwembly's* bridge and went unheard. Two were in Dondragmer's encampment a few hundred yards from the edge of the broad, swift river which now filled the valley. The fourth was in Reffel's helicopter, parked close beside the bulk of the *Gwelf*.

The flying machines were about a mile west of Dondragmer's camp; Kabremm would go no closer, not wanting to take the slightest chance of repeating his earlier slip. He would probably not have moved at all from the site where Stakendee

had found him if the river had not risen. For one thing, he had been fog-bound and had no wish to fly at all. Reffel had been even less anxious. However, there had been no choice, so Kabremm had allowed his craft to float upward on its own lift until it was in clear air, Reffel hovering as close to the other machine's running lights as he dared. Once above the few yards of ammonia droplets they had been able to navigate, and had flown toward Dondragmer's lights until the dirigible's commander had decided they were close enough. Letting the *Gwelf* come to the knowledge of the men above in orbit would be an even more serious mistake than the one he had made already, and Kabremm was still trying to decide what he was going to say to Barlennan about that the next time they met.

Both he and Reffel had also spent some uncomfortable hours before concluding, from the lack of appropriate comment, that the latter had shuttered his vision set quickly enough after coming within sight of the *Gwelf*.

At least, Dondragmer and Kabremm had at last got into personal conversation, and been able to coordinate what they would say and do if there were ever any further repercussions from Easy's recognition. One load was off the captain's mind. However, he was still taking steps connected with that mistake.

The cry of "Beetch!" in Benj's unmistakable voice distracted him from one of these steps. He had been checking over his crew for people who looked as much as possible like Kabremm. The job was complicated by the fact that he had not seen the other officer for several months—Dondragmer had not yet had time to visit the *Gwelf*, and Kabremm would come no closer to the camp for any reason—and had never known him particularly well anyway. His plan was to have all crewmen who might reasonably be mistaken for the *Esker's* first officer to appear unobtrusively and casually but frequently in the field of view of the vision sets. Anything likely to undermine the certainty of Easy Hoffman that it was really Kabremm she had seen was probably worth trying.

However, the fate of the *Kwembly* and his helmsmen had never been very far from the captain's mind in the twelve hours since his cruiser's lights had vanished, and at the sound from the speaker he snapped to full attention.

"Captain!" the boy's voice continued. "Two Mesklinites have just appeared and are climbing up the hull of the *Kwembly*. They came out of the water; they must have been somewhere underneath all the time, even if you couldn't find them. It couldn't be anyone but Beetch and Tak. I can't talk to them until they get to the bridge,

of course, but it looks as though we might get your ship back after all. Two men can drive it, can't they?"

Dondragmer's mind raced. He had not blamed himself for abandoning the cruiser, even though the flood had been such an anticlimax. It had been the most reasonable decision at the time and with the available knowledge. By the time the actual nature of the new flood had been clear, and it was obvious that they could have remained in the cruiser with perfect safety, it had been impossible to get back. Being a Mesklinite, the captain had wasted no time on thoughts of the



"if only" variety; he had known when he left his vehicle that the chances of getting back were rather small, and when she had drifted downstream intact instead of a shattered ruin they had grown smaller. Not quite to zero, perhaps, but not large enough to take seriously any more.

Now suddenly they had expanded again. The *Kwembly* was not only usable, but his helmsmen were alive and aboard her. Something might be done, if . . .

"Benj!" Dondragmer spoke as his thoughts reached this point. "Will you please get your technical men to find as closely as they can just how far from us the *Kwembly* is now? It is perfectly possible for Beetchermarlf to drive her alone, though there are other problems in the way of general maintenance which will keep him and Takoorch busy. However, they should be able to manage. In any case, we must find out whether the distance involved is fifty miles or a thousand—I doubt the latter, since I don't think this river could have carried them so far in twelve hours, but we'll have to know. Get your people at it, and please tell Barlennan what is happening."

Benj obeyed quickly and efficiently. He was no longer the overtired, worried, resentful youngster of a dozen hours before. With the abandonment of the *Kwembly* he had given up hope for his

friend's life and had left the communication room to get some long overdue sleep. He had not expected to be able to accomplish this, but his own body chemistry had fooled him. Nine hours later he had returned to his regular duties in the aerology laboratory; it had been chance alone which had brought him back to the screens within a few minutes of the helmsmen's emergence. He had been sent by McDevitt to collect general data from the other cruisers, but had lingered for a few minutes to watch at the *Kwembly* station. The weatherman had come to depend heavily on Benj's knowledge of the Mesklinite language.

The sleep, and the sudden discovery that Beetchermarlf was alive after all, combined to dispose of the boy's lingering resentment of Dondragmer's policy. He acknowledged the captain's request, called his mother to take his place, and headed for the laboratory decks as rapidly as his muscles would take him up the ladders.

Easy, who had also had some sleep, reported his departure and her own presence to Dondragmer, briefed Barlennan as requested, and switched back to the captain with a question of her own.

"That's two of your missing men. Do you think there is still any chance of finding your helicopter pilots?"

Dondragmer almost slipped on his answer, carefully as he picked

his words. He knew, of course, where Reffel was, since messengers had been passing steadily between the camp and the *Gwelf*; but Ker-venser, to his disappointment, had not been seen by the crew of the dirigible or anyone else. His disappearance was perfectly genuine, and the captain now regarded his chances for survival as even lower than those of the *Kwembly* an hour before. It was safe, of course, to talk about this; his slip consisted of failing to mention Reffel at all. The Stennish forms equivalent to "him" and "them" were as distinct as the human ones, and several times Dondragmer caught himself using the former when talking about his lost pilots. Easy seemed not to notice, but he wondered afterward.

"It is hard to judge. I have not seen either one. If he went down in the area now flooded it is hard to see how they could be alive now. It is very unfortunate, not only because of the men themselves but because with even one of the helicopters we might be able to transfer more men to the *Kwembly* and get her back here more easily. Of course most of the equipment could not be carried that way; on the other hand, if it turns out that the two men cannot bring the cruiser back here for any reason, having one of the fliers could make a great difference to *them*. It is a pity that your scientists cannot locate the transmitter which Reffel

was carrying, as they can the one on the *Kwembly*."

"You're not the first to feel that way," agreed Easy. The matter had been brought up shortly after Reffel's disappearance. "I don't know enough about the machines to tell why the signal strength depends on the picture brightness—I always thought a carrier wave was a carrier wave—but that seems to be it. Either Reffel's set is in total darkness or it has been destroyed.

"I see your life support equipment is set up and working."

The last sentence was not entirely an effort of Easy's to change the subject; it was her first good look at the equipment in question, and she was genuinely curious about it. It consisted of scores—perhaps over a hundred—of square transparent tanks covering altogether a dozen square yards, each about a third full of liquid, with the nearly pure hydrogen which constituted Mesklinite air bubbling through it. A power unit operated the lights which shone on the tanks, but the pumps which kept the gas circulating were muscle-driven. The vegetation, which actually oxidized the saturated hydrocarbons of Mesklinite biological waste and gave off free hydrogen, was represented by a variety of unicellular species corresponding as nearly as might be expected to terrestrial algae. They had been selected for edibility, though not, as

Easy had been given to understand, for taste. The sections of the support equipment which used higher plants—and produced the equivalent of fruit and vegetables—were too bulky to move.

Easy did not know how the non-gaseous items in the biological cycle were gotten into and out of the tanks, but she could see the charging of airsuit cartridges. This was a matter of muscle-driven pumping again, squeezing hydrogen into tanks which contained slugs of porous solid. This material was another strictly non-Mesklinite product, a piece of molecular architecture vaguely analogous to zeolite in structure, which adsorbed hydrogen on the inner walls of its structural channels and, within a wide temperature range, maintained an equilibrium partial pressure with the gas which was compatible with Mesklinite metabolic needs.

Dondragmer answered Easy's remark. "Yes we are safe if not comfortable for food and air. The real problem is what we should do. We saved very little of your planetological equipment; we can't carry on your work. Conceivably we might make our way back to the Settlement on foot, but we'd have to carry the life-support material by stages. That would mean setting up a camp only a few miles from here, transferring the equipment, recharging the air cartridges after cycling had resumed, and

then repeating the process indefinitely. Since the distance to the Settlement is about thirty thousand—excuse me, in your numbers about twelve thousand—of your miles, it would take us years to get there—and I am not being figurative, nor do I mean your short years. If we're to be any further use to your project, we really must get the *Kwembly* back here."

Easy could only agree, though she could see an alternative which the captain had not mentioned. Of course, Aucoin would disapprove—or would he, under the circumstances? A trained and efficient exploring crew represented quite an investment, too. That might be a useful line to follow.

It was several more minutes before Benj returned with his information, and, incidentally, with a following of interested scientists.

"Captain," he called, "the *Kwembly* is still moving, though not very fast—something like twenty cables an hour. She is located, or was six minutes ago, 310.71 miles from your transmitter, in our figures. In your numbers and units that's 233,750 cables. There's a small possible error if there's much difference in elevation. That's great circle distance; we don't have too good an idea of the length of the river, though they have about twenty position readings taken along it since your ship started drifting, so there's a rough river map up in the lab."

"Thank you," came the captain's answer in due course. "Are you in verbal contact with the helmsmen yet?"

"Not yet, but they've gone inside. I'm sure they'll find the communicator on the bridge pretty soon, though I suppose there are other places they'd want to check first. The air must be pretty low in their suits."

This was perfectly correct. It took the helmsmen only a few minutes to ascertain that the cruiser was deserted, and to note that much of the life-support equipment was gone; but this left them with the need to make sure whether the air now aboard had been contaminated with oxygen from outside. Neither of them knew enough basic chemistry to invent a test, and neither was familiar with the routine ones used by Borndender and his colleagues. They were considering the rather drastic technique of testing by smell when it occurred to Beetchermarlf that a communicator might have been left aboard for scientific reasons, and that the human beings might be of help. There was none in the laboratory, but the bridge was the next most likely spot, and his voice was on its way up to the station some ten minutes after the two had come aboard.

Benj postponed greetings when he heard Beetchermarlf's question, and relayed it at once to Dondragmer. The captain called his scien-

tists and outlined the situation, and for over half an hour the relay was very busy as Borndender explained things, and Beetchermarlf checked the explanations back verbally, and then went to the lab to examine material and equipment, and came back to the bridge to make sure of some minor point . . .

Eventually both end members of the conversation felt sure that the instructions had been understood. Benj, at its pivot point, was nearly so. He knew enough physics and chemistry himself to judge that nothing was likely to blow up if Beetch made a mistake, so his only worry was that his friend might perform the tests sloppily enough to miss a dangerous amount of oxygen. The risk was merely one of poisoning, he thought, but wasn't quite sure; hydrogen-oxygen mixtures have other qualities. Of course, at the *Kwembly's* present depth in Dhrawn's atmosphere most of the ship's air was argon to balance the outside pressure, and Benj couldn't remember whether adulterating a hydrogen-oxygen mixture affected its explosive qualities on the basis of percentage or whether it was strictly a matter of partial pressure of the active ingredients. He remained rather tense until Beetchermarlf returned to the bridge with the report that both tests were complete. The catalyst which disposed of free oxygen by accelerating its reaction with ammonia was still active, and the am-

monia-vapor concentration in the ship's air was high enough to give it something to work on. The helmsmen had already removed their airsuits and neither could smell any oxygen—though, as with human beings and hydrogen sulfide, this was not always a reliable check.

At least, the two could live on board for a time. One of their first acts had been to "hand"-pump the feed tank which kept air bubbling through the life-support medium, and to satisfy themselves that most of the plants were still alive. The next problem was navigation.

Benj told his friend as much as possible about his location, that of the rest of the crew, and the *Kwembly's* present rate and direction of travel. There was no trouble in Beetchermarlf's using the information—he could determine direction easily enough. Not only were the stars visible, but he had a perfectly good magnetic compass. Dhrawn's magnetic field was a good deal stronger than Earth's, to the consternation of the scientists who had long since taken for granted a correlation between magnetic field and rotation rate for ordinary planets.

The discussion which produced a detailed operation plan was shorter than the one preceding the oxygen test, though it still involved the long relay. Neither Dondragmer nor the helmsmen had any serious

doubts about what to do or how to do it.

Beetchermarlf was far younger than Takoorch, but there seemed no question as to who was in charge aboard. The fact that Benj always called Beetch by name, rather than addressing the *Kwembly* formally as a ship, may possibly have contributed. Easy and several of the other human beings, however, suspected that Takoorch, in spite of his willingness to discuss his own past accomplishments, was in no great hurry to take on too much responsibility. He tended to agree with Beetchermarlf's suggestions either at once or after only token arguments.

"We're still adrift, and unless this river has some very funny loops farther down we'll never get any closer to the others with its help," the younger Mesklinite summarized at last. "The first job will be to get paddles on some of the powered trucks. Trying to do it with all of them will take forever; a couple of outboard-row ones aft, and maybe a central one forward should give control. With power available on others we can either pull off or get safely ashore if we run aground. Tak and I will go outside and start work right now. You keep an eye on us as much as you can, Benj; we'll leave the set where it is."

Beetchermarlf did not wait for an answer. He and his companion

suited up once more and broke out the paddles which had been designed to pin onto the treads of the drivers. These had been tested on Mesklin but never yet used on Dhrawn; no one really knew how well they would work. Their area was small, since there was little clearance for them above the trucks, and some of that little was taken up by a plastic shield designed to fold them flat as they were riding forward on the top side of the trucks. However, it had been proved that they would supply some thrust. What this would accomplish remained to be seen; the *Kwembly* was floating higher in the ammonia-water solution of Dhrawn, of course, than she had in the liquid hydrocarbon ocean of the world where she had been made.

Installation of the fins and shields was a long and awkward job for two workers. The pieces could be taken out only one at a time, since there was nowhere to put them down with the cruiser afloat. Safety lines persistently got in the way. Mesklinite pincers are rather less effective handling organs than are human fingers, though this is somewhat offset by the fact that their owner can use all four pairs of them simultaneously and in coordination—he has no asymmetry corresponding to human right- or left-handedness.

The need to carry artificial lights was still another bother. As it

turned out, getting twelve paddles and one shield on each of three drivers took a total of almost fifteen hours. It could, Beetchermarlf assured Benj, have been accomplished in two with four workers on each truck.

By this time the trackers had learned that the *Kwembly* was not getting any farther from the camp, though she was still moving. Apparently she had been caught in an eddy some four miles in diameter. Beetchermarlf took advantage of this when he was finally ready to apply power; he waited until the human analysts could tell him that he was being carried south before he set the three finned trucks running. For some seconds it was not apparent that the power was doing any good; then, very slowly, helmsmen and humans alike saw that the great hull was moving gently forward. The Mesklinites could see from the bridge a feeble excuse for a bow wave; the human beings, looking aft, were able to detect small ripples spreading back from the sides.

Beetchermarlf swung his helm hard over to bring the bow in line with Sol and Fomalhaut. For nearly half a minute he was left wondering whether there would be any response; then the stars began to swing overhead as the long hull swerved majestically. Once started it was hard to stop; he over-controlled many times and for a

period of many minutes, sometimes by as much as a full right angle, before getting the feel of the vessel. Then for nearly an hour he managed to hold a southerly heading, though he had no idea of his actual course at first. He could guess from the earlier information that the eddy would be bearing him in the same direction at the start, but then it would presumably carry him eastward.

It was some time, however, before the directional antennae on the shadow satellites and the computers in the station could confirm this guess. About the time they did, the *Kwembly* ran gently aground.

Beetchermarlf instantly shifted drive power to the two farthest forward trucks which had power boxes, letting the paddle-equipped ones idle, and pulled his cruiser out on the shore.

"I'm out of the lake," he reported. "Minor problem. If I travel for any distance on land with the paddles in place, I'll wear them out. If it turns out that I'm on an island, or have to go back to the water for any other reason, an awful lot of time will have been wasted



taking them off and putting them on again. My first thought is to do some exploring on foot, leaving the ship right here, to get some idea of what the chances of staying ashore may be. It will take a long time, but not nearly as long as waiting for daylight. I'll be glad of advice from you humans or orders from the captain; we'll wait."

Dondragmer, when this was relayed to him, was prompt with his answer.

"Don't go out. Wait until the map-makers up above can decide whether you are on the same side of the river as we are, or not. As I



picture the map they've described, there's a good chance that the eddy carried you to the east side, which would be the right bank; we're on the left. If they are even moderately sure of this, get back into the water and head west until they think you're past it . . . no, second thought. Go until they think you're opposite its mouth, then head south once more. I'd like to find out whether you can travel upstream with any speed at all. I know it will be slow, but it may turn out that you can't travel at all in some places along the bank."

"I'll tell Beetch and the map

people, Captain," answered Benj. "I'll try to get a copy of their map and keep it up to date down here; that may save some time in the future."

The directional data was not, as it happened, conclusive. The location of the *Kwembly* could be established well enough, but the course of the river down which she had come was much less certain. The checks were many miles apart, and just sufficient in number to show that it was decidedly crooked. After some further discussion, it was decided that Beetchermarlf

should get back afloat and head westward as close to shore as he could; within sight of it, if the range of his lights and the slope of the lake bottom combined to permit it. If he could locate the river mouth by sight, he was to head up it as Dondragmer had wished; if not, he was to continue along the shore until the men above were reasonably certain that he had passed it, and then turn south.

It did prove possible to keep the shore within range of the *Kwembly's* lights, but it took over two hours to reach the river. The latter apparently took a wide westward bend which had been missed in the spot-checks of the cruiser's position during the downstream drift; then it turned again and entered the lake on an eastward slant which presumably caused the counterclockwise eddy. At least, as one of the planetographers remarked, you couldn't blame the latter on Coriolis force when the lake was only seven degrees from the equator—and on the south side, at that—of a planet which took two months to rotate.

The delta, which caused the shoreline to turn north briefly, was a warning. Beetchermarlf at the helm and Takoorch at the port wing of the bridge sent the *Kwembly* groping around the rather irregular peninsula, several times slowing noticeably as the trucks dragged in soft bottom silt, and finally found their way into a

clear channel and headed into its current.

This was not swift, but neither was the *Kwembly* afloat. The Mesklinites were in no haste; Dondragmer gave a good six hours to the experiment of fighting the stream. Just under ten miles of progress were made in that time. If that rate could be maintained, the cruiser could be back at the camp by a day or two after midnight—that is, in a week or so by human reckoning.

It was impatience which caused the travel policy to change. This could not, of course, be blamed on any Mesklinite; and for once it was not the fault of Benj. The boy was not there. With the journey reduced to something like routine, McDevitt put his young apprentice back to regular work. The boy still spent as much time as he could talking to Beetchermarlf, of course—there was no one else in the station, or within communicator range, who could be described as being in his own age group—but the talks were usually brief.

It was Aucoin, of all people, who decided that a mile and a half an hour was not satisfactory. Dondragmer did not feel at all strongly about the matter, and agreed that research might as well be worked into the trip if possible, so at the planner's suggestion he sent Beetchermarlf angling westward toward what was presumably the near bank of the river. The land seemed

practicable for travel, so with some misgiving he had the helmsmen remove the paddles.

This proved much easier than installing them, since the vehicle was now on dry land; things could be laid down, and life lines were not needed. Benj's next visit to the communication room found the *Kwembly* cruising smoothly south at about ten miles an hour over flat country, interrupted by an occasional outcropping of rock and studded here and there with the scrubby bushes which were the highest life form so far encountered on Dhrawn. The surface was firm sediment; the planetologists judged the area to be a flood plain, which seemed reasonable even to Benj.

Beetchermarlf was willing to talk as usual, but it could be seen that his attention was not entirely on conversation. Both he and Takoorch were looking ahead as sharply as their eyesight and the *Kwembly's* lights would permit. There was no assurance that the going was safe; without air-scouting, the ten-mile speed was all they dared use. Anything faster would have been overrunning their lights. Whenever other duties, such as air-plant maintenance, had to be performed, they stopped the cruiser and did the work together. One set of eyes, they felt, was not enough for safe travel.

Every now and then, as the

hours wore on, whoever was at the helm would begin to feel the treacherous assurance that there could be no danger—that they had, after all, come scores of miles now without having to change heading except to keep the river in sight. A human being would, in nine cases out of ten, have increased the running speed bit by bit. The Mesklinite reaction was to stop and rest. Even Takoorch knew that, when he was feeling tempted to act against the dictates of elementary common sense, it was time to do something about his own condition. Aucion, discovering the vehicle halted when he came to the screens on one occasion, assumed it was a regular air-maintenance stop; but then he saw one of the Mesklinites sprawled idly on the bridge—the set had been put back in its old location, giving a view forward over the helm. Asked why the cruiser was not traveling, Takoorch simply replied that he had found himself getting casual. The administrator left in a very thoughtful mood.

Eventually, this care paid off—or seemed to.

For some miles the outcroppings of bed rock had been more and more frequent, though generally smaller, closer together, and more angular. The planetologists had been making guesses—futile, really, with so little information—about the underlying stratigraphy. The basic surface was still hard-packed sediment, but the watchers sus-

pected that it might be getting shallower, and that some time soon the *Kwembly* might find herself on the same sort of bare rock that formed the substrate at Dondragmer's camp.

The helmsmen occasionally found it necessary now to weave slightly left or right to avoid the rock outcrops, and even to slow down a little from time to time. Several times in the past few hours the planetologists had rather plaintively suggested that the cruiser stop before it was too late, and pick up samples of the sediment she was running over even if the rocks were too big to collect. Aucoin simply pointed out that it would be a year or two before the sample could get up to the station anyway, and refused; the scientists retorted that a year was much better than the time which would be needed if the specimens weren't collected.

But when the *Kwembly* stopped, it was on Beetchermarlf's initiative. It was a minor thing, or seemed to be; the soil ahead seemed a little darker, with a very sharp boundary between it and the surface under the cruiser. The line was not noticeable on the vision screen, but the Mesklinites spotted it simultaneously and, without words, agreed that close examination was in order. Beetchermarlf called the station to inform the human beings and his captain that he and Takoorch would be going outside for a time, and described the situ-

ation. Easy, translating the message, was promptly begged by two planetologists to persuade the Mesklinites to bring samples aboard. She assumed that even Aucoin would hardly object under the circumstances, and agreed to ask them when she called back with Dondragmer's clearance.

The captain, this time, approved the sortie, suggesting only that it be preceded by a careful look around from the bridge with the aid of the spotlights. This proved useful. A hundred yards ahead, not too far out of the range of the running lights, a small stream was running across their path and emptying into the river. Sweeping the light to starboard, this tributary could be seen arcing around parallel to the cruiser's path from the north, then reversing its curve somewhat astern of the big vehicle and disappearing to the northwest. The *Kwembly* was on a peninsula some two hundred yards wide and not quite as long, bounded on the east—left—by the main river she had been following and on the other side by the small tributary. It seemed likely to Mesklinites and human beings alike that the change in soil color which had caught the helmsmen's attention was caused by wetting from the smaller stream, but no one was sure enough of it to cancel the proposed trip outside. Aucoin was not present.

Outside, even with the aid of ex-

tra lights, the line of demarcation between the two kinds of soil was much less visible than before. Eye distance, Beetchermarlf judged, was the main cause. As requested, they scraped up and packaged samples of material from both sides of the line; then they went on to the stream itself. This proved to be a swift-running but shallow brook three or four body-lengths in width, its level an inch or two below the soil through which it was cutting its way. After a brief consultation, the two Mesklinites began to follow it away from the river. They had no way of telling its composition, but a bottle of its contents was secured for possible later testing.

By the time they reached the spot where it was curving away, even the Mesklinites could see that the stream had not been in existence very long. It was eating with visible speed into its banks, washing the sediment on toward the main river. Now that they were on the outside of its curve, the undercutting of the near bank could be seen—and even felt; Beetchermarlf, standing at the edge, had it crumble suddenly away under him and found himself in the stream.

It was only an inch or so deep, so he merely took advantage of the occasion to take another sample from its bottom before climbing out. They decided to follow on up for another ten minutes or so, Beetchermarlf wading and

Takoorch still on the bank; but before the time was up they actually found the source of the watercourse. It was a spring, not half a mile from the *Kwembly*, roiling violently in the center of its basin where an underground source fed it. Beetchermarlf, investigating the middle, was knocked from his feet and carried half a body length by the upward current.

There was nothing in particular to do; they had no camera equipment, no one had seriously suggested that they bring the vision set with them, and there was nothing obvious to be gained by collecting more samples. They returned to the *Kwembly* to give a verbal description of what they had found.

Even the scientists agreed that the best step now was to get the samples back to the camp where Borndender and his fellows could do something useful with them. The helmsmen eased their cruiser into motion once more.

It approached the stream and nosed through it; the mattress took up the slight dip as the trucks crossed the bottom of the valley. Nothing could be felt on the bridge.

Not for another eight seconds.

The hull was rather more than halfway across the little brook when the distinction between solid and liquid began to blur. A slight lurch could be felt on the bridge; it showed on the screen far above as a tiny upward jerk of the few outside features visible.

Forward motion stopped almost instantly, though the drivers kept churning. They could accomplish nothing when completely immersed in slimy mud, which the surface had so suddenly become. There was neither support nor traction. The *Kwembly* settled until the trucks were buried; settled until the mattress was nearly out of sight; settled almost, but not quite, to the level where she would have been literally floating in the semiliquid muck. She was stopped by two of the rock outcrops, one of which caught her under the stern just aft of the mattress, and the other on the starboard side some ten feet forward of the main lock. There was an ugly scraping sound as the cruiser's hull canted forward and to port, and then came to rest.

And this time, as Beetchermarlf's sense of smell warned him only too clearly, the hull had failed somewhere. Oxygen was leaking in.

XV

"It boils down to this," Aucoin said from the head of the table. "We have the choice of sending down the barge, or not. If we don't, the *Kwembly* and the two Mesklinites aboard her are lost, and Dondragmer and the rest of her crew are out of action until a rescue cruiser such as the *Kaliff* can reach them from the Settlement. Unfortunately, if we do try to land

the barge, there's a good chance that it won't help. We don't know why the ground gave under the *Kwembly*, and have no assurance that the same thing won't happen anywhere else in the vicinity. Losing the barge would be awkward. Even if we landed first near Dondragmer's camp and transferred him and his crew to the cruiser, losing the barge could be a waste; there is no assurance that they could repair the *Kwembly*. Beetchermarlf's report makes me doubt it. He says he has found and sealed the major leaks, but he's still getting oxygen inside the hull from time to time. Several of his life-support tanks have been poisoned by it. So far he has been able to clean them out each time and restock them from the others, but he can't keep going forever unless he stops the last of those leaks. Also, neither he nor anyone else has made any concrete suggestion for getting that cruiser loose from the mud, or quicksand, or whatever it's stuck in.

"There is another good reason against landing the barge. If we use remote, live control, there is the sixty-second reaction lag, which would make handling anywhere near the ground really impossible. It would be possible to program its computer to handle a landing, but the risks of that were proved the hard way the first time anyone landed away from Earth. You might as well give the Mesklinites a

quick lesson in flying the thing for themselves!"

"Don't try to make that last sound too silly, Alan," Easy pointed out gently. "The *Kwembly* is merely the first of the cruisers to get into what looks like final trouble. Dhrawn is a very big world, with very little known about it, and I suspect we're going to run out of land-cruisers for rescue or any other purpose sooner or later. Also, even I know that the barge controls are computer-coupled, with push-the-way-you-want-to-go operators. I admit that even so, the chances are ten to one or worse that anyone trying a ground-to-ground flight with that machine on Dhrawn without previous experience would kill himself, but do Beetchermarlf and Takoorch have even that much chance of survival on any other basis?"

"I think they do," replied Aucoin quietly.

"How, in the name of all that's sensible?" snapped Mersereau. "Here all along we've—" Easy held up her hand, and either the gesture or the expression on her face caused Boyd to fall silent.

"What other procedure *which you could conscientiously recommend* would stand any real chance of saving either the *Kwembly* herself, or her two helmsmen, or the rest of Dondragmer's crew?" she asked.

Aucoin flushed deeply, but he answered steadily enough.

"I mentioned it earlier, as Boyd remembers," he said. "Sending the *Kaliff* from the Settlement to pick them up."

The words were followed by some seconds of silence, while expressions of amusement flitted across the faces around the table. Eventually Ib Hoffman spoke.

"Do you suppose Barlennan will approve?" he asked innocently.

"It boils down to this," Dondragmer said to Kabremm. "We can stay here and do nothing while Barlennan sends a rescue cruiser from the Settlement—I assume he can think of some reason for sending one which won't sound too queer, after he failed to do it for the *Esket*."

"That would be easy enough," returned the *Esket*'s first officer. "One of the human beings was against sending it, and the commander simply let him win the argument. This time he could be firmer."

"As though the first time wouldn't have made some of the other humans suspicious enough. But never mind that. If we wait, we don't know how long it will be, since we don't even know whether there's a possible ground route from the Settlement to here. You came from the mines by air, and we floated part of the way.

"If we decide not to wait, we can do either of two things. One is to move by stages toward the

Kwembly, carrying the life equipment as far as the suits will let us and then setting it up again to recharge them. We'd get there some time, I suppose. The other is to move the same way toward the Settlement to meet the rescue cruiser if one comes, or get there on foot if it doesn't. I suppose we'd even get *there*, eventually. Even if we reach the *Kwembly*, there is no certainty that we can repair her; if the human beings have relayed Beetchermarlf's feelings at all adequately, it seems rather doubtful. I don't like either choice because of the wasted time they both involve. There are better things to do than crawl over the surface of this world on foot.

"A better idea, to my way of thinking, is to use your dirigible either to rescue my helmsmen if it is decided to give up on the *Kwembly*, or to start ferrying my crew and equipment over to where she is."

"But that—"

"But that, of course, sinks the raft as far as the *Esket* act is concerned. The human beings couldn't help finding out that we had become partly independent of them, and even getting a pretty good idea how we did it. The question in my mind is whether this game is really worth the deliberate sacrifice of two lives. I admit that it's worth *risk*, of course, or I wouldn't have gone along with it in the first place."

"So I heard," returned Kabremm. "No one has been able to make you see the risk of being completely dependent on beings who can't regard us as real people."

"Quite right. They haven't, and I doubt that anyone will. I made up my mind about human beings the time one of them answered my question about a differential hoist with a good, clear, and detailed explanation, bolstered with my first lesson in the use of mathematics in science. I know, of course, that human beings are no more all alike than we are—certainly that one who talked Barl out of sending help to the *Esket* must be as different as possible from Mrs. Hoffman or my old friend Charles Lackland—but I don't and never will distrust them as a species the way you seem to. I don't think Barlennan really does, either; he's changed the subject more than once rather than argue the point with me, and that's not Barlennan when he's sure he's right. I still think it would be a good idea to lower the sails on this act and ask directly for human help with the *Kwembly*, or at least take a chance on their finding out by using all three dirigibles there."

"There aren't three, any more." Kabremm knew the point was irrelevant, but was rather glad of the chance to change the subject. "Karfrenjin and four men have been missing in the *Elsh* for two of this world's days."

"That news hadn't reached me, of course," said Dondragmer. "How did the commander react to it? I should think that even he would be feeling the temptation to ask for human help, if we're starting to lose personnel all over the map."

"He hasn't heard about it, either. We've had ground parties out searching, using trucks we salvaged from the *Esket*, and we didn't want to make a report until it could be a complete one."

"How much more complete could it be? Karfrenjin and his men must be dead by now. The dirigibles don't carry life-support gear for any two days."

Kabremm gave the rippling equivalent of a shrug. "Take it up with Destigmat. I have my troubles."

"Why wasn't your flier used for the search?"

"It was, until this evening. There are other troubles at the mine, though. A sort of ice river is coming, very slowly, but it will soon cover the whole second settlement if it doesn't stop. It's already reached the *Esket* and started to tip it over; that's why we were able to salvage the trucks so easily. Destigmat sent me to follow back up the glacier and try to find out whether it is likely to keep coming indefinitely, or was just a brief event. I really shouldn't have come this far, but I couldn't make myself stop. It's this same river for the whole distance, sometimes solid

and sometimes liquid along the way—it's the weirdest thing I've seen yet on this weird world. There isn't a chance of the ice's stopping, and the *Esket* settlement is as good as done for."

"And, of course, Barlennan hasn't heard about this either."

"There's been no way to tell him. We only discovered the ice was moving just before dark. It was just a cliff a few dozen cables from the mine up to then."

"In other words, we've lost not only my first officer and a helicopter but a dirigible with six men, and as an afterthought the whole *Esket* project—with my Kwembly probably on the same list. And you still think we shouldn't end this trickery, tell the human beings the whole story, and get their help?"

"More than ever. If they learn we're having this much trouble, they'll probably decide we're no more use to them and abandon us here."

"Nonsense. No one just abandons an investment like this project—but never mind arguing; it's a futile point anyway. I wish . . ."

"What you really wish is that you had an excuse for leaking the whole barrel to your oxygen-breathing friends."

"You know I wouldn't do that. I'm quite ready to use my own judgment in the field, but I know enough history to be afraid of making spot-changes in basic policy.

"Thank goodness. It's all right to like some humans, but they're not all like the Hoffman one. You admitted that yourself."

"What it boils down to," Barlennan said to Bendivence, "is that we were much too hasty in sending Deeslenver to the *Esket* with orders to shutter its vision sets. The whole *Esket* question seems to have quieted down, and that will bring it to life again. We're not ready for the main act yet, and won't be for a year or more. I wasn't sorry for the chance to start the human beings thinking along the lines of a native-menace idea, but Destigr et's crew won't be able to play the part until they have a lot more homemade mechanical and electrical equipment—things that the humans know we don't have. Certainly, unless the native menace seems real, the human beings aren't very likely to take the steps we want.

"If there were any way to go after Dee now and cancel his orders, I'd do it. I wish I'd dared let you go ahead with radio experiments, and had a set on the *Deedee* right now."

"It shouldn't be too risky, and I'd be more than glad to work on it," answered Bendivence. "The waves could be detected by the human beings of course, but if we confined ourselves to brief and rare transmissions and used a simple off-on code they probably wouldn't realize what the source was. How-

ever, it's too late to get Deeslenver, anyway."

"True. I wish I knew why no one up there has said another word about Kabremm. The last time I talked to Mrs. Hoffman, I got the impression that she wasn't quite as sure as before that she'd really seen him. Do you suppose she really made a mistake? Or are the human beings trying to test *us*, the way I wanted to do with them? Or has Dondragmer done something to get us off that reef? If she were really wrong, we'll have to start thinking all over again—"

"And what about that other report we've heard no more of—something sliding across the *Esket's* floor?" countered the scientist. "Was that still another test? Or is something really happening there? Remember, we haven't had any contact with that base for over a hundred and fifty hours. If the *Esket* is really being moved by something, we're much too badly out of date to do anything sensible. You know, without saying anything against the *Esket* act, it's an awful nuisance not to be able to trust your data."

"If there's real trouble at the *Esket* we'll just have to trust Dee's judgment," said the commander, ignoring Bendivence's closing sentence. "Actually, even that isn't the chief problem. The real question is what to do about Dondragmer and the *Kwembly*. I suppose he had good reason to leave his ship and

let her drift away, but the results have been very awkward. The fact that a couple of his men got left aboard makes it almost more so; if they hadn't been, we could just forget about the cruiser and send out the *Kalliff* to pick up the people."

"Why can't we do that anyway? Didn't the human Aucoin suggest it?"

"He did. I said I'd have to think it over."

"Why?"

"Because there is less than one chance in ten, and probably less than one in a hundred, that the *Kalliff* could get there in time to do those two men any good. The chances are small enough that she could get there at all. Remember that snowfield the *Kwemby* crossed before her first flood? What do you suppose that area is like now? And how long do you think two men—competent men, but with no real technical or scientific training—are going to keep that leaking hull habitable?"

"Of course, we could confess the whole act, tell the humans to get in touch with Destigmat through the watch he keeps at the *Esket's* communicators; then they could tell him to send a rescue dirigible."

"That would be wasting a tremendous amount of work, and ruining what still seems a promising operation," Bendivence replied thoughtfully. "You don't want to do that any more than I do; but we can't abandon those helmsmen."

"We can't," Barlennan agreed slowly, "but I just wonder whether we'd be taking too much of a chance on them if we waited out one other possibility."

"What's that?"

"If the human beings were convinced that we could not possibly carry out the rescue, it's just possible—especially with *two* Hoffmans to do the arguing—that they'd decide to do something about it themselves."

"But what could they do? The ship they call the 'barge' will only land here at the Settlement by its automatic controls, as I understand Rescue Plan One. They certainly can't fly it around on this world from out at the orbiting station; if it took them a whole minute to correct any mistake, they'd crash it right away. They certainly can't fly it down personally. It's set up to rescue *us*, with our air and temperature control, and besides Dhrawn's gravity would paint a human being over the deck."

"Don't underestimate those aliens, Ben. They may not be exactly ingenious, but there's been time for their ancestors to think up a lot of ready-made ideas we don't know about yet. I think . . . I wouldn't do it if I felt there was a real chance of our getting there ourselves, but this way we're not putting the helmsmen in any worse danger than they are already . . . that we'll let the human beings get the idea of making the rescue

themselves. It would be much better than giving up the plan."

"What it boils down to," said Beetchermarlf to Takoorch, "is that we somehow have to find time between plugging leaks and cleaning poison out of the air units to convince people that the *Kwembly* is worth salvaging.

"The best way would be to get her going ourselves, though I doubt very much that we can do it. It's the cruiser that's going to set the policy. Your life and mine don't mean very much to the humans—except maybe Benj—who isn't running things up there. If the ship stays alive—if we can keep these tanks going to supply us with food and air, and incidentally keep from being poisoned by oxygen ourselves, and make real, reportable progress in repairing and freeing the cruiser—*then* maybe they'll be convinced that a rescue trip is worthwhile. Even if they don't, we'll have to do all those things for our own sakes anyway; but if we can have the humans tell Barlennan that we have the *Kwembly* out and running, and will get her back to Dondragmer by ourselves, it should make quite a few people happy—especially the commander."

"Do you think we can do it?" asked Takoorch.

"You and I are the first ones to convince," replied the younger helmsman. "The rest of the uni-

verse will be much easier after that."

"What it boils down to," said Benj to his father, "is that we won't risk the barge for two lives, even though that's what it's here for."

"Not quite right on either count," Ib Hoffman answered. "It's a piece of emergency equipment, but it was planned for use if the whole project collapsed and we had to evacuate the Settlement. This was always a possibility; there was a lot that just couldn't be properly tested in advance. For example, the trick of matching outside pressure in the cruisers and airsuits by using extra argon was perfectly reasonable, but we could not be sure there would be no side effects on the Mesklinites themselves—argon is inert by the usual standards, but so is Xenon, which is an effective anesthetic for human beings. Living systems are just too complicated for extrapolation ever to be safe, though the Mesklinites seem a lot simpler physiologically than we are—that may be one reason they can stand such a broad temperature range.

"But the point is, the barge is preset to home on a beam transmitter near the Settlement; it won't land itself anywhere else on Dhrawn. It can be handled by remote control, of course, but not at this range.

"We could, I suppose, alter its on-board computer program to

make it set itself down in other places—at least, on any reasonably flat surface; but would you want to set it down anywhere near your friend either by a built-in, unchangeable program or by long-delayed remote control? Remember the barge uses proton jets, has a mass of twenty-seven thousand pounds, and must put up quite a splash soft-landing in forty gravities—especially since its jets are splayed to reduce cratering.” Benj frowned thoughtfully.

“But why can’t we get closer to Dhrawn, and cut down the remote-control lag?” he asked, after some moments thought. Ib looked at his son in surprise.

“You know why, or should. Dhrawn has a mass of 3,471 Earths, and a rotation period of just over fifteen hundred hours. A synchronous orbit to hold us above a constant longitude at the equator is, therefore, just over six million miles out. If you use an orbit a hundred miles above the surface, you’d be traveling at better than ninety miles a second and go around Dhrawn in something like forty minutes. You’d remain in sight of one spot on the surface for two or three minutes out of the forty. Since the planet has about eighty-seven times Earth’s surface area, how many control stations do you think would be needed to manage one landing or lift-off?”

Benj made a gesture of impatience.

“I know all that, but there is already a swarm of stations down there—the shadow satellites. Even I know that they all have relay equipment, since they’re all reporting constantly to the computers up here and at any given moment nearly half of them must be behind Dhrawn. Why can’t a controller riding one of these, or in a ship at about the same height, tie into their relays and handle landing and lift-off from there? Delay shouldn’t be more than a second or so even from the opposite side of the world.”

“Because,” Ib started to answer, and then fell silent. He remained so for a full two minutes. Benj did not interrupt his thinking; the boy usually had a good idea when he was ahead.

“There would have to be several minutes of interruption of neutrino data while the relays were being preempted,” Ib said finally.

“Out of the how many years that they’re integrating that material?” Benj was not usually sarcastic with either of his parents, but his feelings were once more growing warm. His father nodded silently, conceding the point, and continued to think.

It must have been five minutes later, though Benj would have sworn to a greater number, that the senior Hoffman got suddenly to his feet.

“Come on, Son. You’re perfectly

right. It will work for an initial space-to-surface landing, and for a surface-to-orbit lift-off, and that's enough. For surface-to-surface flight even one second is too much control delay, but we can do without that."

"Sure!" enthused Benj. "Lift-off into orbit, get your breath, change the orbit to suit your landing spot, and go back down."

"That would work, but don't mention it. For one thing, if we made a habit of it there *would* be a significant interruption of neutrino data transmission. Besides, I've wanted an excuse for this almost ever since I joined this project. Now I have one, and I'm going to use it."

"An excuse for what?"

"For doing exactly what I think Barlennan has been trying to maneuver us into doing all along: put Mesklinite pilots on the barge. I suppose he wants his own interstellar ship, some time, so that he can start leading the same life among the stars that he used to do on Mesklin's oceans, but he'll have to make do with one quantum jump at a time."

"Is *that* what you think he's been up to? Why should he care about having his own space pilots so much? And come to think of it, why wasn't that a good idea in the first place, if the Mesklinites can learn how?"

"It was, and there's no reason to doubt that they can."

"Then why wasn't it done that way all along?"

"I'd rather not lecture on that subject just now. I like to feel as much pride in my species as circumstances allow, and the explanation doesn't reflect much credit either on man's rationality, or his emotional control."

"I can guess, then," replied Benj. "But in that case, what makes you think we can change it now?"

"Because now, at the trifling cost of descending to the same general level of emotional reasoning, we have a handle on some of man's less generous drives. I'm going down to the planetology lab and filibuster. I'm going to ask those chemists why they don't know what trapped the *Kwembly*, and when they say it's because they don't have any samples of the mud, I'm going to ask them why they don't. I'm going to ask them why they've been making do with seismic and neutrino-shadow data when they might as well be analyzing mineral samples carted up here from every spot where a Mesklinite cruiser has stopped for ten minutes. If you prefer not to descend to that level, and would rather work with mankind's nobler emotions, begin thinking of all the heart-rending remarks you could make about the horror and cruelty of leaving your friend Beetchermarlf to suffocate slowly on an alien world parsecs from his home. We could use that if we have to take this argument to

a higher authority, like the general public. I don't think we'll really need to, but right now I'm in no mood to restrict myself to clean fighting and logical argument.

"If Alan Aucoin growls about the cost of operating the barge . . . think he has too much sense . . . I'm going to jump on him with both feet. Energy has been practically free ever since we've had fusion devices; what costs is personal skill. He'll have to use Mesklinite crews anyway, so that investment is already made; and by letting the barge drift out here unused he's wasting its cost. I know there's a small hole in that logic, but if you point it out in Dr. Aucoin's hearing I'll paddle you for the first time since you were seven—and I don't think the last decade has done too much to my arm. You let Aucoin do his own thinking."

"You needn't get annoyed with me, Dad."

"I'm not. In fact, I'm not as much annoyed as I am scared."

"Scared? Of what?"

"Of what may happen to Barlennan and his people on what your mother calls 'that horrible planet.'"

"But why? Why now, more than before?"

"Because I'm coming gradually to realize that Barlennan is an intelligent, forceful, thoughtful, ambitious, and reasonably well-educated being, just as my only son was six years ago; and I remember

your diving outfit much too well. Come on. We have an astronautics school to get organized, and a student body to collect."

EPILOGUE

At two hundred miles, the barge was just visible as a starlike object reflecting Lalande 21185's feeble light. Benj had watched the vessel as it pulled up to that distance and moved into what its pilot considered a decent station-keeping orbit, but neither he nor the pilot had discussed technical details. It was so handy to be able to hold a conversation without waiting a full minute for the other fellow's answer that Benj and Beetchermarlf had simply chattered.

These conversations were becoming less and less frequent. Benj was really back at work now and, he suspected, making up for lost time. Beetchermarlf was often too far away on practice flights to talk at all, and even more frequently too occupied to converse with anyone but his instructor.

"Time to turn it over, Beetch," the boy ended the present exchange as he heard Tebbetts' whistling from down the shaft. "The taskmaster is on the way."

"I'm ready when he is," came the reply. "Does he want to use your language, or mine, this time?"

"He'll let you know; he didn't tell me. Here he is," replied Benj.

The bearded astronomer, however, spoke first to Benj after look-

ing quickly around. The two were drifting weightless in the direct-observation section at the center of the station's connecting bar, and Tebbetts had taken for granted that the barge and his student would be drifting alongside. All his quick glance caught was the dull coal of the sun in one direction and the dimly lit disk of Dhrawn, little larger than Luna seen from Earth, in the other.

"Where is he, Benj? I thought I heard you talking to him, so I assumed he was close. I hope he isn't late. He should be solving intercept orbits, even with nomographs instead of highspeed computers, better than that by now."

"He's here, sir." The boy pointed. "Just over two hundred miles away, in a 17.8 minute orbit around the station."

Tebbetts blinked. "That's ridiculous. I don't think this heap of hardware would whip anything around in that time at a distance of two hundred feet, let alone that many miles. He'd have to use power, accelerating straight toward us—"

"He is, sir. About two hundred Gs acceleration. The time is the rotation period of Mesklin, and the acceleration is the gravity value at his home port. He says he hasn't been so comfortable since he signed up with Barlennan, and wishes there were some way to turn up the sunlight."

The astronomer smiled slowly.

"Yes. I see. That does make sense. I should have thought of it myself. I have some more practice exercises for him here, but that's about as good as any of them. I should do more of that sort of thing. Well, let's get at it. Can you stay to check my language? I think I have the Stennish words for everything in today's work, and space is empty enough so that his mistakes and mine should both be relatively harmless, but there's no need to take chances."

"It's too bad the *Kwembly* couldn't be salvaged after all," remarked Aucoin, "but Dondragmer's crew is doing a very good and effective study of the area while they're waiting for relief. I think it was a very good idea to send the *Kalliff* after them with a skeleton crew and let them work while they waited, instead of taking them back to the Settlement in the barge. That would have been pretty dangerous anyway, until there are practiced Mesklinite pilots. The single landing near the *Kwembly* to get the two helmsmen, and a direct return to space while they were trained, was probably the safest way to do it.

"But now we have this trouble with the *Smof*. At this rate we'll be out of cruisers before we're half-way around Low Alpha. Does anyone know the *Smof's* commander the way Easy knows Dondragmer? You don't, I suppose, Easy? Can

anyone give a guess at his ability to get himself out of trouble? Or are we going to have to risk sending the barge down before those two Mesklinites are fully trained?"

"Tebbetts thinks Beetchermarlf could handle a surface landing now, as long as it wasn't complicated by mechanical emergencies," pointed out an engineer. "Personally I wouldn't hesitate to let him go."

"You may be right. The trouble is, though, that we certainly can't land the barge on an ice pack, and not even the barge can lift one of those land-cruisers even if there were a way of fastening them together without an actual landing. Beetchermarlf and Takoorch may as well continue their training for the moment. What I want as soon as possible, Planetology, is the best direction and distance for the *Smof's* crew to trek if they do have to abandon the cruiser—that is, the closest spot where the barge *could* land to pick them up. If it's close to their present location, don't tell them, of course; I want them to do their best to save the cruiser, and there's no point in tempting them with an easy escape." Ib Hoffman stirred slightly, but refrained from comment. Aucoin, from one point of view, was probably justified. The administrator went on, "Also, is there definite word on the phenomenon that trapped the *Kwembly*? You've had specimens of the mud, or whatever it is, that

Beetchermarlf brought up, for weeks now."

"Yes," replied a chemist. "It's a fascinating example of surface action. It's sensitive to the nature and particle size of the minerals present, the proportions of water and ammonia in the lubricating fluid, the temperature, and the pressure. The *Kwembly's* weight, of course, was the main cause of trouble; the Mesklinites could walk around on it—in fact, they did—safely enough. Once triggered by a pressure peak, the strength went out of the stuff in a wave—"

"All right, the rest can serve for a paper," Aucoin nodded. "Is there any way to identify such a surface without putting a cruiser, or the barge, onto it?"

"Hm-m-m. I'd say yes. Radiation temperature should be information enough—or at least, it would serve warning that further tests should be made. For that matter, I wouldn't worry about its ever getting the barge; the jets would boil the water and ammonia out of such a surface safely before touchdown."

Aucoin nodded, and passed on to other matters. Cruiser reports—publication reports—supply reports—planning prospectuses . . .

Ib Hoffman's attention wandered, important though he knew the work to be. His mind kept going back to the *Kwembly* and the *Smof*, and to a well-designed, well-built piece of diving gear which

had almost killed an eleven-year-old boy. The reports, punctuated by Aucoin's sometimes acid comments, droned on; and slowly Ib made up his mind.

"I think we're getting ahead of the situation," remarked Barlennan. "There was a good excuse for taking the communicators out of the *Kwembly*, since she was being abandoned, so we've been able to work on her with no restrictions. Jemblakee and Deeslenver seem to feel that she can be back in running condition in another day." He glanced up at the feeble sun, almost exactly overhead. "The mud holding her has been nearly all washed away from the river side with water; they've jelled it on the other side with ammonia from the spring, so that she wouldn't drift away before we were ready. They have a canal washed all the way to the river. The human chemists were certainly helpful about that stuff. I hated to disappoint them with the report that we had to give up. It was funny how the one who talked to Dee kept insisting that he was only guessing, while he made suggestion after suggestion, and they all worked."

"That seems to be a human trait—lack of self-confidence," remarked Guzmeen. "When did this news come? I didn't see any flier."

"The *Deedee* came in an hour ago, and is gone again. There's too much for that machine to do;

we've got to face that problem. It was bad enough when we lost the *Elsh*, and with Kabremm and his *Gwelf* overdue things are piling up. I hope we find him; he's a good observer, among other things. Maybe the *Kaliff* will turn up something; he was supposed to be scouting a rescue route to get her to Dondragmer's camp, so there's a fair chance that one of Kenanken's scout fliers may spot him. He's less than a day overdue so far, so he should still be alive—"

"And with all this, you say we're ahead of the situation?" cut in Guzmeen.

"Yes. Remember, the whole aim of the *Esket* act was to persuade the human beings to let us use spaceships. That's been accomplished, or at least is beginning. The development of our self-support capacity was incidental to that end, though it was also desirable in itself. It's a nuisance that we've lost so much of it now, but not really a catastrophe. We haven't lost the personnel of the *Esket*, except maybe Kabremm and his dirigible crew and those of the *Elsh*, of course; just a lot of work."

"But even Kabremm and Karfrenjin aren't exactly expendable. There aren't very many of us. If Dondragmer and his crew don't keep alive until the *Kaliff* reaches them, we'll have taken a really serious loss; at least our dirigible crews weren't our scientists and engineers."

"Don's in no real danger. They can always be picked up by Beetchermarlf in the human spaceship—I mean our spaceship."

"And if anything goes wrong with *that* operation we're out not only our only spaceship but our only space pilots."

"Which suggests to me," Barlennan said thoughtfully, "that we should try to regain some lost ground. As soon as the *Kwembly* is ready she should start hunting a suitable place and start replacing the *Esket* settlement. Don's scientists should have little trouble finding a good location; Dhrawn seems to be rich in metal ores. Maybe we should have him search closer to here so that communication will be quicker, though.

"We'll have to build more dirigibles; the one we have left isn't nearly enough for the work. Maybe we ought to design bigger ones."

"I've been wondering about that," a technician who had been listening silently up to this point spoke up. "Do you suppose that it would be smart to find out more—tactfully, of course—from the humans about dirigibles? We've never discussed the subject with them; they showed you about balloons years ago, and some of our own people got the idea of using the human power sources with them. We don't know if *they* ever used them at all. Maybe it isn't just bad luck that we've lost two out of our three in a short time. Maybe there's

something fundamentally wrong with the whole idea."

The commander gave a gesture of impatience.

"That's silly. I didn't try to pick up a complete scientific education from the aliens, since it was obviously going to take too long; but one thing I did gather was that the rules, which are the central theme of the whole field, are essentially simple. Once the humans started concentrating on basic rules, they went from sailing ships to spaceships in a couple of hundred years. Balloons, powered or not, are simple devices; I understand them perfectly myself. Putting an engine aboard doesn't change that; the same rules have to be working."

The technician eyed his commander thoughtfully, and thought briefly of electron tubes and television circuits before replying.

"I suppose," he said thoughtfully, "that a piece of a tent being blown away by the gale, and a ship being tacked into the wind, are also examples of the same rules at work."

Barlennan didn't want to give an affirmative answer, but he could find nothing better.

He was still trying to shrug off the technician's remark, but only succeeding in growing more and more doubtful of his situation, some twenty hours later when a messenger called him to the communication room. As soon as he

entered, Guzmeen spoke briefly into a microphone; a minute later, a human face which neither of them recognized appeared on the screen.

"I am Ib Hoffman, Easy's husband and Benj's father," the stranger began without preamble. "I am speaking to you, Barlennan, and you, Dondragmer, at a time when no one else here is listening but my wife and son. The rest of the observing crew are concentrating on a new emergency involving one of the cruisers. Also, I am using your language as best I can. Easy is listening, knows what I want to say, and will correct me if I err too badly. I have decided that it is critically important to both you and us to clear up some points of misunderstanding. I don't intend to mention these points to anyone else up here, for reasons which will be obvious before I finish talking.

"First, Barlennan, my hearty congratulations. I am just about certain that when we turned the barge over to a Mesklinite pilot we fulfilled one of your chief plans, probably well before you meant or expected it to happen. That's fine. I wanted it to happen, too. Probably you want to make interstellar flights on your own, later on; that's fine with me, too. I'll help.

"You seem to feel that not all human beings agree with me, and that you have to act indirectly. I can't blame you for that. I can't even prove to you that I'm sincere;

you can't observe my actions directly, so what you choose to believe of what I say is beyond my control. I still have to say it.

"I don't know just how far you went to set up the situation which let me argue Aucoin into approving the transfer of the barge. I suspect that the *Esket* disappearance wasn't genuine. I'm not at all sure of the real status of the *Kwembly*. I'm almost certain that you have done a good deal more exploring, one way or another, than you have reported to us. I won't say I don't care, because I do; we're here to learn as much as possible about Dhrawn, and what you don't tell us is a loss to the project. I can't threaten you with penalties for breach of contract, since I'm not completely certain you've broken it and am in no position to carry out threats. I do want to persuade you, though, that it will be better for both of us if we do without secrets. We're at a point where anything less than complete frankness is likely to cost us a lot and cost you everything. To make that point, I'm going to tell you a story.

"You know that human beings breathe oxygen much as you do hydrogen, though being so much larger we need a more complicated pumping system to get it through our bodies. Because of the details of that system, we suffocate if deprived of gaseous, free oxygen within a certain rather narrow range of pressures.

“About three quarters of Earth is covered by water. We cannot breathe under water without artificial equipment, but the use of such equipment is a common human sport. It consists essentially of a tank of compressed air and a valve system which releases the air to our breathing system as needed—simple and obvious.

“Six of our years ago, when Benj was eleven years old, he made such a device, designing it himself with my assistance. He made the pressure tank and regulator, using ordinary fabricating equipment such as may be found in most home workshops, just as he had made more complex things such as small gas turbines. He tested the parts with my help; they worked perfectly. He calculated how long the air in the tank would last him, and then tested the whole assembly under water. I went along as a matter of common-sense safety, using a commercial diving device.

“I am sure you know the principles of hydrostatics and the gas laws—at least, Easy has given me words for them in your language. You can see that at a certain depth, a lungful of air would have only half its volume at the surface. Benj knew this, too, but reasoned that it would still be a lungful as far as oxygen content was concerned, so that a one-hour tank would be a one-hour tank regardless of depth, as long as tank pressure was above that of the water.

“To make a long story short, it didn't. He ran out of air in less than a third of the calculated time, and I had to make an emergency rescue. Because of the quick pressure change and some human peculiarities which you don't seem to share, he was very nearly killed. The trouble turned out to be that the human breathing *action* is controlled, not by oxygen supply in our blood, but by that of carbon dioxide—one of the waste products. To maintain a normal equilibrium of that, we have to run normal *volumes* of air through our lungs, regardless of oxygen content or total pressure; hence, an hour's air supply at normal pressure is only half an hour thirty-three feet under water, a third of an hour at sixty-six, and so on.

“I don't want to insult anyone's intelligence by asking if he understands my point, but I'd like some comment from you on that story.”

The answers were interesting, both in nature and arrival time. Barlennan's popped from the speaker with very little more than light-travel delay; Dondragmer's was much, much later, and did not overlap with his commander's.

“It is obvious that incomplete knowledge can lead to mistakes,” said Barlennan, “but I don't see why that is especially applicable to the present case. We know that our knowledge can't be complete, and that our work here is dangerous for that reason. We have always

known it. Why emphasize the point now? I'd much rather hear your report on the cruiser you say is in trouble. You make me suspect that you are leading up gently to the information that I have lost another cruiser because of something its designing engineers didn't know. Don't worry—I won't blame you for that. None of us could foresee everything."

Ib smiled at the revelation of another human characteristic.

"That's not just what I had in mind, Commander, though there are valid aspects to what you have just said. I'd like to wait for Dondragmer's answer before I say any more, though."

It was another full minute—a slightly strained one—before the voice of the *Kwembly's* captain arrived.

"The face value of your account is plain enough so that you would probably have been briefer had that been all you meant. I suspect that your key point is not so much that your son got into trouble through ignorance, but that he did so even under your adult, experienced supervision. I would take the implication to be that even though you aliens do not claim omniscience or omnipotence, and that we are in a certain amount of danger here no matter how closely you supervise and assist us, we are adding unnecessarily to our danger any time we act on our own—like

the student chemist who experiments on his own." Dondragmer had spent much more time at the College than had his commander.

"Just what I meant," said Ib.

"Just a moment," interrupted Easy. "Hadn't you better relay Don's remark to Barlennan first?"

"Right." Her husband gave a one-sentence summary of the captain's speech, and went on:

"Something has occurred to me; it may help—forestall, let's say—some trouble for you. I know one thing you badly need is a more rapid method of transportation on Dhrawn, and I know you have used a balloon on Mesklin. It might occur to you to try using a balloon, plus an energy pack to drive it, for transport on Dhrawn—a device of the sort humans once used on Earth, called a *dirigible*. It's a rather natural development of the balloon.

"Many of them were built on Earth—and they almost invariably came to a disastrous end. A structure light enough to float in air cannot be sturdy enough to resist the powerful forces of storm winds—even in Earth's mild climate. A free balloon does not resist the wind, and can survive by running as the winds will.

"In Dhrawn's complex ammonia-water-oxygen-whatnot atmosphere, meteorologists say that storm fronts of immense violence, and extreme sharpness, can arise in

a matter of a fraction of a minute.

"Desirable as air-borne transportation would appear to be—on Dhrawn I would suggest you'd better not try it. An atmosphere capable of the sudden violence Dhrawn can manifest, with 40 gravities to drive it, is not suitable for lighter-than-air craft. The helicopters, because they are small, and have high strength-to-area ratios, with fusion powered engines and are stressed for 250 gravity loadings, can survive with a Mesklinite pilot.

"But they cannot be made large, or they, too, would be torn apart in a Dhrawn-type storm.

"The chances are, Barl, that a good number of problems in exploring Dhrawn and maintaining a settlement there, can be eased greatly by a complete and full exchange of information.

"That won't eliminate all problems—but it can reduce fatalities."

"I can't force any policy on you, and would prefer not to even if I could. I don't expect you to make a complete confession of everything that's gone on on Dhrawn since you first built the Settlement. In fact, I'd advise strongly against it; I have enough complications up here with the administration as it is. However, if Easy just happened to get an occasional talk with her old friends Destigmat and Kabremm, just as an example, I would have a better idea of what has gone on and be in a better position to keep

things running smoothly at this end. I don't expect a spot decision on any matter of major policy change, Commander, but please think it over."

Barlennan, however, was a sea captain by training and trade, and accustomed to the need for quick decisions. Furthermore, circumstances had already been forcing thoughts along these same lines to circulate in his tiny head. Finally, his only really basic policy was closely connected with his own survival and that of his crew. He answered Ib promptly.

"Easy may get her talk with Destigmat, but not right away; the *Es-keet* is a long distance from here. I will also have to wait to tell you all that I'd like to, because I must first hear from you the details of the trouble you mentioned when you first called. You said that another of my cruisers was in trouble.

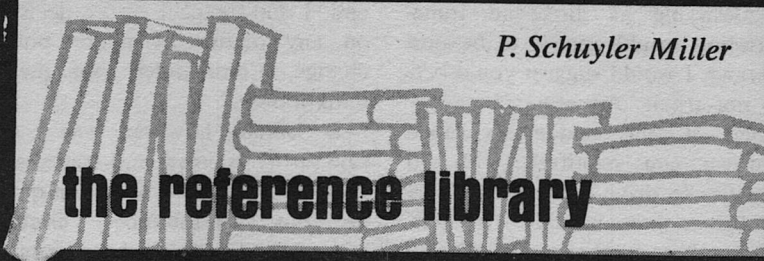
"Please tell me just what has happened, so I can plan what help to request from you."

Ib and Easy Hoffman grinned in mingled relief and triumph.

But it was Benj who made the key remark. This was later on, in the aerology lab, when they were recounting to him and McDevitt all that had been said. The boy looked up at the huge globes of Dhrawn, and the tiny area where the lights indicated partial knowledge.

"I suppose you think he's a lot safer now, down there."

It was a sobering thought. ■



P. Schuyler Miller

the reference library

CRITERIA

The last place you might expect to find a set of sound criteria for good science fiction would be in a magazine for elementary schoolteachers, but the January, 1970 issue of *Instructor* is where you'll find an article and reading list by Dr. Leland B. Jacobs, Professor of Education at Teachers College, Columbia University on "Science Fiction for Children." The article is a good one, and I hope it steers more teachers to the excellent juvenile science fiction that is being published nowadays. However, Professor Jacobs' recommendations don't seem to meet his own criteria in every case. Perhaps he took the recommendations of librarians who couldn't distinguish—as he does—between science and non-science.

Dr. Jacobs presents his criteria as a series of questions the teacher

should ask herself about a book. Only one of the lot, it seems to me, would restrict these standards to strictly juvenile SF. Since the magazine won't be easy for most of you to find, I'll repeat the others here:

"Is the basic story centered on a well developed human enterprise, in which some aspect of science plays a necessary part?" (This is *the* criterion that separated John Campbell's "new" SF from the stories of the Gernsback era.)

"Is the science presented sound both in scientific premises and in science information?" (This is a rather tougher standard than most editors require these days.)

"Is the story free from crude reductions of scientific phenomena—and of human behavior in the presence of such phenomena—to simplistic cause-effect conclusions?"

"Are characters' responses to the scientific ideas not only actively actual but also subtly behavioral in thought and feeling?" (Chew on that one for a while!)

"Does the story encourage wonder, and a respect for the creative in scientific and technological discoveries and advances?"

"Does the story stimulate the reader to extend his point of view about the possibilities of science in his life?"

"Is the story, in some significant way, rooted in the hopes, dreams, and fears of a technologically sophisticated society?"

"Does the story, by its focus on science in persons' lives, illuminate the social impact of science on life?"

This could be passed off as hopeful rhetoric, except that we all know good science fiction can do all these things, and some of the best does many of them. What Dr. Jacobs is saying is that what's sauce for us is also sauce for our youngsters. What I have been saying for a long time—though I have been speaking mainly of teen-age science fiction, that is, for readers older than those Dr. Jacobs has in mind—is that good "juvenile" science fiction is something you should be reading, too. The books I have seen are in the "Advanced Reading" part of Dr. Jacobs's recommended list . . . and I am discouraged at how many I've missed.

As I told you, Dr. Jacobs has

one other criterion which does *not* apply to adult—or, I think, teenage—science fiction:

"Is a child's world, rather than a watered-down adult world, authentically presented?"

A child's world is not necessarily the same as an adult world, and this may open the door to what we would call fantasy . . . but what about time travel, faster-than-light spaceflight, teleportation and other magical effects that we have agreed to let in? Dr. Jacobs's recommended SF stories for small children involve talking animals, witches, and other such near-magical "phenomena." He lists Wibberley's "Encounter Near Venus," which—you may remember—I condemned as not only fantasy but impossible (an invisible planet near Venus). I don't think that Freddy the pig belongs in a list of science fiction, I have strong doubts about Miss Pickerell—though the stories about her are children's classics—and even more about Mr. Bass and the Mushroom Planet. This is why I suspect Dr. Jacobs may have had the help of librarians in making up this list, and hasn't read all the books himself. I wish he had found some of Robert Silverberg's own books as well as his "Men and Machines" anthology.

A quibble, perhaps: Dr. Jacobs's standards are high enough for anyone's taste. He knows good science fiction when he sees it. The next generation is in good hands.

THIS PERFECT DAY

By *Ira Levin* • *Random House, New York* • 1970 • 309 pp. • \$6.95

Having scored a huge success with his witchcraft novel and film, "Rosemary's Baby," Ira Levin is trying his hand at science fiction. The result would be pretty good if the same formula hadn't been used so often, and more expertly, by other writers you all know. I trust that this means he knows nothing about the field and reinvented everything for himself. It may excite the unprepared reader, and it may make him another nice bundle (though witchcraft is "in" and science fiction isn't). It won't do much for veteran SF readers.

Chip—Li RM35M4419, and certainly no relation to "Chip" Delany—is the almost homogenized product of an efficiently homogenized, thoroughly sedated, computer-run future world. He has some maverick genes—at least, one eye is properly brown but the other is improperly green, and he won't have it replaced. He has an uncomfortably independent grandfather who helped entomb UniComp under a mountain in Switzerland—and who knows there is a back door to the tomb). He allows himself to become entangled for a time with a cell of professional dissidents, but is "saved" before he is beyond saving. Then those fermenting genes break through, he "rescues" one of the girls of the

group from darkest Africa, and they make their way to an unreconstructed—and unhappy—colony of dissidents on Majorca.

Finally, as all good future underground heroes must do, he leads a task force to break down Grandpa's secret back door and destroy UniComp. But there's a twist. And a twist on the twist.

If only it hadn't been done so often, and so well, in Analog.

TEN MILLION YEARS TO FRIDAY

By *John Lymington* • *Doubleday & Co., Garden City, N.Y.* • 1970 • 203 pp. • \$4.50

As I have said before and will say again, the English seem to have a predilection for stories of future catastrophes. John Christopher is perhaps the most consistent practitioner of the sub-genre, but J. G. Ballard does pretty well in his intelligible moods. And John Lymington specializes in the monster sub-sub-genre.

English readers may disagree—they know the places where Lymington unleashes his horrors—but his books' main virtue to an outsider is that they give a believable impression of a quiet, rather rural, somewhat backward community where all hell breaks loose. In a couple of his books, published as paperbacks in the States, alien spiders have come raining down from space. This time a totipotent creature out of the first days of the

planet—and I'll bet that title was originally ten *billion* years, because ten million is only a moment in the Earth's life—is awakened from the depths of an ancient mine, deep under Cornwall. Sure enough, all hell breaks loose, while the hero watches from an upstairs window and describes *ragnarok* to a tape recorder.

John Lynington must surely have read Conan Doyle's last Challenger yarn, "When the Earth Screamed." He probably has never read H. P. Lovecraft's "Colour Out of Space." In any case, though his book has elements of both classics in it, it is all his own work. You won't remember it long, but it will spin you along.

THE DALETH EFFECT

By Harry Harrison • G. P. Putnam's Sons, New York • 1970 • 217 pp. • \$4.95

You read a version of this book here in *Analog* as the serial, "In Our Hands, the Stars." Israeli physicist Arnie Klein discovers a potent antigravity force—a kind of "trigger" effect that gets massive results from very little expenditure of energy. With Israel under constant threat of war, he fears that his Daleth effect will be used to destroy rather than to build . . . so he flees to little Denmark, where he was born—and where the author lived for some years. Here, hiding among friends, he perfects his device—but when it is used to rescue

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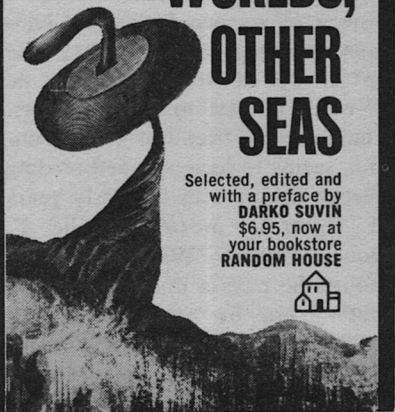
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Selected, edited and with a preface by **DARKO SUVIN**
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RANDOM HOUSE



Russian cosmonauts stranded on the Moon, the secret is out and the pressure is on. Anything that can take a submarine—and later an icebreaker—to the Moon is something the “Great Powers” want.

They go after it. Russia and the United States both try by every means at their disposal to get their hands on the equations, figures, whatever the “secret” may consist of. Israel is in there pitching, and there are some Chinese in the offing. Finally there is a dual attempt to hijack the Danish spaceship, with a tragic conclusion. A cruelly unnecessary conclusion.

Arnie Klein was right about one thing. Denmark is the kind of country that could be trusted with a Daleth effect.

THE FANTASTIC MIRROR

By Benjamin Appel • Pantheon Books, New York • 1970 • 145 pp. • Illustrated • \$3.95

As far as I know, this is the first history of science fiction for children. It is tagged for the “12 and up” crowd, but it will probably be of more interest to their teachers. The author, a friend of Groff Conklin, seems to have stopped reading science fiction with the early years of *Amazing Stories* (Leslie F. Stone, Charles Willard Diffin), though he pays a duty call on the present era by quoting snatches from stories by the USSR’s Valentina Zhuraleva and our Murray Leinster.

In his ramble with “Science Fiction Across the Ages”—the book’s subtitle—Appel hitches together synopses and excerpts from Lucian’s “True History,” Kepler’s “Somnium,” “Gulliver’s Travels,” Poe’s “Balloon Hoax,” Hawthorne’s “Dr. Heidegger’s Experiment,” O’Brien’s “Diamond Lens,” Mark Twain’s “Connecticut Yankee,” Verne’s “20,000 Leagues Under the Sea,” “Journey to the Center of the Earth” and “From the Earth to the Moon,” Frank Stockton’s “The Great War Syndicate,” and Wells’ “War of the Worlds,” plus the two more recent stories I mentioned above—Zhuralev’s “The Astronaut” and Murray Leinster’s “Propagandist.” This 1947 morsel brings us “up to date.”

Someone—and I suspect not the author—has garnished the wreath of posies with an assortment of plates from old prints and photographs. Few of these illustrate anything in the text (“Buck” Rogers is there from the famous 1928 *Amazing* cover by Paul, but not identified; there are also a couple of fascinating seventeenth century submarines that aren’t mentioned at all).

Any kid will get a better start in science fiction by picking up any of Heinlein’s juveniles, anything by Andre Norton, and just about any of the many excellent juvenile SF stories that the publishers are shoving on the shelves these days with little or no fanfare.

THE SHIP WHO SANG

By Anne McCaffrey • Ballantine Books, N.Y. • No. 345-01881-8-095 • 249 pp. • 95¢

This book has evidently been incubating for a long time. The title story, the first of six episodes in the career of Helva, the malformed infant whose brain was built into a spaceship and whose body was that ship, appeared in *Fantasy & Science Fiction* in 1961. The two best episodes were published here in *Analog*: "The Ship Who Mourned" in 1966 and "Dramatic Mission"—which at this writing is a candidate for assorted awards—last year. I haven't seen the final episode in any magazine as yet.

Helva is the ultimate and logical development of the cyborg concept—a human brain which is part of and controls a complex mechanism. Helva is the ship in which her brain has been encased ever since she became an adult—and Anne McCaffrey never lets you doubt her humanity. She is no Hal; she is no Adam Link; and she is always completely feminine. By the very nature of her life, trouble-shooting among the star-worlds, she is usually very close to tragedy. In the opening episode, the tragedy is her own, as her first living partner—her first "brawn" and her first love—is killed. Later she finds that other, whole people have their tragedies too, and so do other ships. Finally, in an episode of outrageous skulduggery, she finds an-

other brawn and freedom to rove the universe as she likes, a free agent. Like Kipling's cat, all places will be alike to her.

There is more than a touch in Helva of Cordwainer Smith's "Lady who sailed the soul." Anne McCaffrey is no Cordwainer Smith. She is more down to earth; her Irish shows. But the Irish are great for singing songs like these.

A Few From Sturgeon

Three reissued books—a novel and two short story collections.

THE SYNTHETIC MAN

By Theodore Sturgeon • Pyramid Books, N.Y. • No. X-2007 • 174 pp. • 60¢

Originally "The Dreaming Jewels." This is Pyramid's fifth paperback reprint. Horty was one of those tortured, strange children who wasn't the freak he seemed.

A WAY HOME

By Theodore Sturgeon • Pyramid Books, N.Y. • No. X-2030 • 192 pp. • 60¢

If ever Sturgeon wrote conventional science fiction, it was in these nine fairly early stories. This collection first came out in 1955 and it isn't dated in the least. The next appeared eleven years later . . .

STARSHINE

By Theodore Sturgeon • Pyramid Books, N.Y. • No. X-1977 • 174 pp. • 60¢

Fewer and stranger stories by a man who gets into hurt people.

brass tacks

Dear Mr. Campbell:

On reading your February Editorial, "Mr. Edison's Magic Lamp," I was reminded of some research that is being conducted in the U.K. at this time.

As you may know, the power and public utility industries in this country have been nationalized for several years, with the sole and irrelevant exception of the solid and liquid-fuel supply companies. Despite the consequent pooling of resources, and in common with the U.S.A. and many other technologically developed countries, they suffer from the effects of surges and slumps in demand and have for some time been searching for a satisfactory solution; what usually happens at present is reductions in voltage or pressure, or even load-shedding. This latter tactic, I may say, is not wildly popular, especially in mid-winter when the lights and heating fail during the climax of the Christmas holiday, leaving one longing for the

"traditional" yule log. (Sometimes I think they had the right idea in the Middle Ages: get a big fire going in the hearth in winter, stick by it until the spring and to hell with the wolves at the door.)

Plans for the future are very different, however. What is intended is that every new load (particularly those in "new towns"—towns planned in their entirety, for a specified population and with the appropriate facilities and public services) should be equipped with apparatus for the remote metering of power consumption in order that a central computer may periodically, say once an hour—or more often during peak periods—monitor every outlet in any given area and so determine the pattern of consumption. From this information, it will control the rerouting of power to those points in need—e.g., industrial—from, or through, those which are quiescent—e.g., residential—according to the time of day; in emergencies, it is further suggested, individual non-vital loads—such as the heating systems of empty buildings at night—would be turned off remotely, to be reconnected once the peak was past.

Of course, all this may never happen at all: perhaps some Ove Rasmussen will develop a workable fusion electric generator in time, or perhaps the self-centered Bastions of Society, Freedom & Co. will see it as the Thin End Of The Wedge and suppress it, rather than recog-

nizing it as a potential godsend if properly used. (They might have a point though: would *you* want everyone else to know that you were in the habit of drawing a cold bath at 3:35 a.m. just before gas-frying some beans to go on a wisp of electrically-burned toast?) Only time will tell.

But the most probable future is this: before too many decades have passed, most homes and factories will be under distant supervision, and complementary control, of electric power, gas and water twenty-four hours a day in order that *all* the lamps do not go out. Field trials have shown it to be a viable proposition; perhaps the mass of humanity may yet continue to believe in Magic, despite the cries of the Jansenists.

I hope so.

To lighter matters, now: a problem in hypothetical physics.

For the sake of simplicity, consider an isolated pair of time lines—see H. Beam Piper, Keith Laumer, et al.—one of which harbors a paratime-traveling race, members of which are in the habit of visiting the other time line on occasion. Now the problem is this: if individual X goes from line A to line B and is killed while there, this being the outcome of a 50-50 situation, what is the result? How many new time lines have been created? None? One or two? Remember the effect on line A, to which X would otherwise have re-

turned. Or, to get to specifics, why has the Imperium never encountered other, slightly different, Imperia as a result of all its shuttling to and fro across the world lines and the various touch-and-go situations that have been delineated in a number of stories? K. Laumer, care to comment? (This is serious interest, not hole-hunting.)

This, however, *is* hole-hunting.

Where did the propeller come from on the “Blaeksprutten” in Kelly Freas’ otherwise superb December cover? Hm-m-m! Otherwise, no complaints; keep up the good work.

ANDREW STEPHENSON

c/o “Woodlands”
Islet Road, Maidenhead,
Berkshire
England

1. That load-shifting business is just fine—so long as there is slack somewhere to take up! In Dayton, Ohio, this past winter very cold weather, with strong winds and snow, built up the heating load to such an extent that the natural gas pipelines could not supply the required volume. Noncritical users were cut off, then industries closed down kilns and furnaces, and finally many schools were closed until the weather moderated.

What do you do when critical loads alone require more than the utility can generate—or pump in? Neither electricity or gas heat is Magic!

2. I'll leave that time-track ques-

tion to Laumer—since Piper is now only on time-tracks other than ours.

3. *The propeller on Kelly Freas' cover for: "In Our Hands, The Stars" came from communicative necessity. Leave off the propeller, and put on jet-housings as the story specified, and you would not have a picture of a submarine-in-space; you'd simply have a rocketship en route to the Moon!*

Dear John:

On my newsstand, I have discovered something called "Astounding Stories" and dated 1970. It is, of course, one of Ultimate Publishing Company's unending stream of cruddy reprint magazines.

I have been a reader of ASF in its various forms, Analog, Astounding SF and Astounding Stories for thirty-five years and it rubs me the wrong way to see Sol Cohen appropriating that proud title for one of his reprint zines. Isn't there something you and Condé Nast can do to stop it?

ROY TACKETT

915 Green Valley Road NW
Albuquerque, New Mexico

Legally, when we changed our title to "Analog," we abandoned the "Astounding" title, putting it into the public domain. Thus, anyone who wants to could appropriate it. Someone did.

Dear Mr. Campbell:

I agree wholeheartedly with the

conclusions of your editorial, "Racial Tensions." It is quite true that the success of one group of people often arouse the ire of other people who fail. A classical case of this is the Mormons.

Most people think that it was polygamy that caused all of the trouble for the early Mormons. In fact, that issue was only a cover story for the final expulsion, from Mauvoo to Salt Lake. Although there was an element of hatred for the "abolitionist" Mormons from the slave-holding Missourians, we see indications that the Mormons were hated for their industry, and its results as well.

This is quoted from "Mormonism, Americanism, and Politics," by Richard Vetterli: "But again, as their neighbors saw their (the Mormons') cities expand and their numbers grow, the old enmity so well-known by (them) manifested itself . . ."

Governor Boggs (Missouri), who had personally fought sorties against Mormon families issued an "extermination order" authorizing their murders, regardless of age or sex. At the Haun's Mill Massacre the next day, seventeen Mormons were killed. A ten-year-old boy found hiding in a blacksmith's shop had the top of his head literally blown off as he pleaded for his life. *Much* later, when Governor Boggs found out that the Mormons were moving out West, he went to Washington to try to get an ap-

pointment as Governor of California.

Even ministers participated in this kind of activity. To them it was abhorrent that so many people were being converted to Mormonism. Incidentally, Mormonism has the dubious honor of being the first American institution fallaciously labeled "communist threat" (c. 1840).

Not many people know that Joseph Smith, the first Mormon Prophet, ran for the Presidency of the United States in 1844. His was the reform ticket, with a platform favoring free agency, the abolition of slavery, nation building, manifest destiny, the annexation of Texas, guarantees for the rights of the individual, political morality, the suppression of mob violence—the lack of which led to the Civil War—and a national banking system.

There is some evidence that a murderer's convention was held after the Reform Party Convention, and before a National Reform Party Convention could be held. Supposedly present were high political figures from all but three states. Among them were Governor Ford (Illinois) and Stephen Douglas (who was Lincoln's opponent later). The decision was to "get rid of Joseph Smith" because his policies "took like wildfire."

Joseph Smith and his brother Hyrum were killed in Carthage Jail while under Governor Ford's "protective custody" by a mob con-

sisting of the Illinois and Missouri militias. Two years later, the Mormons were kicked out of Nauvoo, a city they had built out of a swamp. In the early 1840s, Nauvoo was the largest, cleanest, and best-planned city in Illinois.

Today, Mormons have the conversion and education rates, and lowest divorce and crime rates of most (if not all) religions or social groups. They also have very industrious members who use less sick leave and advance quicker in their work. There are very few Mormons on Welfare, and those who are, need only apply to the Church Welfare Program to get aid.

So they are successful because of their beliefs, and they have a new type of "racial" persecution to prove it. The Black Student Unions of western universities are condemning Brigham Young University—a parochial school, entirely supported by tuition and funds from the Mormon Church—for "racism" in recruiting. In actual fact, more Amerinds go there than go to any other university in the United States, and perhaps the world. Blacks are not excluded, and are occasionally present, but simply do not apply.

Now local white ministers get up in front of white crowds—at least, in Tucson—likening Mormons to a cancer that must be cut out of society. To top this off, a black student threatened to kill, and then attacked a Mormon Elder whose an-

cestors are Chinese, Portuguese, and Polynesian, as well as Anglo-Saxon.

Is there no meaning at all in "Nothing succeeds like success."?

CHARLES R. WATSON

1614 E. 1st Street

Tucson, Arizona

Yes, there's a great deal of meaning—if you give the full statement: Nothing succeeds in arousing envy like success!

Dear John:

There is an additional alternative for Con Ed's power (POWER?) problem. They can simply make it elsewhere and ship it to the city. This they already do, but it is somewhat un-economic, as you mentioned. Hence there is a good deal of development of ultra-high-voltage power transmission systems, as well as cryogenic power transmission systems going on right now. The question becomes one of whether the public can stand the ecological contamination at the local site better than the cost of transportation from a remote—and also ecologically contaminated—site. All the alternatives are both expensive and politically hazardous, but we either will solve them, or simply—as some have proposed—abandon the city.

JOHN ALDERMAN

921 State Street N.W.

Atlanta, Ga.

The point of my editorial is the necessity for being honest in eval-

uating a problem. Long distance transmission is expensive, even when possible. You CAN NOT get something for nothing—and cursing the power company does not alter that fact.

Dear John:

Seems to me that Messrs. Powers and Rounds—March Brass Tacks—put a burr under your saddle and hit a very tender spot.

Your blanket indictment of scientists with a do-nothing attitude in areas of your interest appears to stem from emotional rather than objective analyses. Neither one said that there is no interest in resolving the questions of race and intelligence, but only showed that tools are not yet available to measure parameters that have not yet been defined. Can you say in honesty that no one is trying to find the answers? No one group of scientists can speak for *all* scientists. Agreed?

For the fifteen years that I have been a fan of yours, you have talked about Science as though it were deliberately trying to withhold Truth from society. Perhaps the sacred cow is not dead in many institutions. I would prefer to see you come down from your ivory tower and try to discover if there is a new awareness among scientists today, particularly in private and university laboratories. Freedom of inquiry is also prevalent among many government labs.

Mendel published one of the most important concepts of the 19th century, but it lay idle for thirty-five years until the necessary tools were available to test the concept. Only after the perfection of the light microscope could structure be equated with function. The science of genetics may have developed more rapidly if Mendel had debated Nägeli, or sent a reprint to Darwin; but even today, with the electron microscope and sophisticated techniques in molecular biology, the answers to the ultimate mechanisms of gene expression and regulation will probably have to await a measuring system not yet conceived.

The point is that there are people that care and are trying to discover truth, but they cannot figure out how to obtain measurements. Why do you not begin to report attitudes of the new generation of scientists and their approaches to solving difficult problems in natural, social, and supernatural areas of inquiry? This would be a welcome relief from the negativism you have conveyed—at least to me.

Perhaps our generation hasn't found all the answers, but you could inspire young scientists to exercise their imagination without depriving themselves of the facilities of modern laboratories.

LAWSON WINTON

901 S. Christine

Appleton, Wisconsin 54911

They did indeed hit a tender spot—the proposition that Science shouldn't be expected to tackle any hard problems, in areas where the basic problems have not already been worked out. That Science should ignore problems that haven't already been half solved, in other words. That I object to very strongly. Only the easy, the well-understood, is fit for Science to study?

Then who does the truly basic research?

And Science does cut society off from Truth—by denying the existence of any area which Science has not yet understood, while it refuses to make any attempt to understand that area. As in the critical areas of Race and of Psi.

Sociology is, currently, a Grade A #1 mess of crucial importance. Because we can't solve the problems in that area we have exponentially mounting crime, violence, and war—and the next major war is going to "solve" those problems in the Good Olde Fashioned way—via the Four Horsemen.

Yet sociologists refuse to seek new approaches; they keep saying "All we need is more money to make our Old Reliable methods—that haven't worked whenever tried—do the job!"

Psychology is in an equal mess—yet the new aspects of mind that psi phenomena indicate are absolutely verboten areas of study.

And you're entirely wrong on Mendel. He provided the necessary new tool—and that was what they rejected! He was the first to use statistical analysis to study biological phenomena—and statistical analysis was the essential tool required for studying genetics, not the microscope.

The fundamental error of Science-with-a capital-S is the insistence that the causal relationships must be developed first, before study is possible.

In other words, that we must have the answers before it is worth while to study the problem at all!

Edison did not know what an electric current was when he developed electrical engineering—the electron wasn't discovered till long after.

Watt didn't know anything about thermodynamics.

Chemical engineering was a massive industry before valence forces were understood at all.

It is totally and absolutely unnecessary to know anything whatever about causal forces to be able to observe and correlate phenomena, and apply them usefully to solve vital problems.

If that were not so, no animal, which understands nothing about biochemistry, could eat, digest, and construct its body.

So long as Science insists it has to understand Why before it can study What it will never solve new problems in new areas.

And because Scientists have such high authority status, their rejection of things they cannot understand—no Why explanation available—means that they suppress efforts to study What.

With me, that is indeed a sore point.

Dear Mr. Campbell:

I'm writing this letter because of Mr. Howard's story in the / 2/70 issue. What aroused my curiosity is the name of the main character, Mr. Sirbuh—which when spelled backwards is "hubris." Now, as Mr. Webster and any student of Greek tragedy knows, "hubris" is "wanton arrogance arising from overbearing pride." Considering this and the plot of the story, would this humble reader be correct in assuming that Mr. Howard did this intentionally?

I've been an avid reader of Analog for the last three years and enjoy each issue. John Dalmas, Gordon Dickson, Chris Anvil and James Schmitz have all been first rate. John Norman, one of my favorites, I have never seen in Analog. His Tarnsman series is great. Perhaps he has some short stories along the same plot.

DAVID L. SIMS

149th Ordnance Detachment
Explosive Ordnance Disp.
Edgewood Arsenal, Md. 21010
One would indeed be correct in that assumption. Howard mentioned it in his letter of submission!

EDITORIAL

continued from page 7

Now from the viewpoint of some young workingmen weekend soldiers who've been called up to maintain peace and protect property, the bums and vandals they met at Kent State didn't have any aura of good fun and college high jinks.

The young Guardsmen had already spent several hardworking nights trying to keep peace among another unruly bunch—the wildcat striking truckmen. From the Guardsman's viewpoint, there was damn little difference between a bunch of workmen who were raising hell, and a bunch of men the Guardsman's own age who had already made a mess of the town of Kent, and destroyed the ROTC building on Kent State campus.

Do you want to try explaining why it was perfectly all right for the college kids to burn down parts of the town, but that striking truckmen shouldn't be allowed to do such things?

The students claim that they attacked the Guardsmen with lethal weapons—i.e., rocks, hunks of concrete and bottles—solely because they wanted “the pigs off Campus.”

The students had lost the right of free assembly by assembling to commit arson and vandalism—but

the kids knew that as students they had an absolute right to do whatever they wanted to with complete impunity—no one could punish them! They had absolute immunity. They could do what they wanted and no one could stop them.

They chose to assemble against the rulings—rulings based on sound sense. The Guardsmen carried out orders and advanced to disperse them—and were assaulted with deadly weapons.

And remember this; any weapon which is capable of blinding and killing a grizzly bear is a deadly weapon in any sane semantics. Rocks are deadly weapons.

If you still feel that's a false attitude—try standing out in front of a barrage of thrown rocks yourself some time.

In Biblical times stoning was a regular form of public execution. Slow and painful, but thoroughly permanent.

The Guardsmen advanced, and pushed the students out of the common area with tear gas. This tended to compact the students, as those in the rear moved away slower than those in front—and presently the Guardsmen ran out of tear gas.

Now these young men were workingmen, who served in the State guards force as weekend soldiers, with a couple of weeks each year at camp. They were not profession soldiers—and they definitely don't rate as being “members of the

Establishment," unless that has some weirdly involute meaning I don't appreciate. They were simply local citizens who'd signed up to help protect their homes and communities against disorder or attack.

They were working in a community that had, visibly, been attacked by invading vandals. There was some of the ancient town-vs.-gown tension involved, but there's some question as to who had a better right on that campus—the students or the peace force of the State that owned and operated the State University. The students certainly didn't own it—and they certainly couldn't be trusted to care for it. They preferred—as they had demonstrated—to burn it down, and keep city firemen from extinguishing the fire. (The students chopped the firemen's hoses with machetes when the effort to save the ROTC building was going on.) The Guardsmen had every reason to feel they were facing a dangerous, violent, and destructive mob—the mob was throwing rocks, looked, sounded, and acted violent, and had already committed major destruction.

And they were as young as the college students themselves; they weren't trained, veteran police with the judgment and stability that comes with age (an idea which the students, of course, would deny!) nor were the weekend soldiers combat veterans, nor fully trained regular Army troops.

Something happened which any sociologist or psychologist, who knew something of human motivations, could have predicted months ago—if either sociology or psychology were a science, instead of a half-developed art.

The young Guardsmen panicked. Somebody—deafened to sound communication by the shouts and screams of "Pig" and other less printable comments—saw somebody make a gesture and took it for a command to fire.

The shots came as a terrible, unbelievable shock to the students; they'd *known* that they were immune to punishment—*known* the Guardsmen didn't really have bullets in their guns, or that they were really just blanks, like a war scene in a movie. The idea that anybody could punish *them* for their acts was, of course, impossible!

The result was one of those classic situations where a statistical truth, "The students deserved what they got," is completely at odds with the individual truths, "These young people should not have been shot."

The students earned what happened, those students didn't—save in one sense.

One of the young men who was killed, it now appears, was simply observing the confrontation; he'd picked a place to stand where he could get a good view of the occasion—in no-man's-land between the opposing armies.

There's many a war correspondent who's been killed trying to observe a battle; if someone insists on standing between two battling forces, that's his option—and his responsibility if he gets killed.

The sad part of it was that that young man was so convinced that nothing whatever could be done to the students that he didn't think there was any danger.

He based his action on the concept of Absolute Immunity for Students.

In essence, when a known, violent confrontation is going to take place, there are no truly "innocent bystanders"; anyone who chooses to be a bystander at violence is either stupid, ignorant, or knowingly taking a risk. Since everyone at Kent knew there was violence going on, no bystander could claim to be ignorant; then they were either knowingly taking the risk—or remarkably stupid. It's about equivalent to gawking at an accident on the freeway while standing in the 70-mile-an-hour lane to get a better view. You *might* not get killed by a passing car, but the driver would probably be gawking at the scene, too, and not notice you.

But the major importance of the Kent State affair is that it gives administrations something to count on in the future.

It's going to happen again. It's perfectly predictable. The college students always outnumber the lo-

cal police, so that local police can't handle their mob action. This requires that the Guardsmen be brought in—and the Guardsmen are necessarily weekend soldiers, mostly college-age themselves, with a rather low opinion of the pampered brats whose rich families have sent them off to college, while the Guardsman's busy earning a living. He didn't have the money to get to college.

Being of the same age, he doesn't see any reason why the pampered brats deserve any kid-glove handling; when they destroy property where working men have to make a living, it doesn't seem like "good clean fun" to the working Guardsman. The Guardsman does see that a man his own age, busily throwing rocks, concrete and broken bottles at him, rates as "assaulting with deadly weapons" and does not like it.

When a mass of violent, destructive, and murderously armed students surround him—he's apt to panic. Under those conditions a weekend soldier without combat experience can be expected to use what weapons he has to defend himself. He has the faulty judgment and over-reactions characteristic of not-yet-mature men. He's facing armed peers who are already using their weapons—so he'll use his.

It doesn't make any difference whether he has live ammo in his gun or not; he does have a bayo-

net, and he's also been trained in how to use an empty rifle as a powerful hand-to-hand combat weapon.

The result will be enough serious injuries and deaths to convince *that* bunch of rioting students that they *are not immune to punishment*.

With their sacred immunity stripped from them, naturally they flee in terror. Their whole world-picture has been terribly altered; punishment can happen to them!

It's not important to stew about whether the rifles are loaded or not—that makes almost no difference statistically. The individuals that will be killed will change, but the deaths won't. The sound of shots alerted the whole Kent State mob to the fact that a new factor had been added; the screams of the first few skewered with bayonets would have had the same effect.

Look—I'm neither Conservative, Reactionary, Establishmentarianist or Radical. I'm a Pragmatist. Take a look at the facts, consider what human beings are—not what they say they are—and observe what happens.

Immunity corrupts; absolute immunity corrupts absolutely.

If we continue to hold that college students are allowed absolute immunity to demand anything they want, to destroy anything they feel like, to call arson and vandalism "peaceful demonstration" and throwing lethal rocks as "expressing frustration"—eventually

they will meet a group that uses different semantics.

A couple hundred million years ago mammals invented the idea of punishing the young. Even the higher birds use the idea. Only the reptiles and lower animals leave their young unpunished.

If a young reptile makes a mistake, he doesn't learn from it—he's dead. If a young mammal makes a mistake, Mama may cuff him so he lands twenty feet away—but he survives, and thus learns not to repeat that mistake.

The trouble with the students at Kent State was that they'd been treated like reptiles—they hadn't been punished at earlier, minor incidents so they could learn to avoid the deadly ones.

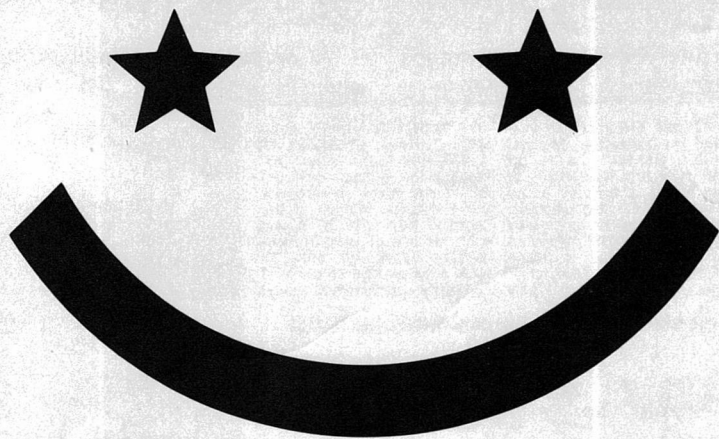
That's why four had to die.

It was too bad that the wrong four died—but for the group of students, punishment was due.

If I'm any judge of the current cultural streams, almost nothing will be learned from this incident. They'll concentrate on the Guardsmen, what orders to give them, and take the bullets out of the guns.

But they will not make it clear to college students that no one in the real world can escape all responsibility for their acts—until the fact is driven home to some more kids in another confrontation with young men their own age who work in the real world, and have learned that reality. ■

THE EDITOR



Discover America. It's 3,000 smiles wide.

See exotic sun-bronzed girls on tropical beaches.

Follow challenging trails up snow-bound peaks in the dead of summer.

Uncover centuries of secrets buried in strangely beautiful caverns.

Delight in authentic native dances: the boogaloo, the shing-a-ling, the skate.

Everywhere you go, friendly natives will introduce you to their strange folkways: the single-minded cult of the surfer, the infinite imagination of the city-dwellers.

America is action, ideas and a million surprises.

Isn't this the year to get out and discover it for yourself?



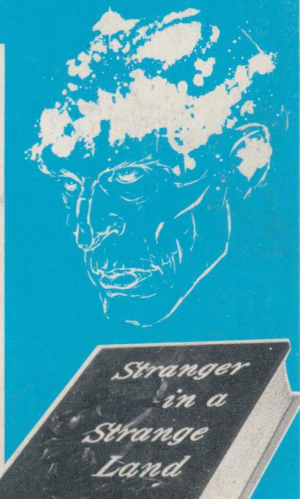
The first human born on Mars was a "grok" specialist!

THAT was the greatest weapon in Valentine Michael Smith's arsenal... a secret that made him irresistible to women but a bitterly hated enemy to the establishment. And all he wanted to do was reform an immoral, troubled world by bringing it peace and tranquility. Some reform! Some revolution! But that's

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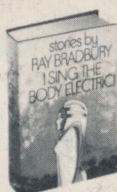
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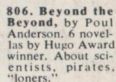
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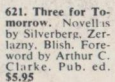
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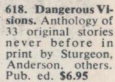
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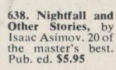
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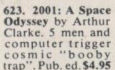
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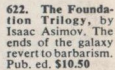
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